SITE CONDITIONS TECHNICAL MEMORANDUM
PRELIMINARY DATA COLLECTION
Frontier Hard Chrome
Vancouver, Washington

Prepared for

U.S. Environmental Protection Agency
Region X
1200 Sixth Avenue
Seattle, Washington 98101

Contract No. 68-W9-0046
Work Assignment No. 46-38-027N
Work Order No. 4000-32-01-3300
Document Control No. 4000-32-01-AABD

June 1997

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ARCS QUALITY ASSURANCE CONCURRENCE

PRELIMINARY DATA COLLECTION
Site Conditions Technical Memorandum

Project Name:	Frontier Hard Chrome Vancouver, Washington
Contract Number:	68-W9-0046
Work Assignment Number:	46-38-027N
Responsible Organization:	Roy F. Weston, Inc. 700 Fifth Avenue, Suite 5700 Seattle, Washington 98104

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SITE CONDITIONS TECHNICAL MEMORANDUM
FRONTIER HARD CHROME
VANCOUVER, WASHINGTON

1. INTRODUCTION

The memorandum is a contract deliverable under the Environmental Protection Agency's (EPA's) Work Assignment No. 46-38-027N to Roy F. Weston, Inc. (WESTON) under the Alternative Remedial Contracting Strategy (ARCS) Contract No. 68-W9-0046. The memorandum summarizes the results of preliminary data collection and site investigations at the Frontier Hard Chrome (FHC) Superfund site located in Vancouver, Washington.

2. SCOPE

The work conducted in support of the preliminary data collection was performed in accordance with the procedures and methods specified in WESTON's Sampling and Analysis Plan (dated 22 January 1997) with Addenda 1 through 3. The scope of services completed for this investigation included the following:

1. Drill and obtain soil samples from six exploratory borings.
2. Submit selected soil samples from the borings for chemical analysis of cation exchange capacity (CEC) and total organic carbon (TOC).
3. Construct and develop 2-inch-diameter PVC monitoring wells in four of the borings.
4. Measure the depth to groundwater in the monitoring wells.
5. Survey the horizontal locations and vertical elevations of the monitoring wells.
6. Collect groundwater samples from selected monitoring wells for chemical analysis of VOC (volatile organic compounds), and total and hexavalent chromium, and water quality parameters.
7. Conduct borehole geophysics on selected monitoring wells and the deep boring using gamma and neutron logging tools.

3. SUBSURFACE SOIL INVESTIGATION PROGRAM

3.1 Well and Boring Installation

Subsurface soil conditions beneath the site were explored by drilling 6 borings at the approximate locations shown in Figure 1. Monitoring wells W97-18A, W97-18-B, and W97-18BA were drilled between 24 and 27 February 1997 to depths of 25, 50 and 50 feet below the ground surface (bgs), respectively. Monitoring well W97-18BA encountered a sewer line and had to be abandoned on 2 February 1997. Monitoring wells W97-19A and W97-19B were drilled on 17 March 1997 to depths of 25 and 50 feet below ground surface (bgs), respectively. Soil boring B97-11 was drilled in two phases.

On 25 and 26 February, B97-11 was drilled to a depth of 38 feet bgs using hollow-stem auger drilling equipment. Drilling was discontinued due to drilling refusal. Air rotary drilling equipment was subsequently mobilized and the boring was extended to a depth of 98 feet bgs on 16 March 1997. The details of the field exploration program and the boring logs are presented in Appendix A and Appendix B, respectively. Two soil samples were collected from B97-11 and one soil sample from W97-18B were submitted for laboratory analysis of TOC and CEC.

3.2 Geophysical Borehole Logging

Selected "B" level monitoring wells and boring B97-11 were borehole geophysically logged using gamma and neutron logging tools. The borehole geophysical logs are presented in Appendix C. The principal purpose of the borehole geophysics was to determine if a fine-grained layer is present between the "A" and "B" aquifers. During the remedial investigation (Dames and Moore, 1987), the "A" and "B" zone aquifers were thought to be separated by a thin silt layer referred to as the "lower aquitard." The silt layer was thought to be about 2 to 4 feet thick because it was not always encountered during drilling using a 5-foot sampling interval. When not encountered, this layer was inferred based on drilling characteristics.

Borehole geophysics was used to supplement the information obtained from drilling. Because soil samples were collected at 5-foot intervals during drilling, thin soil layers can be missed. Borehole geophysics data provide relatively continuous data and can therefore be used to supplement the drilling data to identify changes in soil character missed by the sampling interval during drilling. The utility of borehole geophysics is that changes in the physical character of sediments encountered in the borehole can be identified by changes in the geophysical response. Therefore, the presence or absence of a silt layer may be recognized from changes in geophysical response.

The selection of borehole geophysical techniques tools was limited to gamma and neutron tools because of the presence of cased monitoring wells and borings. The presence of PVC wells and steel-cased borings excluded other commonly used logging tools such as electrical, electromagnetic and acoustic logs. Generally, the combination of the gamma and neutron logs is considered sufficient for the purposes of this study.

The gamma tool measures the natural gamma ray emissions from the formation. In the subsurface, gamma rays are emitted by the radioactive potassium isotope, K^{40}, and by the radioactive elements of the uranium and thorium series. As a general rule, clays, silts, and sands high in minerals such micas and feldspar, generally have higher gamma counts than gravels. On the gamma logs, higher American Petroleum Institute (API) counts correspond to higher gamma counts recorded from the formation.

The neutron tool contains a radioactive source that bombards the formation with neutrons; one or more detectors measure the energy level of the returning neutrons. The number of returning neutrons is related to the amount of hydrogen present, which, in saturated formation, is mostly a function of the water content of the formation near the borehole. Neutron logs measure the moisture content in the unsaturated zone and saturated porosity below the water table. As recorded on the neutron log, higher API values corresponds to higher neutron returns or lower saturated porosity or lower moisture content. The highest API values are associated with the unsaturated zone and vary to moisture content. Below the water table, higher API values are associated with formation materials having lower saturated porosity; lower API values are associated with formation materials having higher saturated porosity values.

The following assumptions were used in interpreting the borehole geophysics:

1. High gamma counts are due to the presence of silts, clays and sands containing mica and feldspars. Gravels have lower gamma counts.

2. Gamma counts are not affected by water content of the formation.

3. The change in neutron logs is a response to the presence of water in the formation.

4. In the unsaturated (vadose) zone, the neutron log is a measure of the moisture content. In the saturated zone, it is a measure of the liquid-filled porosity.

The boundary of the unsaturated and saturated zone can be easily identified by the dramatic decrease in the neutron log response, which generally occurs between 10 and 14 feet bgs.

The first native soil unit identified is generally a silty clay unit called the "upper aquitard" in the remedial investigation report (Dames and Moore, 1987). This silty clay horizon can be identified in the geophysical logs by a characteristic increase in gamma response and low neutron response. The "upper aquitard" was encountered in all the borings except W87-8B. Further, this horizon is very thin (less than 2 feet) in W85-3B probably because the silty clay unit pinches out to the north.

The lower aquitard was identified as a thin (2 to 4 feet) silty sand or sandy silt located between a depth of 30 and 36 feet bgs. According to the boring logs, this unit was sampled in borings PW-1B, W85-7B and W87-8B. It was described in PW-1B as 4 feet of sandy silt with some fine gravel. In W85-7B it consists of 2 feet of silty sand to sandy silt with little fine gravel. As present in W85-8B, it consists of 4 feet of sandy silt to silty sand with some fine gravel. A review of the borehole geophysical responses indicate that there is no obvious or consistent response in either the gamma or neutron logs. There is a significant increase in gamma count at the depth the silt identified in PW-1B but no significant gamma increase in W85-7B and W85-8B. Significant gamma spikes between 25 and 33 feet recorded in W92-15B, W92-16B, and W97-18B suggest that thin lenses of silt exist that were not recorded during drilling.

Significant gamma spikes were also recorded at the 38- to 45-foot bgs interval in W85-8B, W85-7B, W85-3B, W85-1B. These areas correspond to sand to silty sandy gravel intervals, based on drilling information.

The neutron log records show a relatively high saturated porosity, which is associated with “upper aquitard” and the “A” zone aquifer. Most of the neutron logs show a steady decrease in saturated porosity between 30 to 50 feet bgs.

The borehole geophysics indicate that a thin silt layer or lense may be present in the vicinity of the area identified as the lower aquitard, but that the signature is not very distinct, nor much different from the surrounding formations. The presence of interbedded lenses of silty material is common in this type of deposit. The borehole geophysics support the presence of lenses of silty material in the “A” zone aquifer. There is little support to indicate that the “lower aquitard” is continuous or is significant enough to act as an important aquitard to hydraulically separate the “A” and “B” zone aquifers.

4. GROUNDWATER CONDITIONS

Monitoring wells were installed in four of the soil borings. The location of the wells are shown in Figure 1. The construction details of the new and historical monitoring well construction are summarized in Table 1.

The depth to groundwater levels were measured in all new and existing historical monitoring wells in February, March, April and May 1997. The water elevation data is summarized in Table 2. Potentiometric surface contour maps for both the “A” and “B” zones from data collected during April and May 1997 are presented in Figures 2 through 5. The “A” and “B” potentiometric surface is very flat across the site. The average gradient calculated from the April data was 0.0005. The May data were too variable; therefore, groundwater gradients were not able to be determined. There were small differences in water levels between “A” and “B” level well pairs. The lack of significant difference between water levels in the “A” and “B” levels well pairs suggest that the “A” and “B” zones are hydraulically connected and should be considered part of the same aquifer.

4.1 Field Water Quality Parameters

The water quality parameters pH, temperature, oxygen, conductivity, and redox potential were measured in the field during groundwater sampling. The results of field water quality parameter testing are summarized in Table 2.

The pH values measured in groundwater at the site ranged from 4.96 to 6.58. The lowest pH was recorded in W97-14P. The pH of most natural groundwater ranges from 6 to 8.5 (Hem, 1985). Conductivity in groundwater varied from 19 to 440 microsiemens per centimeter (µS/cm). Conductivity is a function of the dissolved ionic materials in groundwater (Hem, 1985). Redox values were positive ranging from 182 to 259 millivolts (mV). The redox data indicate that groundwater at the site is slightly oxidizing. Dissolved oxygen concentrations ranged from 0.2 to 4.9 mg/L

5. GROUNDWATER SAMPLING AND ANALYTICAL RESULTS

5.1 Introduction

Groundwater samples were collected from 25 selected monitoring wells between 24 February and 17 March 1997. The groundwater analytical program is summarized in Table 4. All the groundwater samples were analyzed for total chromium; selected samples were analyzed for hexavalent chromium, volatile organic compounds (VOCs), selected dissolved metals and conventional water quality parameters (alkalinity, fluoride, chloride, sulfate, sulfide, nitrate, orthophosphate), total dissolved solids (TDS), and total organic carbon (TOC). In addition to the water samples collected from the monitoring wells, five groundwater samples were collected using a “Hydropunch-type” sampling device drilling the drilling of deep boring B97-11. These samples were submitted for laboratory analysis of total chromium. The groundwater sampling procedure used during this investigation is presented in Appendix A. The laboratory reports are presented in Appendix D.

The VOCs, inorganics, and conventional groundwater quality parameter analyses were performed by EPA’s Manchester laboratory; TOC and CEC analyses for soil were performed by Analytical Resources Incorporated of Seattle, Washington, in accordance with procedures described in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA SW-846, 3rd edition).

Quality assurance/quality control (QA/QC) reviews of laboratory procedures were performed on an ongoing basis by the laboratory. A data review was performed on laboratory quality control results summary sheets to ensure they met data quality objectives for the project. Data review followed the format outlined in the *Laboratory Data Functional Guidelines for Evaluating Organic Analyses, revision 2/94* and the *Laboratory Data Functional Guidelines for Evaluating Inorganic Analyses, revision 2/94* modified to include specific criteria of the individual analytical methods. Raw laboratory data including calibrations, sample login forms, sample preparation logs and bench sheets, quantitation reports, mass spectra, and chromatograms are kept on file at the laboratory. Results of the data reviews and laboratory data sheets are presented in Appendix D.

5.2 Groundwater Monitoring Well Results

A list of monitoring wells sampled and analyses associated with each well are presented in Table 4.

5.2.1 Volatile Organic Compounds (VOCs)

Eight monitoring wells were sampled for VOCs. The results of VOC analysis are summarized in Table 5. One or more VOCs were detected in all of the wells sampled. Samples primarily contained tetrachloroethene, commonly referred to as perchloroethylene (PCE), and two of its degradation products: trichloroethene (TCE) and cis-1,2-dichloroethene (cis-DCE). Vinyl chloride was not detected in any sample. In addition, 1,1,1-trichloroethane (TCA), 1,1-dichloroethane (DCA), ethylbenzene, and xylenes (dimethylbenzenes) were found in several samples. The highest concentration of PCE (84.2 µg/L) and its degradation products was found in monitoring well W85-3A, though this concentration is almost 100 times less than reported in 1987. Highest concentrations of TCA and DCA were found in monitoring well W92-14P, while the highest concentration of aromatics was detected in monitoring well W92-14A.

The detected VOC concentrations were compared to the MTCA Method A or B cleanup levels (Table 5). TCE concentrations greater than the MTCA Method B cleanup levels (3.83 µg/L) were detected in one water sample (W85-3A, 8.9 µg/L). PCE concentrations greater than the MTCA Method B cleanup levels (80 µg/L) were detected in four wells ranging in concentrations from 7.7 to 84.2 µg/L. The highest TCE and PCE concentrations were detected in well W85-3A. The distribution of PCE is presented in Figure 6.

5.2.2 Chromium

Groundwater samples from all locations were analyzed for total chromium and, at selected locations, for dissolved and hexavalent [Cr(VI)] chromium. Chromium results are summarized in Table 6. The highest concentration of total (19,400 µg/L) and Cr(VI) (18,400 µg/L) was found in monitoring well W92-14A. Hexavalent chromium concentrations across the site average 97 percent of total chromium values. The results indicate that there is little significant difference between the hexavalent and total chromium values and indicate that all of the chromium present in groundwater is in the hexavalent form. This is not unexpected since the only other form of chromium, trivalent Cr^{+3}, is only very-slightly soluble in water. The spatial distribution of total chromium in the “A” and “B” zone wells are shown in Figures 7 and 8.

Groundwater concentrations of chromium have generally decreased over time at all monitoring well locations though data are variable with several concentration “spikes” during previous sample events. Historical concentration trends in chromium for each monitoring well are presented in Figures 9 through 27.

5.2.3 Inorganics

Selected dissolved metals were determined for a number of samples to characterize groundwater chemistry and for potential use in geochemical speciation modeling. Metals included aluminum, barium, calcium, iron, magnesium, manganese, potassium, silicon, and sodium. Results are presented in Table 7.

5.2.4 Conventional Groundwater Quality Parameters

Conventional groundwater quality parameters and anions were determined for a number of samples to characterize groundwater chemistry and for potential use in geochemical speciation modeling. Parameters included alkalinity, chloride, fluoride, nitrate, ortho-phosphate, sulfide, sulfate, TDS, and TOC. Results are presented in Table 8.

5.3 Hydropunch™ Groundwater Samples

Groundwater samples were collected over five depth intervals from station B97-11 using a Hydropunch™ and analyzed for total chromium to determine the vertical extent of contamination. Samples were collected from 20, 40, 60, 80, and 90 feet beneath the surface. Chromium was detected only in the sample collected from the 60 foot interval at 10 µg/L.

5.4 Soil Boring Results

Three soil samples were collected from borings at stations B97-11 and W97-19B, and submitted for TOC and CEC analysis for use in remedial design and to determine if natural attenuation would be possible at the site. CEC of the soil is low with results ranging from 2.3 to 9.9 meq/ 100 g. TOC of the soil is also low ranging from 0.058 to 0.82 percent.

6. CONCEPTUAL HYDROGEOLOGIC MODEL

A conceptual hydrogeologic model was presented in the remedial investigation report (Dames and Moore, 1987). Based on a review of historical data and the data collected during this investigation, the conceptual hydrogeologic model was reevaluated and revised. The revised hydrogeologic model is presented in Figure 28. The revised model differs from the Dames and Moore model primarily in the extent of a confining layer separating the “A” and “B” zones in the aquifer. The distribution of groundwater contaminants, review of the original boring logs, the similarity in potentiometric surface, and the results of borehole geophysics indicate that there is no significant confining layer between the “A” and “B” zone aquifers.

Conventional chemistry results also suggest that there is no difference in groundwater chemistry between the "A" and "B" zone wells. The Piper diagram (Figure 29) graphically illustrates that groundwater in all wells except W92-14P is chemically equivalent. The major difference in monitoring well W92-14P, screened in perched groundwater, is the lack of alkalinity, most likely a result of the low pH at this location.

References

Hem, J.D. 1985. Study and Interpretation of the Chemical Characteristics of Natural Water. United State Geology Survey Water Supply Paper 2254.

EPA. 1986 and updates. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (EPA SW-846, 3rd Edition).

EPA. Laboratory Data Functional Guidelines for Evaluating Organic Analyses, revision 2/94.

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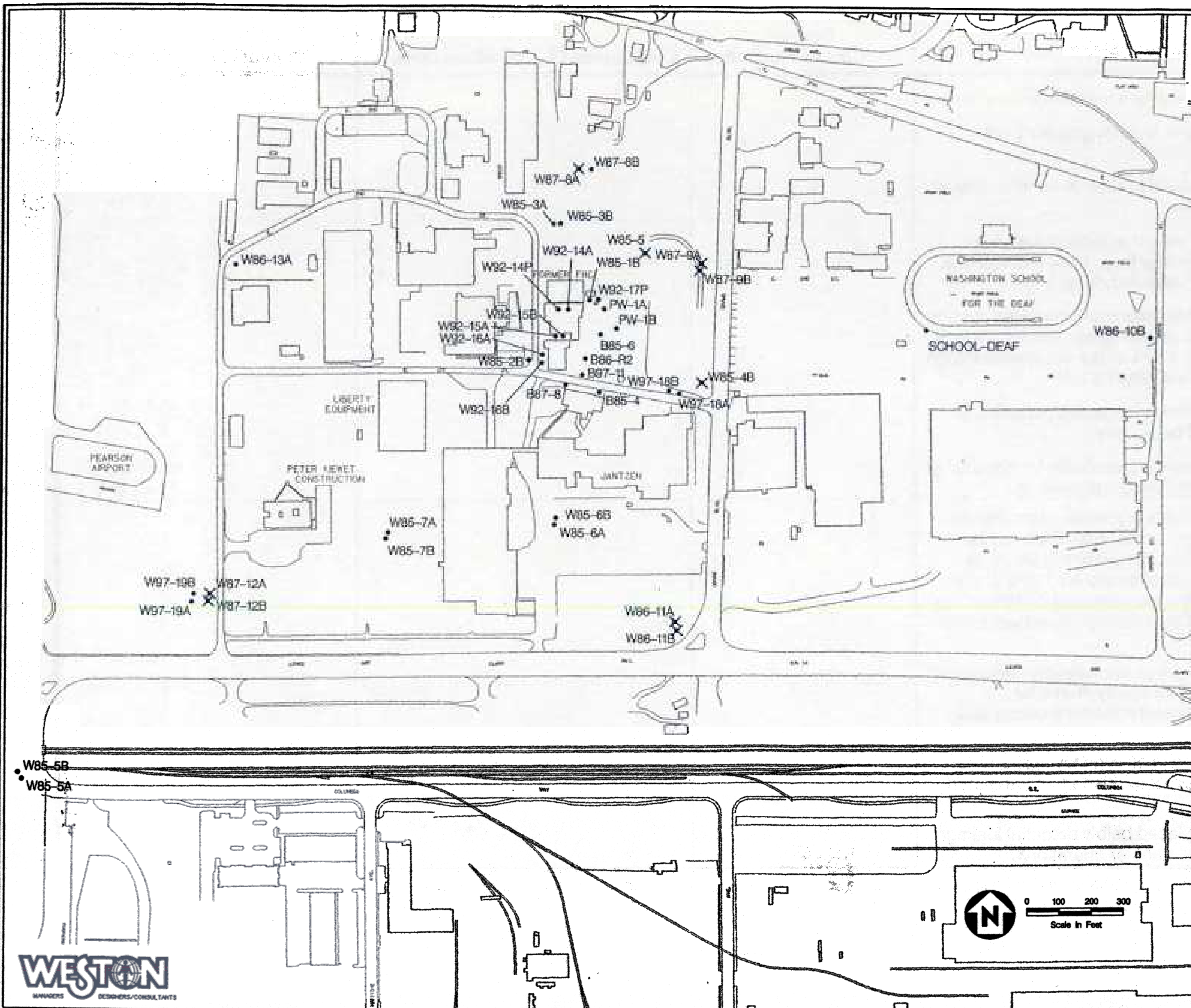
Dames and Moore, Inc. 1987. Remedial Investigation—Frontier Hard Chrome. Final Report (Volume 1 and 2). Prepared for the Washington State Department of Ecology.

FIGURES

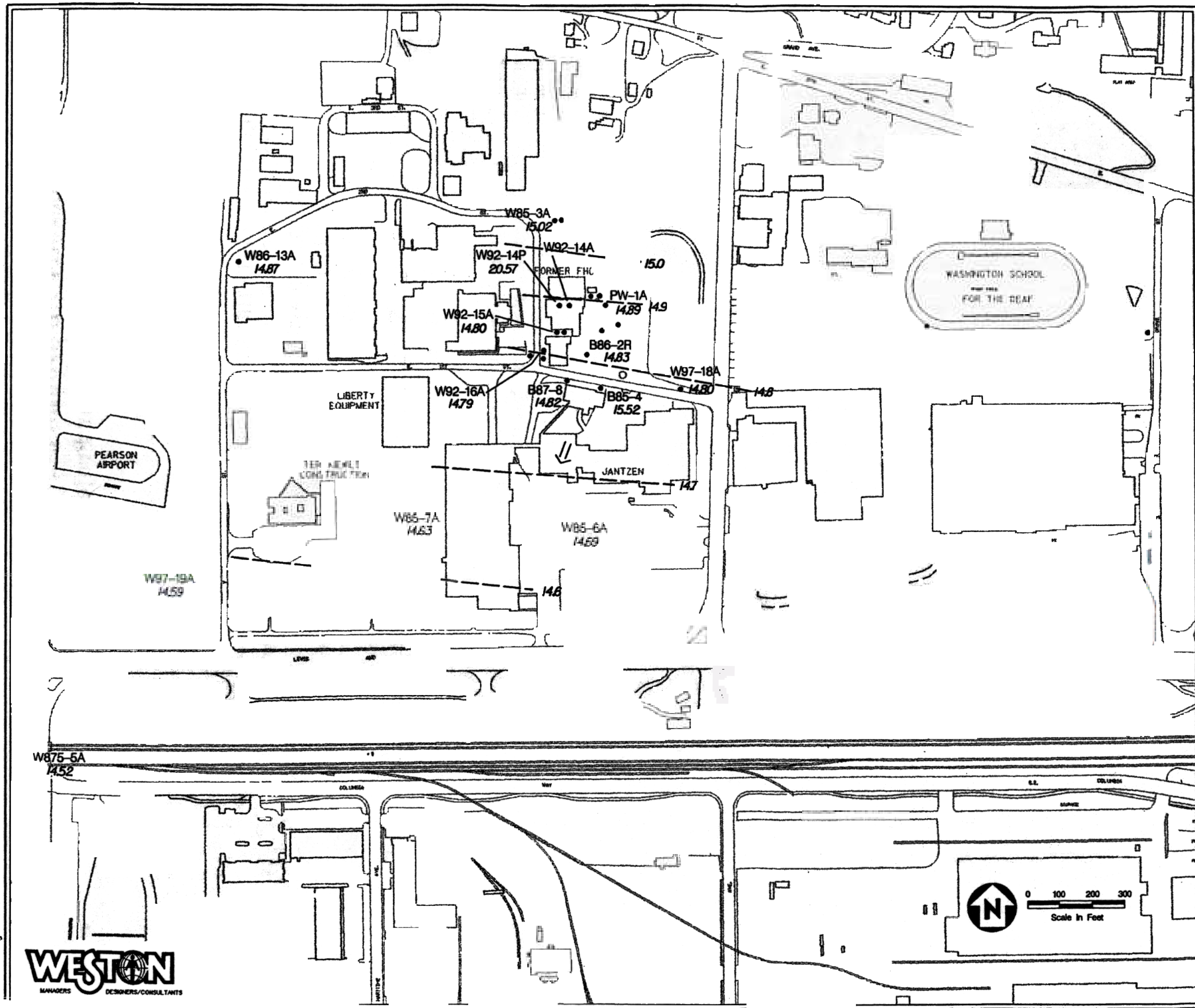


EXPLANATION

- W85-3A • Existing Monitoring Well and Station ID
- W87-8A ✕ Monitoring Well Decommissioned or Abandoned

Frontier Hard Chrome Existing and Historical Monitoring Well Locations

FIGURE 1



EXPLANATION

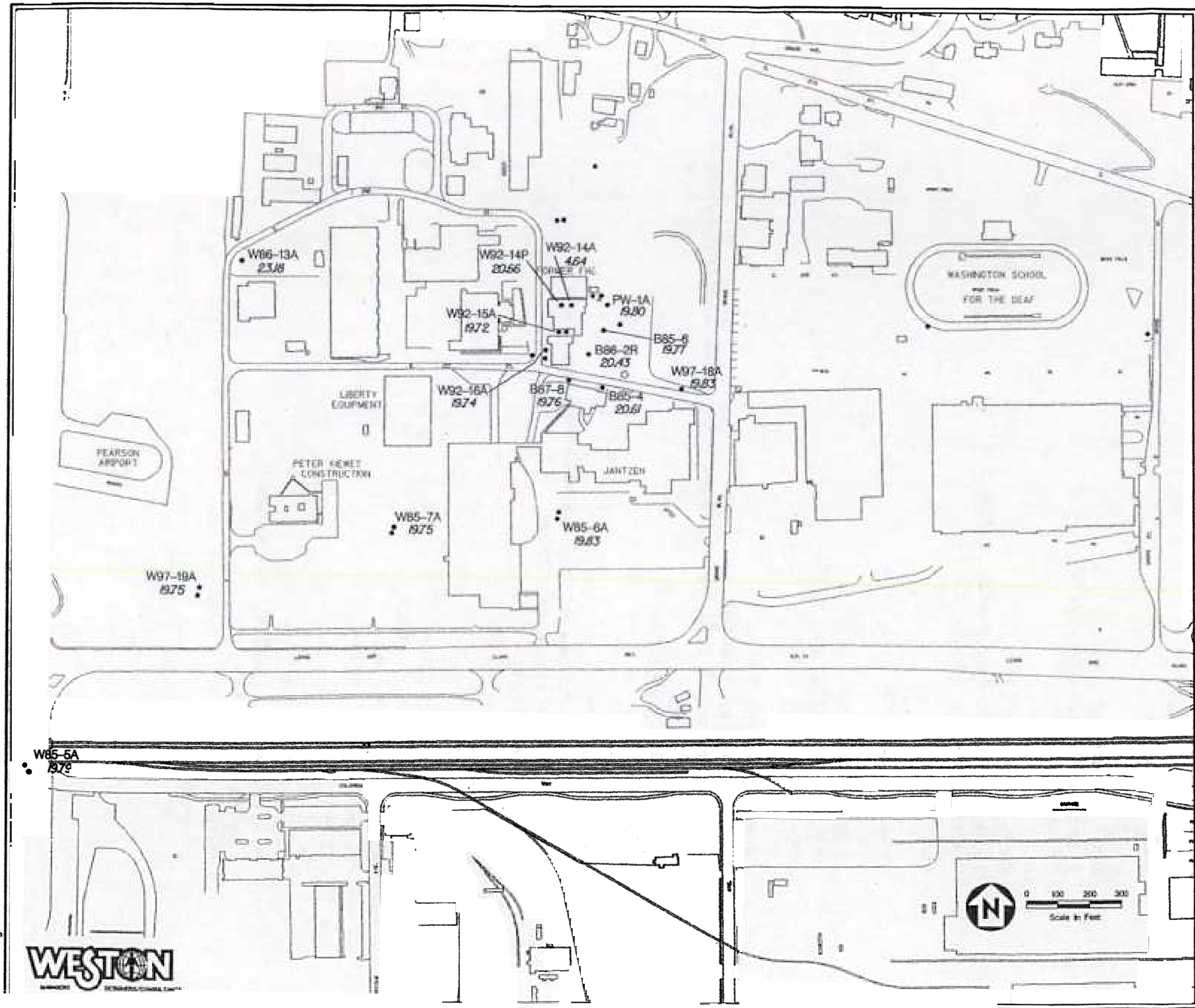
W85-3A 15.02 • Monitoring Well and 18 April 1997 Water Level

15 — — Inferred Groundwater Elevation Contour; Interval 0.1 Feet

⇑ Inferred Groundwater Flow Direction

Frontier Hard Chrome
Water Level Elevation
Perched and
"A" Zone Aquifers
April 1997

FIGURE 2



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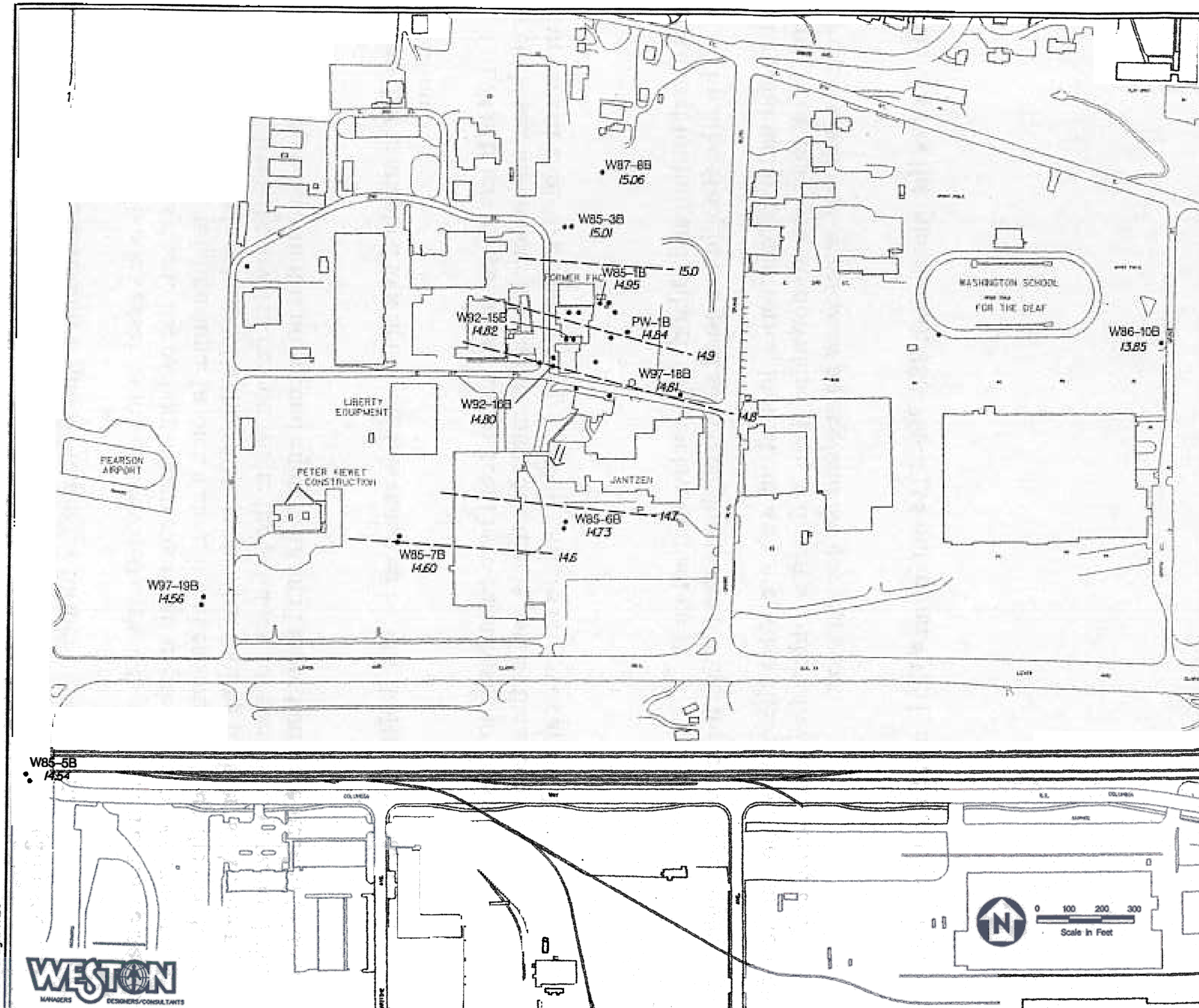
EXPLANATION

W85-7A
19.75 • Monitoring Well and 8 May 1997 Water Level

Frontier Hard Chrome Water Level Elevation Perched and "A" Zone Aquifers May 1997

FIGURE
.3



EXPLANATION

W85-3B 15.01 •	Monitoring Well and 18 April 1997 Water Level
15 — —	Inferred Groundwater Elevation Contour; Interval 0.1 Feet
⇑	Inferred Groundwater Flow Direction

Frontier Hard Chrome Water Level Elevation "B" Zone Aquifer April 1997

FIGURE 4

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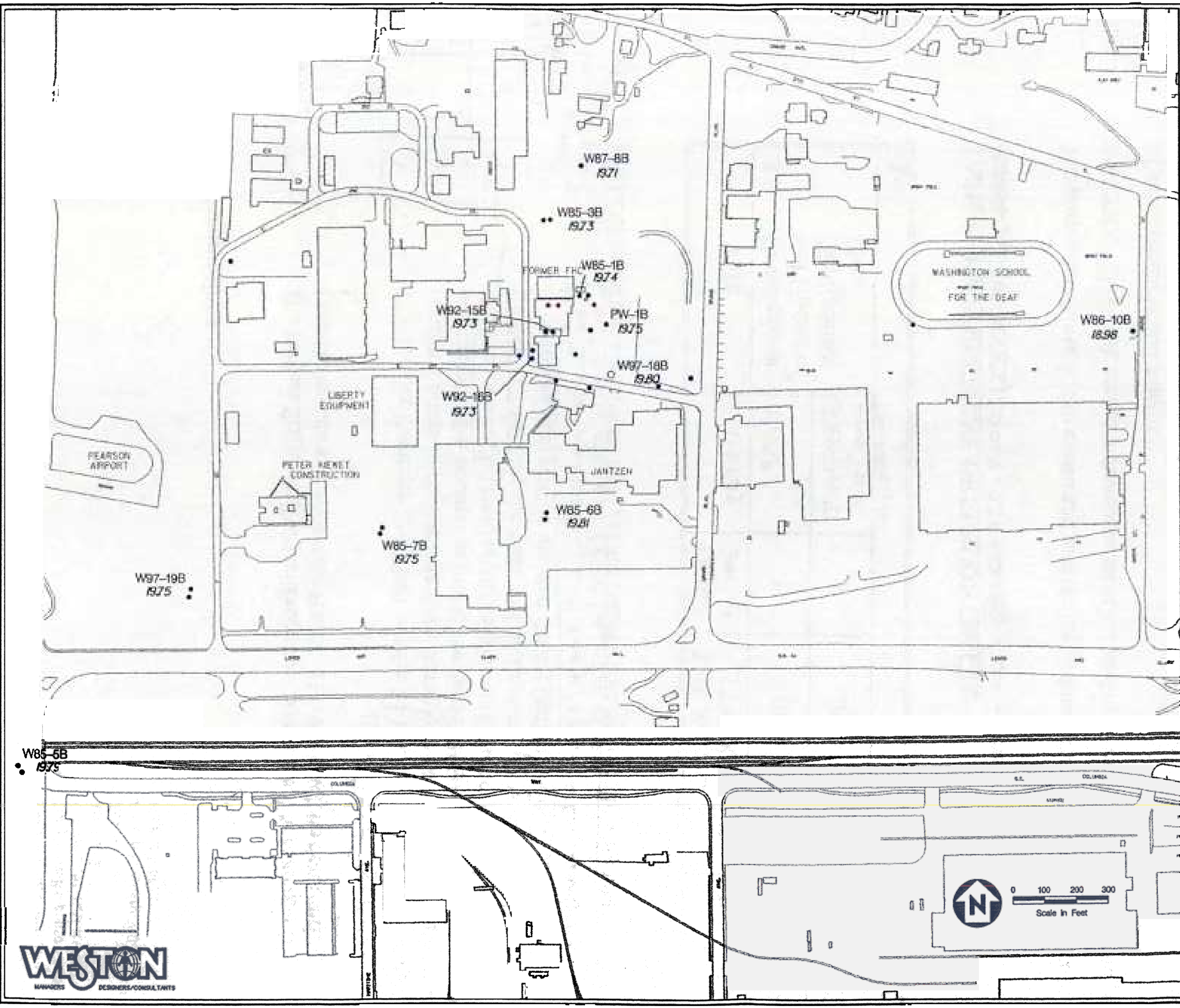
EXPLANATION

W85–7B 19.71 • Monitoring Well and 8 May 1997 Water Level



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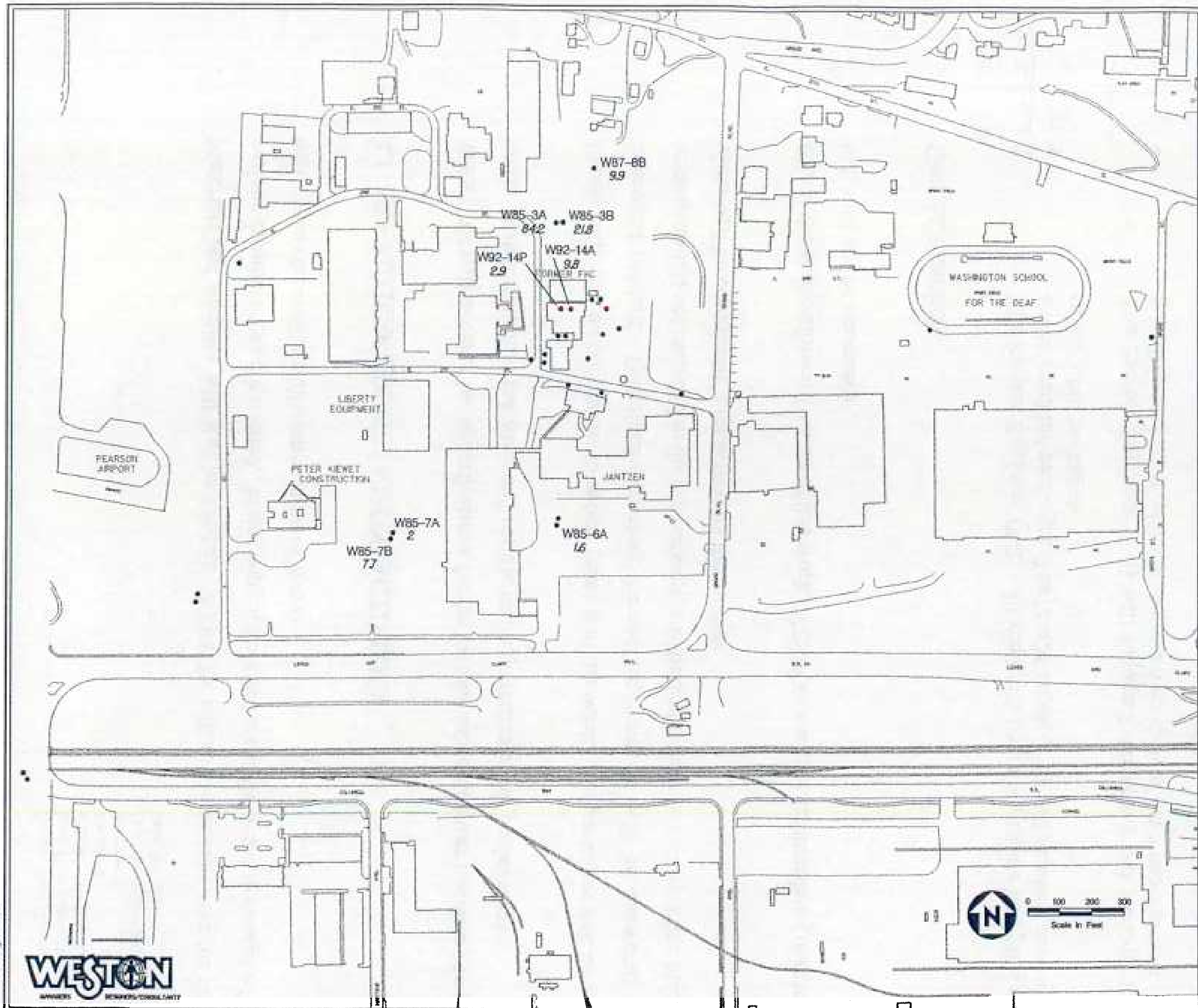
MANAGERS DESIGNERS/CONSULTANTS

Frontier Hard Chrome
Water Level Elevation
"B" Zone Aquifer
May 1997

FIGURE
5

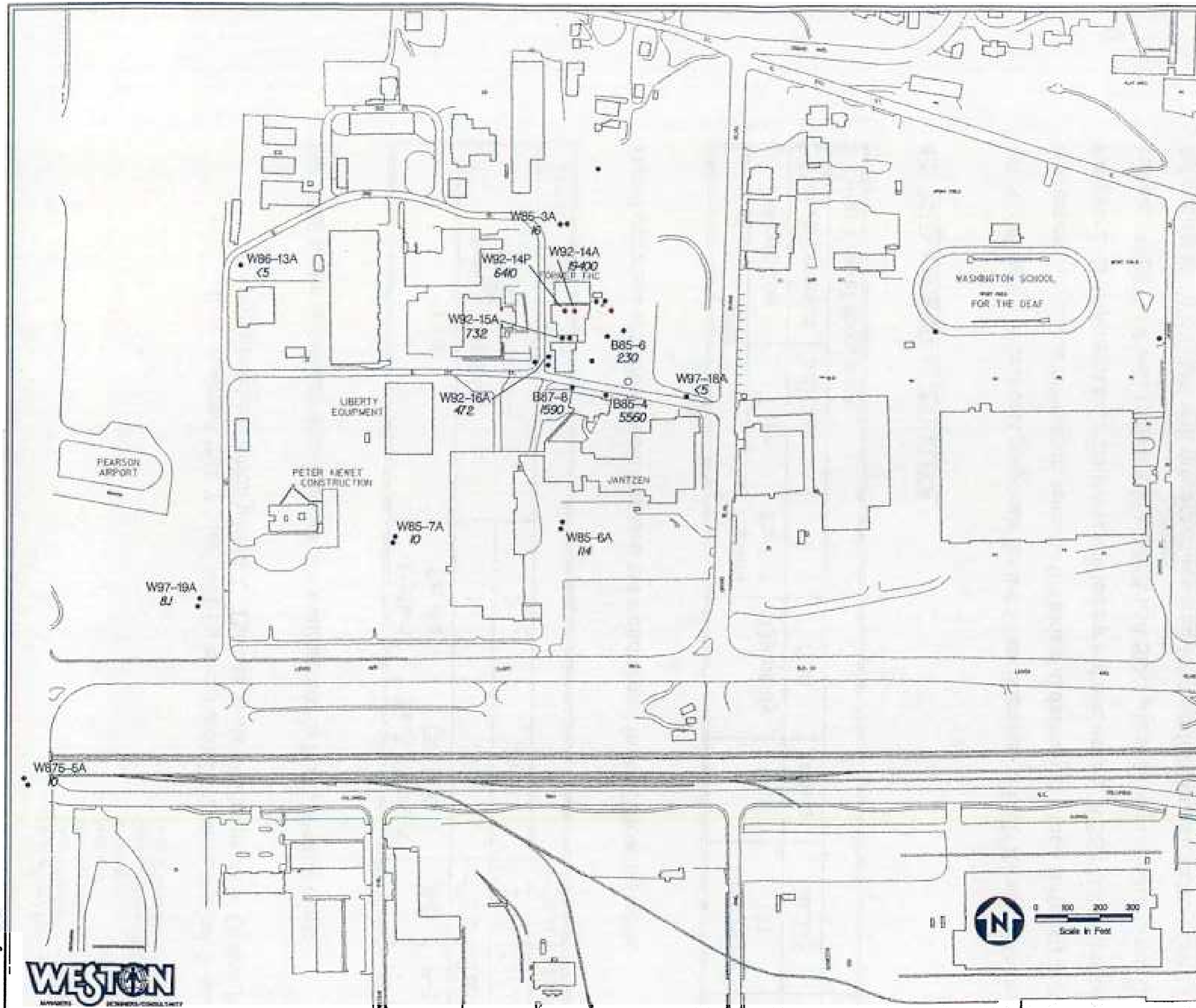


EXPLANATION

W85-3A
3.80 • Monitoring Well and February 1997 PCE Concentrations (µg/L)

Frontier Hard Chrome
Tetrachloroethene
Concentrations in
Groundwater
February 1997

FIGURE
6



EXPLANATION

W85-3A • Monitoring Well and Feb/Mar 1997 Total Chromium Concentration (ug/l)
16

Frontier Hard Chrome Total Chromium Concentration in Groundwater Perched and "A" Zone Aquifers Feb/Mar 1997

FIGURE
7

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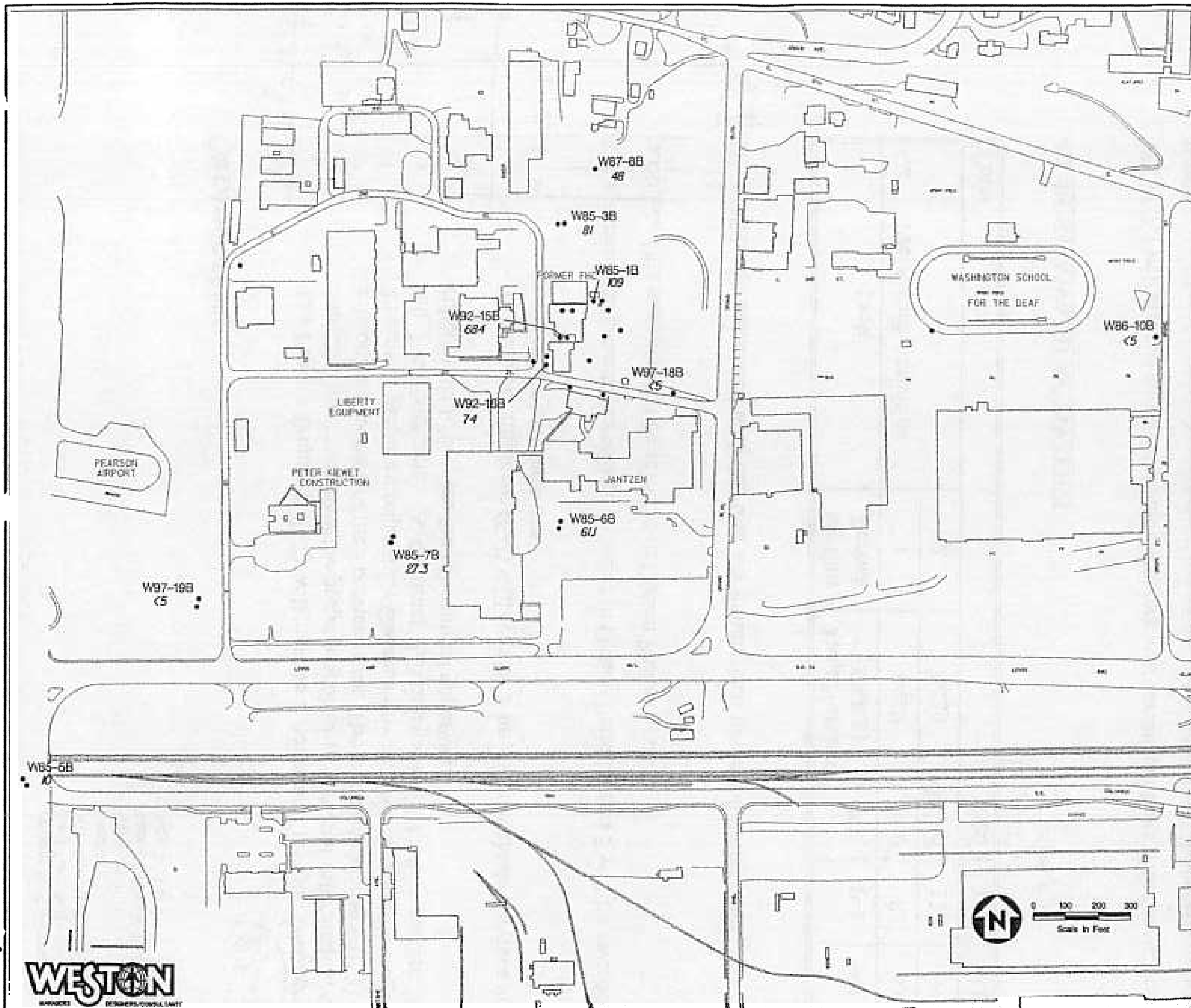

EXPLANATION

W85-3B 81 • Monitoring Well and Feb/Mar 1997 Total Chromium Concentration (ug/L)

Frontier Hard Chrome Total Chromium Concentration in Groundwater Perched and "B" Zone Aquifers Feb/Mar 1997

FIGURE 8

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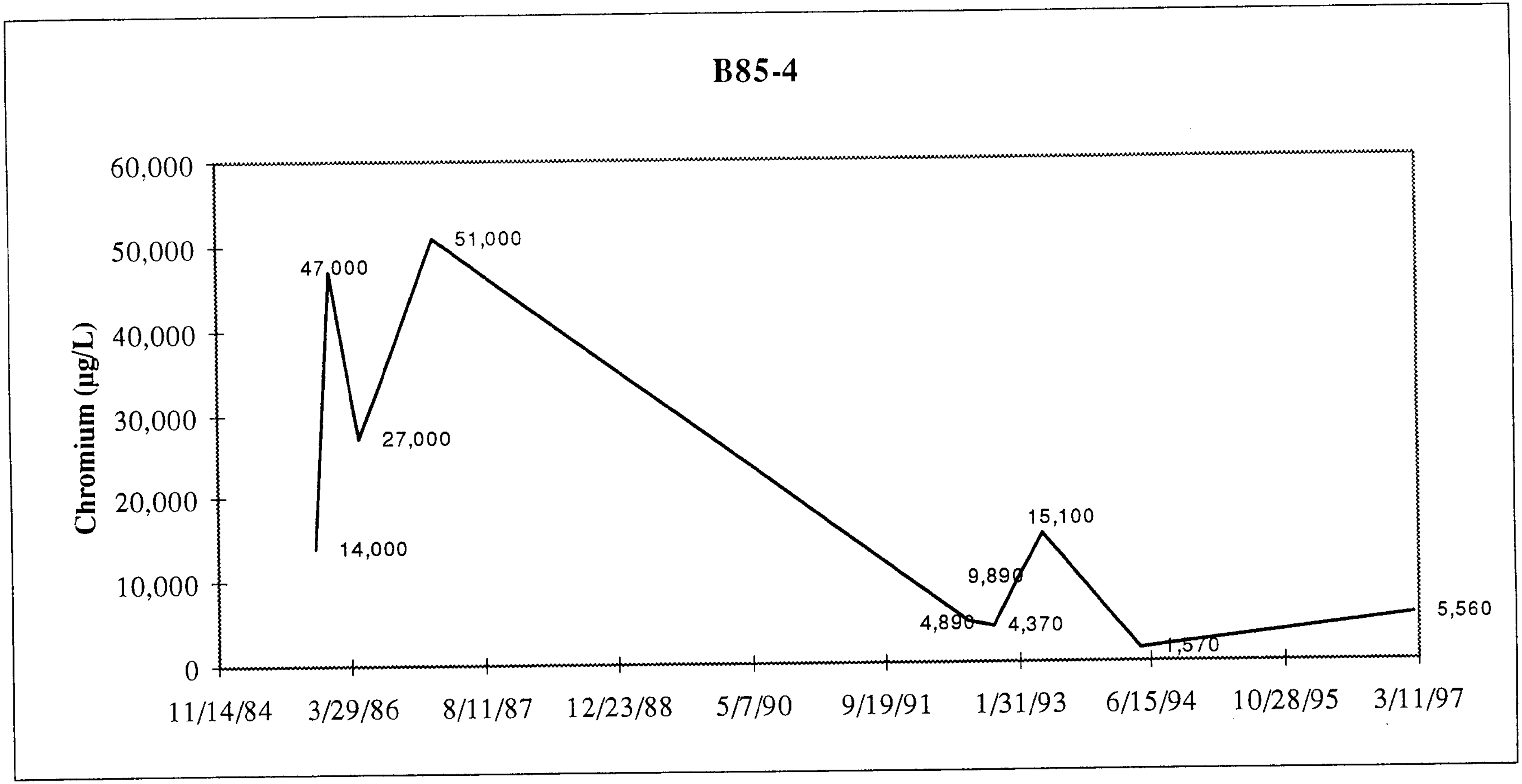

Frontier Hard Chrome
Total Chromium Concentrations - Well B85-4

FIGURE
9

WESTON

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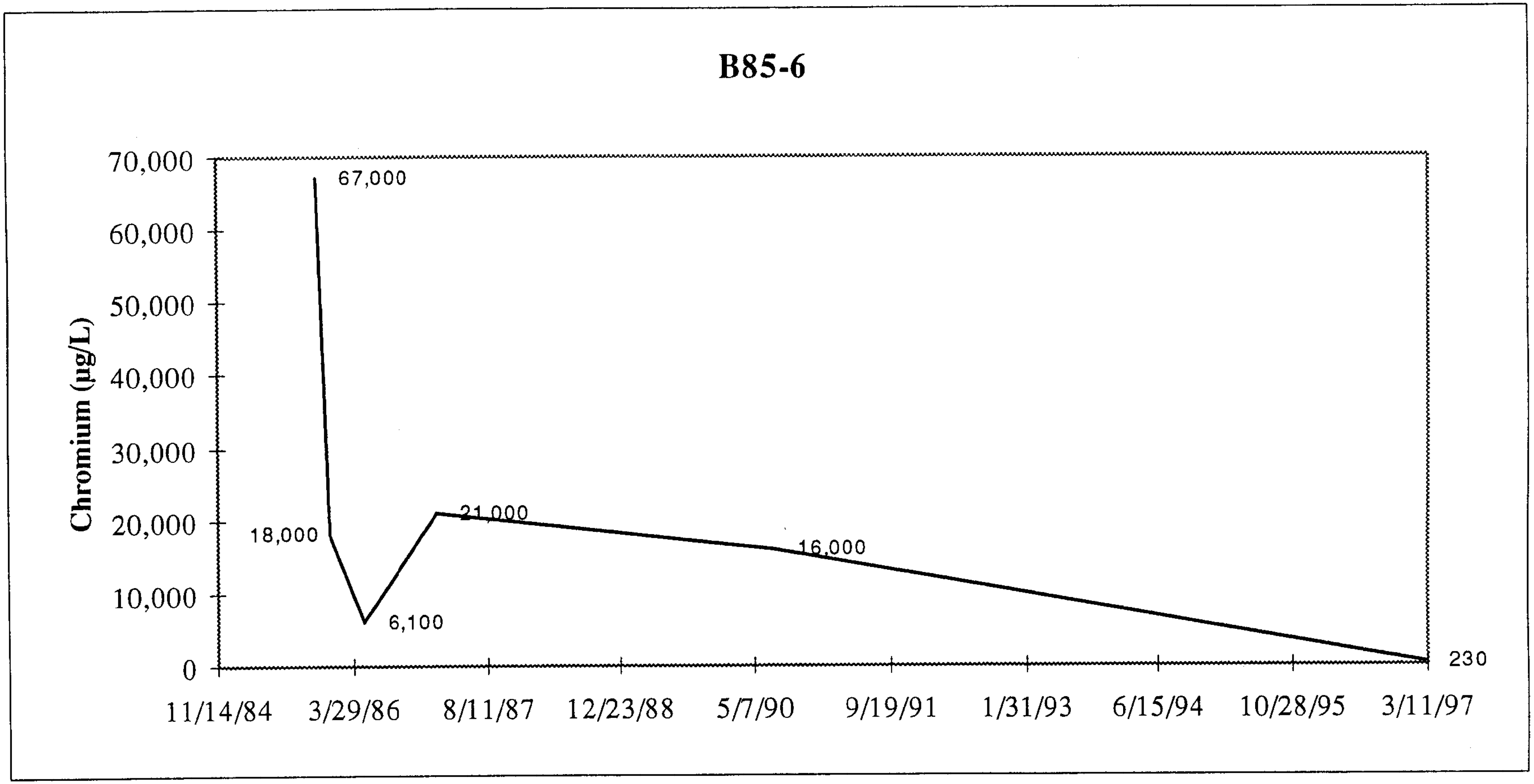

Frontier Hard Chrome
Total Chromium Concentrations - Well B85-6

FIGURE
10

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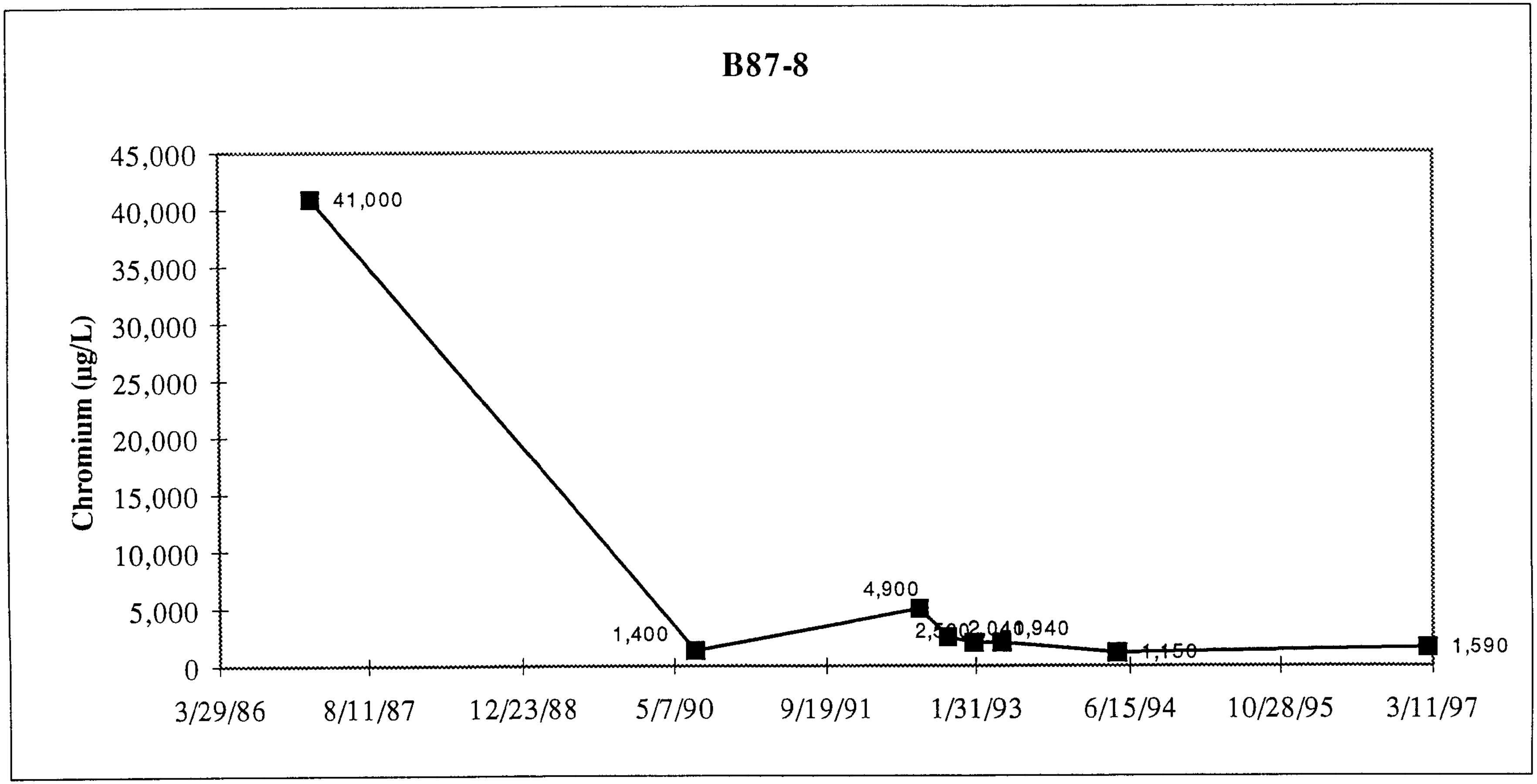

Frontier Hard Chrome
Total Chromium Concentrations - Well B87-8

FIGURE
11

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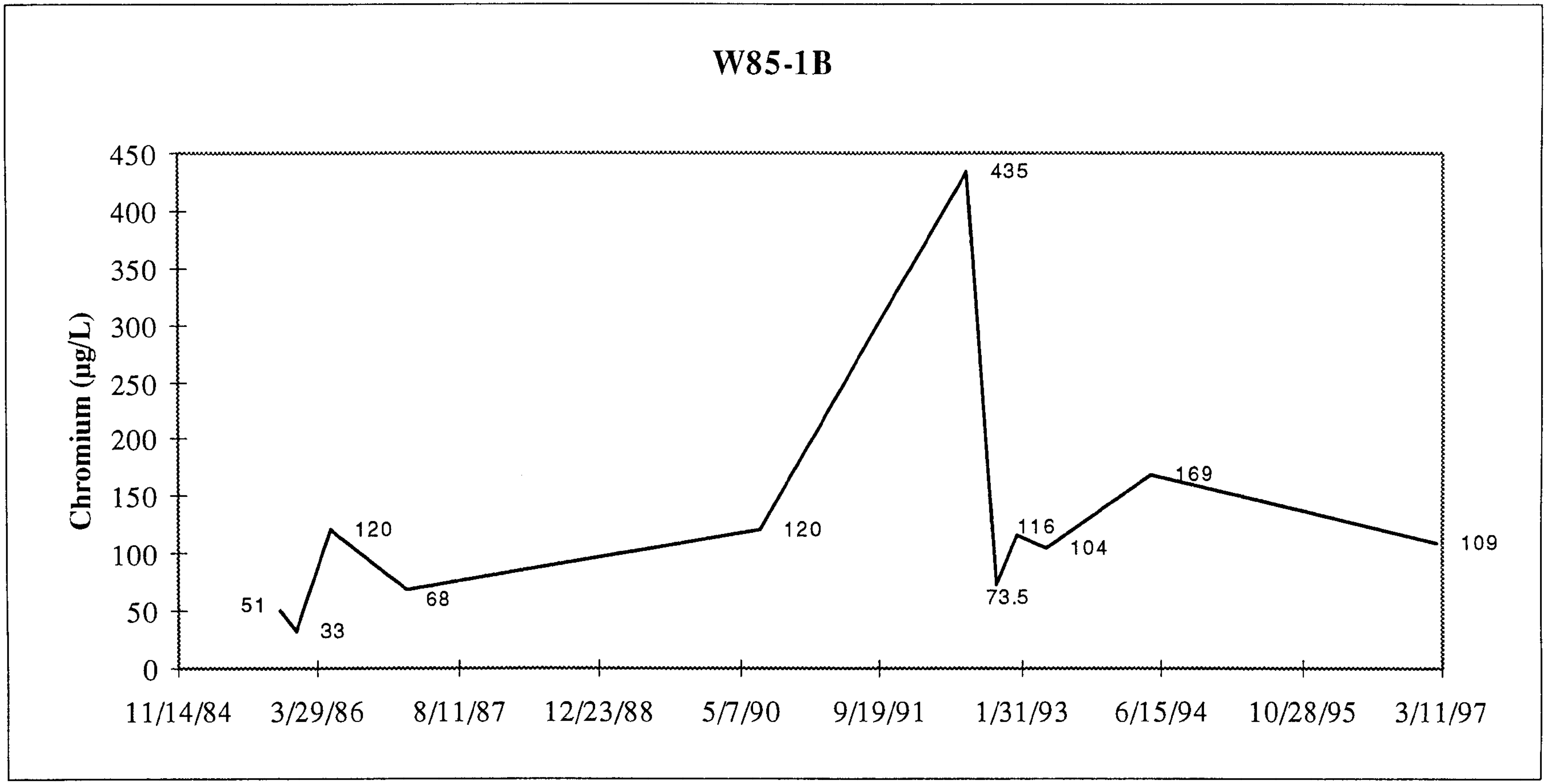

Frontier Hard Chrome
Total Chromium Concentrations - Well W85-1B

FIGURE
12

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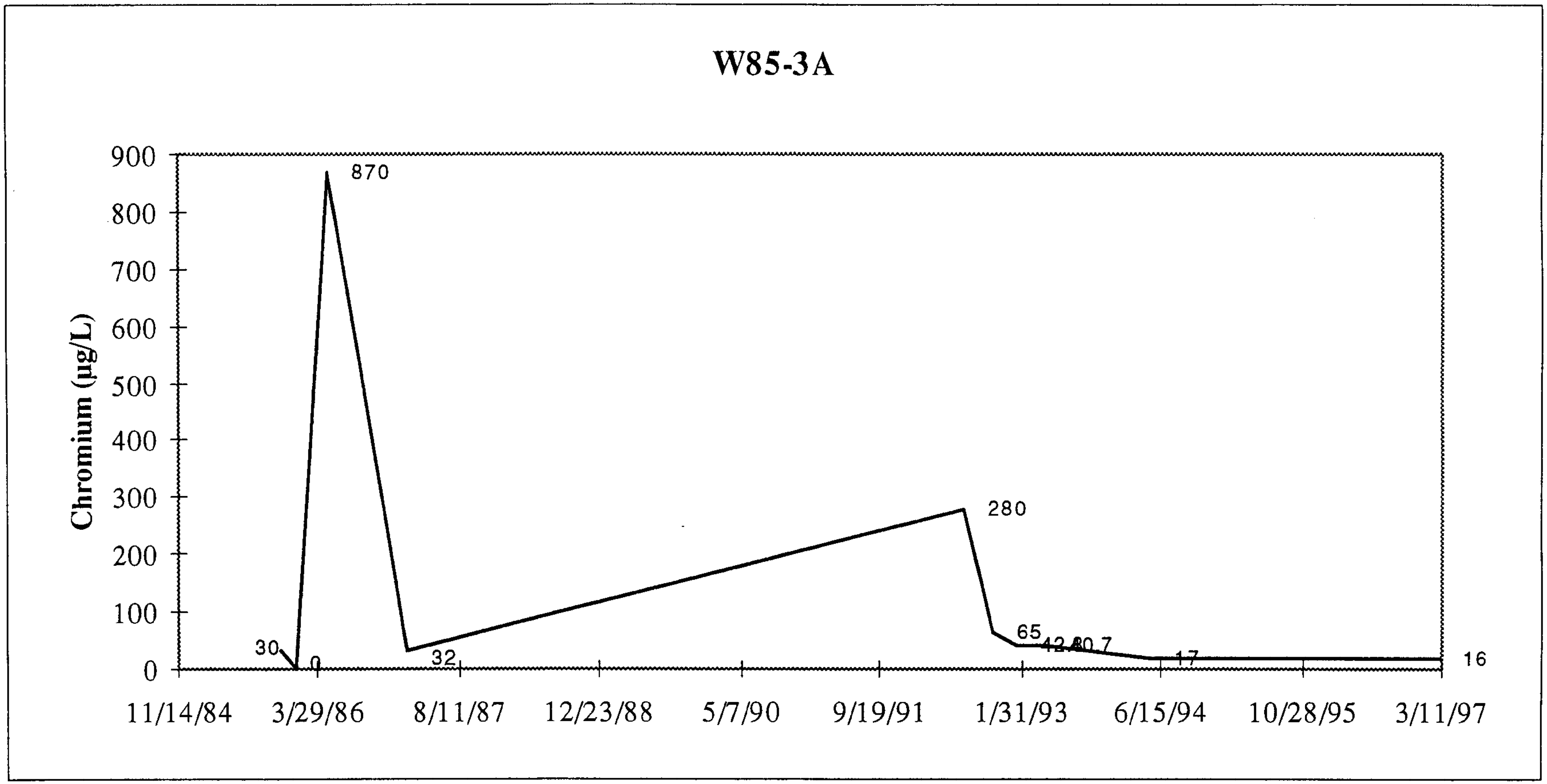

Frontier Hard Chrome

Total Chromium Concentrations - Well W85-3A

FIGURE

13

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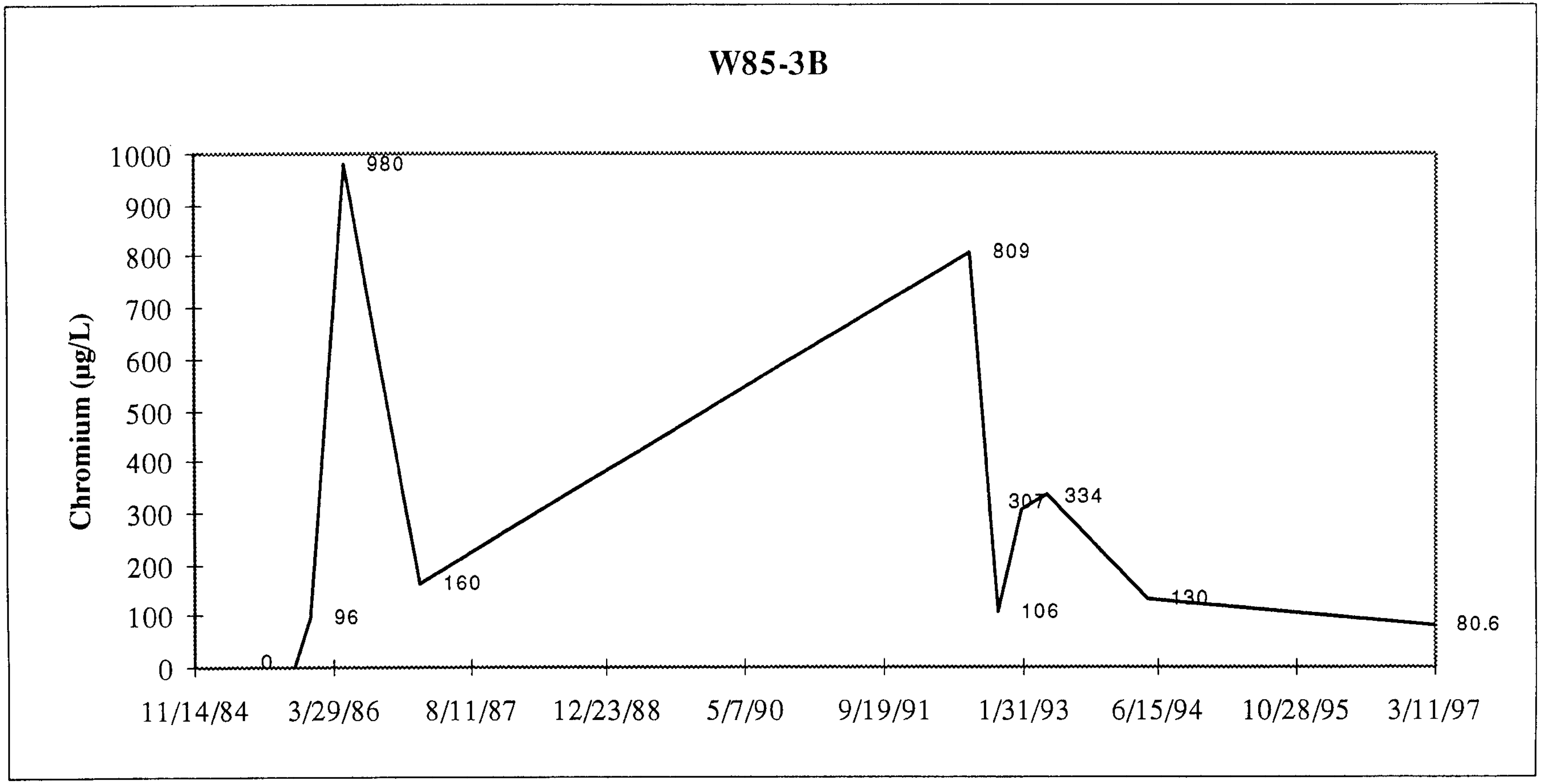

Frontier Hard Chrome
Total Chromium Concentrations - Well W85-3B

FIGURE
14

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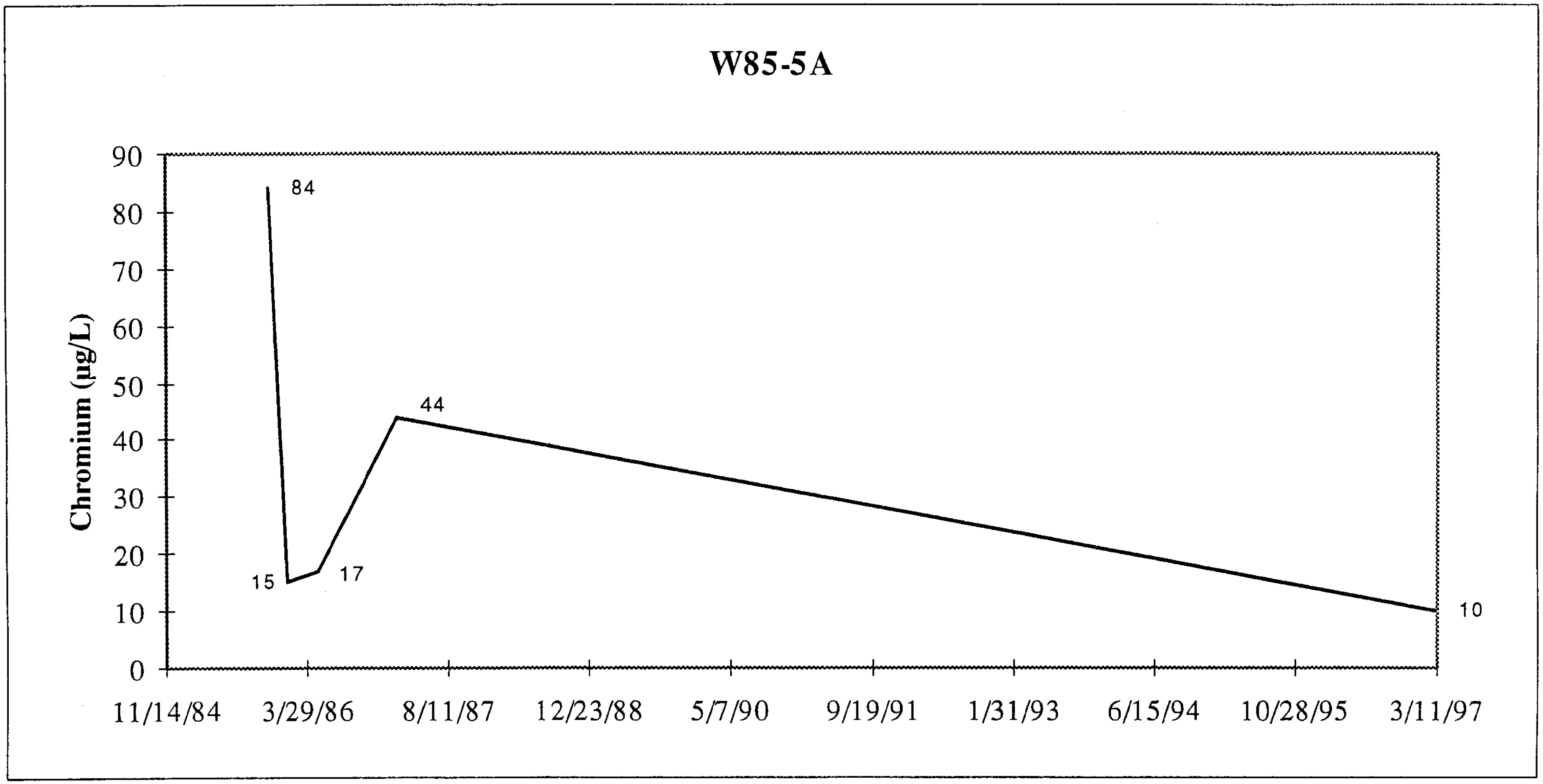

Frontier Hard Chrome
Total Chromium Concentrations - Well W85-5A

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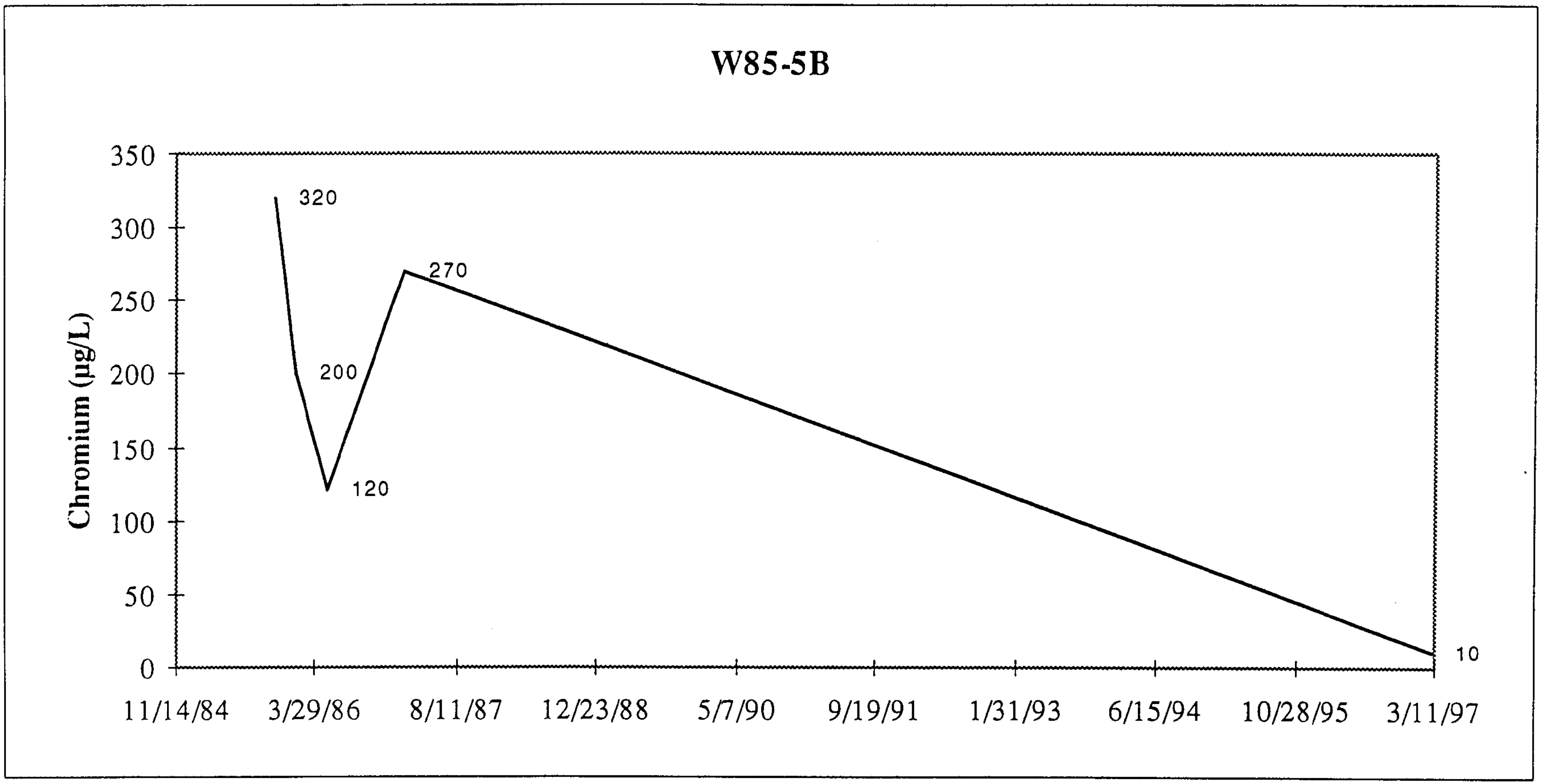
FIGURE
15



Frontier Hard Chrome
Total Chromium Concentrations - Well W85-5B

FIGURE
16

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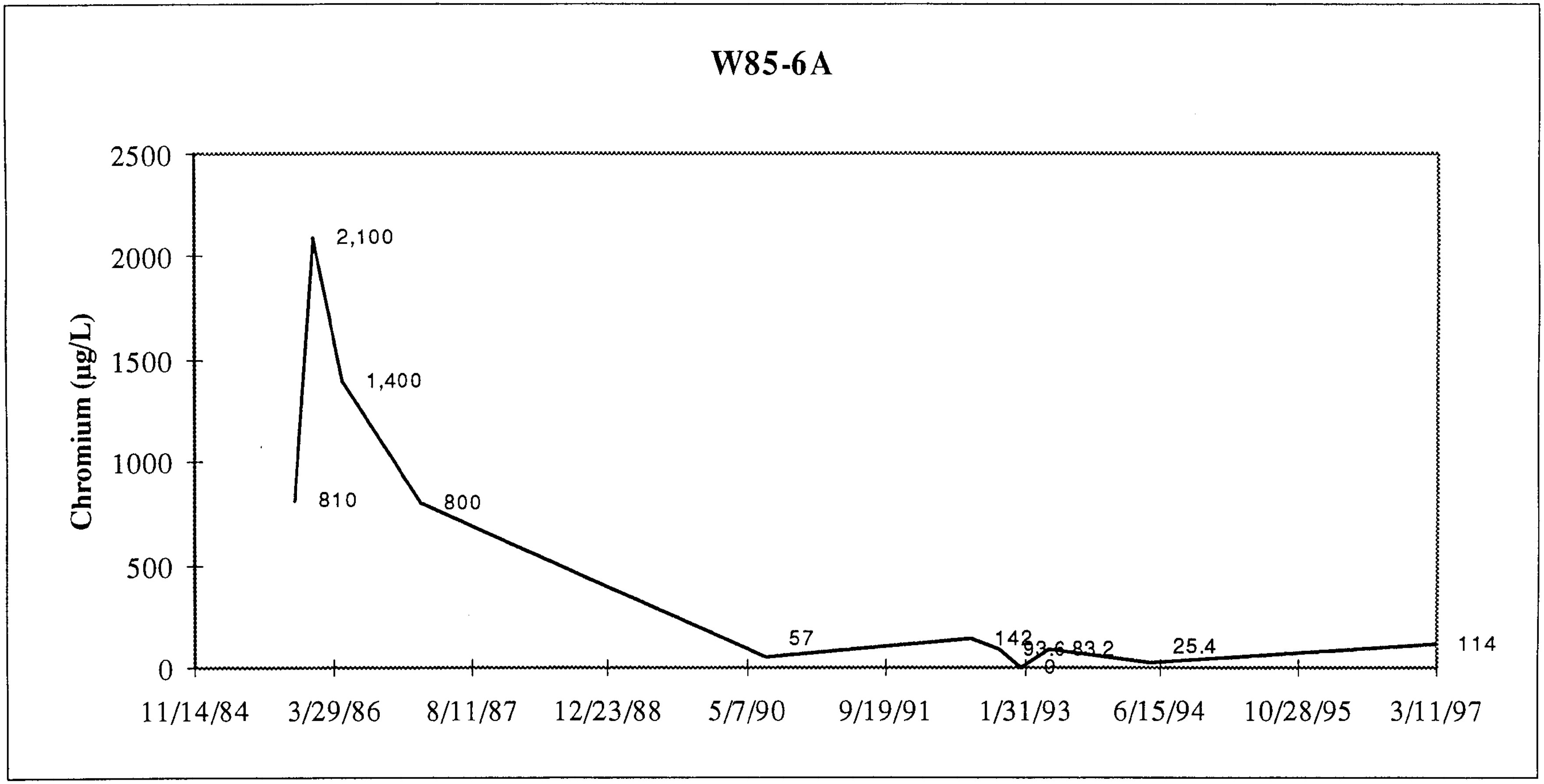

Frontier Hard Chrome
Total Chromium Concentrations - Well W85-6A

FIGURE
17

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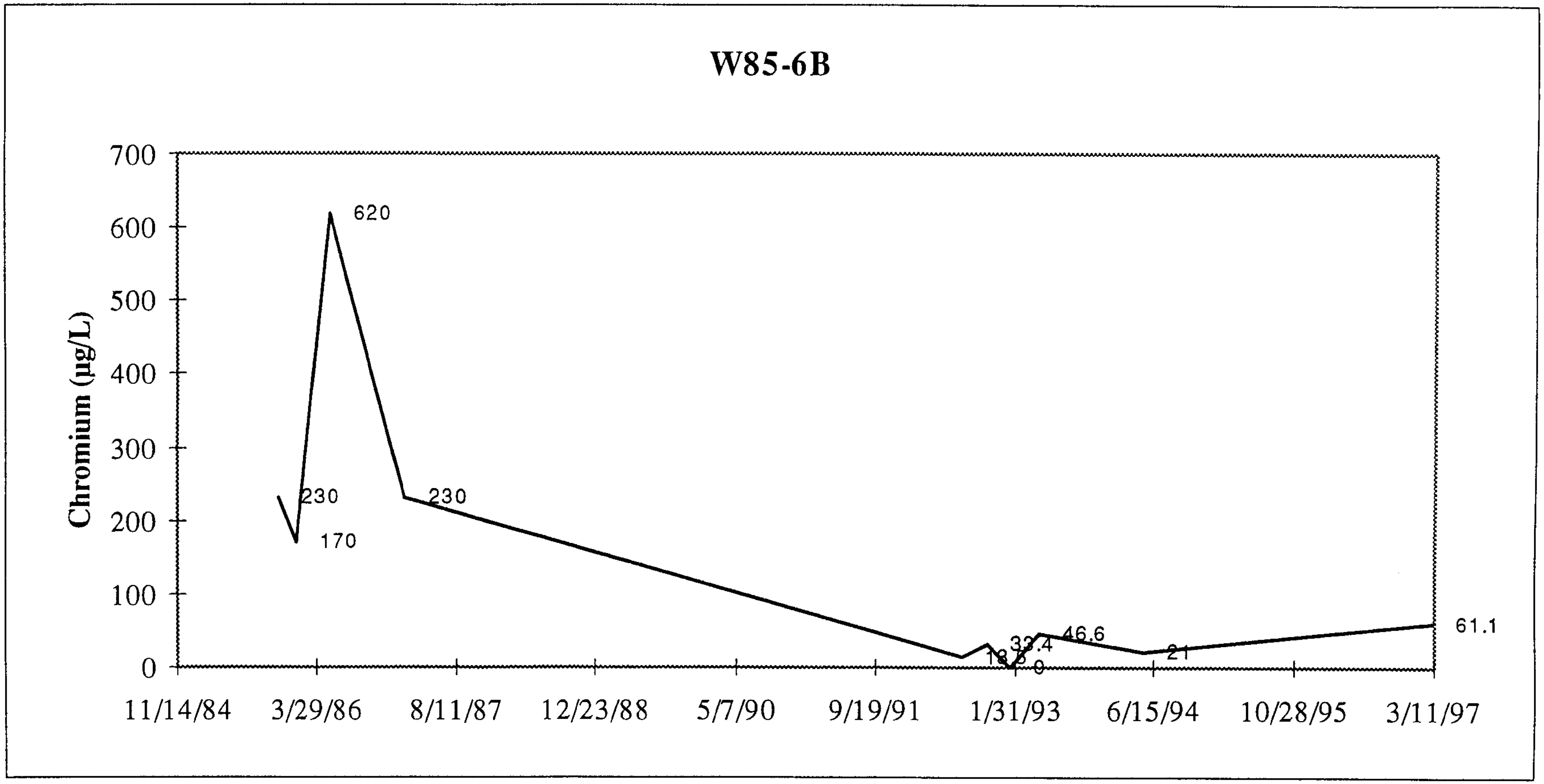

Frontier Hard Chrome
Total Chromium Concentrations - Well W85-6B

FIGURE
18

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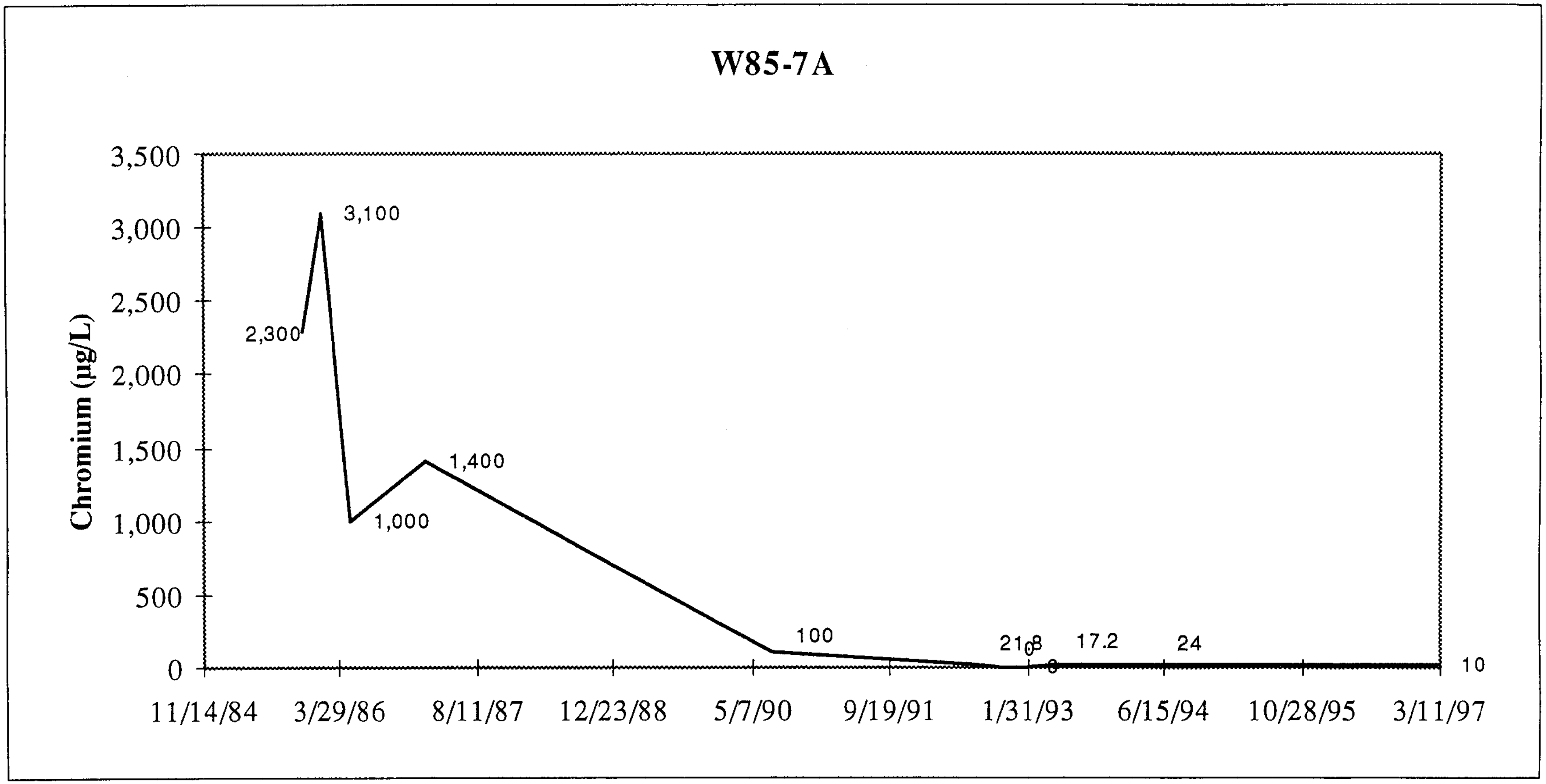

Frontier Hard Chrome
Total Chromium Concentrations - Well W85-7A

FIGURE
19

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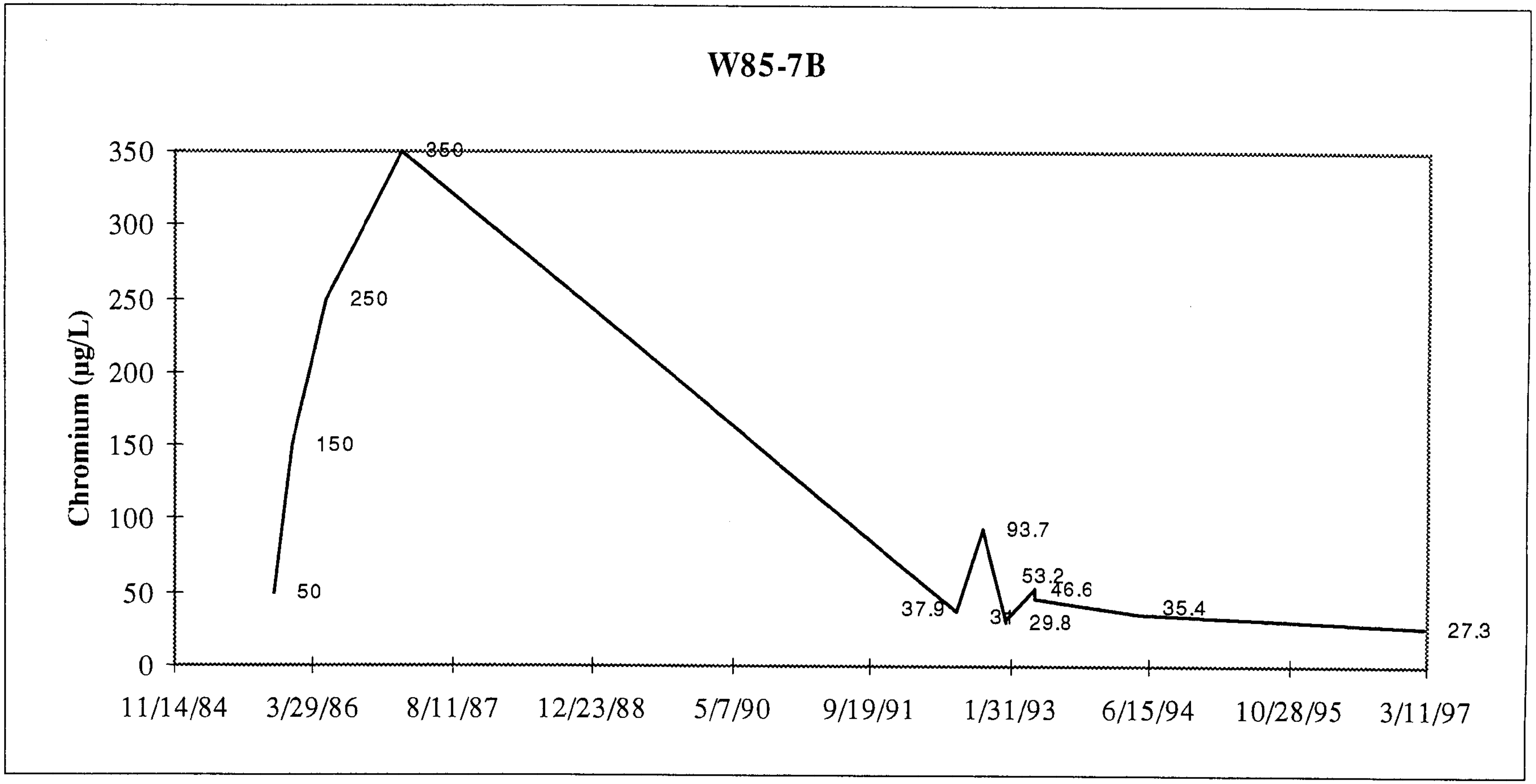
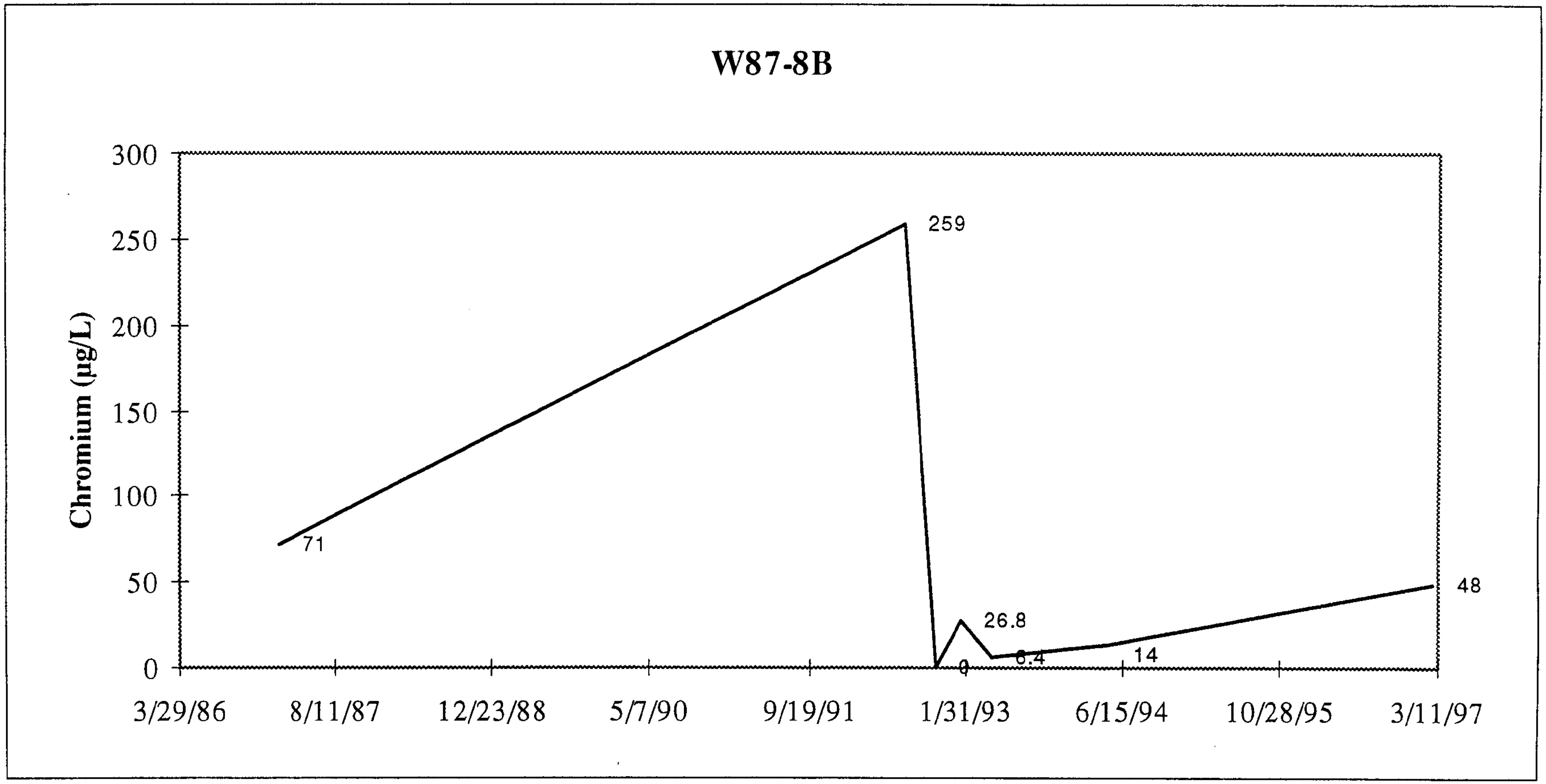


Frontier Hard Chrome
Total Chromium Concentrations - Well W85-7B

FIGURE
20

WESTON

Frontier/97-456.ppt

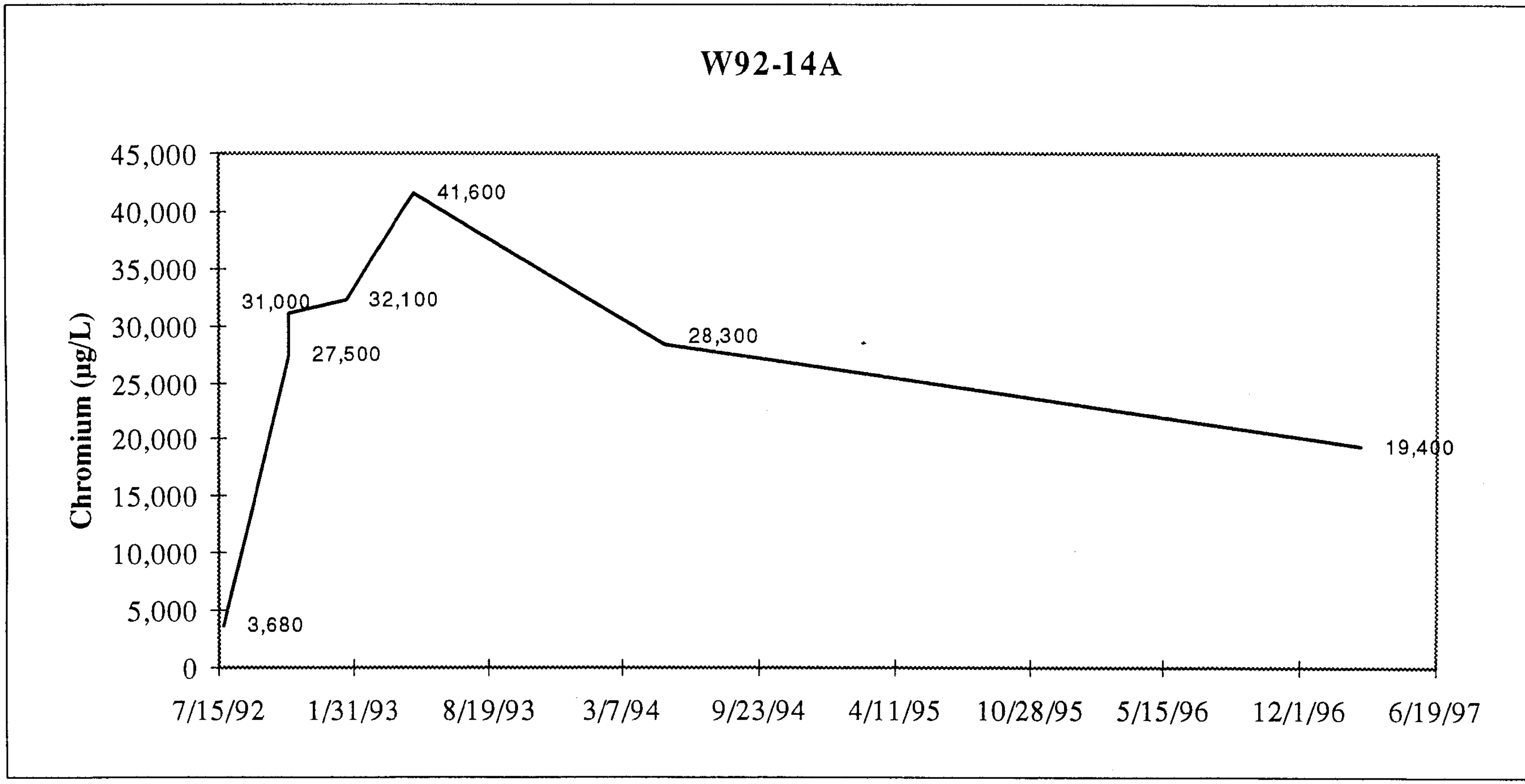


Frontier Hard Chrome
Total Chromium Concentrations - Well W87-8B

FIGURE
21

WESTON

Frontier/97-456.ppt



Frontier Hard Chrome

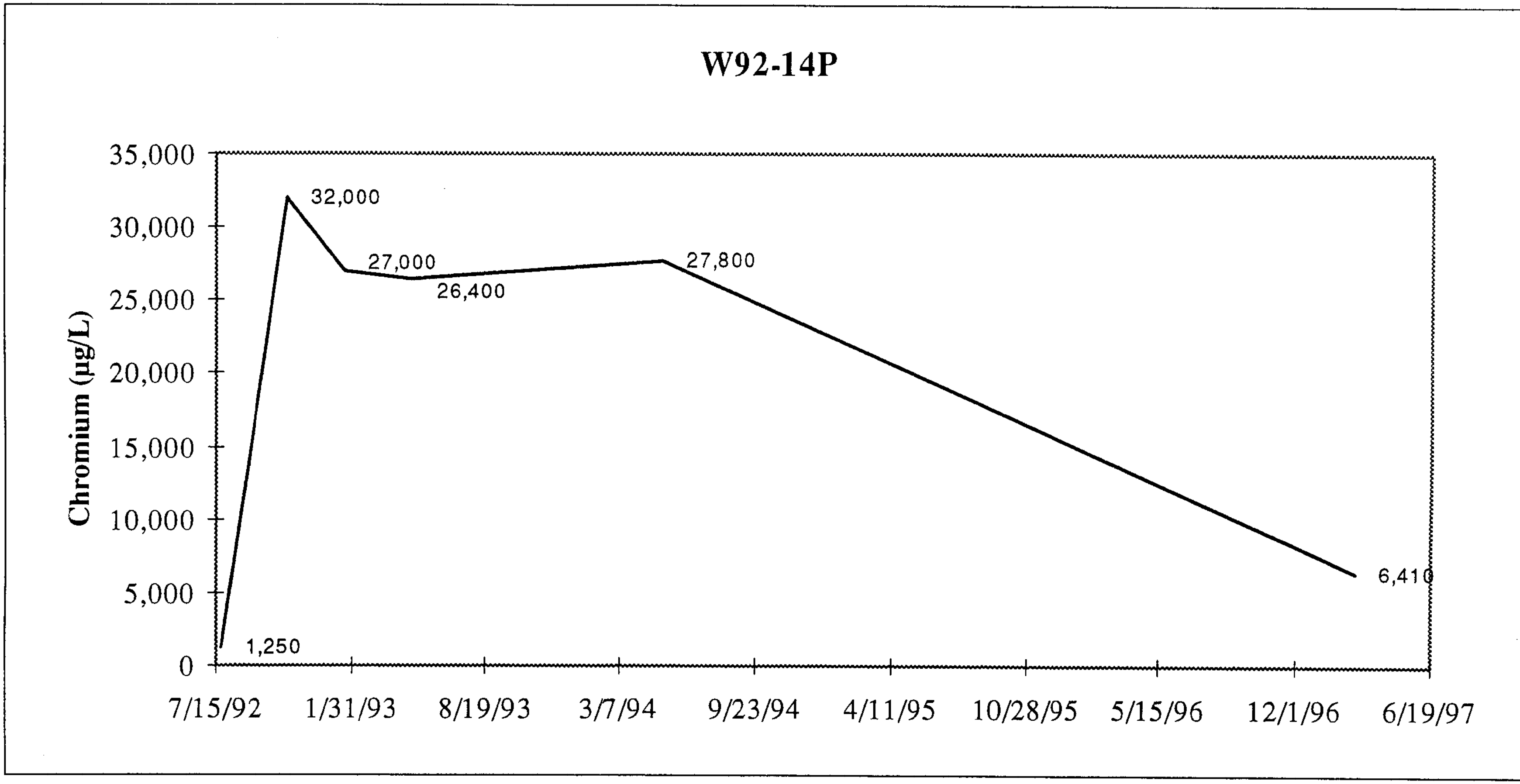
Total Chromium Concentrations - Well W92-14A

FIGURE

22

WESTON

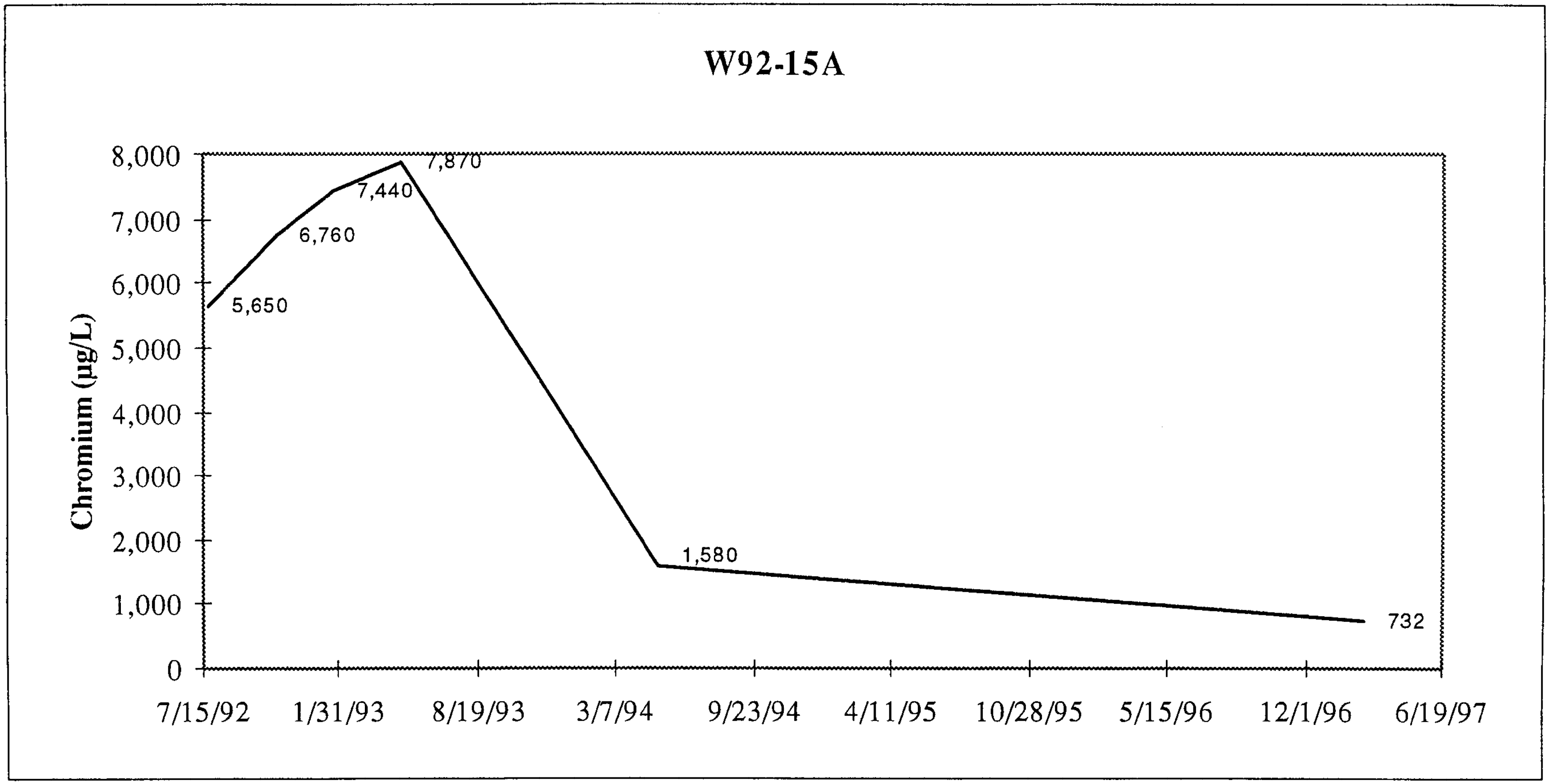
Frontier/97-456.ppt



Frontier Hard Chrome
Total Chromium Concentrations - Well W92-14P

FIGURE
23

Frontier/97-456.ppt

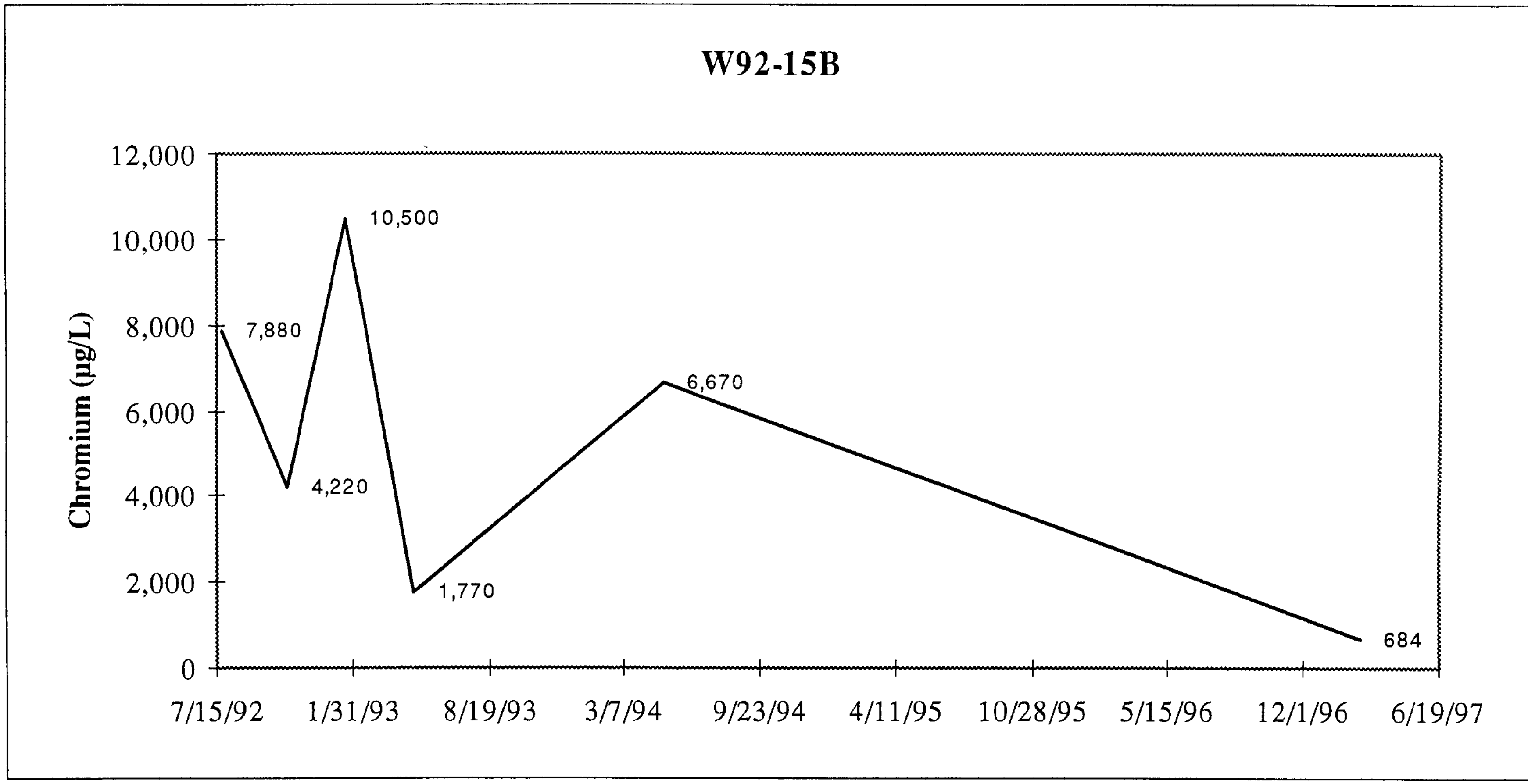


Frontier Hard Chrome
Total Chromium Concentrations - Well W92-15A

FIGURE
24

WESTON

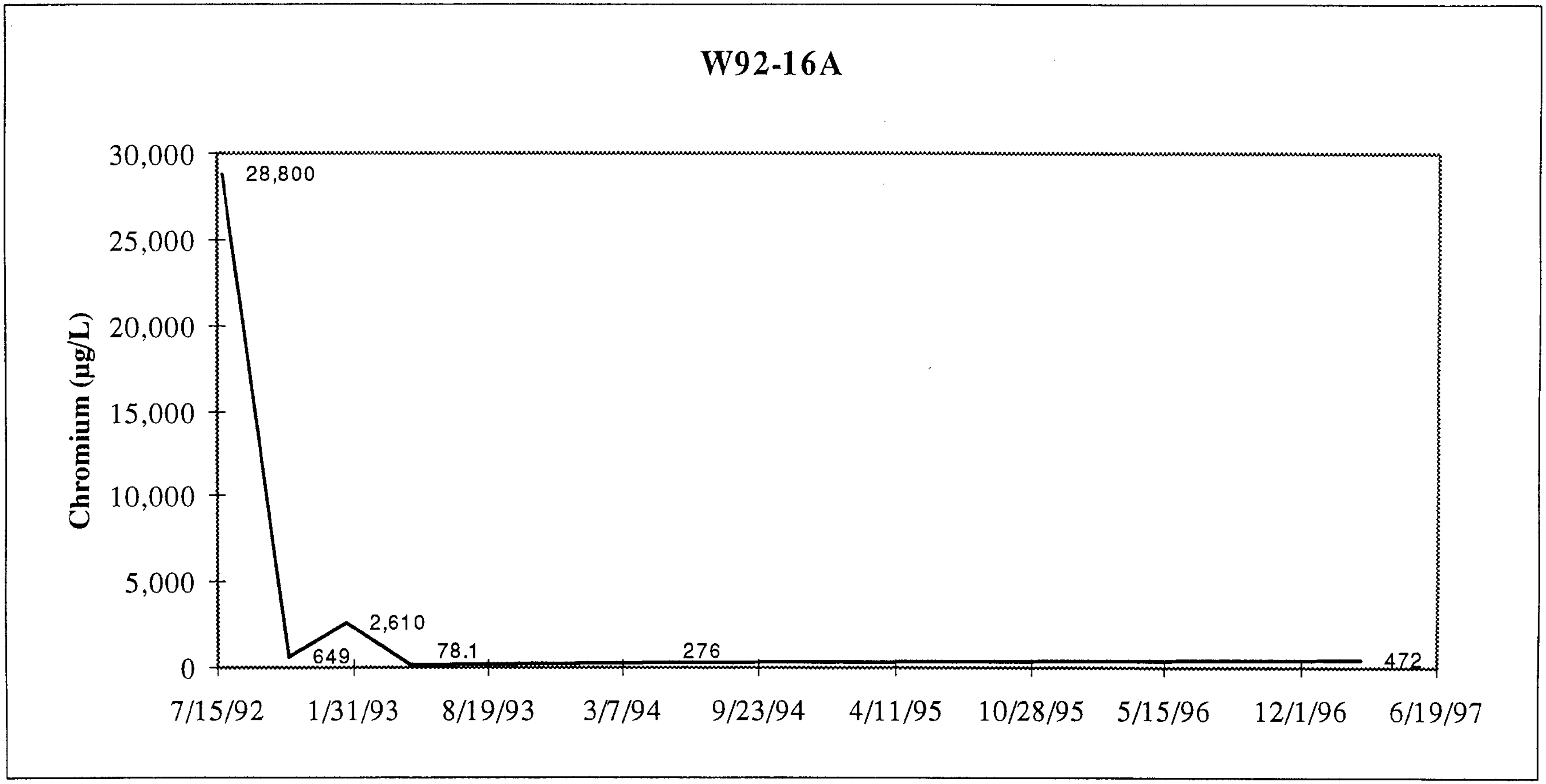
Frontier/97-456.ppt



Frontier Hard Chrome
Total Chromium Concentrations - Well W92-15B

FIGURE
25

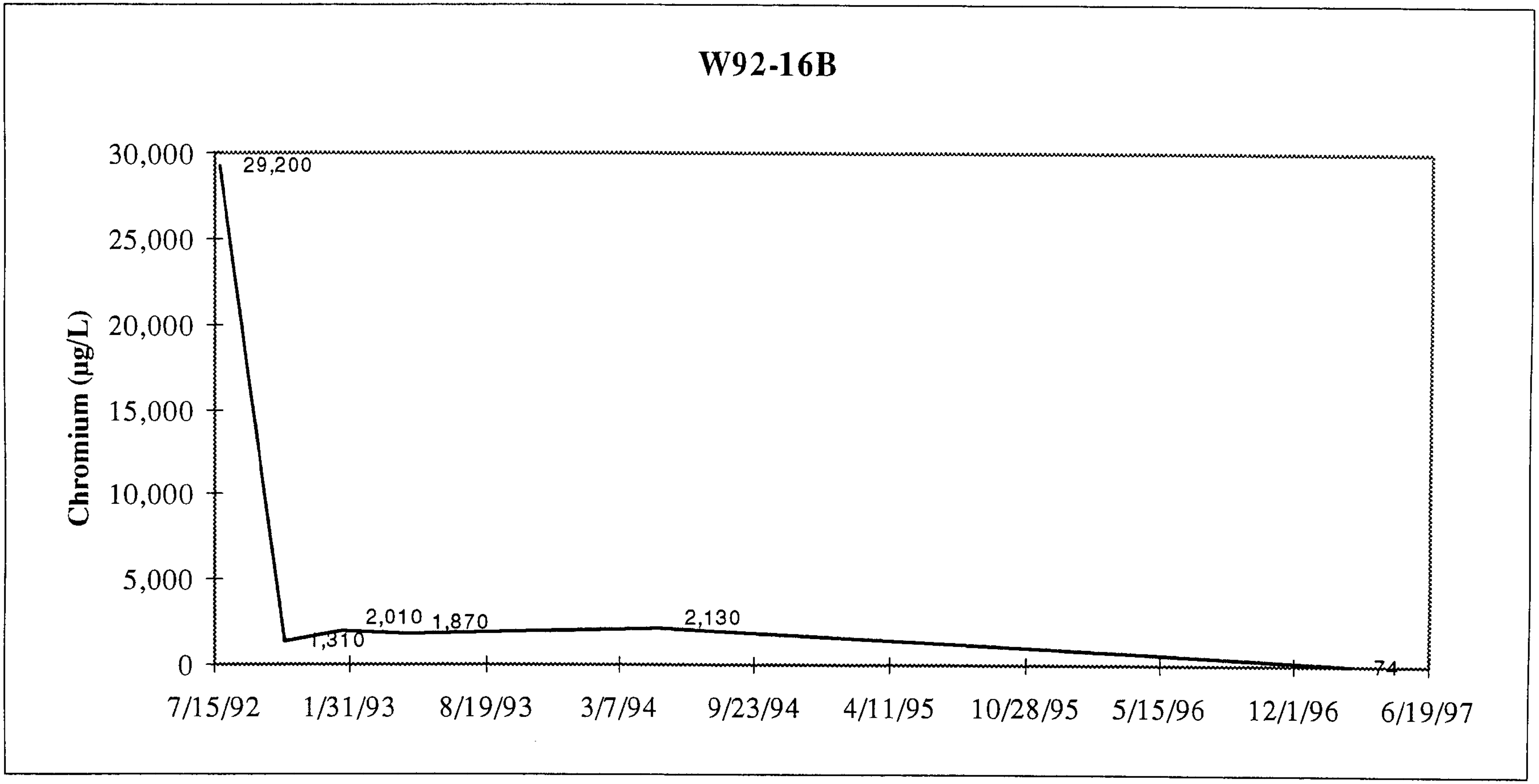
Frontier/97-456.ppt



Frontier Hard Chrome
Total Chromium Concentrations - Well W92-16A

FIGURE
26

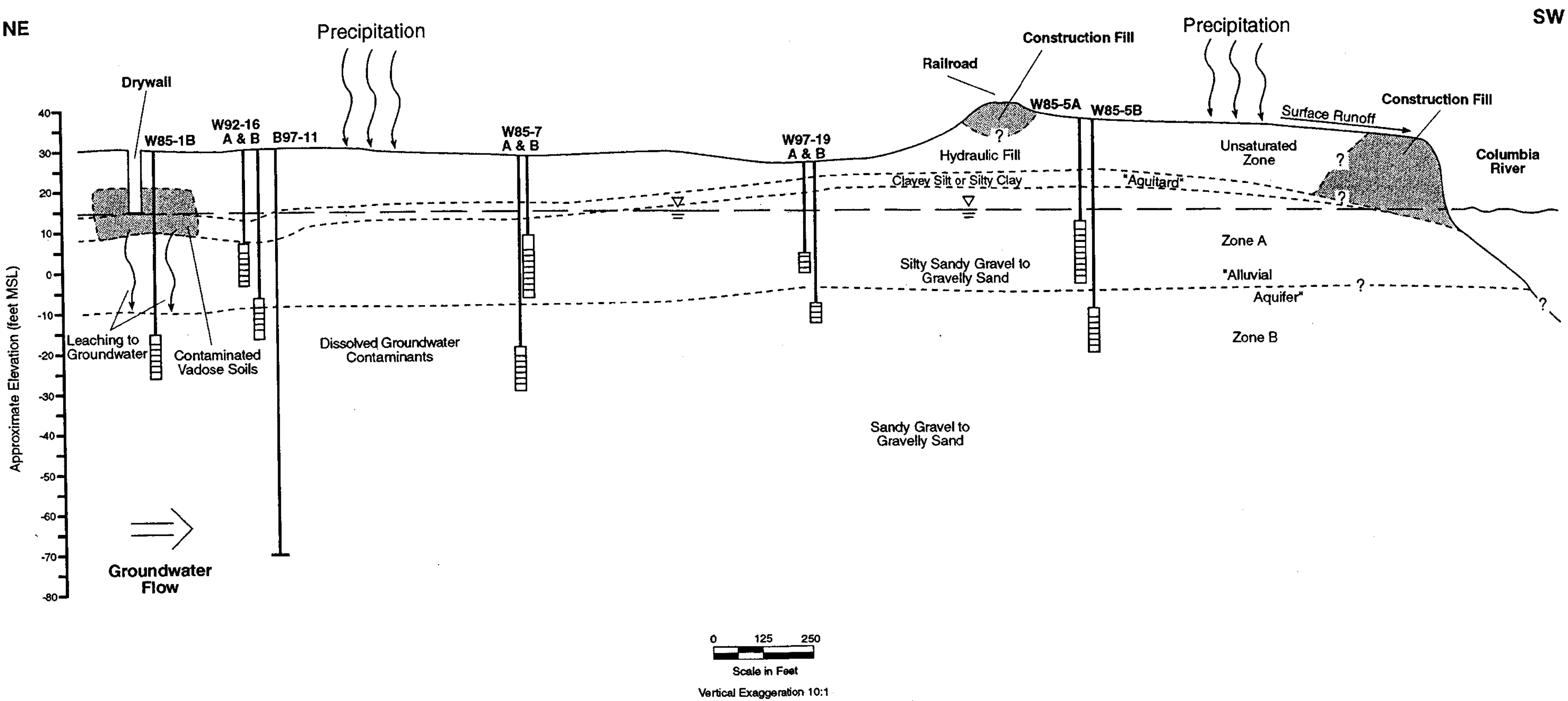
Frontier/97-456.ppt



Frontier Hard Chrome
Total Chromium Concentrations - Well W92-16B

FIGURE
27

Frontier/97-456.ppt



EXPLANATION

Monitoring Well

Note:

1) Groundwater elevation can vary by as much as 5 feet.

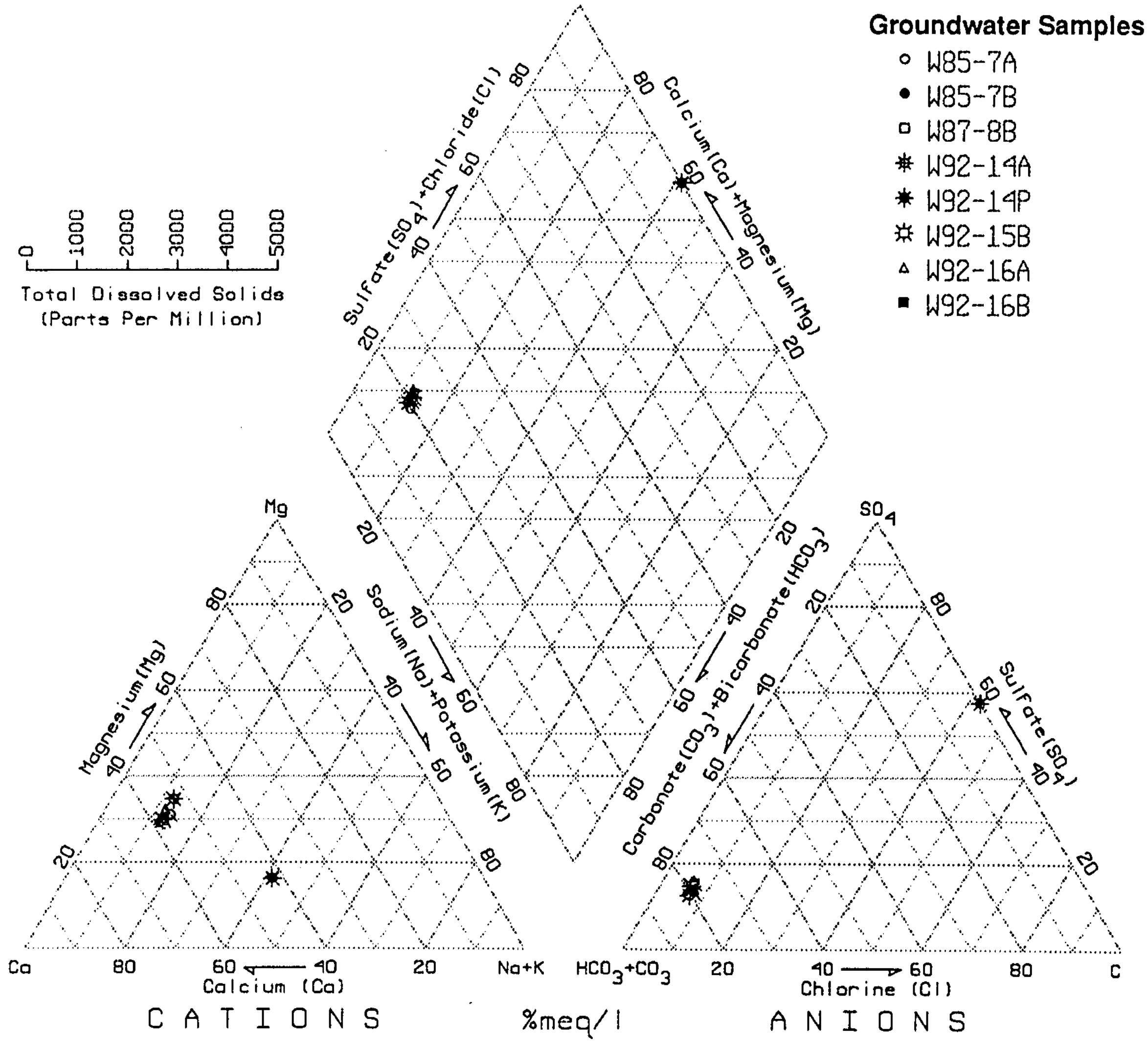
2) Water levels in the Columbia River can vary by as much as 10 feet due to seasonal and tidal influences.

WESTON
MANAGERS DESIGNERS/CONSULTANTS

97-456 Fig28chm.fh5

Frontier Hard Chrome
Conceptual Hydrogeologic Model

FIGURE
28



Frontier Hard Chrome
Piper Diagram

FIGURE
29

WESTON

Frontier/97-456.ppt

TABLES

Table 1—Monitoring Well Construction Details

Station Name	Date Construct	Log Avl	Ground Surface Elevation	Well Casing Elevation	Depth to Bottom Boring	Depth to Bottom Well	Diameter Well Casing	Depth to Top Screen	Depth to Bottom Screen	Length Well Screen
W85-1B	8/27/1985	Y	29.69	29.06	50.00	49.00	4.00	44.00	49.00	5.00
W85-3A	9/5/1985	Y	30.73	30.19	30.00	29.50	2.00	19.50	29.50	10.00
W85-3B	9/4/1985	Y	30.80	30.56	51.50	49.00	4.00	44.00	49.00	5.00
W85-5A	9/17/1985	Y	36.70	35.17	32.50	31.00	2.00	21.00	31.00	10.00
W85-5B	9/13/1985	Y	36.63	35.17	50.00	48.50	4.00	43.50	48.50	5.00
W85-6A	10/12/1985	Y	29.88	29.15	28.00	27.00	2.00	17.00	27.00	10.00
W85-6B	10/11/1985	Y	29.78	29.03	49.50	49.00	4.00	44.00	49.00	5.00
W85-7A	10/22/1985	Y	27.55	26.72	27.50	26.50	2.00	16.50	26.50	10.00
W85-7B	10/21/1985	Y	27.59	26.54	50.00	49.00	2.00	44.00	49.00	5.00
W87-8B	1/8/1987	Y	30.22	29.90	50.00	49.00	4.00	44.00	49.00	5.00
W86-10B	12/12/1986	Y	29.24	29.55	50.00	49.00	4.00	44.00	49.00	5.00
W86-13A	12/16/1986	Y	30.12	30.15	29.00	28.50	4.00	23.50	28.50	5.00
B86-2R	12/18/1986	Y	29.47	29.06	33.50	30.00	4.00	25.00	30.00	5.00
B85-4	10/10/1985	Y	29.95	29.95	33.00	26.50	2.00	21.50	26.50	5.00
B85-6	10/15/1985	Y	29.12	28.40	30.00	29.50	2.00	24.50	29.50	5.00
B87-8	1/13/1987	Y	29.96	29.71	32.00	29.50	4.00	24.50	29.50	5.00
PW-1A	1/29/1987	Y	28.96	28.55	31.00	30.50	6.00	20.50	30.50	10.00
PW-1B	1/26/1987	Y	28.38	28.38	55.00	54.00	6.00	38.00	54.00	16.00
W92-14A	6/27/1992	Y	29.92	29.57	28.50	28.50	2.00	23.50	27.50	4.00
W92-14P	6/27/1992	Y	29.95	29.61	17.00	17.00	2.00	12.00	17.00	5.00
W92-15A	6/24/1992	Y	30.16	29.77	34.00	34.00	4.00	24.00	34.00	10.00
W92-15B	6/24/1992	Y	30.12	29.64	43.50	43.50	4.00	33.00	43.00	10.00
W92-16A	6/23/1992	Y	29.72	29.36	34.00	34.00	4.00	24.00	34.00	10.00
W92-16B	6/23/1992	Y	29.61	29.26	46.00	45.00	4.00	35.00	45.00	10.00
W97-18A	04/00/97	Y	29.54	29.23	26.00	25.00	2.00	20.00	25.00	5.00
W97-18B	04/00/97	Y	29.48	29.15	46.00	44.50	2.00	39.50	44.50	5.00
W97-19A	04/00/97	Y	26.76	26.22	28.00	27.50	2.00	22.50	27.50	5.00
W97-19B	04/00/97	Y	26.33	25.49	49.00	45.50	2.00	40.50	45.50	5.00

Table 2—Summary of Groundwater Elevation Data

Station Name	Well Casing Elevation	Date	Time	Depth to Water	Ground-water Elevation
W92-14P	29.61	27-Feb-97	15:45	8.70	20.91
		28-Feb-97	12:35	8.71	20.90
		20-Mar-97	12:19	8.35	21.26
		18-Apr-97	15:39	9.04	20.57
		8-May-97	12:05	8.95	20.66
W85-3A	30.19	25-Feb-97	15:19	13.90	16.29
		28-Feb-97	12:15	14.42	15.77
		20-Mar-97	12:59	12.68	17.51
		18-Apr-97	14:45	15.17	15.02
W85-5A	35.17	26-Feb-97	10:08	19.80	15.37
		28-Feb-97	10:30	19.45	15.72
		20-Mar-97	13:38	17.40	17.77
		18-Apr-97	16:20	20.65	14.52
		8-May-97	13:38	15.38	19.79
W85-6A	29.15	25-Feb-97	12:45	13.00	16.15
		28-Feb-97	10:40	13.65	15.50
		20-Mar-97	11:55	11.30	17.85
		18-Apr-97	13:38	14.46	14.69
		8-May-97	10:47	9.32	19.83
W85-7A	26.72	26-Feb-97	16:55	10.80	15.92
		28-Feb-97	10:05	11.10	15.62
		20-Mar-97	13:26	8.98	17.74
		18-Apr-09	16:05	12.09	14.63
		8-May-97	10:33	6.97	19.75
W86-13A	30.15	24-Feb-97	11:02	13.90	16.25
		28-Feb-97	12:05	14.45	15.70
		20-Mar-97	13:06	12.62	17.53
		18-Apr-97	14:40	15.28	14.87
		8-May-97	10:03	6.97	23.18
B86-2R	29.06	28-Feb-97		14.23	14.83
		18-Apr-97	15:15	14.23	14.83
		8-May-97	9:01	8.63	20.43
B85-4	29.95	24-Feb-97	12:10	13.80	16.15
		28-Feb-97	11:50	13.64	16.31
		20-Mar-97	12:51	11.35	18.60
		18-Apr-97	15:10	14.43	15.52
		8-May-97	11:35	9.34	20.61
B85-6	28.40	26-Feb-97	12:00	12.50	15.90
		28-Feb-97	12:30	12.73	15.67
		20-Mar-97	12:26	10.68	17.72
		8-May-97	9:09	8.63	19.77

Table 2—Summary of Groundwater Elevation Data

Station Name	Well Casing Elevation	Date	Time	Depth to Water	Ground-water Elevation
B87-8	29.71	24-Feb-97	12:50	13.35	16.36
		28-Feb-97	11:55	14.11	15.60
		20-Mar-97	12:47	12.02	17.69
		18-Apr-97	15:05	14.89	14.82
		8-May-97	11:50	9.95	19.76
PW-1A	28.55	28-Feb-97		NA	NA
		18-Apr-97	15:30	13.66	14.89
		8-May-97	11:18	8.75	19.80
W92-14A	29.57	27-Feb-97	14:45	13.20	16.37
		28-Feb-97	12:40	13.04	16.53
		20-Mar-97	12:16	12.25	17.32
		8-May-97	12:10	9.78	19.79
W92-15A	29.77	24-Feb-97	16:06	13.40	16.37
		28-Feb-97	13:00	14.16	15.61
		20-Mar-97	12:36	12.15	17.62
		18-Apr-97	12:30	14.97	14.80
		8-May-97	11:57	10.05	19.72
W92-16A	29.36	26-Feb-97	14:10	13.45	15.91
		28-Feb-97	12:55	13.76	15.60
		20-Mar-97	12:40	11.75	17.61
		18-Apr-97	12:40	14.57	14.79
		8-May-97	11:53	9.62	19.74
W97-18A	29.23	28-Feb-97	11:20	14.75	14.48
		20-Mar-97	12:04	11.38	17.85
		18-Apr-97	13:05	14.49	14.74
		8-May-97	11:10	9.40	19.83
W97-19A	26.22			NA	NA
		20-Mar-97	13:09	8.50	17.72
		18-Apr-97	14:20	11.63	14.59
		8-May-97	10:15	6.47	19.75
W85-1B	29.06	24-Feb-97	14:10	12.65	16.41
		28-Feb-97	12:25	13.35	15.71
		20-Mar-97	13:03	11.42	17.64
		18-Apr-97	14:56	14.12	14.94
		8-May-97	9:56	9.32	19.74
W85-3B	30.56	25-Feb-97	14:39	14.30	16.26
		28-Feb-97	12:20	14.80	15.76
		20-Mar-97	12:57	13.00	17.56
		18-Apr-97	14:50	15.55	15.01
		8-May-97	9:50	10.83	19.73

Table 2—Summary of Groundwater Elevation Data

Station Name	Well Casing Elevation	Date	Time	Depth to Water	Ground-water Elevation
W85-5B	35.17	26-Feb-97	10:40	19.45	15.72
		28-Feb-97	10:25	19.78	15.39
		20-Mar-97	13:35	17.37	17.80
		18-Apr-97	16:25	20.63	14.54
		8-May-97	13:40	15.38	19.79
W85-6B	29.03	25-Feb-97	11:20	12.85	16.18
		28-Feb-97	10:45	13.48	15.55
		20-Mar-97	11:57	11.25	17.78
		18-Apr-97	13:49	14.30	14.73
		8-May-97	10:45	9.22	19.81
W85-7B	26.54	28-Feb-97	9:00	11.25	15.29
		28-Feb-97	10:00	11.23	15.31
		20-Mar-97	13:28	8.80	17.74
		18-Apr-97	15:56	11.94	14.60
		8-May-97	10:37	6.79	19.75
W87-8B	29.90	26-Feb-97	15:45	13.80	16.10
		28-Feb-97	11:35	14.10	15.80
		18-Apr-97	14:06	14.84	15.06
		8-May-97	10:59	10.19	19.71
W86-10B	29.55	25-Feb-97		14.40	NA
		20-Mar-97	11:45	12.58	16.97
		18-Apr-97	14:10	15.70	13.85
		8-May-97	10:53	10.57	18.98
PW-1B	28.38			NA	NA
		18-Apr-97	15:20	13.44	14.94
		8-May-97	11:25	8.63	19.75
W92-15B	29.64	24-Feb-97		13.30	16.34
		28-Feb-97		14.13	15.51
		20-Mar-97	12:32	12.02	17.62
		18-Apr-97	12:12	14.82	14.82
		8-May-97	11:59	9.91	19.73
W92-16B	29.26	25-Feb-97		13.10	16.16
		28-Feb-97		13.66	15.60
		20-Mar-97	12:44	11.65	17.61
		18-Apr-97	12:45	14.46	14.80
		8-May-97	11:52	9.53	19.73
W97-18B	29.15	28-Feb-97		14.75	14.40
		20-Mar-97		11.55	17.60
		18-Apr-97	13:20	14.34	14.81
		8-May-97	11:06	9.35	19.80
W97-19B	25.49			NA	NA
		20-Mar-97		7.75	17.74
		18-Apr-97	14:25	10.93	14.56
		8-May-97	10:16	5.74	19.75

Table 3—Field Groundwater Sampling Parameters

Groundwater Wells	Sampling Device	pH	Conductivity (μS)	Temperature (°C)	Eh (mV)	Color/Turbidity (NTU)	Dissolved Oxygen (mg/l)
Sampled Wells							
W85-1B	peristaltic	5.87	232.0	13.5	225	clear [a]	
W85-3A	Grundfos	6.68	316.0	15.8	199	18.40	0.4
W85-3B	Grundfos	6.87	267.0	14.5	182	5.60	3.3
W85-6A	Grundfos	6.45	196.0	16.2	208	3.10	3.2
W85-6B	peristaltic	6.58	250.0	13.2	211	6.10	NA [b]
W85-7A	Grundfos	6.27	41.4	11.9	211	clear [c]	3.0
W85-7B	Grundfos	6.28	225.0	13.8	226	3.70	3.9
W87-8B	peristaltic	6.42	275.0	14.0	214	1.34	3.5
W86-10B	peristaltic	6.56	202.0	11.8	210	clear [a]	4.9
W86-13A	peristaltic	6.31	148.0	11.9	188	clear [a]	1.1
W92-14A	Grundfos	6.06	471.0	13.5	225	47.2 [d]	1.1
W92-14P	Grundfos	4.96	19.0	16.0	278	3.6 [d]	1.0
W92-15A	peristaltic	6.02	262.0	14.1	233	cloudy [a]	2.5
W92-15B	peristaltic	5.22	239.0	13.9	259	clear [a]	3.0
W92-16A	peristaltic	6.46	274.0	13.5	204	0.28	0.8
W92-16B	peristaltic	6.86	244.0	13.4	227	22.90	4.0
B85-4	peristaltic	6.07	440.0	14.5	200	sl. cloudy [a]	0.3
B85-6	peristaltic	6.23	448.0	11.8	186	6.80	0.4
B87-8	peristaltic	6.09	248.0	14.8	218	clear [a]	0.2
W85-5A	peristaltic	6.13	199.0	13.4	219	2.00	3.6
W85-5B	peristaltic	6.29	200.0	12.7	225	1.60	3.8
W97-18A	peristaltic	5.75	70.8	12.9	106	33	0.5
W97-18B	peristaltic	7.18	314.0	14.70	73	67	0.7
W97-19A	peristaltic	6.52	195.0	13.90	59	77	1.8
W97-19B	peristaltic	7.06	224.0	14.90	-465	22	0.2

[a] turbidity meter was inoperable at the time well was sampled.

[b] dissolved oxygen sensor had failed at time of sampling.

[c] turbidity meter was in use with second sampling team at the time of sampling W85-7A.

[d] water sample was yellow/green in color

Table 4—Groundwater Analytical Program—Spring 1997

Well Designation	Sample ID	EPA ID	Volatiles	Total Chromium	Hexavalent Chromium	Total Organic Carbon	Sulfide	Dissolved Metals	Alkalinity	Sulfate	Chloride	Fluoride	Orthophosphate	Total Dissolved Solids	Nitrate
W85-1B	GWR1-WP851B-0	97094115		X											
W85-3A	GWR1-WP853A-0	97094116	X	X											
W85-3B	GWR1-WP853B-0	97094117	X	X											
W85-6A	GWR1-WP856A-0	97094118	X	X											
W85-6B	GWR1-WP856B-0	97094119		X											
W85-7A	GWR1-WP857A-0	97094120	X	X	X	X	X								
W85-7A	GWR1-WP857A-0	97094121						X	X	X	X	X	X	X	X
W85-7B	GWR1-WP857B-0	97094122	X	X		X	X								
W85-7B	GWR1-WP857B-0	97094123						X	X	X	X	X	X	X	X
W86-10B	GWR1-WP8610B-0	97094124		X											
W86-13A	GWR1-WP8613A-0	97094125		X											
W87-8B	GWR1-WP878B-0	97094128	X	X	X	X	X								
W87-8B	GWR1-WP878B-0	97094129						X	X	X	X	X	X	X	X
W92-14A	GWR1-WP9214A-0	97094130	X	X	X	X	X								
W92-14A	GWR1-WP9214A-0	97094131						X	X	X	X	X	X	X	X
W92-14P	GWR1-WP9214P-0	97094132	X	X	X	X	X								
W92-14P	GWR1-WP9214P-0	97094133						X	X	X	X	X	X	X	X
W92-15A	GWR1-WP9215A-0	97094134		X											
W92-15B	GWR1-WP9215B-0	97094135		X	X	X	X								
W92-15B	GWR1-WP9215B-0	97094136						X	X	X	X	X	X	X	X
W92-16A	GWR1-WP9216A-0	97094137		X	X	X	X								
W92-16A	GWR1-WP9216A-0	97094138						X	X	X	X	X	X	X	X
W92-16B	GWR1-WP9216B-0	97094139		X	X	X	X								
W92-16B	GWR1-WP9216B-0	97094140						X	X	X	X	X	X	X	X
B85-4	GWR1-B854-0	97094141		X											
B85-6	GWR1-B856-0	97094142		X											
B87-8	GWR1-B878-0	97094143		X											
W97-18A	GWR1-WP9718A-0	97124580		X											
W97-18B	GWR1-WP9718B-0	97124581		X											
W97-19A	GWR1-WP9719A-0	97124582		X											
W97-19B	GWR1-WP9719B-0	97124583		X											
W85-5A	GWR1-WP975A-0	97094148		X											
W85-5B	GWR1-WP975B-0	97094149		X											
Duplicate	GWR1-W878B-1	97094150	X	X	X	X	X								
Duplicate	GWR1-W878B-1	97094151						X	X	X	X	X	X	X	X
Duplicate	GWR1-W856B-1	97094152		X											

Metals = Aluminum, barium, calcium, chromium, iron, magnesium, manganese, potassium, silica, and sodium

Table 5—VOC Concentrations in Groundwater (μg/L)

Station ID EPA ID Date Collected	W85-3A 97094116 2/25/1997	W85-3B 97094117 2/25/1997	W85-6A 97094118 2/25/1997	W85-7A 97094120 2/26/1997	W85-7B 97094122 2/28/1997	W87-8B 97094128 2/26/1997	W87-8B (DUP) 97094150 2/26/1997	W92-14A 97094130 2/27/1997	W92-14P 97094132 2/27/1997	MTCA GW Cleanup Levels[1]
1,1,1-Trichloroethane	**0.93 J**	**0.92 J**	1 U	1 U	1 U	1 U	1 U	**0.7 J**	**50.2**	200
1,1-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**3.5**	**40.9**	800
1,2-Dimethylbenzene	1 U	**0.13 J**	1 U	1 U	1 U	1 U	1 U	**2.3**	1 U	
cis-1,2-Dichloroethene	**16.2**	**2.2**	1 U	1 U	**0.68 J**	1 U	1 U	**2.6**	**0.38 J**	80
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**0.79 J**	1 U	30
Tetrachloroethene	**84.2**	**21.8**	**1.6**	**2**	**7.7**	**9.9**	**10.9**	**9.8**	**2.9**	5
Total Xylenes	**0.52 J**	**0.69 J**	2 U	2 U	2 U	2 U	**0.22 J**	**2.2**	**0.22 J**	20
Trichloroethene	**8.9**	**2.2**	1 U	1 U	**0.68 J**	1 U	1 U	**1.8**	**0.54 J**	5

U - Undetected

J - Estimated

[1] Based on Washington State Department of Ecology MTCA Method A or B groundwater cleanup levels in ug

Table 6—Chromium Concentrations in Groundwater (µg/L)

Location	EPA ID	Total Chromium	Cr VI	Dissolved Chromium
W85-1B	97094115	**109**		
W85-3A	97094116	**16**		
W85-3B	97094117	**80.6**		
W85-5A	97094148	**10**		
W85-5B	97094149	**10**		
W85-6A	97094118	**114**		
W85-6B	97094119	**61.1 J**		
W85-6B (dup)	97094152	**211 J**		
W85-7A	97094120	**10**	10 U	**11**
W85-7B	97094122	**27.3**		**27.2**
W86-10B	97094124	5 U		
W86-13A	97094125	5 U		
W87-8B	97094128	**48**	**47.8**	**46.5**
W87-8B (dup)	97094150	**47.4**	**45.5**	**49**
W92-14A	97094130	**19,400**	**18,433 H**	**18,500**
W92-14P	97094132	**6,410**	**6,130 H**	**6,530**
W92-15A	97094134	**732**		
W92-15B	97064135	**684**	**762**	**669**
W92-16A	97094137	**472**	**463**	**473**
W92-16B	97094139	**74**	**63.7**	**62.9**
B85-4	97094141	**5,560**		
B85-6	97094142	**230**		
B87-8	97094143	**1,590**		
W97-18A	97124580	5 U		
W97-18B	97124581	5 U		
W97-19A	97124582	**8.1**		
W97-19B	97124583	5 U		

U - Undetected

J - Estimated

H - Exceeded holding time limit, value is an estimate

Table 7—Dissolved Metals Concentrations in Groundwater (µg/L)

Location	EPA ID	Aluminum		Barium	Calcium	Iron		Magnesium	Manganese		Potassium		Silica	Sodium
W85-7A	97094121	20	U	**5.95**	**16,100**	**20**		**5,460**	**1.8**		**880**		**30,400**	**4,000**
W85-7B	97094123	20	U	**16**	**32,200**	10	U	**9,730**	1	U	**2,590**		**47,400**	**6,210**
W87-8B	97094129	20	U	**12.7**	**38,600**	**15**		**12,200**	1	U	**3,340**		**50,700**	**7,730**
W87-8B (dup)	97094151	20	U	**13.1**	**38,300**	**17**		**12,100**	1	U	**3,560**		**50,100**	**7,630**
W92-14A	97094131	20	U	**90.2**	**60,300**	10	U	**23,900**	**8,180**		**1,900**		**48,500**	**15,100**
W92-14P	97094133	**146**		**104**	**4,010**	10	U	**928**	**35.4**		650	U	**44,200**	**4,500**
W92-15B	97094136	20	U	**12**	**36,800**	10	U	**11,500**	**1.2**		**3,120**		**49,600**	**7,470**
W92-16A	97094138	20	U	**14.1**	**38,700**	10	U	**13,600**	**837**		**2,450**		**43,700**	**7,970**
W92-16B	97094140	20	U	**14.5**	**34,100**	10	U	**10,700**	**1.1**		**3,400**		**50,200**	**6,850**

U - Analyte not detected. The associated value is the sample quantitation limit.

Table 8—Conventional Parameter Concentrations in Groundwater (mg/L)

Location	EPA ID	Alkalinity	Chloride	Fluoride	Nitrate	Ortho-Phosphorous	Sulfide	Sulfate	TDS	TOC
W85-7A	97094120/97094121	**52.2**	**2.44**	0.1 U	**2.47**	0.1 U	**0.34**	**6.6**	**202**	5 U
W85-7B	97094122/97094123	**102**	**5.52**	0.1 U	**2.79 JH**	0.1 UJH	0.2 U	**13.5**	**196**	5 U
W87-8B	97094128/97094129	**125**	**6.23**	0.1 U	**3.13**	0.1 U	0.2 U	**19.2**	**370**	5 U
W87-8B (dup)	97094150/97094151	**125**	**6.02**	0.1 U	**3.13**	0.1 U	0.2 U	**19.1**	**358**	5 U
W92-14A	97094130/97094131	**233**	**11.7**	**0.22**	0.1 U	0.1 UJH	0.2 U	**28.9**	**386**	**5.65**
W92-14P	97094132/97094133	10 U	**4.26**	0.1 U	**0.91**	0.1 UJH	0.2 U	**7.84**	**95**	5 U
W92-15B	97064135/97094136	**121**	**5.72**	0.1 U	**2.67 H**	0.1 U	0.2 U	**17.8**	**392**	5 U
W92-16A	97094137/97094138	**133**	**6.11**	0.1 U	**1.72**	0.1 U	0.2 U	**21.5**	**374**	5 U
W92-16B	97094139/97094140	**113**	**5.68**	0.1 U	**2.97**	0.1 U	0.2 U	**15.2**	**388**	5 U

The first EPA ID is the total fraction of the sample and the second ID is the dissolved fraction.

U - Undetected
J - Estimated
H - Holding time limit exceeded, value is an estimate

APPENDIX A

FIELD METHODOLOGY

APPENDIX A

FIELD METHODOLOGY

The section summarizes the field methodology used by WESTON to conduct its field activities investigations. All field activities were conducted in general accordance with a Sampling and Analysis Plan prepared by WESTON (dated 22 January 1997 with Addenda 1 through 3). Specific elements of the field investigation and sample collection tasks are discussed below.

Deviations from the Work Plan

Deviations from the work plan are noted below:

1) Well W87-8A was not sampled because it was determined that W87-8A had been abandoned in 1994.

2) Orthophosphate and hexavalent chromium were not analyzed in the sample from W85-7B because their holding times were exceeded.

3) W85-5A and W85-5B were sampled for total chromium and W85-5B was borehole geophysically logged. These wells could not be located until an accurate map showing their location was found. They were included in the field program once they had been located in the field.

4) Induction logging was not included in the borehole geophysics program. Induction logging cannot be used in the presence of metal casing or centralizers. The absence of induction logging was not considered to be significant for the purposes of this study.

Drilling and Soil Sampling Program

Six borings were advanced to depths ranging from 25 to 98 feet below ground surface (bgs) by Cascade Drilling Co. of Portland, Oregon between February 24 and March 17, 1997. W97-18A, W97-18B, and W97-18B' were drilled between 24 and 27 February 1997 to depths of 25, 50 and 50 feet below the ground surface (bgs), respectively. W97-18B' hit a sewer line and had to be abandoned on February 24, 1997. W97-19A and W97-19B were drilled on 17 March 1997 to depths of 25 and 50 feet bgs, respectively. A truck-mounted, 4-inch-inside-diameter (ID) hollow-stem augur (HSA) drill rig was used to drill these borings. The boring and well completion logs are presented in Appendix B.

The deep boring B97-11 was drilled in two phases. On February 25 and 26, B97-11 was drilled to a depth of 38 feet bgs using hollow-stem auger drilling equipment. Drilling was discontinued due to drilling refusal. Air rotary drilling equipment was mobilized and the boring was extended to a depth of 98 feet bgs on 16 March 1997 to a depth of 98 feet bgs.

Soil samples were collected using a 2.5-inch ID split-spoon sampler. A 2.5-foot sampling interval used to sample borings W97-18B, W97-18B' and W97-19B. Boring B97-11 was sampling continuously to a 2.5 foot sample interval. Borings W97-18A and W97-18B were not sampled. The sampler was driven approximately 18 inches (or to refusal) using a 140- or 300-pound hammer falling a distance of approximately 30 inches. Hammer blow counts, which provide a measurement of relative density of soil, were recorded in 6-inch intervals over the 18-inch sampling interval.

Drilling was conducted under the observation of a WESTON geologist. The WESTON representative visually logged the soils in general accordance with the Unified Soil Classification System described according to ASTM Designation D 2488-69 and created detailed logs of subsurface soil types and field screening results.

Sealed and labeled soil samples were placed in an ice chest containing ice for transport to the analytical laboratory. Chain-of-custody forms were completed in the field and accompanied the samples to the analytical laboratory.

All downhole drilling equipment and PVC well material was cleaned with a hot-water pressure washer before use and between each boring to reduce the potential for cross-hole contamination.

Borehole Geophysics

Borehole geophysics logging was performed by Welenco, Inc. of Kennewick WA. Selected wells and one borehole (B97-11) was geophysically logged using natural gamma and neutron logging tools. The values were recorded in API unit. Gamma and neutron logging tools are calibrated to standards set by the American Petroleum Institute and are recorded in API Unit. The borehole geophysical logs are presented in Appendix C.

Monitoring Well Construction

Four borings were completed as monitoring wells, designated W97-18A, W97-18B, W97-19A and W97-19B in general accordance with Ecology regulations. Monitoring wells were installed with 5-feet 2-inch-diameter, Schedule 40, PVC flushed-threaded screen having 0.020 inch wide slots. The well completion logs are presented in Appendix B.

Monitoring Well Development

The new monitoring wells were developed within 24 to 48 hours after installation by overpumping with a 2-inch Grundfos submersible pump. During well development, water quality parameters were monitored (i.e., pH, conductivity, turbidity, temperature, Eh, and dissolved oxygen) using a flow cell. Approximately 6 to 11 well volumes were removed from each well. Groundwater recharge was poor in W97-18B during development.

Surveying

The existing and new monitoring wells were surveyed by White Shield on March 1997 Measurements were relative to a datum to a precision of 0.01 foot. Horizontal locations were also surveyed.

Groundwater Elevations

The depth to groundwater table relative to the monitor well casing rims was measured in each well. Water level measurements were taken using an electronic water level indicator interface probe. The probe was cleaned between each well measurement with an Alconox wash and a distilled water rinse.

Groundwater Sampling

The monitoring wells were purged and sampled using a peristaltic pump with the exception of wells that were sampled for VOCs. These wells were purged and sampled with a Grundfos 2-inch diameter-pump. The tubing or pump was lowered slowly into the well to minimize disturbance and down to the center of the screen and at least 2 feet above the bottom of the well during purging. The wells were purged at low pumping rate to minimize drawdown until the field parameters (temperature, conductivity, pH, redox and dissolved oxygen) were stabilized. All field parameter measurements wee obtained using water quality meters with a flow-through-cell. Turbidity was also monitored during purging. Water was diverted into a clean container and the turbidity of the water sample was measured with a hand held turbidity meter in NTUs.

Samples collected for total and hexavalent chromium and water quality parameters were taken directly from the peristaltic pump tubing after removing the water quality meter flow-through-cell and placed into a bottle and preserved. The VOC samples were put directly into prepreserved vials from the Grundfos hose after the water quality meter flow-through-cell has been removed.

Direct Push Groundwater Sampling

Five groundwater samples were collected using a Hydropunch™ direct push sampling device during the drilling of B97-11. The sampler were driven at the bottom of the boring at five depth intervals (i.e., 24, 38, 60, 80 and 98 feet). The sampler was driven a minimum of 2 feet into the formation prior to collecting the sample. Each of the collected groundwater samples was filtered in the field using a peristaltic pump fitted with a 0.45-micron filter.

Boring Abandonment

Well W97-18B' was drilling on February 24, 1997. During the installation of a 2-inch monitoring well running water was observed in the boring upon retrieval of the augur. It was determined that the augur had drill through a 12-inch PVC sewer line situated approximately 10 feet bgs. The well was immediately abandoned with bentonite chips per Ecology regulations. The City of Vancouver was notified of the rupture and a repair crew from the city was dispatched to the site. It was verified that WESTON contacted to the city locating service on 14

February 1997 (10 day prior to drilling at the location) and that the intercepted sewer line was not previously located by the city.

INVESTIGATION-DERIVED WASTE MANAGEMENT

Soil and waste water generated during field activities were stored in 55 gallon DOT approved IDW drums placed on pallets. A contractor was be retained to dispose of the IDW.

ANALYTICAL METHODS

Groundwater samples were analyzed by EPA's Manchester Laboratory. Soil samples were analyzed by ARI of Seattle, Washington.

The following methods were used in analyzing groundwater samples:

VOCs	EPA Method 8260
Dissolved metals	EPA Method 6010
Hexavalent chromium	EPA Methods 218.5 and 218.6.
alkalinity	EPA Method 310.1
chloride	EPA Method 325
fluoride	EPA Method 340.2
nitrate	EPA Method 353
orthophosphate	EPA Method 365.2
sulfate	EPA Method 375.2
sulfide	EPA Method 376.2
total dissolved solids	EPA Method 160.1
total organic carbon	EPA Method 415.1/906