INTERIM CHANGE NOTICE (ICN)

A. Document No.: PNNL-13024 **Revision No.:** 1 **Document Title: RCRA Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area C at the Hanford Site** **Document's Original Author: D. G. Horton and S. M. Narbutovskih**	**Effective Date of ICN:** June 5, 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:

(1) **Reason for Change**: Update groundwater quality monitoring plan at WMA C (PNNL-13024) to document an improved understanding of the local groundwater flow direction, to redefine up gradient versus down gradient monitoring wells, to provide the updated critical means for indicator parameters and to update the sampling and analysis schedule.

Description of Change:

(2) Attach pages 1.3, 2.25, and 2.26 to the back of pages (1.3, 2.25, and 2.26) to document the changes in the interpretation of the local groundwater flow direction to southwest based on an integration of refined water level data and in situ flow measurements.

(3) Attach pages 4.1 to 4.5, 4.7 to 4.10 and 4.11 to 4.12 to the back of pages (4.1 to 4.5, 4.7 to 4.9 and pages 4.10 to 4.11) to redefine up gradient versus down gradient monitoring wells based on the southeast flow direction, to provide the updated critical means for indicator parameters and to update the sampling and analysis schedule.

(4) On page 4.6, change "Figure 4.1" to read "Figure 4.2."

E. Document Management Decisions:

See attached distribution list.

F. Approval Signatures
(Please Sign and Date)

Type of Change: (Check one):
____ Minor __X_ Major

Process Quality Department: T. G. Walker [signature: Thomas H. Walker] Date: 6/25/02
Approval Authority: S. P. Luttrell [signature] Date: 6/21/02
Other Approvals: S. M. Narbutovskih, Technical [signature: S. M. Narbutovskih] Date: 6/21/02

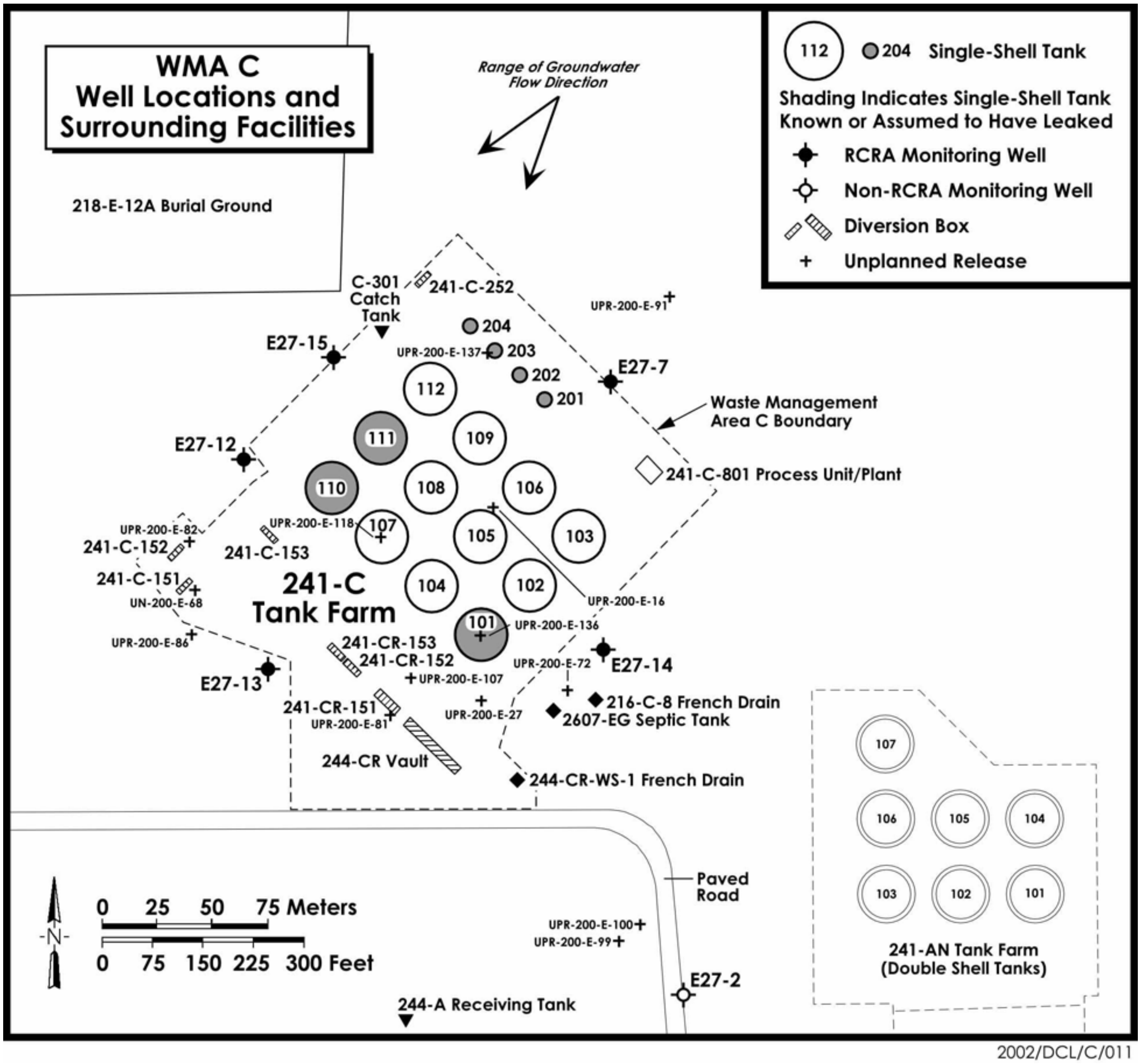

Figure 1.2. Location Map of WMA C and Surrounding Facilities

the Washington State Department of Ecology (Ecology) to regulate the hazardous component of radioactive mixed waste within the State of Washington (51 FR 24504). Consequently, DOE (radioactive constituents) and Ecology (hazardous chemical constituents) jointly regulate the waste stored in the SSTs.

In May 1989, DOE, EPA and Ecology signed the Tri-Party Agreement (Washington State Dept. of Ecology 1994). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes the SST RCRA Waste Management Areas. As part of the RCRA regulatory process, an interim status RCRA Part A permit application (DOE/RL-88-21 1996) and closure/work plan (DOE/RL-89-16 1996) have been submitted to

Thin silt lenses overlie some individual beds within the Hanford formation sand sequence. These lenses are generally 6 in (0.15 m) or less in thickness. The silt lenses cannot be correlated among boreholes. However, samples are usually collected every 5 ft (1.5 m) during drilling such that most thin silt lenses are unrecognized. The base of the Hanford formation sand sequence is picked at the top of a thin muddy gravelly sand, where present, or at the top of a thick (<30 ft [9 m]) sequence of sandy gravel. The top of the sequence is the base of a thick sequence of gravelly sand or sandy gravel.

The Hanford formation upper gravel sequence overlies the sand sequence. The Hanford formation upper gravel sequence is described on borehole logs of cuttings as consisting of interbedded sandy gravels, gravelly sands, and sands. This sequence is equivalent to the Hanford formation upper gravel sequence of Lindsey et al. (1992), the Hanford formation H1 sequence of Lindsey et al. (1994), and Qfg of Reidel and Fecht (1994). Caggiano and Goodwin (1991) did not differentiate this sequence and the underlying Hanford formation sand sequence. The upper gravel sequence consists of the gravel-dominated facies and was deposited by high-energy, glacial flood waters.

The Hanford formation upper gravel sequence varies from 20 to 40 ft (6 to 12 m) thick in the WMA C Area and averages about 32 ft (10 m) thick. This unit was removed from most, if not all, of the tank farm during construction and replaced as backfill after construction was complete. The base of the sequence was picked at either the top of the first sand or muddy sand sequence that was at least 10 ft (3 m) thick or at a subtle shift in the gross gamma-ray log at about 30 to 40 ft (9 to 12 m) depth. This contact may be arbitrary, particularly in the south and southwest part of the tank farm where the underlying Hanford formation sand sequence contains numerous gravelly beds.

Within the 241-C Tank Farm, the upper 40 ft (12 m) of material is backfill consisting of mixed gravel, sand and silt excavated from the Hanford formation during construction of the tank farm (Narbutovskih et al. 1996). Areas outside the tank farm have a variable thickness from 0 to 15 ft (0 to 4.5 m) of Holocene eolian sediment where the surface has not been disturbed by construction. Price and Fecht (1976) state that clastic dikes were detected in the 241-C Tank Farm during construction although they could not be mapped. Clastic dikes were not detected during drilling of the RCRA wells in 1989. However they are extremely difficult to recognize from drill cuttings.

2.4.3 Aquifer Properties

This section provides information on the current nature of the unconfined, uppermost aquifer in the immediate region of WMA C. Aquifer properties were determined from stratigraphic interpretations, current water elevations, in situ flow measurements and previous aquifer test results. Currently, the water table beneath WMA C lies 400 ft (122 m) above sea level with about 255 ft (77 m) of vadose zone above. The aquifer thickness, based on the top of basalt at 355 ft (108 m), is approximately 44 ft (13.4 m). The aquifer materials consist dominantly of sandy gravel or silty sandy gravel. Although there is some consolidation of the sediment within the unconfined aquifer, there is little evidence of compaction or cementing. Consequently, permeability is high and relatively homogeneous within the aquifer.

Figure 2.9 shows hydrographs for four of the five RCRA network wells that are currently used to monitor the water table at WMA C. The water level data from well 299-E27-15 is historically inconsistent with data from the other wells in the WMA C network and with the regional water table data (Hartman 1999). However, after water elevations are corrected for deviations of the borehole from vertical, data from this well is found to be consistent with the water levels from other wells. .

The data in Figure 2.9 show that groundwater well 299-E27-7 is the upgradient well and 299-E27-13 is the downgradient well. Wells 299-E27-15 and 299-E27-14 have similar and intermediate water table elevations. Although not shown for clarity, well 299-E27-12 plots similarly to well 299-E27-14. Furthermore, these data show that the flow direction at WMA C is toward the southwest, which is consistent with the regional water table map (Hartman 1999). The original groundwater monitoring network, currently used, was designed for a flow direction from east to west with wells 299-E27-7 and 299-E27-14 as upgradient wells (Caggiano and Goodwin 1991). Recent direct flow measurements with the colloidal borescope support the southwesterly flow (214 degrees) determined from regional and local water level hydrographs shown in Figure 2.9.

The rate of groundwater flow is calculated for a homogeneous, isotropic aquifer using the Darcy equation (Hartman 1999), which incorporates values for the estimated hydraulic conductivity, the gradient across the site, and the porosity of the sediments in the aquifer. There are various published values for hydraulic conductivities in the 200 East Area (Newcomer et al. 1990, Connelly et al. 1992). Values used

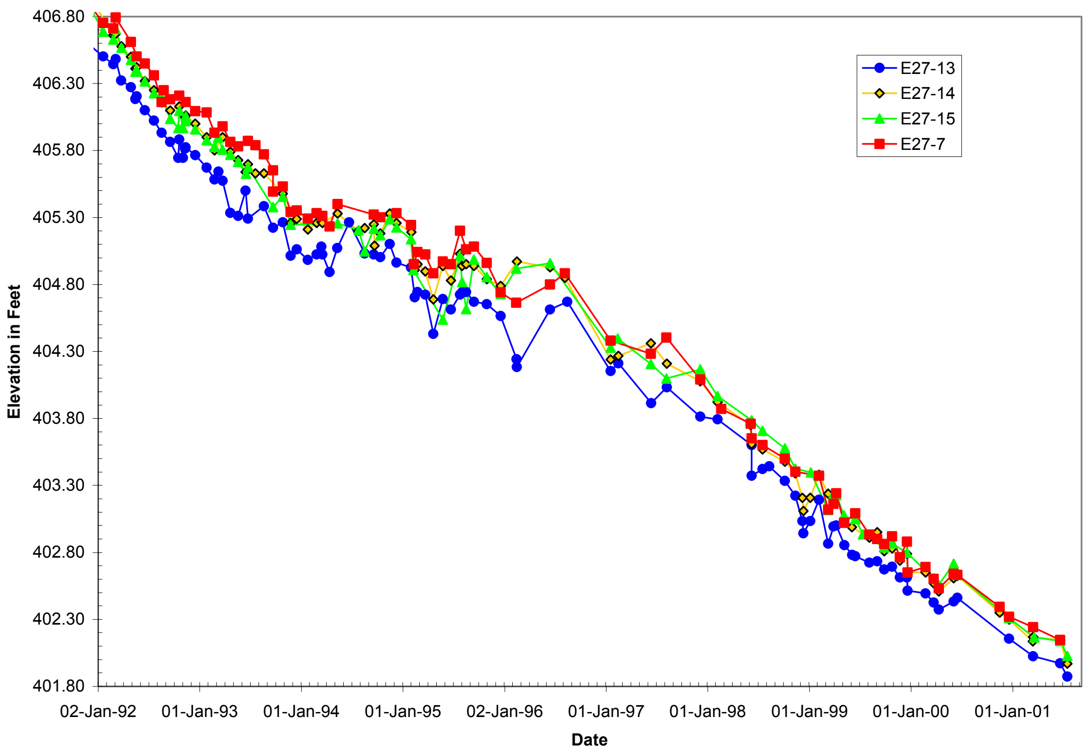

Figure 2.9. Hydrographs for Wells in the WMA C Monitoring Network. All data referenced to the NAVD88 datum. Spurious data have been removed.

4.0 Detection Monitoring Program

The detection monitoring program employed at WMA C was designed to detect the presence of hazardous waste constituents at the point of compliance located along the west side of the WMA. This program currently in use is based on the waste inventory in the tanks and on our knowledge in the early 1990s of the local hydrogeology. Based on water level data, vertical correction of boreholes and in situ flow measurement, it has been determined that the flow direction is to the southwest. The detection monitoring plan presented herein contains the:

- design of the basic interim status RCRA-compliant monitoring well network along with asbuilt diagrams of both RCRA and non-RCRA groundwater monitoring wells available for monitoring
- current methods employed to routinely determine rate and direction of groundwater flow
- indicator parameters used to detect the presence of groundwater contamination
- frequency of groundwater sampling
- sampling, analysis, and statistical procedures currently used for detection monitoring.

The following sections provide a discussion of monitoring objectives specific to WMA C. A description of the current detection-monitoring plan with suggestions for needed modifications to allow reliable detection of contamination from WMA C is also included. Steps required to implement these modifications are provided. A proposed assessment monitoring plan outline is contained as required in Appendix B with details of local well construction given in Appendix C. An explanation of the statistical calculations along with the Field Sampling Plan (FSP) and Quality Assurance Program Plan (QAPP) are provided in Appendix D.

4.1 Objectives

In accordance with 40 CFR 265 by reference of WAC 173-303-400 (3), which describes requirements for a detection monitoring program, the general objectives of the WMA C groundwater monitoring plan are to:

- Monitor to detect indicator parameters, hazardous waste constituents, and reaction products that provide a reliable indication of the presence of dangerous constituents in the uppermost aquifer underlying WMA C. This includes the SSTs, diversion boxes, and the 244-CR Vault.

- Operate a groundwater monitoring system at the compliance point, i.e., at the downgradient wells to detect dangerous waste constituents that degrade groundwater quality. Provide evidence of leaks occurring at or near the surface to allow mitigation of groundwater pollution from WMA C.

- Collect groundwater samples at the optimal time interval specifically determined for WMA C to detect dangerous waste constituents and/or indicator parameters to facilitate early detection.

The manner in which these general goals are achieved at WMA C is, to some extent, dependent on the site characteristics. For example, WMA C is not surrounded by operating facilities or past-practice, liquid waste, or disposal facilities as are the other tank farms in the 200 East Area. The 216-C-8 french drain is southeast of the WMA C, but there is little potential that waste from this facility could impact the groundwater under WMA C.

Although there are a few operating and past-practice facilities adjacent to WMA C, there are regional plumes beneath the WMA that must be differentiated from waste originating from WMA C. Regional groundwater plumes beneath WMA C include tritium and ^{129}I. Since the groundwater-monitoring plan is designed to identify wastes emanating from WMA C, the upgradient monitoring wells are used to identify dangerous waste constituents entering the groundwater outside the area.

Site-specific goals for the groundwater-monitoring program at WMA C are to monitor at locations and frequencies for constituents so that, it can be determined whether or not WMA C is the source of the groundwater contamination. To achieve this goal the efficiency of the existing groundwater-monitoring network was evaluated with the assistance of the Monitoring Efficiency Model (MEMO) (Golder 1990).

4.2 Groundwater Monitoring Plan

This section describes the existing interim-status groundwater-monitoring network that is used now that the flow direction has been verified and will continue to be used. It was designed in accordance with RCRA, as presented in 40 CFR 265, Subpart F. The first section defines the monitoring network (number and locations of monitoring wells, well construction), provides the method currently used to determine flow direction/rate and evaluates the network with respect to flow direction. Monitoring issues are identified. The groundwater sampling parameters are presented next with the sampling frequency. The currently used sampling frequency is evaluated with respect to the program objectives of reliable and adequate contaminant detection. Next, problems with the groundwater monitoring system that were found to be deficient are reiterated and clarified so that tasks can be planned to rectify these deficiencies. This section covers the manner in which data are stored and retrieved, lists data interpretation methods and provides the reporting requirements for the program.

4.2.1 Monitoring Network

The present groundwater-monitoring network consists of four RCRA standard wells and one older carbon-steel well (Figure 1.2). All five wells are used for water level measurements. Water level measurements are made over a short time period to eliminate daily earth tide effects and to reduce barometric effects caused by changing atmospheric pressure.

The monitoring system at dangerous waste sites is located along the hydraulically downgradient limit of the waste management area, defined as the area on which waste is stored at the regulated unit. Monitoring wells are placed as close as reasonably possible to the WMA. As can be seen from Figure 1.2, all five monitoring wells in the WMA C network are close to the WMA boundary.

The quarterly water level measurements are made separately from the sampling events. Sampling was done monthly during the time that sluicing operations were conducted in WMA C. Sluicing of tank 241-C-106 began in November 1998 and concluded in October 1999. Since sluicing operations at tank 241-C-106 have concluded, the groundwater will be sampled quarterly in accordance with a request from the Washington Depart of Ecology. In Table 4.1 well-by-well information is provided on the position of each well with respect to flow direction, sampling objective, and sampling frequency. Although the location of some wells with respect to flow direction is cross gradient, upgradient and downgradient wells are marked according to the southwestward flow direction defined in this monitoring plan for WMA C.

The basic well design of the four RCRA wells was according to WAC 173-160*, Minimum Standards for Construction and Maintenance of Wells*. Completion dates for all four wells was 1989. A 4-in. (10-cm) inner diameter, stainless steel casing was set to within about 5 ft (1.5 m) above the water table. A 20 ft (6.1 m) length of 10-slot, stainless steel screen with channel pack was placed from 5 ft (1.5 m) above to 15 ft (4.6 m) below the water table. The open portion of the screen in the unsaturated zone provided for any rises in groundwater over time.

A 16-30 mesh (20-40 mesh for well 299-E27-14) silica sand pack was placed above and around the screen. An annular seal consisting of about 3 ft (1 m) of 0.25 in. (0.6 cm) bentonite pellets was put above the silica sand and 8-20 mesh bentonite crumbles were placed from the top of the pellets to within 18 to 20 ft (5.2 to 6.1 m) below the ground surface. Surface casing was set and sealed with cement from 20 ft (6.1 m) to ground level. The wells were finished with a cement pad and 4 posts for well protection. The annular seals assure that no vertical contaminant moves along the outside of the casing. Dedicated pumps are installed in each well. The wells are capped and locked when not in use.

Table 4.1. Network Monitoring Wells

Well Name	Completion Date	Upgradient Downgradient	Sampling Objective	Sampling Frequency
299-E27-7	1982	Up	C, WL	Q, SA
299-E27-12	1989	Cross	C, WL	Q, SA
299-E27-13	1989	Down	C, WL	Q, SA
299-E27-14	1989	Cross	C, WL	Q, SA
299-E27-15	1989	Marginally Up	C, WL	Q, SA

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

Well 299-E27-7 was completed in 1982. The well has a 40 ft (12 m) long, 6 in. (15 cm) stainless steel screen with a 5 ft (1.2 m) section of blank casing welded to the top. A 6 in. (15 cm) carbon steel casing extends from 240 ft (73 m) depth to 1.3 ft (0.4 m) above ground surface. There is also an 8 in. (20 cm) stainless steel casing from 150 ft (46 m) depth to ground surface. The 8 in. (20 cm) casing is perforated from 150 to 25 ft (46 to 6.1 m) below ground surface. The space between the two casings is filled with cement grout, as is the space outside. Details concerning well construction, well location, surveyed elevation, total depth, and general lithology for all the wells in the WMA C monitoring network are given in Appendix C.

Screened intervals below the water table range from 8 to 11 ft (2.4 to 3.35 m) in length. If the recent increase in water level decline from 0.3 ft (9 cm) per year to almost 0.8 ft (24 cm) per year continues, some wells in the WMA C network may require replacement within about 6 years.

Groundwater Flow Determination

The current water table is nearly flat throughout the 200 East Area. Although this low gradient is caused, in part, by the dissipating groundwater mound under B-Pond, it is primarily due to the high aquifer permeability in the 200 East Area compared to upgradient regions to the west where permeability is considerably less. Before formation of the groundwater mound beneath B-Pond, the groundwater flowed regionally to the southeast towards the 300 Area. As evidenced by the large tritium plume from waste disposed to the PUREX cribs, the effective flow from the southeast corner of the 200 East Area is to the east and southeast. Maximum flow rates are estimated from 2.4 to 63 ft (0.6 to 19 m) per day (Hartman et al. 2000).

When considering the flow for sites with small areas such as WMA C, knowledge of the local flow is required to ensure proper placement of downgradient wells with respect to the waste storage units and ancillary equipment. The objective of interim detection monitoring is not to discern where 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 only 500 ft wide (152 m).

Until this year, the flow direction has been 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 borehole deviations from vertical are enough to cause uncertainties in local flow direction anywhere in the 200 East Area. As reported in Hartman et al. (2000), water level data alone are insufficient to determine flow direction in this area. Direct flow measurements were made in 4 wells at this tank farm to help determine flow direction and thereby minimize the uncertainty in flow direction.

It is especially important that an adequate understanding of flow direction be obtained at WMA C because of the highly concentrated waste stored at this site. With moderate liquid volumes of stored waste, the eventual use of sluicing to remove tank waste and the ongoing of waste transfer for interim stabilization efforts, early detection of leaking contaminants is important. Recent direct flow measurements with the colloidal borescope in wells 299-E27-14 (southeast of C tank farm), 299-E27-13 (southwest of C tank farm), and 299-E27-7 (northeast of C tank farm) indicate an average southwesterly flow direction of approximately 214 degrees from true north (Figure 4.1). Actual measurements in these three wells range from 200 to 235 degrees from true north. Only data from well 299-E27-12, which is located west of the C tank farm, indicate an easterly flow direction. However, the two interpretable records from this well are suspect because they display primarily vertical flow.

According to water table elevations based on surveys referenced to NAVD88 and colloidal borescope data, the direction of flow at WMA C appears to be southwest. The current monitoring network was designed for a flow direction to the west with two upgradient wells, 299-E27-7 and 299-E27-14, and three downgradient wells, 299-E27-12, 299-E27-13, and 299-E27-15. As seen on Figure 1.2, only well 299-E27-13 is downgradient if the flow direction is southwest or south-southwest while well 299-E27-12 and 299-E27-14 are cross gradient, providing little if any coverage of the WMA.

The flow rate is calculated with the Darcy equation for a homogeneous, isotropic porous medium. The current estimate is between 2.4 and 4.8 ft (0.7 and 1.4 m) per day. Values obtained from wells 299-E27-13 and 299-E27-14 using the colloidal borescope, after corrections for in well flow rates, indicate in well flow rates of 4 to 6.3 ft/day (1.2 to 1.9 m/day). These values, although higher, are still within reasonable agreement with rates determined from the Darcy equation. Direct measurements of flow rates based on tracer tests and plume tracking suggest flow rates in excess of 60 ft (18 m) per day (Hartman 1999). Early groundwater detection of tank-related contaminants leaking to the uppermost aquifer is important because 241-C Tank Farm is one of the closest SST sites to the Columbia River.

Network Evaluation

The efficiency of the groundwater-monitoring network was evaluated using a simple two dimensional, horizontal transport model called the monitoring efficiency model (MEMO) (Golder 1990). This model estimates the efficiency of a monitoring network at the point of compliance. The model simulates a contaminant plume originating from a series of grid points within a WMA using the Domenico-Robbins method (Domenico and Robbins 1985). The model calculates both advective flow and dispersive flow in two dimensions and determines whether the resulting plume will be detected by a monitoring well before the plume travels some arbitrary distance beyond the WMA boundary. The arbitrary distance is termed the buffer zone. The ratio of the area within the WMA over which detection will occur before impacting the buffer zone to the total area of the WMA is the monitoring efficiency. Output from the model is a map of the WMA showing areas where leaks would not be detected under the given site-specific parameters provided as input to the model.

Figure 4.2 shows the result of three runs using the MEMO model. The figure shows that a westerly groundwater flow direction, for which the WMA C monitoring network was originally designed, results in a monitoring efficiency of 86%. The areas shown in black on the figure are the areas where leaks can

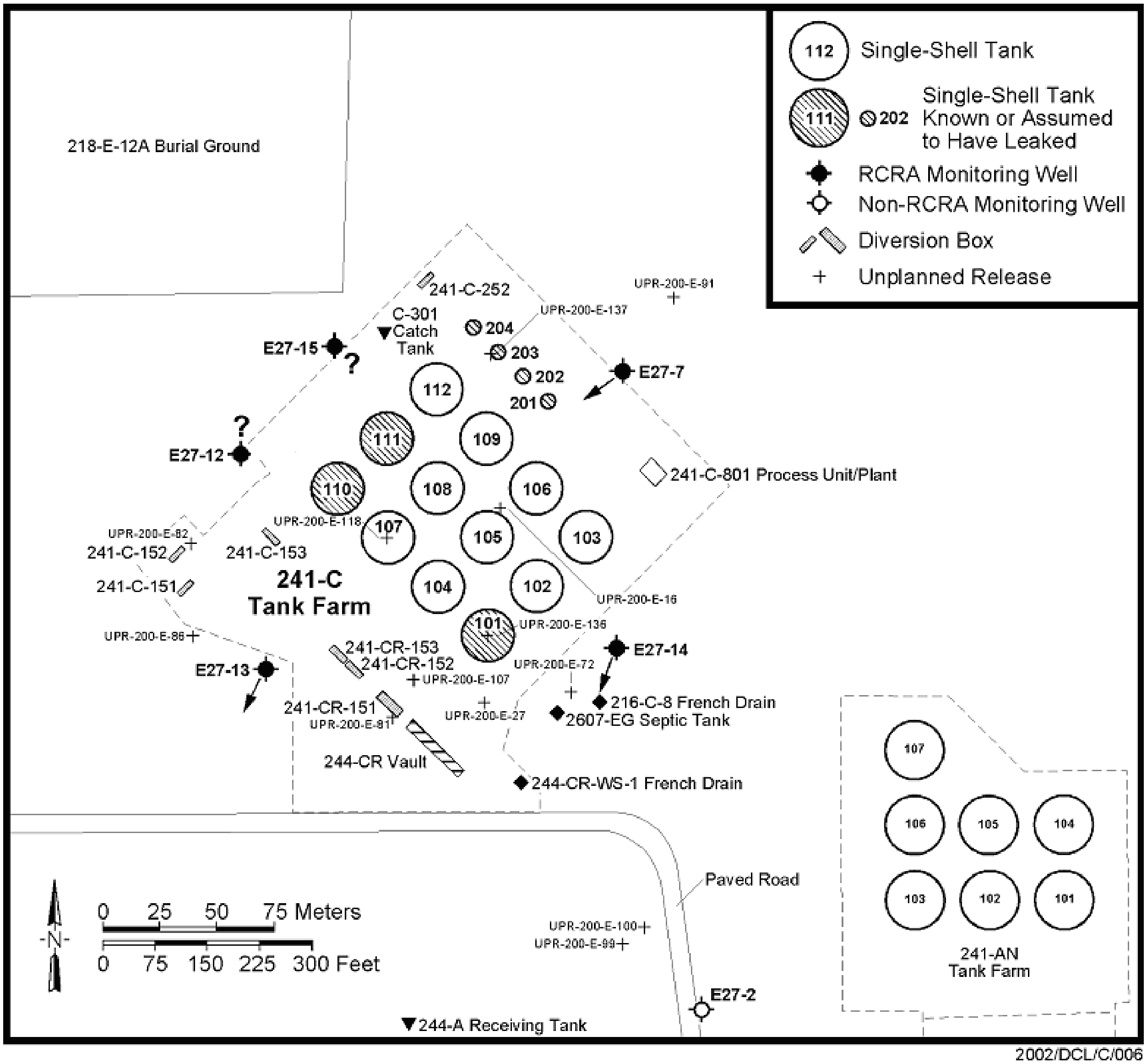

Figure 4.1. Flow Direction Map of Wells Around Waste Management Area C Based on Colloidal Borescope Measurements

occur without detection by the current monitoring network for the specified flow direction. With the current monitoring well network, the monitoring efficiency decreases as the flow direction shifts toward the south. The monitoring efficiency is 73% with a southwest flow direction and 63.2% with a southerly direction. This means that a plume emanating from one-fourth to one-third of the WMA would go undetected with the current monitoring network

The current groundwater-monitoring network at WMA C leaves nearly a third of the site unmonitored. Well 299-E27-7 remains an upgradient well but well 299-E27-15 changes from a downgradient well to a marginally useful upgradient well. Well 299-E27-13 remains a downgradient well. Well 299-E27-12 may be too far west to be useful as either an upgradient or a downgradient well, while well 299-E27-14 is not upgradient but may be cross gradient. Because the current flow direction beneath WMA C is to the southwest, additional wells may be necessary.

Plans to develop and implement an improved monitoring network are discussed in Section 4.2.3. Direct measurements of groundwater flow direction and flow rate within the screened intervals of WMA C monitoring wells were made to help evaluate the monitoring network. Based a general groundwater flow direction to the southwest, a modified network should provide nearly complete coverage of the WMA, even if flow shifts to the south to southeast over the next several years or decades.

4.2.2 Dangerous Waste Constituents

It is required under 40 CFR 265.94(a)(2) and WAC 173-313-400 that indicator parameters (i.e., pH, conductivity, total organic carbon, total organic halogen) be monitored to provide a reliable indication of the presence of dangerous constituents in groundwater. The site-specific constituents for WMA C were determined based on:

- types and concentrations of dangerous waste constituents in the stored wastes
- mobility, stability, and persistence of dangerous waste constituents in the unsaturated zone beneath WMA C
- detectability of waste constituents in the groundwater
- concentrations or values of the monitoring parameters or constituents in the groundwater background chemistry.

The site-specific sampling needs and issues at WMA C are presented in the following section. The sampling and analysis plan (SAP), consisting of the field sampling plan (FSP) and the quality assurance project plan (QAPP), are provided in Appendix D.

Groundwater Sampling Parameters

According to 40 CFR 265.92, and by reference WAC 173-303-400(3), the owner/operator of an interim-status hazardous waste facility must establish initial background concentrations for the contamination indicator parameters of electrical conductivity, pH, total organic carbon, and total organic halogens. Background values for WMA C were determined first in 1992. Four replicate analyses for each indicator parameter from each monitoring well were obtained quarterly for one year. The averaged replicate t-test is the statistical method used to determine whether significant differences occur in the concentration of indicator parameters from downgradient wells compared to the initial background concentrations from upgradient wells (NWWA 1986). This test is applied to the data from an upgradient well to determine the initial background arithmetic mean and variance (40 CFR 265.93[b]).

Details of the statistical method are given in Appendix D. New critical mean values were determined in 2001. Four replicate samples were collected on a semiannual frequency between June 2000 and September 2001 from crossgradient well 299-E27-14. The resulting critical means for WMA C are presented in Table 4.2. These background values will continue to be used until any new wells are installed. After the network is upgraded, interim-detection sampling will be performed to calculate new critical means for the indicator parameters.

Table 4.2. Critical Mean Values for WMA C [(a)]

Constituent, Unit	Average Background	Standard Deviation	Critical Mean	Upgradient/ Downgradient Comparison Value
Conductivity, μhos/cm	523.05	77.478	1,212.4	1,212.4
Field pH	8.264	0.128	[6.90, 9.63]	[6.90, 9.63]
Total Organic Carbon [(b)] μg/L	676.25	69.597	1,608.7	1,608.7
Total Organic Halides, [(b, c)] μg/L	3.272	0.815	14.2	15.1

(a) Data collected from June 2000 to September 2001 for cross gradient well 299-E27-14.
(b) Critical mean calculated from values reported below vendor's specified method detection limit.
(c) Up gradient/down gradient comparison value is the limit of quantitation, which is revised quarterly.

A table of indicator parameters along with site-specific constituents are presented in Table 4.3 in conformance with 40 CFR Part 265, Subpart F. Indicator parameters are evaluated semi-annually under the current monitoring system. The sampling frequency of each site-specific constituent is provided.

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, DBP, EDTA, HEDTA, and butanol. The analysis for total organic carbon is performed in quadruplicates to monitor for these organics. Cyanide is included in the constituent list because it was in the waste streams routed to 241-C Tank Farm that resulted from in-tank scavenging conducted in the 244-CR vault. Specific conductance, pH, and total organic halides are indicator parameters required by regulations. Phenols, which are not significant constituents of tank waste, will be analyzed annually as required by regulation.

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. 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 radionuclides are ^{99}Tc, ^{125}Sb, ^{60}Co, and ^{137}Cs. Of these ^{99}Tc is the most mobile species. Various uranium isotopes are monitored with a total uranium analysis.

Table 4.3. Indicator Parameters, Site-Specific Dangerous Waste Constituents, and Sampling Frequencies [(a)]

Contaminant Indicator Parameters	**Sampling Frequency**
pH	Semiannual
Conductivity	Semiannual
Total Organic Carbon	Semi-annual, Quadruplicates
Total Organic Halogens	Semi-annual, Quadruplicates
Site Specific Constituents [(b)]	**Sampling Frequency**
Alkalinity	Semiannual
Anions	Semiannual
Cyanide	Semiannual
Phenols	Annual
ICP Metals (filtered)	Semiannual
(a) By special request from the Washington State Department of Ecology, sampling for some constituents is performed quarterly. (b) Additional constituents may be added if warranted by changing groundwater conditions.	

Table 4.4. Radionuclides and Sampling Frequencies

Radionuclides	**Sampling Frequency**
Low-level gamma Scan [(a)]	Semiannual
Gross Beta	Semiannual
Technetium-99	Semiannual
Total Uranium	Annual
(a) Gamma scan includes ^{125}Sb, ^{60}Co, and ^{137}Cs	

4.2.3 Monitoring Issues and Resolutions

Monitoring issues specific to WMA C have been identified in the above discussions of the groundwater monitoring plan. These issues are reiterated in this section for clarity along with solutions to solve monitoring problems. The specific issues are as follows:

- The water table is essentially flat across the 200 East Area making it difficult to use the water table gradient alone to determine the local flow direction across the. Because the local flow can be quite different from the regional flow and flow directions may change 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 referenced to a more recent well elevation survey, data from the gyroscope surveys that correct for vertical borehole deviations, and data from colloidal borescope measurements that measure the in situ flow directions, the current flow direction is to the southwest ranging from 200 degrees to 235 degrees azimuth.

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

- Model studies using a southwest flow direction result in a monitoring efficiency of 73%, suggesting contamination entering the groundwater under one fourth of the WMA may not be detectable with the current location of wells.

- Revisions to the Part A Permit for WMA C added the 244-CR vault, eight diversion boxes, and ancillary equipment to the WMA. The existing groundwater-monitoring network was not designed to monitor the facilities recently added to the WMA

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

A monitoring network that includes the existing monitoring wells and new downgradient wells has a closer well spacing providing sufficient coverage to detect contamination originating from WMA C. The modified network will account for monitoring the 244-CR vault and seven of the eight diversion boxes that were recently incorporated into the WMA. Consideration will also be given to existing wells that may eventually become unusable due to declining water levels. The design modifications to the existing network will account for current conditions and eventual changes in flow direction. Future well locations will also been chosen to allow differentiation, to the degree possible, between waste from other facilities and waste from the SSTs. MEMO studies will be performed in support of network design.

Eight diversion boxes were added to the single-shell tanks permit. Seven of the diversion boxes are located within the 241-C Tank Farm fence line and are available for use during waste transfer operation. The eighth diversion box, 241-C-154, is located about 30 ft (9 m) southeast of the 201-C process building, which is about 1,600 ft (500 m) southwest of the 241-C Tank Farm. The monitoring network does not cover this diversion box. The 241-C-154 diversion box was decommissioned in 1985 as part of the Semi-Works decommissioning effort that included isolating the lines, sealing the diversion box, filling it with concrete, and covering the area with ash (DOE 1993b). It is unlikely that diversion box 241-C-154 will cause an impact on the groundwater. Consequently, it is not monitored with the current network.

Because of the flat gradient, the exclusive use of water levels to determine flow direction left a high degree of uncertainty. Therefore, the colloidal borescope was used to confirm the flow direction and rate currently estimated from water level data. The colloidal borescope is an in situ technique 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. The colloidal borescope has been used successfully in 1994, 1999, and 2001 in wells at the Hanford Site. These 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 Ringold Formation sediments when properly applied.

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