INTERIM CHANGE NOTICE
(ICN)

A. Document No.: PNNL-13023 Revision No.: 1 Document Title: RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site Document's Original Author: S. M. Narbutovskih and D. G. Horton	Effective Date of ICN: July 15, 2002 Change Requested By: S. M. Narbutovskih

B. Action:
Make changes in the monitoring plan as described below in Section D. Attach this ICN to the front of the document just before the title page.

C. Effect of Change:
This ICN documents an improved understanding of the local groundwater flow direction, defines up gradient versus down gradient monitoring wells, provides updated critical means for indicator parameters and updates the sampling and analysis schedule. Project scientist will provide a schedule change request providing a list of constituents and sample frequencies to the sample scheduler.

D. Reason for Change/Description of Change:

Reason for Change: Update groundwater quality monitoring plan at WMA A-AX (PNNL-13023) to document an improved understanding of the local groundwater flow direction, to redefine up gradient versus down gradient monitoring wells, to update the sampling and analysis schedule and to update the critical means for indicator parameters. Also included are minor editorial changes noted below.

Description of Change:
(1) Added the reference "Hartman (2000)" after "Caggiano (1991)" at the end of the first paragraph on page 2.1 to document the source of information in this section.
(2) Attach 2.25 to 2.28 to the backs of pages 2.25 to 2.29 to document the changes in the interpretation of the local groundwater flow direction from southwest to southeast based on an integration of refined water level data and in situ flow measurements.
(3) Draw a line through Table 4.1 on page 4.3 and attach the new Table 4.1 to that page to document the network monitoring wells. Draw a line through Table 4.2 on page 4.8 and attach the new Table 4.2 to that page to update the critical means for indicator parameters. Draw a line through Table 4.3 on page 4.9 and attach the new Table 4.3 to that page to update the sampling and analysis schedule.
(4) Attach pages 4.5 to 4.6 to the back of page 4.5 and attach pages 4.9 to 4.10 to the back of pages 4.9 to 4.10 to update the current groundwater monitoring network, redefining upgradient versus downgradient monitoring wells, and to update the sampling and analysis schedule.

E. Document Management Decisions:
See attached distribution list.
TJW
7-11-02

F. Approval Signatures
(Please Sign and Date)

Type of Change: (Check one):
___ Minor _X_ Major

Process Quality Department: T. G. Walker Thomas H Walker Date: 7/11/02
Approval Authority: S. P. Luttrell [signature] Date: 7/10/02
Other Approvals: S. M. Narbutovskih Technical S M Narbutovskih Date: 6/26/02

other network wells. Because water elevations are the most common data set used at the DOE Hanford Site to determine flow direction, a switch in the relative water elevations of wells used to determine direction could affect the interpretation of the flow direction.

For example, Figure 2.7 shows the hydrographs for four RCRA network wells and one older well 299-E25-2, that are currently used to monitor the water table at WMA A-AX referenced to NGVD29-2. Spurious data were removed. Figure 2.8 shows the same 'depth to water' data as Figure 2.7 but referenced to NAVD88 except for well 299-E24-20. For this well, the NAVD88 reference elevation was calculated from the original NGVD29 elevation. The hydrograph in Figure 2.7 is using a survey conducted in the early 1990s, whereas the hydrograph in Figure 2.8 uses a survey from the late 1990s. Except for well 299-E25-46, the relative elevations of the wells appear to be almost unaffected by switching surveys, demonstrating repeatability of the elevation values. The reference elevations from these wells, therefore, are probably reliable. Although the absolute difference is small, the relative position of the water table in well 299-E25-46 switches from being high in Figure 2.7 to being lower with respect to the other wells in Figure 2.8. This difference is enough to demonstrate some degree of nonrepeatability for the well. The late 1990s survey used in Figure 2.8 is considered more reliable.

Hydrographs of the five wells gives a consistent picture of relative water elevations over time (Figure 2.8). The flow direction appears to be east to southeast. Based on these hydrographs, well 299-E24-20 is the upgradient well, while the others are down gradient. This scenario results in a generally east to southeast direction across the site. This direction has been confirmed with the use of an alternative in situ method to determine flow direction. Recent direct measurements using the colloidal borescope in wells 299-E25-46 (southeast of A tank farm), 299-E25-41 (southeast of AX tank farm), and 299-E25-42 (southeast of A Tank Farm) indicate a southeasterly flow direction.

Another well, 299 E24-19, was eliminated from the analysis because results from this well form a slight trough between E24-20 and E25-46. The water elevations in this well are low regardless of which survey is used, which has confused interpretation of the flow direction in the past. Based on recent findings with vertical borehole deviations, this well may be out of plumb, explaining the abnormal trough. Consequently this well was eliminated from the network for flow direction determinations until vertical corrections are available.

Unfortunately, the original groundwater-monitoring network, which is still in use today, was designed for a narrowly focused southwest flow direction. The consequences of having a southeast flow direction on the RCRA network compliance is discussed more fully in Section 4.2. However, as can be seen from Figure 1.2, the current monitoring wells are not placed to provide adequate upgradient/downgradient coverage for this WMA for a southeasterly flow direction. Well 299-E25-40 is too far north to provide much coverage, which leaves wells 299-E25-41 and 299-E25-46 as the only functional downgradient wells.

The rate of groundwater flow is calculated for a homogeneous, isotropic aquifer using the Darcy equation (Hartman 1999) incorporating an effective hydraulic conductivity, the gradient across the site and the porosity of the sediments in the aquifer. Currently, there is a discrepancy in reported hydraulic conductivity values for the area. Values are estimated between 24 and 110 ft (7.3 and 33.5 m) per day

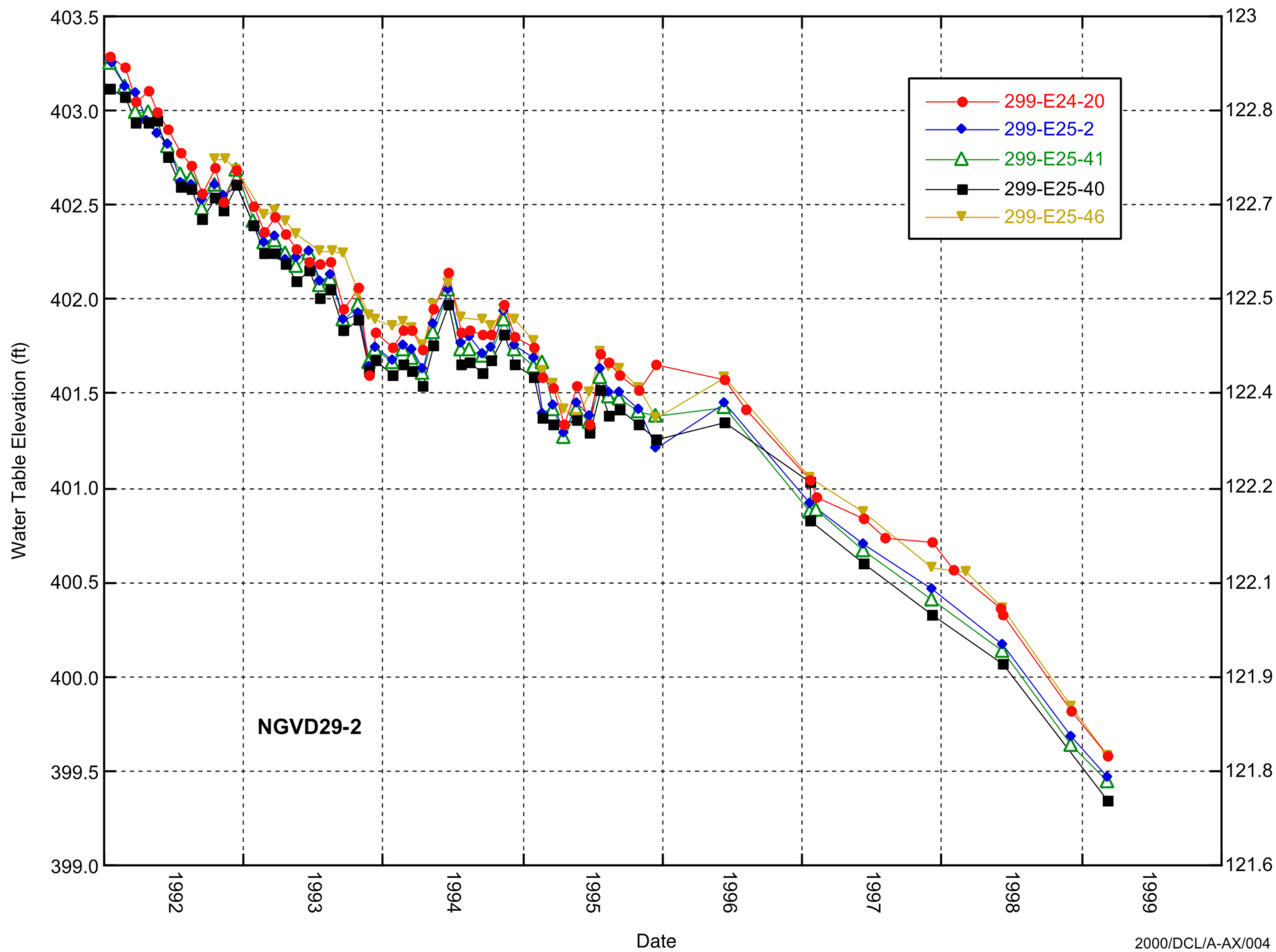

Figure 2.7. Hydrograph Showing Groundwater Elevations using the NGVD29 Datum, and an Early 1990's Survey Used at this Site up Until FY 1998. Even though the difference between interwell elevations are just a few inches, Wells 299-E25-46 and 299-E24-20 have displayed consistently higher water elevations over time with respect to the other wells at WMA A-AX. Spurious data have been removed.

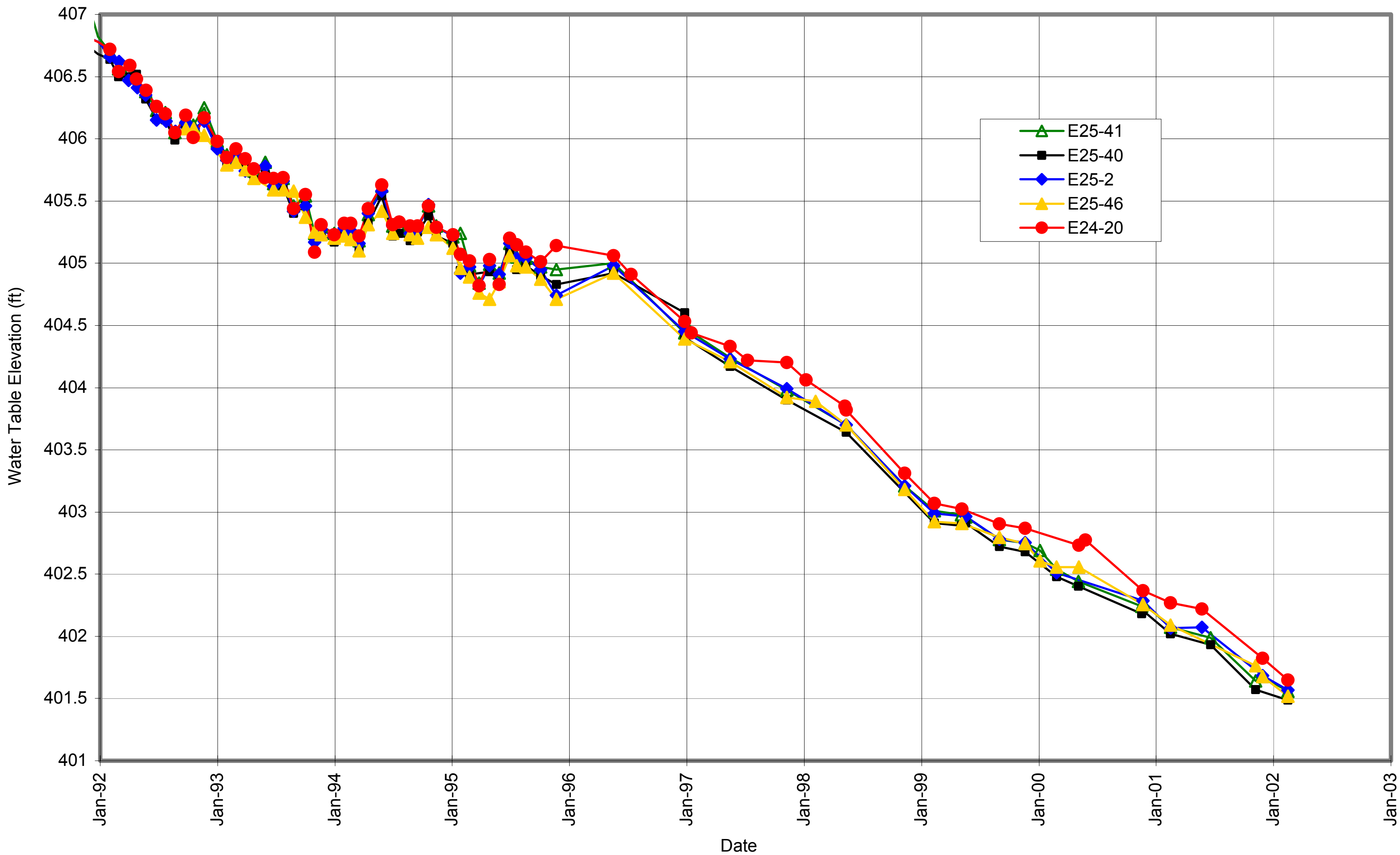

Figure 2.8. Hydrograph Showing Groundwater Elevations Referenced to the Datum, NAVD88, and a Late 1990's Survey, Except for Well 299-E24-20. Spurious data have been removed.

based on slug injection/withdrawal tests. Higher values of 6,500 ft (1,981 m) per day are reported based on pumping tests for the area (Newcomer et al. 1990; Connelly et al. 1992). In the FY 1992 hydrogeologic model for the 200 East Area, values of 6,200 to 6,500 ft (1,889.8 to 1,982 m) per day are reported at WMA A-AX (Connelly et al. 1992). Trent (1992) reports conductivities that range from 8,264 ft (2,518.9 m) per day to 6,500 ft (1,982 m) per day for wells in the immediate area of WMA A-AX. Finally, Hartman (1999) reported hydraulic conductivities that range from 33,000 ft (10,000 m) per day to 9,843 ft (3,000 m) per day for Hanford sediments. The low results from slugs tests are likely inherent in the method. The test has a limited areal extent (i.e., interrogates a low volume), applies a limited stress to the aquifer and is valid over a limited range of conductivities (Thorne and Newcomer 1992).

Porosity is generally estimated to be about 30% for unconsolidated, coarse-grained sediments at the DOE Hanford Site (Hartman 1999). Because it has not been possible to collect intact core from the aquifer during past drilling, direct methods of determining porosity have not been used. The lack of direct measurements combined with the cobble to boulder grain size of the aquifer suggests 30% may be an underestimate for effective porosity.

Using NAVD88-1, water elevations across WMA A-AX vary from 402.9 to 403.1 ft (122.80 to 122.86 m) or 2.4 in. (6.1 cm). The local gradient between well 299-E25-41 and 299-E24-20 is 0.000078 based on March 1999 water levels. Based on hydraulic conductivity values from pumping tests, the effective flow rate at WMA A-AX is estimated to be between 2.2 and 2.6 ft (0.67 to 0.79 m) per day. This equates to 803 to 949 ft (245 to 289 m) of groundwater movement per year. However, the Hanford formation is known to contain coarse gravel channels and other sedimentary features that may produce preferential groundwater flow paths. Consequently, a flow velocity of 2.6 ft (0.79 m) per day may be low if such preferred flow zones are identified.

Currently for RCRA network wells, screened intervals within the aquifer range from 7.2 to 14.8 ft (2.2 to 4.5 m) thick. The rate of water table decline has increased from 0.3 ft (9.1 cm) per year in June 1997 to 1 ft (30.5 cm) per year from mid-1998 to March 1999. If this current rate continues, three of the RCRA compliant wells at WMA A-AX with less than 10 ft (3 m) of water may become unusable in less than six years.

In the past, the flow direction and rate at WMA A-AX were poorly understood. This was due, in part, to the artificial recharge of the aquifer, which occurred during the last 50 years when waste effluent was discharged to the subsurface. Since 1995 when most liquid discharges to the ground ceased, the water table has begun to drop to near pre-Hanford levels. The original local flow direction was likely in the direction of the Columbia River, southeasterly. The combination of an exceptionally flat water table, decreasing water levels and changing local flow directions has complicated groundwater monitoring at WMA A-AX. However by integrating water table elevations with in situ flow measurements, it is now known that the direction is generally southeasterly.

Table 4.1. Network Monitoring Wells

Well Name	Completion Date	Up gradient Down gradient	Sampling Objective	Sampling Frequency
299-E24-19	1989	Cross	C, WL	SA, Q
299-E24-20	1991	Up	C, WL	SA, Q
299-E25-2	1955	Down	C, WL	SA, Q
299-E25-40	1989	Marginally Down	C, WL	SA, Q
299-E25-41	1989	Down	C, WL	SA, Q
299-E25-46	1992	Down	C, WL	SA, Q

WL Water level measurement.
C Chemistry monitoring.
Q Quarterly.
SA Semi-annual.

Table 4.2. Critical Means Values for Waste Management Area A-AX for Fiscal Year 2002 Comparisons[(a)]

Constituent, unit	n	df	t_c	Average Background	Standard Deviation	Critical Mean	Up gradient/ Down gradient Comparison Value
Specific conductance, µS/cm	5	4	8.1216	338.70	20.007	516.7	516.7
Field pH	5	4	9.7291	8.242	0.134	[6.81, 9.67]	[6.81, 9.67]
Total organic carbon,[(b,c)] µg/L	5	4	8.1216	595.00	233.499	2,672.4	2,672.4
Total organic halides,[(b,c)] µg/L	5	4	8.1216	2.894	1.685	17.9	17.9

(a) Based on semiannual sampling events from February 2000 to July 2001 for up gradient well 299-E24-20.
(b) Critical mean calculated from values reported below vendor's specified method detection limit.
(c) Up gradient/down gradient comparison value is the most recent determined limit of quantitation.
df = Degrees of freedom (n-1).
n = Number of background replicate averages.
t_c = Bonferroni critical t-value for appropriate df and 16 comparisons.

Table 4.3. Indicator Parameters, Site-Specific Dangerous Waste Constituents and Sampling Frequency

Contaminant Indicator Parameters	**Sampling Frequency**
pH	Semi-annual quadruplicates
Conductivity	Semi-annual quadruplicates
Total organic carbon	Semi-annual quadruplicates
Total organic halides	Semi-annual quadruplicates
Site Specific Constituents [(a)]	**Sampling Frequency**
Alkalinity	Semi-annual
Anions	Semi-annual
Phenols	Annual
ICP metals	Semi-Annual

(a) Additional constituents may be added or the sampling frequency increased if warranted by changing groundwater conditions.

contamination is moving across the Hanford Site but to discern if waste from the WMA is entering the groundwater. Consequently, the regional flow directions and plume trends, as evidenced over miles, can be misleading when determining the local flow across a site that is 500 ft wide (152.4 m). It is especially important that an adequate understanding of flow direction be obtained at WMA A-AX because of the potential risk to human health and safety related to the waste stored at this site. Because of large liquid volumes of stored waste, the proposed eventual use of sluicing to remove tank waste, and the ongoing waste transfer for interim stabilization efforts, early detection of leaking contaminants is important.

Previous to recent studies, the flow direction was determined exclusively from gradient calculations based on local water elevations. Unfortunately, across the 200 East Area, the differences in water elevation between wells are small, on the order of a few inches. The combined errors from water level measurements, survey elevations and slight borehole deviations from vertical are enough to cause uncertainties in local flow direction anywhere in the 200 East Area. As reported in Hartman (1999), water level data alone are insufficient to determine flow direction in this area. The authors of that report suggest that other information be considered to determined flow direction in the 200 East Area. Other methods of determining groundwater flow rate and direction, such as direct measurement techniques, were used to help resolve flow direction uncertainties.

According to water elevations based on surveys referenced to NAVD88, the direction of flow is easterly to southeasterly. The current network was designed for a southwest flow direction with two up gradient wells (then 299-E25-40 and 299-E25-41) and only 3 down gradient wells, 299-E24-19, 299-E24-20 and 299-E25-46. However, recent measurements with the colloidal borescope in wells 299-E25-46, 299-E25-42 (both southeast of A tank farm) and 299-E25-41 (southeast of AX tank farm) confirm a southeasterly flow direction of approximately 125 degrees from true north (Figure 4.1). Data from well 299-E25-40, which is located northeast of the A-X tank farm, indicated easterly flow. The data from this well indicated primarily vertical flow, thus the flow in the well may be deviated with respect to the surrounding aquifer due to local borehole conditions. Results from well 299-E24-20 display a southwest direction, which, although southerly, does not agree as well with either the water level data or the other borescope data. The results from this well may reflect borehole effects or perturbations of flow caused by local heterogeneities of the permeability at this location. As shown in Figure 4.1 only well 299-E25-41 is completely down gradient. Well 299-E24-20 is marginally up gradient while well 299-E25-46 is marginally down gradient but only for the 241-A Tank Farm. Well 299-E25-19 is cross gradient providing little, if any, coverage of the WMA. Thus, the current well network may be inadequate for detecting possible contamination emanating from the tank farms.

The flow rate is calculated with the Darcy equation for a homogeneous, isotropic porous medium. The current estimate is between 2.6 and 2.2 ft (0.79 to 0.67 m) per day. As discussed in Section 2.4, the flow rate may be in excess of the rate calculated from gradient data and the effective hydraulic conductivities. Direct measurements of flow rates based on tracer tests and plume tracking suggest flow rates in excess of 10 ft (3 m) per day (Hartman 1999). In-well flow rates, which are approximately 1 to 4 times that of the rate in the natural sediments surrounding the well screen, were determined using the colloidal borescope. Values obtained from wells 299-E25-46 and 299-E25-41, corrected from in-well rates indicate aquifer flow rates of 1.5 to 7.5 ft/day (0.5 to 2.3 m/day), which agree with the rates determined from traditional methods. If these fast flow rates do indeed control contaminant movement, then early groundwater detection of tank-related contaminants leaking to the uppermost aquifer is important because 241-A and 241-AX Tank Farms are the SST sites closest to the Columbia River.

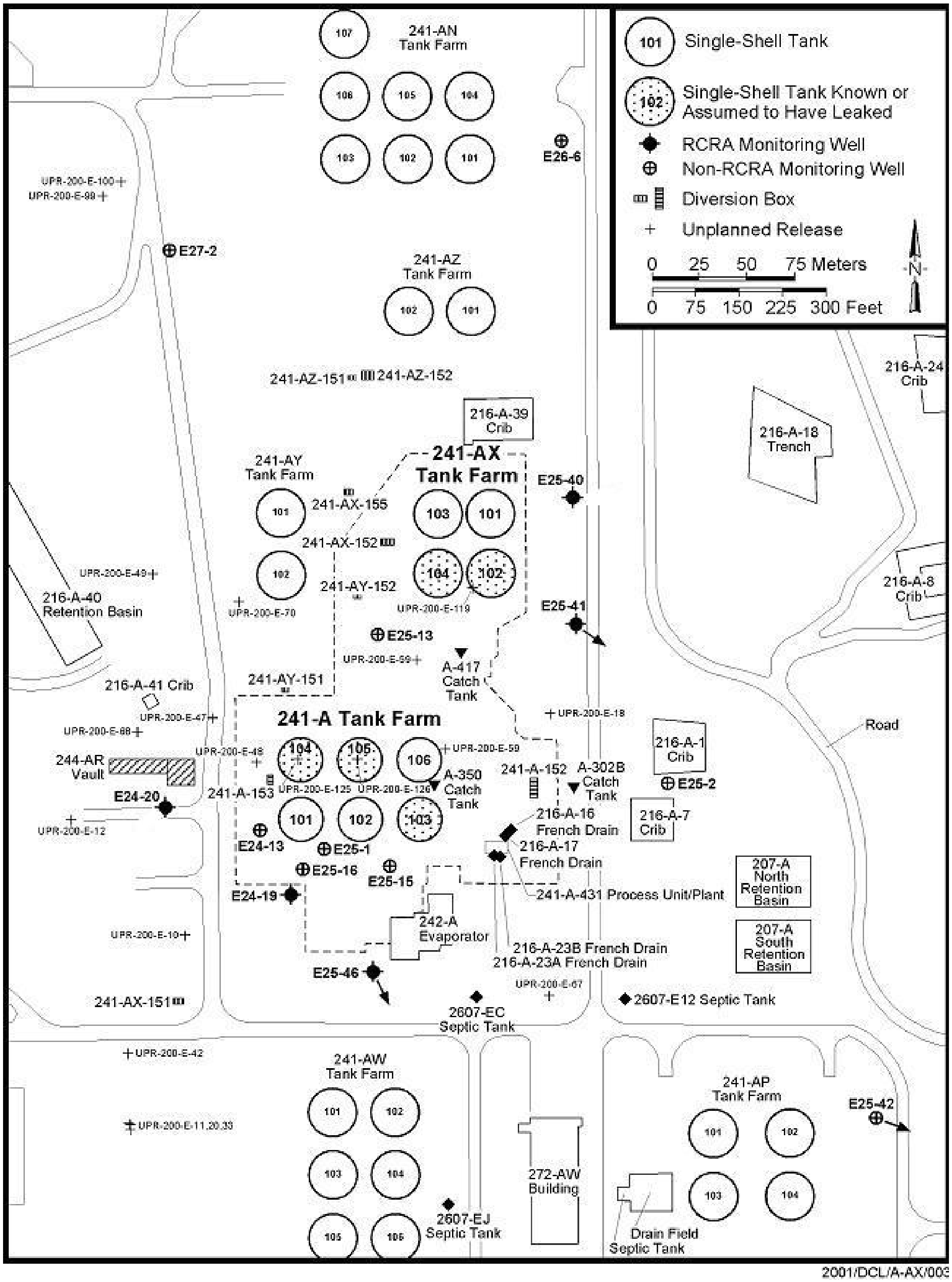

Figure 4.1. Map of Wells Around Waste Management Area A-AX Showing Flow Direction Based on Colloidal Borescope Measurements

Table 4.4. Radionuclides and Sampling Frequencies

Radionuclides	Sampling Frequency
Low-level gamma scan	Annual
Gross beta	Semi-annual
Technetium-99	Semi-annual
Uranium	Annual
Tritium	Annual
Iodine-129	Annual
Strontium-90	Annual
(a) Gamma scan includes ^{125}Sb, and ^{137}Cs	

The analysis for anions captures the values for nitrate, nitrite sulfate and chloride, which are the main mobile anionic species found in these tanks. The metals analysis provides concentrations for sodium, aluminum, calcium, iron, chromium, and potassium, the main mobile cations found in tank waste. The organics listed in tank waste with the greatest concentrations are glycolate, dibutyl phosphate (DBP), ethylenediaminetetraacetic acid (EDTA), N-(2-hydroxyethyl) ethylenediaminetetraacetic acid (HEDTA), and butanol. The analysis for TOC is performed in quadruplicates to monitor for these organics. Although some of the site-specific constituents appear to be relatively immobile, it is prudent to sample at least annually for detection, especially as surface operations change due to interim stabilization and waste removal operations.

Radionuclides are excluded from regulation under RCRA; however, selected radionuclides are analyzed to meet requirements of the Atomic Energy Act of 1954 (AEA). These are included in this plan for completeness and because the groundwater signatures of these elements are useful in source identification. Radionuclides that are monitored and the sampling frequency are provided in Table 4.4. The results of these analyses will be used in the evaluation of potential non-RCRA regulated impacts on groundwater quality. The primary fission products are tritium, ^{90}Sr, ^{99}Tc, ^{125}Sb, and ^{137}Cs. Of these, tritium and ^{99}Tc are the most mobile species. Various uranium isotopes are monitored with a total uranium analysis. The WMA is located within a regional ^{129}I plume. Although ^{129}I is not a major constituent in the tanks, it is analyzed annually in support of AEA requirements because of its mobility in groundwater.

Recent observations at other SST sites indicate that sampling on a semi-annual frequency may not be adequate to detect short-lived pulses of waste from the tank farms (Narbutovskih 1998). MEMO monitoring efficiencies are based on continuous leak sources. If sudden releases occur as would be expected for a leaking line during limited waste transfers or from remobilized plumes due to water line ruptures, pulses of short duration may not be detected by the network since the wells are not close enough or monitored often enough for short duration contaminant events. This is because a plume from a pulse source would not be as dispersed as one for a continuous source. Consequently, these events may go unobserved with a semi-annual monitoring frequency and coarse well spacing.

4.2.3 Monitoring Issues and Resolutions

Monitoring issues specific to WMA A-AX have been identified in the above discussions of the groundwater monitoring plan. These issues are reiterated in this section for clarity along with solutions or tasks to solve monitoring problems. A tentative schedule for each task is also provided. The specific issues are as follows:

- The water table is essentially flat across the 200 East Area. Because the local flow can be quite different from the regional flow combined with changing flow directions as the B-Pond mound diminishes, regional water table contours and/or regional plume directions are unreliable for determining local flow across the site.

- Based on consistent water levels and a recent colloidal borescope investigation, the predominant flow direction is to the southeast from the WMA A-AX.

- The current network was designed for flow specifically to the southwest. Determination of this flow direction was based on a presumed regional flow due the presence of the B-Pond mound. No wells were placed to allow for changes in flow direction over time.

- Model studies using a southeast flow result in a monitoring efficiency of 45.8%, suggesting contamination entering the groundwater under half of the WMA is not detectable with the current location of wells.

- Recent revisions to the Part A Permit application for WMA A-AX have added the 244-AR Vault and farm ancillary equipment to the WMA. The vault is outside the boundary of either 241-A- or 241-AX Tank Farm, about 150 ft (47 m) west of the 241-A Tank Farm. The approximate southeast flow direction indicates that well 299-E24-20 may be adequately placed to monitor this small facility.

- Finally, with the present rate of water table decline, some wells in the network may be unusable in about six years.

Because water levels do not assure determination of the flow direction, colloidal borescope investigations were used to increase the level of confidence in flow direction and rate. The colloidal borescope is an in situ technique used to directly measure the flow rate and direction through the well screen by digitally recording the movement of colloidal particles through the open interval in the well. Results of its use at Hanford indicate that the tool can provide useful, reliable information on flow properties in both the highly permeable Hanford formation and less permeable Ringold Formation sediments when properly deployed and used in conjunction with water level and other types of flow direction data.

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