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Draft Remedial Investigation/Feasibility Study Work Plan for the 300-FF-5 Operable Unit, Hanford Site, Richland, Washington

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1.0 INTRODUCTION

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended, focuses on waste site cleanups whenever there is a release or substantial threat of release to the environment by a hazardous substance, pollutant, or contaminant. Under such conditions, the U.S. Environmental Protection Agency (EPA) is authorized to undertake removal and/or remedial action. At Hanford, operational protocols are established by the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement 1989). That agreement specifies that EPA is the lead regulatory agency and CERCLA is the guiding law for the 300-FF-5 operable unit on the Hanford Site. As summarized in EPA guidance documents, a specific process has been established to identify potentially hazardous sites, characterize site contamination, assess treatment technologies, and then design and construct appropriate treatment facilities (e.g., EPA 1988a). The pre-record of decision process supporting these activities is displayed in Figure 1. An initial activity of the Remedial Investigation/Feasibility Study/Record of Decision (RI/FS/ROD) process is the issuance of a work plan. The work plan for the 300-FF-5 groundwater operable unit on the Hanford Site is the topic of this document.

This 300-FF-5 Work Plan is written as an addendum to the 300-FF-1 Work Plan. The 300-FF-5 operable unit consists of the groundwater aquifer beneath the 300-FF-1, 300-FF-2, and 300-FF-3 source operable units and adjacent areas defined by the extent of groundwater contamination (WHC 1989). The outline used in this addendum generally follows that of the 300-FF-1 Work Plan. This addendum is complete in its coverage of all outline sections, but where possible, the 300-FF-1 Work Plan is referenced rather than duplicating major discussions.

1.1 PURPOSE AND SCOPE OF THE REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

The purposes of an RI/FS are to determine the nature and extent of the threat posed by a release of hazardous substances to the environment and to evaluate proposed remedies for such a release [40 CFR 300.8(d)].

Production of this work plan initiates the RI/FS process for the 300-FF-5 groundwater operable unit in the 300 Area at the Hanford Site. The Hanford Site has been proposed for inclusion on the EPA's National Priorities List under CERCLA, as amended. Section 120 of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (Federal Facility Compliance) sets a rigorous schedule for initiation of compliance activities at all Federal facilities, with emphasis on those being proposed for the National Priorities List. The work plans are scheduled to meet the requirement for completion of an approved work plan for each National Priorities List site within 6 mo of nomination to the final National Priorities List. As part of this process, Stenner et al. (1988) have completed the preliminary assessment/site inspection (see Figure 1) for Hanford waste facilities by determining hazard ranking system scores for the administrative aggregate sites.

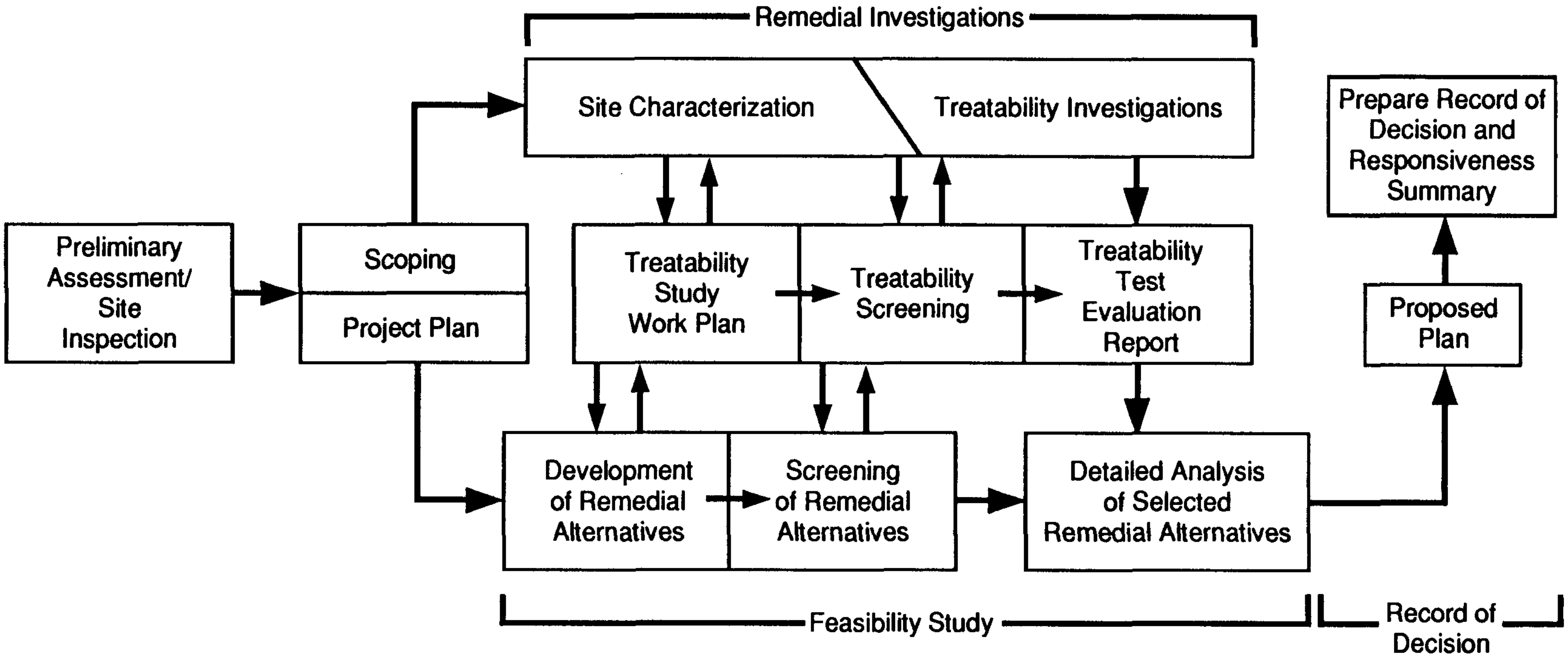

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Figure 1. Information Flow in the Pre-Record of Decision Process of CERCLA.

The Westinghouse Hanford Company (Westinghouse Hanford), acting for the U.S. Department of Energy (DOE), has concurrently initiated the RI/FS process on two operable units in the 300 Area: 300-FF-1 and 300-FF-5. The scope of these operable units is depicted in Table 1. The 300-FF-1 operable unit focuses on some disposal sites and associated unplanned releases within the 300 Area, while the 300-FF-5 operable unit considers all contaminant sources in the 300 Area that contribute to existing groundwater contamination beneath the 300 Area and the surrounding environment.

Table 1. Scope of the 300-FF-1 and 300-FF-5 Operable Units.

300-FF-1	300-FF-5
Waste source	Groundwater
Contaminated soils	Soil
Air	Surface water/sediment
Terrestrial biota	Aquatic biota

Within this plan, the RI/FS work to be conducted is described and prioritized. Site-specific plans for conducting the RI/FS are presented. Typical activities include evaluating existing site data, identifying potential applicable or relevant and appropriate requirements (ARARs), specifying data quality objectives, assessing remedial alternative objectives, and preparing site-specific plans.

Site characterization studies are conducted as part of the remedial investigation for such purposes as defining the nature and extent of contamination, modeling waste migration and transport characteristics, developing a baseline risk assessment, and determining initial cleanup goals. This information is combined with the results of remedial alternative screening and treatability investigation results to substantiate a remedial selection decision.

Treatability investigations are needed to determine the feasibility of treatment technologies to meet remedial action objectives. As seen in Figure 1, these investigations will be planned (Treatability Study Work Plan), screened (Treatability Screening), and implemented as part of the RI/FS process. Data collected will be used to determine whether the technology warrants further consideration for the site under investigation. Information needed from these tests includes technology effectiveness, implementability, cost, and potential environmental impact.

Feasibility studies are designed to identify potential treatment technologies and their containment or disposal requirements, to screen remedial alternatives based on technology effectiveness, implementability, and cost, and then to subject the screened alternatives to detailed comparative analyses. A range of alternatives for potential source control and response actions must be assessed.

It is important to recognize that the remedial investigations and feasibility studies are conducted concurrently and that data collected in one activity may influence decisions made in other activities. In a similar fashion, all data collection, whether in the field or laboratory, should be looked on as a focusing process where key unknowns are addressed first, with subsequent information filling critical data gaps.

Following completion of RI/FS activities, a Proposed Plan, a Record of Decision, and a Responsiveness Summary are prepared to summarize all previous work, document decisions made or recommended, and formally respond to public comments.

Within this work plan, existing information on the 300-FF-5 operable unit is summarized, a technically sound rationale for future environmental investigations is presented in a series of investigative elements, and initial RI/FS activities for the 300-FF-5 operable unit are described. This plan was developed in accordance with the following requirements:

- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended
- National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR 300).

Also followed were additional requirements contained in EPA guidance documents.

1.2 PROJECT GOALS

The following are the goals of the 300-FF-5 operable unit RI/FS process:

- determine the nature and extent of contamination in the unconfined and confined groundwater and associated sediments, surface water and associated sediments, and aquatic biota
- assess the potential threat to the public and surrounding environment from the discharge of contaminated groundwater into the Columbia River
- develop and evaluate remedial alternatives that may be used to protect public health and the environment.

The nature and extent of the studies involved in reaching each of these goals will be based on decisions of what is necessary and sufficient to judge human health and environmental risks associated with any remedial alternatives. Data required to support decisions regarding the ultimate disposition of the 300-FF-5 operable unit will be considered in the execution of this RI/FS process.

1.3 PROJECT PLAN ORGANIZATION

This 300-FF-5 Work Plan generally conforms with current draft guidance for RI/FS activities under CERCLA (EPA 1988a).

This 300-FF-5 Work Plan is intended to be an evolving document that will be amended, as necessary, throughout the project. Document revisions will be made in accordance with the Tri-Party Agreement (1989, p. 9-7). In this manner, this work plan will provide an effective direction consistent with goals. A dynamic plan also helps document the rationale for decisions and conclusions, thereby assisting in subsequent remediation decisions. This plan is an addendum to the 300-FF-1 Work Plan and extensive references are made to that plan. No attempt has been made to make this 300-FF-5 Work Plan stand alone.

This 300-FF-5 Work Plan consists of seven chapters, in addition to this introduction and supporting appendices. Chapter 2.0 presents the location and current definition of the 300-FF-5 operable unit, its potential contaminant sources, and current knowledge of the environmental setting.

Available data and potential contaminant exposure pathways are reviewed in Chapter 3.0 to develop a conceptual model for the operable unit. Waste sources, quantities, and characteristics are identified, along with the current understanding of the extent of contamination in the various environmental media. Potential applicable or relevant and appropriate environmental standards, requirements, criteria, and limitations (ARARs) for remedial action are identified, potential impacts to public health and the environment are assessed, and preliminary remedial action objectives are presented.

Chapter 4.0 provides the rationale and objectives for RI/FS activities. Data needs and required data quality to attain these objectives are defined.

Chapter 5.0 presents the activities necessary to conduct the two elements of the remedial investigation (operable unit characterization and treatability investigation) and the three elements of the feasibility study (remedial alternatives development, screening, and evaluation). Specific activities for the treatability investigation are not set forth because such activities will be dependent on the information gathered during site characterization of the remedial investigation and the results of the initial portions of the feasibility study.

Project schedules are presented in Chapter 6.0. Modifications to the schedules may need to be made as information is obtained during project implementation. Chapter 7.0 discusses project management responsibilities, and references for literature cited are provided in Chapter 8.0.

In addition, the following plans are attached or referenced:

- Attachment 1--Sampling and Analysis Plan
  - Part 1--Field Sampling Plan
  - Part 2--Quality Assurance Project Plan
- Attachment 2--Health and Safety Plan
- Attachment 3--Project Management Plan
- Attachment 4--Data Management Plan
- Attachment 5--Community Relations Plan.

The Sampling and Analysis Plan is composed of two subcomponent plans: Part 1--Field Sampling Plan and Part 2--Quality Assurance Project Plan. The Field Sampling Plan specifies types of samples and sampling objectives needed to fulfill the site characterization objectives of the remedial investigation. Sampling locations, frequencies, and sample designations are also specified in that plan. Coordination of data requirements, sampling locations, and common field investigations between the 300-FF-1 and 300-FF-5 projects will be discussed. The Quality Assurance Project Plan specifies analytical objectives. Also specified are sampling and.quality assurance/ quality control procedures needed to ensure that the project provides information of defendable quality.

The Health and Safety Plan specifies occupational health and safety procedures to ensure the maintenance of the health of personnel involved in RI/FS field activities. The Health and Safety Plan presented in this 300-FF-5 Work Plan references the 300-FF-1 Health and Safety Plan, with additions to provide for safety concerns specific to groundwater investigations and other items not included in the 300-FF-1 Health and Safety Plan.

The Project Management Plan supplements Chapter 7.0 of this work plan. The Data Management Plan specifies data management procedures for the project.

The Community Relations Plan (CRP 1989) specifies activities that will be used to keep the potentially impacted and interested communities informed of project progress and results. The Community Relations Plan also specifies activities needed to obtain and incorporate appropriate community feedback on the project.

2.0 OPERABLE UNIT BACKGROUND AND SETTING

2.1 SITE DESCRIPTION

2.1.1 Location

The 300-FF-5 operable unit is a groundwater operable unit and consists of the aquifer beneath the 300-FF-1, 300-FF-2, and 300-FF-3 operable units. The operable unit is defined by "the observed and assumed extent of uranium contamination in the groundwater" (WHC 1989). Ultimately, the extent of the operable unit will include all significant contamination emanating from 300-FF-1, 300-FF-2, and 300-FF-3 detected below the water table. The 300-FF-5 operable unit is located on the southeasternmost section of the Hanford Site in Benton County, Washington adjacent to the Columbia River (Figure 2). The Columbia River forms the eastern boundary of the unit and the northern, western, and southern boundaries have been located as shown in Figure 3. For ease of location, Lambert coordinates have been used in the preparation of the figures. The latter three boundaries are defined for the first time in this document. This geographic location represents the potential extent of groundwater contamination migrating from three (300-FF-1, 300-FF-2, and 300-FF-3) source areas and the primary pathway to the Columbia River from other upgradient sources [300-IU-1 (located approximately 3 mi northwest of the 300 Area), Horn Rapids Landfill (part of 1100-EM-1), 300-FF-4 (Fast Flux Test Facility), and some of the tritium contamination emanating from 200-PO-2 (200 East Area)].

The 300-FF-5 operable unit was designated to address the groundwater/surface-water pathway under the 300 Area and to aid in identifying source areas of contamination that commingle in the groundwater environment before discharging into the Columbia River.

2.1.2 History of Operations

The general history of operations in the 300 Area is described in Section 2.1.2 of the 300-FF-1 Work Plan.

Because the 300-FF-5 operable unit lies under the entire 300 Area, it is potentially affected by several operable units in addition to 300-FF-1 (described in the 300-FF-1 Work Plan).

The 300-FF-2 operable unit consists primarily of waste management units that received solid waste and contaminated equipment from fuel fabrication operations in the 300 Area. Two of the waste units in the 300-FF-2 operable unit were associated with other than solid waste. These waste units were involved either in the treatment of waste from 300 Area operations or in research and development of waste treatment technologies (DOE 1989).

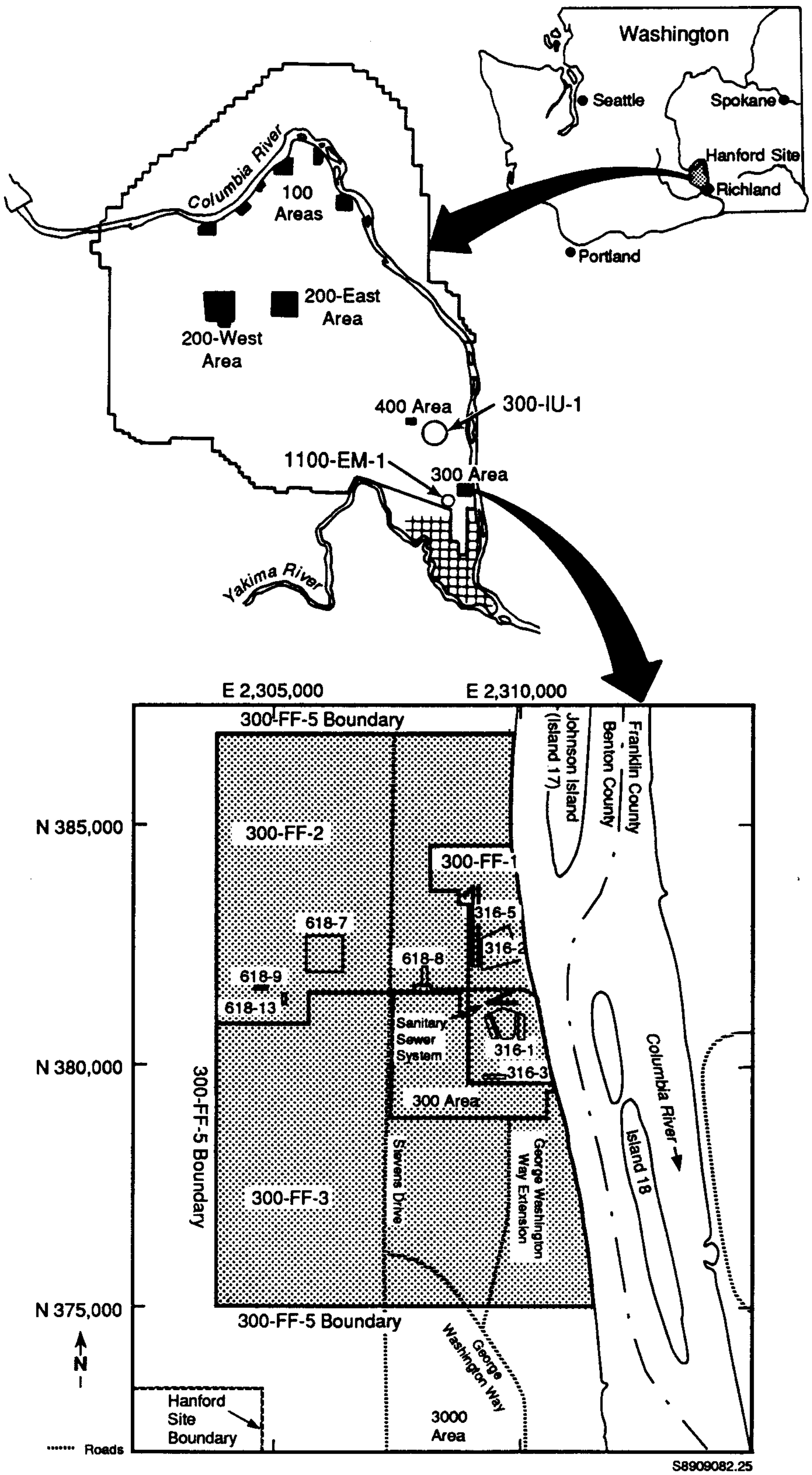


Figure 2. Location of the 300-FF-5 Operable Unit on the Hanford Site.

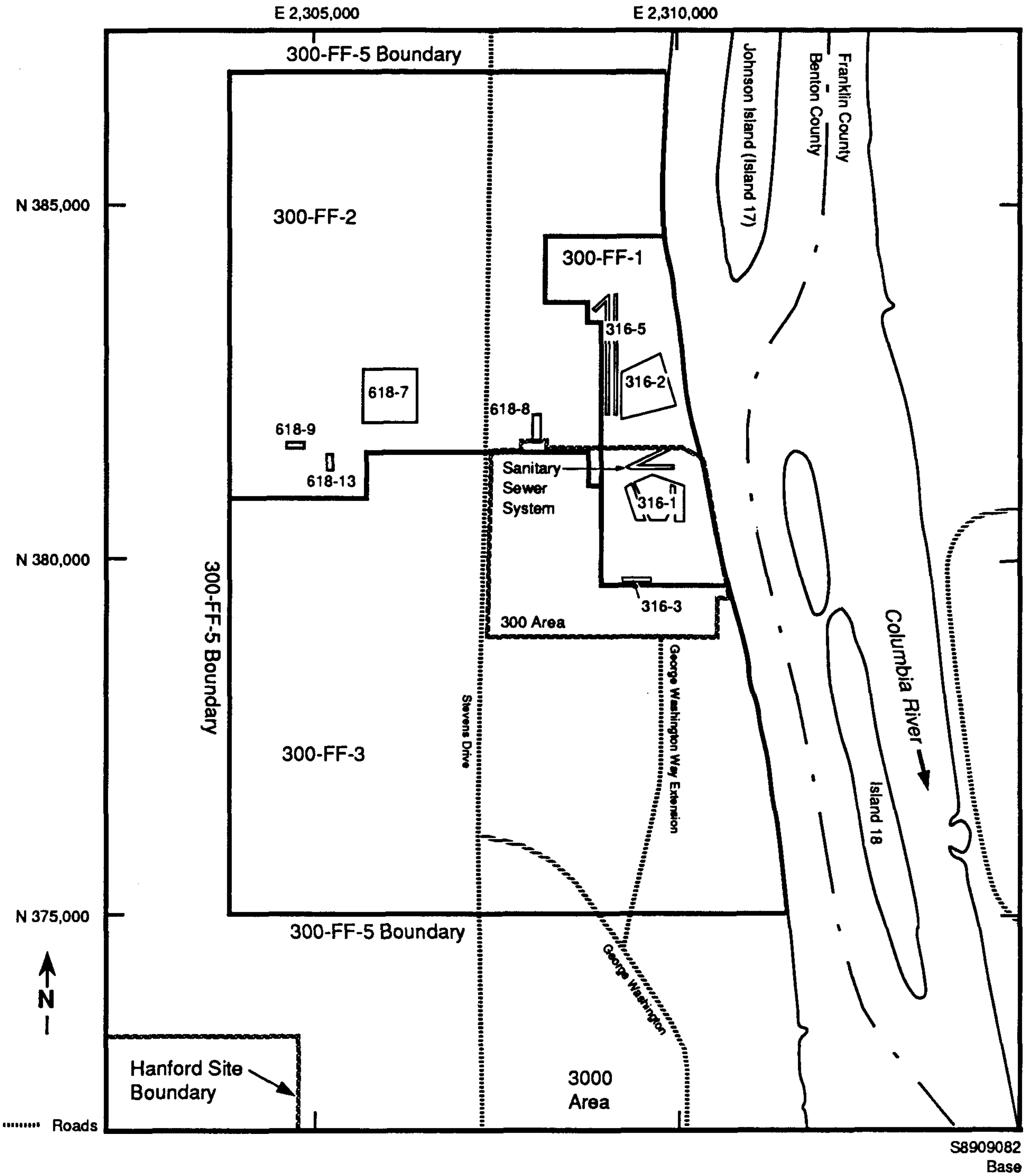


Figure 3. Layout of the 300-FF-5 Operable Unit Within the 300 Area of the Hanford Site.

The 300-FF-3 operable unit consists of various miscellaneous waste management units that received waste from many different operations and/or facilities. The types of operations or facilities that contributed waste to the units in this operable unit include fuel fabrication facilities, sanitary waste facilities (e.g., drain fields), the retired Plutonium Recycle Test Reactor (a test reactor used to study the use of plutonium as a fuel in a thermal power reactor), life-science research activities, research and development activities, and support facilities (DOE 1989).

The 300-IU-1 operable unit (located approximately 3 mi northwest of the 300 Area) consists of various waste management units that received waste from fuel fabrication operations in the 300 Area and miscellaneous construction debris from various construction sites (Stenner et al. 1988, DOE 1989).

2.1.3 Waste Generation Processes

Most of the waste generation activities whose discharges could potentially affect the 300-FF-5 operable unit are discussed in the 300-FF-1 Work Plan. These activities/processes include fuel fabrication operations, water treatment operations, support operations (e.g., convertible coal/oil powerhouse), and sanitary waste from the various facilities in the 300 Area. Many of the individual waste management units in other operable units (300-FF-2, 300-FF-3, and 300-IU-1) potentially affecting the 300-FF-5 operable unit receive(d) waste from these same activities.

The largest volume of waste generated in the 300 Area is from the fuel fabrication operations and is disposed in the 300-FF-1 operable unit. Some additional wastes are disposed, stored, or treated in facilities in the other source operable units that could potentially affect the 300-FF-5 operable unit.

The fuel fabrication operations generate both liquid and solid waste. Most of the liquid waste generated during fuel fabrication is disposed in the waste management units assigned to the 300-FF-1 operable unit. The fuel fabrication operations also generate solid waste that is disposed in solid waste burial grounds. Most of these burial grounds are in the 300-FF-2 or 300-IU-1 operable units, but one is in the 300-FF-3 operable unit. The solid waste burial grounds contain mixed waste of mostly unknown composition, but are known to contain various fission products and isotopes of uranium and plutonium. In addition to these waste management units, a number of unplanned releases are assigned to the 300-FF-2, 300-FF-3, and 300-IU-1 operable units. Unplanned releases are accidental spills or releases of waste or contaminated substances. In general, the substances spilled (thus constituting an unplanned release) are associated with fuel fabrication operations (Stenner et al. 1988); therefore, the potential contaminants are those discussed in Section 2.1.3.1 of the 300-FF-1 Work Plan.

The 300-FF-3 operable unit contains a wide variety of waste management units. These units include active waste staging areas, active and inactive waste storage facilities, waste treatment facilities, fuel fabrication facilities, and sanitary waste and water treatment facilities. Several units located in this operable unit were associated with an experimental reactor, the Plutonium Recycle Test Reactor, that tested the use of plutonium as a reactor fuel. These units received radioactive contaminated waste.

An unplanned release in the 300-FF-3 operable unit and a waste unit in the 300-IU-1 operable unit received waste from operations related to the development of the reduction-oxidation (REDOX) and the plutonium-uranium extraction (PUREX) processes. These processes were used to separate plutonium from fission products, uranium, and other transuranics in irradiated fuel. The contaminants that these facilities could contain include (Stenner et al. 1988) the following:

- methyl isobutyl ketone (MIBK or hexone)
- tributyl phosphate
- nitrate
- nitric acid
- uranium.

2.1.4 Waste Transfer, Storage, Treatment, and Disposal Facility Characteristics

Waste transfer, storage, treatment, or disposal facilities that are associated with the 300-FF-1 operable unit are discussed in the 300-FF-1 Work Plan. Facilities associated with the 300-FF-2, 300-FF-3, or 300-IU-1 operable units are discussed in this section.

Tables 2, 3, and 4 list the individual waste management units, the type of waste unit, their dates of operation, and the description of waste types and amounts contained in the units assigned to or located in the 300-FF-2, 300-FF-3, and 300-IU-1 operable units, respectively. These units include liquid waste disposal units, solid waste burial grounds, hazardous waste storage facilities, waste treatment facilities, and unplanned releases. The locations of the individual waste management units assigned or located in the 300-FF-2, 300-FF-3, and 300-IU-1 operable units are shown in Figures 4, 5, and 6, respectively.

2.1.5 Interactions with Other Operable Units

The groundwater that constitutes the 300-FF-5 operable unit lies beneath three source operable units, 300-FF-1, 300-FF-2, and 300-FF-3. These three operable units have or have the potential to directly release contaminants into the 300-FF-5 operable unit. In addition to these three operable units, several other operable units have the potential to contribute contamination to 300-FF-5. These operable units are 200-PO-2, 300-FF-4, 300-IU-1, and 1100-EM-1. The locations of these operable units will be used to determine locations of wells to access background concentrations.

Table 2. Waste Management Units in the 300-FF-2 Operable Unit (DOE 1989). (Sheet 1 of 2)

Unit name	Unit type	Service period	Waste types and amounts
300 Area vitrification test site	Test treatment or support facility	1983 - 1986	Vitrification was performed at this site on wastes containing the following radionuclides: ^{241}Am, 0.0095 Ci; ^{239}Pu, 0.0053 Ci; ^{238}Pu, 0.0018 Ci; ^{137}Cs, 0.020 Ci, ^{106}Ru, 0.021 Ci; ^{90}Sr, 0.680 Ci; ^{60}Co, 0.10 Ci.
618-1	Burial ground	1945 - 1957	The site contains uranium, plutonium, and fission products from the 300 Area laboratories.
618-2	Burial ground	1951 - 1954	The burial ground was used for disposal of uranium-contaminated equipment and materials, plutonium, and fission products. The uranium waste was typically solid metallic-uranium oxides in the form of metal cuttings from reactor fuel fabrication facilities in the 300 Area.
618-3	Burial ground	1954 - 1955	The site was primarily used for the disposal of uranium waste in the form of contaminated building material derived from the 313 buildings.
618-7	Burial ground	1960 - 1973	The site contains low-level uranium and thorium-bearing material from 300 Area fuel fabrication.
618-8	Burial ground	1943 - 1944	The site was mainly used for the disposal of uranium-contaminated solid waste derived from reactor fuel fabrication.

Table 2. Waste Management Units in the 300-FF-2 Operable Unit (DOE 1989). (Sheet 2 of 2)

Unit name	Unit type	Service period	Waste types and amounts
618-9	Burial ground	1950 - 1956	The site contains 55-gal drums of uranium-contaminated organic solvent (5,000 gal) from the 321 Building. It was removed from service, backfilled, identified with markers, and stabilized. (Tributyl phosphate - 6,000 kg; kerosene - 10,000 kg).
618-13	Burial ground	1951 - 1974	This site received the top soil from the 303 Building area, which was removed in 1950 and piled approximately 1/2 to 3/4 mi northwest of the 300 Area and covered with 2 ft of clean soil.
300 Area solvent evaporator (TSD: T-3-1)	Evaporator	1975 - November 1985	The unit received ~600 gal/yr of solvents and steam condensate.

TSD = Treatment, storage and disposal unit.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 1 of 11)

Unit name	Unit type	Service period	Waste types and amounts
300 Area interim filter backwash disposal	Neutralization unit	January 1987 - April 1987	The unit received water and nonhazardous alum from backwashing filters used to filter water for sanitary and process use, about 650,000 gal.
309-TW-1	Storage tank	1960 - 1973	The unit received aqueous nonhazardous radioactive wastes from the operation of the Plutonium Recycle Test Reactor (PRTR). The unit is now empty.
309-TW-2	Storage tank	1960 - 1973	The unit received aqueous nonhazardous radioactive wastes from the operation of the PRTR. The unit is now empty.
309-TW-3	Storage tank	1960 - 1973	The unit received aqueous nonhazardous radioactive wastes from the operation of the PRTR. The unit is now empty.
315 retired sanitary drain field	Drain field	1950 - 1978	The unit received unknown amounts of sanitary wastes from office buildings.
323 Tank No. 1	Storage tank	1945 - 1968	The unit received uranium-contaminated water and acid solutions from reprocessing research and development. The volume of liquid remaining is unknown.
323 Tank No. 2	Storage tank	1945 - 1968	The unit received uranium-contaminated water and acid solutions from reprocessing research and development. The volume of liquid remaining is unknown.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 2 of 11)

Unit name	Unit type	Service period	Waste types and amounts
323 Tank No. 3	Storage tank	1945 - 1968	The unit received uranium-contaminated water and acid solutions from reprocessing research and development. The volume of liquid remaining is unknown.
323 Tank No. 4	Storage tank	1945 - 1968	The unit received uranium-contaminated water and acid solutions from reprocessing research and development. The volume of liquid remaining is unknown.
331 LSL Drain Field	Drain field	1970 - 1974	The unit received ~0.66 gal/h of sanitary waste water.
331 LSL Trench 1	Trench	1966 - 1974	From 1966 to 1969, the unit received ~9.0 gal/h of sanitary waste water. From 1969 to 1974, the unit received ~8.33 gal/h of sanitary waste water.
331 LSL Trench 2	Trench	1969 - 1974	The unit received ~8.33 gal/h of sanitary waste water.
335 and 336 Retired Sanitary Drain Field	Drain field	1973 - 1978	The unit received unknown amounts of sanitary wastes from office buildings.
618-6	Burial ground	1944 - 1962	The unit contained solid waste, and the waste was exhumed in 1962.
UN-300-10	Unplanned release	Discovered 1977	The release consisted of waste from the radioactive liquid waste sewer from the 325-B hot cells, including waste from dissolution of highly radioactive samples including irradiated reactor fuels.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 3 of 11)

Unit name	Unit type	Service period	Waste types and amounts
UN-300-12	Unplanned release	January 8, 1979	Approximately 4,000 gal of radioactive rinse water overflowed. The waste contained nitrate ions, promethium-147, fission product radionuclides, and transuranic nuclides.
UN-300-13	Unplanned release	July 31, 1973	The release consisted of spent process acid that included 4,432 lb of NO_3, 477 lb of copper, and 3 lb (0.0005 Ci) of uranium.
UN-300-17	Unplanned release	September 2, 1979	Rain caused uranium shavings in a garbage can to ignite. The can was inside a plastic-lined wooden burial box, which also caught on fire. Readings to 15,000 counts/min at 2 ft from the burial box were measured.
UN-300-18	Unplanned release	August 27, 1962	The release consisted of low-level cesium waste.
UN-300-39	Unplanned release	1954	The release consisted of incoming caustic solution, containing 50% sodium hydroxide. Soil around the tanks still exhibits high pH, necessitating use of chemical-resistant suits when excavating in the area.
UN-300-4	Unplanned release	1945 - 1955	The release consisted of leaks from equipment during the development of reduction-oxidation (REDOX) and plutonium-uranium (PUREX) processes.
UN-300-40	Unplanned release	1961	The release consisted of uranium-bearing acid waste, containing nitric and sulfuric acid with uranium in solution.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 4 of 11)

Unit name	Unit type	Service period	Waste types and amounts
UN-300-42	Unplanned release	October 12, 1983	The release consisted of 200 to 300 gal of No. 6 fuel oil.
UN-300-43	Unplanned release	July 1986	The release consisted of <55 gal of solvent-refined coal (light fraction), nonradioactive.
UN-300-44	Unplanned release	January 1985	The release consisted of an unknown amount of uranium-bearing acid (nitric and sulfuric acid with uranium in solution) and waste-etch acid (nitric, hydrofluoric, and chromic acids with uranium, copper, and zirconium metals in solution). The possibly contaminated with byproduct waste material.
UN-300-45	Unplanned release	February 1985	The release consisted of <10 gal of uranium-bearing waste acid identified as nitric and sulfuric with uranium in solution.
UN-300-5	Unplanned release	August 31, 1973	The release consisted of low-level radioactively contaminated water overflow from a storage basin.
UN-300-7	Unplanned release	August 7, 1972	The release consisted of approximately 850 gal of fuel oil overflow from a full clay tank behind the 384 Building when oil was transferred from the storage bunker.
300 Area Powerhouse HWSA	Staging area	Active	The outside area typically contains empty drums of water treatment chemicals (approximately 10 drums per month).

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 5 of 11)

Unit name	Unit type	Service period	Waste types and amounts
303-K Contaminated Waste Storage (TSD: S-3-1)	Storage facility	January 1986 to the present	The area is used for storage of containers of small quantities of miscellaneous wastes (waste oils, cutting lubricants) potentially contaminated with uranium, and for the occasional storage of concreted waste from the 304 facility, heat treat salts, and solids from 313 recovery operations. Approximately 50 to 100 55-gal drums per year are accumulated.
303-M Storage Area	Storage facility	May 1983 to the present	The area is used for storage of uranium metal chips and fines (ignitable) awaiting treatment in the 303-M oxidation facility. Waste quantities are estimated at 31 tons/yr [fiscal year (FY) 1986 generation rate].
303-M Uranium Oxide Facility	Test treatment or support facility	May 1983 to the present	Oxidation process feed material is uranium containing Zircaloy-2 metal chips and fines (ignitable). Approximately 31 tons/yr of uranium (FY 1986 generation rate) are converted to a nonignitable oxide via incineration.
304 Concretion Facility (TSD: TS-3-2)	Building	January 1969 to the present	Previous waste for treatment consisted of scrap metal (beryllium/zirconium alloy) lathe chips and depleted uranium (2.1%) chips and fines.

Table 3. Waste Management Units In the 300-FF-3 Operable Unit (DOE 1989). (Sheet 6 of 11)

Unit name	Unit type	Service period	Waste types and amounts
304 Storage Area (TSD: TS-3-2)	Storage facility	January 1969 to the present	The area is used for storage of containers of miscellaneous potentially contaminated wastes, primarily heat treat salts (sodium chloride, potassium chloride, sodium nitrate, sodium nitrite, and potassium nitrate), depleted uranium chips and fines (ignitable), and beryllium/zirconium chips and fines (ignitable and carcinogenic). The chips and fines are in storage, awaiting concretion. Approximately 50 to 100 55-gal drums per year are accumulated.
305-B Storage Facility (TSD: S-3-2)	Storage facility	January 1978 to the present	--
311 Methanol Tank No. 1	Storage tank	1955 - 1987	Prior to 1987, the tank contained ~10,000 gal of a 4% aqueous solution of methanol. The tank was emptied in 1987.
311 Methanol Tank No. 2	Storage tank	1955 - 1971	Prior to 1987, the tank contained ~10,000 gal of a 4% aqueous solution of methanol. The tank was emptied in 1987.
311 Neutralized Waste Tank No. 1 (TSD: TS-3-1)	Storage tank	1973 to the Present	The unit receives 420,000 gal/yr of waste solutions, consisting of neutralized liquid from the nonrecoverable uranium stream and filtrate from processing of the uranium-bearing waste stream from the 313 Building recovery operations.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 7 of 11)

Unit name	Unit type	Service period	Waste types and amounts
311 Neutralized Waste Tank No. 2 (TSD: TS-3-1)	Storage tank	1973 to the present	The unit receives 420,000 gal/yr of waste solutions, consisting of neutralized liquid from the nonrecoverable uranium stream and filtrate from processing of the uranium-bearing waste stream from the 313 Building recovery operations.
313 Centrifuge (TSD: TS-3-1)	Equipment	Active	--
313 Copper Remelt Operations	Building	Active	Copper-silicon alloy waste from the fuel fabrication process is melted, cast, and machined in preparation for reuse. The unit processes 600 lb/d when in operation.
313 East Side Storage Pad	Storage pad	Active	The unit is used for storage of byproduct waste materials from the fuel fabrication process, including neutralized solids (sodium fluoride, sodium nitrate, sodium sulfate, metal precipitates, including copper, uranium, zirconium) from the 313 Building recovery operations. Approximately 320,000 lb/yr (total for this waste stream for the 313 Building, inside and outside storage, and at the 303-K storage pad) are accumulated.
313 Filter Press (TSD: TS-3-1)	Equipment	Active	--
313 Methanol Tank	Storage tank	1955 - 1987	Prior to 1987, the tank contained ~600 gal of a 0.7% aqueous solution of methanol. The tank was emptied in 1987.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 8 of 11)

Unit name	Unit type	Service period	Waste types and amounts
313 Uranium Recovery Operations	Building	Active	The unit receives ~270,000 gal/yr of waste acids from the fuel fabrication process, containing nonrecoverable and recoverable uranium. Approximately 28.4 tons of uranium are recovered (FY 1986 generation rate).
313 Waste Acid Neutralization Tank (TSD: TS-3-1)	Test treatment or support facility	Active	--
324 Sodium Removal Pilot Plant (TSD: T-3-3)	Building	1979 to the present	--
325 Waste Treatment Facility (TSD: T-3-4)	Test treatment or support facility	1978 to the present	--
331-C HWSA	Staging area	Active	The area typically contains corrosives, ignitables, and regulated empty containers; ~600 gal/yr total.
333 Chromium Treatment Tank No. 1 (TSD: TS-3-1)	Storage tank	Active	This tank is used for storage of spent etch acids (nitric and sulfuric acid with uranium in solution). Estimated accumulation rate is 60,000 gal/yr. Not all of this volume is routed to the storage tank outdoors; most is routed to a storage tank inside the facility.
333 Chromium Treatment Tank No. 2 (TSD: TS-3-1)	Storage tank	Active	--

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 9 of 11)

Unit name	Unit type	Service period	Waste types and amounts
333 East Side Heat-Treat Salt Storage Area	Building	Active	The area is used for storage of containers of solidified waste heat treat salts from the fuel fabrication facility, consisting of sodium chloride, potassium chloride, sodium nitrate, sodium nitrite, and potassium nitrate. Approximately 30 to 50 55-gal drums per year are accumulated.
333 East Side HWSA	Staging area	Active	--
333 Laydown HWSA	Staging area	1971 - 1986	The area typically contains corrosive and EP-toxic (Extraction Procedure) (for chromium) wastes.
333 West Side Waste Oil Tank	Storage tank	Active	--
334 Tank Farm Waste Acid Storage Tank	Storage tank	Inactive	The unit was used infrequently for storage of waste acids from the fuel fabrication process, containing nonrecoverable uranium.
334-A Waste Acid Storage Tank No. 1 (TSD: TS-3-1)	Storage tank	April 1973 to the present	The unit receives 210,000 gal/yr of waste acids from the fuel fabrication process, containing nonrecoverable uranium (primarily hydrofluoric, nitric, sulfuric, and chromic acids with copper, zirconium, and uranium in the solution).

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 10 of 11)

Unit name	Unit type	Service period	Waste types and amounts
334-A Waste Acid Storage Tank No. 2 (TSD: TS-3-1)	Storage tank	April 1973 to the present	The unit receives 210,000 gal/yr of waste acids from the fuel fabrication process, containing nonrecoverable uranium (primarily hydrofluoric, nitric, sulfuric, and chromic acids with copper, zirconium, and uranium in the solution).
350 HWSA	Staging area	Active	The area typically contains ~600 gal/yr of corrosives, 600 gal/yr of used oils and polychlorinated biphenyl-contaminated oil, and 40 nonregulated empty containers per year.
3712 Uranium Scrap Storage Area	Storage facility	Active	The building is used for storage of uranium scrap awaiting transportation for recovery to the feed site (Fernald, Ohio). Waste quantities are estimated at 140 tons/yr (FY 1986 generation rate). Previously, the area was used to store concreted billets of ignitable uranium chips and fines.
3713 Paint Shop Hazardous Waste Satellite Area	Staging area	Active	The area contains miscellaneous small quantities (<55 gal accumulated at any one time) of waste solutions, including solvent and paint solids from sign and paint shop operations.
3713 Sign Shop Hazardous Waste Satellite Area	Staging area	Active	The area contains miscellaneous small quantities (<55 gal accumulated at any one time) of waste solutions (non-solvents) from sign shop operations. Less than 55 gal/yr area accumulated.

Table 3. Waste Management Units in the 300-FF-3 Operable Unit (DOE 1989). (Sheet 11 of 11)

Unit name	Unit type	Service period	Waste types and amounts
3718-F Alkali Metal Treatment Facility (TSD: TS-3-3)	Test treatment or support facility	Active	Typically, the largest single container is 55 gal. Waste is stored inside the building.
3718-F Burn Shed	Building	1968 to September 1968	--
3718-F Treatment Tank No. 1 (TSD: TS-3-3)	Storage tank	1968 to September 1968	--
3718-F Treatment Tank No. 2 (TSD: TS-3-3)	Storage tank	1968 to September 1968	--
3746-D Silver Recovery	Building	Active	Corrosive silver, containing waste photo-chemicals (1,530 gal/yr), is processed for reclamation of silver (1,119.19 troy oz/yr).
Biological Treatment Test Facilities (TSD: T-X-1)	Test treatment or support facility	1988 to the present	--
Physical and Chemical Treatment Test Facilities (TSD: T-X-2)	Test treatment or support facility	January 1979 to the present	--
Thermal Treatment Test Facilities (TSD: T-X-3)	Test treatment or support facility	January 1978 to the present	--

TSD = Treatment, storage, and disposal unit.
-- = No information available.

Table 4. Waste Management Units in the 300-IU-1 Operable Unit (DOE 1989). (Sheet 1 of 2)

Unit name	Unit type	Service period	Waste types and amounts
316-4	Crib	1948 - 1956	The site received hexone-bearing uranium wastes and limited amounts of other uranium-bearing wastes from the 321 buildings. (1,000 kg nitrate, 3,000 kg methyl isobutyl ketone, 2,000 kg uranium).
618-10	Burial ground	1954 - 1963	The site contains a broad spectrum of low- to high-level dry wastes, primarily fission products and plutonium from the 300 Area. Low-level wastes are buried in trenches, and medium- to high-level beta/gamma wastes are stored in the pipe facilities.
618-11	Burial ground	1962 - 1967	The site contains a broad spectrum of low- to high-level dry waste, primarily fission products and plutonium. Low-level wastes were buried in the trenches, and high-level wastes were buried in the pile storage units and caissons.
J.A. Jones 1	Landfill	1975 - 1979	This site contains miscellaneous non-radioactive solid wastes from various construction sites, including wood scraps, concrete, and miscellaneous construction wastes. It has been backfilled and covered to grade.

Table 4. Waste Management Units in the 300-IU-1 Operable Unit (DOE 1989). (Sheet 2 of 2)

Unit name	Unit type	Service period	Waste types and amounts
UN-600-11	Unplanned release	May 29, 1980	The release occurred when workers excavated 100 yd^3 of berm material and and buried it in a clean landfill (J.A. Jones Construction Pit No. 1) before contamination was detected. The contamination is believed to have originated from discarded asphalt blacktop rubble at the south end of the berm.

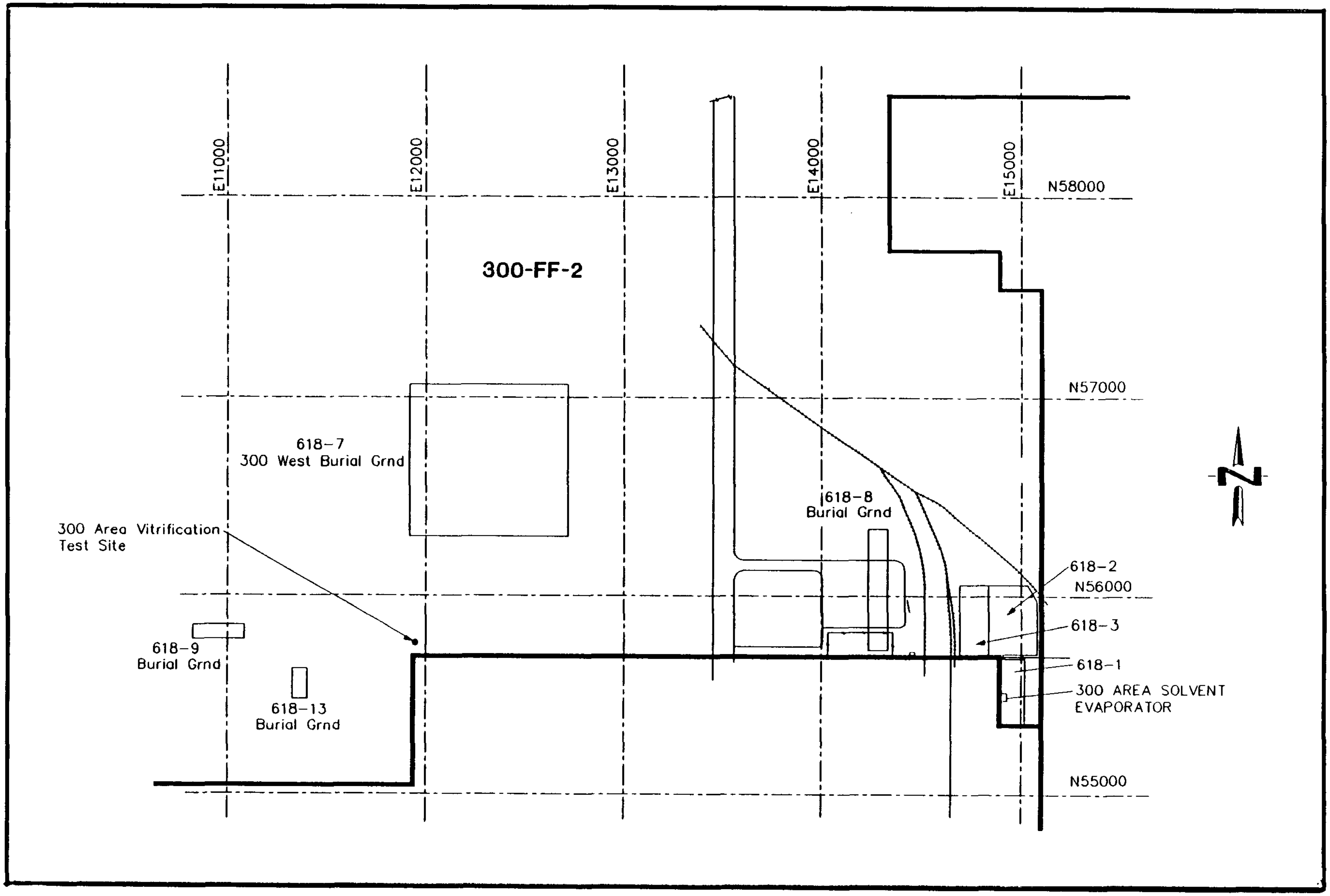


Figure 4. Waste Management Units in the 300-FF-2 Operable Unit (from WHC 1989).

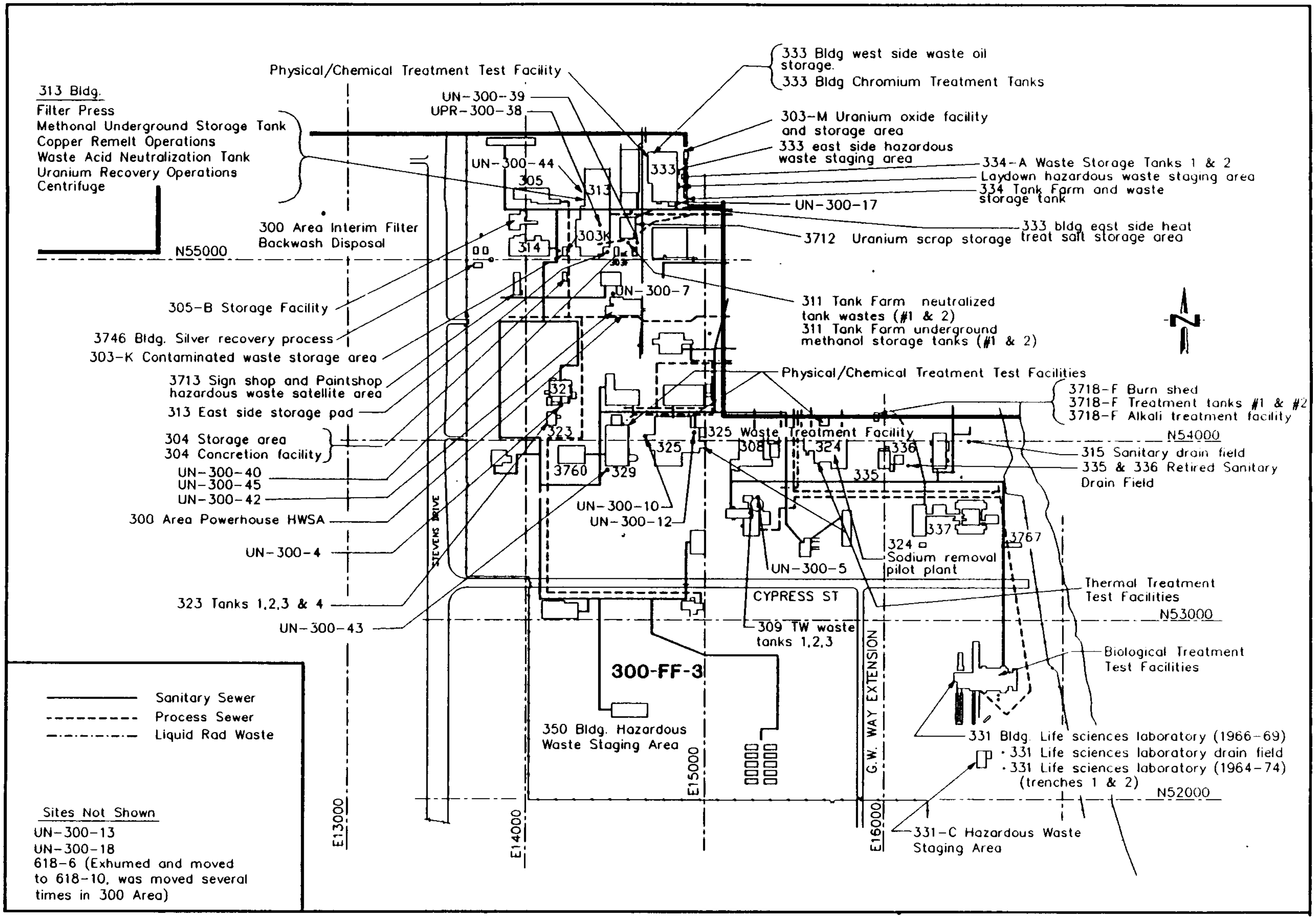


Figure 5. Waste Management Units in the 300-FF-3 Operable Unit (from WHC 1989).

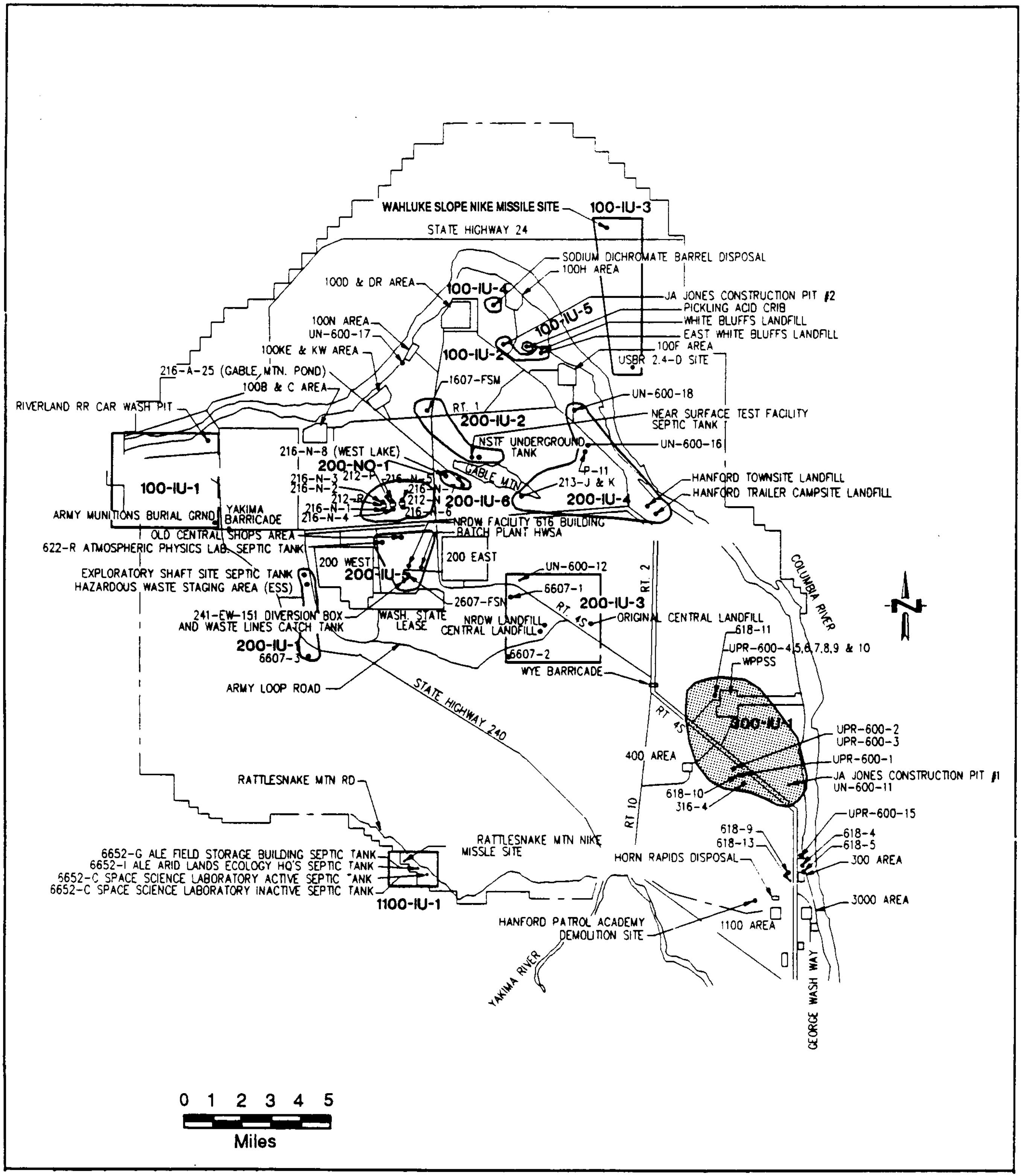


Figure 6. Waste Mangement Units in the 300-IU-1 Operable Unit (from WHC 1989).

The tritium/nitrate emanating from the 200-PO-2 operable unit is at elevated levels in wells located approximately 2.4 mi north of the 300 Area (Evans et al. 1988a, 1988b). This unit receives waste associated with operations at the PUREX Plant in the 200 East Area (WHC 1989). It appears that this contamination may be moving to the south before entering the Columbia River. Thus, this contamination could potentially affect the 300-FF-5 operable unit.

The 300-FF-4 operable unit is composed of the waste management units located at the Fast Flux Test Facility (also known as the 400 Area) (WHC 1989). This operable unit is located approximately 6 mi northwest of the 300 Area. Contaminants potentially entering the aquifer beneath the 300-FF-4 operable unit, due to the southeasterly flow of the groundwater, could affect a portion of the 300-FF-5 operable unit.

The 300-IU-1 operable unit, which was discussed in Sections 2.1.2, 2.1.3, and 2.1.4, is located approximately 3 mi northwest of the 300 Area. Contamination potentially entering the groundwater beneath this operable unit could affect the 300-FF-5 operable unit.

A waste management unit assigned to the 1100-EM-1 operable unit, Horn Rapids Landfill, is located approximately 1 mi west of the southern portion of the 300-FF-5 operable unit (WHC 1989). Groundwater beneath the Horn Rapids Landfill is believed to flow to the east, thus potentially adding to the 300-FF-5 operable unit contamination.

2.1.6 Resource Conservation and Recovery Act Site Interactions

The Resource Conservation and Recovery Act (RCRA) of 1976 site interactions are described in Section 2.1.7 of the 300-FF-1 Work Plan. Twenty-two additional RCRA units are present in the 300-FF-2 and 300-FF-3 operable units. These units were identified in Tables 2 and 3. All but four of these units have RCRA Part A permits. The major waste disposal facility currently operating under RCRA authority in the 300 Area is the 316-5 process trenches. A closure plan for 316-5 is scheduled for submittal to the EPA in September 1992. A groundwater monitoring system is operating for that facility and is described in Schalla et al. (1988). Other RCRA units are considered of lesser concern than 316-5 because they consist of contained facilities (such as tanks, drum storage, and process equipment) where the objective is to contain wastes rather than disperse them to the environment.

2.2 PHYSICAL SETTING

2.2.1 Topography

The regional and general topography of the 300-FF-5 operable unit is the same as that described in the 300-FF-1 Work Plan, except the range of elevation is greater. Excluding the steep cliff along the edge of the Columbia River (in Benton County), the elevation in the 300-FF-5 operable unit ranges from approximately 380 to 410 ft above mean sea level.

2.2.2 Geology

The generalized stratigraphy of the 300-FF-5 operable unit is shown in Figure 7. The four uppermost stratigraphic units within the 300 Area, in ascending order, are the Saddle Mountains Basalt, the fluvial-lacustrine Ringold Formation, the glaciofluvial Hanford formation (informal name), and these are blanketed by recent eolian (wind-transported) sands. The Ringold and Hanford Formations are subdivided according to lithofacies, rather than the more traditional basal, lower, middle, and upper units (Myers/Price et al. 1979). The use of informal lithofacies is a more appropriate method to describe stratigraphic units, since they better represent lithologic heterogeneity (Lindsey et al. 1989) and are not based on the false assumption that Ringold units must correlate in time or stratigraphically over a large area. A north-south geologic cross section through the 300-FF-5 operable unit is presented in Figure 8.

The three-dimensional relationships among lithofacies in the central portion of the 300 Area are shown in a fence diagram (Figure 9). It should be noted, however, that interpretations of the geology beneath the 300 Area are highly subjective due to problems with (1) inconsistent documentation of borehole information among drillers and (2) cable-tool samples that may not be totally representative of the formation being drilled. For these reasons, neither accurate nor detailed lithofacies relations can be presented at this time. The following discussion of the geology of the 300 Area is modified after Lindberg and Bond (1979) and Schalla et al. (1988).

2.2.2.1 Saddle Mountains Basalt. The Saddle Mountains Basalt is the uppermost formation of the Columbia River Basalt Group (Swanson et al. 1979). Geologic samples collected from the 300 Area are characterized as dark gray to black basalt mixed with gray clay and concentrations of calcium carbonate. The basalt exhibits a scoriacious texture with surface stains of iron oxide and sulfide mineralization. During emplacement and cooling of basalt flows, vesiculation, brecciation, and fractures can develop within flows, which can influence groundwater flow across flow boundaries (DOE 1988).

The youngest basalt flows in the 300 Area belong to the Ice Harbor Member. There are two flows present in the Ice Harbor Member within the 300 Area, the Martindale and Goose Island flows. The Goose Island flow overlies the Martindale flow in the northern portion of the 300 Area; to the south, the Goose Island flow is not present.

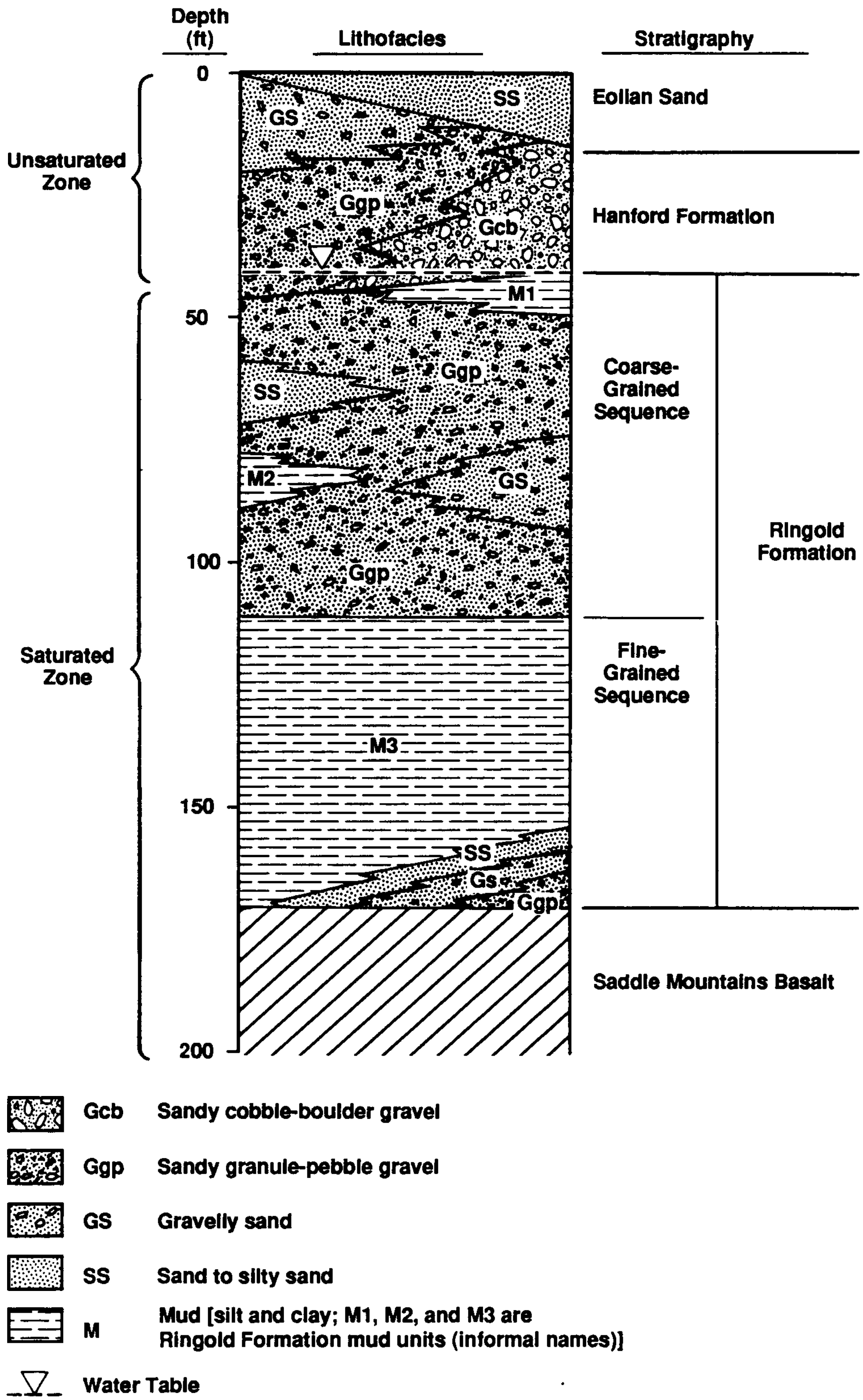


Figure 7. Generalized Upper Stratigraphy of the 300-FF-5 Operable Unit.

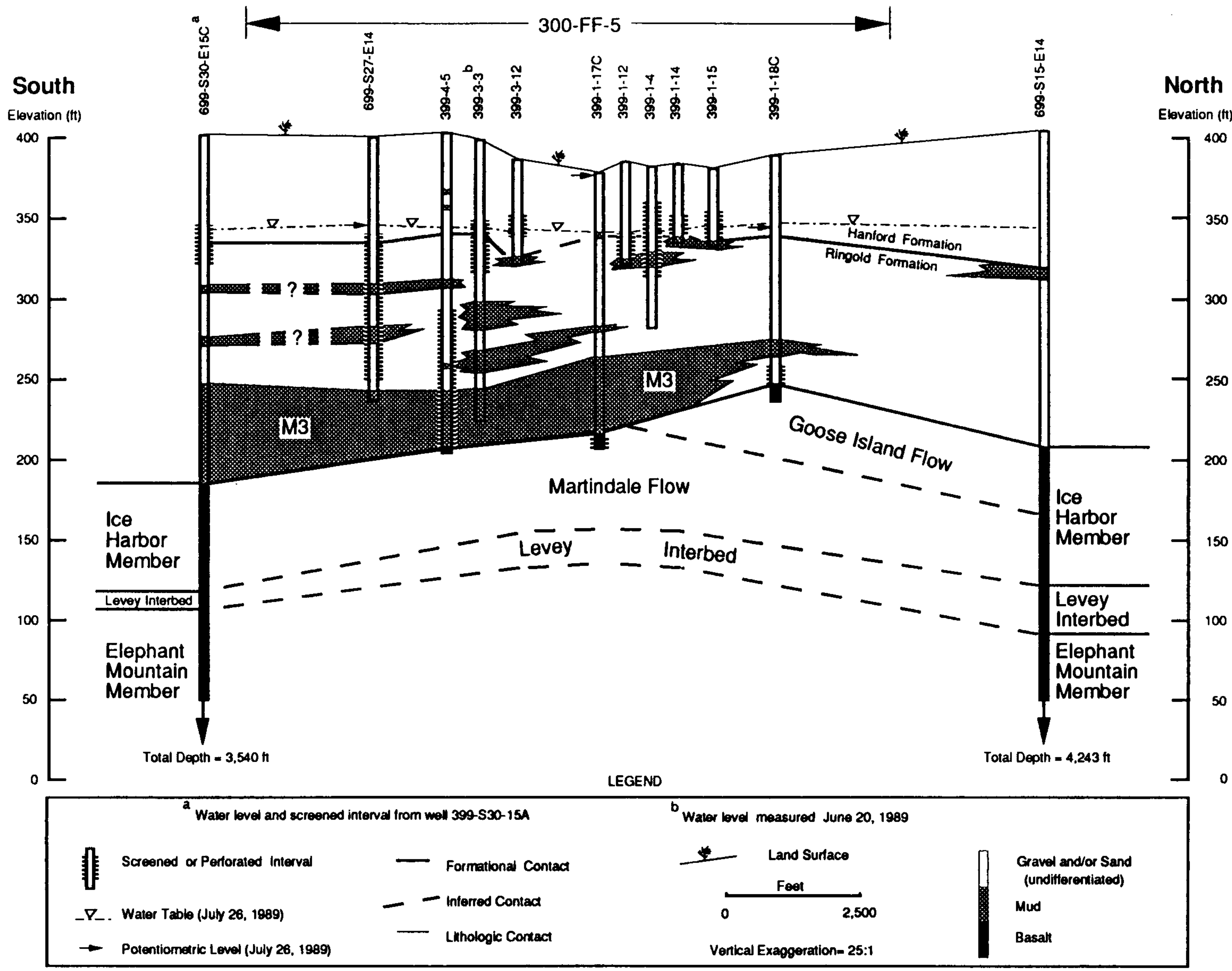


Figure 8. Geologic Cross Section of the 300-FF-5 Operable Unit.

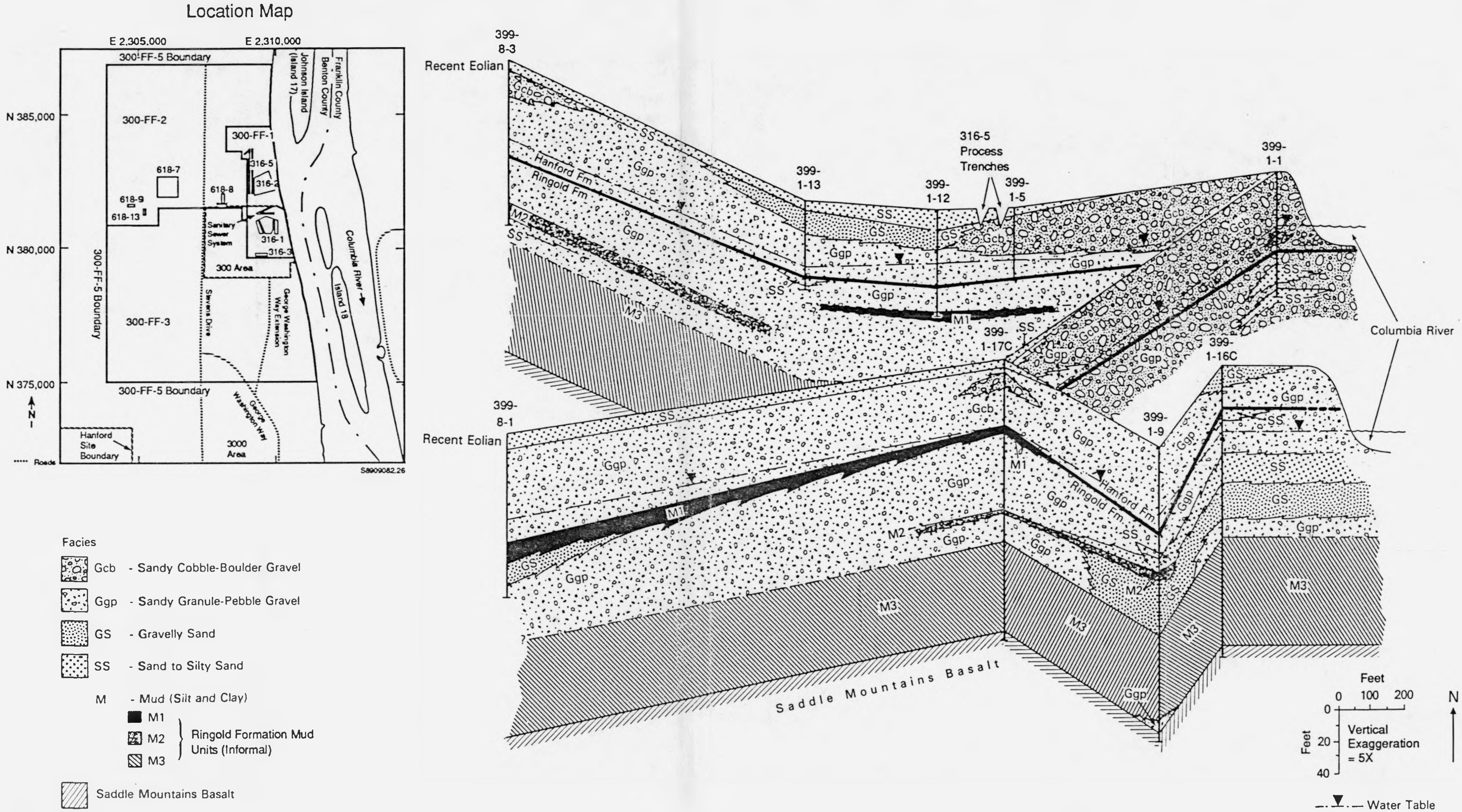


Figure 9. Geologic Fence Diagram for the 300-FF-5 Operable Unit.

2.2.2.2 Ringold Formation. The Saddle Mountains Basalt is overlain by fluvial-lacustrine deposits belonging to the Ringold Formation (Newcomb et al. 1972). This formation in the Pasco Basin ranges in age from 3.9 to 8.5 million years (DOE 1988). The Ringold Formation (Merriam and Buwalda 1917) in the 300 Area is dominated by a thick (50- to 70-ft) sequence of fine-grained mud overlain by up to 80 ft of mostly coarse-grained gravel and sand (see Figure 7). For the purposes of discussion, these are referred to as the Ringold fine-grained and coarse-grained sequences, respectively.

2.2.2.2.1 Fine-Grained Sequence. The fine-grained sequence (facies M3 in Figures 7, 8, and 9) consists of mostly a bluish-green clay, grading to a brownish clay/silt with depth. Based on present information, this unit appears to be continuous across the 300 Area and is equivalent to the "blue-clays" member as described by Newcomb et al. (1972). The configuration of the top of the M3 facies is shown in Figure 10. This information is important because it reflects the possible migration directions for dense nonaqueous-phase liquids if present (Section 3.1.3.2.3). Locally, this unit may grade downward into a well-consolidated clayey sand, gravelly sand, or sandy gravel that varies in thickness from 0 to 17 ft. The sand is primarily basaltic, with some quartz and feldspar, and ranges from very fine to medium sand-sized particles. The gravel fraction, only found locally (e.g., well 399-1-9 in Figure 9), is dominantly basaltic, with some granitic and metamorphic clasts. A calcic paleosol is found locally along the Ringold-basalt contact.

2.2.2.2.2 Coarse-Grained Sequence. The coarse-grained sequence is characterized as moderately to well consolidated, brown to gray sandy gravel, with discontinuous silt, sand, and/or gravelly sand lenses. This sequence is probably equivalent to the middle Ringold unit (Myers/Price et al. 1979). Coarse-grained Ringold sediments are exposed directly across the Columbia River along the White Bluffs, where they consist of a bimodal mixture of a clast-supported, pebble-cobble conglomerate in a well-sorted, coarse to medium sand matrix. Locally, the sandy gravels may be cemented with a ferruginous or calcareous cement. The gravel fraction consists of mostly well-rounded and polished quartzite, granitic, volcanic porphyry, as well as 20% to 40% basalt clasts. These deposits are mostly massive, except for some crudely graded bedding and clast imbrication; occasionally within the gravels there are isolated lenses of cross-bedded, well-sorted, medium to coarse sand.

Based on well cuttings, the coarse-grained sequence beneath the 300 Area is composed of mostly sandy granule-pebble gravel (facies Ggp in Figure 9). This facies may be coarser in situ; however, more like the pebble-cobble gravel exposed across the river, since gravel clasts are readily broken and crushed during drilling. Discontinuous fine-grained lenses of mud, sand, and/or gravelly sand are present also within the coarse-grained sequence. These include at least two discontinuous mud units (facies M1 and M2 in Figure 9) that may act locally as aquitards. Other mud units, most of them discontinuous, appear to be present beneath the 300 Area (see Figure 8).

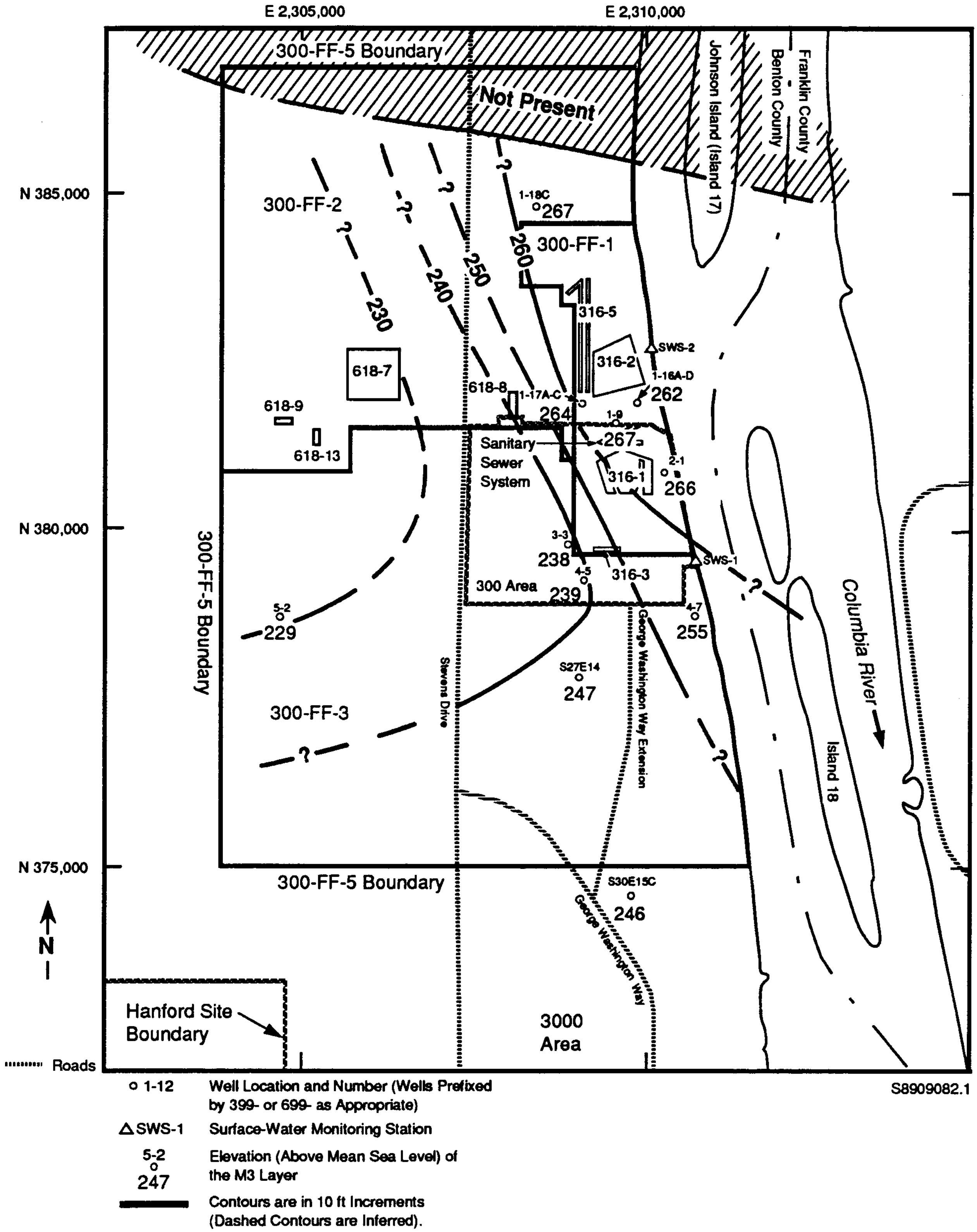


Figure 10. Surface of the M3 Layer in the 300-FF-5 Operable Unit.

2.2.2.3 Hanford Formation. Overlying the Ringold Formation are mostly coarse-grained deposits, belonging to the Hanford formation. The Hanford formation is composed of deposits derived from the sudden release of Pleistocene-age ice-dammed lakes located north and east of the Columbia Plateau. The earliest floods occurred >800,000 yr ago (Bjornstad and Fecht 1989); the last flood occurred approximately 13,000 yr ago (Mullineaux et al. 1978). Within the Pasco Basin, these floods incised into and stripped away much of the Ringold Formation.

In the 300 Area, these cataclysmic floods eroded into the coarse-grained Ringold sequence and then blanketed the area with layers of flood gravel (i.e., Pasco Gravels). An excavation in the 300 Area in 1958 disclosed the presence of a paleochannel filled with flood gravels just west of the present channel of the Columbia River (Lindberg and Bond 1979). Lindberg and Bond (1979) surmised that between these channels lies an erosional remnant of less-permeable Ringold Formation that, locally, may restrict the movement of groundwater from the 300 Area directly to the Columbia River. Evidence for an erosional remnant of the Ringold Formation is apparent in well 399-1-16C (see Figure 9), where the Ringold-Hanford contact extends above the water table; elsewhere in Figure 9 the Hanford-Ringold contact lies below the water table. The paleochannel, confirmed by more recent drilling logs, samples, and aquifer tests, appears to merge with the present Columbia River channel somewhere north of the 300 Area and exits near the south end of the 300 Area (Schalla et al. 1988). This erosional remnant is important and needs better definition in location and extent. The remnant may form a hydraulic barrier, or partial barrier, to water flow between the 300 Area and the Columbia River or, because there are indications that breaches may occur in the remnant, water flow could be selectively channeled to the river.

Flood gravels consist of very coarse, sandy, cobble-boulder gravel (facies Gcb in Figure 9) within and adjacent to the main flood channels; elsewhere in areas marginal to flood channels, in the western portion of the 300 Area for example, it appears that finer grained deposits, consisting of pebbly gravels and sands (facies Ggp and GS) were deposited. On the other hand, these finer grained deposits may be only an artifact of drilling. Absent from the 300 Area are slack-water facies of the Hanford formation, apparently because of the extremely high energy associated with cataclysmic flooding in the area.

The boundary between the Ringold and Hanford formations beneath the 300 Area appears to be gradational, both in lithologic as well as hydrologic properties. In general, flood gravels of the Hanford formation are differentiated from coarse-grained Ringold deposits by (1) less consolidation, (2) less alteration, (3) poorer sorting, and (4) higher percentages of angular basalt clasts. However, the contact is indistinct where flood gravels overlie coarse-grained Ringold facies because sediment transported along the bases of flood channels consisted of mostly reworked deposits of the easily erodible Ringold Formation. Based on borehole cuttings alone, then, it is extremely difficult to differentiate between reworked and intact portions of the Ringold.

2.2.2.4 Eolian Deposits. Overlying the Hanford formation in most of the 300 Area is a thin veneer of fine- to coarse-grained eolian sand deposits (uppermost facies SS in Figure 9). The thickness of this unit is quite varied, ranging from 0 to 15 ft. Eolian sand is generally lacking in areas where the surface has been disturbed by man. The contact between the eolian deposits and the Hanford formation is well defined.

2.2.3 Geohydrology

Unconfined and numerous confined aquifers are present beneath the 300-FF-5 operable unit. The uppermost aquifer is unconfined; the first underlying confined aquifer is contained in the flow top of the uppermost basalt flow and, in some areas of 300-FF-5, the lowermost portion (less than 5 ft thick) of the Ringold Formation. The following discussion of the uppermost aquifer systems in the 300-FF-5 operable unit is derived largely from Schalla et al. (1988); however, additional details and modifications have been made. The most significant modification is the elimination of the use of stratigraphic subdivisions (i.e., basal, lower, middle, and upper units) of the Ringold Formation and replacement with lithofacies that describe geologic sediments in terms of lithologic similarity rather than geologic age. This modification was presented in Section 2.2.2. The primary advantages are that the units will be grouped into units (facies) of similar geologic (lithofacies) and, therefore, similar hydrologic (hydrofacies) properties (e.g., hydraulic conductivity). This grouping will facilitate more useful correlations for predicting contaminant pathways and rates of migration.

Figure 7 showed the generalized upper geostratigraphic column for the 300 Area that is applicable to the 300-FF-5 operable unit. The upper stratigraphic units are, in ascending order: (1) the upper section of the Saddle Mountains Basalt; (2) the gravels, sands, silts, and clays of the Ringold Formation; (3) the gravels, sands, and silts of the Hanford formation; and (4) eolian sand. The figure graphically showed sediment classification, induration, and general water-table elevation (referenced to depth below ground surface) of the unconfined aquifer at the 300 Area.

Some natural recharge to the unconfined aquifer may occur from precipitation on higher elevations in the western part of the Hanford Site. Other sources of recharge are infiltration from small ephemeral streams and water from the Columbia and Yakima Rivers along influent reaches. Artificial recharge to the unconfined aquifer occurs from discharges of large volumes of cooling and process water on the Hanford Site, presently in and near the 200 and 300 Areas. Local recharge to the upper basalt aquifers is believed to be from precipitation and runoff along the margins of the Pasco Basin. Discharge of water from the unconfined and upper confined aquifers is to, and along, the Columbia River.

2.2.3.1 Confined Aquifer. The Saddle Mountains Basalt consists of a series of basalt flow interiors of relatively low hydraulic conductivity, separated by thin basalt flow tops and sedimentary interbeds of high hydraulic conductivity (Gephart et al. 1983). In the context of this 300-FF-5 Work Plan, "confined aquifer" is used to designate the uppermost aquifer of the Saddle

Mountains Basalt that underlies the Hanford and Ringold Formations. This aquifer is effectively confined, with increased hydraulic heads, by the lowermost clay facies (M3 in Figure 9) of the Ringold Formation. This setting allows the overlying unconfined aquifer to be treated as a separate hydrologic unit in the 300-FF-5 area.

The 300 Area is near the axis of the Pasco Basin syncline. This axis location is considered to be the regional sink or discharge area for the confined aquifers, with groundwater flowing upward through the confining layer regionally because of the hydraulic head difference and into the overlying unconfined aquifer. Hydraulic head differences across the confining unit of the Ringold Formation have been measured in the range of 20 to 35 ft, with higher heads below the confining layer, indicating a large upward gradient. The rate and volume of flow through the confining layer are probably quite low at a given location, but regionally may contribute to maintaining the water level in the unconfined aquifer and supplying base flow to the Columbia River.

The confined aquifer occurs within the uppermost basalt flow of the Saddle Mountains Basalt and is penetrated by only seven wells (399-1-9, 399-1-16C, 399-1-16D, 399-1-17C, 399-1-18C, 399-4-5, and 399-5-2) at six locations within the 300-FF-5 operable unit (Figure 11). Two of these wells, 399-4-5 and 399-5-2, penetrate more than 100 ft into the Saddle Mountains Basalt, while the other 5 penetrate only a few feet. Water levels in all of the wells, except 399-1-18C, are approximately 20 to 35 ft higher than water levels in adjacent monitoring wells screened in the unconfined aquifer; therefore, a significant upward gradient exists between the confined aquifer and the overlying unconfined aquifer (Schalla et al. 1988). The water level in well 399-1-17C is often a few tenths of a foot higher than land surface. The lowermost mud facies (M3 in Figure 9) of the Ringold Formation is relatively impervious and appears to be the primary confining layer for this aquifer. Despite the large upward gradient, only extremely small volumes of water are transported through the silts and clays of the M3 layer. The water level in well 399-1-18C is the same as in the unconfined aquifer, yet it is screened in the confined geologic facies below the M3 layer. Schalla et al. (1988) concluded that this well must be interconnected to the unconfined aquifer. This connection has not been observed in other wells screened in the confined aquifer. This situation is more completely discussed in Section 3.1.3.2.

Transmissivities of the uppermost zone of the Saddle Mountains Basalt measured in the 300 Area vary from 125 to 1,300 ft^2/d (Schalla et al. 1988). Across the Hanford Site, the transmissivities of the Saddle Mountains Basalt vary from 1.6 to 100 ft^2/d. Hydraulic conductivities measured in the 300 Area vary from 6 to 260 ft/d, compared to hydraulic conductivities in the flow tops of the Saddle Mountains Basalt that vary from 0.01 to 1,000 ft/d across the Hanford Site (Gephart et al. 1983). The dense interiors of the basalt flows are both considerably less permeable and thicker than the flow contacts and form confining layers. Sedimentary interbeds between successive basalt flows

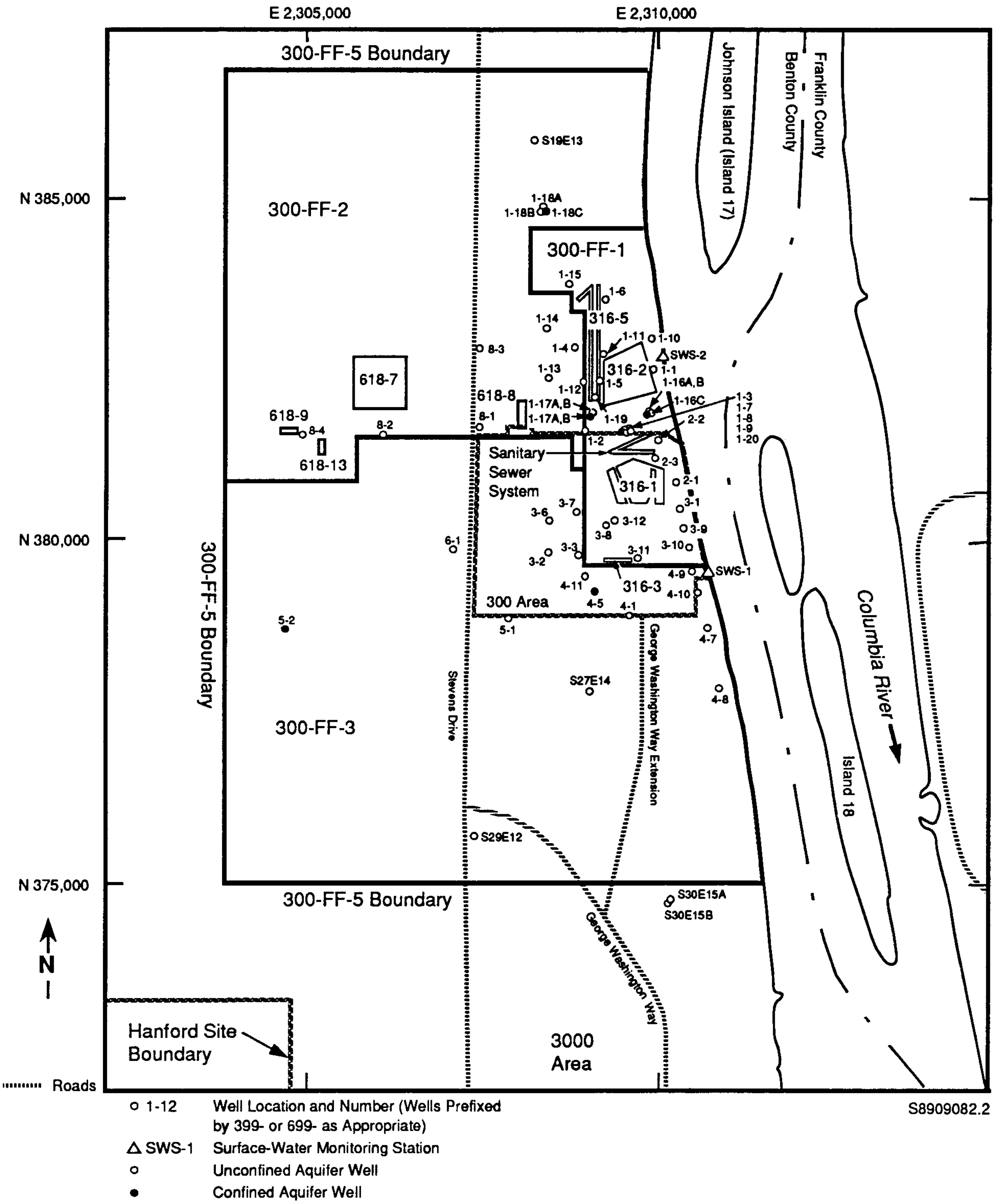


Figure 11. Location of 300-FF-5 Operable Unit and All Existing Wells Screened in the Confined or Unconfined Aquifers as of June 1989.

generally consist of silts and clays, with intermittent sand or gravel stringers. The majority (80%) of sedimentary interbeds within the upper basalts have moderate hydraulic conductivities, ranging from 1 to 10 ft/d (DOE 1988). Sediments immediately overlying the erosional surface of the basalt flows in the 300 Area may contribute a substantial portion of the total transmissivity of the uppermost permeable zone in the confined aquifer (Schalla et al. 1988).

Table 5 summarizes the hydraulic properties of the suprabasalt aquifer units and the upper confined aquifer in the 300 Area in comparison with the hydraulic properties of the same units over the Hanford Site in general. The values for the Hanford Site do not include the 300 Area because those values are cited from more recent work (Schalla et al. 1988).

Table 5. Hydraulic Properties of Aquifer Units (from DOE 1988, Schalla et al. 1988).

Hydraulic property	Hanford Site	300 Area
Hydraulic conductivity (ft/d)		
Hanford formation	500-20,000	11,000-50,000
Undiff. Hanford/Middle Ringold	100-7,000	ND
Ringold Formation	0.1-7,000	1.9-10,000
Middle Ringold	20-600	ND
Lower Ringold	0.11-10	ND
Upper confined aquifer	0.01-1,000	ND
Transmissivity (ft^2/d)		
Hanford formation	ND	40,000-200,000
Upper Ringold Formation	ND	10,000-1,000,000
Lower Ringold Formation	ND	8-200
North Gable Mountain/ Gable Butte	4,000-25,000	ND
Flank Gable Mountain/ Gable Butte/ paleochannels	40,000-600,000	ND
Other Hanford areas	2,000-40,000	ND
Upper confined aquifer	ND	1.6-200
Storage coefficient		
Hanford formation	0.03-0.2	ND
Ringold Formation	0.0002-0.05	0.008
Throughout suprabasalt section	0.01-0.1	ND

ND = No data available.

2.2.3.2 Unconfined Aquifer. In the 300-FF-5 operable unit, the water table is located near the contact between the Hanford and Ringold Formations. The water table is at a depth of approximately 30 to 70 ft below land surface, and the contact between the Hanford and Ringold Formations is between 35 to 65 ft below land surface. Therefore, depending on location, the water table is present in both formations. The lower part of the unconfined aquifer in the Ringold Formation may be hydraulically isolated in some sand and gravel lenses by the thin interbeds of silt and clay (e.g., M1 and M2 in Figure 9).

The hydraulic properties of the unconfined aquifer vary considerably with location due to changes in local stratigraphy. The hydraulic conductivity of the unconfined aquifer generally decreases with depth. Hydraulic conductivities measured in the 300 Area for the Hanford formation vary from 11,000 to 50,000 ft/d, compared to hydraulic conductivities in the Hanford Site that vary from 500 to 20,000 ft/d (Gephart et al. 1979). Hydraulic conductivities measured in the 300 Area for the Ringold Formation vary from 1.9 to 10,000 ft/d, compared to hydraulic conductivities in the Hanford Site that vary from 0.1 to 10,000 ft/d (DOE 1988, Schalla et al. 1988). Storage coefficients are estimated to vary from 0.03 to 0.2 for the Hanford formation and 0.0002 to 0.05 for the Ringold Formation (DOE 1988). Only one storage coefficient (0.008) was determined in the 300 Area; it is for the lowermost sandy gravels of the Ringold Formation above the M3 (see Figure 9) mud layer (Schalla et al. 1988).

The Hanford formation in the 300 Area typically consists of sandy gravel with few cobbles and boulders in the upper half of the unit and sandy gravel with more cobbles and boulders in the lower half. Only a small portion of the lower half of the Hanford formation is usually saturated with water. These sediments vary from 30 to 65 ft in thickness. The transmissivity is consistently high, varying from 40,000 to 200,000 ft^2/d (Schalla et al. 1988). Aquifer test data indicate that much of the transmissivity in the unconfined aquifer in the 300 Area is attributable to the uppermost Ringold Formation sediments, varying from 10,000 to 1,000,000 ft^2/d (Schalla et al. 1988). The transmissivity of the Ringold Formation decreases with depth. For example, the 10-ft interval above the M3 (see Figure 9) mud layer has transmissivities ranging from 8 to 200 ft^2/d.

Natural recharge of the unconfined aquifer beneath the Hanford Site occurs at the northwestern margin of the Pasco Basin along topographic ridges. Artificial recharge occurs from current operations in the 200 Areas (that are near the center of the Hanford Site) and in the 300 Area. Groundwater flows in a general southeasterly direction from these recharge areas toward the 300 Area. In the southeastern corner of the Hanford Site, groundwater recharge is mainly from the Yakima River. The 300 Area is located approximately at the point where these two groundwater sources meet. As a result, groundwater enters the 300 Area from the northwest, west, and southwest (Lindberg and Bond 1979). A contour map of the water-table surface for the Hanford Site is shown in Figure 12.

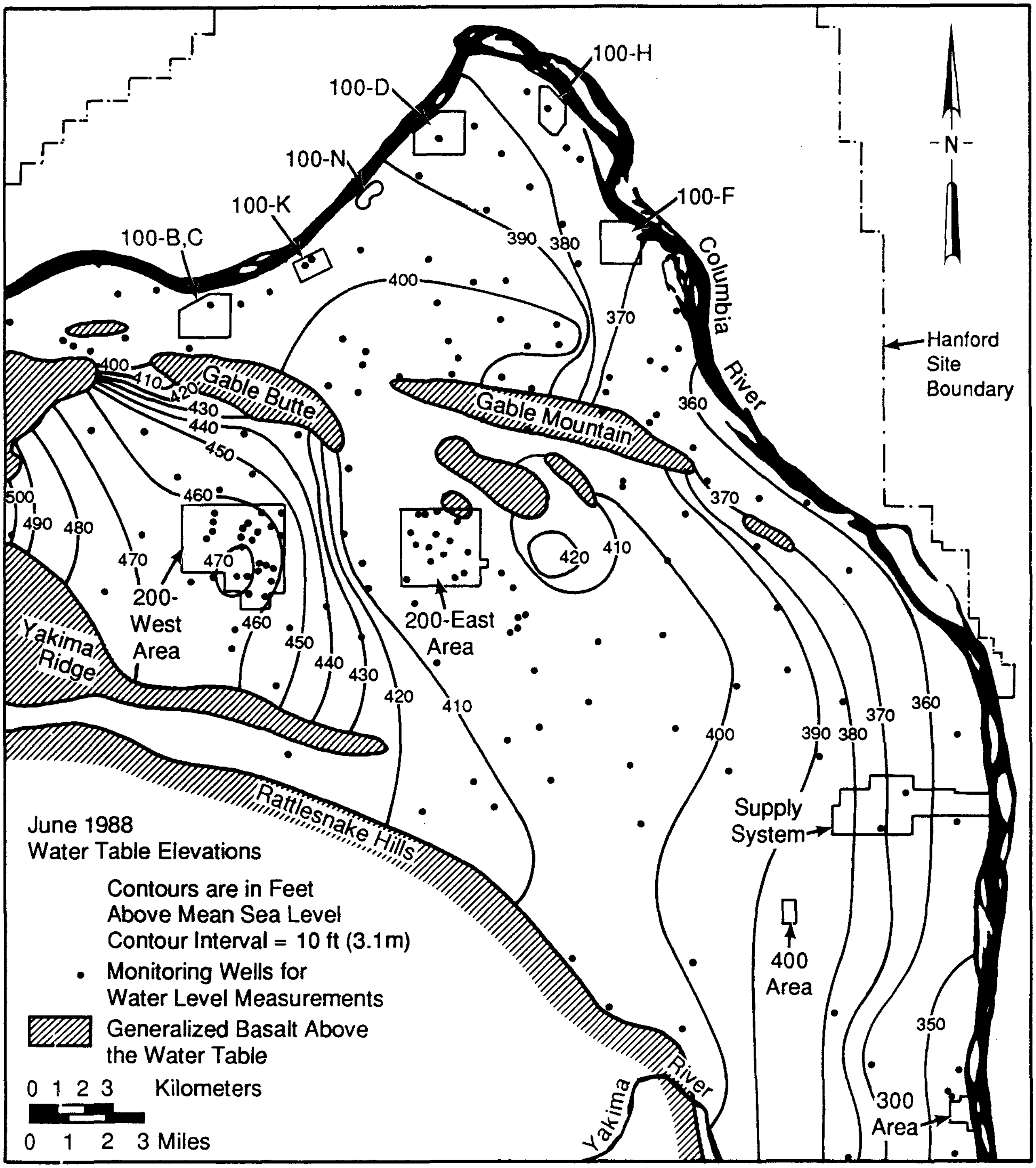


Figure 12. Water-Table Elevations for June 1988 (from Evans et al. 1989).

In the 300 Area, groundwater generally flows toward the Columbia River to the southeast (Figures 13 and 14). The exact direction of groundwater flow at any given time, however, is influenced by both natural and anthropogenic factors. The primary factor influencing groundwater levels is the water level in the Columbia River. Lindberg and Bond (1979) verified that when the river stage rises during spring runoff, bank storage occurs and causes a reversal in the normal water-table gradient in the 300 Area. During these times, groundwater tends to flow in a more southerly direction, roughly subparallel to the river, as shown Figure 15. When the river level drops, the normal gradient is restored and groundwater flows more easterly in a direction nearly perpendicular to the river. The effects of river-level fluctuation have been measured at locations up to 2.5 mi from the river. These effects are dampened with distance from the river.

Lindberg and Bond (1979) suggest that the former river channel (paleochannel) exposed in a 1958 excavation is responsible for the rapid response of groundwater levels to changes in river stage. The response is more rapid than elsewhere because Hanford formation gravels and reworked Ringold Formation gravels are more permeable than most of the surrounding Ringold Formation sediments. For example, the hydraulic gradient is steeper in the Ringold Formation sediments to the west and south of the 300 Area than in the paleochannel that extends north and south under the 300 Area (see Figure 15). A remnant of lower conductivity Ringold Formation sediments is believed to be present along the river adjacent to the 300-FF-5 operable unit. These sediments are of lower hydraulic conductivity than the surrounding reworked gravel and may act as a hydraulic barrier to easterly groundwater flow. However, based on water-level contour maps, there appear to be breaches in this barrier. Evidence of this phenomena is indicated in Figure 14 by small areas along the river with steep gradients. Lindberg and Bond (1979) suggested that the channel merges with the Columbia River approximately 2 mi to the north and approximately 1 mi to the south of the 300 Area.

The primary anthropogenic influence on groundwater levels and flow directions in the 300 Area is from 316-5 (the process trenches). Discharges to the trenches peaked at 3,000,000 gal/d in 1987 and declined to 1,000,000 gal/d with the end of fuel fabrication activities in February 1987. Discharges to the nearby sanitary trenches range up to 500,000 gal/d. These large volumes of water percolate quickly to the groundwater and create small groundwater mounds. The mounds increase the water-table gradient and produce divergent flow particularly around 316-5 (see Figure 13).

2.2.3.3 Vadose Zone. The vadose zone that lies above the water table is described in the 300-FF-1 Work Plan. The description of the vadose zone given in the 300-FF-1 Work Plan is considered to be representative of this zone in the 300-FF-5 area. No reasons or data are known to suggest that the conditions described for 300-FF-1 are discontinuous or different in the 300-FF-5 area.

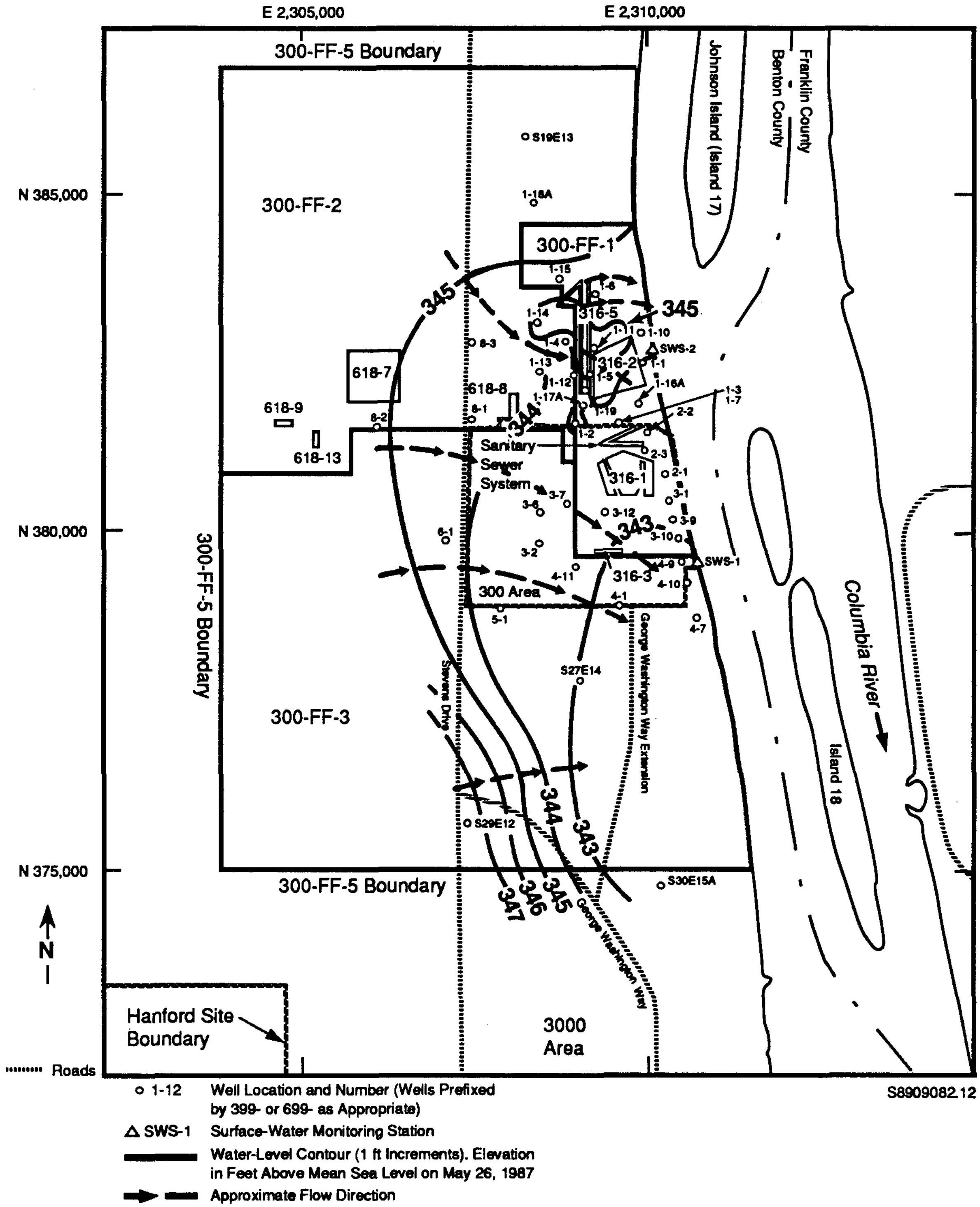


Figure 13. Water-Level Contour Map of the Unconfined Aquifer, Measured on May 26, 1987 (after Schalla et al. 1988).

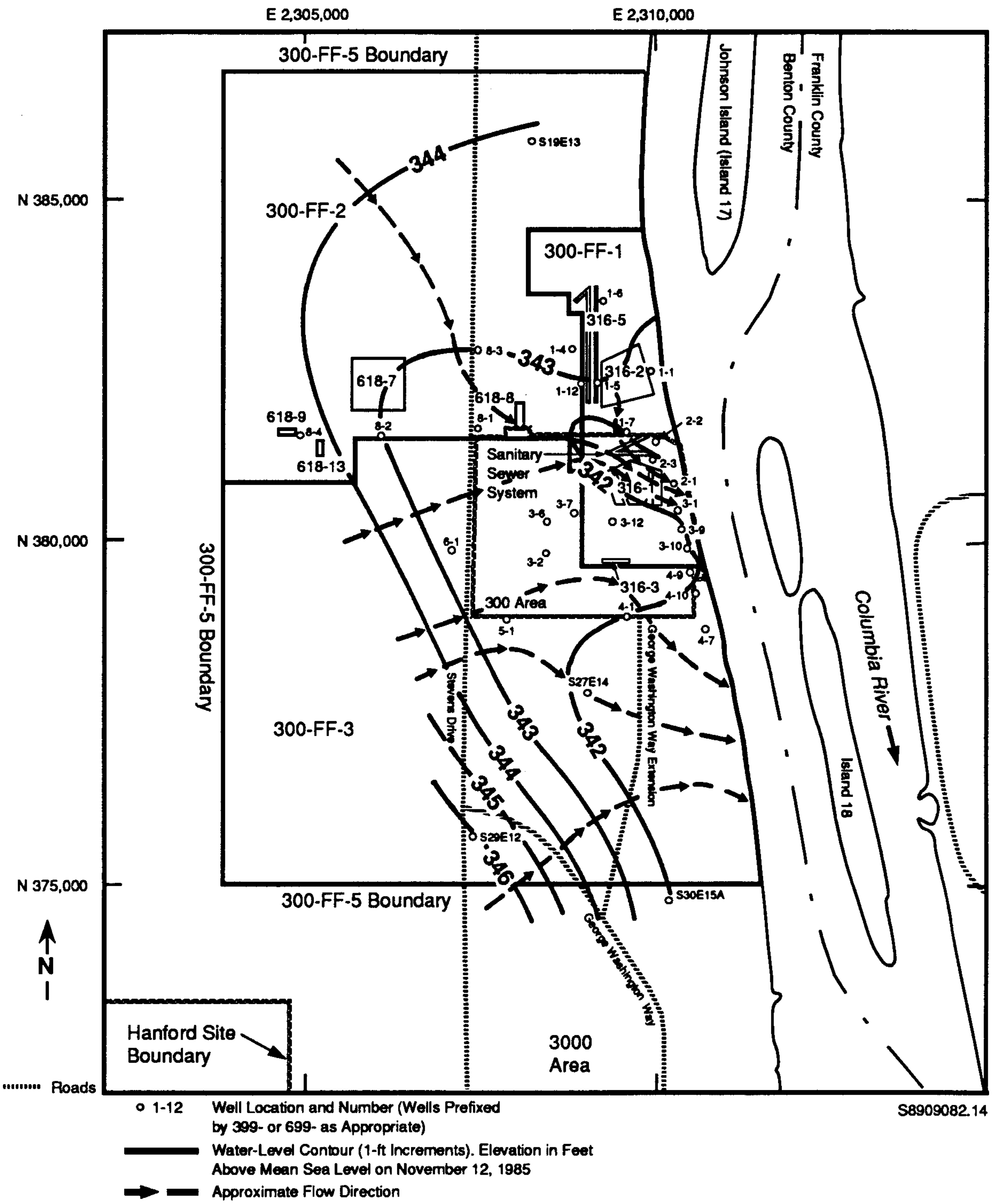
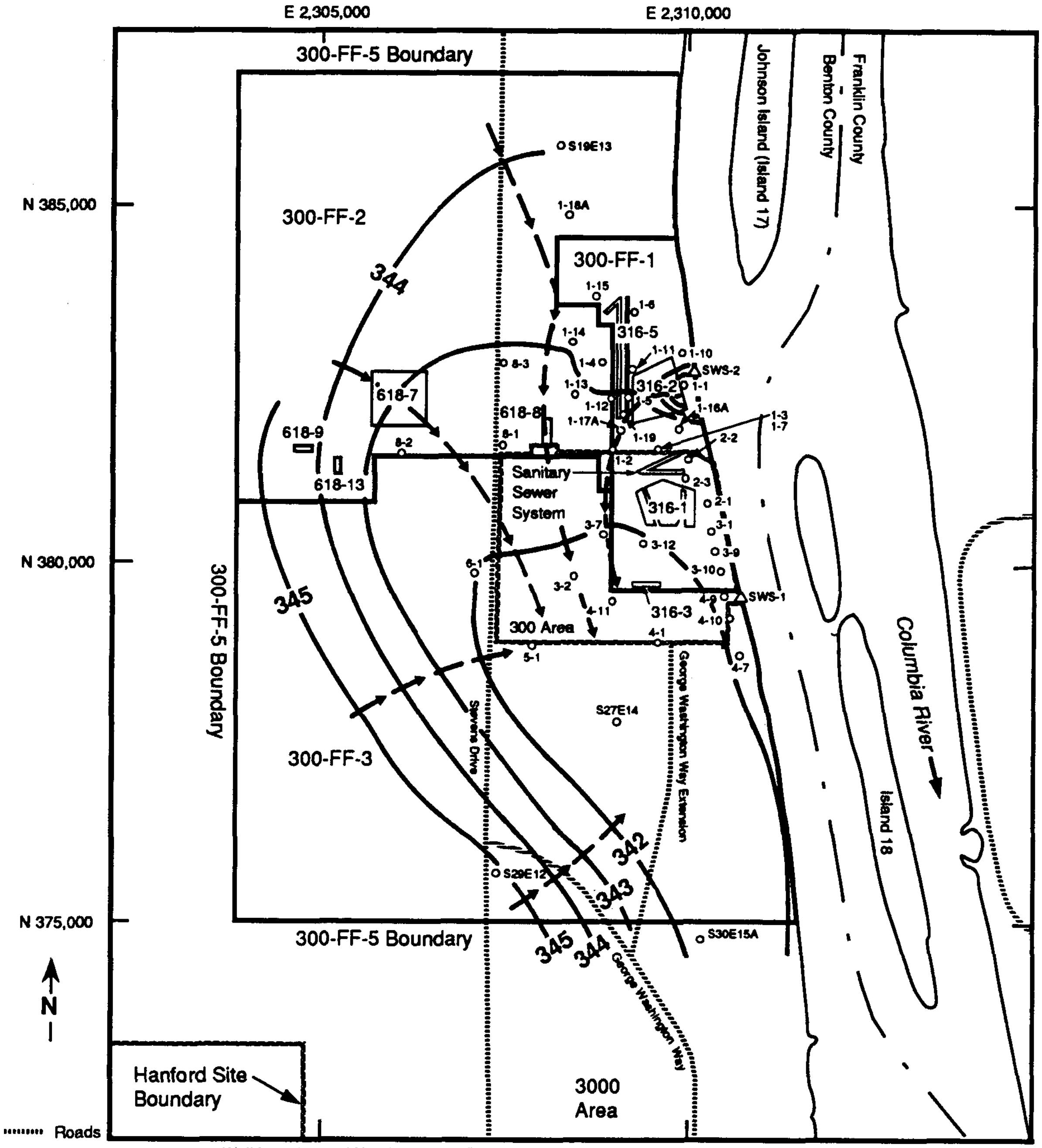


Figure 14. Water-Level Contour Map of the Unconfined Aquifer, Measured on November 12, 1985 (after Schalla et al. 1988).



o 1-12 Well Location and Number (Wells Prefixed by 399- or 699- as Appropriate)

△ SWS-1 Surface-Water Monitoring Station

Water-Level Contour (1-ft Increments). Elevation in Feet Above Mean Sea Level on April 30, 1987

Approximate Flow Direction

Figure 15. Water-Level Contour Map of the Unconfined Aquifer, Measured on April 30, 1987 (after Schalla et al. 1988).

2.2.4 Surface-Water Hydrology

2.2.4.1 Drainage Patterns. No well-defined drainage channels exist within the 300-FF-5 operable unit.

As described in Section 2.2.2, soils of the 300-FF-5 operable unit consist primarily of coarse sands, pebbles, cobbles, and boulders that are highly permeable. Direct precipitation over the unit is essentially lost through evapotranspiration and infiltration (ERDA 1975). Average precipitation, 6.25 in./yr (Stone et al. 1983), in combination with high potential evapotranspiration, approximately 60 in./yr (Gee et al. 1989), and soil infiltration capacities, is generally insufficient to generate surface runoff. Typically, there are only two occurrences per year with precipitation of 0.5 in. or more during a 24-h period, which may result in some local ponding (Stone et al. 1983). However, no runoff from the operable unit is expected during these events. This will be addressed in the RI/FS for 300-FF-1, 300-FF-2, and 300-FF-3.

2.2.4.2 Surface Water. Two types of surface water exist on the 300-FF-5 operable unit: the Columbia River and groundwater seeps along the riverbank. Small groundwater seeps have been observed along the stretch of the river bounded by the operable unit. Several seepage areas (groundwater discharge) have been documented within the 300-FF-5 operable unit boundaries as shown in Figure 16 (after McCormack and Carlile 1984). These relatively small springs flow intermittently, influenced primarily by changes in river level. During periods of high river stage, the flow of groundwater may be temporarily reversed, as discussed in Section 2.2.3. The volume of the seep discharges has not been quantified. However, estimates of seepage from a stretch of the river upstream of the operable unit were as low as 3 ft^3/s, as compared to the 100,000 ft^3/s of the Columbia River (Cline et al. 1985). No other naturally occurring surface water exists on or near 300-FF-5.

The only permanently flowing surface water at the 300-FF-5 operable unit is the Columbia River. The Columbia River is the largest river in the Pacific Northwest and the fifth largest river (by volume) in North America. Above Priest Rapids Dam, the Columbia River drains an area of approximately 95,500 mi^2 in Washington, Idaho, Montana, and British Columbia. The river's flow is regulated by 11 dams within the United States: 7 upstream and 4 downstream of the Hanford Site. A schematic of the hydraulic regime of the Columbia River within the United States is provided in Figure 17. Priest Rapids Dam, located at approximate river mile 397, is the nearest impoundment upstream of the Hanford Site. McNary Dam is the nearest dam downstream, at river mile 292. The 300-FF-5 operable unit lies between approximate river miles 345.5 and 344.5. No perennial or ephemeral tributaries enter the Columbia River between Priest Rapids Dam and the Yakima River confluence just south of the city of Richland. Irrigation return flow does enter the Columbia River on the Franklin County side in the form of distributed seeps and constructed wasteways.

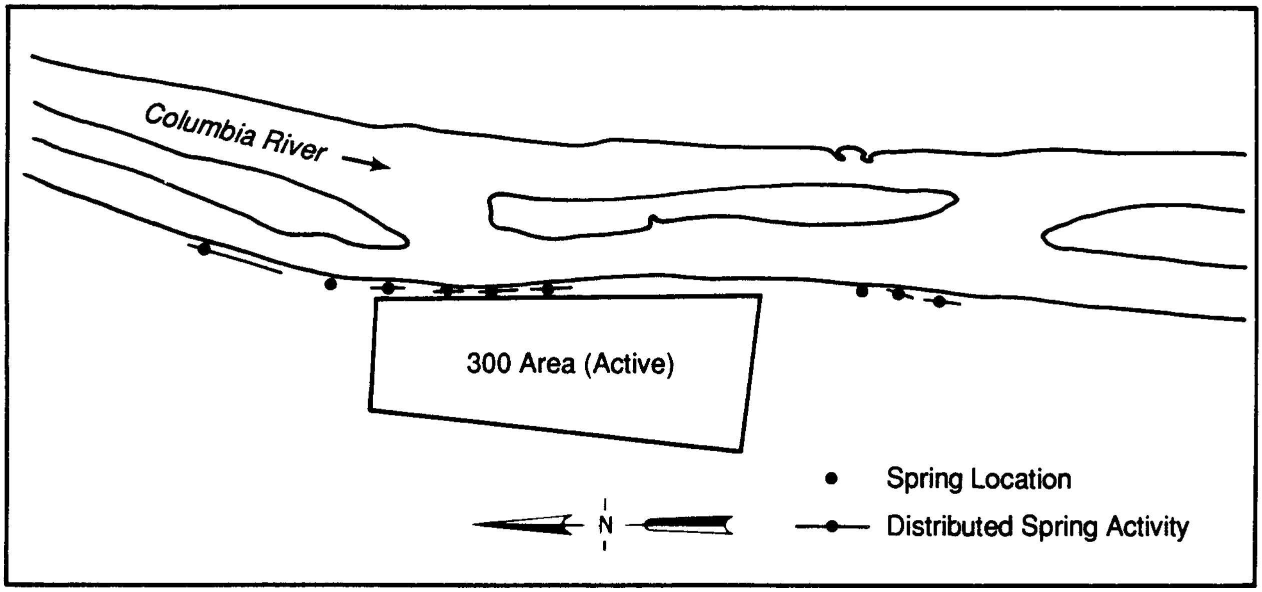


Figure 16. Approximate Locations of Riverbank Springs (after McCormack and Carlile 1984).

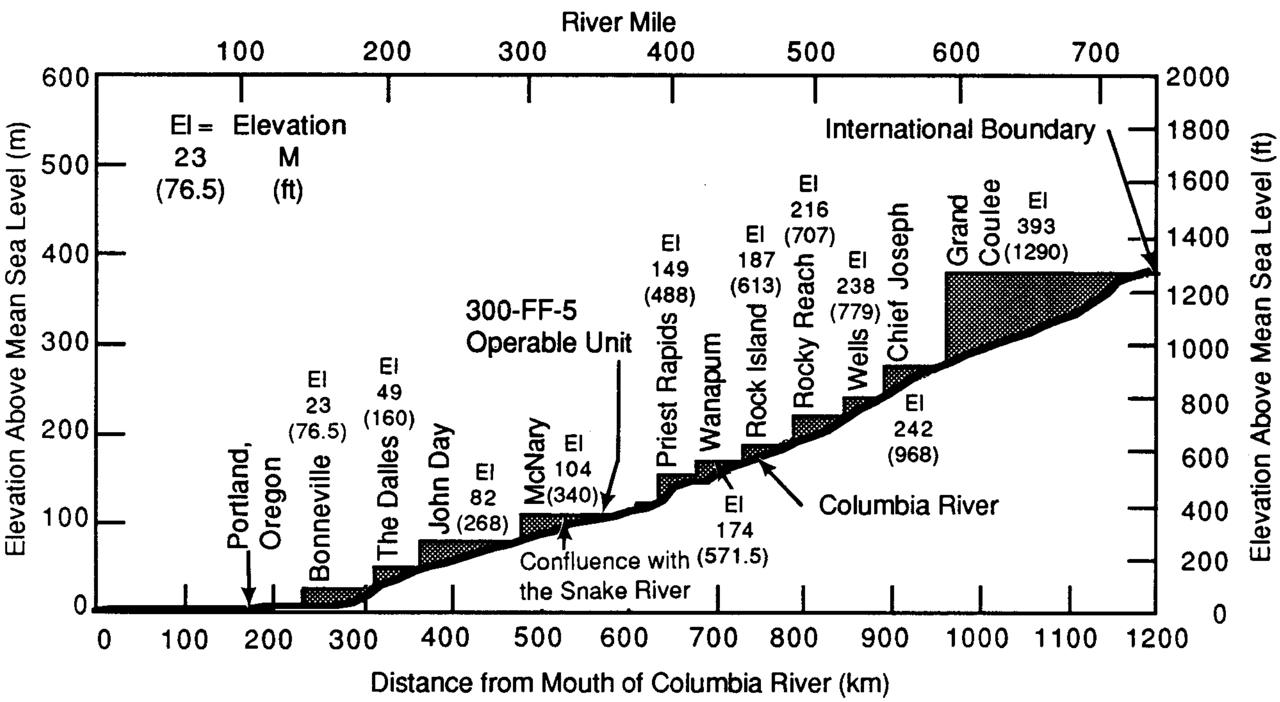


Figure 17. Schematic Representation of the Hydraulic Regime of the Columbia River, Showing Major Dams (after DOE 1982).

The Hanford reach, the last free-flowing stretch of the Columbia River in the United States, extends from Priest Rapids Dam to the head of Lake Wallula, which is created by McNary Dam, at approximate river mile 351 near the operable unit. The river near 300-FF-5 is, therefore, influenced by both the upstream flow patterns and the operational practices downstream at McNary Dam. The wetted width of the river near the operable unit varies from approximately 1,800 to 3,000 ft. The range is due, primarily, to the presence of islands. Through the Hanford reach, the Columbia River is characterized by a narrow modern floodplain, one- to two-terrace levels, numerous point bars, and extensive islands. Typical maximum river depths in the vicinity of the 300-FF-5 operable unit range from 10 to 40 ft at normal flow rates. The current channel is relatively stable, with no documented changes in width or depth (other than those due to impoundment by dams) since 1891, despite the 1894 and 1948 floods. River elevation may fluctuate several feet daily near 300-FF-5 as a result of hourly variations in water releases from nearby dams (ERDA 1975).

Although the Hanford reach is free flowing, the flow rate is regulated. Flows through this stretch fluctuate significantly because of the relatively small storage capacities and the operational practices of the nearby upstream dams. Flow through the Hanford reach of the river is relatively swift, with surface velocities of less than 3 ft/s to greater than 11 ft/s, depending on the river flow rate (ERDA 1975). A minimum flow rate of 36,000 ft^3/s has been established at Priest Rapids Dam. Typical daily flows during the summer, fall, and winter range from 36,000 to 250,000 ft^3/s. Flows up to 450,000 ft^3/s are frequently recorded during periods of peak spring runoff. Average monthly flow rates generally peak from April through June, and the lowest monthly mean flows are observed during September and October. Recent annual average flows at Priest Rapids Dam range from 100,000 to 120,000 ft^3/s. The long-term average annual flow at Priest Rapids Dam, based on 68 yr of record, is approximately 120,000 ft^3/s (McGavock et al. 1987).

Maximum Columbia River floods of historical record occurred in 1894 and 1948. Maximum flows during these floods were approximately 740,000 and 690,000 ft^3/s, respectively (McGavock et al. 1987). Similar floods today would be of little consequence to the 300-FF-5 operable unit (DOE 1982). Construction of several flood-control, water-storage, and electric power-generation dams upstream of the Hanford Site since the 1948 flood has significantly reduced the likelihood of flows of this magnitude occurring in this reach (DOE 1987). The probable maximum flood, a theoretical maximum flood resulting from the most severe combination of environmental and hydrologic conditions reasonably possible in the region, was calculated by the U.S. Army Corps of Engineers to produce a flow, under current regulated conditions, of approximately 1,400,000 ft^3/s (ERDA 1975). This flood is determined using conditions that result in maximum runoff, such as maximum precipitation falling on the drainage area and the upper limits of other hydrologic factors, including antecedent moisture conditions, snowmelt and tributary conditions. A flood of this magnitude would be expected to inundate much of the river shoreline and essentially separate the operable unit from the mainland (DOE 1982, 1987; Cushing 1988). However, most of the land surface above the 300-FF-5 operable unit would not be expected to be submerged (Figure 18).

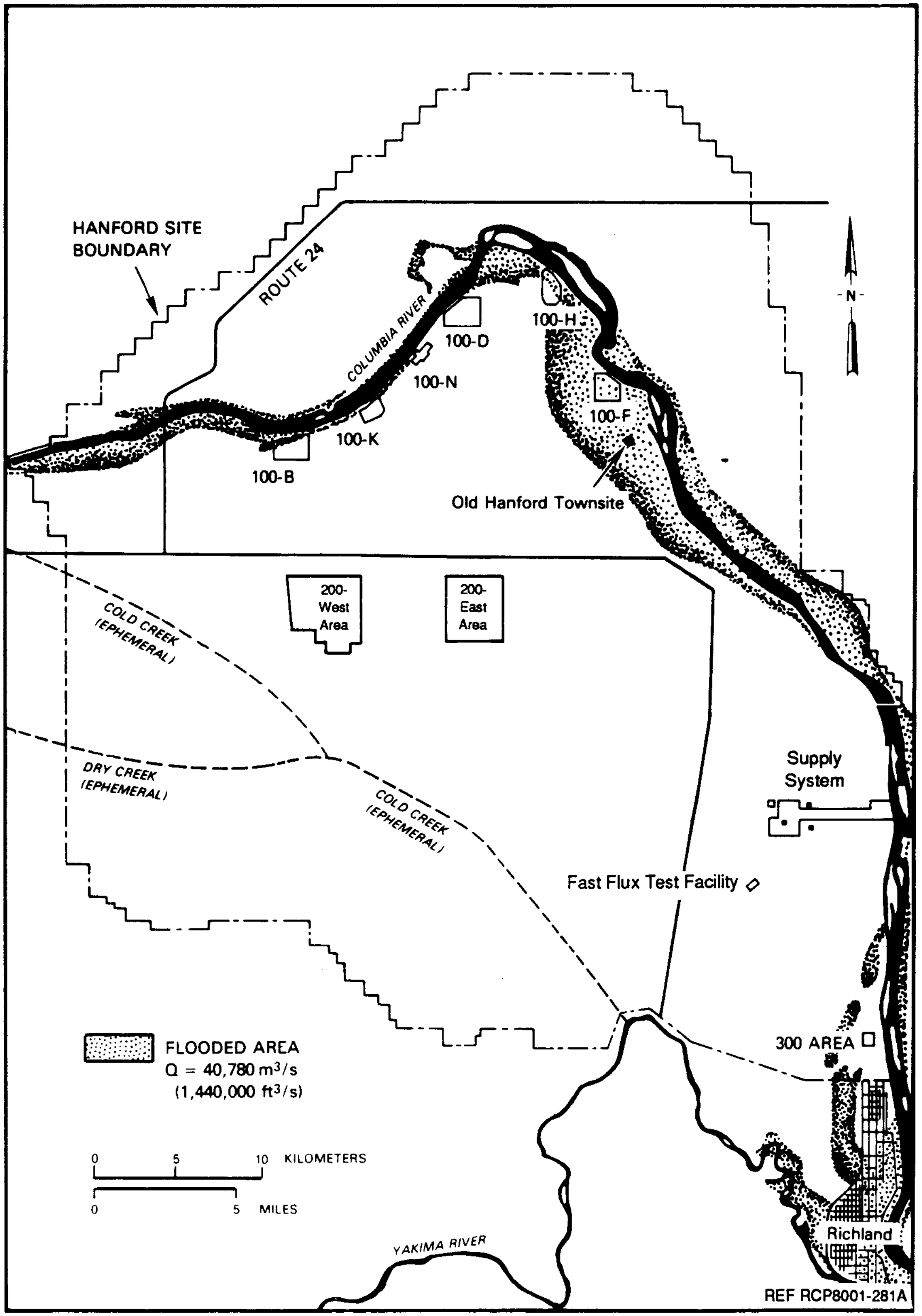


Figure 18. Flooded Area for the Probable Maximum Flood (after DOE 1982).

Flow around and between islands is complex and changes with changing flow rate. In the vicinity of the 300 Area, the deepest part of the channel crosses from its position east of Johnson Island to a location west of the unnamed islands adjacent to and downstream of the area. Once south of those islands, the channel again crosses over to the east and remains in that position until about the location of the city of Richland, where it establishes a more central course. Dye and contaminant dispersion studies indicate that channelization of flow is strong at low discharges, but becomes more diffuse at higher flows.

In the vicinity of the 300 Area, the channel bed of the Columbia River is composed of an undetermined thickness of cobbles and boulders. The boulders may be up to 1 m or more in diameter. Underlying finer material consists of pebbles and coarse to fine sand that have been trapped in the interstices either through kinetic sieving or as a lag deposit. Near-shore and beach area sediments are predominantly coarse to fine or very fine sand with some cobbles and boulders. Slack-water sediments in some slough areas grade from sand to silt and clay. Islands in the channel adjacent to the 300 Area are predominantly coarse grained, consisting primarily of cobbles and coarse sand, with possibly some finer sand and silt blown in or deposited as overbank sediment.

2.2.5 Meteorology

Meteorology related to the 300-FF-5 operable unit is discussed in Section 2.2.5 of the 300-FF-1 Work Plan. It is essentially the same for both operable units.

2.2.6 Environmental Resources

The Columbia River is the dominant aquatic ecosystem on the Hanford Site near the 300 Area, and supports a large and diverse community of plankton, benthic invertebrates, fish, and other communities. Plankton populations in the Hanford reach are influenced by communities that develop in the reservoirs of upstream dams, particularly Priest Rapids reservoir. Phytoplankton and zooplankton populations at Hanford are largely transient, flowing from one reservoir to another. Generally, insufficient time is available for characteristic endemic groups of phytoplankton and zooplankton to develop in the Hanford reach.

The Columbia River is a complex ecosystem because of its size, number of manmade alterations, diversity of the biota, and size and diversity of its drainage basin. Streams in general, especially smaller ones, usually depend on organic matter from outside sources (terrestrial plant debris) to provide energy for the ecosystem. The Columbia River, with its series of large reservoirs, contains significant populations of primary energy producers (algae, plants) that contribute to the basic energy requirements of the biota. Phytoplankton (free-floating algae) are abundant throughout the river, and periphyton (sessile algae) are abundant in the littoral zone in the river and provide food for herbivores, such as immature insects that are consumed by carnivorous species. Figure 19 shows a simplified diagram of the food-web relationships in selected Columbia River biota and represents probable major energy pathways.

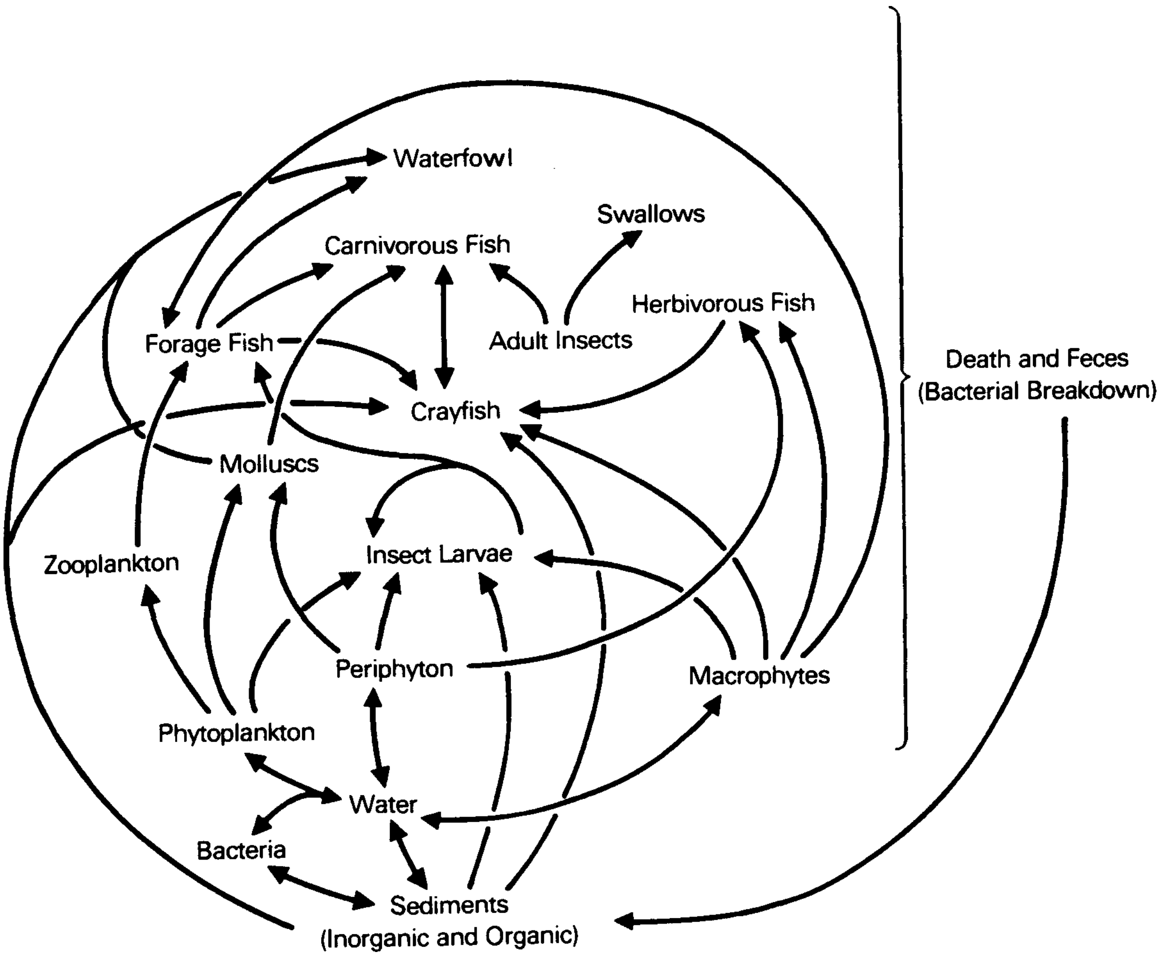


Figure 19. Food Web in the Columbia River.

2.2.6.1 Flora and Fauna

2.2.6.1.1 Riparian Flora. The shoreline vegetation along both sides of the Columbia River in the vicinity of the 300-FF-5 operable unit consists mostly of a narrow zone of perennial herbs with a few scattered deciduous trees and shrubs. The important shrubs and trees are willows, *Salix exigua*, *Salix* spp., and mulberry, *Morus alba*. Reed canary grass, *Phalaris arundinacea*, is an abundant grass. Other plant species are coreopsis, *Coreopsis atkinsonia*, gaillardia, *Gaillardia aristata*, lupine, *Lupinus* spp., sedges, *Carex* spp., wiregrass, *Eleocharis* spp., and others. These plants provide food and cover for wild animals that inhabit the riparian zone. Garden asparagus, *Asparagus officinalis*, also grows in the riparian zone in the operable unit.

Persistent sepal yellow cress, *Rorippa columbiae*, is an important riparian zone plant because it is regarded as a candidate for the Federal endangered species list (Sauer and Leder 1985, DNR 1988). Persistent sepal yellow cress grows all along the riparian zone of the Columbia River on the Hanford Site and is likely to be found in the 300 FF-5 operable unit. If present, it would require special protection if any remedial actions take place in the riparian zone and the State of Washington Heritage Program Office would be notified.

The shoreline vegetation along the Hanford reach has been changing from year to year as a result of regulated water-level fluctuations created by upstream hydroelectric dams (Fickeisen et al. 1980, Rickard et al. 1980). Generally, the water-level fluctuations have favored the growth of shrub willows and reed canary grass at the expense of short, water-saturated herbs.

2.2.6.1.2 Aquatic Flora

2.2.6.1.2.1 Phytoplankton. Phytoplankton species identified from the Hanford reach include diatoms, golden or yellow-brown algae, green algae, blue-green algae, red algae, and dinoflagellates. Diatoms are the dominant algae in the Columbia River phytoplankton, usually representing more than 90% of the populations. The main genera include *Asterionella*, *Cyclotella*, *Fragillaria*, *Melosira*, *Stephandodiscus*, and *Synedra* (Neitzel et al. 1982a). These forms are typical of those found in lakes and ponds and they originate in upstream reservoirs. A number of algae found as free-floating species in the Hanford reach are derived from the periphyton; they are detached and suspended by the current and frequent water-level fluctuations. The peak concentration of phytoplankton is observed in April and May, with a secondary peak in late summer/early autumn (Cushing 1967a). The spring pulse in phytoplankton density is probably related to increasing light and water temperature rather than to availability of nutrients because phosphates and nitrates are not limiting. Minimum numbers are present in December and January. Green algae, *Chloroplyta*, and blue-green algae, *Cyanophyta*, occur in the phytoplankton community during warmer months, but in substantially fewer numbers than the diatoms. Diversity indices, carbon uptake, and chlorophyll α concentrations for the phytoplankton at various times and places can be found in Wolf et al. (1976), Beak (1980), and Neitzel et al. (1982a).

2.2.6.1.2.2 Periphyton. Communities of periphytic species (benthic microflora) develop on suitable solid substrates wherever there is sufficient light for photosynthesis. Peaks of production occur in spring and late summer (Cushing 1967b). Dominant genera are the diatoms *Achnanthes*, *Asterionella*, *Cocconeis*, *Fragillaria*, *Gomphonema*, *Melosira*, *Nitzchia*, *Stephanodiscus*, and *Synedra* (Page and Neitzel 1978, Page et al. 1979, Beak 1980, Neitzel et al. 1982a).

2.2.6.1.2.3 Macrophytes. Macrophytes are sparse in the Columbia River because of its strong currents, rocky bottom, and frequently fluctuating water levels. Rushes, *Juncus* spp., and sedges occur along the shorelines of the 300 Area. Macrophytes are present also along gently sloping shorelines that are subject to flooding during the spring freshet and daily fluctuating river levels (below Coyote Rapids and the 100-D Area). Commonly found plants include duckweed, *Lemna*, pondweed, *Potamogeton*, waterweed, *Elodea*, and watermilfoil, *Myriophyllum*. Where they exist, macrophytes have considerable ecological value; they provide food and shelter for juvenile fish and spawning areas for some species of warm-water game fish.

2.2.6.1.3 Aquatic Fauna

2.2.6.1.3.1 Zooplankton. The zooplankton populations in the Hanford reach are generally sparse. In open-water regions, crustacean zooplankters are dominant. Dominant genera are *Bosmina*, *Diaptomus*, and *Cyclops*. Densities are lowest in winter and highest in summer. Summer peaks are dominated by *Bosmina* and range up to 4,500 organisms/m^3. Winter densities are generally less than 50 organisms/m^3. *Diaptomus* and *Cyclops* dominate in winter and spring, respectively (Neitzel et al. 1982b).

2.2.6.1.3.2 Benthic Macroinvertebrates. Benthic organisms are found either attached to or closely associated with the substrate. All major fresh-water benthic taxa are represented in the Columbia River. Insect larvae, such as caddisflies, *Trichoptera*, midge flies, *Chironomidae*, and black flies, *Simuliidae*, are dominant. Dominant caddisfly species are *Hydropsyche cockerelli*, *Cheumatopsyche campyla*, and *C. enonis*. Other benthic organisms include limpets, snails, sponges, and crayfish. Peak larval insect densities are found in late fall and winter, and the major emergence is in spring and summer (Wolf 1976). Stomach contents of fish collected in the Hanford reach from June 1973 through March 1980 revealed that benthic invertebrates are important food items for nearly all juvenile and adult fish. A close relationship exists between food organisms in the stomach contents and those in the benthic and invertebrate drift communities. Two candidates for inclusion on the threatened and endangered species list are the giant Columbia River limpet, *Fisherola nuttalli*, and the great Columbia River spire snail, *Fluminacola columbiana*.

2.2.6.1.3.3 Fish. Gray and Dauble (1977) list 43 species of fish in the Hanford reach; since 1977 the brown bullhead, *Ictalurus nebulosus*, also has been collected, bringing the total number of fish species identified in the Hanford reach to 44 (Table 6). Of these 44 species, the chinook salmon, *Oncorhynchus tshawytscha*, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *Oncorhynchus kisutch*, and steelhead trout, *Oncorhynchus mykiss*, use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. The fall chinook salmon and steelhead trout also spawn in the Hanford reach. Since 1962, the Hanford reach spawning population has represented approximately 15% to 20% of the total fall chinook escapement to the river. The destruction of other mainstream Columbia River spawning grounds by dams has increased the relative spawning importance of the Hanford reach (Watson 1970, 1973).

Table 6. Fish Species in the Hanford Reach of the Columbia River. (Sheet 1 of 2)

Common name	Scientific name
White sturgeon	*Acipenser transmontanus*
Bridgelip sucker	*Catostomus columbianus*
Largescale sucker	*Catostomus macrocheilus*
Mountain sucker	*Catostomus platyrhynchus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
American shad	*Alosa sapidissima*
Prickley sculpin	*Cottus asper*
Mottled sculpin	*Cottus bairdi*
Piute sculpin	*Cottus beldingi*
Reticulate sculpin	*Cottus perlexus*
Torrent sculpin	*Cottus rhotheus*
Chiselmouth	*Acrocheilus alutaceus*
Carp	*Cyprinus carpio*
Peamouth	*Mylocheilus caurinus*
Northern squawfish	*Ptychocheilus oregonensis*
Longnose dace	*Rhinichthys cataractae*
Leopard dace	*Rhinichthys falcatus*

Table 6. Fish Species in the Hanford Reach of the Columbia River. (Sheet 2 of 2)

Common name	Scientific name
Speckled dace	*Rhinichthys osculus*
Redside shiner	*Richardsonius balteatus*
Tench	*Tinca tinca*
Burbot	*Lota lota*
Threespine stickleback	*Gasterosteus aculeatus*
Black bullhead	*Ictalurus melas*
Yellow bullhead	*Ictalurus natalis*
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Yellow perch	*Perch flavescens*
Walleye	*Stizostedion vitreum vitreum*
Sand roller	*Percopsis transmontanus*
Pacific lamprey	*Entosphenus tridentatus*
River lamprey	*Lampetra ayresi*
Lake whitefish	*Coregonus clupeaformis*
Coho salmon	*Oncorhynchus kisutch*
Sockeye salmon	*Oncorhynchus nerka*
Chinook salmon	*Oncorhynchus tshawytscha*
Mountain whitefish	*Prosopium williamsoni*
Cutthroat trout	*Oncorhynchus clarki*
Rainbow trout (steelhead)	*Oncorhynchus mykiss*
Dolly varden	*Salvelinus malma*

The annual average Hanford reach steelhead spawning population estimates for 1962 to 1971 were approximately 10,000 fish. The estimated annual sport catch for the period 1963 to 1968 in the Hanford reach, from Ringold to the mouth of the Snake River, was approximately 2,700 fish (Watson 1973).

The American shad, *Alosa sapidissima,* another anadromous species, also may spawn in the Hanford reach. The upstream range of the shad has been increasing since 1956, when less than 10 adult shad ascended McNary Dam. Since then, the number ascending Priest Rapids Dam has risen to many thousands each year, and the young of the year have been collected in the Hanford reach. The shad is not dependent on specific current and bottom conditions required by the salmonids for spawning, and has apparently found favorable conditions for reproduction throughout much of the Columbia and Snake Rivers.

Other important fish to sport fishermen are the whitefish, *Coregonus clueaformis*, sturgeon, *Acipenser transmontanus*, smallmouth bass, *Micropterus dolomieui*, crappie, *Pomoxis annularis* and *nigromaculatus*, catfish, *Ictalurus punctatus*, walleye, *Stizostedion vitreum vitreum,* and perch, *Perch flavescens.* Also, large populations of rough fish are present, including carp, *Cyprinus carpio*, shiners, *Richardsonius balteatus*, suckers, *Catostomus macrocheilus*, and squawfish, *Ptychocheilus oregonensis.*

2.2.6.1.4 Birds

2.2.6.1.4.1 Waterfowl. Migrating waterfowl, especially ducks and geese, use the Columbia River in the vicinity of the 300-FF-5 operable unit as a resting place in fall and winter months. Peak use occurs in the late-December through mid-January period, with numbers dropping in February. Most of the migrating birds are mallards, *Anas platyrhynchos*, and these birds make daily foraging flights to nearby agricultural fields. The islands near the 300-FF-5 operable unit are used extensively by waterfowl hunters during the fall-winter hunting season.

A resident population of Great Basin Canada geese, *Branta canadensis moffitti*, nest on islands close to and downstream from the 300-FF-5 operable unit (Fitzner and Rickard 1983). The mineral composition of eggs obtained from geese nesting on these islands provides data to determine if contaminants ingested by geese can be passed to eggs and embryos (Rickard and Fitzner 1985).

2.2.6.1.4.2 Fish-Eating Birds. Thousands of ring-billed gulls, *Larus delawarensis*, and California gulls, *L. californicus*, nest on islands close to and downstream of the 300-FF-5 operable unit. These islands also provide nesting sites for a few hundred Forster's terns, *Sterna forsteri.* Great blue herons, *Ardea herodias*, forage throughout the Hanford reach. The American white pelican, *Pelecanus erythrorhynchos*, has been seen roosting and feeding on and around islands 17 and 18. This species is listed as sensitive by the U.S. Fish and Wildlife Service.

2.2.6.1.4.3 Upland Game Birds. A few California quail, *Callipepla californicus*, ring-necked pheasants, *Phasianus colchicus*, along with a few mourning doves, *Zenaidura macroura*, nest in the riparian zone along the 300-FF-5 operable unit.

2.2.6.1.4.4 Shorebirds. The long-billed curlew, *Numenius americanus*, nests on the Hanford Site mostly in dry rangeland habitats dominated by cheatgrass, *Bromus tectorum*, and/or Sandberg's bluegrass, *Poa sandbergii*. Curlews are known to nest within 500 m of the western boundary of the 300-FF-5 operable unit (Allen 1980).

2.2.6.1.4.5 Birds of Prey. Bald eagles, *Haliaeetus leucocephalus*, occur along the Columbia River only during fall and winter months, when they feed on waterfowl and dead salmon. However, most of the eagle use is located well upstream from the 300-FF-5 operable unit (Fitzner and Hanson 1979, Fitzner et al. 1981). The bald eagle is of special concern because it is listed as a threatened species by the U.S. Fish and Wildlife Service. Bald eagles are occasionally seen along the river in the vicinity of the 300-FF-5 operable unit.

Peregrine falcons, *Falco peregrinus*, also may occur in the vicinity of the operable unit because of the abundance of wintering waterfowl, their preferred prey. However, there are apparently no authenticated sightings of this endangered species in this area. Other birds of prey that have been observed on or near the 300 Area are the red-tailed hawk, *Buteo jamaicensis*, ferruginous hawk, *Buteo regalis*, Swainson's hawk, *Buteo swainsoni*, golden eagle, *Aquila chrysaetos*, northern harrier, *Circus cyaneus*, horned owl, *Bubo virginianus*, burrowing owl, *Athene cunicularia*, prairie falcon, *Falco mexicanus*, and kestrel, *Falco sparverius*.

2.2.6.1.4.6 Passerine Birds. More than 25 species of passerine birds use the riparian zone of the Columbia River as foraging or nesting habitat (Books 1984). However, no specific studies of the use of riparian habitat by passerine birds in the immediate vicinity of the 300-FF-5 operable unit have been conducted.

2.2.6.1.5 Mammals

2.2.6.1.5.1 Mule Deer. The most abundant big game mammal inhabiting the Hanford Site is the mule deer, *Odocoileus hemionus*. Mule deer occur throughout the Hanford Site, including the 300-FF-5 operable unit. They rely on Columbia River islands as fawning habitat and use various species of riparian plants as a source of green forage when upland plants are dry from summer drought. Deer are very mobile; deer tagged as new-born fawns on the Hanford Site have travelled as far as 100 km from their point of initial capture (Hedlund 1975).

2.2.6.1.5.2 Furbearers. Coyotes, *Canis latrans*, are common on the Hanford Site and they have been seen around the 300-FF-5 operable unit. Badgers, *Taxidea taxus*, are present also, but in lesser abundance. Both species feed principally on vertebrates of the riparian zone.

Beaver, *Castor canadensis*, and muskrats, *Ondatra zibethica*, are present in the back-water areas of the Columbia river and may occur also in the vicinity of the 300-FF-5 operable unit. Beavers eat the wood and bark of willows, and muskrats eat the herbaceous plants that grow in the riparian zone.

2.2.6.1.5.3 Small Mammals. There have been no studies made of the abundance of small mammals in the riparian zone along the Hanford reach of the Columbia River. Common mice thought to inhabit the riparian zone at the 300-FF-5 operable unit are the montane vole, *Microtus montanus*, and the deer mouse, *Peomyscus maniculatus*. The food of the vole is mostly green leaves and stems of riparian zone plants.

2.2.6.1.5.4 Hares and Rabbits. Black-tailed hares (jackrabbits), *Lepus californicus*, generally inhabit the dry rangeland habitats of the Hanford Site, but occur also in small numbers in the vicinity of the 300-FF-5 operable unit. Cottontail rabbits, *Sylvilagus nuttalli*, are often found around buildings, construction material laydown areas, and other places that provide cover from predators. Jackrabbits eat a variety of plants, including sagebrush, *Artemesia tridentata*, and rabbitbrush, *Chrysothammus nauseosus*, leaves.

2.2.6.1.6 Reptiles and Amphibians. No detailed studies have been made of the abundance or the distribution of reptiles or amphibians on the Hanford Site. However, the species likely to inhabit the riparian zone near the 300-FF-5 operable unit are Woodhouses' toad, *Bufo woodhousei*, spadefoot toad, *Spea (Scaphiopus) intermontanus*, common garter snake, *Thamnophis sirtalis*, green racer, *Coluber constrictor*, gopher snake, *Pituophis melanoleucus*, and rattlesnake, *Crotalus viridis*.

2.2.6.2 Critical Habitats. Critical habitats are those areas that are essential to the existence of threatened or endangered species. Critical habitats are designated by the U.S. Fish and Wildlife Service.

The small amount of riparian habitat in the vicinity of the 300-FF-5 operable unit is probably not critical to the continued survival of any known animal or plant species on the Hanford Site. However, the riparian zone does provide forage for adult and juvenile geese, especially during spring and summer months.

2.2.7 Population and Land Use

The demography, current land use, and archaeological, historical, and cultural resources of the 300 Area and vicinity are discussed below.

2.2.7.1 Demography. Based on the 1980 census, 53,000 people live within 10 mi of the 300 Area (PNL 1987). There is only one residence within a 1-mi radius of the 300-FF-5 operable unit, approximately 0.9 mi across the Columbia River. The City of Richland corporate boundary is approximately 1.2 mi to the south, and the nearest residences are approximately 3 mi from the operable unit. In 1980, Richland had a population of 34,000, and has declined slightly since that census. The working population in the 300 Area is approximately 3,000 (Stenner et al. 1988).

2.2.7.2 Land Use. The majority of the 300-FF-5 operable unit is used for research and development by the DOE. Smaller portions around the area perimeter are wildlife habitat.

2.2.7.3 Archaeological, Historical, and Cultural Resources. The reach of the Columbia River included in the 300-FF-5 study area contains culturally significant sites. The significance is in the realms of archaeology and Native American traditional use areas, although there was some Euro-American activity in the area in the late 19th and early 20th centuries.

2.2.7.3.1 Archaeology. The shoreline of the Columbia River has been surveyed for archaeological sites on three occasions (Drucker 1948, Cleveland et al. 1976, Thoms 1983), and a number of smaller scale surveys have been conducted on inland areas (Morgan 1981; additional information from the Hanford Cultural Resources Laboratory). However, the land surface of the 300 Area itself has never been surveyed. Archaeological surveys, including subsurface testing under fill material, will need to be conducted as part of site characterization work for this operable unit. These surveys will be conducted at surface exposures and in pits dug by backhoe or in augered test locations.

Six prehistoric archaeological sites have been identified in the 300-FF-5 operable unit (45BN29, 45BN30, 45BN105, 45BN106, 45BN162, and 45BN163). Thoms (1983) found these sites to be eligible for inclusion on the National Register of Historic Places, suggesting they be added to the already-listed Wooded Island Archaeological District. A nomination was prepared by the U.S. Army Corps of Engineers, listing these sites in the Upper McNary Archaeological District. The nomination was later withdrawn.

This zone is an archaeologically sensitive area and requires a detailed archaeological investigation before the initiation of any potentially destructive subsurface activities. All sites are located along the riverbank within 400 m of the high-water mark. They are all open camps. One, 45BN163, may contain house pits, and human bone has been found weathering from a cut bank in the portion of this site that lies in the 300-FF-5 operable unit. This site should, therefore, be considered to be a cemetery. Sites appear to have been partially disturbed by historic farming activity and 300 Area construction, but not severely. Some unauthorized artifact collection may occur, but is limited to surface collection.

2.2.7.3.2 Native-American Cultural Resources. The 300-FF-5 area was occupied in the 19th and early 20th centuries by members of the Chamnapum and Wanapum Bands of mid-Columbia Sahaptians (Spier 1936, Relander 1956). The Chamnapum, whose territory centered about the present-day Richland, are considered a band of the Yakima Nation. These people used the area primarily for fishing later in the year, when they could gather spawned-out fish from the riverbanks (Relander 1956). They were often accompanied in this activity by members of other nearby bands and tribes, including the Walla Walla, Umatilla, Palouse, and other bands of the Yakima. An anthropological consultant to the Pacific Northwest Laboratory (PNL) has recently interviewed a few elders of the Palouse, Wanapum, and Umatilla, who made no special reference to the study area, other than to confirm information found in Relander (1956). The Walla Walla Indian Tribe (now part of the Confederated Tribes of the Umatilla Indian Nation) ceded in this area to the U.S. Government in the treaty of 1855 and retained an interest in the area's archaeological resources.

Cemeteries are considered to be sacred by the Indian people. Because of human bones found weathering out of the bank at site 45BN163, it is considered to be a cemetery. Therefore, the riverbank north of the 300 Area fence is sacred to local Indian people. The river itself and the fish that spawn there also are sacred in the Sahaptian world view.

2.2.7.3.3 History. During the late 19th and early 20th centuries, the study area was used primarily for pasture and hay fields. Trash dumps and occasional remnants of farm machinery and irrigation systems attest to this activity, but none are considered to be historically significant. A plaque on Stevens Drive, just south of the Cypress Street gate to the 300 Area, attests to the presence of a school in the vicinity prior to 1943, but the exact location formerly occupied by that building cannot be determined. No buildings remain from the period before World War II, and there are no records of significant events having occurred here. In 1943, the area became dedicated to defense materials production and associated administrative activities as part of the Manhattan Project. In the post-War era, the area assumed the roles of fuel fabrication and research and development. The latter role continues today.

3.0 INITIAL EVALUATION

3.1 KNOWN AND POTENTIAL CONTAMINATION

3.1.1 Sources

The primary contaminants that are disposed, stored, or treated in the source operable units that could potentially affect the 300-FF-5 operable unit are discussed in the 300-FF-1 Work Plan. Only a few additional constituents are unique to the 300-FF-2, 300-FF-3, or 300-IU-1 operable units, based on constituents known to be present in these operable units. The following are the additional contaminants:

- methanol
- polychlorinated biphenyls
- methyl isobutyl ketone (MIBK or hexone)
- solvent-refined coal (light fraction)
- ^{147}Pm.

The amounts of contaminants disposed to waste management units in the 300-FF-2, 300-FF-3, or 300-IU-1 operable units are poorly known. Tables 2, 3, and 4 presented the reported types and amounts found in these units.

3.1.2 Soil

A few studies have been conducted to determine concentrations of contaminants in 300 Area vadose zone sediments. The sediments beneath and directly adjacent to 316-1, 316-2, 316-3, and 316-5 have been studied. All of these facilities are part of the 300-FF-1 operable unit. Detailed descriptions of the facilities, past and present conditions, and chemical contaminant status are presented in the 300-FF-1 Work Plan. A brief summary is presented here for convenience. The 300-FF-1 Work Plan also reports radionuclide concentrations in sediment around a radioactive waste-water line that leaked prior to 1969.

No other contaminant data on soils and sediments could be found for other facilities within 300-FF-1 or facilities within 300-FF-2 and 300-FF-3. Further, no data could be found that pertain to the concentration of contaminants within the saturated sediments of the upper unconfined aquifer beneath the 300 Area. The saturated sediments are in contact with groundwater contaminant plumes and are, thus, likely to contain quantities of the contaminants identified in the groundwater (Section 3.1.3 discusses groundwater in greater detail). The contaminant concentrations bound to the saturated sediments are likely lower than those found in the unsaturated sediments within, below, and directly adjacent to the disposal facilities. Immobile contaminants would not reach the water table in large concentrations, and mobile contaminants do not partition onto sediments strongly, such that the saturated sediments within the 300-FF-5 operable unit likely do not exhibit high concentrations of hazardous materials. One exception could be pockets of nonaqueous organic liquids that become trapped in sediments distant from the disposal facilities. Dense organic liquids may be present along the bottom of the unconfined aquifer.

Dennison et al. (1988) reviewed the sediment chemistry of unsaturated sediments within the 300-FF-1 operable unit. Their report is the basis for most of the discussion in this and the 300-FF-1 Work Plan.

The average background values reported in Table 7 are from five sediment samples obtained from a pit (S-7) near 316-1 (the south process pond). These five samples were chosen as background because they were the only samples collected from a position considered outside of known sources at the time. Future samples collected in remedial investigations for 300-FF-1, 300-FF-2, and 300-FF-3 will include verification that sediments from pit S-7 is, in fact, representative of uncontaminated Hanford vadose sediments above the 300-FF-5 operable unit. The values for 316-1 and 316-2 (the south and north process ponds, respectively), 316-3 (the 307 process trench), and 316-5 (the active 300 Area process trenches) are the maximum values reported and are taken from the 300-FF-1 Work Plan.

Table 7. Sediment Chemical Analyses. (Sheet 1 of 2)

Constituent	Units	Sediment background (average value)	316-1 and 316-2 (maximum values)	316-3 (maximum values)	316-5 (maximum values)
Aluminum	mg/kg	9,690	81,800	26,700	19,500
Antimony	mg/kg	<10	20[a]	ND	140
Arsenic	mg/kg	2.7	148	ND	221
Barium	mg/kg	93	994	133	485
Beryllium	mg/kg	0.4	7	8	6
Bismuth	mg/kg	ND	ND	ND	37.2
Boron	mg/kg	ND	ND	ND	100
Cadmium	mg/kg	0.2	13	1	6,440
Calcium	mg/kg	7,010	55,100	33,200	17,600
Cerium	mg/kg	ND	ND	ND	2,270
Chromium	mg/kg	9.7	30,000	259	551
Cobalt	mg/kg	ND	ND	ND	19.8
Copper	mg/kg	17.6	87,000	2,850	8,470
Iron	mg/kg	27,300	44,400	33,500	36,400
Lanthanum	mg/kg	ND	ND	ND	182
Lead	mg/kg	5.0	390	ND	486
Magnesium	mg/kg	6,090	12,100	11,600	5,800
Manganese	mg/kg	391	746	396	6,740
Mercury	mg/kg	<0.1	16	2.8	825
Molybdenum	mg/kg	ND	ND	ND	34
Nickel	mg/kg	7.5	3,100	221	4,700
Potassium	mg/kg	1,590	2,320	1,830	2,060
Selenium	mg/kg	<0.5	8.2[a]	ND	135
Silicon	mg/kg	ND	ND	ND	385
Silver	mg/kg	<1	349	18	245
Sodium	mg/kg	287	2,940	401	1,440
Strontium	mg/kg	23.2	410	67	175
Thallium	mg/kg	<1.0	2.8[a]	ND	7,460[a]
Tin	mg/kg	ND	ND	ND	375
Titanium	mg/kg	ND	ND	ND	2,370
Tungsten	mg/kg	ND	ND	ND	97
Uranium	mg/kg	7.5	23,000	ND	4,210
Vanadium	mg/kg	59.6	107	73	207
Zinc	mg/kg	49.5	770	97	895
Zirconium	mg/kg	ND	36,000	ND	425

Table 7. Sediment Chemical Analyses. (Sheet 2 of 2)

Constituent	Units	Sediment background (average value)	316-1 and 316-2 (maximum values)	316-3 (maximum values)	316-5 (maximum values)
Chloride	mg/kg	1.1	405	1.1	25
Cyanide	mg/kg	ND	ND	ND	1.3
Fluoride	mg/kg	0.9	200,000[b]	2.0	33[a]
Nitrate (as NO_3^-)	mg/kg	0.6	8,000[b]	30.4	467
Phosphate	mg/kg	<2.0	8.3[a]	ND	9,440[c]
Sulfate	mg/kg	6.6	4,400[b]	52.0	66.3
Sulfide	mg/kg	ND	ND	ND	500[a]
Arochlor-1248	mg/kg	ND	42.0	9.90	ND
Arochlor-1254	mg/kg	ND	0.4[a]	ND	ND
Butylbenzylphalate	mg/kg	ND	1.8[a]	ND	3.3[a]
Diethylphalate	mg/kg	ND	2.1[a]	ND	ND
Bis(2-ethylhexyl) phthalate	mg/kg	ND	1.1[a]	ND	ND
Methylene chloride	mg/kg	ND	0.09	ND	0.04
Trichloroethene	mg/kg	ND	0.05[a]	ND	ND
Benzol [a]pyrene	mg/kg	ND	ND	ND	25[a]
Benzol [b]fluoranthene	mg/kg	ND	ND	ND	14[a]
Chrysene	mg/kg	ND	ND	ND	12
1,2-Dichloroethene	mg/kg	ND	ND	ND	0.04
Tetrachloroethene	mg/kg	ND	ND	ND	0.01
Toluene	mg/kg	ND	ND	ND	0.02[a]
Meta-xylene	mg/kg	ND	ND	ND	0.02[a]
Ortho and para-xylene	mg/kg	ND	ND	ND	0.03[a]
Gross alpha	pCi/g	4.6	1,960	234	1,870
Gross beta	pCi/g	21.3	2,140	378	27,600
^{137}Cs	pCi/g	ND	1.7	ND	ND
^{60}Co	pCi/g	ND	87.7[d]	ND	ND

[a]Less than 7% of samples showed detectable levels.
[b]Represents analyses of a precipitated material on the surface of the pond bottom; not soil, per se.
[c]Total phosphorus was measured; assuming all present as phosphate.
[d]1973 analyses showed 4,000 pCi/g.
ND = Not data available.

In general, the concentrations of contaminants, especially metals, decrease with distance from disposal facility inlet and with depth. Many constituents are significantly above background from the bottom of the disposal facility to 4 ft deeper into the sediment profile, but few are found above background beyond 20 ft below the facility bottom.

Based on data reviewed in Dennison et al. (1988) and Schalla et. al (1988), the lateral movement of contaminants beyond facility boundaries has generally been small in the vadose zone because of the coarse nature of the sediments (water percolates vertically). Material dredged from the pond bottoms to improve percolation was spread around the perimeter of several of the disposal facilities, resulting in a wider distribution of contaminated sediments than would be expected under natural conditions.

The actual areal and vertical extent of contaminants in the vadose zone sediments in the 300 Area will be ascertained during remedial investigations for the 300-FF-1, 300-FF-2, and 300-FF-3 operable units. The extent of sediment contamination in saturated sediments in the 300-FF-5 operable unit and the nature of the binding of the contaminants to sediments are important to understand future groundwater flushing and are described in Section 5.3.3.

An analysis of the data presented in Table 7 and groundwater quality data presented in Schalla et al. (1988) suggest that key contaminants to study in the unconfined aquifer within 300-FF-5 are uranium, nitrate, trichloroethene, and 1,2-dichloroethene. Uranium and nitric acid were major constituents in the processes discussed in Section 2.1.3 and, in fact, can be delineated as groundwater plumes. Trichloroethene and 1,2-dichloroethene are known to be mobile organics and are present in some monitoring wells in the 300-FF-5 operable unit. Of lesser importance are copper, chloride, and chloroform. These three constituents are found in the groundwater, and the latter two are mobile and should help delineate the extent of contaminated sediments.

3.1.3 Groundwater

The following are supplements and, in a few instances, clarifications to the 300-FF-1 Work Plan. The information is an evaluation of the known nature and extent of contamination in groundwater beneath the 300-FF-5 operable unit.

3.1.3.1 Background Groundwater Quality. Groundwater in the unconfined aquifer on the Hanford Site is categorized as calcium bicarbonate dominated (Evans et al. 1988a). Background groundwater quality is defined as the solute content of natural groundwater in the unconfined aquifer in the Hanford and Ringold Formations on the Hanford Site, where the groundwater is unaffected by Hanford Site waste disposal operations. The natural groundwater on the Hanford Site is of excellent quality, with moderate total hardness (~120,000 μg/L) and moderate total dissolved solids content (~250,000 μg/L). Primary natural (inorganic) constituents found in this water are calcium, bicarbonate, sulfate, silica, sodium, chloride, magnesium, and potassium. A wide variety of secondary constituents, such as barium, fluoride, manganese, and strontium, occur in trace (<1,000-μg/L) amounts. Table 8 (modified from Evans et al. 1988a) lists estimated background levels for selected constituents in Hanford Site groundwater. Background levels were determined from historical groundwater-monitoring analyses in areas on the Hanford Site where there were no influences from nuclear materials production and separations activities. These analyses were made over the years under the Hanford Sitewide groundwater monitoring project (Evans et al. 1988a, 1988b). Comparison of selected water quality indicators (hardness, total dissolved solids, and specific conductance) for Hanford groundwater (see Table 8) and Columbia River water (discussion provided in Section 3.1.4.1) shows that the groundwater has more than three times the total dissolved solids, approximately three times the specific conductance, and approximately twice the hardness of Columbia River water.

Table 8. Background Levels for Selected Constituents in Hanford Site Groundwater (modified from Evans et al. 1988a).

Constituent	Unit	Detection limit	Background concentration
Aluminum	µg/L	150	<150
Ammonia	µg/L	50	60 ± 47
Arsenic	µg/L	5	<5
Barium	µg/L	6	43 ± 21
Cadmium	µg/L	2	<2
Calcium	µg/L	50	43,000 ± 14,000
Chloride	µg/L	500	9,430 ± 5,530
Chromium	µg/L	10	<10
Copper	µg/L	10	<10
Cyanide	µg/L	10	<10
Fluoride	µg/L	500	630 ± 240
Lead	µg/L	5	<5
Magnesium	µg/L	10	11,700 ± 2,750
Manganese	µg/L	5	16 ± 25
Mercury	µg/L	0.1	<0.1
Nickel	µg/L	10	<10
Nitrate (as NO_3^-)	µg/L	500	2,700 ± 1,100
Phosphate	µg/L	1,000	<1,000
Potassium	µg/L	100	5,835 ± 1,378
Selenium	µg/L	5	<5
Silver	µg/L	10	<10
Sodium	µg/L	10	20,540 ± 6,690
Strontium	µg/L	300	320 ± 86
Sulfate	µg/L	500	40,100 ± 13,200
Vanadium	µg/L	5	17 ± 7
Zinc	µg/L	5	10 ± 11
Alkalinity	µg/L	ND	123,000 ± 21,000
pH	unitless	ND	7.64 ± 0.16
Total organic carbon	µg/L	200	586 ± 347
Conductivity	µmho/cm	1	380 ± 82
Total dissolved solids	µg/L	ND	250,000 ± 70,000
Hardness (total)	µg/L	ND	120,000 ± 25,000
Gross alpha	pCi/L	0.5	2.5 ± 1.4
Gross beta	pCi/L	4	19 ± 12
Radium	pCi/L	0.2	<0.2
Tritium	pCi/L	200	<200

ND = No data available.

Background concentrations for groundwater on the northern boundary of 300-FF-5 are represented by data from well cluster 399-1-18 (Figure 20) during the period March 1987 to June 1989. Data from the same well cluster are reported as background concentrations in Section 3.1.3.1 of the 300-FF-1 Work Plan. Currently, no monitoring wells are located along the western margin of the 300-FF-5 operable unit; therefore, no background can be established for this area.

Background concentrations in the top of the unconfined aquifer (shallow zone; Schalla et al. 1988) are represented by well 399-1-18A (Table 9). These concentrations are similar to Hanford-wide background concentrations (see Table 9), except for two constituents that are consistently higher in the 300 Area. These constituents are chloride and nitrate at concentrations that are approximately two and ten times greater than Hanford-wide background concentrations.

Background concentrations in the bottom of the unconfined aquifer along the northern boundary of 300-FF-5 (intermediate zone; Schalla et al. 1988) are represented by data from well 399-1-18B. The well is screened just above the M3 layer (see Figure 9). These concentrations differ significantly from the Hanford-wide background concentrations for eight constituents. Fluoride, manganese, and sodium are consistently higher than either Hanford-wide background concentrations and those for the top of the unconfined aquifer. The five constituents that have concentrations in well 399-1-18B that are only a small percentage of the Hanford-wide background are calcium (25%), magnesium (50%), nitrate (20%), sulfate (2%), and vanadium (50%). This means that nitrate concentrations in the top of the unconfined aquifer are more than 40 times greater than in the bottom of the unconfined aquifer.

Background concentrations in the upper confined aquifer (deep zone; Schalla et al. 1988) along the northern boundary of 300-FF-5 are represented by well 399-1-18C. The phrase "deep zone" used in Schalla et al. (1988) is equivalent to the "upper confined aquifer" used in this report. The groundwater chemistry in well 399-1-18C is the same as for other locations in the confined aquifer, even though its water potential is the same as the water table. This suggests that the "confined aquifer" in well 399-1-18C is not confined at that location but is hydraulically connected with the unconfined system.

Well 399-1-18C is completed in what would be described best as a unique portion of the unconfined aquifer compared to confined aquifer wells such as 399-1-17C (see Figure 8). Like most wells screened in the confined aquifer, well 399-1-18C is screened below the M3 layer (see Figure 9); however, it is underlain by the Goose Island flow not the Martindale flow. A possible explanation for the data is that groundwater from the confined aquifer may slowly flow from the Martindale flow upward through the Goose Island flow and into the gravelly sand above the Goose Island flow. Because the hydraulic gradient is upward from the Martindale flow, the water chemistry in the well 399-1-18C is the same as well 399-1-17C. The hydraulic head could be lower in 399-1-18C for two reasons: (1) most of the hydraulic head is lost by overcoming the resistance to upward flow as the groundwater flows through the dense columnar

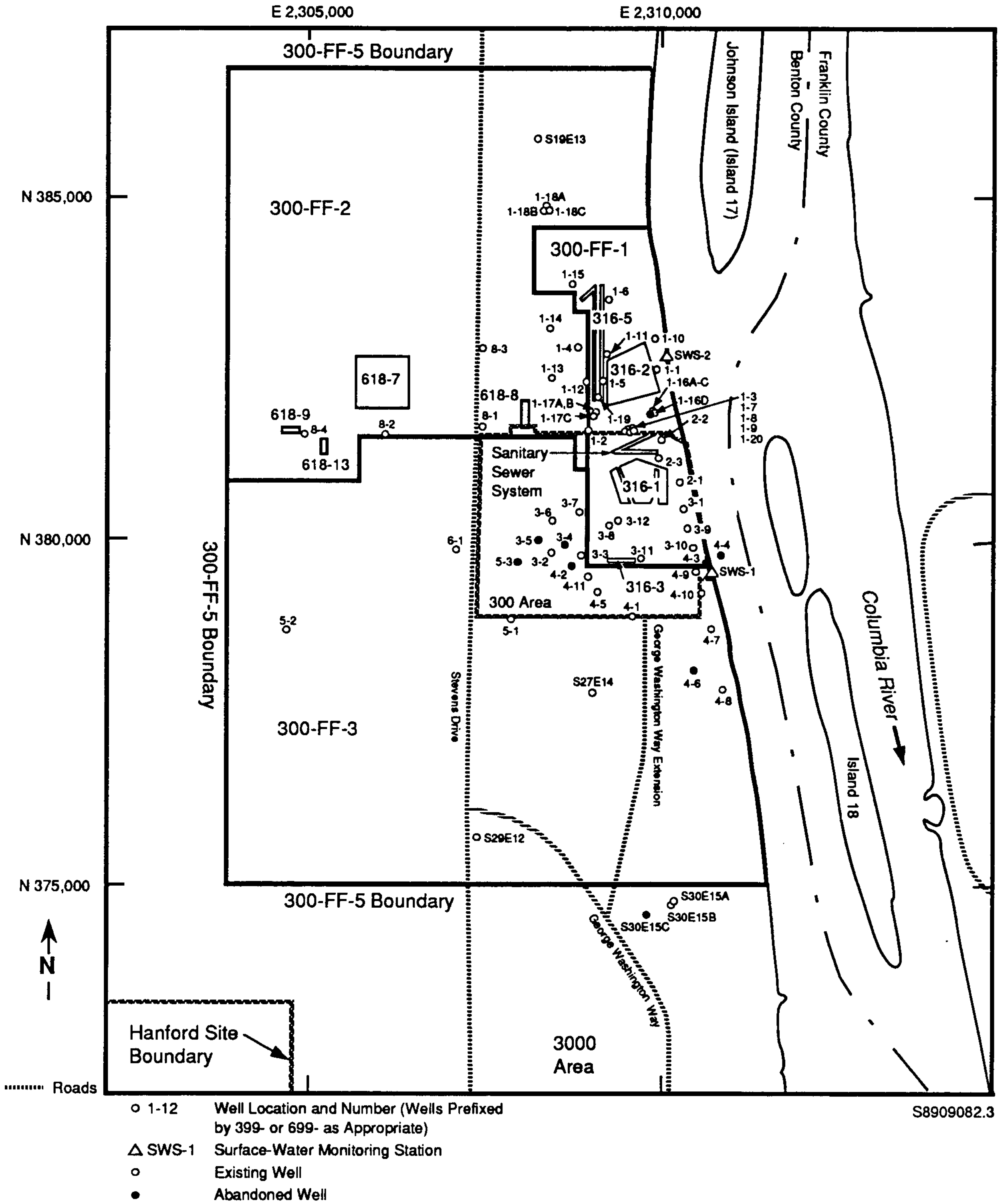


Figure 20. Location of the 300-FF-5 Operable Unit and All Existing and Abandoned Wells as of June 1989.

Table 9. Background Concentrations for Selected Constituents in the 300 Area and Hanford Site Groundwater. (Sheet 1 of 2)

Constituent, units	Concentration at top of unconfined aquifer (well 399-1-18)			Concentration at bottom of unconfined aquifer (well 399-1-18B)			Concentration at upper confined aquifer (well 399-1-18C)			Hanford-wide background concentrations	
	Mean	n	Standard deviation	Mean	n	Standard deviation	Mean	n	Standard deviation	Mean	Standard deviation
Ammonium ion, µg/L[a]	51.6	8	4.6	100	7	26.4	118	6	36.6	60	47
Arsenic, µg/L[a]	5.5	10	0.707	5	9	0	5	7	0	<5	0
Arsenic, filtered, µg/L[a]	5.6	10	0.843	5	9	0	5	7	0	ND	ND
Barium, µg/L	47.4	10	3.86	39.7	9	3.64	68.9	7	4.88	43	21
Barium, filtered, µg/L	46.6	10	2.91	41.7	9	3.97	69	7	5.48	ND	ND
Cadmium, filtered, µg/L[a]	2	10	0	2.09	9	0.333	2	7	0	<2	0
Calcium, µg/L	44,800	10	5,550	12,100	9	849	12,600	7	1,450	43,000	14,000
Calcium, filtered, µg/L	43,400	10	2,710	12,700	9	1,380	12,400	7	1,110	ND	ND
Chloride, µg/L	17,700	23	1,890	11,300	9	1,330	11,500	7	1,460	9,430	5,530
Chromium, µg/L[a]	10.7	10	2.21	16.7	9	9.27	17.4	7	8.12	<10	0
Chromium, filtered, µg/L[a]	10	10	0	10.7	9	2	10	7	0	ND	ND
Coliform bacteria, MPN[a]	2.2	10	0	2.2	9	0	4.17	7	5.22	ND	ND
Fluoride, µg/L	530	23	130	1,530	9	294	1,670	7	331	630	240
Gross alpha, pCi/L	3.04	9	0.838	-0.0354	8	0.652	0.343	7	0.419	2.5	1.4
Gross beta, pCi/L	12.7	10	4.45	8.9	9	2.53	8.52	7	1.2	19	12
Iron, µg/L[a]	71	10	55.2	238	9	60.7	151	7	36.9	ND	ND
Iron, filtered, µg/L[a]	43.2	10	16.9	167	9	24	92.3	7	15.7	ND	ND
Lithium, µg/L	10	1	ND	18	1	ND	ND	ND	ND	ND	ND
Lithium, filtered, µg/L	10	1	ND	18	1	ND	ND	ND	ND	ND	ND
Magnesium, µg/L	12,500	10	1,120	5,240	9	280	5,320	7	192	11,700	2,750
Magnesium, filtered, µg/L	12,100	10	453	5,390	9	394	5,270	7	222	ND	ND
Manganese, µg/L[a]	5	10	0	44.7	9	5.68	51.9	7	3.24	16	25
Manganese, filtered, µg/L[a]	5	10	0	43.9	9	4.14	47.9	7	2.91	ND	ND
Methylene chloride (dichloromethane), µg/L	7.73	22	2.88	9.44	9	1.67	10.	7	0	ND	ND
Nickel, µg/L[a]	10	10	0	10.8	9	1.72	10.6	7	1.13	<10	0
Nitrate (as NO_3^-), µg/L	21,600	23	907	500	9	0	500	7	0	2,700	1,100
pH, field, unitless	7.88	22	0.332	7.71	9	0.448	7.93	7	0.415	7.64	0.16
Potassium, µg/L	6,310	10	493	6,520	9	448	6,800	7	281	5,835	1,378
Potassium, filtered, µg/L	6,080	10	271	6,690	9	437	6,620	7	395	ND	ND
Radium, total, pCi/L	0.103	10	0.0642	0.0784	9	0.0757	0.134	7	0.0586	ND	ND
Sodium, µg/L	23,600	10	1,420	64,100	9	3,780	67,000	7	1,330	20,540	6,690
Sodium, filtered, µg/L	22,700	10	976	66,100	9	4,540	66,200	7	3,150	ND	ND
Specific conductance, field, µmho/cm	416	22	45.2	355	9	44	363	7	37.2	380	82

Table 9. Background Concentrations for Selected Constituents in the 300 Area and Hanford Site Groundwater. (Sheet 2 of 2)

Constituent, units	Concentration at top of unconfined aquifer (well 399-1-18)			Concentration at bottom of unconfined aquifer (well 399-1-18B)			Concentration at upper confined aquifer (well 399-1-18C)			Hanford-wide background concentrations	
	Mean	n	Standard deviation	Mean	n	Standard deviation	Mean	n	Standard deviation	Mean	Standard deviation
Strontium, µg/L	229	3	14.2	80.3	3	7.57	80	1	ND	320	86
Strontium, filtered, µg/L	220	3	2.08	83	3	5.29	80	1	ND	ND	ND
Sulfate, µg/L	49,000	23	1,430	522	9	67	1,780	7	425	40,100	13,200
Tetrachloromethane (carbon tetrachloride), µg/L	6.18	22	2.13	7.22	9	2.64	ND	ND	ND	ND	ND
Total alkalinity, as $CaCO_3$, µg/L	127,000	2	1,410	186,000	2	1,410	ND	ND	ND	123,000	21,000
Total carbon, µg/L	29,700	2	212	43,000	2	778	40,800	1	ND	ND	ND
Total dissolved solids, µg/L	278,000	2	14,800	253,000	2	0	ND	ND	ND	250,000	70,000
Total organic carbon, µg/L	375	13	149	314	12	53	370	7	133	586	347
Total organic halogens (quit October 88), µg/L	53.9	6	50.8	61.6	5	526	47.8	5	48	ND	ND
Total organic halogens, low detection limit, µg/L	4.96	7	1.97	6.29	7	4.64	5.68	2	7.53	ND	ND
Uranium, pCi/L	3.61	13	0.713	0.176	1	0.256	ND	ND	ND	ND	ND
Uranium, chemical, µg/L	4.3	3	0.985	0.0433	1	ND	0.0712	1	ND	ND	ND
Vanadium, µg/L[a]	11.5	10	3.17	5	9	0	5	7	0	17	7
Vanadium, filtered, µg/L[a]	10.7	10	2.54	5	9	0	5	7	0	ND	ND
Zinc, µg/L[a]	5.2	10	0.632	9.22	9	3.7	8.86	7	5.96	10	11
Zinc, filtered, µg/L[a]	5	10	0	8.44	9	7.26	7.14	7	3.67	ND	ND

NOTE: The time periods are February 23, 1987 to August 6, 1989 for well 399-1-18A, March 31, 1987 to June 8, 1989 for well 399-1-18B, and March 31, 1987 to August 16, 1988 for well 399-1-18C.

[a]Most values are at or below detection limit.

MPN = Most probable number.

ND = No data available.

n = Number of analyses.

basalt of the Goose Island flow and (2) the M3 layer is not as thick as in most of 300-FF-5 and, therefore, the remaining confined hydraulic head is lost when the hydraulic head in the gravelly sands at well 399-1-18C equilibrate with the hydraulic head in the unconfined aquifer.

3.1.3.2 Groundwater Contamination. Groundwater in the 300-FF-5 operable unit has been widely contaminated by wastes disposed to ground in the 300 Area (Jaquish and Mitchell 1988). Although there are a number of contaminant indicator species, uranium, chloroform, trichloroethene, 1,2-dichloroethene, chloride, and nitrate serve as sensitive indicators of groundwater contamination in the 300-FF-5 operable unit.

Groundwater on the Hanford Site is sampled routinely to monitor the concentration and distribution of contaminants from Hanford operations and to evaluate the impact of these operations on the geohydrologic environment (Jaquish and Mitchell 1988). Groundwater monitoring in the 300 Area has been implemented using monitoring wells. A total of 67 temporary or permanently cased wells have been drilled in the 300-FF-5 operable unit since 1942. These wells were shown in Figure 20. A summary of the completion characteristics for these wells is presented in Table 10. Nine of these wells have been abandoned, as noted in Figure 20. Of the remaining 58 wells, 6 are screened in the upper confined aquifer and 52 in the unconfined aquifer (see Figure 11). There are 29, 12, and 17 wells in the 300-FF-1, 300-FF-2, and 300-FF-3 operable units, respectively (Figures 21, 22, and 23, respectively). The fact that the number of wells in 300-FF-1 is equal to that in 300-FF-2 and 300-FF-3 combined reflects the importance of 300-FF-1 as a major influence on groundwater quality in 300-FF-5.

The existing wells will be evaluated as to their suitability for both water-level monitoring and water sampling. This will be done (1) by visual inspection using a downhole camera and (2) by comparison of groundwater chemistry and water levels in existing wells and nearby new wells drilled for this project. The downhole camera will provide visual physical integrity evidence of the well, especially in the sample zone below the water table. If the existing wells provide adequate chemistry and water-level data, this should be reflected in comparisons with data in adjacent wells and with general trends in the data across the site.

Up to 48 of the existing monitoring wells have been used during a single monitoring period to define the extent of contamination in the 300-FF-5 operable unit. However, generally, only 27 to 34 have been used on a regular basis and most of them were in the 300-FF-1 operable unit.

A Westbay multiport system was installed in well 399-1-20 in late-December 1988 to monitor six zones in the unconfined aquifer. The purpose of this system was to determine the vertical variation in water chemistry and contaminant distribution in the unconfined aquifer (Gilmore 1989). No chemistry data are available at this time.

Table 10. Summary of Completion Information for Wells and Pumps Installed in the 300 Area Through January 1, 1989. (Sheet 1 of 2)

Permanent well number	Former designation	Completion date[a]	Drilled depth[b] (ft)	Present depth to bottom[b,c] (ft)	Initial depth to water[b,c] (ft)	Depth to open interval[c] (ft)	Depth to pump intake[b,c] (ft)	Casing diameter[c] (in.)	Casing height above ground[c] (ft)
399-1-1	303-3	11-48	77	74	42	20-75 p	42 sq	8.0 c	2.3
399-1-2	303-4	4-50	101	100	45	25-75 p	48 sq	8.0 c	1.3
399-1-3	303-6	4-50	102	77	37	25-70 p	48 sq	8.0 c	1.7
399-1-4	303-7	5-50	101	78	42	23-70 p	44 sq	8.0 c	1.5
399-1-5		2-75	45	45	35	23-45 s	41 sq	6.0 ss	3.0
399-1-6		2-75	44	44	33	22-44 s	36 sq	6.0 ss	3.0
399-1-7	T-1	3-85	75	75	37	25-75 s	49.5 h0	6.0 c	2.8
399-1-8	T-2	8-85	118	105	39	85-105 s	50.7 h0	6.0 ss	1.6
399-1-9	S2	2-12-87	181	180	9	170-180	60 h1	6.0 c	1.6
399-1-10	S3	12-1-86	45	39.5	29	24.5-39.5	35 h0	6.0 ss	1.7
300-1-11	S4	11-20-86	47	47	37	27-47	40 h0	6.0 ss	1.6
399-1-12	S5	11-3-86	65	60	39.1	45-60	50 h0	6.0 ss	2.4
399-1-13	S6	11-5-86	56	53	43	38-53	49 h0	6.0 ss	2.8
399-1-14	S7	11-14-86	50	46	36.5	31-46	39 h0	6.0 ss	2.8
399-1-15	S8	11-7-86	48	44	33.3	29-44	40 h0	6.0 ss	1.8
399-1-16A	C1A	12-5-86	48	47.5	37.3	32.5-47.5	46 h0	6.0 ss	1.3
399-1-16B	C1D	2-10-87	118	115	37.9	105-115	61 h1	6.0 ss	1.1
399-1-16C	C1B	1-16-87	178	177.5	9	167.5-177.5	60 h0	6.0 ss	1.9
399-1-16D	C1C	1-29-87	180	AW	40.5	AW	AW	6.0 ss	AW
399-1-17A	C2A	11-13-86	41	40	31.9	25-40	40 h0	6.0 ss	2.3
399-1-17B	C2B	12-19-86	115	110	32.9	100-110	60 h0	6.0 ss	2.4
399-1-17C	C2C	1-16-87	173	171	0.2	161-171	60 h1	6.0 ss	2.5
399-1-18A	C3A	11-12-86	63	54	44.2	39-54	49 h0	6.0 ss	3.0
399-1-18B	C3B	1-23-87	125	118	45.5	108-118	59 h0	6.0 ss	2.7
399-1-18C	C3C	1-6-87	153	140	42.8	130-140	59 h1	6.0 ss	2.7
399-1-19	T3	5-23-86	45	45	38.0	35-45	40 h0	6.0 ss	2.5
399-1-20	WB2	12-2-88	187	132	42.0	120, 103, 86	74, 56, 44 WB	1.5 pvc	2.3
399-2-1	303-2	11-48	77	73	40	18-73 p	41 sq	8.0 c	3.1
399-2-2		10-76	65	63	39	35-55 s	41 s'	8.0 c	2.0
399-2-3		10-76	65	63	40	35-55 s	41 s'	8.0 c	1.1
399-3-1	303-1	10-48	74	74	43	20-65 p	46 s'	8.0 c	2.3
399-3-2	300-3 905-3	10-47	102	89	53	40-75 p	45 s'	10.0 c	-3.4
399-3-3	300-4 905-4	1-48	175	83	52	52-83 p	50 s'	10.0 c	2.0
399-3-4	30-3 T.H.	5-51	40	cr	cr	AW	AW	8.0 c	AW
399-3-5	30-4 T.H.	5-51	40	cr	cr	AW	AW	8.0 c	AW
399-3-6	300-D1W 905-1	8-43	85	85	48	42-55 p	72 s'	10.0 c	2.1
399-3-7	300-D2W 905-2	1-44	86	86	63	52-70 p	68 sq	12.0 c	2.5
399-3-8		3-70	48	48	43	28-48 p	None	8.0 c	2.0
399-3-9		8-76	70	65	45	45-55 s	52 s'	8.0 c	2.0
399-3-10		9-76	67	63	40	34-49 s	47 sq	8.0 c	2.7
399-3-11		9-76	72	70	47	47-70 s	61 s'	8.0 c	2.0
399-3-12		9-80	65	65	46	35-49 p	50 s'	6.0 c	1.4

Table 10. Summary of Completion Information for Wells and Pumps Installed in the 300 Area Through January 1, 1989. (Sheet 2 of 2)

Permanent well number	Former designation	Completion date[a]	Drilled depth[b] (ft)	Present depth to bottom[b,c] (ft)	Initial depth to water[b,c] (ft)	Depth to open interval[c] (ft)	Depth to pump intake[b,c] (ft)	Casing diameter[c] (in.)	Casing height above ground[c] (ft)
399-4-1	303-10	2-51	101	84	52	25-80 p	58 sq	8.0 c	2.7
399-4-2	300-1 T.H.	5-51	42	cr	cr	AW	AW	8.0 c	AW
399-4-3		4-58	100	cr	cr	AW	AW	8.0 c	AW
399-4-4		5-58	40	cr	cr	AW	AW	6.0 c	AW
399-4-5		8-58	200	196	50	100-195 p	160 s'	12.0 c	NA
399-4-6		7-58	134	cr	cr	AW	AW	8.0 c	AW
399-4-7		11-61	155	82	35	21-82 p	42 sq	8.0 c	1.5
399-4-8		10-71	72	72	41	35-53 p	NA	8.0 c	2.0
399-4-9		9-76	65	59	32	38-58 s	46 s'	8.0 c	2.3
399-4-10		9-76	60	55	33	37-50 s	42 s'	8.0 c	1.9
399-4-11	S1	11-26-86	95	70	59.9	55-70	65 h1	6.0 ss	1.7
399-5-1	303-11	2-51	102	90	52	23-100 p	60 s'	8.0 c	2.6
399-5-2	303-13	7-54	424	417	40	192-412 p	None	8.0 c	2.0
399-5-3	300-2 T.H.	5-51	36	cr	cr	AW	AW	8.0 c	AW
399-6-1	303-9	5-50	101	62	42	24-75 p	50 s'	8.0 c	1.2
399-8-1	303-5	4-50	102	98	52	35-83 p	60.2 h0	8.0 c	2.0
399-8-2	303-8	5-50	119	92	53	43-72 p	64 sq	8.0 c	1.4
399-8-3	303-12	3-51	102	94	50	25-99 p	61.0 h0	8.0 c	1.2
399-8-4		9-79	65	61	45	42-60 p	57 s'	8.0 c	2.0
699-S30-E15A	49-17A	10-71	80	78	58	58-78 s	64 sq	6.0 c	2.5
699-S30-E15B	49-17B	10-71	93	93	58	NA	None	6.0 c	NA
699-S30-E14	99-S30E15C DDH-3, 3099-49-16	8-62	219	211	56	45-160 p	AW	1.5 c	AW
699-S29-E12	50-15	11-71	80	79	40	37-79 p	50 s'	6.0 c,ss	3.5
699-S27-E14	3000-7	4-48	165	105	58	60-150 p	71 s'	8.0 c	0.9
699-S19-E13	4N	11-71	80	78	46	50-78 p	53 sq	6.0 c	3.1

[a]Month, date (when known), and year completed.
[b]All depths are given relative to land surface.
[c]Explanation of symbols:
AW = Abandoned well
c = Carbon steel casing, which is commonly A53, Grade B, schedule 40
cr = Casing removed
h0 = HydroStar pump, Model 8000
h1 = HydroStar pump, Model 8001
NA = Information not available
p = Perforated interval (steel casing)
pvc = Polyvinyl chloride casing and screen
q = QED bladder pump, Model T-1200
s = Screened interval (stainless steel, wire wrap, type 304)
s' = Peabody Barnes; 3/4-hp submersible pump
sq = Both the QED bladder pump and the submersible pump
ss = Stainless steel casing and wire wrap screen, type 304 or 304L
WB = Westbay multiport sampling system.

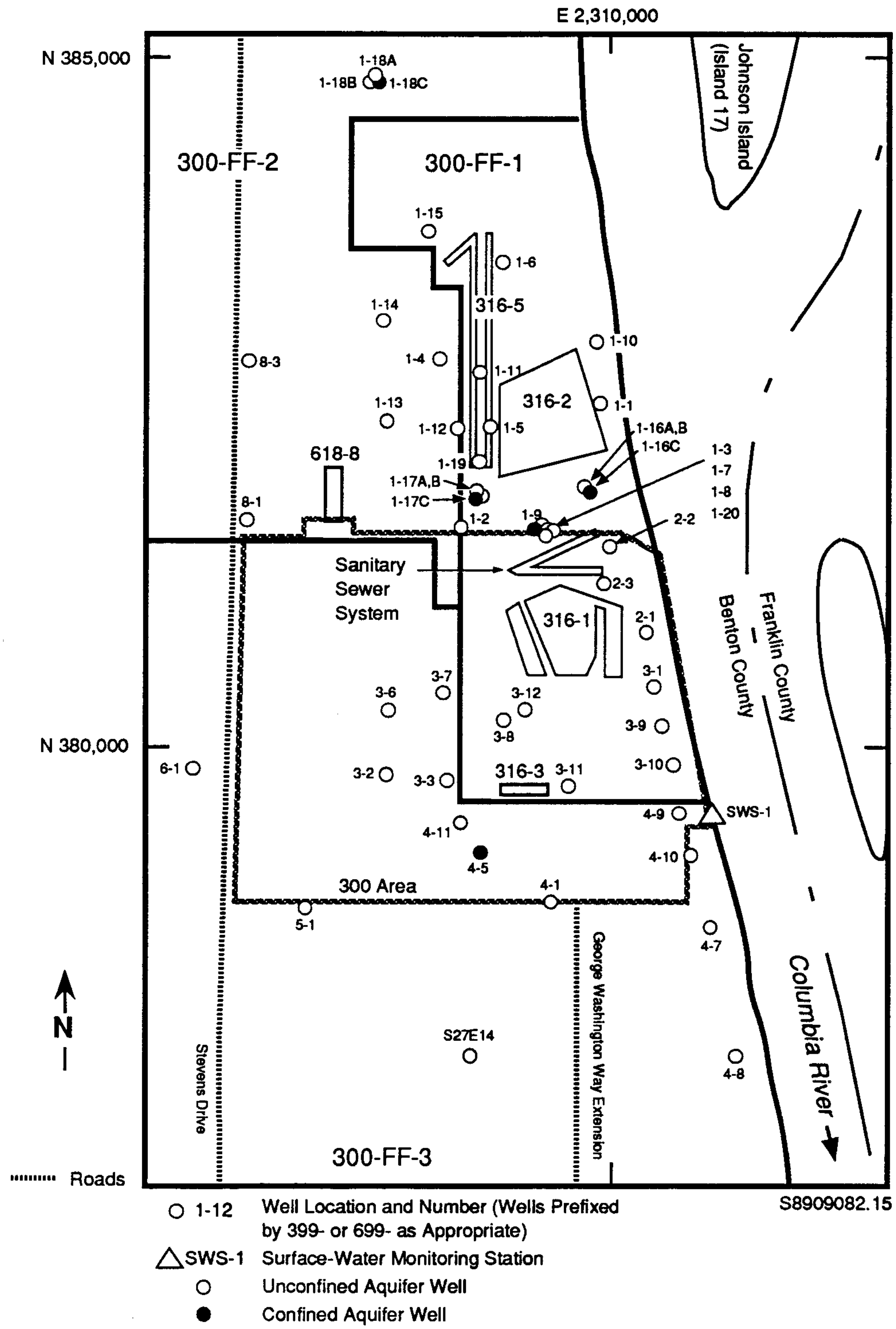


Figure 21. Location of the 300-FF-1 Operable Unit and All Existing Wells Screened in the Unconfined or Confined Aquifers.

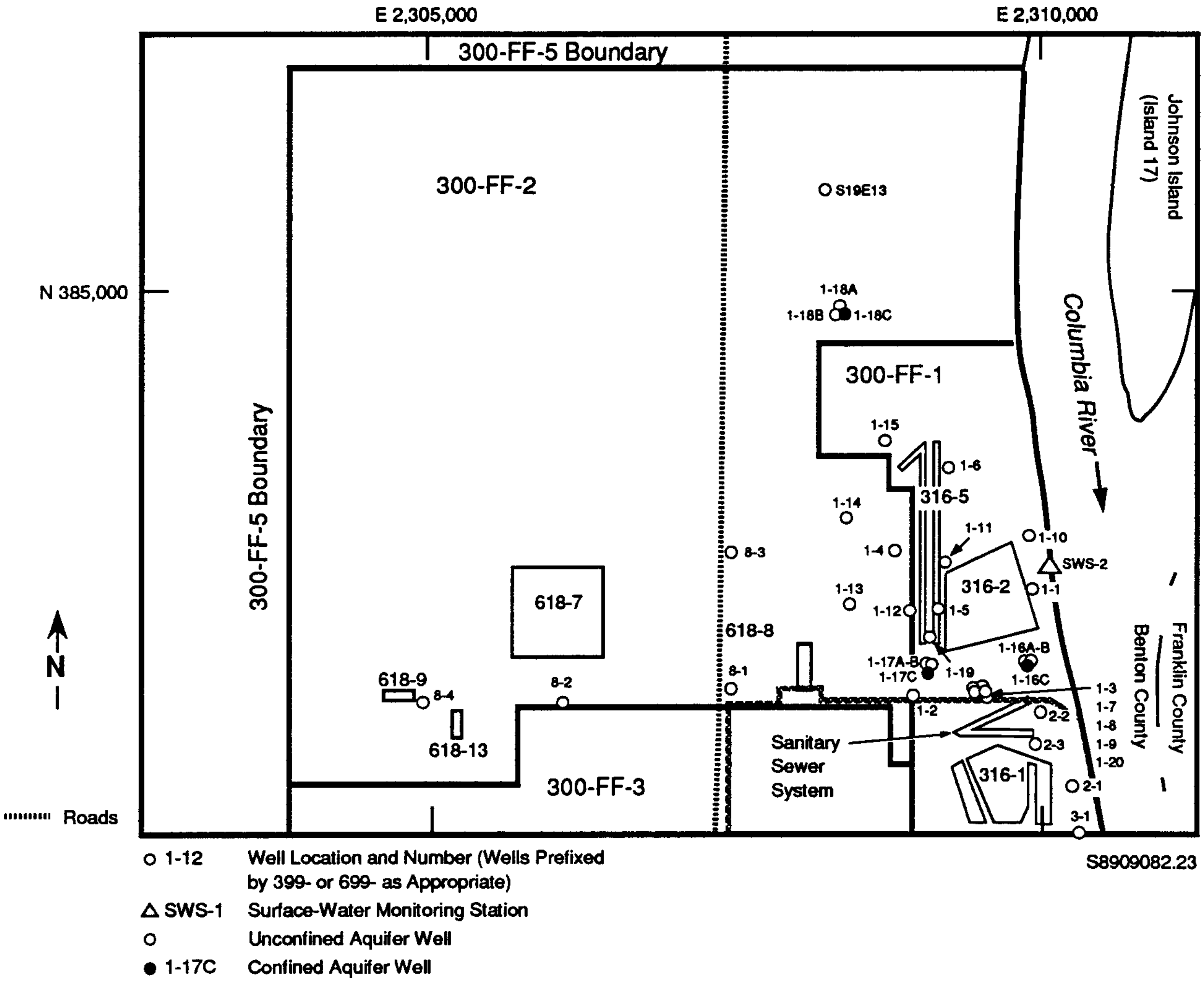


Figure 22. Location of the 300-FF-2 Operable Unit and All Existing Wells Screened in the Unconfined or Confined Aquifers.

Groundwater quality data were obtained from three sources: (1) Schalla et al. (1988), (2) Appendix B of the 300-FF-1 Work Plan, and (3) Jaquish and Mitchell (1988). Schalla et al. (1988) document contaminant distributions in the groundwater in 300-FF-5 for the 316-5 RCRA groundwater monitoring program. Appendix B of the 300-FF-1 Work Plan provides a complete database printout of measured groundwater parameters for selected wells in 300-FF-5. The data available in Jaquish and Mitchell (1988) provide information for a greater number of wells.

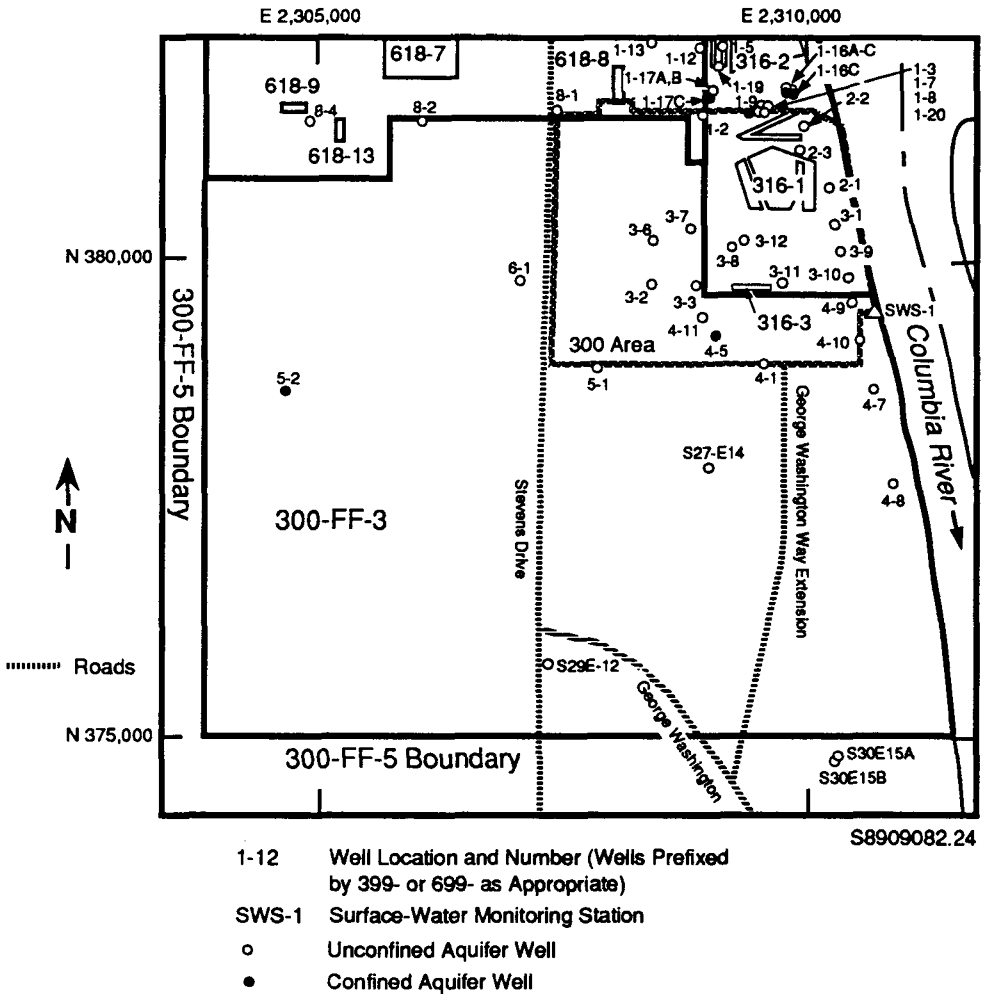


Figure 23. Location of the 300-FF-3 Operable Unit and All Existing Wells Screened in the Unconfined or Confined Aquifers.

Comparison of the water quality obtained from Appendix B of the 300-FF-1 Work Plan indicates that the maximum concentrations of some of the parameters identified in Tables 11, 12, and 13 are highly elevated above preliminary background levels. Groundwater at the bottom of the unconfined aquifer and in the upper confined aquifer has a different water chemistry than the top of the unconfined aquifer, with the bulk of the contamination restricted to the shallow zone (Schalla et al. 1988). The scarcity of monitoring wells and the potential for nonaqueous-phase liquid contaminants to be present at the bottom of the unconfined aquifer make determination of the quantity of contamination in that zone difficult. Therefore, most of the discussion will be directed toward contamination in the top of the unconfined aquifer. Contamination will be discussed by three groups of constituents, including radionuclides, metals and anions, and volatile halogenated hydrocarbons.

Table 11. Groundwater Quality for the Top of the Unconfined Aquifer in the 300-FF-1 Operable Unit. (Sheet 1 of 2)

Parameters detected		Units	Detection limit	Maximum value detected	Detections/ analyses
Gross alpha[a]		pCi/L	4	208	317/324
Gross beta[a]		pCi/L	8	121	351/421
pH[a]		std units	0.1	6.4 - 8.5	405/412
Specific conductance		μmho/cm	1	456	404/413
Total coliform[a]		MPN/100 mL	2.2	43	161/319
Total organic carbon[a]		μg/L	1,000	8,030	63/272
Total organic halogen[a]		μg/L	100	24,500	32/272
Aluminum	(total)[a]	μg/L	150	1,210	25/287
	(filtered)[a]	μg/L	150	700	2/173
Arsenic	(total)[a]	μg/L	5	17	8/287
Barium	(total)[a]	μg/L	6	719	323/323
	(filtered)[a]	μg/L	6	66	173/173
Cadmium	(total)[a]	μg/L	2	6.6	10/323
Carbon	(total)[b]	μg/L	?	25,700	15/15
Chromium	(total)[a]	μg/L	10	257	17/322
	(filtered)[a]	μg/L	10	21	1/173
Copper	(total)[a]	μg/L	10	516	148/287
	(filtered)[a]	μg/L	10	48	84/173
Iron	(total)[a]	μg/L	50	8,300	172/287
	(filtered)[a]	μg/L	50	4,870	18/173
Lead	(total)[a]	μg/L	5	173	35/356
	(filtered)[a]	μg/L	5	6.1	2/147
Magnesium	(total)[a]	μg/L	?	11,800	160/160
	(filtered)[a]	μg/L	?	13,200	173/173
Manganese	(total)[a]	μg/L	5	191	20/287
	(filtered)[a]	μg/L	5	53	10/173
Mercury	(total)[a]	μg/L	0.1	8.9	9/287
Nickel	(total)[a]	μg/L	10	95	8/287
	(filtered)[a]	μg/L	10	39	6/173
Potassium	(total)[a]	μg/L	100	6,040	287/287
	(filtered)[a]	μg/L	100	5,910	173/173
Silver	(total)[a]	μg/L	10	19	1/287
Sodium	(total)[a]	μg/L	100	29,700	287/287
	(filtered)[a]	μg/L	100	258,000	173/173
Strontium	(filtered)[a]	μg/L	300	310	1/23
Uranium	(total)[a]	μg/L	0.725	446	136/136
Vanadium	(total)[a]	μg/L	5	30	63/287
	(filtered)[a]	μg/L	5	11	29/173
Zinc	(total)[a]	μg/L	5	260	104/185
	(filtered)[a]	μg/L	5	47	44/173

Table 11. Groundwater Quality for the Top of the Unconfined Aquifer in the 300-FF-1 Operable Unit. (Sheet 2 of 2)

Parameters detected	Units	Detection limit	Maximum value detected	Detections/ analyses
Ammonium[a]	µg/L	50	1,630	90/290
Chloride[a]	µg/L	500	122,000	385/386
Cyanide[a]	µg/L	10	11	1/283
Fluoride	µg/L	500	1,870	184/479
Nitrate (as NO_3^-)[a]	µg/L	500	82,000	495/497
Phosphate[a]	µg/L	1,000	3,240	2/386
Sulfate	µg/L	500	47,900	386/386
Sulfide[a]	µg/L	1,000	3,000	4/269
Chloroform[a]	µg/L	10	42	340/402
Bis(2-ethyl hexyl) phthalate[a]	µg/L	10	50	2/33
Methylene chloride[a]	µg/L	10	3,040	40/329
Methyl ethyl ketone	µg/L	10	18	4/417
Tetrachloroethene[a]	µg/L	10	39	15/427
^{60}Co[a]	pCi/L	22.5	64	5/142
Tritium	pCi/L	500	6,480	34/131
^{90}Sr[a]	pCi/L	5	5.6	2/22
^{99}Tc[a]	pCi/L	15	55	5/9
Uranium[a]	pCi/L	0.5	120	172/174

[a]Maximum value detected exceeds the upper 95% confidence limit for the 0.95 background quantile.
[b]Only one background data point.
MPN = Most probable number.

Table 12. Groundwater Quality for the Bottom of the Unconfined Aquifer in the 300-FF-1 Operable Unit. (Sheet 1 of 2)

Parameters detected		Units	Detection limit	Maximum value detected	Detections/ analyses
Gross alpha[a]		pCi/L	4	47.3	22/35
Gross beta[b]		pCi/L	8	29.9	29/35
pH		std units	0.1	6.7 - 8.3	39/39
Specific conductance		µmho/cm	1	370	39/39
Total coliform[c]		MPN	2.2	3	9/35
Total organic carbon[a]		µg/L	1,000	3,850	4/35
Total organic halogen[a]		µg/L	100	2,940	3/35
Aluminum	(total)[a]	µg/L	150	180	1/35
Barium	(total)[a]	µg/L	6	80	35/35
	(filtered)[a]	µg/L	6	69	24/24
Cadmium	(total)[a]	µg/L	2	9	2/35
Calcium	(total)[a]	µg/L	50	24,300	26/26
	(filtered)[a]	µg/L	50	24,900	24/24
Carbon	(total)[c]	µg/L	?	40,700	3/3
Chromium	(total)[a]	µg/L	10	19	7/35
Copper	(total)[a]	µg/L	10	42	8/35
	(filtered)[a]	µg/L	10	11	1/24
Iron	(total)[a]	µg/L	50	1,130	21/35
	(filtered)[a]	µg/L	50	140	11/24
Lead	(total)[a]	µg/L	5	5.6	1/35
Magnesium	(total)[a]	µg/L	?	7,060	26/26
	(filtered)[a]	µg/L	?	7,220	24/24
Manganese	(total)[a]	µg/L	5	91	35/35
	(filtered)[a]	µg/L	5	96	24/24
Mercury	(total)[a]	µg/L	0.1	0.2	1/35
Nickel	(total)	µg/L	10	16	1/35
Potassium	(total)	µg/L	100	6,650	35/35
	(filtered)	µg/L	100	6,120	24/24
Sodium	(total)	µg/L	100	61,400	35/35
	(filtered)	µg/L	100	54,200	24/24
Uranium	(total)[c]	µg/L	0.725	24.8	2/2
Vanadium	(total)[a]	µg/L	5	8	1/35
	(filtered)[a]	µg/L	5	6	1/24
Zinc	(total)	µg/L	5	53	13/26
	(filtered)	µg/L	5	18	7/24
Ammonium		µg/L	50	595	22/35
Chloride[a]		µg/L	500	38,500	35/35
Fluoride		µg/L	500	1,770	25/35
Nitrate (as NO_3^-)[a]		µg/L	500	17,600	22/35
Sulfate		µg/L	500	18,900	35/35

Table 12. Groundwater Quality for the Bottom of the Unconfined Aquifer in the 300-FF-1 Operable Unit. (Sheet 2 of 2)

Parameters detected	Units	Detection limit	Maximum value detected	Detections/ analyses
Chloroform[a]	µg/L	10	16	3/34
Methylene chloride[a]	µg/L	10	1,500	4/33
Methyl ethyl ketone	µg/L	10	23	1/39
Trans-1,2-dichloroethene[a]	µg/L	10	72	14/18
Trichloroethene[a]	µg/L	10	24	8/39
^{90}Sr	pCi/L	5	5.3	1/4
Uranium[a]	pCi/L	0.5	30.9	4/9

[a]Maximum value detected exceeds the upper 95% confidence limit for the 0.99 background quantile.
[b]Maximum value detected exceeds the upper 95% confidence limit for the 0.95 background quantile.
[c]Only one background data point.
MPN = Most probable number.

Table 13. Groundwater Quality for the Upper Confined Aquifer in the 300-FF-1 Operable Unit.

Parameters detected	Units	Detection limit	Maximum value detected	Detections/ analyses
Gross alpha[a]	pCi/L	4	4.2	1/18
Gross beta[a]	pCi/L	8	54.7	14/18
pH	std units	0.1	6.7 - 8.3	21/21
Specific conductance	μmho/cm	1	517	21/21
Aluminum (total)[a]	μg/L	150	540	3/18
Barium (total)[a]	μg/L	6	129	17/18
(filtered)[a]	μg/L	6	125	17/18
Calcium (total)[a]	μg/L	50	21,200	17/18
(filtered)[a]	μg/L	50	19,200	17/18
Chromium (total)[a]	μg/L	10	64	9/18
Iron (total)[a]	μg/L	50	1,380	16/18
(filtered)[a]	μg/L	50	560	12/18
Magnesium (total)[a]	μg/L	?	7,860	17/18
(filtered)[a]	μg/L	?	7,600	17/18
Manganese (total)[a]	μg/L	5	90	17/18
(filtered)[a]	μg/L	5	80	17/18
Nickel (total)	μg/L	10	32	3/18
(filtered)[a]	μg/L	10	11	1/18
Potassium (total)[a]	μg/L	100	11,300	17/18
(filtered)[a]	μg/L	100	11,100	17/18
Sodium (total)	μg/L	100	68,300	17/18
(filtered)	μg/L	100	71,400	17/18
Uranium (total)[b]	μg/L	0.725	2.51	1/2
Zinc (total)	μg/L	5	60.0	11/18
(filtered)[c]	μg/L	5	41.0	3/18
Ammonium	μg/L	50	158	17/18
Chloride	μg/L	500	16,200	17/18
Fluoride	μg/L	500	2,080	17/18
Nitrate (as NO_3^-)[a]	μg/L	500	1,800	4/18
Sulfate	μg/L	500	12,000	10/18
Trans-1,2-dichloroethene[a]	μg/L	10	20	1/8
Uranium	pCi/L	0.5	2.66	2/8

[a]Maximum value detected exceeds the upper 95% confidence limit for the 0.99 background quantile.
[b]Only one background data point.
[c]Maximum value detected exceeds the upper 95% confidence limit for the 0.95 background quantile.

3.1.3.2.1 Radionuclides. Radionuclides have previously been identified as contaminants within soils of the 300-FF-5 operable unit. The extent of radionuclide contamination within the groundwater is preliminarily delineated by the distribution of uranium in the shallow aquifer zone.

The distribution of uranium contamination in groundwater beneath the 300 Area in late 1987 is presented in Figure 24. The highest concentrations of uranium are found near 316-5, but an additional "high" is located along the river south of 316-1. The plume at the south end of 316-5 emanates radially outward from the trenches and is consistent with generally higher soil alpha concentrations in that area. The amount of gross alpha contamination can be attributed to the uranium present (Schalla et al. 1988). This is borne out by the close similarity in mapped plumes for uranium and gross alpha (Figure 25). Uranium concentrations decrease rapidly with increasing distance from the pond inlets. Contaminants in particulate form would be expected to rapidly settle once entering the waste disposal facilities. This should be particularly true for uranium because of its high density. An additional plume exists adjacent to the Columbia River, south of 316-1. Recent isotopic analysis (Evans et al. 1989) confirms that 316-5 is not the source of the uranium "high" south of 316-1. In 1988, isotopic analyses of water samples from the two plumes indicated a distinct difference in the isotopic ratios of ^{235}U and ^{238}U. Groundwater nearest 316-5 had ratios typical of an enriched uranium source, whereas wells to the south had ratios typical of natural uranium. 316-5 releases an enriched source of uranium, and an as-yet-unidentified southern source releases uranium with naturally occurring isotopic ratios. Potential sources within the southern area are 316-3 or leakage from the radioactive or process waste-water lines (Lindberg and Bond 1979, Stenner et al. 1988). Documented spills have been recorded in this area (Stenner et al. 1988). Isotopes and ratios of ^{234}U and ^{236}U also may prove useful for differentiating sources, particularly during analysis of river sediments.

Other radiation parameters found at concentrations above background levels beneath the 300-FF-5 operable unit include gross alpha, gross beta, and tritium. Trace amounts of many radionuclides are routinely found in the springs along the reach of the Columbia River that forms the eastern boundary of the 300-FF-5 operable unit.

3.1.3.2.2 Metals and Anions. A large number of metals have been detected at elevated concentrations within the soils of the 300-FF-1 operable unit. A few metals are found also in groundwater above background concentrations. These include silver, cadmium, chromium, copper, mercury, nickel, and lead. These metals have been detected in the groundwater sporadically since monitoring for these constituents began in June 1985, but they are generally present in concentrations near or below their detection limits and always below drinking water standards. Copper distributions (Figure 26) are used to illustrate the approximate extent of metals in the shallow aquifer zone. Copper has been shown to be associated with high levels of radioactivity in the soils of 316-1 and 316-2 (Dennison et al. 1988).

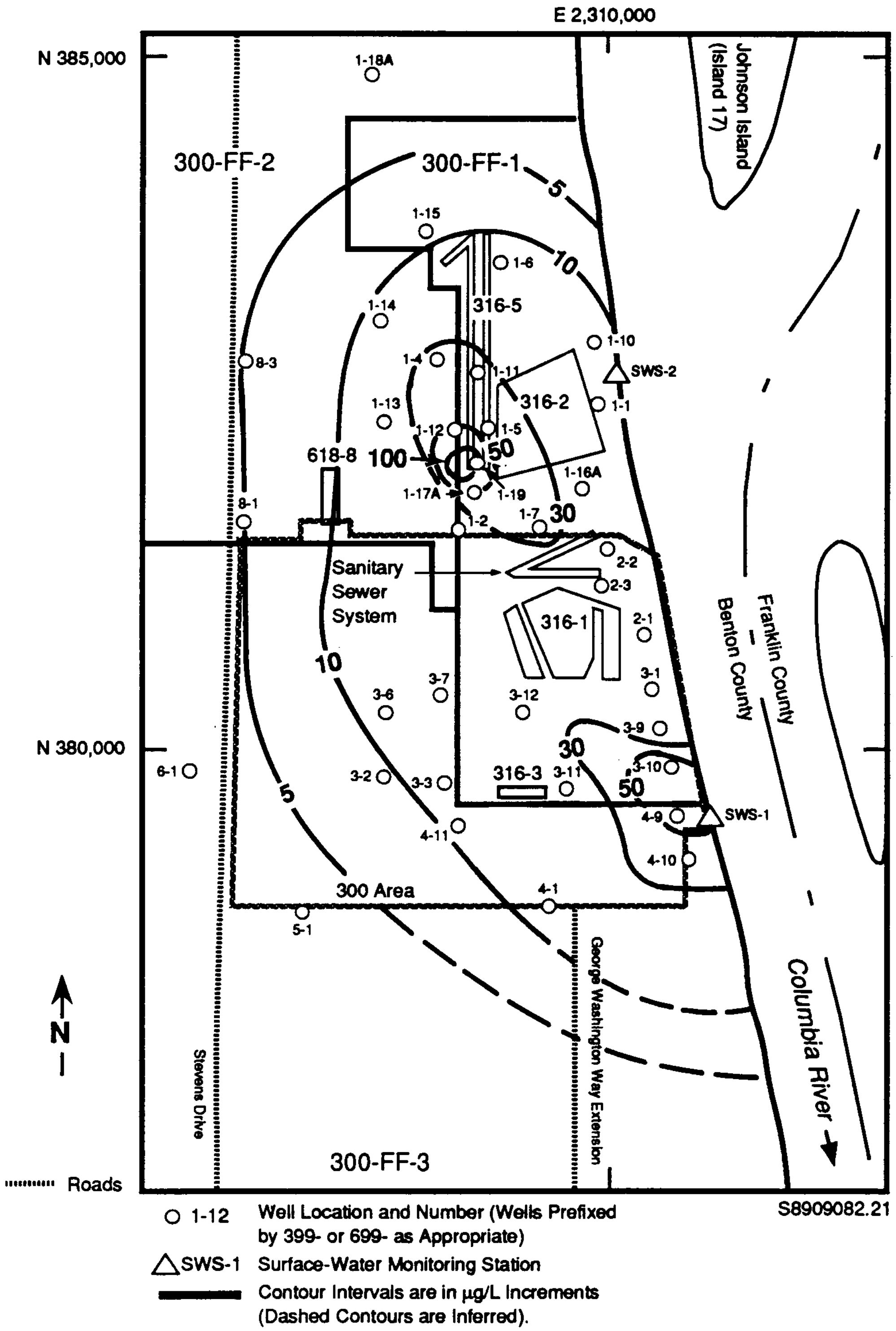


Figure 24. Uranium Plume in the 300-FF-5 Operable Unit, Measured in November 1987.

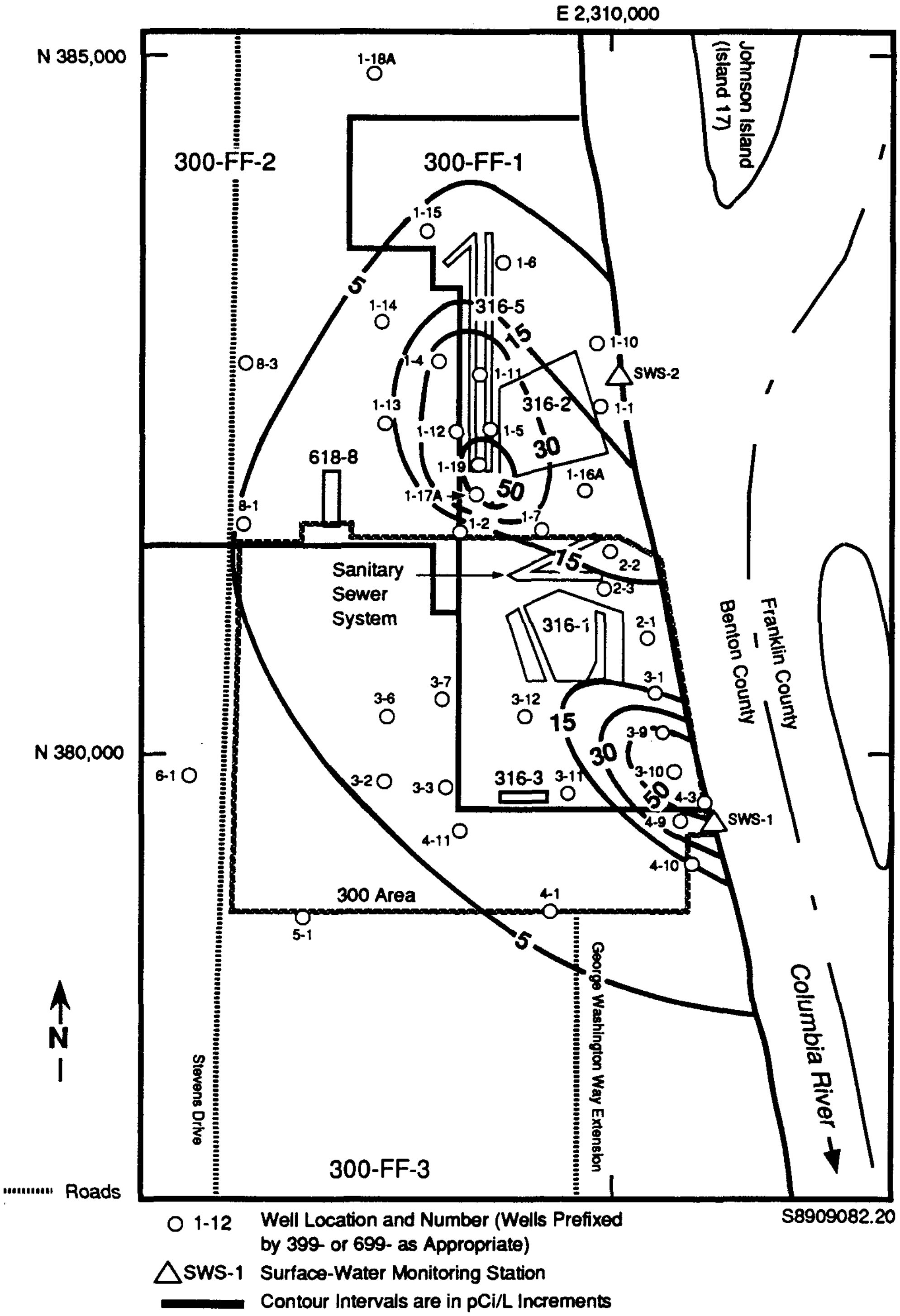
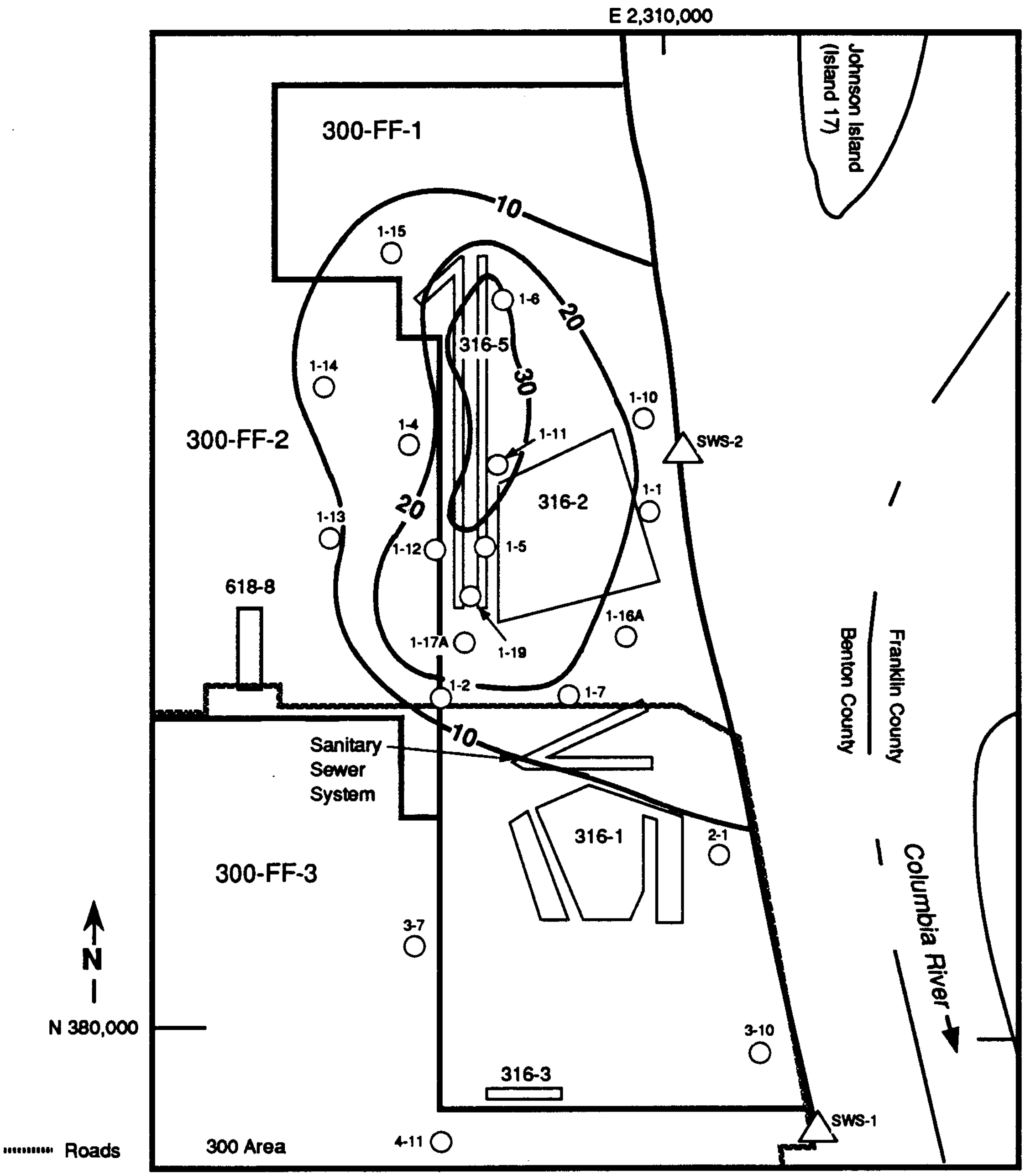


Figure 25. Gross Alpha Activity in the 300-FF-5 Operable Unit, Measured in November 1987.



○ 1-12 Well Location and Number (Wells Prefixed by 399- or 699- as Appropriate)

△ SWS-1 Surface-Water Monitoring Station

━━ Contour Intervals are in µg/L Increments

Figure 26. Copper Plume in the 300-FF-5 Operable Unit, Measured in March 1987.

The well water analyses during the last 4 yr indicate that most of the groundwater in and adjacent to the 300-FF-5 operable unit is contaminated with nitrate from 316-5 and possibly from upgradient sources. Nitrate levels have never been measured above the drinking water standard of 45,000 $\mu g/L$ in wells in 300-FF-5, except for two wells in the southwest quadrant of 300-FF-5 where nitrate concentrations were slightly above the limit (Figure 27). Figure 27 presented the 1986 nitrate distribution in the 300-FF-5 operable unit when 316-5 received nitrate-bearing waste. Since that time, nitrate concentrations in 300-FF-5 groundwaters have decreased to below background (upgradient) levels, as shown in Figure 28.

Elevated concentrations of chloride appear to be closely associated with 316-5. Approximately 75 tons of sodium chloride are discharged to 316-5 annually from filter backwash operations used in water treatment processes.

Fluoride has been found at concentrations up to 1,600 $\mu g/L$ in the upper confined aquifer and to approximately 1,400 $\mu g/L$ in the bottom of the unconfined aquifer in 300-FF-5. These levels are less than the EPA drinking water standard of 4,000 $\mu g/L$. Currently, the source of this fluoride is thought to be the deeper confined basalt aquifers that contain up to 45,000 $\mu g/L$ (Early et al. 1986). In the vicinity of 300-FF-5, upper Saddle Mountains Basalt aquifers contain fluoride at approximately 2,000 $\mu g/L$. In the deeper Wanapum Basalt aquifers, fluoride concentrations increase to 10,000 $\mu g/L$ or greater. Because fluoride concentrations increase with depth throughout the Hanford Site, the fluoride concentrations detected in 300-FF-5 are thought to be natural.

3.1.3.2.3 Hydrocarbons. Several volatile organic chemicals were detected in groundwater samples from 300-FF-5. They include chloroform (trichloromethane), methylene chloride, perchloroethene, trichloroethene, 1,2-dichloroethene (cis and trans isomers), 1,1,1-trichloroethane, and tetrachloromethane (carbon tetrachloride). In 1988, only trichloroethene and 1,2-dichloroethene were present in concentrations greater than their respective maximum contaminant levels. These eight chemicals can be separated into three groups according to likely source areas. Chloroform, methylene chloride, and perchloroethene historically originated from 316-5. The trichloroethene and 1,2-dichloroethene probably originated from another source within the 300-FF-1 operable unit, but also occur probably as degradation products of perchloroethene. Because 1,1,1-trichloroethane and carbon tetrachloride are most often detected in wells that are upgradient of the 300-FF-1 operable unit, they probably originate from sources that are somewhere within the 300-FF-2 operable unit or from some sources to the west or north of 300-FF-2.

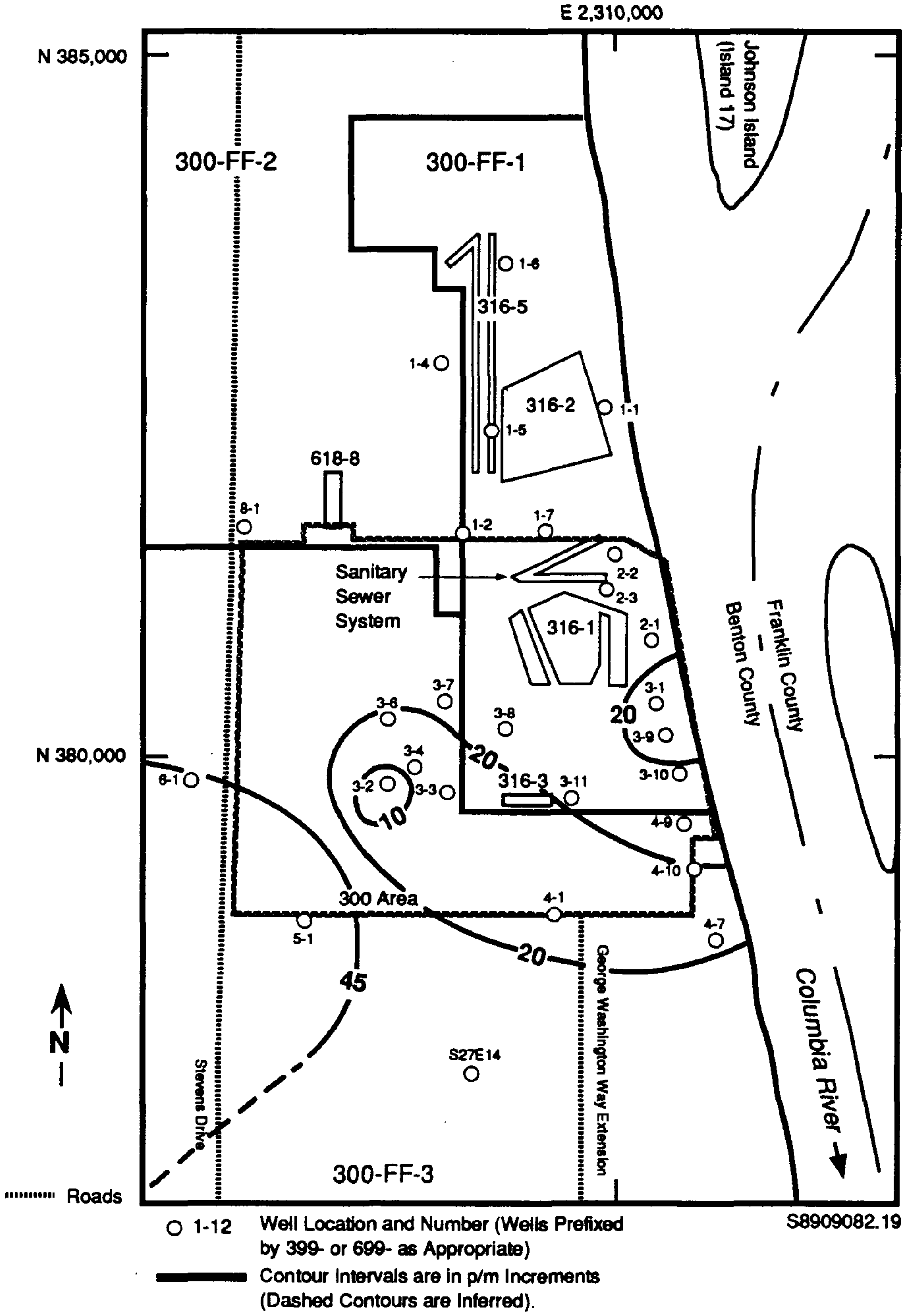


Figure 27. Nitrate Plume in the 300-FF-5 Operable Unit, Measured in June 1986.

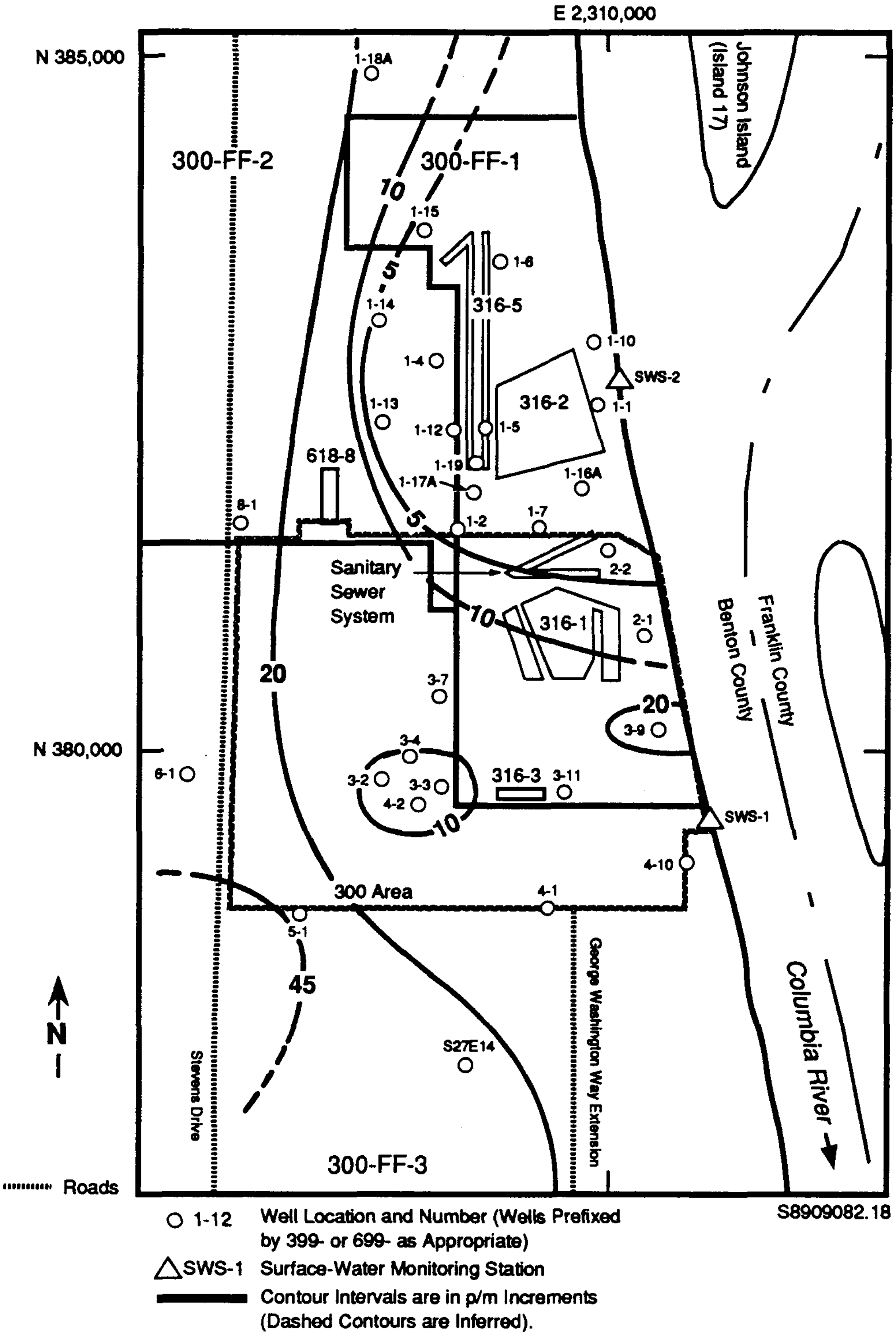


Figure 28. Nitrate Plume in the 300-FF-5 Operable Unit, Measured in August 1988.

In the first group of three volatile organic chemicals, chloroform is the only one consistently present in concentrations above detection limits. Chloroform is known to be ubiquitous in the environment (Callahan et al. 1979), and is particularly common in finished drinking water (Jolley et al. 1984) and waste water effluent. Concentrations of chloroform vary from winter and spring lows of less than 20 μg/L (Figure 29) to a summer high of approximately 40 μg/L near 316-5 (Figure 30), forming a persistent plume that varies in concentration (Schalla et al. 1988). Chloroform is limited to the top of the unconfined aquifer and is always below the detection limit at the bottom of the unconfined and top of the confined aquifers. The drinking water standard for chloroform is 100 μg/L.

Methylene chloride has been detected to 27,000 μg/L at various times from June 1985 to the present in the 316-5 monitoring network (Schalla et al. 1988). Because of contamination problems with sampling pumps and external sources of contamination on laboratory samples, it is not known if significant releases of methylene chloride occurred from 316-5 (Schalla et al. 1988). During the last year, concentrations have been below its detection limit of 10 μg/L. Methylene chloride is commonly used for cleaning laboratory equipment and, therefore, the laboratory could be a source of contamination.

Perchloroethene has been detected sporadically in a few wells since the 1982 and 1984 spills reported by Cline et al. (1985), but usually near its detection limit of 5 μg/L and rarely in more than one well during a sampling period. The sporadic appearance of perchloroethene at concentrations at this level may be caused by the release of residual perchloroethene left over from the 1982 and 1984 spills, from fuel rod assembly process water, or from the chemistry or instrumentation laboratories where perchloroethene is commonly used. Commonly associated with perchloroethene are its degradation products, trichloroethene, 1,2-dichloroethene, and 1,1-dichloroethene. The residual contamination present in the bottom of the unconfined aquifer is probably due to dissolution of dense nonaqueous-phase liquids composed of trichloroethene and 1,2-dichloroethene, which may have collected on the bottom of the aquifer.

Presently, concentrations of trichloroethene and 1,2-dichloroethene are detected at the bottom of the unconfined aquifer and in the upper confined aquifer (i.e., wells 399-1-16B, 399-1-16C, and 399-1-17B). These wells were first sampled in March 1987, at which time 1,2-dichloroethene was near or above the EPA-proposed maximum contaminant level of 70 μg/L. Trichloroethene also has been detected at 33 μg/L; several times above its maximum contaminant level of 5 μg/L. It was not surprising to find these contaminants on the bottom of the unconfined aquifer because they are "dense nonaqueous-phase liquids;" that is, they are fluids more dense than water. However, only aqueous-phase samples were collected and analyzed and, therefore, only the quantity of the organic fluids that dissolved in water was detected. It was determined that communication between the unconfined and confined aquifers is occurring because a section of broken steel casing remains in well 399-1-16D, allowing this communication (Schalla et al. 1988). Abandonment of well 399-1-16D to isolate the two aquifers was completed on January 24, 1989. The abandonment effort did not restore hydraulic isolation between the aquifers. This conclusion was reached because trichloroethene and 1,2-dichloroethene

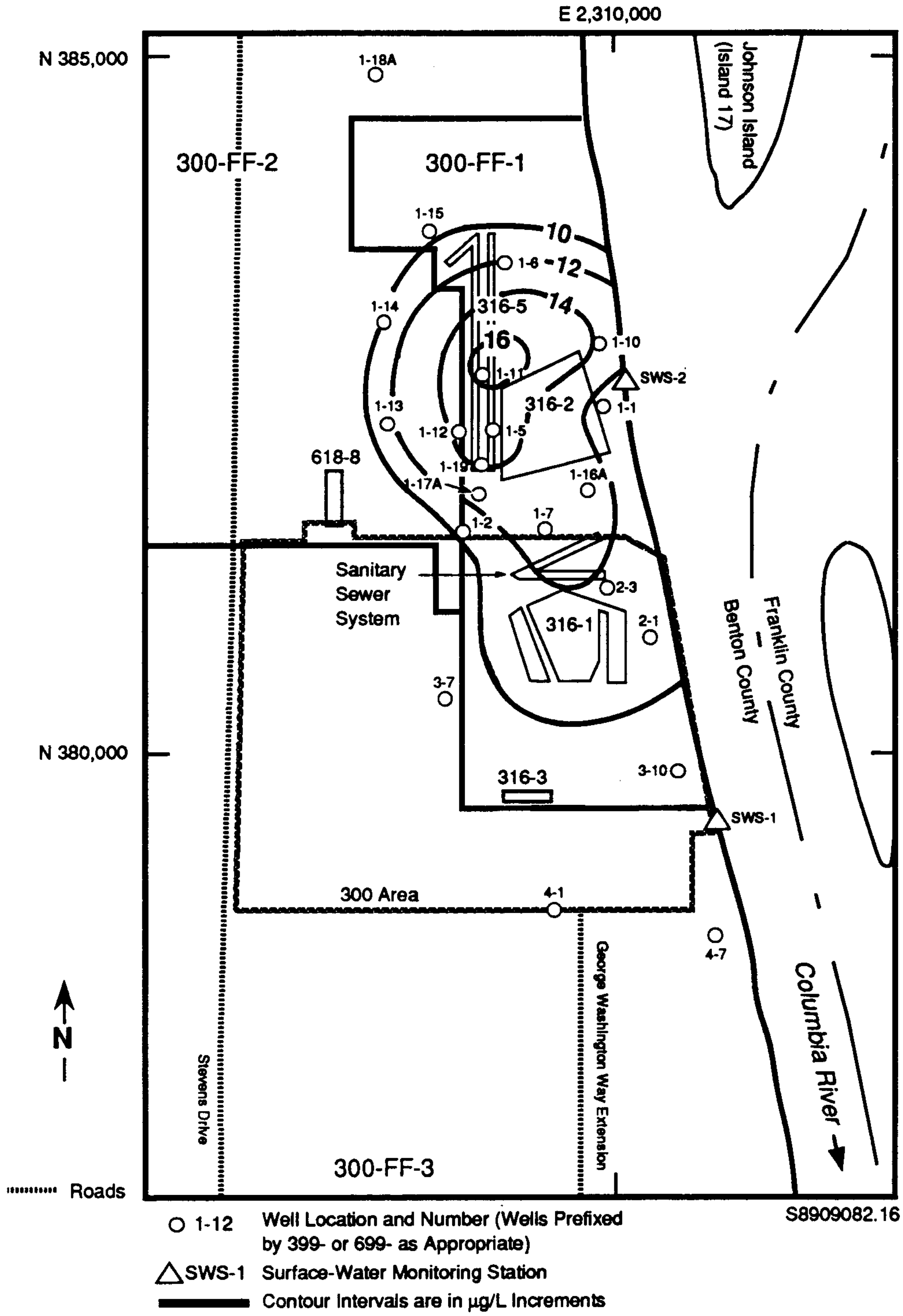


Figure 29. Chloroform Activity in the 300-FF-5 Operable Unit, Measured in April 1987.

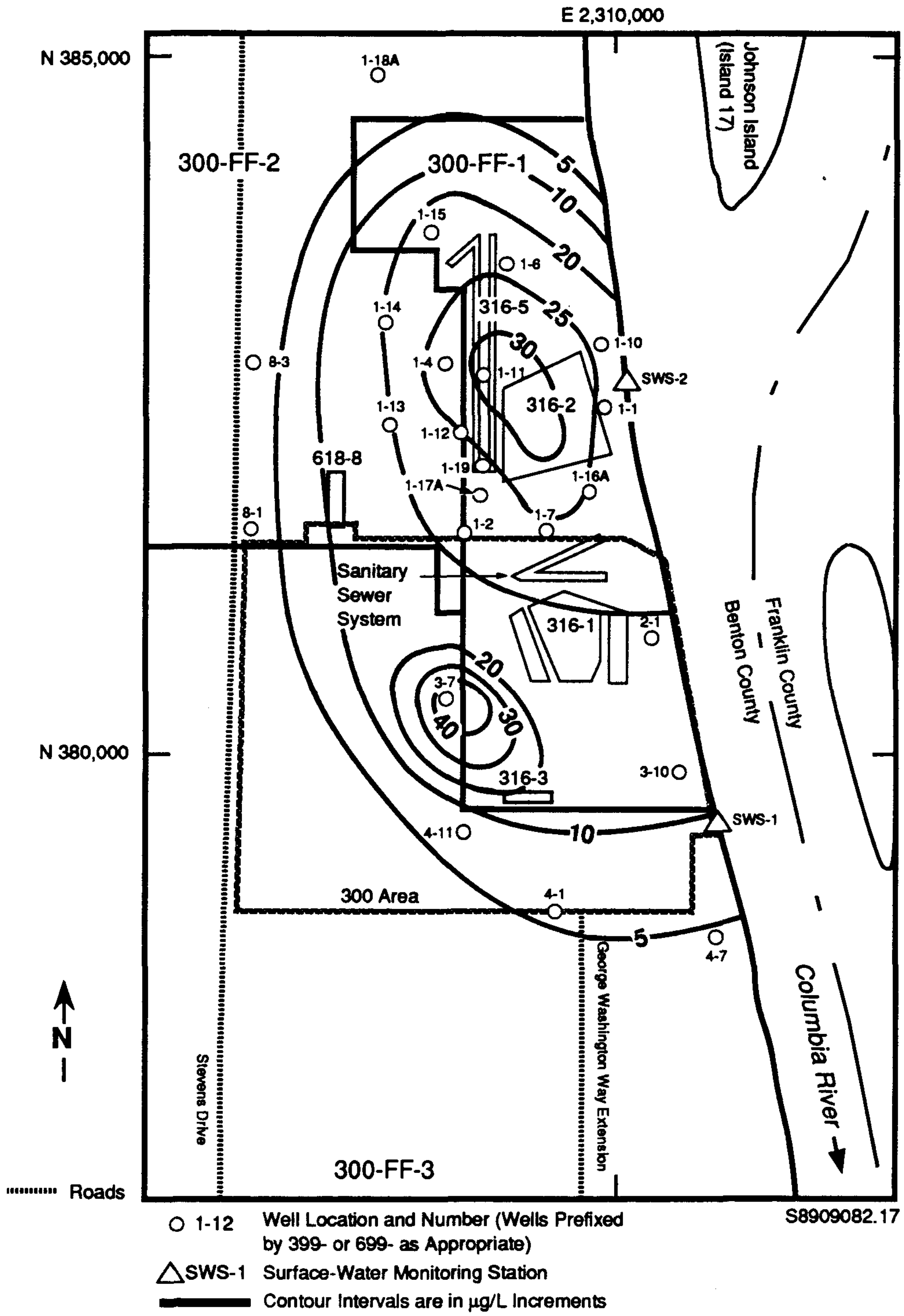


Figure 30. Chloroform Activity in the 300-FF-5 Operable Unit, Measured in August 1988.

continue to be detected in the confined aquifer at that sampling location. In addition, the confined aquifer water level has not returned to typical confined aquifer water levels 28 ft higher than the unconfined aquifer at the same location (Figure 31). In fact, water levels in well 399-1-16-C are approximately equal to those in adjacent well 399-1-16A that is completed in the unconfined aquifer. At two other well clusters, the hydraulic isolation has been maintained, as shown in the hydrographs in Figures 32 and 33. The water level in confined aquifer well 399-1-9 began to decline in the summer of 1988 as the cone of depression (created by leakage between the aquifers at well 399-1-16D) extended to well 399-1-9 (see Figure 32). To date, the cone has not reached confined well 399-1-17C, where hydraulic isolation continues to be maintained (see Figure 33). Water levels in well 399-1-18C are similar to the unconfined aquifer because of its unique hydraulic relationship with the unconfined and confined aquifers (that relationship was discussed in Section 3.1.3.2) (Figure 34).

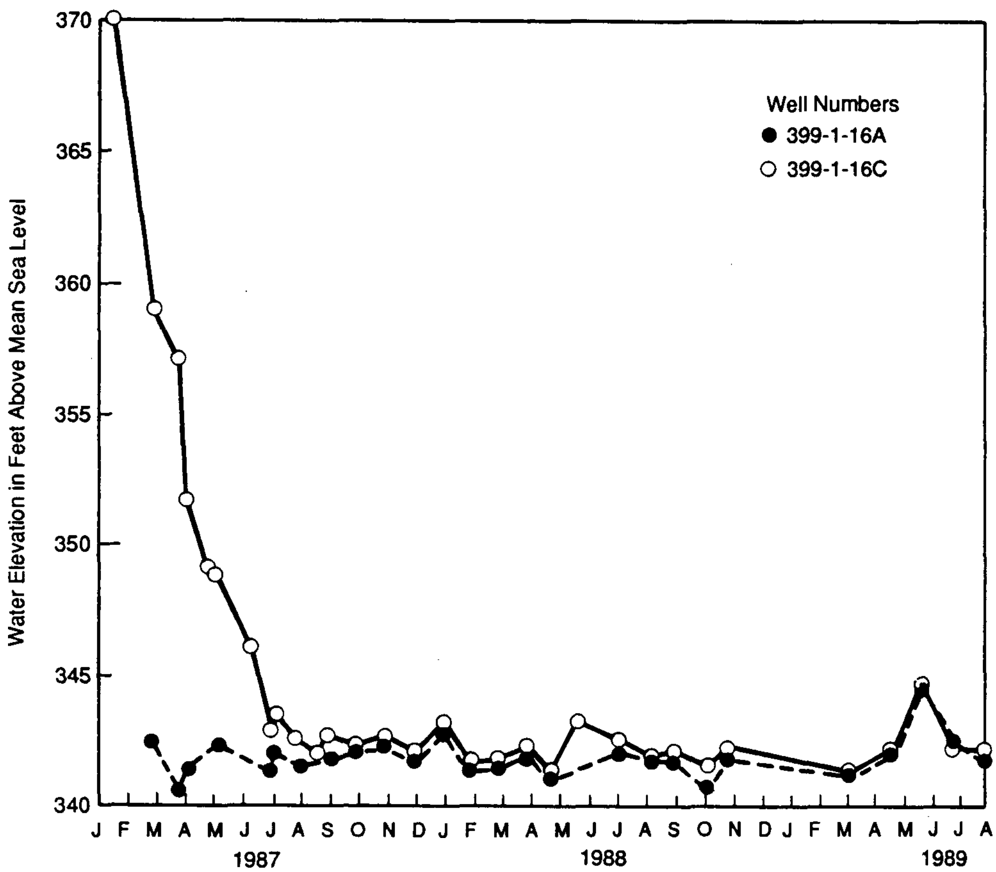


Figure 31. Hydrograph Comparing Water Levels in Confined Aquifer Well 399-1-16C and Unconfined Aquifer Well 399-1-16A

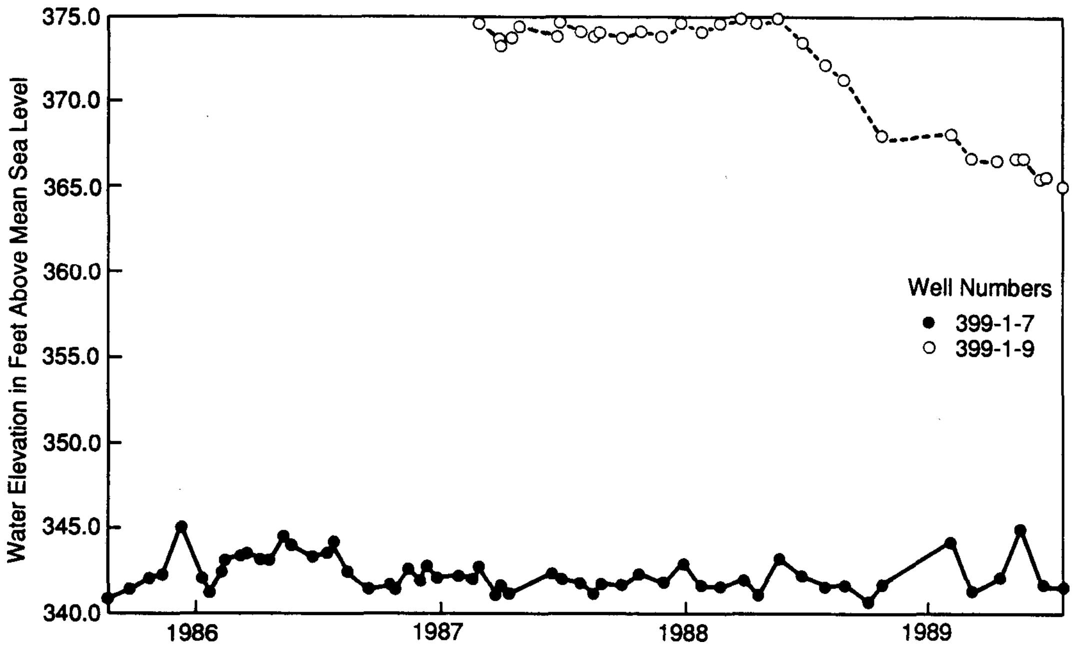


Figure 32. Hydrograph Comparing Water Levels in Confined Aquifer Well 399-1-7 and Unconfined Aquifer Well 399-1-9

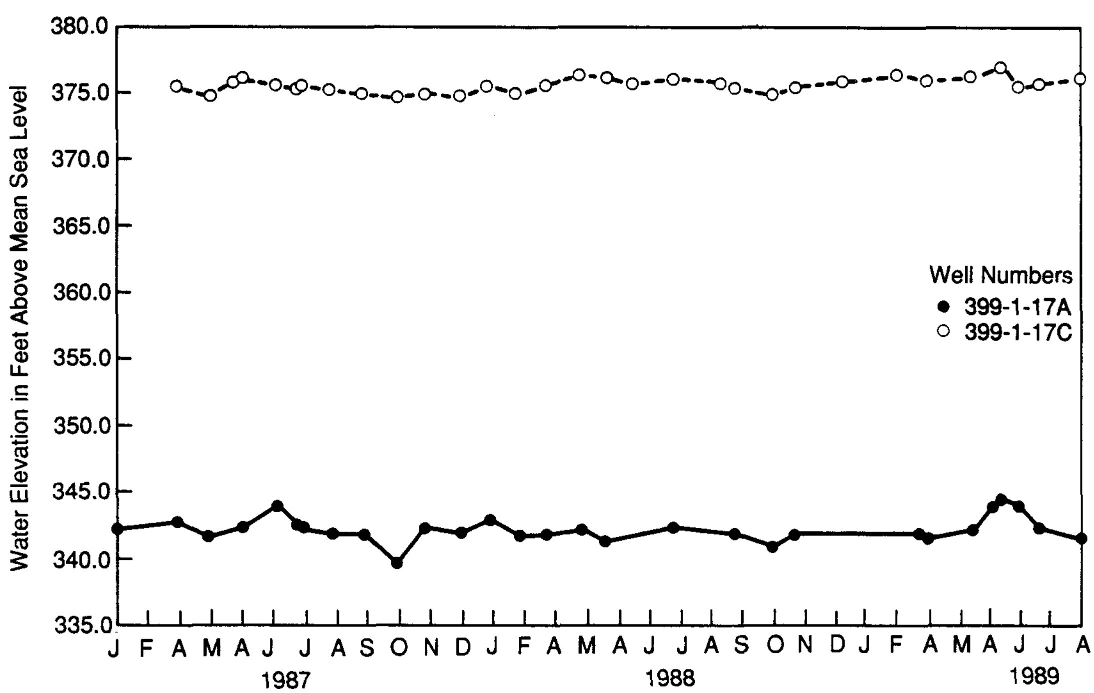


Figure 33. Hydrograph Comparing Water Levels in Confined Aquifer Well 399-1-17A and Unconfined Aquifer Well 399-1-17C

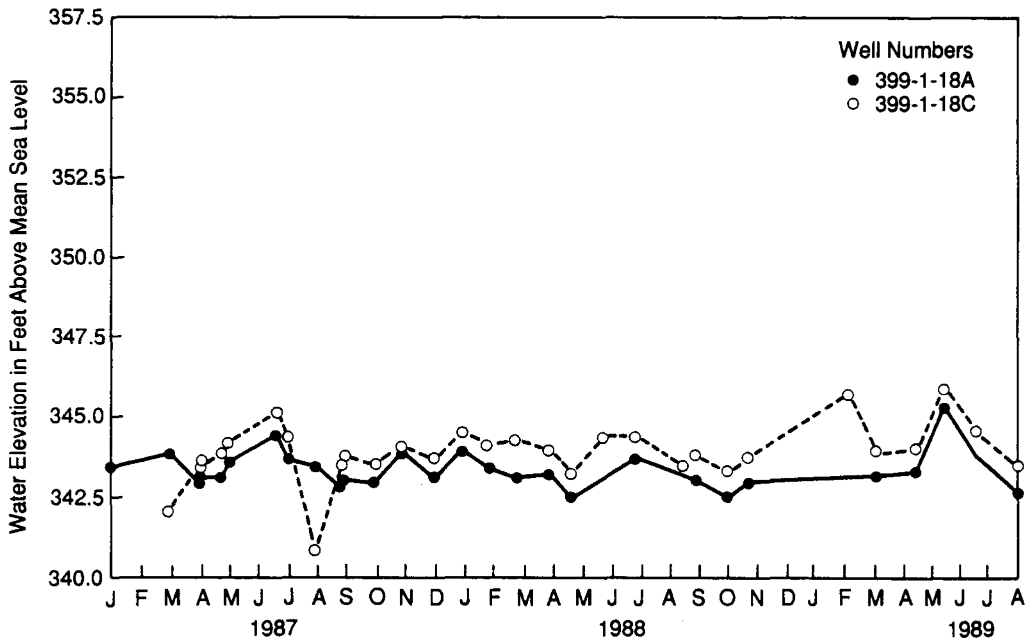


Figure 34. Hydrograph Comparing Water Levels in Confined Aquifer Well 399-1-18A and Unconfined Aquifer Well 399-1-18C

Between November 1988 and January 1989, concentrations of dichloroethene isomers (trans-1,2 and cis-1,2) were determined. Cis-1,2-dichloroethene was the dominant isomer found, as expected, based on experimental anaerobic biodegradation rates and field experience at hazardous waste sites (Wilson et al. 1983a, 1983b; Schalla et al. 1984, 1986). Because trans-1,2-dichloroethene is formed very slowly relative to cis-1,2-dichloroethene during biodegradation, its concentration remains very low. Cis-1,2-dichloroethene was the dominant isomer, with trans-1,2-dichloroethene representing only 1% to 5% of the total 1,2-dichloroethene present (~70 μg/L). Distinguishing isomers may provide information about location of contamination source areas based on their unique ratios and concentrations.

Both trichloroethene and 1,2-dichloroethene are found only at the bottom of the unconfined aquifer downgradient of 316-2 and 316-5. The consistent presence of these two chemicals at these locations indicates that these compounds were probably the result of a previous solvent spill. Where and when the spill occurred are somewhat uncertain. It is unlikely that the current contamination is related to either the 1982 or 1984 spills of perchloroethene (reported by Cline et al. 1985) for two reasons. First, trichloroethene is always in lesser concentrations than its degradation isomer, cis-1,2-dichloroethene, but much greater than trans-1,2-dichloroethene at the bottom of the unconfined aquifer. Second, perchloroethene, the parent isomer to trichloroethene, is typically less than 1% of the concentration of the degraded trichloroethene. For trichloroethene and cis-1,2-dichloroethene to degrade to their current relative proportions [based on experimental anaerobic biodegradation rates (Vogel and McCarthy 1985)] indicates that if the original contaminant was trichloroethene, it must have been in the groundwater system undergoing anaerobic biodegradation at least 1 to 6 yr prior to January 1989. If the original contaminant was perchloroethene, trichloroethene would never be 100 times the concentration of perchloroethene because their biodegradation half-lives are similar. Because there are insufficient intermediate-depth wells in 300-FF-5 and no record exists of such a trichloroethene spill, it is not possible to determine the source and maximum level of trichloroethene contamination in the groundwater. It has been noted also that perchloroethene replaced trichloroethene as the primary degreaser used in fuel fabrication in 1972; therefore, perchloroethene has been in use in the 300 Area for only 16 yr.

Although most sources of contamination seem to emanate from within the 300-FF-1 operable unit, others (such as tetrachloromethane and 1,1,1-trichloroethane) appear to have sources within the 300-FF-2 or 300-FF-3 operable units, or they may originate from a source that is upgradient of these operable units. Tetrachloromethane had concentrations of 6 and 5 μg/L (the maximum contaminant level) in upgradient wells 399-1-18A and 399-8-2 in 1988.

Analyses of volatile organic constituents indicate that volatile organics entered the confined aquifer from the unconfined aquifer during 1987. Communication between the unconfined and confined aquifers is occurring because of a section of broken steel casing in well 399-1-16D as previously discussed. Abandonment activities conducted in late 1988 and completed in early 1989 were unsuccessful in achieving hydraulic isolation, and contaminants continue to enter the confined aquifer from the bottom of the unconfined aquifer.

Insufficient monitoring wells, completed at the bottom of the unconfined aquifer and in the confined aquifer, preclude meaningful description of contaminant distribution patterns in these zones.

3.1.4 Surface Water and Sediment

Routine monitoring of the Columbia River water and sediment was initiated during 1945 shortly after the startup of the original plutonium production reactors and continues today as part of DOE's Hanford environmental monitoring. The monitoring programs have undergone many changes over the years in response to changing operational conditions, monitoring needs, and as a result of improving techniques in sample collection and analysis. Throughout the years, sample locations upstream of the Hanford Site, outside the influence of site operations, and downstream of all site facilities have been maintained to provide information about the background conditions in the Columbia River and to identify influences from Hanford Site operations. Unfortunately, the monitoring programs have not been and are not now designed specifically to differentiate the contributions of contaminants from individual operating facilities, operable units, or areas. As such, increases in contaminant concentrations observed downstream of Hanford cannot be attributed readily to any one facility or operation, such as the 300-FF-5 operable unit.

Results of the Hanford-wide monitoring programs are published annually in the Hanford environmental monitoring reports (e.g., Jaquish and Mitchell 1988). Although not directly applicable to the 300-FF-5 operable unit, monitoring data for the Columbia River are presented in this section to provide an indication of the known and potential contaminant concentrations present in the river system.

3.1.4.1 Background Surface-Water Quality. Columbia River water samples were collected upstream of Hanford facilities at Priest Rapids Dam and near the Vernita Bridge to provide background data from locations unaffected by site operations (Jaquish and Mitchell 1988). Samples collected at Priest Rapids Dam are analyzed for radiological constituents, while nonradiological analyses are performed on those samples collected near the Vernita Bridge as part of DOE's Hanford environmental monitoring. In addition to the Columbia River monitoring performed by PNL, the river water quality is monitored by the U.S. Geological Survey as part of the National Stream Quality Accounting Network (McGavock et al. 1987), and provides primarily hydrologic and nonradiological water quality data.

Results of the radiological analysis of Columbia River water samples collected at Priest Rapids Dam during 1987 are summarized in Table 14 (from Jaquish and Mitchell 1988). Two types of water-sampling systems were used to collect radiological samples: (1) a composite system that collected a fixed volume of water at set intervals at each location during each sample period and (2) a specially designed system that continuously collected waterborne radionuclides from the river on a series of filters and ion exchange resins. As observed in Table 14, radionuclide concentrations in the river water are extremely low. Several of the radionuclides identified are undetectable without the use of special sampling techniques and/or analytical procedures. Radionuclides consistently found in measurable quantities in river water are tritium, ^{90}Sr, ^{129}I, ^{234}U, ^{235}U, ^{238}U, and $^{239,240}Pu$ (Jaquish and Mitchell 1988). All these radionuclides exist in worldwide fallout, as well as in effluents from Hanford facilities. In addition, tritium and uranium occur naturally in the environment. The 1987, average radionuclide concentrations shown in Table 14 are more than an order of magnitude lower than the applicable drinking water standard in all cases and are similar to those observed during recent years.

Nonradiological water quality data for the Columbia River upstream of the Hanford Site are summarized in Table 15. The data include a number of parameters for which no regulatory limit exists, but that are useful as indicators of water quality. The results, where duplicated, were in general agreement and were comparable to levels observed during recent years. In all cases, applicable standards for Class A-designated water were met.

Table 14. Radionuclide Concentrations Measured in Columbia River Water at Priest Rapids Dam in 1987 (from Jaquish and Mitchell 1988).

Radionuclide[a]		No. of samples	Concentration (pCi/L)[b]			Drinking water standard[c]
			Maximum	Minimum	Average	
Composite system						
Gross alpha		12	0.92 ± 0.46	0.19 ± 0.28	0.44 ± 0.16	15
Gross beta		12	2.1 ± 1.4	0.19 ± 0.92	0.92 ± 0.52	50
Tritium		12	110 ± 10	50 ± 10	70 ± 10	20,000
^{89}Sr		12	0.10 ± 0.08	-0.06 ± 0.12	0.015 ± 0.041	20
^{90}Sr		12	0.18 ± 0.04	0.10 ± 0.03	0.14 ± 0.02	8
^{234}U		12	0.29 ± 0.05	0.17 ± 0.04	0.24 ± 0.02	d
^{235}U		12	0.028 ± 0.022	0.004 ± 0.006	0.013 ± 0.006	d
^{238}U		12	0.37 ± 0.06	0.15 ± 0.04	0.21 ± 0.03	d
Total uranium		12	0.57 ± 0.07	0.33 ± 0.05	0.46 ± 0.04	d
Continuous system						
^{60}Co	P	24	0.0038 ± 0.009	-0.0070 ± 0.007	-0.0006 ± 0.0015	100
	D	24	0.0074 ± 0.008	-0.0066 ± 0.013	-0.0004 ± 0.0026	
^{95}Nb	P	24	0.0043 ± 0.003	-0.004 ± 0.004	0.0007 ± 0.0012	300
	D	24	0.0071 ± 0.013	-0.0072 ± 0.0072	0.0006 ± 0.0024	
^{95}Zr	P	24	0.0043 ± 0.0034	-0.004 ± 0.004	0.0004 ± 0.0012	200
	D	24	0.010 ± 0.021	-0.012 ± 0.019	-0.0010 ± 0.0037	
^{106}Ru	P	24	0.020 ± 0.065	-0.054 ± 0.046	-0.013 ± 0.010	30
	D	24	0.034 ± 0.064	-0.10 ± 0.095	-0.032 ± 0.021	
^{129}I	D	4	0.000012 ± 0.000001	0.000004 ± 0.0000004	0.000007 ± 0.000004	1
^{131}I	P	24	0.011 ± 0.007	-0.005 ± 0.007	0.003 ± 0.002	
	D	24	0.039 ± 0.031	0.001 ± 0.0096	0.013 ± 0.006	3
^{134}Cs	P	24	0.0023 ± 0.0035	-0.004 ± 0.0057	-0.0004 ± 0.0011	
	D	24	0.0052 ± 0.0074	-0.005 ± 0.011	0.0006 ± 0.0021	20,000
^{137}Cs	P	24	0.0026 ± 0.0018	-0.010 ± 0.006	-0.0017 ± 0.0016	
	D	24	0.0085 ± 0.010	-0.012 ± 0.012	-0.0014 ± 0.0026	200
^{144}Ce	P	24	0.0081 ± 0.017	-0.057 ± 0.051	-0.011 ± 0.006	d
	D	24	0.056 ± 0.071	-0.085 ± 0.069	-0.013 ± 0.012	
^{238}Pu	P	4	0.0000008 ± 0.0000020	-0.0000006 ± 0.0000036	0.0000002 ± 0.000001	d
	D	4	0.00003 ± 0.00004	-0.000005 ± 0.00005	0.000012 ± 0.000024	
$^{239,240}Pu$	P	4	0.000028 ± 0.000007	0.000004 ± 0.000002	0.000019 ± 0.000012	d
	D	4	0.00014 ± 0.00007	0.00007 ± 0.00004	0.00011 ± 0.00004	

[a]Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on samples collected by the composite system.
[b]Maximum and minimum values ±2 sigma counting error. Average ±2 standard error of the calculated mean. It is not uncommon for individual measurements of environmental radioactivity to result in values of zero or negative numbers from subtracting out instrumental background.
[c]WAC 248 and 40 CFR 141.
[d]No drinking water standard.

Table 15. Columbia River Water Quality Data for 1987, Measured Upstream of the Hanford Site (from Jaquish and Mitchell 1988)

Analysis	Unit	Vernita bridge (upstream)				State standard[b]
		No. of samples	Maximum	Minimum	Annual average[a]	
Pacific Northwest Laboratory environmental monitoring						
pH	unitless	12	8.3	7.3	NA	6.5 to 8.5
Fecal coliform	#/100 mL	12	64	2	5	100
Total coliform	#/100 mL	12	2,400	2	110[c]	NA
Biological oxygen demand	mg/L	12	8.3	0.4	2.48 ± 1.25	NA
Nitrate (as NO_3^-)	mg/L	12	0.17	0.02	0.09 ± 0.03	NA
U.S. Geological Survey sampling program[d]						
Temperature[e]	°C	365	20.2	3.0	11.7	20 (maximum)
Dissolved oxygen	mg/L	6	13.3	9.6	11.2 ± 1.4	8 (minimum)
Turbidity	NTU[f]	6	2.6	0.1	1.2 ± 0.8	5 + background
pH	unitless	6	8.4	7.9	NA	6.5 to 8.5
Fecal coliform	#/100 mL	6	7	<1	1.5[c]	100
Suspended solids, 105°C	mg/L	4	16	7	7.8 ± 6.2	NA
Dissolved solids, 180°C	mg/L	6	92	70	77 ± 7	NA
Specific conductance	µmhos/cm	6	161	127	138 ± 11	NA
Hardness, as $CaCO_3$	mg/L	6	76	59	67 ± 7	NA
Phosphorus, total	mg/L	6	0.03	0.01	0.02 ± 0.01	NA
Chromium, dissolved	µg/L	3	1	<1	<1	NA
Nitrogen, Kjeldahl	mg/L	6	0.7	<0.2	0.4 ± 0.1	NA
Total organic carbon	mg/L	4	40	1.2	11.2 ± 19.2	NA
Iron, dissolved	µg/L	4	11	3	5.3 ± 3.9	NA
Ammonia, dissolved (as N)	mg/L	6	0.07	<0.01	0.03 ± 0.02	NA

[a]Average values ±2 standard error of the calculated mean.
[b]WAC 173-201.
[c]Annual median.
[d]Provisional data subject to revision.
[e]Maximum and minimum represent daily averages.
[f]Nephelometric turbidity units.
NA = Not applicable.

Groundwater seeps located along the riverbank near the 300-FF-5 operable unit have been sampled periodically over the last few years, but not routinely. The last documented sampling performed by PNL occurred during 1982 and 1983 (McCormack and Carlile 1984). Because these seep areas are the result of groundwater discharge to the river, background contaminant concentrations are best defined through the analysis of groundwater samples. Background groundwater quality was discussed in Section 3.1.3.1.

3.1.4.2 Surface-Water Contamination. Columbia River water samples were collected at two locations downstream of Hanford, the 300 Area water intake and the Richland Pumphouse to identify any possible influence on contaminant concentrations from Hanford operations (Jaquish and Mitchell 1988). Samples collected from the 300 Area water intake were analyzed for radiological constituents, while the Richland Pumphouse samples were analyzed for radiological and nonradiological parameters. As was the case in the background sample locations, the U.S. Geological Survey monitors the Columbia River at the Richland Pumphouse, primarily for nonradiological water quality parameters. In addition, the U.S. Geological Survey monitors river water quality at several locations farther downstream of the Hanford Site.

Results of the radiological analysis of the Columbia River water samples collected from the 300 Area water intake and the Richland Pumphouse during 1987 are summarized in Tables 16 and 17, respectively (from Jaquish and Mitchell 1988). Two types of water-sampling systems were used to collect radiological samples: (1) a composite system that collected a fixed volume of water at set intervals at each location during each sample period and (2) a specially designed system that continuously collected waterborne radionuclides from the river on a series of filters and ion exchange resins. All radionuclide concentrations observed during 1987 at the 300 Area water intake and the Richland Pumphouse were well below drinking water standards.

Radiological and nonradiological pollutants are known to enter the Columbia River along the Hanford Site. In addition to direct discharges from Hanford facilities, contaminants in the groundwater from past effluent discharges are known to seep into the river. Potential sources of pollutants entering the river along the Hanford reach not associated with Hanford operations include irrigation returns and extensive groundwater seepage, resulting from extensive agricultural practices north and east of the river. As mentioned previously, contaminant concentrations observed at the 300 Area water intake and the Richland Pumphouse reflect contributions from several pollutant sources, including those not related to the 300-FF-5 operable unit or the Hanford Site. The analyses do not specifically identify contributions attributable to the 300-FF-5 operable unit. As such, data presented in Tables 16 and 17 provide contaminant information not directly attributable to the 300-FF-5 operable unit, but are indicative of levels of contaminants in the river.

Table 16. Radionuclide Concentrations Measured in Columbia River Water at the 300 Area in 1987 (from Jaquish and Mitchell 1988).

Radionuclide[a]		No. of samples	Concentration (pCi/L)[b]			Drinking water standard[c]
			Maximum	Minimum	Average	
Composite system						
Gross alpha		4	0.79 ± 0.41	0.43 ± 0.35	0.59 ± 0.26	15
Gross beta		4	2.8 ± 1.5	1.2 ± 1.3	2.1 ± 1.0	50
Tritium		4	200 ± 10	130 ± 10	170 ± 40	20,000
^{89}Sr		4	0.20 ± 0.12	-0.011 ± 0.12	0.097 ± 0.12	20
^{90}Sr		4	0.15 ± 0.03	0.092 ± 0.044	0.13 ± 0.04	8
^{234}U		4	0.33 ± 0.05	0.25 ± 0.05	0.30 ± 0.05	d
^{235}U		4	0.021 ± 0.013	0.004 ± 0.007	0.009 ± 0.010	d
^{238}U		4	0.26 ± 0.05	0.24 ± 0.05	0.25 ± 0.03	d
Total uranium		4	0.61 ± 0.07	0.49 ± 0.07	0.56 ± 0.07	d
Continuous system						
^{60}Co	P	24	0.0048 ± 0.0053	-0.0026 ± 0.0046	0.00017 ± 0.0012	100
	D	24	0.021 ± 0.015	-0.0047 ± 0.009	0.0032 ± 0.0030	
^{95}Nb	P	24	0.0047 ± 0.0053	-0.0037 ± 0.0038	0.00075 ± 0.0010	300
	D	24	0.0072 ± 0.007	-0.0060 ± 0.0085	0.0010 ± 0.0019	
^{95}Zr	P	24	0.0048 ± 0.008	-0.0053 ± 0.0059	0.0002 ± 0.0016	200
	D	24	0.013 ± 0.019	-0.015 ± 0.011	0.0024 ± 0.0034	
^{106}Ru	P	24	0.0098 ± 0.017	-0.028 ± 0.043	-0.0099 ± 0.0074	30
	D	24	0.043 ± 0.046	-0.087 ± 0.067	-0.022 ± 0.018	
^{129}I	D	4	0.00013 ± 0.00001	0.000079 ± 0.000007	0.00011 ± 0.00003	1
^{131}I	P	24	0.0079 ± 0.0061	0.00009 ± 0.0034	0.0033 ± 0.0013	3
	D	24	0.017 ± 0.020	0.0013 ± 0.0160	0.0083 ± 0.0031	
^{134}Cs	P	24	0.0035 ± 0.0056	-0.0024 ± 0.0020	0.00024 ± 0.00094	20,000
	D	24	0.0050 ± 0.0068	-0.012 ± 0.0094	-0.00035 ± 0.0021	
^{137}Cs	P	24	0.00093 ± 0.0023	-0.0058 ± 0.0054	-0.0015 ± 0.0010	200
	D	24	0.0031 ± 0.0039	-0.014 ± 0.010	-0.0019 ± 0.0022	
^{144}Ce	P	24	0.0028 ± 0.04	-0.016 ± 0.015	-0.0054 ± 0.0034	d
	D	24	0.045 ± 0.051	-0.041 ± 0.081	0.0085 ± 0.0087	
^{238}Pu	P	4	0.000001 ± 0.000004	0.0000005 ± 0.0000035	0.0000007 ± 0.000001	d
	D	4	0.000009 ± 0.00002	-0.00001 ± 0.00005	-0.0000003 ± 0.00002	
$^{239,240}Pu$	P	4	0.000033 ± 0.000008	0.000008 ± 0.000006	0.00002 ± 0.00001	d
	D	4	0.00006 ± 0.00005	0.00004 ± 0.00002	0.00005 ± 0.00002	

[a]Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on samples collected by the composite system.
[b]Maximum and minimum values ±2 sigma counting error. Average ±2 standard error of the calculated mean. It is not uncommon for individual measurements of environmental radioactivity to result in values of zero or negative numbers from subtracting out instrumental background.
[c]WAC 248 and 40 CFR 141.
[d]No drinking water standard.

Table 17. Radionuclide Concentrations Measured in Columbia River Water at the Richland Pumphouse in 1987 (from Jaquish and Mitchell 1988).

Radionuclide[a]		No. of samples	Concentration (pCi/L)[b]			Drinking water standard[c]
			Maximum	Minimum	Average	
Composite system						
Gross alpha		12	0.89 ± 0.43	0.05 ± 0.26	0.53 ± 0.21	15
Gross beta		12	2.4 ± 1.4	0.21 ± 1.17	1.1 ± 0.5	50
Tritium		12	180 ± 10	70 ± 10	130 ± 10	20,000
^{89}Sr		12	0.11 ± 0.07	-0.05 ± 0.11	0.040 ± 0.035	20
^{90}Sr		12	0.18 ± 0.04	0.10 ± 0.03	0.14 ± 0.02	8
^{234}U		12	0.45 ± 0.06	0.14 ± 0.03	0.27 ± 0.05	d
^{235}U		12	0.037 ± 0.017	0.003 ± 0.011	0.013 ± 0.007	d
^{238}U		12	0.36 ± 0.05	0.18 ± 0.04	0.22 ± 0.03	d
Total uranium		12	0.84 ± 0.08	0.33 ± 0.05	0.51 ± 0.08	d
Continuous system						
^{60}Co	P	26	0.0051 ± 0.007	-0.0039 ± 0.0047	-0.0012 ± 0.0015	100
	D	26	0.010 ± 0.013	-0.0087 ± 0.018	0.0018 ± 0.0029	
^{95}Nb	P	26	0.0049 ± 0.005	-0.0016 ± 0.0024	0.0015 ± 0.0012	300
	D	26	0.011 ± 0.012	-0.0060 ± 0.0069	0.0028 ± 0.0028	
^{95}Zr	P	26	0.0057 ± 0.010	-0.0070 ± 0.0089	0.0001 ± 0.0020	200
	D	26	0.086 ± 0.017	-0.019 ± 0.019	-0.0012 ± 0.0039	
^{106}Ru	P	26	0.025 ± 0.068	-0.045 ± 0.033	-0.016 ± 0.011	30
	D	26	0.063 ± 0.070	-0.14 ± 0.10	-0.028 ± 0.027	
^{129}I	D	4	0.00013 ± 0.00001	0.000080 ± 0.000007	0.00010 ± 0.00002	1
^{131}I	P	26	0.013 ± 0.092	-0.0093 ± 0.015	0.003 ± 0.002	3
	D	26	0.030 ± 0.027	-0.0025 ± 0.013	0.011 ± 0.005	
^{134}Cs	P	26	0.0034 ± 0.0039	-0.0098 ± 0.0086	-0.0003 ± 0.0014	20,000
	D	26	0.012 ± 0.0093	-0.0065 ± 0.0074	0.0007 ± 0.0024	
^{137}Cs	P	26	0.0038 ± 0.0072	-0.0076 ± 0.0064	-0.0011 ± 0.0015	200
	D	26	0.0085 ± 0.0064	-0.019 ± 0.010	-0.0044 ± 0.0032	
^{144}Ce	P	26	0.0055 ± 0.015	-0.018 ± 0.014	-0.0067 ± 0.0043	d
	D	26	0.0055 ± 0.059	-0.049 ± 0.050	-0.021 ± 0.008	
^{238}Pu	P	4	0.000004 ± 0.000004	0.0000007 ± 0.000005	0.000002 ± 0.00000	d
	D	4	0.00002 ± 0.00003	-0.000004 ± 0.00002	0.000008 ± 0.00002	
$^{239,240}Pu$	P	4	0.00006 ± 0.00001	-0.000017 ± 0.000008	0.00004 ± 0.00002	d
	D	4	0.00010 ± 0.00005	0.00005 ± 0.00004	0.00008 ± 0.00003	

[a]Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately. Other radionuclides are based on samples collected by the composite system.
[b]Maximum and minimum values ±2 sigma counting error. Average ±2 standard error of the calculated mean. It is not uncommon for individual measurements of environmental radioactivity to result in values of zero or negative numbers from subtracting out instrumental background.
[c]WAC 248 and 40 CFR 141.
[d]No drinking water standard.

In general, concentrations observed at the 300 Area water intake and the Richland Pumphouse were similar to those observed at Priest Rapids Dam, indicating no measured effect from Hanford operations on water quality at these locations. Tritium and ^{129}I concentrations were identified as being statistically higher at the Richland Pumphouse than at Priest Rapids Dam, indicating an influence from Hanford operations. The statistical analysis consisted of a paired sample comparison, Student's t-test of differences using a 5% significance level (Snedecor and Cochran 1980). No other statistically significant differences were noted between concentrations of radionuclides at the 300 Area water intake, Richland Pumphouse, and Priest Rapids Dam during 1987 (Jaquish and Mitchell 1988).

Nonradiological river water quality data at the Richland Pumphouse for 1987 are summarized in Table 18. In general, concentrations of nonradiological water quality parameters were similar at Priest Rapids Dam and the Richland Pumphouse. There was no measured indication of any significant deterioration of water quality resulting from Hanford operations between the two sampling points. As was the case at Priest Rapids Dam, applicable standards for Class A waters were met at the Richland Pumphouse.

Results of samples collected from riverbank springs along the 300-FF-5 operable unit shoreline are presented in Table 19 (after McCormack and Carlile 1984). The analyses of these samples were limited to uranium and nitrate. The concentrations of contaminants present in these samples are similar to those observed in the local groundwater and are likely attributable to the 300-FF-5 operable unit.

Although available data show the levels of contaminants in the Columbia River water to be low, localized areas of elevated concentrations attributable to specific area operations may exist. The dilution and dispersion of uranium entering the river via the groundwater beneath the 300 Area have been discussed, indicating the contaminants remain relatively close (within 50 yd) to the shoreline for several hundred yards, while gradually dispersing across the river (Haney 1957). Other dispersion studies of 300 Area effluents entering the river (Backman 1962) concluded that vertical mixing of contaminants is relatively rapid, within 100 yd of the effluent outfall. Site-specific sampling plans are needed to fully evaluate the potential impact of the 300-FF-5 operable unit on the water quality of the Columbia River. Quantification of the 300-FF-5 impact will require a specific study of ground- and river-water hydrology at and adjacent to the 300-FF-5 operable unit.

3.1.4.3 Background Sediment Quality. Columbia River sediment (or mud as it was referred to in the early days) was sampled routinely during 1945 through 1960 at a number of locations along the Hanford reach. Special studies of the river sediment and associated radionuclides continued through the years. The State of Oregon and PNL have published reports (Beasley et al. 1981 and Sula 1980, respectively) pertaining to radionuclide concentrations in the Columbia River sediments. Background sediment samples were collected from behind Priest Rapids Dam in 1976 (Robertson and Fix 1977). Cesium-137 was the most abundant fallout radionuclide detected, with trace amounts of ^{238}Pu, $^{239/240}Pu$, and ^{241}Am also present.

Table 18. Columbia River Nonradiological Water Quality Data for 1987, Measured at the Richland Pumphouse.

Analysis	Unit	Richland Pumphouse (downstream)				State standard[b]
		No. of samples	Maximum	Minimum	Annual average[a]	
Pacific Northwest Laboratory environmental monitoring						
pH	unitless	12	8.3	7.2	NA	6.5 to 8.5
Fecal coliform	#/100 mL	12	240	2	22[c]	100
Total coliform	#/100 mL	12	1,600	2	49[c]	NA
Biological oxygen demand	mg/L	12	3.0	0.5	2.0 ± 0.5	NA
Nitrate (as NO_3^-)	mg/L	12	0.77	0.05	0.2 ± 0.1	NA
U.S. Geological Survey sampling program[d]						
Temperature[e]	°C	365	20.4	2.8	12.0	20 (maximum)
Dissolved oxygen	mg/L	4	13.6	9.5	11.3 ± 2.0	8 (minimum)
Turbidity	NTU[f]	4	10.0	0.7	3.8 ± 4.3	5 + background
pH	unitless	4	8.2	8.0	NA	6.5 to 8.5
Fecal coliform	#/100 mL	4	5	1	1.59[c]	100
Suspended solids, 105°C	mg/L	4	11	<1	6.5 ± 5.8	NA
Dissolved solids, 180°C	mg/L	4	95	61	76 ± 14	NA
Specific conductance	µmhos/cm	4	150	127	134 ± 11	NA
Hardness, as $CaCO_3$	mg/L	4	75	59	65 ± 7	NA
Phosphorus, total	mg/L	4	0.03	0.01	0.025 ± 0.01	NA
Chromium, dissolved	µg/L	3	<10	<1	<7	NA
Nitrogen, Kjeldahl	mg/L	4	0.8	<0.2	0.5 ± 0.25	NA
Total organic carbon	mg/L	4	97	1.4	35 ± 45	NA
Iron, dissolved	µg/L	4	14	4	8 ± 4.5	NA
Ammonia, dissolved (as N)	mg/L	4	0.04	<0.01	0.02 ± 0.01	NA

[a]Average values ±2 standard error of the calculated mean.
[b]WAC 173-201.
[c]Annual median.
[d]Provisional data subject to revision.
[e]Maximum and minimum represent daily averages.
[f]Nephelometric turbidity units.
NA = Not applicable.

Table 19. Uranium and Nitrate Concentrations in Riverbank Springs in the 300-FF-5 Operable Unit (after McCormack and Carlile 1984).

Sample collection			Analyses	
Hanford river mile[a] location	Sample identification[b]	Date/time collected	Uranium (pCi/L ± 2σ)	Nitrate (p/m)
41.8	41-1 Sp	12-20-82/1235	9.03 ± 3.16	3.98
42.0	42.0 RW	12-20-82/1235	1.57 ± 0.549	2.12
	42-1 Sp	12-20-82/1235	15.4 ± 5.40	12.6
		01-22-83/1530	19.0 ± 6.64	ND
42.25	42-2 Sp	12-20-82/1305	16.2 ± 5.67	2.21
		01-22-83/1500	8.72 ± 3.05	ND
42.5	42.5 RW	12-20-82/1314	0.612 ± 0.214	0.26
	42-4 Sp	12-20-82/1314	8.35 ± 2.92	8.41
		01-22-83/1515	8.38 ± 2.93	
43.0	43.0 RW	12-20-82/1327	0.401 ± 0.140	0.75
43.5	43.5 RW	12-20-82/1340	0.325 ± 0.114	0.26
	43-1 Sp	12-20-82/1340	12.2 ± 4.26	1.15
43.8	43-3 Sp	12-20-82/1359	2.99 ± 1.05	0.44
44.0	44.0 RW	12-20-82/1350	0.391 ± 1.37	0.18
	41.5/44 Comp. RW	12-20-82/1350	0.746 ± 0.261	0.66

[a]Hanford river mile locations based on markers indicating shoreline distance downstream from the Vernita Bridge.
[b]Sp = Riverbank spring sample, RW = River water sample collected from surface within 2 to 4 m of the Hanford shoreline, Comp. RW = Composite river-water sample composed of aliquots from immediately preceding sample locations.
ND = No data available.

Sediment sampling above Priest Rapids and McNary Dams was recently reinitiated as part of DOE's Hanford environmental monitoring. Recent (1987 and 1988) background radionuclide concentrations in river sediments above Priest Rapids Dam, not yet published, will be included in the 1988 Hanford environmental monitoring report. Concentrations observed above Priest Rapids Dam reflect concentrations upstream of all Hanford facilities and are not specific to the 300-FF-5 operable unit. These data, when available, will provide background information on sediment concentrations upstream of Hanford, including 300-FF-5.

3.1.4.4 Sediment Contamination. River sediment data specifically related to the 300-FF-5 operable unit are lacking. Radionuclides, including neutron activation products, fission products, and trace amounts of transuranics, were discharged into the Columbia River as a result of reactor operations upstream of the operable unit (Robertson and Fix 1977). The radioactive material was dispersed in the river water and sorbed onto detritus and inorganic particles, incorporated into the aquatic biota, or in the case of larger particles of insoluble material, deposited on the riverbed. Some of this material has been deposited along the shoreline areas above the low river level. Radiation surveys of the exposed shorelines from the 100-B Area to the confluence of the Snake River during 1978 and 1979 revealed several areas throughout this reach with elevated (>25 μR/h) exposure rates (Sula 1980). One of these areas was located on the island directly offshore from the 300 Area. The predominant radionuclides present in the sediments from areas with elevated exposure rates were ^{60}Co, ^{137}Cs, and ^{152}Eu (Sula 1980).

Sediment samples collected in 1976 from behind McNary Dam, downstream of Hanford, also identified ^{60}Co, ^{137}Cs, and $^{152-154}$Eu as the major gamma-emitting radionuclides present (Robertson and Fix 1977). Also detected were ^{238}Pu, $^{239/240}$Pu, and ^{241}Am in sediments collected behind McNary Dam, but at extremely low levels that were also typical of concentrations observed in Priest Rapids Dam sediments. Using isotopic ratios, it has been reported that 20% to 25% of the plutonium inventory behind McNary Dam is attributable to reactor operations (Beasley et al. 1981).

3.1.5 Air

Known and potential air contamination for the 300-FF-5 operable unit are described in the 300-FF-1 Work Plan and will be covered in future RI/FS work plans for the 300-FF-2 and 300-FF-3 operable units.

3.1.6 Biota

3.1.6.1 Terrestrial Biota. Known and potential contamination of terrestrial biota for the 300-FF-5 operable unit is described in the 300-FF-1 Work Plan and will be covered in future RI/FS work plans for the 300-FF-2 and 300-FF-3 operable units.

3.1.6.2 Aquatic Biota. Site-specific data concerning the contamination levels of aquatic fauna in the vicinity of the 300 Area are virtually nonexistent. Radionuclide activities in aquatic biota are presented in Jaquish and Mitchell (1988) for whitefish muscle and carcass collected upstream near the 100-D Area and for bass muscle and carcass and for various aquatic organisms collected just downstream from the 100-H Area in 1971-1972 by Cushing et al. (1981). These data are presented in Table 20. Data similar to those presented in Jaquish and Mitchell (1988) are available for years previous to 1987 in the annual publications reporting on the radiological surveillance of the Hanford Site. The levels reported in earlier years, circa 1980, are similar to those shown in Table 20.

Table 20. Radionuclide Concentrations in Aquatic Biota.

Type	1987[a] (pCi/g wet weight)			1971-1972[b] (pCi/g dry weight)			
	^{60}Co	^{90}Sr	^{137}Cs	^{60}Co	^{65}Zn	^{46}Sc	^{54}Mn
Whitefish							
Muscle	0.011 (0.006)[c]	0.001 (0.001)	0.022 (0.016)	ND	ND	ND	ND
Carcass	ND	0.024 (0.018)	ND	ND	ND	ND	ND
Bass							
Muscle	0.002	0.003	0.044	ND	ND	ND	ND
Carcass	ND	0.049	ND	ND	ND	ND	ND
Seston	ND	ND	ND	5.5	2.5	ND	ND
Periphyton	ND	ND	ND	2.2	2.0	ND	ND
Suckers	ND	ND	ND	0.27	5.0	ND	<1.0
Squawfish	ND	ND	ND	0.22	7.5	ND	ND
Caddisfly larvae	ND	ND	ND	12.0	11.0	ND	ND
Large fish	ND	ND	ND	ND	ND	0.03	ND

[a]1987 data from Jaquish and Mitchell (1988), and collected from the 100-D Area.
[b]1971-1972 data from Cushing et al. (1981), and collected between the 100-H and 100-F Areas.
[c]Values in parentheses are analyses of samples from fish collected upstream from the Hanford Site boundary.
ND = No data available.

An extensive survey of the radionuclide concentrations in aquatic biota at the 100-F Area was done in 1966-1967 (Watson et al. 1970). A summary of the concentrations of radionuclides found in the biota is given in Table 21. These data were obtained while the reactors were still operating and represent radionuclides collected under those conditions. All of these radionuclides are from reactor effluents and are not found naturally. Thus, they would not be found in samples collected above the Hanford Site. No similar data are available for the 300 Area.

Table 21. Mean Radionuclide Concentrations (pCi/g dry weight) in Columbia River Biota at the 100-F Area, 1966-1967 (Watson et al. 1970).

Type	^{32}P	^{65}Zn	^{51}Cr	^{54}Mn	^{59}Fe	$^{95}Zr/Nb$	^{46}Sc
Net plankton	10,000	10,000	50,000	1,000	5,000	100	ND
Periphyton	60,000	10,000	70,000	3,000	6,000	2,000	ND
Caddisfly larvae	20,000	5,000	7,000	1,000	1,000	700	ND
Limpets							
Soft parts	20,000	8,000	7,000	700	1,000	800	ND
Shell	800	200	100	300	100	70	ND
Shiners	9,000	2,000	ND	ND	100	ND	ND
Sucker							
Muscle	90	90					
Carcass	2,000	80	70	10			
Gut contents	9,000	800	10,000	700	1,000	800	1,000
Chiselmouth							
Muscle	2,000	200	ND	ND	ND	ND	ND
Squawfish							
Muscle	200	100					
Carcass	500	200	ND	30	ND	ND	ND

ND = No data available.

Cushing (1979) presents concentrations of 22 stable trace elements in phytoplankton, caddisfly larvae, and whitefish muscle. All these samples were collected from the Columbia River downstream of the 100-H Area. These data do not represent contamination levels for these elements because concentrations of these elements are not affected by reactor operations. These data provide reference information that could be used to assess present or future samples of these organisms.

3.1.6.3 Riparian Biota. A brief general description of the riparian plants and animals of the 300-FF-5 operable unit was presented in Section 2.2.6.1.1. This section reviews recent information concerning the roles of riparian plants and animals as biological indicators of chemical contaminants that may have moved from their original sites of disposal via surface or groundwater flow(s) from the operable unit.

Most of the environmental monitoring of biota on the Hanford Site has been concerned with radionuclide uptake by plants and animals or by abiotic movement (e.g., wind, surface water, groundwater). There has been relatively little attention paid to hazardous metals or organic substances in biota.

Many plants are known to take up heavy metals, radionuclides, and tritiated water from contaminated soils or waters. For example, enhanced levels of ^{90}Sr are present in the leaves and stems of reed canary grass growing in the vicinity of seeps near the 100-N Area (Rickard and Price 1989a). Tritium, as tritiated water, was detected in the leaves of black locust trees, *Robinia pseudoacacia*, growing near the Columbia River shoreline at the 100-K Area, even though tritiated groundwater is more than 20 ft below the ground surface (Rickard and Price 1989b). Although, neither ^{90}Sr nor tritium are expected in the groundwater seepages in the 300-FF-5 operable unit, plants growing in the presence of contaminated soils and seepage water are likely to retain certain fractions of that contamination.

3.1.6.4 Terrestrial Biota. The terrestrial wild animals of the 300-FF-5 operable unit include pocket mice, *Perognathus parvus*, black-tailed jackrabbits, cottontails, western meadowlarks, *Sturnella neglecta*, and horned larks, *Eremophila alpestris*. Domestic pigeons, *Columba livia*, also nest on the industrial buildings inside the 300 Area exclusion zone and have access to drinking water and plant seeds in the 300 FF-5 operable unit. Pigeons, badgers, and black-tailed jackrabbits have been implicated in the spread of radioactive material in the waste management areas on the 200 Areas plateau (O'Farrell and Gilbert 1975).

The common terrestrial plants in the 300-FF-5 operable unit are sagebrush, rabbitbrush, cheatgrass, tumble mustard, *Sisymbrium altissimum*, and Russian thistle, *Salsola kali*. Russian thistle is an early invader of severely disturbed ground and is known to assimilate radionuclides from contaminated soil. Cheatgrass assimilated ^{90}Sr and ^{137}Cs from the soil in experimentally contaminated field plots in the 100-F Area, but ^{90}Sr was assimilated more readily than ^{137}Cs (Cline and Rickard 1972).

3.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Remedial actions carried out under CERCLA must attain a degree of cleanup that ensures protection of human health and the environment (Section 121 of CERCLA). Section 121 of CERCLA identifies the necessary degree of cleanup as that which meets "legally applicable or relevant and appropriate" requirements (ARARs). The EPA defines these terms as follows (52 FR 32496):

> "'Applicable requirements' means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
>
> "'Relevant and appropriate requirements' means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria or limitations promulgated under Federal or State law that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."

Identification of a potential ARAR as either applicable or relevant and appropriate under the above definitions can be subject to interpretation and to possible differences of opinion [see, for example, the CERCLA Compliance with Other Laws Manual (EPA 1988b)]. For the purpose of this work plan and at this time, however, it is not necessary to make this distinction. The following discussion, therefore, focuses on potential ARARs and not on distinctions.

The EPA further defines ARARs as chemical specific, action specific, and location specific (52 FR 32496). A chemical-specific requirement is one that sets concentration limits in various environmental media for specific hazardous substances, pollutants, or contaminants. An action-specific requirement sets controls or restrictions on activities related to the management of hazardous substances, pollutants, or contaminants. A location-specific requirement sets restrictions on activities that depend on the characteristics of a site or its immediate environs.

In the RI/FS process, ARARs are identified on a preliminary basis during scoping of the RI/FS, more comprehensively during the RI/FS process, and definitively at the time of selection of the remedial alternative, at which time they become part of the interagency agreement between EPA and DOE [CERCLA Section 130(e)] and part of the Record of Decision (52 FR 32496). Substantial consultation and coordination among DOE, EPA, the State of Washington, and the public during the RI/FS process will be required to negotiate and agree on final ARARs that ensure protection of human health and the environment and that are also reasonable, relevant, possible to attain, and cost effective. When a cleanup alternative is selected, it must be able to attain all ARARs, unless one of five statutory waivers is invoked. Potential ARARS are discussed in the following sections.

3.2.1 Chemical-Specific Requirements

In this section, contaminants known to be present in groundwater in the 300-FF-5 operable unit that might be subject to remedial action are listed, and chemical-specific requirements that are potential ARARs are cited. For CERCLA purposes, the term chemical includes radionuclides. If other contaminants are later identified, they will be added to the list.

3.2.1.1 Summary of Contaminants. Contaminants observed in groundwater collected from monitoring wells within the 300-FF-5 geographic area that might be subject to remedial action include tritium, ^{90}Sr, gross alpha, gross beta (possibly as ^{99}Tc), chromium, uranium, nitrate, chloroform, carbon tetrachloride, trichloroethene, 1,2-dichloroethene, tetrachloroethene, and 1,1,1-trichloroethane. Not all of these contaminants exceed standards. While these contaminants may reach the Columbia River, none are known to exceed any standard in the river.

3.2.1.2 Water Standards. The drinking water standards in 40 CFR 141 apply to public water systems. The maximum contaminant levels in 40 CFR 141, which apply at the tap, are not legally applicable to the groundwater in the 300-FF-5 operable unit because that groundwater is not currently being used for public drinking water. Nevertheless, maximum contaminant levels are enforceable standards and could be relevant and appropriate. The potential chemical-specific ARARs are listed in Table 22. Also, 40 CFR 141.16 states that, "The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year." The EPA's background information document on drinking water standards (EPA 1976) lists concentrations that correspond to the 4-mrem/yr limit. The State of Washington drinking water standards in WAC 248-54-175 for the contaminants of concern are equivalent to the Federal standards. The State of Washington surface-water quality standards in WAC 173-201-035 incorporate 40 CFR 141 by reference. WAC 173-201 also lists the water quality of the Hanford reach of the Columbia River as Class A or "excellent," and gives the water quality criteria for Class A waters. These criteria may be relevant (as ARARs) to the water quality of the Columbia River.

The EPA regulations promulgated under RCRA cite the same maximum contaminant levels for chromium as cited in 40 CFR 141. The RCRA regulations appear in 40 CFR 264. Regulations in WAC 173-303-645 also list the same maximum contaminant levels for chromium.

The EPA's regulations in 40 CFR 193, when promulgated, are expected to contain groundwater-protection standards for radionuclides equivalent to the radionuclide standards in 40 CFR 141.

The point of applicability of any chemical-specific ARAR for the 300-FF-5 operable unit will need to be determined during the RI/FS process. Also, the possible use of alternate concentration limits, for which CERCLA provides, will need to be determined later in the RI/FS process.

3.2.2 Action-Specific Requirements

Action-specific requirements set controls or restrictions on the management of hazardous substances. For the 300-FF-5 operable unit, which consists of contaminated groundwater and aquifer sediments, the management or treatment of hazardous substances might include incinerating or otherwise treating sediments and/or pumping the water, removing and disposing of the contaminants, and discharging the remaining water, either by discharge to the river, by discharge or injection to the ground, or by evaporation to the atmosphere. Although Section 121 of CERCLA states that no Federal, state, or local permit need be obtained for remedial action conducted entirely onsite, discharge or evaporation of the treated water could be construed to be an offsite action requiring a permit. Action-specific requirements may include meeting the requirements of, and might possibly include acquiring permits under, the regulations listed below. Only Federal regulations are listed here. Equivalent state regulations that may be potential ARARs will be identified during development of remedial alternatives in the feasibility study.

Table 22. Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements.

Substance	Concentration	Regulatory citation
Carbon tetrachloride	0.005	a
Chloroform	0.1 mg/L	a,b,c
Chromium	0.05 mg/L	a, b, c, d, e
1,2-Dichloro-ethene	f	g
Gross alpha (excluding uranium)	15 pCi/L	a, b, c
Gross beta	50 pCi/L	b, g
Nitrate (as N)	10 mg/L	a, b, c
^{90}Sr	8 pCi/L	a, b, c
Tetracloroethene	h	h
1,1-Trichloroethane	0.2	a
Trichloroethene	0.005 mg/L	a
Tritium	20,000 pCi/L	a, b, c
Uranium	4 mrem/yr	a, b, c

[a] 40 CFR 141.
[b] WAC 248-54-175.
[c] WAC 173-201-035.
[d] 40 CFR 264.
[e] WAC 173-303-645.
[f] Cis and trans isomers are proposed at 0.07 and 0.1 mg/L, respectively, for 40 CFR 141 in 54 FR 22062.
[g] EPA 1976.
[h] Proposed at 0.005 mg/L for 40 CFR 141 in 54 FR 22062.

- 40 CFR 260 through 268 and 270 through 272--Substantive RCRA requirements may apply as ARARs to onsite disposal of the contaminants removed from the water, and a RCRA permit could be required for the offsite disposal of the contaminants.

- 40 CFR 122--Substantive National Pollutant Discharge Elimination System requirements may apply as ARARs to the release of treated water to the Columbia River, and a National Pollutant Discharge Elimination System permit could be required for release of the treated water to the Columbia River, if that release is considered to be an offsite action.

- 40 CFR 144 through 147--Substantive underground injection control program requirements may apply as ARARs to the return of treated water into the aquifer, and an underground injection control permit could be required if that return is considered to be an offsite action.

- 40 CFR 52, 60, and 61--Substantive air quality regulations may apply as ARARs to the evaporation and release of water vapor to the atmosphere. Both National Emission Standards for Hazardous Air Pollutants and prevention of significant deterioration authorizations could be required if the release is construed to be an offsite action. Also, best available control technology could be required.

3.2.3 Location-Specific Requirements

Location-specific requirements affect the cleanup actions that can be taken at a given site because of the impact those actions might have on characteristics of the site other than the existence of hazardous waste. For example, in effecting a cleanup, it is necessary to meet the requirements of the following regulations related to floodplain/wetland preservation, historic preservation, and species protection.

- 10 CFR 1022--This regulation applies to DOE activities that are proposed to take place either in wetlands or in floodplains.

- 25 CFR 261, 36 CFR 800, 43 CFR 3 and 7--These regulations apply to the protection of historic and cultural properties, including both existing properties and those discovered during excavation or construction.

- 33 CFR 322 through 323 and 40 CFR 230 through 233--Substantive U.S. Army Corps of Engineers and EPA requirements may apply to any new intake and outlet structures in the Columbia River, to work in the Columbia River, and to the discharge of dredged or fill material into the Columbia River. Permits could be required if these actions are construed to be offsite actions.

- 50 CFR 10 through 24 and 402--These regulations apply to the protection of specific plant and animal species at all times.

3.3 POTENTIAL IMPACTS TO PUBLIC HEALTH AND THE ENVIRONMENT

3.3.1 Conceptual Exposure Pathway Model

The conceptual model postulates the potential scenarios by which contaminants could reach receptors and/or the environment. Based on the information presented thus far, a conceptual model of contaminant exposure pathways has been developed for the 300-FF-5 operable unit. During the remedial investigation, conceptual model hypotheses are tested and refined in an iterative manner until an understanding of the contaminant exposure pathways is sufficient to support decisions regarding remediation. By conducting the remedial investigation in this manner, the project becomes more efficient because data are included in the conceptual model as they become available.

3.3.1.1 Pathways. Figure 27 in the 300-FF-1 Work Plan illustrates the different pathways by which contaminants can reach various receptors. Potential exposures resulting from the waste sources and contaminated soils (such as direct exposure to the waste itself) are beyond the scope of this 300-FF-5 Work Plan. These pathways are addressed in the 300-FF-1 Work Plan. The routes by which contaminants in the 300-FF-5 groundwater operable unit can be transported to locations where exposure can occur are (1) transport by the groundwater in the unconfined aquifer, (2) transport by the Columbia River, and/or (3) volatilization from the groundwater and/or surface water.

Although transport of contaminants in the unconfined aquifer is an important transport pathway, it is not an important route for exposure because groundwater in the aquifer is not used before it discharges to the river. Reversals in groundwater flow occur during periods of spring runoff in the Columbia River, but the groundwater eventually discharges to the river. The unconfined aquifer is used on the opposite side of the river from the 300-FF-5 operable unit. However, recharge from irrigation on the Franklin County side creates a hydraulic gradient toward the river, so that groundwater in the unconfined aquifer discharges from both sides to the river (DSHS 1988). Contaminants from the 300-FF-5 operable unit, therefore, cannot flow under the river in the unconfined aquifer.

The upper confined aquifer is used as a source of drinking and irrigation water across the Columbia River from the 300-FF-5 operable unit. Therefore, it represents a potential transport pathway if the confined and unconfined aquifers are hydraulically connected and hydraulic gradients are such that water moves from the unconfined aquifer into the confined aquifer. This would allow contaminants in the unconfined aquifer to be transferred to the uppermost confined aquifer and then be transported across the river. Currently, it is not known to what extent the unconfined aquifer and the uppermost confined aquifer are naturally interconnected in the vicinity of the 300-FF-5 operable unit. One existing connection is located at failed well 399-1-16D. The interconnection of these aquifers will be investigated during the geohydrologic characterization of the operable unit. The likelihood of this pathway being important over large areas is further reduced because the confined system has higher water potentials than the unconfined system. If a connection exists between the two systems, groundwater flow will be from the confined into the unconfined aquifer. Dissolved contaminants would, therefore, not move into the confined aquifer, but any free-phase liquids present could move contrary to the hydraulic gradient and into the confined aquifer. In localized areas (such as near 399-1-16D) the aquifers remain connected (Smith et al. 1989) and contamination may enter the confined aquifer during developmental pumping of adjacent wells prior to sampling.

The Columbia River is the primary transport pathway resulting in the potential exposure of receptors. Contaminants from the 300-FF-5 operable unit can reach the river in two ways: (1) through discharge of contaminated groundwater and (2) via overland runoff from contaminated areas. Although overland runoff represents a potential transport pathway, it is unlikely that it results in a large percentage of the total amount of contaminant migration to the river because of the small precipitation rates and high infiltration capacity of soils inherent to the Hanford Site (DOE 1987). Thus, the likely primary pathway for transport of contaminants into the river is by discharge of contaminated groundwater to the river. Based on samples of groundwater seeps and springs along the riverbank, it is known that the river receives contaminants from the unconfined aquifer (see Section 3.1.4.2). Once these contaminants are in the river, they migrate to downstream potential receptors.

Volatilization of contaminants from the unconfined aquifer and subsequent migration of vapors in the vadose zone to the atmosphere represent a potential pathway. The same is true of volatilization of contaminants from the Columbia River that are further diluted by river water. Although no atmospheric monitoring data exist, based on the relatively low concentrations of volatile organic compounds in samples of groundwater from the current monitoring network (Evans et al. 1988a, 1988b, 1989), it is believed that this pathway represents a small fraction of the potential exposure to receptors for contaminants in the 300-FF-5 operable unit.

Based on current information, the primary pathway by which contaminants can reach various receptors is by transport of contaminants in the unconfined aquifer and discharge to the Columbia River. Once in the river, the contaminants are transported downstream to potential receptors.

3.3.1.2 Receptors. The Columbia River downstream of the 300-FF-5 operable unit is used as a source of irrigation water for farms and gardens, for recreation (such as swimming, boating, and fishing), and as a source of domestic water for downstream populations. The downstream populations are potentially exposed to contaminants by the following exposure pathways:

- drinking and bathing in treated river water by municipal water supply systems
- consumption of foodstuffs irrigated with contaminated water
- consumption of fish from the river

- consumption of other animals and plants that use the river
- direct exposure by river recreation.

The cities of Richland, Pasco, and Kennewick withdraw water from the river as a source of domestic water. The Richland water intake is located approximately 4 mi downstream from the 300-FF-5 operable unit. Kennewick withdraws water from wells adjacent to the river. However, Kennewick has an emergency connection with the water-supply system for the City of Richland. The populations served by these systems are approximately 68,000 for Richland and Kennewick combined and 18,000 for Pasco. The Richland water supply is the closest downstream point of withdrawal from the river to the 300-FF-5 operable unit.

3.3.2 Preliminary Toxicity Assessment

Potential contaminants of concern for the 300-FF-5 operable unit are presented in Table 23. The contaminants of concern for the 300-FF-5 operable unit are the same as those listed for the 300-FF-1 operable unit. The list was based on the previous evaluation of waste volumes and characteristics and the known nature and extent of contamination. The table contains all waste constituents of primary importance, as identified in Section 3.1.1. Those parameters known to be both highly elevated above-background levels (values found above the upper 95% confidence limit for the 0.99 quantile) and commonly found (present in at least 10% of the samples) in 300-FF-5 groundwater, as presented in Sections 3.1.2 and 3.1.3, also are included as target contaminants. In addition, the parameters identified in Section 3.1.1 as present but poorly characterized in terms of the amounts disposed are included as contaminants requiring additional characterization. These contaminants include methanol, polychlorinated biphenyls, methyl isobutyl ketone, and ^{147}Pm.

A preliminary toxicity assessment that further focuses attention on those parameters that are most toxic to human and environmental receptors was performed to identify contaminants of concern. The initial assessment performed for the 300-FF-5 operable unit compares critical toxicity values for each parameter, where available, to the levels found within the environment. Those parameters that meet or exceed their critical levels will be focused on during the RI/FS. The assessment also provides a means by which to select the level of analytical quality needed for the remedial investigation--the lower the parameter's critical toxicity value, the more sensitive the analytical method must be to provide meaningful data for the baseline risk assessment.

Table 23. Potential Contaminants of Concern[a] for the 300-FF-5 Operable Unit.

Gross alpha		Ammonium
Gross beta		Chloride
pH		Fluoride
Total coliform		Nitrate (as NO_3^-)
Total organic carbon		Nitrite
Total organic halogen		Sulfate
Aluminum	Manganese	Arochlor 1248
Antimony	Mercury	Chloroform
Arsenic	Nickel	1,2-Dichloroethene
Barium	Potassium	Methanol
Beryllium	Selenium	Methyl isobutyl ketone
Cadmium	Silver	Methylene chloride
Calcium	Sodium	Tetrachloroethene
Chromium	Strontium	Trichloroethene
Chromium	Strontium	^{60}Co
Copper	Thallium	^{99}Tc
Iron	Vanadium	^{147}Pm
Lead	Zinc	^{235}U
Magnesium		^{238}U
		Tritium

[a]Parameters that occur above the upper 95% confidence limit for the 0.99 background quantile in soil or groundwater and are found in at least 10% of the environmental samples in either medium.

Table 24 lists the critical toxicity value for each of the target parameters for the 300-FF-5 operable unit. The value chosen, when available, is the strictest potential ARAR for human and wildlife exposures in water (see Section 3.2). If no potential ARAR is established for a particular target parameter, the critical toxicity value is calculated from available reference dose or carcinogenicity information, as appropriate. Critical toxicity values for carcinogens are expressed as concentrations that would result in a 10^{-6} incremental lifetime cancer risk. The EPA has yet to establish acceptable exposure levels for carcinogens, but a 10^{-6} risk level is generally regarded as being insignificantly small compared to natural background exposures. Critical toxicity values for noncarcinogens are expressed as concentrations that would result in the reference dose--the estimated daily exposure that is likely to result in no deleterious effects over a lifetime.

Table 24. Preliminary Toxicity Assessment for Groundwater in the 300-FF-5 Operable Unit.

Substance or parameter	Strictest ARAR	Critical toxicity value	Maximum value detected[a]
Gross alpha	15 pCi/L (excluding uranium and randon)	NV	208 pCi/L (including uranium and radon)
Gross beta	50 pCi/L	NV	121 pCi/L
pH	6.5 to 8.5 standard units	NV	6.4 to 8.5 standard units
Total coliform	1 MPN/100 mL	NV	43 MPN
Total organic carbon	NV	NV	8,030 µg/L
Total organic halogen	NV	NV	24,500 µg/L
Aluminum	NV	NV	700 µg/L
Antimony	NV	14 µg/L[b]	<100 µg/L
Arsenic	50 µg/L	NV	17 µg/L
Barium	1,000 µg/L	NV	125 µg/L
Beryllium	NV	0.0068 µg/L[c]	<5 µg/L
Cadmium	0.81 µg/L[d]	NV	9 µg/L
Calcium	NV	NV	24,900 µg/L
Chromium	11 µg/L	NV	64 µg/L
Copper	8.2 µg/L[d]	NV	48 µg/L
Iron	300 µg/L	NV	4,870 µg/L
Lead	1.8 µg/L[d]	NV	6.1 µg/L
Magnesium	NV	NV	13,200 µg/L
Manganese	50 µg/L	NV	96 µg/L
Mercury	0.012 µg/L	NV	8.9 µg/L
Nickel	13.4 µg/L[d]	NV	39 µg/L
Potassium	NV	NV	11,100 µg/L
Selenium	10 µg/L	NV	<5 µg/L
Silver	0.12 µg/L	NV	19 µg/L
Sodium	NV	NV	258,000 µg/L
Strontium	NV	NV	310 µg/L
Thallium	NV	13 µg/L[e]	<5 µg/L
Vanadium	NV	700 µg/L[b]	11 µg/L
Zinc	47 µg/L	NV	47 µg/L
Ammonium	NV	NV	1,630 µg/L
Chloride	250,000 µg/L	NV	122,000 µg/L
Fluoride	2,000 µg/L	NV	2,080 µg/L
Nitrate (as NO_3^-)	44,000 µg/L	NV	82,000 µg/L
Nitrite	NV	200 µg/L[f]	NT
Sulfate	250,000 µg/L	NV	47,900 µg/L
Arochlor 1248 (PCBs)	NV	0.000079 µg/L[c]	<1 µg/L
Chloroform	100 µg/L	NV	42 µg/L
1,2-Dichloroethene	NV	NV	72 µg/L
Methylene chloride	NV	5 µg/L[g]	3,040 µg/L
Tetrachloroethene	NV	0.7 µg/L[g]	39 µg/L
Trichloroethene	0 µg/L	NV	24 µg/L
^{60}Co	100 pCi/L	NV	64 pCi/L
^{99}Tc	900 pCi/L	NV	55 pCi/L
Tritium	20,000 pCi/L	NV	6,480 pCi/L
Uranium	NV	NV	120 pCi/L

[a]Filtered values reported for metals analyses.
[b]Concentration at the reference dose for human consumption of water; Integrated Risk Information System (IRIS; EPA 1989).
[c]Concentration at the 10^{-6} incremental cancer risk level for human consumption of water aquatic organisms (IRIS).
[d]Hardness-dependent fresh-water quality criterion; the average hardness of 65 mg/L for the Columbia River was used.
[e]Threshold toxicity protection for human consumption of water and aquatic organisms (IRIS).
[f]Concentration protective of salmonid fishes (EPA 1986a).
[g]Concentration at the 10^{-6} incremental cancer risk level for human consumption of water (IRIS).
NT = Never tested.
NV = No value.

The preliminary toxicity assessment for the 300-FF-5 operable unit was limited to the maximum concentrations found in groundwater. The groundwater discharges into the Columbia River and the exposure pathways evaluated for the 100-HR-3 operable unit could be evaluated for the 300-FF-5 operable unit. However, the preliminary toxicity assessment, based on groundwater concentrations, is sufficient for the initial evaluation of the potential impacts to public health and the environment. Detailed evaluation of the transport and exposure pathways and the risks associated with the contamination in the 300-FF-5 operable unit will be done in the baseline risk assessment.

As indicated in Table 24, no critical toxicity values are available from EPA CERCLA-related sources for the following:

- total organic carbon
- total organic halogen
- aluminum
- calcium
- magnesium
- potassium
- sodium
- strontium
- ammonium
- 1,2-dichloroethene
- uranium.

The first two parameters, total organic carbon and halogen, are gross indicators of contamination. Thus, they would not be expected to have specific toxicity values. Calcium, magnesium, potassium, and sodium are essential nutrients and, for all practical purposes, are nontoxic. The lack of standards and toxicity information on strontium also indicates that it is relatively nontoxic.

Aluminum has no current potential ARAR, but water quality criteria development is pending (EPA 1986a). Aluminum is known to be toxic to aquatic life in certain forms.

Ammonium, while not particularly toxic, is present in equilibrium with ammonia, the principal toxic form of this substance. Ammonia has been reported to be acutely toxic to fresh-water organisms at concentrations as low as 530 $\mu g/L$, depending on the pH and temperature of the water (EPA 1986a).

No standards exist for 1,2-dichloroethene; however, the EPA has proposed a maximum contaminant level goal of 70 $\mu g/L$ (50 FR 46936).

There are no relevant existing EPA standards for uranium. Uranium is, however, a high-volume waste constituent, and is perhaps the contaminant of most concern for the operable unit. The EPA is currently developing standards for uranium. A value of 3.3 pCi/L is the low end of those under consideration (Baker et al. 1988).

3.3.3 Contaminant Characteristics

Most of the inorganic contaminants listed in Table 24 are relatively persistent in the environment, with half-lives of decay greater than 1 yr (tritium has a half-life of 12.3 yr), with few exceptions. The nonradioactive inorganic constituents do not decay in the environment, with the exception of nitrate that is converted in the environment to nitrous oxide and/or nitrogen by denitrifying bacteria. The rate of this transformation depends on several environmental factors and Hanford Site-specific information is currently not known (Buelt et al. 1988). Concentrations of organic constituents (e.g., chloroform, trichloroethene) in aquatic environments are reduced by biological degradation and volatilization. Other mechanisms (hydrolysis, oxidation, photolysis, etc.) relating to the persistence of these compounds in the environment do not appear to be important (Callahan et al. 1979).

The constituents detected in the groundwater of the 300-FF-5 operable unit will move at the rate of or slower than the rate of groundwater flow and will be eventually discharged to the Columbia River. Contaminants that sorb onto sediments in the aquifer will move at rates slower than the groundwater flow, provided colloid transport is not significant. If colloid transport is significant and the colloids are strong absorbers of selected contaminants, then migration potential can increase. At this time, there is no technical consensus as to the importance of colloid transport. Constituents such as ^{137}Cs are highly attenuated in Hanford sediments (Routson et al. 1981) and will move at a rate much slower than the groundwater flow. Other constituents, including tritium and uranium, are not attenuated by Hanford Site sediments and travel at the rate of groundwater flow. The relative mobility of contaminants of concern in the 300-FF-5 operable unit will be investigated in Task 3 of the remedial investigation.

3.3.4 Contaminants of Concern

Table 25 presents those parameters known to exceed or approach their critical toxicity values in the 300-FF-5 operable unit. Because groundwater flow is part of the primary contaminant transport pathway for the operable unit, these are the parameters on which the baseline risk assessment and, therefore, the RI/FS should focus.

Aluminum, ammonium, nitrite, 1,2-dichloroethene, and uranium (two isotopes) are retained on this list for the reasons specified in Section 3.3.2. Arochlor 1248 also is retained, even though it has never been detected in the groundwater. The extremely low critical toxicity value provides the rationale for this decision.

Even though no gamma-emitting radionuclides met the criteria for being designated as a contaminant of concern, gamma scans will be performed because of the general nature of wastes disposed within the source operable units overlying the 300-FF-5 groundwater operable unit. In conjunction with measurements of gross alpha and gross beta, all radiation contamination will be accounted for.

Table 25. Contaminants of Concern for the 300-FF-5 Operable Unit.

Gross alpha Gross beta Total coliform pH	Ammonium Fluoride Nitrate (as NO_3^-) Nitrite Sulfate
Aluminum Antimony Beryllium Cadmium Chromium Copper Iron Lead Manganese Mercury Nickel Silver Zinc	Arochlor 1248 1,2-Dichloroethene Methylene chloride Tetrachloroethene Trichloroethene ^{60}Co ^{90}Sr ^{137}Cs ^{235}U ^{238}U

3.3.5 Imminent and Substantial Endangerments to Public Health and the Environment

Based on the extensive amount of environmental data available, including a recent radiation risk assessment for the Hanford Site as a whole (Jaquish and Mitchell 1988), the 300-FF-5 operable unit does not appear to pose any imminent or substantial endangerment to public health or the environment. The contaminants of concern identified in the preliminary toxicity assessment will be evaluated in the baseline risk assessment.

3.4 PRELIMINARY REMEDIAL ACTION OBJECTIVES, PRELIMINARY TECHNOLOGIES, AND ALTERNATIVES

A range of approaches to manage/remediate contaminated groundwater, sediments, and surface water in the 300-FF-5 operable unit will be developed. Remedial action objectives will be based on the following general objectives: (1) protecting human health by ensuring that ARARs will not be exceeded and that health risks, as determined through analysis of all exposure pathways, will be kept at or below acceptable limits and (2) ensuring acceptably low risks to the environment, such as to Columbia River biota. General response actions and, subsequently, remedial action alternatives to meet these objectives will be developed to provide a range of cleanup efficiencies, schedules, and costs. The development of these remedial action alternatives will consider, where appropriate, those alternatives developed to meet the remedial action objectives for adjacent operable units located within the 300 Area.

3.4.1 Remedial Action Objectives

Media-specific remedial action objectives and general response actions will be established for all contaminants of concern for each medium within the 300-FF-5 operable unit that are identified in the remedial investigation. The objectives for protection of human receptors will address both exposure routes and target contamination levels. The objectives for protection of environmental receptors will address target cleanup levels.

Section 3.3.4 provided a preliminary listing of the contaminants of concern for groundwater within the 300-FF-5 operable unit. These will serve as the contaminants of concern for all media within the 300-FF-5 operable unit, pending further characterization of the unit during the remedial investigation. These contaminants of concern are based on those listed in Table 25 in Section 3.3.3 of the 300-FF-1 Work Plan. This list will be amended as more is learned about the 300-FF-5 operable unit during the remedial investigation.

Section 3.2.1 identified chemical-specific ARARs that will serve as the initial basis for establishing target contaminant levels for each medium within the 300-FF-5 operable unit. These ARARs provide a basis for establishing acceptable contaminant levels for the protection of both human health and the environment. These lists will be amended, as appropriate, as more is learned about the 300-FF-5 operable unit during the remedial investigation.

Both individual and combinations of general response actions have been identified that are applicable to achieving the remedial action objectives for each medium. Table 26 summarizes the applicable general response actions for each medium within the 300-FF-5 operable unit. A no-action response will be evaluated for each medium and will serve as a baseline general response action. The no-action general response action may include monitoring and institutional controls, where appropriate. Containment as a general response action will be developed to the extent possible for each medium and, where appropriate, preserved as an option in the development of alternatives. Because of the extent of the operable unit, containment may be applicable only to portions of the groundwater plume, Columbia River sediments, and to spring water and sediments.

3.4.2 Preliminary Remedial Technologies

A preliminary list of general remedial action technologies for the 300-FF-5 operable unit that have been identified for initial screening are shown in Table 27. These technologies are listed as a subset of the individual general response actions identified in Section 3.4.1. Shown in Table 28 is a list of potential process options for each technology that

Table 26. Preliminary Medium-Specific General Response Actions for the 300-FF-5 Operable Unit.

Groundwater	River/spring sediments	River/spring surface water
No action/ institutional controls	No action/ institutional controls	No action/ institutional controls
Containment/institutional controls	Containment/institutional controls	Containment/institutional controls
Collection/treatment/ disposal	Collection/treatment/ disposal	Collection/treatment/ disposal
Treatment	Collection/disposal	
	Treatment	

may be applicable for one or more general response action and for one or more medium. A brief description of each of these process options was summarized in Table 28. Because of the range of contaminants of concern and their respective concentrations in the various media, it is possible that more than one process option within the various treatment technologies will be needed to achieve the remedial action objectives for a given medium.

3.4.3 Preliminary Remedial Alternatives

Potential treatment technologies, based on applicable and representative process options identified in Tables 27 and 28 will be linked together to form several remedial alternatives that could meet remedial action objectives. These remedial alternatives will be initially developed for each medium, but will be eventually combined to address all media. Because of the large size of the operable unit and the large number of potential contaminants of concern, it is possible that some alternatives will include combinations of technologies and process options to produce general response actions that can meet the remedial action objectives for all media in the 300-FF-5 operable unit. The development of these alternatives is discussed in more detail in Section 5.4.

Table 27. Preliminary Technologies and Process Options for General Response Actions. (Sheet 1 of 2)

General response action	Technology	Process options
No action	None	None
Institutional actions	Access restrictions	Groundwater restrictions
		Land use restrictions
		Fencing
		Sign posting/patrolling
	Alternate water supply	Access to existing alternate water supply
		New water supply
	Monitoring	Groundwater monitoring
		Surface-water monitoring
Collection	Groundwater collection	Extraction wells
	Surface-water collection	Collection basins
	Sediment removal	Mechanical dredging
		Hydraulic dredging
Discharge	Sediment disposal	Onsite landfill
		Offsite landfill
		Onsite relocation/cap
	Groundwater/surface-water disposal	Reinjection wells
		Recycling as process water
		Surface discharge to river
		Surface discharge to soil
		Discharge to water treatment plant
Containment	Sediment containment	Surface sealing
		In situ grouting
	Groundwater containment	Groundwater extraction/reinjection wells
		Slurry walls
		Grouting
		Sheet piling
		Bottom sealing
	Surface-water containment	Groundwater extraction/injection wells

Table 27. Preliminary Technologies and Process Options for General Response Actions. (Sheet 2 of 2)

General response action	Technology	Process options
Treatment	Biological	Activated sludge
		Lagoons
		Anaerobic filters
		Trickling filters
		Stabilization ponds
		In situ biological method
	Contaminated water chemical treatment	Precipitation/coagulation/ flocculation
		Solvent extraction
		Ion exchange
		Reduction
		Electrodeposition
	Contaminated sediments/ secondary solid wastes chemical treatment	Solidification/ stabilization
		Solvent extraction
	Contaminated water physical treatment	Adsorption
		Evaporation
		Membrane separation
		Stripping
	Contaminated sediment/ secondary waste solids physical treatment	Gravity separation
		Granular bed filtration
		Evaporation
		Vitrification
	Contaminated solvents/ secondary waste solids thermal treatment	Incineration/pyrolysis

Table 28. Description of Process Options. (Sheet 1 of 2)

Technology	Process option	Process description
Access restrictions		Legal and physical means of restricting access to a site or a specific source of groundwater
Alternate water supply		Water supplied to a user from an uncontaminated source to preclude the need for using contaminated groundwater
Monitoring		Periodic acquisition and analysis of water samples to monitor restoration of a contaminated body of water
Groundwater collection	Extraction wells	Wells used for collecting and transporting groundwater to the surface
Surface-water collection	Collection basins	Basins constructed for collecting water from springs
Sediment removal		Mechanical and hydraulic dredges used to remove sediment for subsequent transport to a treatment/ disposal facility
Sediment/secondary solid waste disposal		Sediments and secondary solid wastes are disposed in a RCRA-approved landfill or relocated to another site and contained using a cap
Sediment containment		Surface sealing and in situ grouting used for isolating contaminated sediment from other nearby media
Groundwater containment	Groundwater extraction and reinjection	A system of wells used for extracting and injecting uncontaminated groundwater to isolate a contaminated plume from the uncontaminated groundwater, thereby preventing movement of the plume due to a hydraulic head
	Slurry wall, grouting, sheet piling, and bottom sealing	Provides barriers between the contaminated groundwater and nearby media and environment
Surface-water containment	Groundwater extraction wells	A system of wells used for extracting groundwater near spring source, thereby reducing hydraulic head responsible for surface flow
Biological treatment		Various biological treatment methods, including activated sludge, anaerobic filters, lagoons, trickling filters, stabilization ponds, and novel in situ concepts using indigenous bacteria employed to metabolize organic contaminants and remove, via coagulation, certain dissolved inorganic compounds from contaminated water
Contaminated water chemical treatment	Precipitation/coagulation/flocculation	Addition of various chemicals and adjustment of pH to cause the removal of soluble metals from water as solids
	Solvent extraction	Selective transfer of a dissolved substance to a solvent that preferentially dissolves that substance
	Ion exchange	Resins used to exchange hazardous dissolved inorganics in contaminated water with innocuous inorganics

Table 28. Description of Process Options. (Sheet 1 of 2)

Technology	Process option	Process description
Contaminated water chemical treatment (contd)	Reduction	Chemicals added to reduce the valence state of certain metal ions, thereby facilitating their removal, and, in certain cases, producing a less-toxic ion
	Electrodeposition	An electric current passed through an aqueous metal-bearing solution between a cathode and an insoluble anode causing metal ions to deposit as metal on the cathode
Contaminated sediments/ secondary waste solids chemical treatment	Solidification/ stabilization	Chemicals added producing chemical reactions that result in the immobilization of the contaminated waste
	Solvent extraction	Water or some other suitable solvent used to leach contaminants from solids
Contaminated water physical treatment	Adsorption	Adsorbents, such as activated carbon, clays, and synthetic resins, used to selectively adsorb dissolved metals and organic compounds from aqueous solutions
	Evaporation	Nonvolatile components in a solution or slurry concentrated by vaporizing the water
	Stripping	Volatile organic compounds separated from aqueous solutions by passing steam or air through the solution
	Membrane separation	Membrane-separation techniques, including reverse osmosis and ultrafiltration, use pressure to force water through a semipermeable membrane resulting in concentration of contaminants in the remaining water
Contaminated sediment/ secondary waste solids physical treatment	Gravity separation	Separation techniques, including clarification, centrifugation, and hydrocyclones, that rely on differences in specific gravity between the solids and water to obtain separation
	Granular bed filtration	Solids removed from water by forcing the mixture through filter media
	Evaporation	Moisture content of slurries reduced prior to subsequent disposal
	Vitrification	Waste materials thermally incorporated into a glass matrix by the introduction of electric currents

RCRA = Resource Conservation and Recovery Act.

4.0 PROJECT PLAN RATIONALE

The purposes of a project plan are to describe the known environmental characteristics of an operable unit, to identify deficiencies in that knowledge base, to complete the database required to judge human health and environmental risks posed by the unit, and to evaluate remedial alternatives. Further purposes of this chapter are to discuss data quality objectives and to describe the approaches planned to collect the data identified.

4.1 DATA QUALITY OBJECTIVES

Data quality objectives specify the quality of data required to support decisions to meet remedial action objectives. Data quality objectives are divided into four categories: data uses, data types, data quality, and data quantity. Each of these categories is described in relation to the 300-FF-5 RI/FS. Although the nature and processes that created the contamination in the 300-FF-5 operable unit are understood to some degree, the extent and spatial distribution of each contaminant present in each medium (e.g., groundwater, Columbia River sediments) are lacking. Current groundwater data are adequate for predicting worker health and safety during remedial investigations and for generating a qualitative conceptual model of the pathways, receptors, and risk. However, additional data are needed to quantify the baseline risk assessments, contaminant transport through each pathway, and rate of migration through the groundwater to the Columbia River, where the threat to public health and aquatic biota can be determined. This is especially true for regions outside the 300-FF-1 operable unit. Determining the contaminant concentrations in the aquifer (both groundwater and sediments) and the general water chemistry as a function of space (including different depths) is necessary to assess the technical feasibility, time periods, and cost of candidate remedial actions. Particular attention must be placed on determining whether a significant connection exists between the shallow and deep aquifers and whether contamination exists within the deeper aquifers. Groundwater flow into the vicinity of the 300-FF-5 operable unit is generally from the west, but significant components also originate to the northwest and southwest. Therefore, aquifer characteristics must be determined in those three regions to establish boundary conditions for the unit. Finally, data must be collected to substantiate whether the near-shore Columbia River waters, sediments, and aquatic biota are contaminated at levels high enough to merit remedial action.

4.1.1 Data Uses

Most data uses during the RI/FS process fall into one or more of the following categories:

- site characterization
- worker health and safety

- public health evaluation and risk assessment
- evaluation of remedial alternatives and engineering design of selected alternatives.

Site characterization refers to the determination and evaluation of the physical and chemical properties of the site, development and refinement of the conceptual model, and evaluation of the nature and extent of contamination. This latter category includes geologic, hydrologic, meteorologic, and specific contaminant data.

The worker health and safety category includes data collected to establish the level of protection for workers during various remedial investigation activities. In addition, these data are used to determine if there is an immediate concern for the population living in the vicinity of the site. More discussion and a listing of data needs specific to worker health and safety are addressed in Attachment 2--Health and Safety Plan.

Data collected to conduct the public health evaluation and risk assessment include input parameters for various performance assessment models, site characteristics, and contaminant data required to evaluate the potential threat to public health and welfare posed by the site.

Data collected to support evaluation of remedial alternatives include site characteristic and engineering data required to evaluate the behavior of contaminants for initial screening of alternatives, feasibility-level design, and preliminary cost estimates.

4.1.2 Data Types

Table 29 outlines data types, uses, and objectives. Data requirements for the contaminant sources, surrounding vadose zone sediments, air, and terrestrial biota are described in the 300-FF-1 Work Plan or will be described in future RI/FS work plans for the 300-FF-2 and 300-FF-3 operable units.

Table 29. Data Requirements. (Sheet 1 of 2)

Data needed	Method	Analytical level	Data objective
Determine nature and extent of contamination (site characterization) (worker health and safety)			
Chemical analyses of groundwater	Pump existing and new monitoring wells (concentrate on unconfined aquifer)	For all RI work, use Levels III and IV. For field analyses, use Level I and II.	Measure indicator species and major cations, anions, pH, and Eh on all water samples; complete list of regulated chemicals on all samples; compare with ARARS
Chemical analyses of aquifer sediments	Obtain core or cuttings from new monitoring wells; soil gas analysis	For all RI work, use levels III and IV. Soil gas analyses are Level II.	Measure indicator species on all samples, major and trace elements, and regulated chemicals on all samples

Table 29. Data Requirements. (Sheet 2 of 2)

Data needed	Method	Analytical level	Data objective
Determine nature and extent of contamination (contd)			
Contaminant Levels in riverbank springs	Measure water flow/ volume in springs	For all RI work, use Levels III and IV.	Measure indicator species and major cations, anions, and pH.
Support conceptual model development/baseline public health evaluation and risk assessment			
Hydrologic flow field and travel times	Measure water levels in wells and Columbia River; perform aquifer tests, tracer tests among wells (concentrate on unconfined aquifer, but also assess interconnection with deeper aquifers)	Not applicable for physical measurements; Level II for tracer test analyses.	Determine water potentials, streamlines, in situ hydraulic conductivity, discharge locations, boundary conditions
Contaminant migration rates	Measure concentrations in water and sediments; laboratory batch and column adsorption and leach/ desorption tests, field tracer tests	For all RI work, use levels III and IV.	Calculate retardation factors and/or distribution coefficients for risk assessment, remedial action evaluation
Contaminant levels in Columbia River water, suspended river sediments, bed sediments, and biota	Chemical analyses of each medium, Columbia River water level, and flow rate; measure suspended sediment load; emphasize river work during low-flow periods and concentrate near shore; emphasize biota collection during prime growing season	For all RI work, use levels II through IV.	Data used to refine conceptual model of pathways and receptors, and to quantify risk; compare with ARARs
Support remedial action alternatives evaluation			
Chemical analyses of groundwater and sediments	Pump existing and new monitoring wells; obtain core or cuttings from new monitoring wells (concentrate on unconfined aquifer)	For all RI work, use levels III and IV.	Measure indicator species and major cations, anions, pH, and Eh on all water samples; complete list of regulated chemicals on selected samples; measure indicator species on all sediment samples, major and
Contaminant-sediment interactions	Measure concentrations in water and sediments; use laboratory batch and column adsorption and leach/ desorption tests, field tracer tests	For all RI work, use levels III and IV.	For pumping/treatment/reinjection feasibility evaluation
Areal extent of contaminants and existing flow regime	Measure concentrations in water and sediments; perform aquifer tests	For all RI work, use levels III and IV.	Need flow rates and paths for pumping/treatment/reinjection or in situ injection feasibility evaluation

ARAR = Applicable or relevant and appropriate requirements.
RI = Remedial investigation.

Table 29 presents general data requirements and attempts to emphasize the most important data needs. As more data are collected, other data quality objectives or data needs may become apparent, or the ranking of which are most important could change. As an example of how the table focuses on key needs, the only media considered under "Determine nature and extent of contamination" are groundwater, aquifer sediments, and riverbank springs. Columbia River water and sediments and aquatic biota are not cited. This is because available data discussed in Chapter 3.0 suggest these latter media are not presently significantly contaminated. The key issues for the 300-FF-5 operable unit at the moment are the spatial extent (both horizontal and vertical) of groundwater contamination, the extent of interaction of the contaminants, especially indicator species, with aquifer sediments, and the concentration of riverbank springs as indicators of groundwater contamination entering the Columbia River. Given the current data, it does not appear that the Columbia River and sediments and aquatic biota within 300-FF-5 exhibit significant contamination; thus, they will not be extensively sampled to delineate the existing areas of contamination. However, to objectively and quantitatively develop a conceptual model of contaminant transport and to perform the baseline public health evaluation and risk assessment, these media must be considered. Thus, they appear within the fifth block of data needs in Table 29. Finally, current knowledge suggests that any remedial action alternatives evaluation should concentrate on groundwater in the unconfined aquifer and the aquifer's sediments. Should the extent of contamination prove to be larger than presently suspected, remedial action evaluation of other media (e.g., riverbank springs, Columbia River water and sediments, or aquatic biota) might be considered in later phases. There may be changes to data quality objectives as this work plan is modified.

Currently, considerable information is available on the chemical composition of the unconfined aquifer as discussed in Chapter 3.0. The groundwater investigation during the remedial investigation will focus on delineating the boundaries of the plume(s), ascertaining whether the 300 Area plumes are connected to sources to the west and north, and whether any significant connection exists between the unconfined and confined aquifers. Chemical analyses will be directed on determining the concentrations of the indicator species of uranium, chloroform, trichloroethene, and 1,2-dichloroethene. However, selected water samples will be extensively characterized (analyses for constituents noted in Section 5.3.4.2) to corroborate that other regulated contaminants are not present above ARARs and operable unit-specific background values (wells on the perimeter of the north, west, and south boundaries of the operable unit).

Chemical analyses of the unconfined aquifer sediments within the existing plume have not been performed. Chemical analyses should be performed (including studies of change versus depth) to provide background data on in situ distribution coefficients. These data can be used in transport calculations and remedial action alternatives evaluations. If the sediments contain significant concentrations of the contaminants, remedial actions (such as pumping, treatment, and reinjection) may require numerous cycles to cleanse the sediments. Sediments in the confined aquifers will be analyzed only if contamination is found in sediments at the bottom of the unconfined aquifer. All sediment samples will be obtained during well drilling activities discussed in Section 5.3.4.

Chemical analyses have been conducted on samples of spring and Columbia River waters adjacent to the 300-FF-5 operable unit, but the data available are limited to a few select chemical species or limited in spatial representation. During the proposed remedial investigation, complete chemical analyses of spring and Columbia River water will be obtained on samples above, within, and below the 300-FF-5 operable unit boundaries for comparison with other areas and natural background values.

During the proposed remedial investigation, samples of suspended and Columbia River bed sediments and aquatic biota adjacent to the 300-FF-5 operable unit boundaries will be obtained and chemically analyzed for the indicator species. The information will be used to clarify the exposure pathways and risk assessment and ecosystem impacts. Appropriate biological communities for study would be game fish for human risk assessment and benthic macroinvertebrates for ecosystem impacts. To assess risks to humans, the concentration of contaminants in the edible tissue of game fish must be determined. This will be done by extrapolation of concentrations determined in benthic macroinvertebrates. To assess ecosystem impact, changes are analyzed in types of benthic macroinvertebrates and/or quantity of biota within the Columbia River adjacent to the 300-FF-5 operable unit.

4.1.3 Data Quality

Data quality objectives are qualitative and quantitative statements that specify the quality of data required to support decisions during remedial response activities. A discussion of the PARCC parameters (precision, accuracy, representativeness, completeness, and comparability) is presented in Chapters 3.0 and 7.0 of Part 2--Quality Assurance Project Plan in Attachment 1--Sampling and Analysis Plan. A variety of analytical methods are generally available to provide data. Increasing accuracy and precision are obtained with increasing cost and time. Therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 30 defines five analytical levels based on overall data quality as defined by the EPA (1987). Individual data objectives and appropriate analytical levels associated with each data need were given in Table 29. In general, objectives for the initial remedial investigation are intended to obtain data to accomplish the following:

- locate boundaries of contaminated groundwater
- detect presence of any contaminant and determine its concentration to the extent that a comparison to ARARs and other action levels can be made

Table 30. Analytical Levels.

Level	Description
I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but they are available in real time. This is the least costly of the analytical options. Instruments may not respond to all compounds and may not be able to identify compounds. If the instruments are calibrated properly and data are interpreted correctly, Level I techniques can provide an indication of contamination.
II	Field analyses using more sophisticated portable analytical procedures, such as gas chromagraphy for organics and atomic absorption or x-ray fluorescence for metals. The instruments may be set up in a mobile onsite laboratory. Results are available in real time or within several hours, and may provide tentative identification of compounds or be analyte specific. Data are typically reported in concentration ranges, and detection limits may vary from low parts per million to low parts per billion. Data quality depends on the use of suitable calibration standards, reference materials, sample-handling procedures, and training of the operator. In general, Level II techniques and instruments are mostly limited to volatiles and metals.
III	All analyses performed at an offsite analytical laboratory. Level III analyses may or may not use Contract Laboratory Program procedures, but do not usually use the validation or documentation procedures required of Contract Laboratory Program Level IV analysis. Detection limits and data quality are similar to Level IV, but results will generally be available in a shorter time.
IV	The Contract Laboratory Program routine analytical services. All analyses are performed in an offsite Contract Laboratory Program analytical laboratory following Contract Laboratory Program protocols. Generally, low microgram-per-liter detection limit for substances on the Hazardous Substance List (EPA 1986a), but also may provide identification of non-Hazardous Substance List compounds. Sample results may take several days to several weeks, and additional time may be required for data validation. Level IV results have known data quality supported by rigorous quality assurance and quality control protocols and documentation.
V	Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory that may or may not be a Contract Laboratory Program laboratory. Method development or method modification may be required for specific constituents or detection limits, and additional lead time may be required. Detection limits and data quality are method specific. The Contract Laboratory Program special analytical services are Level V.

- determine site characteristics, contaminant properties, and probable contaminant transport pathways to the degree required to support a preliminary risk assessment
- protect worker health and safety during remedial investigation activities.

Once completed, the comparison to ARARs and preliminary risk assessment will be used to determine the following:

- if any of the groundwater contaminant plumes pose an immediate threat to human health or to the environment
- if any of the groundwater contaminant plumes pose a potential long-term risk to human health or the environment, such that future RI/FS work is warranted
- if site controls and levels of protection are sufficient for workers' performance in future remedial investigation work and site remediation.

Groundwater analyses are well established for most chemical constituents and most laboratories can perform the analyses. Chemical analyses of sediments and biota are less straightforward and may require some testing/verification methods. The hydrologic field testing methodology is well established and should require no extensive development. The laboratory adsorption-desorption/leaching methodology is available for indicator species (such as uranium). If any organic constituents merit study, some method development involving two-phase systems will likely be required.

4.1.4 Data Quantity

The primary decision to be made on the basis of the initial remedial investigation data is whether to continue the RI/FS process for each plume. This decision can be stated in terms of a statistical hypothesis (e.g., the site is uncontaminated), with the decision being to accept or reject the hypothesis on the basis of data obtained from the remedial investigation. Four outcomes are possible for such a decision:

- to implement remedial action when true conditions are such that remedial action is required (correct decision)
- not to implement remedial action when true conditions are such that remedial action is required (type II error)
- not to implement remedial action when true conditions are such that remedial action is not required (correct decision)
- to implement remedial action when true conditions are such that remedial action is not required (type I error).

For the primary decision, the consequences associated with a type II error are much more serious than those associated with a type I error. For example, the decision not to continue the RI/FS when remedial action is required would mean that a significant hazard to human health and/or the environment may continue to exist. However, conducting the RI/FS when remedial action is not required represents a waste of resources, but does not result in any risk to human health or the environment other than that associated with conducting the RI/FS itself. Therefore, demonstrating that the probability of a type II error is acceptably small is necessary. If no contaminants are found, the decision to terminate the RI/FS must be made to a high degree of confidence, but if contaminants are found, the RI/FS will likely be continued. If the process continues, type II errors become more unlikely, leaving the only significant error possible a type I error, the consequences of which are much less significant in terms of risk to human health or the environment.

Hence, the quantity and quality of data collected during each iteration of the remedial investigation must be sufficient to demonstrate the presence or absence of a particular contaminant to a high degree of confidence. The data necessary to more fully evaluate concentrations and to better define the extent of contamination can be obtained in later phases of the remedial investigation. In the event that a type II error has been made, subsequent remedial investigation activities will provide sufficient data to detect the error, and the RI/FS can be discontinued at that time. This will result in the most cost-effective approach because the data collection effort necessary to fully define the extent of contamination will only be undertaken if contamination is detected.

Currently, as discussed in Chapter 3.0, data are available on the chemical composition of groundwater from numerous monitoring wells. The data adequately cover most of the indicator species and should allow statistical analysis tools to be used to guide future remedial investigation activities. Statistical techniques (such as Kriging) may be applied to evaluate the spatial distribution of contaminants and comparisons of measured values to ARARs or established background values will be used to judge if significant trends exist.

Currently, no data are available on the contaminant concentrations in aquifer sediments underlying the 300-FF-5 operable unit or on the suspended sediments in the Columbia River, springs on the banks of the river, or biota within the river directly adjacent to 300-FF-5. Scattered chemical composition data exist for the river, springs, and biota germane to Hanford Site background and other contaminated areas that can be used qualitatively to plan sample quantity needs.

The approach to be used in this RI/FS will be to evaluate data as they are generated, such that data quantity can be continuously assessed. The remedial investigation will continue in iterative steps until a sufficient amount of information is available to adequately satisfy the needs of site characterization, public health evaluation, and preliminary risk assessment and evaluation of remedial alternatives.

Some key questions that will influence sample location and numbers include the following:

- What are the boundary conditions, both hydraulic and geochemical, along the north and west sides of the 300-FF-5 operable unit?
- What is the extent of contamination in the southern portion of the operable unit and along the bottom of the unconfined aquifer and in the upper confined aquifer?
- Do the indicator species, uranium, chloroform, trichlorethene, and 1,2-dichloroethene, react with the aquifer sediments to retard their transport through the aquifer?
- Do the concentrations of any indicator species in spring water, Columbia River water, suspended sediments, bed sediments, and aquatic biota exceed background and thus merit further study?
- What is the nature of the interaction between the Columbia River and groundwater in relation to groundwater flow and contaminant transport?

4.2 PROJECT PLANNING APPROACH

A general overview of data usage is presented in this section. The collection and analysis of those data are presented in Chapter 5.0 and Attachment 1--Sampling and Analysis Plan. The RI/FS tasks described in Chapter 5.0 will be conducted in a phased manner to optimize project efficiency. The 300-FF-5 Work Plan will be integrated with 300-FF-1 (ongoing) and 300-FF-2 and 300-FF-3 (as they are initiated).

4.2.1 Investigation Methodology

The methodology identified for implementation of the RI/FS process in the 300-FF-5 operable unit is a staged approach. Execution of this approach requires that the RI/FS be performed in a sequence to optimize the data gathering and evaluation. The key components of that sequence are as follows.

4.2.1.1 Operable Unit Characterization (Remedial Investigation)

- Task 1--Source Investigation

- determine primary sources of groundwater contamination within 300-FF-5. This work is documented in the 300-FF-1 Work Plan and will be addressed in similar plans for the 300-FF-2 and 300-FF-3 operable units. The location of groundwater contamination and trends in groundwater concentrations will be used to identify areas where contaminants enter the groundwater.

- Task 2--Geologic Investigation

- delineate significant lithofacies in 300-FF-5

- conduct geophysical surveys to support delineation of major subsurface geologic features and a postulated groundwater flow barrier along the Columbia River.

- Task 3--Soil Investigation

- determine the distribution of contaminant concentrations on aquifer sediments

- evaluate transport characteristics of contaminants by sorption and desorption studies in support of risk assessment and remedial alternatives.

- Task 4--Groundwater Investigation

- delineate significant hydrofacies between the water table and the top of basalt

- determine nature and extent of contamination within the hydrofacies (both horizontal and vertical extent)

- determine contaminant concentrations in water pumped from the unconfined aquifer and used in the 300 Area

- determine hydrologic properties of units so that groundwater flow velocities can be calculated

- determine whether there is hydraulic connection between the unconfined and upper confined aquifers

- develop conceptual and numerical representation of groundwater and contaminant transport processes for the operable unit.

- Task 5--Surface-Water and Sediment Investigation

- develop detailed map of bank springs that may discharge contaminated groundwater to the Columbia River

- perform surface-water/sediment sampling for contaminants at identified discharge locations (i.e., springs and process discharge locations) and sample and analyze water samples collected from the 300 Area water intake

- monitor water levels in the river and adjacent groundwater to assess physical groundwater/surface-water interactions

- develop conceptual and numerical representation of groundwater and surface-water interactions.

- Task 7--Biota Investigations

- identify aquatic and riparian biota important for contaminant transport and exposure analysis

- determine the extent and concentrations of contaminants in biota at positions adjacent to groundwater contamination.

- Task 8--Data Evaluation

- map analytical data to produce areal, cross-sectional, and temporal depictions of contaminant distributions in geologic media, groundwater, surface water, and biota; statistical techniques (such as Kriging) and data comparisons may be used to evaluate spatial distributions of contaminants

- map groundwater potentials in plan and cross-sectional views as a function of time to delineate groundwater flow directions

- calculate distribution coefficients, retardation factors, or sorption isotherms that relate contaminant concentrations in solution to those on the solid phase at equilibrium

- quantify groundwater and surface-water flow and contaminant transport processes using numerical models.

- Task 9--Baseline Risk Assessment

- develop exposure scenarios

- use contaminant concentrations (either measured or calculated using transport models) in groundwater, surface water, and biota in conjunction with exposure scenarios to quantify human health and environmental impacts of the existing site condition and various treatment alternatives.

- Task 10--Preliminary Site Characterization Summary Reports.

4.2.1.2 Remedial Alternatives Development (Feasibility Study)

- determine remedial action objectives
- develop general response actions
- identify potential remedial alternatives
- assemble remedial alternatives
- identify action-specific ARARs
- communicate data needs to remedial investigation
- coordinate with other operable units.

4.2.1.3 Remedial Alternatives Screening (Feasibility Study)

- refine remedial action objectives
- identify remedial alternatives
- screen alternatives
- refine action-specific ARARs
- reassess current data needs; report to remedial investigation
- coordinate with other operable units
- write preliminary feasibility study report.

4.2.1.4 Treatability Investigations (Remedial Investigation)

- prepare plan(s)
- perform treatability investigations
- coordinate with other operable units
- document in remedial investigation report.

4.2.1.5 Remedial Alternatives Analysis (Feasibility Study)

- identify remaining remedial alternatives
- perform detailed analysis
- compare alternatives (one versus one)
- coordinate with other operable units
- document in feasibility study report.

4.2.1.6 Proposed Plan and Record of Decision

- summarize all technical information leading to a cleanup decision
- document the selection of chosen remedy.

The details provided emphasize early work efforts. As data are obtained, specific details for later efforts will be spelled out in the preliminary remedial investigation and feasibility study reports. The coordination identified with other operable units (such as 300-FF-1, 300-FF-2, and 300-FF-3) are especially critical for choosing and screening remedial action alternatives.

4.2.2 Data Evaluation Methodology

Data gathered during the initial remedial investigation of the 300-FF-5 operable unit will be evaluated rapidly to facilitate rescoping and focusing as appropriate. The data will be documented and summarized as part of the annual remedial investigation report. Task 8--Data Evaluation is the task in which the data are interpreted to identify the final list of contaminants and groundwater and surface-water location- and contaminant-specific ARARs. In addition, data will be evaluated as to impact on the aquatic and riparian life within that section of the Columbia River bounding 300-FF-5. Further discussions of the data evaluation process are contained in Task 5 of Chapter 5.0.

The data also will be used in Task 9 to prepare a baseline risk assessment that includes discussion on exposure, toxicity, and risk characterization.

The development, screening, and evaluation of remedial alternatives in the feasibility study will rely on remedial investigation data from this and the previously identified companion operable units, available technical knowledge, standard costing, and professional judgment.

4.2.3 Integration of Remedial Investigation and Feasibility Study

The RI/FS activities for the 300-FF-1 and 300-FF-5 operable units will be an integrated program. Each operable unit investigation will proceed through logical phases (discussed in detail in Chapter 5.0 of this 300-FF-5 Work Plan and in the 300-FF-1 Work Plan) to identify whether remedial actions are needed and if so, which remedial alternatives are likely to effectively reduce health and environmental risks to acceptable levels and be cost effective. Areas for potential integration of resources and effort are surface geophysics, well drilling, database administration, quality assurance/quality control, project administration, and administrative protocols for performing work. Technical integration will focus on contaminant distributions, contaminant transport, exposure scenarios, and ultimately, on the remedial treatments selected and applied.

4.2.4 Community Relations

A Community Relations Plan has been developed for the Hanford Site (CRP 1989) and, therefore, a specific plan is not presented with this work plan. All community interactions associated with activities addressed in this work plan shall be administered in accordance with the plan. Attachment 5--Community Relations Plan presents a brief description of this activity.

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

5.1 PROJECT MANAGEMENT

The purpose of project management is to define the administrative and institutional tasks necessary to support RI/FS activities in the 300-FF-5 operable unit. Attachment 5--Project Management Plan for the 300-FF-1 operable unit presents the descriptions of project management for the 300-FF-5 RI/FS.

5.2 COMMUNITY RELATIONS

A Community Relations Plan has been developed for the Hanford Site (see Chapter 1.0 and CRP 1989). Because community relations activities are common to many operable units, a decision was made to develop a single Community Relations Plan for all Hanford remedial and corrective actions that will provide continuity and general coordination of all community relations activities. The site-wide Community Relations Plan discusses Hanford Site background information, history of community involvement at Hanford, and community concerns. The Community Relations Plan also delineates the community relations program that DOE-RL, EPA Region X, and State of Washington Department of Ecology (Ecology) will cooperatively implement throughout cleanup of all operable units at the Hanford Site. All community relations activities associated with this 300-FF-5 Work Plan will be conducted under this overall Hanford Site plan. The Community Relations Plan meets the objectives discussed in and was developed in accordance with EPA's recommended community relations handbook (EPA 1988c).

5.3 REMEDIAL INVESTIGATION/SITE CHARACTERIZATION

Chapters 2.0 and 3.0 provided discussions about the current knowledge of the environmental characteristics and distributions of contaminants in the 300-FF-5 operable unit. These discussions provided the basis for identifying additional data needed to evaluate hazards associated with the 300-FF-5 operable unit and to design and implement remedial actions. Chapter 4.0 presented these needs in the form of 10 specific tasks. These tasks are discussed individually in this section. The data needed, techniques for collecting the data, and data uses are presented.

5.3.1 Task 1--Source Investigation

The 300-FF-5 operable unit contains no waste sources, but underlies and is downgradient of several source operable units described in Section 2.1.3. Investigations of these sources will be administered by work plans for those operable units. Analysis of contaminant plumes in 300-FF-5 may provide evidence for specific locations where contaminants from the various source operable units enter the unconfined aquifer.

5.3.2 Task 2--Geologic Investigation

The existing geologic data for the 300-FF-5 operable unit, presented in Section 2.2.2, are insufficient to adequately characterize the site. The approach presented in this section to collect the required geologic data involves geophysical surveys and traditional geologic characterization of sediment samples obtained during well drilling.

5.3.2.1 Task 2a--Geophysical Surveys. The geophysical surveys will address two main objectives. The first is to evaluate the reflection properties of the major sedimentary units, the water table, and the top of the basalt. This will involve the collection of geophysical data along a set of widely spaced traverse lines that will cover a major portion of the 300-FF-5 operable unit. This information is required to obtain an overall understanding of the geometry of the unconfined aquifer and vadose zone underlying the 300-FF-5 operable unit. The second objective is to investigate and map the apparent paleochannel in the uppermost sediments of the Ringold Formation (see Section 2.2.2.3). The east side of this channel is believed to have the form of an embankment or barrier that tends to block the flow of groundwater from the 300 Area to the Columbia River. Existing hydrologic data suggest that this barrier has been breached at several locations along the river. Thus, it is important to determine the longitudinal profile of the barrier, identifying any lows that would represent channels for the flow of groundwater into the river.

5.3.2.1.1 300-FF-5-Wide Geophysical Surveys. Surface-based geophysical surveys will help to determine the lateral extent of some of the major sedimentary units and can be used to delineate variations in the depth of the underlying basalt surface. The traverse lines along which the geophysical survey will be performed will extend between the new geologic characterization wells shown in Figure 35. This will permit the geophysical data to be correlated with the stratigraphic information provided by the core samples and the well logs. The geophysical sensing methods that will be employed to obtain these large-scale profiles are acoustic reflection profiling and ground-penetrating radar.

The acoustic reflection profiling survey will provide stratigraphic data for depths greater than those accessible by the ground-penetrating radar method. In particular, the acoustic method is expected to produce profiles of the basalt surface at depths of 200 ft or more, in addition to showing the extent and thickness of major sedimentary layers at shallower depths. The technique can be implemented with relatively standard instruments and procedures; however, the presence of eolian sand deposits over much of the study area will make it difficult to achieve good acoustic coupling. Preliminary tests will be required to define a combination of instruments and techniques that yield the desired stratigraphic information in a cost-effective manner. For example, it may be possible to reduce the expected problems of poor coupling and strong surface waves by placing the sound source in a shallow augured hole. Appropriate sources include a vacuum ram and a propane-oxygen detonator. The relatively low-frequency surface waves will be further attenuated by the use of high-frequency geophones and bandpass filters. Additional instrument features will include microcomputer-based control of source

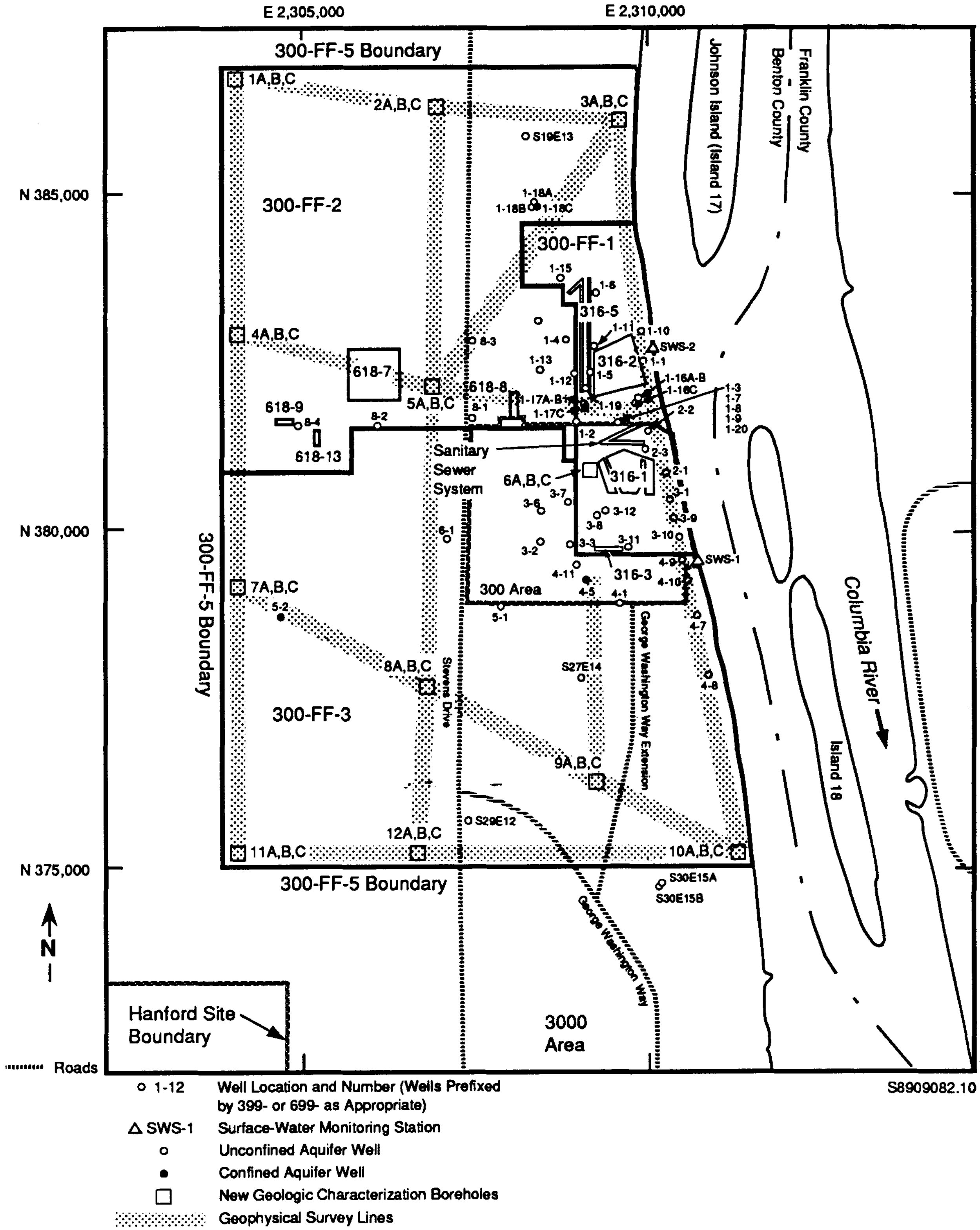


Figure 35. Location of Geophysical Survey Lines for the 300-FF-5 Operable Unit.

triggering and data acquisition, digital data recording and processing, signal averaging, and multichannel amplifiers with selectable time-varying gain.

The ground-penetrating radar method will complement the acoustic method by providing stratigraphic data from a shallow depth range, where the acoustic method tends to be ineffective. More specifically, the ground-penetrating radar profiles will show the base of the eolian surface deposits and possible layering in the uppermost part of the underlying Hanford formation. The maximum effective penetration depth at this site is expected to be approximately 25 to 35 ft. This estimate is based on measurements of ground-penetrating radar signal attenuation rates at other locations on the Hanford Site (6 to 8 dB/m in the 100- to 200-MHz frequency range). The resolution of the radar system in this frequency range is adequate to delineate distinctive layers in the near-surface sediments if they are a few centimeters or more thick. The main factors that influence the detectability of a given interface are the contrasts in texture and composition between two layers. The instrument to be used will be of the type marketed by Geophysical Survey Systems, Inc., and will incorporate digital data recording, signal-to-noise enhancement by signal averaging, and capability for both monostatic and bistatic transmitter/receiver configurations. Digital methods will be utilized to process and display the collected data.

5.3.2.1.2 Paleochannel Delineation. According to the information presented by Lindberg and Bond (1979), the possible paleochannel in the Ringold sediments is filled with and covered by approximately 40 to 80 ft of flood gravels of the Hanford formation. The barrier between this channel and the channel of the Columbia River is presumably covered by a thinner layer of sand. Thus, the cross-sectional and longitudinal profiles of the barrier may not be observable in the acoustic reflection profiles to be obtained in the survey discussed above (because reflected signals from the top of the paleo-embankment may be obscured by surface waves).

Three other geophysical survey methods may be more effective than the acoustic reflection method for detecting and mapping the barrier profile. These methods are (1) ground-penetrating radar, (2) electromagnetic induction measurements of ground conductivity, and (3) acoustic refraction profiling. Because the available geologic data do not definitively describe the differences (texture, composition, and density) that exist at the interface between the sediments of the Hanford formation and those of the underlying Ringold Formation, there is no sound basis on which to predict the success or failure of any of these methods. Therefore, surveys utilizing all three methods will be performed along the west bank of the Columbia River within the accessible portions of an area approximately 2 mi long by 500 ft wide (Figure 36). In each case, traverses will be run roughly parallel to the river to define the longitudinal barrier profile. Additional traverses will be run in an orthogonal direction, as feasible and appropriate, to determine the cross-sectional profiles of the barrier.

As discussed above, the maximum effective depth for ground-penetrating radar profiling in the area of interest is expected to be approximately 25 to 35 ft. This depth may be sufficient to define the barrier profile. However, a greater penetration depth might be achieved at this particular location if the sediments present near the river contain a lower percentage of

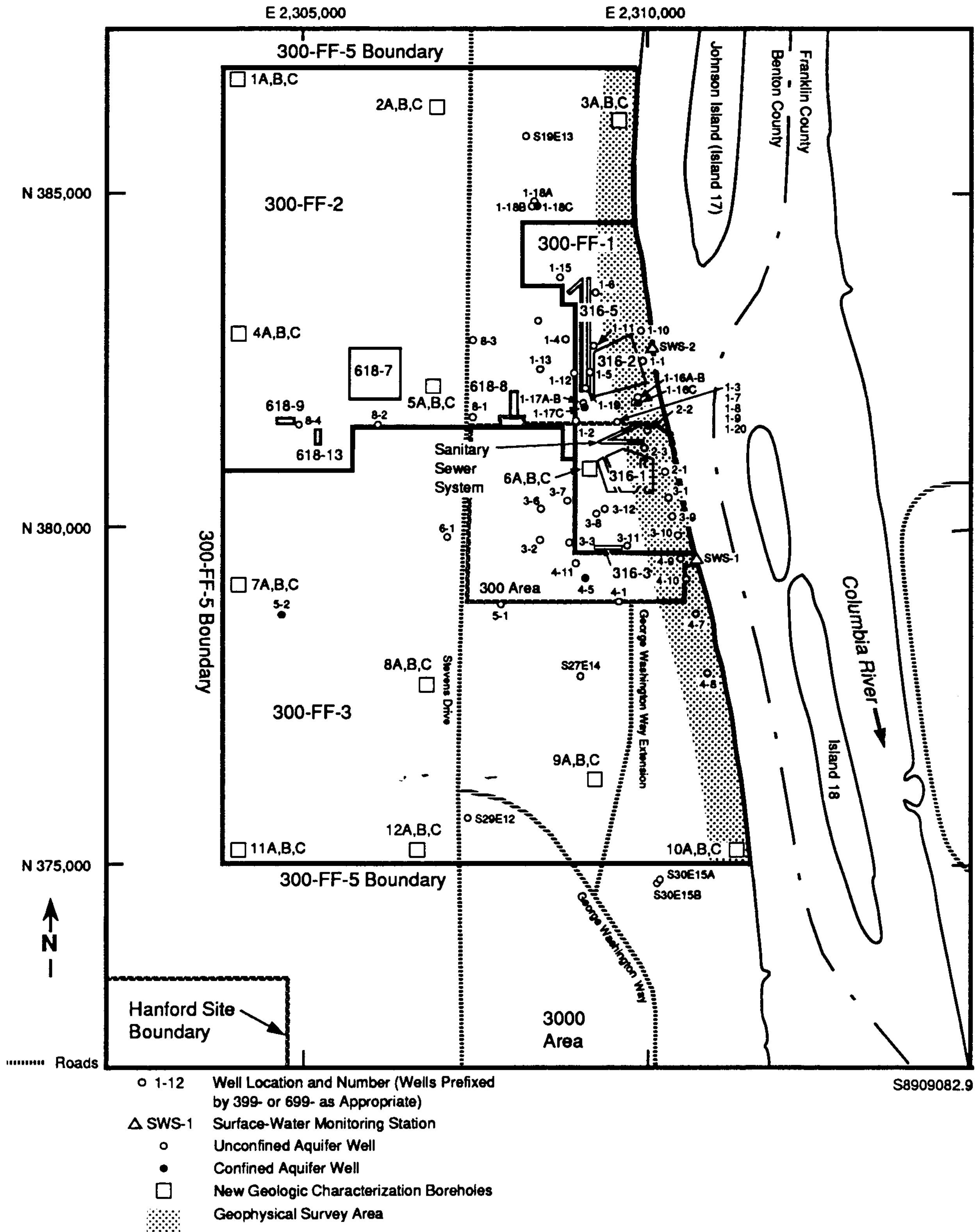


Figure 36. Geophysical Survey Area for Investigation of the Paleochannel.

silt or clay than do the sediments at the "inland" locations, where the earlier measurements of signal attenuation were made.

The electromagnetic induction ground-conductivity profiles will involve the use of a ground-conductivity meter. Measurements will be made at 50-ft intervals, with the transmitter and receiver coils spaced at the distance corresponding to the nominal 20-m penetration-depth setting of the instrument. Anomalous zones of electrical conductivity in the resulting profiles might reflect textural or compositional variations in the sediments that correspond to the suspected breaches in the barrier separating the paleochannel from the Columbia River.

Acoustic refraction measurements are generally effective for detecting and mapping shallow sedimentary interfaces if the sedimentary layers are thick and reasonably continuous and if each successively deeper layer has an acoustic velocity that is appreciably different from and greater than that of the layer above. Because of the limited objective of this refraction survey, it is primarily necessary that the acoustic velocity of the Hanford formation sediments be significantly less than that of the Ringold Formation sediments. The sensors and data-recording instruments to be used for this survey are essentially the same as those described above in connection with the acoustic reflection surveys. Each traverse line will be covered by a set of overlapping refraction lines, or linear geophone arrays, where each line may be a few hundred feet in length. Line lengths and geophone spacings will be determined by field tests. The generalized reciprocal method of data interpretation (Palmer 1981), or a similar method, will be utilized to derive the barrier profile from the digitally recorded refraction data.

5.3.2.2 Task 2b--Geologic Characterization. A total of 12 new boreholes are planned for detailed characterization of the sediments to provide a broad base of geologic data for the 300-FF-5 operable unit. The 12 geologic characterization boreholes will each be located ~25 ft hydraulically downgradient of each new groundwater monitoring well nest identified in Section 5.3.2.3. These wells will be located on a grid overlying the 300-FF-5 area shown in Figure 37. Drilling of baseline wells through the predominantly loose, coarse-grained Hanford formation will be performed using the reverse air-rotary (i.e., Becker or an acceptable alternative) method. After penetrating the Hanford formation, drilling of the more compact, fine- to coarse-grained Ringold Formation sediments to the top of the M3 layer (see Figure 9) will be performed using mud rotary with continuous wireline core sampling to obtain undisturbed samples for laboratory analysis (Section 5.3.2.3). Samples for geologic characterization of the M3 layer and underlying basalt will be accomplished by split-spoon drive barrel and hard-tool, using cable-tool, methods in the adjacent well nest borehole.

Seven additional wells, described in Section 5.3.4.1.1, will be installed within the 300-FF-5 operable unit to monitor dense nonaqueous-phase liquids and/or to help define the extent of uranium contamination. Geologic data will be collected from these wells, even though they are not intended for detailed characterization.

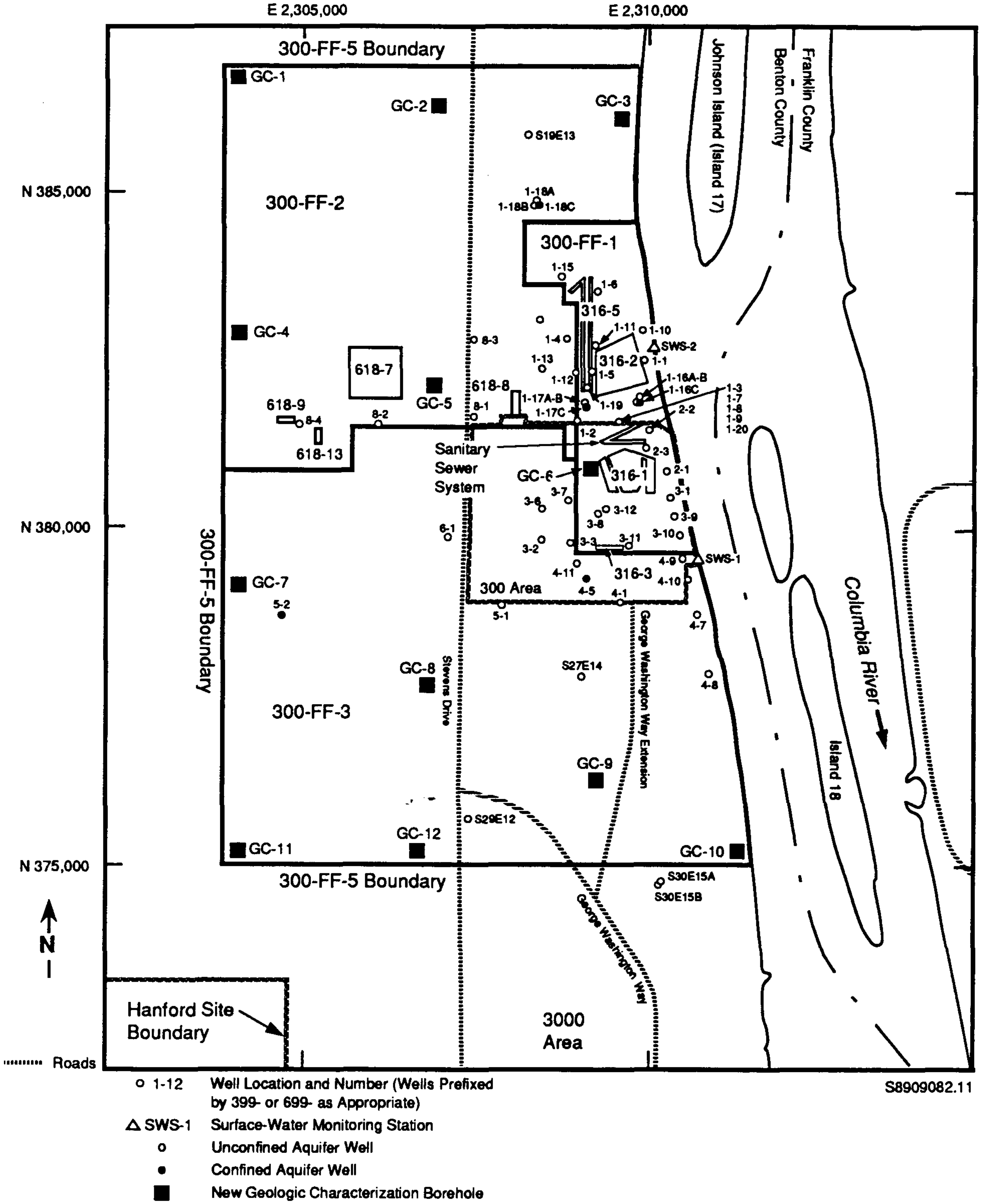


Figure 37. Locations of Proposed Geologic Characterization Boreholes.

Intact core samples are needed for characterization for two reasons: (1) to provide intact samples for hydrologic parameter testing [particle-size distribution, permeameter, and bulk mass density (i.e., porosity)] and (2) to evaluate the degree of vertical anisotropy (interlayering of contrasting facies) within the sedimentary column. It is estimated that the level of detail necessary to accurately model the 300-FF-5 groundwater hydrology is equivalent to the identification of hydrofacies that are 5 ft or more thick. With continuous core, it will be possible to identify the contacts between hydrofacies and to understand the inherent heterogeneities of the stratigraphic system. This will provide the necessary information needed to select aquifer test and groundwater sampling intervals so that tests are performed on individual hydrofacies. In the past, without core samples, aquifer tests have often been performed across facies boundaries, which may lead to erroneous results.

Interpretation of the geohydrology up to the present is based primarily on hard-tool samples. The present well network in the vicinity of the 300-FF-5 operable unit consists of approximately 60 wells that penetrate to the top of the unconfined aquifer or beyond. All these wells were cable-tool drilled with a hard-tool bit (Schalla et al. 1988).

5.3.2.2.1 Problems with Hard-Tool Drilling. Many problems exist with geohydrologic interpretations based on hard-tool samples collected in the past. First, interpretations are very subjective because samples are only collected every 5 ft. At this sampling interval, any contrasts in the sedimentary layering less than 5 to 10 ft thick go undetected. For example, consider the results if, after drilling through 4 ft of permeable sandy gravel, a 1-ft clay aquitard were drilled. The resultant mixture (clayey sandy gravel) would have very different hydrologic properties that would mask the presence of an aquitard. Furthermore, even if a contact were suspected, the decision of where to place the contact is questionable. Another problem is that differential settling can occur within the bailer, especially below the water table as sediments are retrieved from the bottom of the well. As a result, the particle-size distributions and other characteristics of the sample at the bottom of the bailer may be significantly different from those at the top.

A third problem is that sedimentary particles are easily broken and crushed by the hard-tool bit during drilling, the amount of which may vary, depending on the driller, shift, schedule, etc. The end result is a sample with greater amounts of silt and sand, and perhaps significantly less gravel, than is representative of the formation. Hard-tool samples still may be used, but with caution, and should be examined carefully in conjunction with samples collected by other more representative sampling techniques.

For these reasons, the two drill methods that will be used in this task (reverse air rotary and diamond core) will be the preferred methods for the 12 new geologic characterization boreholes (nested wells). Based on past experience, the diamond core method will provide good recovery of relatively undisturbed samples of the Ringold Formation. Coring of the relatively unconsolidated Hanford formation has not been successful in the past, so the reverse air-rotary method will be used in place of the diamond core method.

While the reverse air-rotary method will not provide intact samples, it will provide more representative samples than can be obtained with cable-tool methods.

5.3.2.3 Field and Laboratory Analyses in Support of Geohydrologic Characterization. A variety of field and laboratory analyses are planned to characterize the 300-FF-5 operable unit. Field analysis, listed in Table 31, will include a detailed geologic description and classification of sediment samples at the drill site, according to the methods described in Last and Liikala (1987). During geologic logging, samples will be collected for those laboratory analyses listed in Table 32. These will include (1) particle-size distributions (sieve analysis of gravel/sand fraction; hydrometer analysis of silt/clay); (2) small-scale hydrologic parameter tests (permeameter; bulk mass density); and (3) mineralogic analyses (petrography; x-ray diffraction). The purpose of a petrographic analysis of the sediments is twofold: (1) to identify the major and minor mineral constituents to determine how these might interact with contaminants and (2) for stratigraphic studies, particularly for verifying the contact between the Hanford and Ringold Formations, which have distinct hydrologic properties. Also planned are ammonium acetate extraction to determine cation exchange capacity, pH testing, and chemical analyses using a variety of techniques. In addition, groundwater and sediment samples will be analyzed at regular intervals for hazardous chemicals and radionuclides. The analytical methods, associated parameters, potential uses, sample frequency, method of sample collection, and procedures for these analyses were provided in Table 32.

Other field analyses to be performed as part of geohydrologic characterization (see Table 31) include geophysical logging, as well as aquifer tests, tracer tests, and water-level measurements. Geophysical logging techniques will include the natural-gamma log. Downhole camera surveys will be performed to check and verify well construction. Aquifer tests will be performed after detailed geologic and geophysical logging is complete. Aquifer tests will be used to evaluate the hydraulic conductivity, transmissivity, and storativity properties of hydrofacies. The intent will be to test specific hydrofacies so as to obtain representative aquifer properties on the total range of different geohydrologic units present.

5.3.3 Task 3--Soil Investigation

The goal of the soil investigation task is to characterize the chemical content of saturated zone sediments within the 300-FF-5 contamination area and of unsaturated sediments outside the vertical projection of source boundaries that are being studied in companion RI/FS operable units.

Characterization includes not only chemical analyses to determine the areal extent and distribution of contaminants, but sediment leaching and sediment adsorption-desorption tests to ascertain the nature of the contaminant binding to sediments (i.e., potential for remobilization), as presented in Table 32.

Table 31. Field Analyses to be Performed as Part of Geohydrologic Characterization of the 300-FF-5 Operable Unit.

Field analysis	Parameter measured	Limitations	Potential uses	Test frequency	Method of data collection
Lithologic description and classification of cuttings/core	Qualitative estimate of grain size, sorting, mineralogy, roundness, color, consistency, structure, fabric, etc.	Cuttings may not be totally representative of formation	Stratigraphic correlation; facies distribution; depositional environment	Every 5 ft or change in lithology	Cable-tool, air-rotary, and/or core drilling
Natural-gamma log	Qualitative estimate of clay content	Should be used in combination with other techniques (e.g., geologist log, sieve data)	Aquitard/stratigraphic unit identification; zones of radionuclide contamination	After each change in casing and on reaching total depth	In situ
Downhole television log	Quality check of well construction	Turbidity limits visibility and usefulness	Quality assurance; trouble-shooting	Once, at well completion	Videotape of in situ conditions
Water-level measurements	Hydraulic gradient	Must compare similar positions and times within the same aquifer	Determine direction of groundwater flow	Monthly/quarterly; some continuous	In situ
Aquifer tests	Hydraulic conductivity, transmissivity, storativity	Isolated, homogeneous units	Provide hydraulic parameters for contaminant transport models	Every major hydrofacies below water table	In situ and/or observation well
Tracer tests	Groundwater travel time, dispersivity, direction of groundwater flow	Adequate number and spacing of observation wells	Direct observation of groundwater movement; validate groundwater flow models; evaluate effective porosity	Irregular intervals, depending on season and river stage	Observation wells
Field contamination	pH, organic/toxic gases, radiation	Specific contaminant may not be identifiable in field	Safety	Suspect zones, otherwise random	Air at top of well casing, sediment samples, groundwater samples

Table 32. Laboratory Analyses to be Performed as Part of Geologic Characterization of the 300-FF-5 Operable Unit. (Sheet 1 of 2)

Laboratory analysis	Parameter measured	Sample requirements/limitations	Potential uses	Sample frequency	Method of sample collection	References
Sieving	Particle-size distribution of sand to gravel-size particles	Individual particles must be disaggregated and unbroken to yield accurate results	Proxy for hydraulic parameters; groundwater modeling; estimate sorption properties	Every 5 ft or change in lithology	H, D, S, C	ASTM (1972), Gee and Bauder (1986)
Hydrometer	Particle-size distribution of mud-size particles (i.e., silt and clay)	<2-mm sediment-size fraction	Characterize aquitards; groundwater modeling; estimate sorption properties	All fine-grained intervals	H, D, S,	ASTM (1972), Gee and Bauder (1986)
Permeameter	Saturated hydraulic conductivity	Undisturbed/intact sedimentary core	Small-scale estimate of groundwater travel time; check for aquifer tests; groundwater modeling	Selected intervals	S, C	ASTM (1968), Klute and Dirksen (1986)
Moisture content	% water	Vadose zone samples	Identification of perched water zones; vadose zone modeling	Every 5 ft or change in lithology above the water table	D, S, C	ASTM (1980)
CO_2 gasometer	$\%CaCO_3$ content	<2-mm sediment-size fraction	Aquitard identification; stratigraphic marker horizons; chemical interactions	Every 5 ft or change in lithology	H, D, S, C	Nelson (1986)
Saturated paste pH	pH	Bulk samples (~20 g)	Evaluate chemical interactions with contaminants	Every 5 ft or change in lithology	H, D, S, C	McLean (1986)
Organic carbon content	Organic carbon	<2-mm sediment-size fraction	Evaluate organic sorption capacity	Every 5 ft or change in lithology	H, D, S, C	Nelson and Sommers (1986)
Ammonium acetate extraction	Cation exchange capacity	<2-mm sediment-size fraction	Sorptive properties	Every 5 ft or change in lithology	H, D, S, C	Rhoades (1986)
Petrography	Mineral content/ concentration	Sand-sized fraction	Determine sorptive potential of primary mineral species; differentiate among hydrostratigraphic units	Major changes in lithology	H, D, S, C	Kerr (1959)

Table 32. Laboratory Analyses to be Performed as Part of Geologic Characterization of the 300-FF-5 Operable Unit. (Sheet 2 of 2)

Laboratory analysis	Parameter measured	Sample requirements/limitations	Potential uses	Sample frequency	Method of sample collection	References
X-ray diffraction	Clay mineral identification	Fine-grained sediments (silt and clay)	Sorptive characteristics; hydrostratigraphic unit identification	Selected fine-grained intervals	D, S, C	Drever (1973), Rich and Barnhisel (1977), MacEwan and Wilson (1980)
X-ray fluorescence and/or proton-induced X-ray emission	Major and trace element concentrations	<2-mm-size fraction from representative sediment sample	Hydrostratigraphic unit identification; determine natural background and levels of contaminants in sediments; identify basalt flows	Selected intervals where lithology changes	H, D, S, C	Birks (1969), Muller (1972), Lim and Jackson (1986)
Adsorption tests	Chemical change from influent to effluent	<2-mm-size fraction from representative sediment sample	Determine distribution coefficient for risk assessment and remedial alternatives	Selected representative sediment samples from below water table (analyze in conjunction with contaminated vadose zone samples from 300-FF-1, 300-FF-2 and 300-FF-3)	D, S, C	Relyea et al. (1980), ASTM (1983)
Leaching/desorption tests	Release of contaminants from sediments	<2-mm-size fraction from representative sediment sample or material from adsorption test	Determine distribution coefficient for risk assessment and remedial alternatives	Selected representative sediment samples from below water table (analyze in conjunction with contaminated vadose zone samples from 300-FF-1, 300-FF-2 and 300-FF-3)	D, S, C	Gallagher (1979), ASTM (1988)
Bulk mass density	Bulk porosity	Undisturbed/intact sedimentary core	Determine hydraulic parameters; groundwater modeling	Selected intervals	S, C	ASTM (1986)
Radionuclides, hazardous chemicals	Concentrations of radionuclides and hazardous chemicals in groundwater and sediments	Nonturbid groundwater and selected representative sediment samples	Test for groundwater contamination	On reaching groundwater; every 20 ft or at major lithologic changes within aquifer	Pump from completed well; <2-mm representative samples; intact core for organics	Section 5.3.4.

H = hard tool (may not be representative of the formation), D = drive-barrel drill method, S = split-spoon drill method, C = diamond core.

Samples of vadose zone sediment and aquifer sediments will be taken from all boreholes (at 5-ft-depth intervals and at distinct stratigraphic changes) installed during the 300-FF-5 RI/FS (Section 5.3.4). Samples from boreholes distant and upgradient from known sources will be used to generate baseline or background concentrations of all major constituents and potential contaminants. In coordination with the source operable unit RI/FS activities (i.e., 300-FF-1, 300-FF-2, and 300-FF-3), vadose zone sediments and aquifer sediments from boreholes near known sources will be characterized to help delineate the spatial distribution of contaminants.

Selected sediment samples within the vadose zone and within the upper unconfined aquifer that contain high concentrations of contaminants will be tested in the laboratory to determine the leachability of contaminants. When possible, pore waters within the sediments will be expelled and contaminant concentrations measured to allow in situ distribution coefficients to be calculated.

The laboratory leach and adsorption-desorption tests will concentrate on determining leach rates and distribution coefficients of indicator species (such as uranium, nitrate, trichloroethene, and 1-2 dichloroethene). The leach rates and distribution coefficients are direct input to transport models used to predict future migration and environmental effects. Further, leach rates and distribution coefficients are used to assess the efficacy of remedial alternatives that rely on water or chemical reagent flushing or washing of the sediments.

Other common measurements (such as major cations and anions, total organic and inorganic carbon content, particle-size distribution, qualitative mineralogy, and saturated paste pH) will be performed on selected sediment samples to aid in contaminant mobility and remedial alternatives assessment. The selection criteria include the 10 samples chosen for leach/desorption testing, the 30 samples chosen for complete chemical analyses, and other samples that have distinctive attributes (such as moisture content and color).

For initial screening purposes, up to 30 sediment samples collected near and distant from the disposal sites will be characterized for all potential chemical and radionuclide contaminants. Up to 10 samples with the highest levels of contaminants will be completely characterized in the laboratory to evaluate contaminant-sediment chemical interactions. Should this preliminary sediment characterization effort inadequately define the types of contaminants, their extent, and transport properties, additional work will be performed in accordance with the data needs identified. Details on methods, procedures, instrumentation needs, sampling frequencies, etc. are presented in Attachment 1--Sampling and Analysis Plan.

In summary, the soil investigation will aid (1) the delineation of contaminant distributions in the vadose and aquifer sediments, (2) the development of contaminant transport models (and/or expansion/revision of existing models) that predict the volume of groundwater and concentration of contaminants entering the Columbia River, and (3) collection of leachability and adsorption/desorption data for remedial alternatives evaluation.

5.3.4 Task 4--Groundwater Investigation

The goal of the groundwater investigation task is to assess the impact of waste disposal activities in the 300-FF-1, 300-FF-2, and 300-FF-3 operable units on the groundwater system. The objectives are to characterize the distribution and concentration of groundwater contaminants in the operable unit and to evaluate contaminant transport in the unconfined and confined aquifers. The approach planned to achieve these objectives consists of five tasks:

- Task 4a--characterize the hydrostratigraphy within the unit using new and existing geohydrologic data
- Task 4b--determine the distribution of contaminants in the soil and groundwater
- Task 4c--determine hydraulic properties of the unconfined and upper confined aquifers and the overlying layers
- Task 4d--determine the extent of aquifer intercommunication within the unconfined and confined aquifers
- Task 4e--develop numerical hydrologic and contaminant transport models (and/or expand/revise existing models) to simulate the geohydrochemical system(s) within the operable unit and predict the present and future volume of groundwater and concentration of contaminants entering the Columbia River.

In all of the groundwater investigation tasks, activities will be conducted in phases. Conducting work using this iterative approach allows for more effective and efficient data collection. Details on methods, procedures, instrumentation, specific data, sampling frequencies, analyses, and database formulation used in implementation of Task 4 are presented in Attachment 1--Sampling and Analysis Plan.

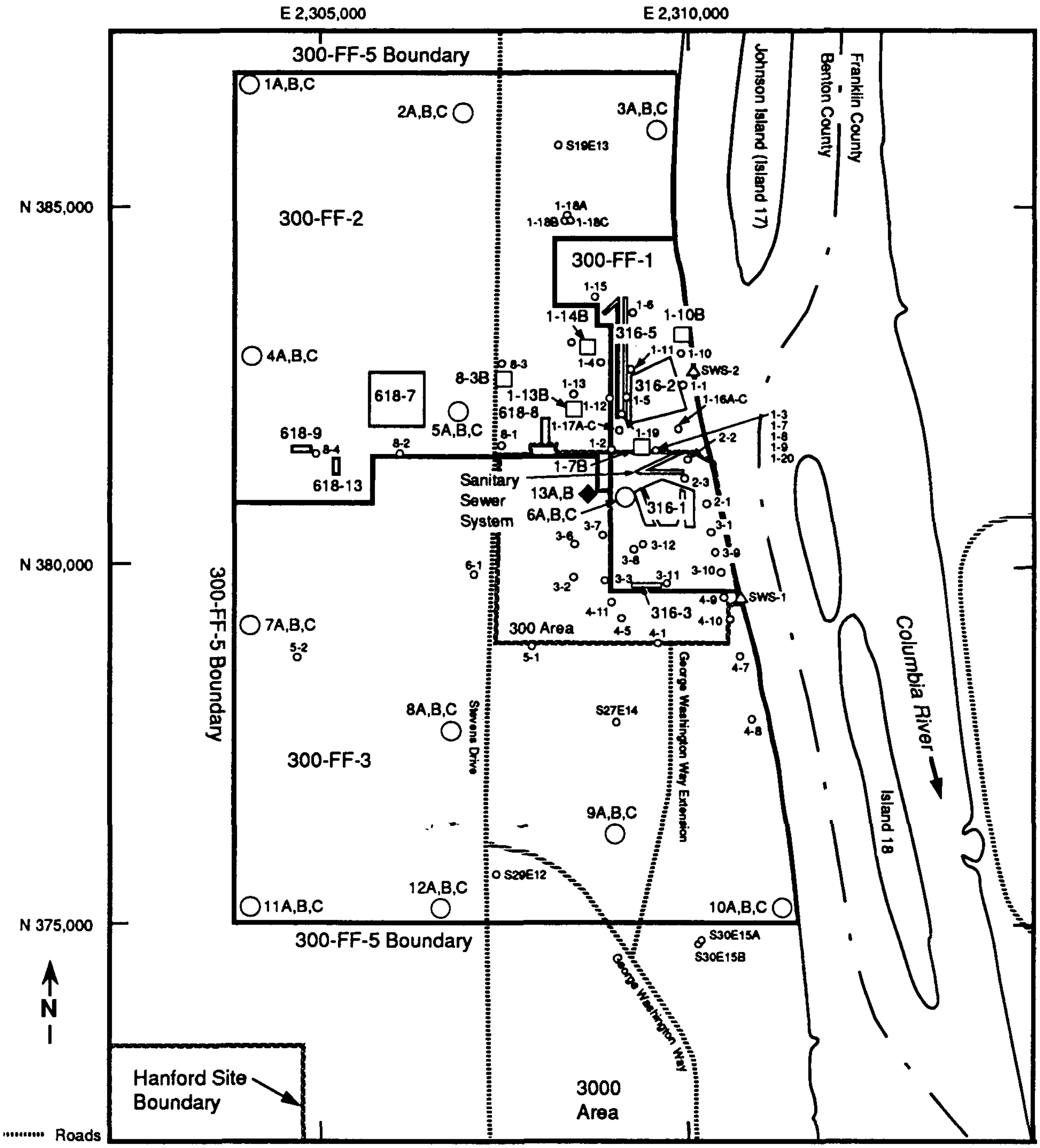
The proposed groundwater investigation will address two key criteria. First, the new wells will provide data to assess whether past disposal practices in the 300-FF-5 operable unit are the sources of the existing groundwater contamination observed beneath the 300 Area. Second, all of the Phase I monitoring wells will be installed in multiple horizons to determine the distribution of groundwater contaminants. For example, have contaminants such as trichloroethene and 1,2-dichloroethene been collected along the bottom of the unconfined aquifer, are they distributed throughout the aquifer, or are they located primarily in the upper part of the unconfined aquifer. Also, can the migration of these constituents into the confined aquifer (top of the Saddle Mountains Basalt) be stopped if they are present in concentrations that should cause concern. The latter point is important because the deeper, and possibly even the most shallow, confined aquifers are continuous under the Columbia River into Franklin County where several drinking and irrigation wells are present.

5.3.4.1 Task 4a--Hydrostratigraphy. This task is closely related to Task 2--Geologic Investigation; considerable background work for this task will have been completed in Task 2. The scope of this task includes the delineation of hydrofacies based on the identified lithofacies. For example, information about the major sedimentary units, the confined and unconfined aquifers, the topography of the basalt surface, and the paleochannel along the Columbia River will be provided by the geophysical surveys performed under the tasks noted in Sections 5.3.2.1.1 and 5.3.2.1.2.

Considerable data on the geohydrology within the 300-FF-5 operable unit exist from past and ongoing studies (Lindberg and Bond 1979, Zimmerman and Kossik 1987, Schalla et al. 1988). Data from these reports are the basis for planning data collection activities that are executed by drilling wells in three phases. At the end of each phase, an evaluation of the data obtained will serve as the basis for the decision to begin or forego the next phase of data collection. The three phases progress from filling existing gaps in our current understanding of the geohydrologic system in Phase I to evaluation of complex groundwater flow relationships between groundwater systems and the Columbia River.

5.3.4.1.1 Well Drilling. During Phase I, 43 new monitoring wells (Figure 38) will be installed within the 300-FF-5 operable unit to augment the existing monitoring wells. The first 36 wells will be nested, with 3 wells in each of the 12 large-diameter boreholes. A single borehole will be used to reduce drilling, material, and completion costs and to minimize well installation time. Precautions will be taken to prevent the loss of the integrity of the M3 confining layer during and after well construction. At each location, wells will be completed with screened intervals at the top and bottom of the unconfined aquifer and the third well will be completed in the upper confined aquifer. Each well will be instrumented with continuous water-level data loggers to determine flow direction in both the confined and unconfined aquifers. These wells will be used to obtain baseline geologic, hydrologic, and chemistry data. These multilevel structures will be nested wells rather than well clusters (such as wells 399-1-17A, B, C) or multiport systems (such as the Westbay system in well 399-1-20) (Figure 39). In addition, one two-well nest, completed at the top and bottom of the unconfined aquifer, and five monitoring wells, screened in the bottom of the unconfined aquifer, will be constructed during Phase I to more completely define the geohydrology and associated flow paths of contaminants in the eastern half of 300-FF-5. The locations of the Phase I wells were shown in Figure 38 and the primary and secondary purposes of the proposed wells are presented in Attachment 1--Sampling and Analysis Plan.

The 12 well nests were distributed over the site to provide broad geologic, hydrologic, and water chemistry data. The locations are skewed to the western margins of the operable unit where few data are available. The wells for monitoring dense nonaqueous-phase liquids have been distributed near the 316-2 and 316-5 facilities where these materials have been detected in groundwater samples. These wells were paired with existing wells screened in the top of the unconfined aquifer. The uranium monitoring wells were located in an area between two possible uranium sources.



o 1-12 Well Location and Number (Wells Prefixed by 399- or 699- as Appropriate)

△ SWS-1 Surface-Water Monitoring Station

○ Nested Wells

□ Wells for Monitoring Dense Nonaqueous-Phase Liquids

◆ Wells for Differentiating the Extent of Uranium Plumes

Figure 38. Proposed Locations and Primary Purposes for Phase I Monitoring Well Nests in the 300-FF-5 Operable Unit.

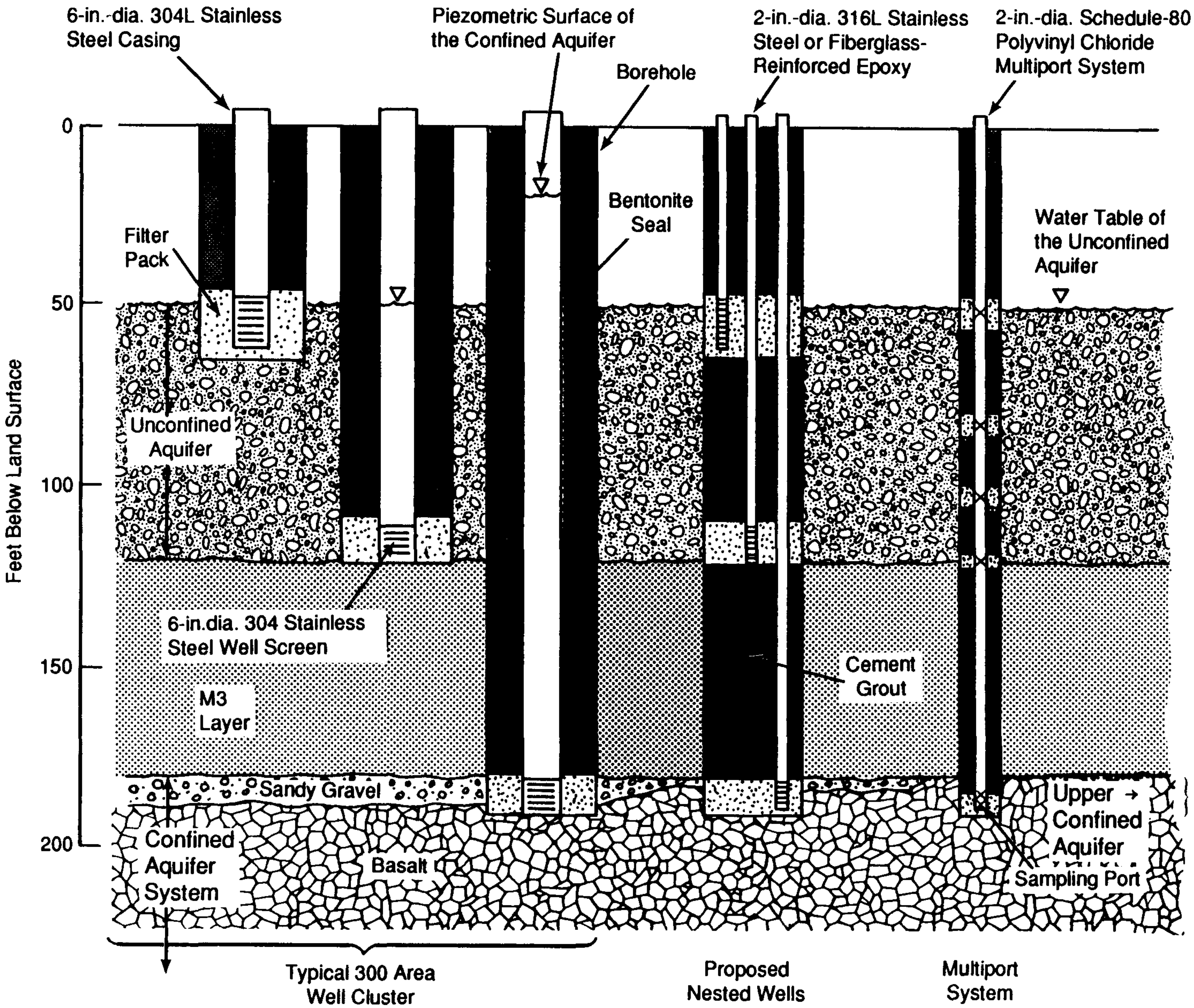


Figure 39. Comparison of Existing and Proposed Methods for Monitoring Multiple Stratigraphic Horizons in the 300-FF-5 Operable Unit.

Continuous core samples will be collected from each well throughout the M3 layer and underlying sediments. Sediment samples collected in the vadose zone will be archived for use in Task 3--Soil Investigation. Sediment samples from within the unconfined aquifer will be used in contaminant adsorption-desorption tests to provide data for transport calculations (risk assessment) and remedial action technique evaluation. Continuous cores and selected samples collected using core-barrel techniques will be analyzed in the laboratory for various physical and chemical properties described in Sections 5.3.2 and 5.3.3. Before completion, all wells will be geophysically logged with natural-gamma probes to assist with stratigraphic analysis. Although borehole geophysical logs have not been very useful to date in the 300 Area for correlation, source identification, or estimating sediment properties, they may be useful in areas to the west of the 300 Area, within the 300-FF-5 operable unit boundaries. Layers of similar lithologic characteristics are considered lithofacies. These lithofacies will be grouped into layers having similar hydrologic characteristics and thus can be correlated as equivalent hydrofacies. Hydrofacies are the same as hydrostratigraphic units because they are sedimentary layers correlated on the basis of similar hydrologic characteristics, particularly hydraulic conductivity. They differ because hydrofacies need not be of equivalent geologic age as are hydrostratigraphic units. The correlation of hydrofacies is essential for determination of contaminant pathways needed for the RI/FS process, whereas age dating for stratigraphic correlation is not.

Large-diameter test wells (for Phase I; discussed in Section 5.3.4.3) will be logged, using drill cuttings, and, where practical, intact samples will be collected to confirm correlation with adjacent Phase I monitoring wells. In addition to refining the extent of contamination plumes, Phase II wells will be installed to define anomalies in the horizontal continuity of major lithofacies, such as if the M3 confining layer (see Figure 9) were found to be discontinuous or terminated near 300-FF-5. Table 33 presents a summary of the proposed structures and activities related to stratigraphic and hydrologic characterization of the 300-FF-5 operable unit.

If Phase III wells are needed, they will be located on islands in the Columbia River or across the river in Franklin County; they will be continuously cored, if possible. Wells drilled through the river bottom, coupled with bathymetric surveys in the river, will allow determination of the continuity of the confined and unconfined aquifers and their confining layers across the river.

Table 33. Stratigraphic and Hydrologic Characterization Structures and Activities.

Phase I
12 boreholes with 3 monitoring wells nested inside each borehole: 1 open in top of unconfined aquifer 1 open in bottom of unconfined aquifer 1 open in top of upper confined aquifer 1 two-level nest of monitoring wells open in top and bottom of unconfined aquifer (uranium plume) 5 monitoring wells open in bottom of unconfined aquifer (dense nonaqueous-phase liquids) 6 large-diameter wells for pumping tests; monitor in nested monitoring wells 3 tracer tests with tracer injection into 316-5 process trenches 1 in April (before high Columbia River levels) 1 in late summer (during shortest, most direct paths to the Columbia River) 1 in fall (during typical southeasterly groundwater flow patterns) 1 wave propagation study to determine correlation between Columbia River stages and water levels in approximately 10 wells in 300 Area
Phase II
Additional wells, as needed, for better definition of plume(s) and to resolve anomalies from Phase I; same Phase I drilling techniques planned
Phase III
Wells, if needed, to determine continuity of hydrostratigraphic units across and under the Columbia River; drilling techniques for river bed and island drilling are currently unknown

Additional lithologic data collected from cores of the new monitoring wells will serve as a baseline for hydrofacies interpretation. This baseline hydrostratigraphic data from Phase I boreholes will serve as the foundation for interpretation of the geophysical data. Phases II and III borehole data from wells installed throughout the 300-FF-5 operable unit will be used to supplement the existing information obtained in Phase I. In particular, wells will be used for confirming hydrofacies and hydraulic characteristics near the river shoreline, using physical analyses of core or cutting samples from boreholes of wells installed in Phase III. Emphasis will be placed on the near-shore hydrostratigraphy in Phase III because it is the most likely location for installing a remediation system for intercepting contamination from either sources within 300-FF-5 or sources entering from upgradient areas outside of 300-FF-5.

5.3.4.1.2 Topographic Maps. Topographic maps of the 300-FF-5 operable unit are not required. The upper boundary of 300-FF-5 is the water table. Topographic maps must be prepared for the 300-FF-1, 300-FF-2, and 300-FF-3 operable units. Geophysical and soil gas survey grids and wells must be accurately located to within ±3.0 ft in the horizontal. Within the 300-FF-5 operable unit, the top of the casing of every new monitoring well must be surveyed in the vertical component to within ±0.05 ft, even though the goal of each individual survey loop will be closure to ±0.01 ft. This ±0.05 ft is the maximum error amount that should occur when the errors of all survey loops within 300-FF-5 are totaled. This level of vertical accuracy is necessary to accurately define groundwater flow directions and gradient within the 300-FF-5 operable unit. Specific survey methods to be used must meet or exceed the above accuracy requirements. All surveys should use the Lambert coordinate system for horizontal control and the National Geodetic Survey system for vertical control.

5.3.4.2 Task 4b--Contaminant Distributions in Soil and Groundwater. Considerable data on the distribution of contaminants in the soil and groundwater within the 300-FF-5 operable unit exist from past and ongoing studies (Lindberg and Bond 1979, Cline et al. 1985, Zimmerman and Kossik 1987, Dennison et al. 1988, Hall 1988, Schalla et al. 1988, Fruland et al. 1989). Groundwater quality data have been collected, evaluated, and reported for many years under the Hanford Site-wide groundwater monitoring project. The latest data are reported in Jaquish and Mitchell (1988) and Evans et al. (1989). A comprehensive investigation of the geohydrology and groundwater contamination in the vicinity of 316-5 was completed and reported also (Schalla et al. 1988). The inactive CERCLA waste sites at Hanford Site were evaluated, ranked as to contaminant hazard, and reported (Stenner et al. 1988). Waste disposal sites were selected and prioritized using the CERCLA Hazard Ranking System scores, as defined in Stenner et al. (1988). The highest priority sites are shown in Table 34. Recommendations made in that document considered these rankings, but were not exclusively guided by them. The study of contaminant distributions will be conducted in three phases.

Table 34. Hazard Ranking System Scores for Waste Disposal Sites Affecting the 300-FF-5 Operable Unit.

Disposal facility	Waste source	HRS[a] score
316-1	South process pond	79
316-2	North process pond	79
316-3	307 Leaching trenches	79
316-5	300 Area process trenches (active)	NR
618-9	300 West burial ground	NR
600 Area (TSD: T-3-1)	300 Area solvent evaporator	NR
300 Area	Unplanned releases and leaks	59

[a]CERCLA hazard ranking system score (Stenner et al. 1988).
NR = Not ranked.
TSD = Treatment, storage, and disposal unit designation.

During Phase I, soil gas surveys in specific areas will be used to determine if volatile aromatic or halogenated aliphatic hydrocarbons are present in the soil. Soil gas surveys will be conducted near the 618-9 burial ground and the 300 Area solvent evaporator [treatment, storage, and disposal unit (TSD) T-3-1] in the 300-FF-2 operable unit (Figure 40). The 618-9 burial ground contains 5,000 gal of kerosene contaminated with uranium from the 321 Building. The kerosene is contained in 55-gal drums in a trench that is 20 ft wide and 140 ft long. The subsurface behavior of kerosene hydrocarbons is often difficult to predict because of their tendency to float on water and to mound beneath underground leaks. Floating kerosene can often move in directions other than the regional gradient, thus complicating the siting of monitoring wells. Kerosene is made up of a group of relatively low-molecular-weight hydrocarbons (e.g., 2-methylhexane, hexane, octane, etc.) that can partition into and diffuse through soil vapor as a result of their low aqueous solubility (except for xylene and toluene) and high vapor pressure. Therefore, the initial delineation of kerosene will be performed using soil gas sampling and analysis. An initial soil gas sampling program, involving 12 to 18 sampling locations per site, is proposed for areas around the burial ground as shown in Figure 40. If volatile organics are encountered, a more detailed investigation will be conducted using a finer grid spacing in that specific area.

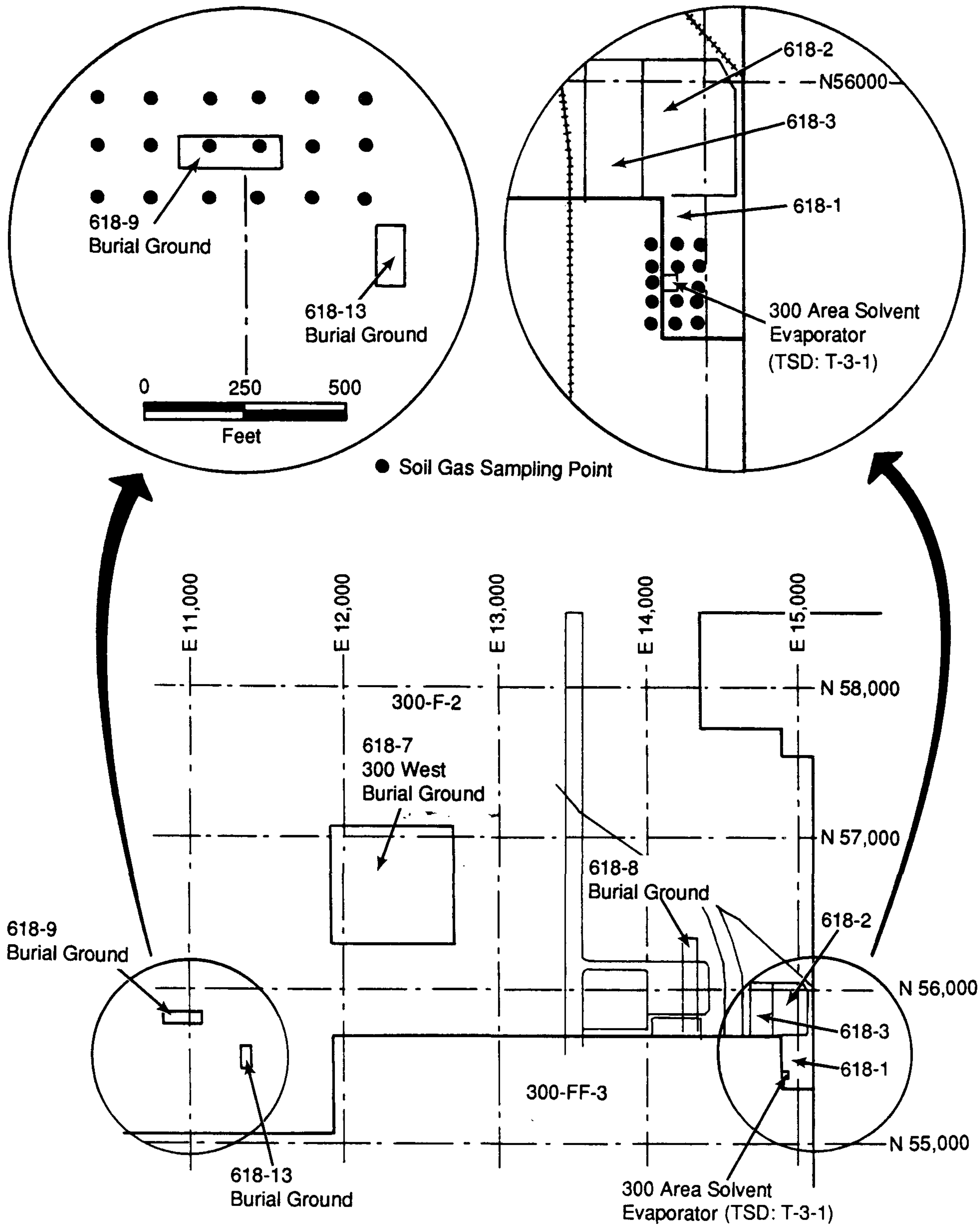


Figure 40. Proposed Locations of Soil Gas Sampling Points at the 618-9 Burial Ground and the 300 Area Solvent Evaporator for Phase I in the 300-FF-5 Operable Unit.

During Phase I, monitoring wells will be installed and instrumented throughout 300-FF-5 to determine groundwater flow directions and to determine if waste disposal sites that are considered actual or potential major sources of contamination are contributing to groundwater contamination. During Phase II, monitoring wells will be installed to fill data gaps near major waste disposal sites and contaminant plumes that were discovered in Phase I studies. During Phase III, wells will be constructed distant from the disposal sites within the operable unit (generally in the 600 Area) or across the Columbia River to provide geohydrologic, contaminant background, and contaminant migration data. Additional wells east of the 300-FF-5 eastern river shore boundary may include installing wells on the islands in or across the Columbia River. Some contaminant-sediment interaction testing (adsorption-desorption) will be performed on core material obtained during monitoring well installation in each phase. Phases I and II will concentrate solely on indicator species (i.e., nitrate, gross beta, tritium, uranium, trichloroethene, 1,2-dichloroethene, and chloroform). Phase III interaction work would include studies of any other potential contaminants identified (i.e., wells closest to contaminant sources will be resampled during Phase III and constituents measured).

Analysis and evaluation of waste disposal impact on the groundwater in the 300-FF-5 operable unit and estimation of contaminant movement into the accessible surface-water environment will be completed at the end of Phase III. However, throughout the duration of all phases of the investigation, evaluation of the contribution of contaminant source terms, characterization of the geohydrologic systems, and determination of concentration and distribution of contaminants in the groundwater will be made continually from available data.

During Phase I, 43 new monitoring wells (see Figure 38) will be installed within the 300-FF-5 operable unit to augment the existing monitoring wells. The first 36 monitoring wells will be installed, with 3 each in 12 large-diameter boreholes, to provide baseline chemistry data in the aquifers of the 300-FF-5 operable unit. In each nest of three wells, the three screened intervals will be the top of the unconfined, the bottom of the unconfined, and the upper confined aquifers. In addition to these 36 monitoring wells, 5 wells screened in the bottom of the unconfined aquifer will be installed near 316-2 and 316-5, primarily to determine the extent of contamination of trichloroethene and 1,2-dichloroethene. One dual-well nest will be completed in both the top and bottom of the unconfined aquifer, primarily to aid in differentiating between two uranium contaminant plumes with different isotopic ratios. In 1988, some data in the 300 Area indicated a distinct difference in the isotopic ratios of ^{238}U and ^{235}U in the groundwater. The 316-5 process trenches release an enriched uranium (^{235}U) source, and an as-yet-unidentified southern source releases uranium with naturally occurring isotopic ratios (Evans et al. 1989). Future determination of the contribution and the areal extent of the uranium plume is needed to differentiate the sources and to aid in identifying the southern source of uranium.

In addition to the primary purposes of the 43 Phase I wells described above and in other sections of the groundwater investigation, there are several important secondary reasons for their proposed location. One obvious factor controlling the placement of new monitoring wells is the location and depth of existing monitoring wells. Most of the new wells are located along the northern, western, and southern boundaries of the 300-FF-5 operable unit where little groundwater information exists. The new wells also will provide needed spatially distributed monitoring locations in the bottom of the unconfined aquifer and in the upper confined aquifer. These wells also will be used to identify contaminant plumes entering the 300-FF-5 operable unit from upgradient sources. The primary and secondary purposes of the proposed wells are presented in Attachment 1--Sampling and Analysis Plan.

Approximately 50 of the existing monitoring wells will be used in the 300-FF-5 sampling network for Phase I, although each of these wells will be evaluated with regard to adequacy of completion method, condition, and sampling zone prior to inclusion in the network. The first sampling round planned for Phase I is comprehensive, consisting of 93 sampling wells screened in 3 stratigraphic horizons. These wells will be sampled for a comprehensive list of analytical parameters (Table 35) consistent with the WAC 173-303-9903 list. Perchloroethene (the parent product to trichloroethene), trichloroethene, 1,2-dichloroethene (both cis and trans isomers), 1,1-dichloroethene, vinyl chloride, and related species will be analyzed by high-sensitivity methods (such as gas chromatography/electron capture and gas chromatography/flame ionization detection) to determine the distribution and sources of the observed trichloroethene and dichloroethene contamination. Also, all wells, regardless of depth or screened interval that show at least 5 μg/L uranium in the Phase I sampling, also will be analyzed to determine their concentrations and ratios for ^{234}U, ^{235}U, and ^{238}U, and where possible, analyzed for ^{236}U. Also, some wells (the first 12 Phase I monitoring wells) will be specified for multilevel completion to permit continuous measurement of groundwater potentials that will allow meaningful interpretation of contaminant concentration throughout vertical profiles within the unconfined and confined aquifers. Based on the results of this first sampling, a smaller subset of wells will be sampled and the samples analyzed for a shorter, specific list of constituents on a quarterly basis.

Table 35. Contract Laboratory Program Target Compound List. (Sheet 1 of 5)

Volatiles	CAS[a] number
Chloromethane	74-87-3
Bromomethane	74-83-9
Vinyl chloride	75-01-4
Chloroethane	75-00-3
Methylene chloride	75-09-2
Acetone	67-64-1
Carbon disulfide	75-15-0
1,1-Dichloroethene	75-35-4
1,1-Dichloroethane	75-34-3
1,2-Dichloroethene (total)	540-59-0
Chloroform	67-66-3
1,2-Dichloroethane	107-06-2

Table 35. Contract Laboratory Program Target Compound List. (Sheet 2 of 5)

Volatiles (contd)	CAS[a] number
2-Butanone	78-93-3
1,1,1-Trichloroethane	71-55-6
Carbon tetrachloride	56-23-5
Vinyl acetate	108-05-4
Bromodichloromethane	75-27-4
1,2-Dichloropropane	78-87-5
1,3-Dichloro-1-propene (Z)	10061-01-5
Trichloroethene	79-01-6
Dibromochloromethane	124-48-1
1,1,2-Trichloroethane	79-00-5
Benzene	71-43-2
trans-1,3-Dichloropropene	542-75-6
Bromoform	75-25-2
4-Methyl-2-pentanone	108-10-1
2-Hexanone	591-78-6
Tetrachloroethene	127-18-4
Toluene	108-88-3
1,1,2,2-Tetrachloroethane	79-34-5
Chlorobenzene	108-90-7
Ethyl benzene	100-41-4
Styrene	100-42-5
Xylenes (total)	1330-20-7
Semivolatiles	**CAS[a] number**
Phenol	108-95-2
bis(2-Chlorethyl) ether	111-44-4
2-Chlorophenol	95-57-8
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
Benzyl alcohol	100-51-6
1,2-Dichlorobenzene	95-50-1
2-Methylphenol	95-48-7
bis(2-Chloroisopropyl) ether	39635-32-9
4-Methylphenol	106-44-5
N-Nitroso-di-n-dipropylamine	621-64-7
Hexachloroethane	67-72-1
Nitrobenzene	98-95-3
Isophorone	78-59-1
2-Nitrophenol	88-75-5
2,4-Dimethylphenol	105-67-9
Benzoic acid	65-85-0
bis(2-Chloroethoxy) methane	111-91-1
2,4-Dichlorophenol	120-83-2
1,2,4-Trichlorobenzene	120-82-1
Naphthalene	91-20-3
4-Chloroaniline	106-47-8

Table 35. Contract Laboratory Program Target Compound List. (Sheet 3 of 5)

Semivolatiles (contd)	CAS[a] number
Hexachlorobutadiene	87-68-3
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7
2-Methylnaphthalene	91-57-6
Hexachlorocyclopentadiene	77-47-4
2,4,6-Trichlorophenol	88-06-2
2,4,5-Trichlorophenol	95-95-4
2-Chloronaphthalene	91-58-7
2-Nitroaniline	88-74-4
Dimethylphthalate	131-11-3
Acenaphthylene	208-96-8
2,6-Dinitrotoluene	606-20-2
3-Nitroaniline	99-09-2
Acenaphthene	83-32-9
2,4-Dinitrophenol	51-28-5
4-Nitrophenol	100-02-7
Dibenzofuran	132-64-9
2,4-Dinitrotoluene	121-14-2
Diethylphthalate	84-66-2
4-Chlorophenyl-phenyl-ether	7005-72-3
Fluorene	86-73-7
4-Nitroaniline	100-01-6
4,6-Dinitro-2-methylphenol	534-42-1
N-nitrosodiphenylamine	86-30-6
4-Bromophenyl-phenylether	101-55-3
Hexachlorobenzene	118-74-1
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Anthracene	120-12-7
Di-n-butylphthalate	84-74-2
Fluoranthene	206-44-0
Pyrene	129-00-0
Butylbenzylphthalate	85-68-7
3,3′-Dichlorobenzidine	91-94-1
Benzo(a)anthracene	56-55-3
Chrysene	218-01-9
bis(2-Ethylhexyl)phthalate	117-81-7
Di-n-octylphthalate	117-84-0
Benzo(b)fluoranthene	205-99-2

Table 35. Contract Laboratory Program Target Compound List. (Sheet 4 of 5)

Pesticides/polychlorinated biphenyls	CAS[a] number
Benzo(k)fluoranthene	207-08-9
Benzo(a)pyrene	50-32-8
Indeno (1,2,3-cd)pyrene	193-39-5
Dibenz(a,h)anthracene	53-70-3
Benzo(g,h,i)perylene	191-24-2
Alpha-BHC	319-84-6
Beta-BHC	319-85-7
Delta-BHC	319-86-8
Gamma-BHC (Lindane)	58-89-9
Heptachlor	76-44-8
Aldrin	309-00-2
Heptachlor epoxide	1024-57-3
Endosulfan I	959-98-8
Dieldrin	60-57-1
4,4'-DDE	72-55-9
Endrin	72-20-8
Endosulfan II	33213-65-9
4,4'-DDD	72-54-8
Endosulfan sulfate	1031-07-8
4,4'-DDT	50-29-3
Methoxychlor	72-43-5
Endrin ketone	53494-70-5
Alpha-Chlordane	5103-71-9
Gamma-Chlordane	5103-74-2
Toxaphene	8001-35-2
Aroclor-1016	12674-11-2
Aroclor-1221	11104-28-2
Aroclor-1232	11141-16-5
Aroclor-1242	53469-21-9
Aroclor-1248	12672-29-6
Aroclor-1254	11097-69-1
Aroclor-1260	11096-82-5

Table 35. Contract Laboratory Program Target Compound List. (Sheet 5 of 5)

Analyte[b]	Radionuclides[c]	Inorganic anions[c]
Aluminum	Gamma scan	Bicarbonate
Antimony	Gross alpha	Carbonate
Arsenic	Gross beta	Chloride
Barium	Iodine-129	Fluoride
Beryllium	Plutonium	Phosphate
Cadmium	Strontium-90	Nitrate (as NO_3)
Calcium	Technetium-99	Sulfate
Chromium	Tritium	
Cobalt	Uranium isotopes	
Copper		
Cyanide	**Other[c]**	
Iron		
Lead	Alkalinity/acidity	
Magnesium	Ammonia-N	
Manganese	Biological oxygen demand	
Mercury	Chemical oxygen demand	
Nickel	Dissolved oxygen	
Potassium	Hardness	
Selenium	Total organic carbon	
Silver	Total organic halogen	
Sodium	Total dissolved solids	
Thallium	Total suspended solids	
Vanadium		
Zinc		

[a]From American Chemical Society system for compounds.

[b]Analyses will be for dissolved metals only.

[c]These parameters are not on the Contract Laboratory Program target compound list, but are included for completeness.

In Phase I, core material from well installations will be used in contaminant-sediment interaction testing (see detailed discussion in Section 5.3.3). In general, core material from the saturated zone of the unconfined aquifer will be used in laboratory tests to determine the adsorption-desorption properties of the key contaminants (e.g., trichloroethene, 1,2-dichloroethene, and uranium).

A special tracer test is needed to determine an apparent leak in the process waste-water line somewhere near the 307 and 325 Buildings. Concentration contours of nitrate and chloroform sampled in August 1988 (see Figures 28 and 30, respectively) indicate that substantial quantities of process water are entering the groundwater in the vicinity of these buildings. It is suspected that the process water is essentially uncontaminated, but acts as the transport fluid for uranium as it passes through an unknown buried source of unenriched uranium. This accounts for the continued presence of natural uranium entering the groundwater and forming a plume superimposed on the enriched plume of uranium migrating from 316-5 (the process trenches). This may be the same leak as reported by Lindberg and Bond (1979). It may be possible to use helium as a tracer and perform a soil gas survey to find the leak; if not, then multiple mobile tracers could be used to differentiate between incoming lateral lines to determine where the main line or lateral is leaking. If the leak is in one lateral, then only one isomer will be seen; however, if the leak is in the main line, then only tracers from upgradient incoming lateral lines will be detected in nearby monitoring wells. If monitoring wells are used, it should be possible to detect the leakage with six existing shallow monitoring wells. This work will be conducted as part of the 300-FF-3 RI/FS.

Near-source wells will be installed adjacent to lower priority waste disposal sites during Phase II. Also in Phase II, additional wells will be located near high-priority waste disposal sites if contaminants are detected.

During Phase III, additional wells may be constructed distant from the disposal sites within the 300-FF-5 operable unit (generally in the 600 Area) to provide geohydrologic and contaminant plume data. Additional work may include installing wells on the river islands and across the Columbia River to determine the migration of contaminants in the confined aquifer. The wells would be completed at multiple depths, as far down as the confined aquifer in the top of the Saddle Mountains Basalt. Groundwater in the unconfined aquifer on the Hanford side of the river cannot enter the unconfined aquifer on the Franklin County side of the river because the river is "base level" for the unconfined groundwater systems on both sides of the river; thus, groundwater flow from both systems is to the river (DSHS 1988). It is likely that the water chemistry of the unconfined wells drilled in the river islands will be the same as the river and, therefore, very different from the water in the unconfined aquifer in the 300 Area.

5.3.4.3 Task 4c--Hydraulic Properties. During Phase I, all new wells will be completed as multipurpose structures to provide contaminant source, geohydrologic, and groundwater contamination data. Hydraulic properties of the aquifer will be determined, as necessary, during all three phases of the RI/FS. Properties to be determined include hydraulic head, transmissivity, storativity, effective porosity, and flow velocity. Determination of these properties is essential for defining the geohydrologic system and the rate and direction of contaminant migration. The variation in hydraulic head will be determined using both manual and automated water-level measurement devices. The proposed methods for determining the other hydraulic properties include the following: single well pumping tests and slug tests in small-diameter wells, multiple well aquifer tests, wave propagation (cyclic fluctuations in groundwater levels in relation to changes in river stage with time), and multiple tracer tests.

During all three phases, water levels will be measured in wells to determine hydraulic head in three dimensions across 300-FF-5. Water levels at 30 selected well locations and two river-gauging stations will be monitored continually (hourly) for 1 yr following completion of all of the Phase I monitoring wells to determine the interrelationship between the groundwater and surface water (Columbia River).

Water levels in wells near the river are highly correlated with river stage. An understanding of the rate and magnitude of water-level changes is used to predict contaminant migration pathways. Hourly measurements are excessive for predicting contaminant pathways (measurements every 2 h would be adequate for interpretation); however, they are essential for calculating hydraulic properties using wave propagation. Water levels will be measured in 10 of the 30 wells used during the first year and at 2 surface-water stations approximately every 2 to 4 h for the next 3 yr to allow for prediction of contaminant pathways and interpretation of observed concentration distributions. There are three very important time scales of variability in the Columbia River: (1) daily variations associated with power production at Priest Rapids dam; (2) weekly changes associated with power production that reflect the business cycle needs; and (3) seasonal variations associated with highly regulated discharges of the upper Columbia River system to meet irrigation, flood control, and fishery conservation goals. There is a fourth, and less important, time scale that involves the natural hydrologic cycle. The natural hydrologic variability of the river system now occurs over a period of several years, and represents only a very small percentage of the variability in river stages. Although daily cycles can have some impact on pathways and travel times near the river, the effect is attenuated substantially approximately 0.5 mi inland (Figure 41). Therefore, emphasis on delineating groundwater flow patterns in relation to river stage will focus primarily on weekly and seasonal variations.

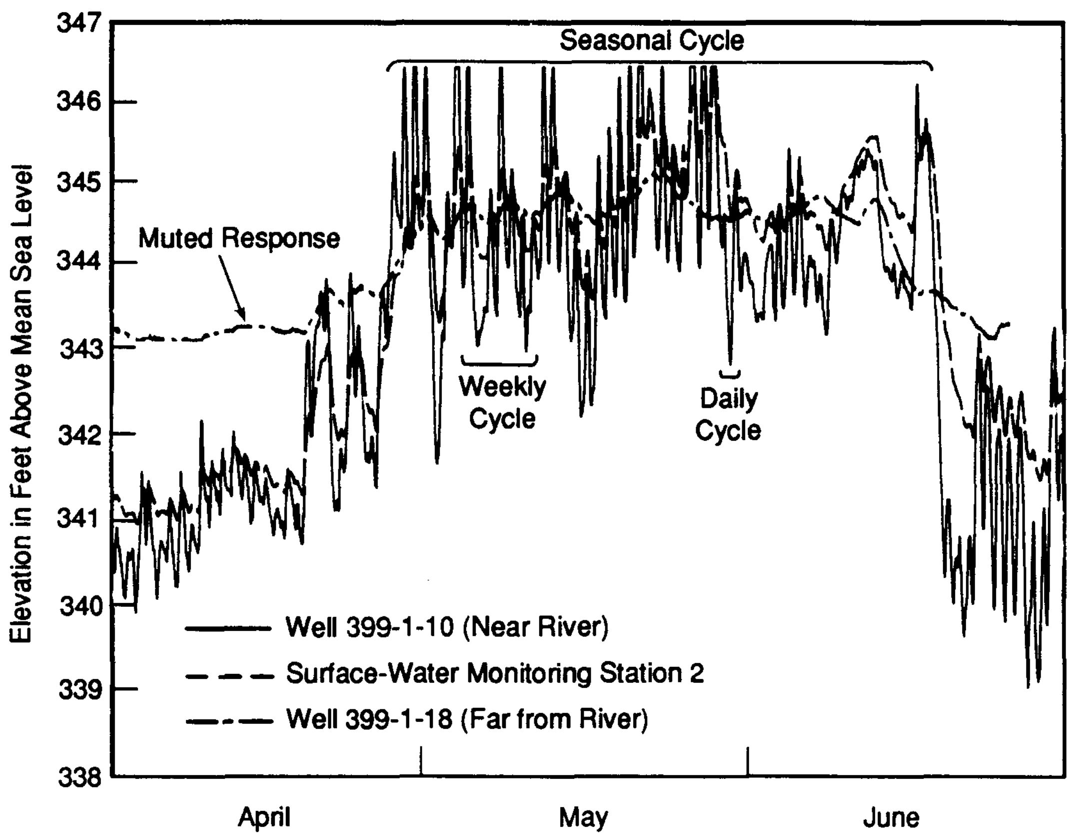


Figure 41. Hydrograph of Columbia River for the 300-FF-5 Operable Unit.

Major renovation of SWS-2 will be needed to convert it to a permanent station, and SWS-1 will need minor modification. Each well will be equipped with a multiple-channel data logger and one to three transducers (three for nested wells). Each data logger will be equipped with electrical solar panels for recharging batteries and a radio telemetry system for transmitting the data to the project office. These data will be evaluated to obtain data sets of sufficiently large time steps useful for interpreting and predicting future contaminant migration or the effectiveness of cleanup methods. The vertical accuracy of each unit will be to within 0.06 ft of the actual water-level elevation; this includes the 0.04 ft caused by inaccuracies in the vertical surveys. Therefore, precision will be 0.02 ft.

The 30 selected well locations will include the 4 existing well clusters; the 12 new monitoring nests; 2 dual-well cluster locations (399-1-10 and 399-1-14) near the 316-5 process trenches; and 12 well locations distributed throughout the central and eastern portions of the 300-FF-5 operable unit, with 6 of these wells distributed near the river (wells 399-1-1, 399-2-1, 399-3-1, 399-3-9, 399-4-7, and 399-4-9) and the other six wells (399-S27-E14, 399-3-12, 399-4-1, 399-4-11, 399-5-1, and 399-6-1) distributed farther from the river. The vertical distribution of the 68 monitoring points includes 16 in the confined aquifer, 18 in the bottom of the unconfined aquifer, and 34 in the top of the unconfined aquifer, and 34 in the top of the unconfined aquifer.

If contamination above drinking water limits is not detected in wells screened in the bottom of the unconfined aquifer or the upper confined aquifer, then single well aquifer tests will be performed to determine transmissivity in those zones during Phase I. If contamination is present in these wells, slug or injection tests will be conducted, if possible, to determine aquifer transmissivity. Pumping tests will not be conducted in areas contaminated above drinking water standards because of the high cost of disposing of large quantities of contaminated discharge water generated during the test.

The influence of the daily cycle of surface-water fluctuations on the rate of change in water levels (wave propagation) in groundwater monitoring wells will be evaluated, using the cyclic evaluation technique (Ferris 1952) to provide additional information on aquifer transmissivity and storativity. This work will be coordinated with similar measurements made under Task 5--Surface-Water and Sediment Investigation. Aquifer properties, transmissivity, and storativity can be determined from the response function between wells and the river. This can be done for large areas near the Columbia River, yielding large-scale estimates of aquifer properties under natural conditions.

Three tracer tests will be conducted in Phase I to determine transmissivity, groundwater flow velocity, and possibly longitudinal dispersion in the eastern half of the 300-FF-5 operable unit. In the eastern half of 300-FF-5, aquifer testing may not be feasible because of elevated contamination in the groundwater and the strong influence of the Columbia River on water levels. Tracer tests will be performed in the top of the unconfined aquifer. Tracer tests will be conducted by releasing potassium bromide or a similar tracer compound into the process trenches, then monitoring the migration of bromide through the top and bottom of the unconfined aquifer. Flow velocities will be determined using arrival times of peak concentration correlated with continuous water-level data from 20 data loggers, plus manual water-level measurements taken during sampling of wells for bromide. Bromide was selected because it does not adsorb onto soils, is not radioactive, and will enable determination of longitudinal dispersion (Levy and Chambers 1987). One tracer test will be initiated just before the beginning of the high-river stage in April. This test will provide information on flow velocity and pathways when the river produces predominantly southern flow within the unconfined aquifer. The second tracer test will be conducted during the summer months when river levels are low and flow paths are predominantly eastward, directly into the river. The third tracer test will be conducted during the fall to demonstrate flow velocities and pathways that are more typical of the predominantly southeasterly flow pattern.

During Phase I, six large-diameter test wells will be installed for use as pumping wells for aquifer tests. These wells will be approximately 16 to 20 in. in diameter to allow pumping of 500 to 2,000 gal/min. Large-diameter test wells will be designated for more extensive aquifer testing and will utilize the multiple-horizon monitoring wells as adjacent wells for observing groundwater levels during aquifer tests. These tests will be conducted on selected wells in the western half of the 300-FF-5 operable unit where the Columbia River fluctuations will have a minimal effect during an 8- to 24-h-long aquifer test (see Attachment 1--Sampling and Analysis Plan). These tests will be conducted to determine large-scale values for transmissivity and storage and, depending on test design, to evaluate the integrity of the M3 confining layer (see Figure 9).

Additional monitoring wells for confirming hydrostratigraphy and hydraulic characteristics near the river shoreline using wave propagation will be installed in Phase III if needed. These wells will be used to provide additional information regarding preferential pathways to the river via the unconfined aquifer and the amount of intercommunication between the aquifer and the river.

5.3.4.4 Task 4d--Aquifer Intercommunication. All 12 Phase I monitoring well nests (36 wells) will be completed at three levels to permit measurement of groundwater potentials and contaminant concentrations throughout vertical profiles within the unconfined aquifer and between the unconfined and upper confined aquifers. During Phase II, some of these wells will serve as observation wells for large-diameter test wells to further evaluate the hydraulic relationship between the unconfined and confined aquifers by noting the response (change in water levels) to pumping the unconfined aquifer. If Phase III wells are drilled on islands in the river and across the river in Franklin County, they will be continuously cored, if possible. These river-island wells, coupled with bathymetric surveys in the river, will allow determination of the continuity of the confined and unconfined aquifers and their confining layers beneath the river. This information, coupled with hydraulic heads and changes in water level in relation to river stage, should permit determination of the intercommunication of the unconfined and confined aquifers with the Columbia River.

Hydraulic isolation between the confined and unconfined aquifers must be restored in the vicinity of well 399-1-16C early in Phase I to stop groundwater flow and contaminant migration from the unconfined aquifer to the confined aquifer. It is recommended that cement grout be pumped through the screen to seal the entire confined aquifer in the vicinity of the well. Successful hydraulic isolation will be reflected by the restoration of higher water levels in nearby monitoring wells. If this is unsuccessful, a borehole should be drilled, cased, and set with a packer so that the confined aquifer is sealed off with cement grout.

The borehole should be drilled adjacent to wells 399-1-16C and 399-1-16D to a depth of 180 ft. A cement seal should be set opposite the M3 layer (see Figure 9) with a steel casing liner prior to penetrating the last 20 ft of the borehole. After the cement seal has set, the well should be deepened to 180 ft. A tremie pipe with an inflatable packer should be lowered to near the bottom of the casing opposite the M3 layer and the packer inflated. Grout should be pumped under pressure through the tremie pipe to seal off approximately 1 acre of the upper confined aquifer. This method does not require sealing the vertical pathway through the M3 layer along the broken casing near well 399-1-16D because the grouting reduces the upper confined aquifer hydraulic conductivity to that of the M3 layer.

5.3.4.5 Task 4e--Groundwater Modeling. Water levels, contaminant distributions, aquifer properties, and geology will be used to develop conceptual models for groundwater flow and contaminant transport within the 300-FF-5 operable unit. Based on these conceptual models, numerical models will be developed to quantify groundwater flow and contaminant transport. As new data become available, the conceptual model and numerical models will be updated. The numerical model will be used to guide data collection during the calibration process. Spatial and temporal uncertainties in the ability to predict flow and contaminant transport will be assessed. Decisions will be made regarding the need and benefits of where additional data should be collected to improve the predictive accuracy of the models.

Numerical models may be adaptations or extensions of existing models [the Variable Thickness Transient Groundwater Flow Model of Reisenauer (1979) and the Coupled Fluid, Energy, and Solute Transport Code of Gupta et al. (1982)] or they may be developed independently, specifically for the 300-FF-5 RI/FS. Implementation of the models will permit simulation and prediction of groundwater and contaminant movement through the groundwater to the Columbia River. As backup and support to the modeling efforts, analog methods (such as flow net composition) will be applied to provide similar data on groundwater and contaminant movement through the geohydrologic systems. The models will enable evaluation of the impact and effectiveness of various cleanup and closure scenarios on groundwater quality.

5.3.5 Task 5--Surface-Water and Sediment Investigation

The goal of the surface-water and sediment investigation task is to accurately assess the impact of past facility operations and waste disposal activities in the 300-FF-5 operable unit on the quality of Columbia River water and sediment. The objectives of the investigation are to identify and characterize, to the extent possible, the distribution and concentration of contaminants present in Columbia River water and sediment as a result of past effluent discharges directly into the river from the 300 Area and to evaluate surface-water and groundwater interactions. Seepage of contaminated groundwater into the river occurring along the 300-FF-5 operable unit also will be assessed. Information obtained through this investigation will be used in the risk assessment and remedial alternatives evaluation and selection processes.

This task is closely related to Task 4--Groundwater Investigation and Task 7--Biota Investigations. In some cases, activities within Task 5 will be determined based on findings and/or projections from the other related investigations, primarily the groundwater investigation. In addition, RI/FS activities for other operable units within 300-FF-5 may influence this investigation. Operations among the investigations will be coordinated to the extent possible to prevent duplication of effort and to ensure all needs are met and use of data is optimized.

This task consists of the following major activities: (1) obtain and compile existing data relative to Columbia River water, sediment, and the 300-FF-5 operable unit; (2) collect and analyze water and sediment samples from the active springs or seepage areas; (3) collect and analyze water and sediment samples from the river at near-shore locations adjacent to active seeps and along the contaminated groundwater plume as identified or projected in the groundwater investigation; (4) collect and analyze water samples from river cross sections at transect locations established along the 300-FF-5 operable unit; (5) monitor the river stage adjacent to 300-FF-5; (6) establish boundary conditions for groundwater flow and contaminant transport models along the Columbia River; and (7) develop numerical algorithms for calculating dispersion of contaminants at the groundwater/surface-water boundary. Data evaluation and interpretation are included in these activities.

The phased approach used in this task is designed to provide the data required at evolving stages of the conceptual model. To this end, a comprehensive sampling plan that considers the various media studies is proposed. Existing information from past field studies will be used to identify zones of high uncertainty on and adjacent to the 300 Area that require further sampling. The first set of additional sampling locations will provide a minimum degree of resolution for the large-scale variability of the site. Subsequent sampling excursions will be directed at zones critical to the physical understanding that require finer resolution.

For descriptive purposes, the data collection activities are divided into a hierarchy of three phases. Phase I consists of compiling existing information and field sampling directed at basic characterization of surface water processes and contaminant inventories. Phase II will be performed if Phase I results warrant further investigation. Phase II sampling will be directed at more detailed evaluation of physical processes that affect groundwater/surface-water interactions. Phase III will be performed to support a robust surface-water modeling study. The use of three phases is arbitrary and is not intended to be applied uniformly across the 300 Area.

5.3.5.1 Task 5a--Relative Data Compilation. Data applicable to the 300-FF-5 operable unit relative to the Columbia River will be obtained, inventoried, evaluated, and assembled in the Task 5 files. Specific data useful or necessary to develop an understanding of physical and chemical processes operative on the 300-FF-5 operable unit may be entered into a computer database to facilitate data comparisons, manipulation, and presentation. Hydrologic data from the U.S. Geological Survey's gauging stations located at Priest Rapids Dam and McNary Dam on the Columbia River will be included, as well as data from Kiona on the Yakima River. Information relative to the river stage and discharge in the vicinity of the 300-FF-5 operable unit also will be obtained from existing gauging stations. Data relative to Columbia River water and sediment quality along the 300-FF-5 operable unit also will be included, as will applicable riverbank spring data. The information gathered will be useful in characterizing the Columbia River environment near the 300-FF-5 operable unit, in determining optimum sampling times and locations, and in interpreting data obtained through this investigation.

5.3.5.2 Task 5b--Riverbank Springs. Several riverbank springs or groundwater seepage areas have been observed along the shoreline of the 300-FF-5 operable unit. Although the locations of these seeps have been documented by PNL with respect to local landmarks and river mile markers, no previous attempts to survey them have been noted. The 300-FF-5 operable unit shoreline will be visually inspected for the presence of riverbank springs and near-shore submerged springs, with special attention paid to those areas previously identified with active seepage areas. This survey will be conducted in late summer or early fall when the river stage is generally lowest. Active springs will be identified on appropriate maps, and the sites will be accurately surveyed, with vertical and horizontal benchmarks. The locations of bank springs will be used to formalize sampling locations and to identify discharge zones and material types associated with spring formation. Surveys will be necessary on both sides of the Columbia River to identify potential sources of pollutants entering the river along the operable unit that may influence the final data interpretation.

Samples of the seep water from both sides of the river will be collected from active flows above the river level located during this portion of the investigation. Field measurements will be made to determine the seep-water temperature, pH, conductivity, and nitrate, phosphate, and potassium concentrations. Laboratory analyses of the initial seep-water samples will be consistent with those planned for the initial groundwater samples (see Section 5.3.4). Comparison of hydrochemistry from seeps on either side of the river may provide some evidence to determine if groundwaters on either side of the river are of similar or diverse origins. Background contaminant concentrations for groundwater also will serve as background for the riverbank spring samples. Sample results will be compared with background concentrations and applicable ARARs.

Although the seeps located above the river water level represent only a portion of the total flow of groundwater into the river, estimates or measurements of the spring flow, where possible, will be made to compare with the projections obtained through the modeling activities. Standard velocity/area measurement techniques to estimate the seep discharges will be used if possible. In cases where the springs are too small or where seepage occurs over a general area, best technical judgment and field estimates will be necessary.

Subsequent or followup sampling of the springs will be conducted, as warranted, concurrent with the Phase II near-shore river sampling activities. Analysis of subsequent samples will depend on the contaminants and levels of contaminants identified in the initial analysis of the groundwater samples collected near the river and initial riverbank spring sample results. Data obtained during Phase II sampling will be used in conjunction with groundwater modeling activities, as well as to further characterize the localized impact of the groundwater discharge.

Sampling will be conducted during periods of low river flow to maximize the potential for the seeps to be actively flowing and to maximize the impact of the contaminated groundwater entering the river along the 300-FF-5 operable unit. Past discharge data for the Columbia River at Priest Rapids Dam indicate the lowest flows typically occur during September and October. River-stage recorders will be established and operated throughout the study at two locations that are part of the ongoing RCRA assessment of 316-5. These recorders will be used to determine optimum sampling times in conjunction with related groundwater investigation activities.

The riverbank springs provide a unique environment for sediment uptake of contaminants. Samples of the spring sediment, or more appropriately the material through which the seepage is flowing, will be collected in addition to the water samples. Chemical analyses of these samples will indicate the contaminants present in the shoreline material and their concentrations, and may identify some contaminants that are indicative of the 300-FF-5 operable unit. These results also will screen out unnecessary analyses or undetectable constituents. The results will be evaluated and used to determine appropriate analyses to be included in future river sediment samples. These samples also can be used in sorption/desorption studies to determine contaminant mobility.

The success of past spring and river sampling activities has been greatly enhanced through the cooperation of the Bonneville Power Administration and the U.S. Army Corps of Engineers in controlling the flow rate of the river before and during sampling activities. Such cooperation will be sought during this investigation.

5.3.5.3 Task 5c--Near-Shore River Water and Sediment. Routine monitoring of the Columbia River has shown that radionuclide concentrations in river water are extremely low, essentially undetectable without using special sampling techniques and analytical procedures. As previously discussed, because of the extremely small volume of contaminated (the quantity of groundwater discharging into the Columbia River along the operable unit has not been quantified) groundwater entering the river along the 300-FF-5 operable unit relative to the flow of the Columbia River (100,000 ft^3/s), it is expected that the concentration of most contaminants will be diluted rapidly to levels below detection limits. However, past special studies have indicated that localized areas of elevated contaminant concentrations exist near contaminated groundwater discharge areas (McCormack and Carlile 1984). Past studies also have indicated that shoreline discharges tend to remain close to the shoreline for relatively long distances, with contaminant concentrations decreasing with distance away from the shore and with distance downstream from the discharge (Haney 1957).

Thus, near-shore sampling of river water and sediment should provide the most sensitive indication of the extent and relative concentrations of groundwater contaminants entering the river along the shoreline. In addition, initial sampling in areas believed to be most likely to contain elevated contaminant levels will allow for an evaluation of the adequacy of existing techniques and the identification of detectable constituents under these conditions. This will provide data useful in development of subsequent RI/FS sampling activities and eliminates unnecessary analytical expenses. Results of initial near-shore sampling may indicate the extent of the areas of impact from the active seepage and may provide guidance on the level of effort necessary or appropriate in subsequent sampling activities.

Based on the previous discussion, near-shore river water sampling will be conducted in two phases. Phase I will concentrate on near-shore sampling locations along the active seep sites (discussed above). Phase II will include sampling of the near-shore areas along active seep sites and will cover the broader general area identified as the discharge area of the contaminated groundwater plume(s). This area will be defined with existing groundwater data (see Figure 24) and groundwater contaminant data and modeling projections. Part of Phase I activities will include sampling and analysis of process water pumped from the Columbia River at the 300 Area.

Phase I near-shore river water samples will be collected at locations near the actively flowing riverbank springs or seep areas. Four water samples will be associated with each spring, not including the spring water sample. Figure 42 illustrates locations with respect to the discharge point of the spring. Location 1 provides a site-specific "background" immediately upstream, yet out of the influence, of the seep itself. Location 2 represents a point of maximum influence from the seepage of contaminated water into the river. Locations 3 and 4 are positioned to provide information on the extent of the area influenced by the seep entering the river. If the seepage is over a general area of the shoreline rather than a specific spring, then location 1 will be upstream of the farthest upstream edge of the discharge area. Similarly, location 2, in this case, would be at the downstream edge of the discharge area. Samples will be collected as near to the bottom as possible without disturbing the bottom sediments.

Phase I near-shore sampling activities will be conducted concurrent with initial sampling of riverbank springs. Field measurements will be consistent with those conducted on the spring samples, including temperature, pH, conductivity, nitrate, phosphate, and potassium. Laboratory analyses of the Phase I near-shore water samples will be consistent with those for the riverbank spring water samples. Sediment samples will not be collected during Phase I near-shore sampling activities, pending results of the riverbank spring sediment sample analysis so that constituents of significance can be determined. However, observations of potential sediment sample locations will be documented for use during Phase II.

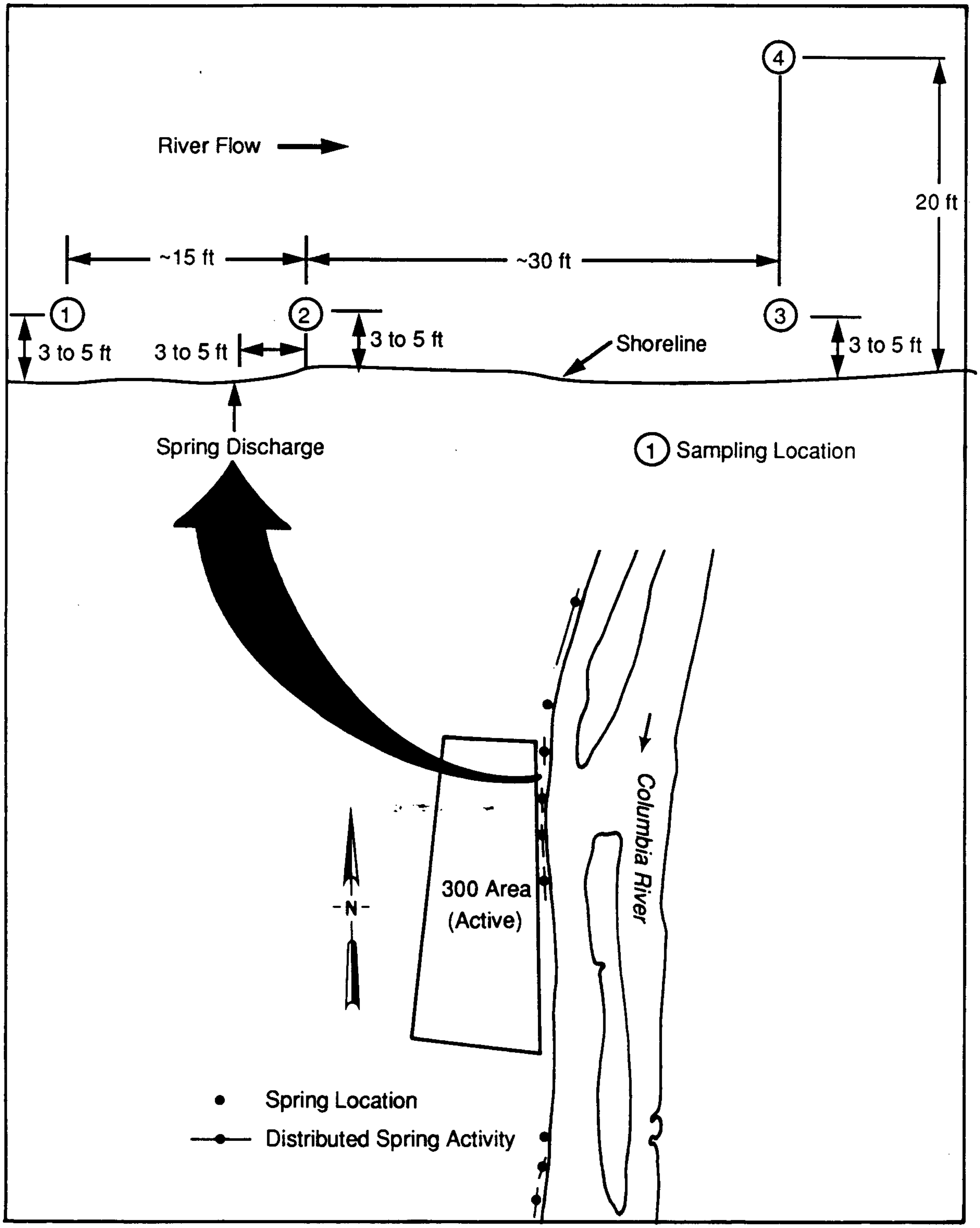


Figure 42. River Sampling Layout Associated with Riverbank Spring Locations.

The Phase II near-shore water and sediment sampling will proceed following receipt of analytical results from the Phase I near-shore river water samples, the riverbank water and sediment samples, and the groundwater samples. Modeling projections of the volume of groundwater and concentrations of contaminants entering the river also will be used in designing Phase II sampling. If the results of the riverbank spring and Phase I river sampling do not define the extent of the area of influence from the spring discharge, Phase II sampling will expand on Phase I sampling to further define the affected area. Information obtained during the initial riverbank spring sampling and Phase I of the near-shore river sampling will be used to determine specific sample locations and constituents to be analyzed during Phase II.

In addition to sampling activities directly related to active seeps, Phase II near-shore sampling will be conducted along the shoreline in those areas shown to be within the contaminated groundwater plume. Results from groundwater monitoring will be used to identify these areas. Specific locations along the shoreline will depend on the extent of the affected shoreline. Each near-shore site will consist of a partial transect extending into the river perpendicular to the river flow. Samples will be collected at the shoreline and at 20-yd intervals out to 100 yd. Because these samples are intended to show maximum effects, water samples will be collected as near to the river bottom as possible without disturbing bottom sediments. As discussed earlier, analysis of Phase II water samples will be determined by the results of riverbank spring, initial near-shore river water, and groundwater samples. In the event that no information exists from earlier sampling activities that relates directly to the sampling location in question, then the samples will be analyzed for those constituents listed in Table 35.

Background concentrations will be determined at near-shore sites directly upstream of the 300-FF-5 operable unit. Background samples will be collected at the beginning of the Phase II sampling activities and periodically throughout the sampling efforts to indicate contaminant concentrations present during the entire sample collection time. In addition to comparisons with background concentrations, results will be evaluated with respect to previous study findings, modeling projections, and applicable standards.

Sediment samples also will be collected in Phase II if adequate amounts of sediment are available. The number of sediment samples collected at the specific spring sites and the analyses to be performed will be determined by the results from the spring mud samples and the saturated zone sediment samples collected in conjunction with the borehole sampling. Sediment samples also will be obtained, as available, from sample locations along the groundwater plume concurrent with the Phase II water samples. Background sediment samples will be collected at locations similar to the background water samples discussed above. To the extent possible, sediment sampling will be limited to those near-shore areas having sufficient quantities of sediment to allow the use of standard clamshell-type samplers. Due to the relatively swift river flow and the rocky nature of the river bottom, special collection methods may be needed in some areas to augment traditional methods. Experience and visual observations along this stretch of the river indicate that traditional sampling methods can be used. The total number of sediment samples to be collected during Phase II activities is not expected to exceed 30.

In conjunction with the near-shore river sampling activities, preliminary bathymetric surveys and velocity measurements will be performed simultaneously with the collection of water samples. Detailed bathymetric and velocity measurements will be performed in support of contaminant transport modeling as needed. These surveys and measurements will provide for a better understanding of the flow regime in the vicinity of the groundwater discharges and how contaminant mixing and dispersion occur in the Columbia River along the operable unit.

5.3.5.4 Task 5d--Transect River Water. River water will be collected at two transect locations: (1) near the upstream boundary of the 300-FF-5 operable unit and (2) near the downstream boundary of the 300-FF-5 operable unit. Sampling traverses will be performed at the two transect locations to determine whether there is any measurable effect on the quality of the Columbia River water attributable to the 300-FF-5 operable unit. Open-channel flow measurements will be made in accordance with standard velocity-area methods (EPA 1982, ASTM 1988b). Bathymetric surveys also will be performed in conjunction with the transect sampling activities.

Stations along the traverse will be determined such that no one section represents more than 10% (ideally 5%) of the total river discharge. Samples will be collected at multiple depths (20%, 60%, and 80% of the river depths) at each station to provide the maximum amount of information relative to the amount and distribution of contaminants in the river at the transect locations. Analyses will be determined by the results observed during previous sampling activities, limited to those that will provide useful information relative to the 300-FF-5 operable unit. All contaminants detected above ARARs in either the groundwater near the river or in springs will be included in the transect river water sample analyses. Should the transect sample results reveal the presence of contaminants attributable to 300-FF-5 downstream of the operable unit, additional transect sampling may be warranted for input into the remedial alternative selection process.

5.3.5.5 Task 5e--River Stage. River stage in the Columbia River is subject to seasonal, weekly, and diurnal cycles due to runoff, power demands, and other water management considerations. The unconfined aquifer system that is in direct contact with the river is composed of highly transmissive materials; consequently, the aquifer reacts very strongly to changes in river stage. River stage can change by several feet in the span of an hour, sending a pressure wave inland through the aquifer. The effect of river fluctuations has been detected up to 2.5 mi from the river; however, the magnitude of the disturbance to the aquifer potential surface decreases with distance from the river. The effect of river-stage dynamics on local groundwater velocity fields, submerged interflow, and bank storage/release is not well defined. The sensitivity of the 300 Area unconfined aquifer to fluctuations in river stage has been documented in the past (Haney 1957). The effect on contaminant transport, however, has yet to be investigated. It is not clear whether the diurnal, weekly, or seasonal fluctuations of river stage are more important to the mixing processes for contaminant plumes in the unconfined aquifer.

Riverbank springs and submerged interflow are tied directly to the river-stage fluctuations: the bank springs require a seepage face boundary condition that will be physically moving in relation to the river water boundary and the free surface of the unconfined aquifer. The submerged interflow through the river bottom will be represented by a time-dependent head (river stage) specified along the bottom boundary of the river. Thus, time histories of river stage in the vicinity of the 300 Area are critical pieces of information required by the modeling analysis.

In Phase I, two river-gauging stations will be located on the Hanford side of the Columbia River to characterize the spatial and temporal variability of river stage: (1) upstream end of 300-FF-5, make the RCRA SWS-2 permanent and (2) midpoint of 300-FF-5, make the RCRA SWS-1 permanent. If required, as determined from data obtained from these two stations, a third station will be installed downstream of the 300-FF-5 operable unit. All gauges will be equipped with stilling basins, staff gauges (to periodically monitor the calibration), and continuously recording pressure transducers capable of 30-min integration periods.

5.3.5.6 Task 5f--Boundary Conditions Along the Columbia River. The interface between the aquifer and the river represents the largest uncertainty in the conceptual model. The specification of this boundary condition for the groundwater model (see Section 5.3.4.5) will dictate the water flux and the contaminant mass flux to the river. The proximity of the 300 Area source terms to the river makes the accurate specification of this boundary condition crucial to successful modeling of groundwater and/or contaminant flux from groundwater to the river.

In this instance, Phase II is directed at more detailed study of the physical driving forces along the aquifer-river interface. Fundamental to the specification of driving forces is the definition of the extent of the model domain. In the context of the river, there are two boundaries that require definition: (1) the seepage face along the banks of the Columbia River and (2) the river bottom.

An accurate survey of the 300 Area topography is necessary for the identification of bank exposure and inundation zones. The identification of these zones is critical to the modeling of the seepage and interflow boundary faces. Surveys with the capability of resolving 1-ft contours will be necessary to define the dynamic relationship between changing river stage and the exposed bank seepage zone. Soil types will be mapped concurrently with the topographic survey to characterize zones of varying hydrogeologic properties that can enhance the understanding of the groundwater/surface-water interface.

Somewhat related to the land surface topographic survey is a bathymetric survey of the Columbia River in the vicinity of the 300 Area. The survey should strive to resolve 1-ft contours near the shoreline and 3- to 5-ft contours in deeper sections. This information is important to the identification of the interface between the aquifer and the river bottom. This interface is postulated to be the primary pathway for contaminated groundwater to reach the river.

5.3.5.7 Task 5g--Numerical Algorithms for Groundwater to Surface-Water Dispersion. Numerical algorithms used to describe movement of water and contaminants from the groundwater into the river may range from simple to complex. Dilution models, based on measured contaminant concentrations in groundwater or springs and adjacent river concentrations and dye studies, are on the simple extreme, while three-dimensional groundwater/surface-water models lie on the complex extreme.

In Phase I of the site characterization, simple dilution models will be used. This involves measuring contaminant concentrations in the groundwater or riverbank springs and in adjacent river water to develop an estimate of the dispersion (dilution) that occurs when groundwater enters the river. In addition, dye studies will be conducted to empirically determine the dispersion occurring in the river. This dispersion factor is used for all future estimates regardless of flow conditions and contaminants. The advantage of this method is that it is simple and straightforward. This technique assumes that all contaminants behave similarly and that all flow conditions produce the same dispersion. Until it is determined that groundwater contaminant concentration on 300-FF-5 warrants additional sophistication, this approach will be used in Phase I.

The next level of sophistication involves establishing the eastern boundary of the model at the line of wells along the Columbia River and calculating extreme groundwater fluxes by assigning constant maximum water levels in the wells and a minimum water level in the river. Under these conditions, maximum groundwater and contaminant fluxes into the river would occur, producing the highest river concentrations possible. This approach also will be used in Phase I groundwater modeling.

The greatest level of sophistication involves modeling the river and groundwater interactions in three dimensions. This will require a detailed understanding of the geology, water levels, and aquifer properties beneath the 300-FF-5 operable unit and the river, river stage as a function of time, and discharges from the groundwater along the riverbank and through the bottom of the river. In addition, the flux of water moving past 300-FF-5 in the river also must be understood. This will require modeling of the river discharge and contaminant transport from Priest Rapids Dam to McNary Dam. This last level of modeling would only be required if less-sophisticated analyses indicated that the river could be contaminated above ARARs.

5.3.6 Task 6--Air Investigation

The existing data and sampling of the air above the 300-FF-5 operable unit are discussed in the 300-FF-1 Work Plan. Wind data are similar for both operable units, and no further air investigation is planned for 300-FF-5. Related air investigations will occur for the 300-FF-2 and 300-FF-3 operable units.

5.3.7 Task 7--Biota Investigations

5.3.7.1 Aquatic Biota. The objectives of the aquatic biota sampling program are (1) to document the presence or absence of contamination from the 300-FF-5 operable unit in the aquatic biota and (2) finding such contamination, to determine the extent of that contamination in the aquatic biota and to provide data to interpret contaminant levels in nonaquatic biota.

Sampling of aquatic biota will initially emphasize the lower trophic levels that are most likely to contain measurable amounts of contaminants. Further sampling and analysis of higher trophic-level organisms will be predicated on the results of the initial lower trophic-level samples and analyses.

5.3.7.1.1 Contamination-Level Sampling. Several different organisms/communities will be collected and analyzed for potential contaminants. Organisms/communities include periphyton, macrophytes, benthos, and fish. Samples will be collected in likely areas of contamination (such as near seeps and springs) associated with the 300-FF-5 operable unit. Sampling for this subtask will be at transects 3D and 3F, located downstream from the two main springs (Figure 43). Sampling will be done annually or semiannually for the following organisms/communities:

1. Periphyton--The periphyton community is the closely adhering group of organisms found forming matlike communities on rocks and other solid objects. It is composed of algae, bacteria, fungi, detritus, and other microscopic heterotrophic organisms; it is usually dominated by algae. Because of the large surface to volume ratio of its constituents, it has been found to be an excellent indicator community for the accumulation of contaminants. Cushing (1967b), Watson et al. (1970), and Cushing et al. (1981) have analyzed this community for its ability to accumulate radionuclides in the Columbia River. Samples for contaminant-level sampling will be collected. The sampling method and analyses for this community are described in Section 5.3.7.1.2.

2. Macrophytes--Pondweeds will be sampled if they are found in the 300-FF-5 operable unit. Generally, they are found where slack water occurs, allowing soft sediments to accumulate so that the plants can become rooted. Because they are sessile and they accumulate radionuclides and stable compounds via roots and leaves (Cushing and Thomas 1980), collection and analysis of these organisms may provide useful information concerning contamination levels in the vicinity of the 300 Area. Plants will be collected by underwater divers or by wading. Because the focus of the RI/FS is knowing what contaminants may be passed on to other organisms in the food web, only stems and leaves will be collected and analyzed. Oven-dried weights will be obtained on the samples before analysis for selected contaminants.

3. Benthos--For purposes of the RI/FS, two separate communities of benthic macroinvertebrates are defined: the rock benthos and the soft bottom benthos. The rock benthos is defined as the macroscopic invertebrates inhabiting the surface of the rocks on the bottom of the river. The soft bottom benthos is defined as those macroscopic invertebrates inhabiting mud or silt substrates. Because these organisms are essentially stationary communities, they, too, are good integrators of past contamination in their habitat. The rock benthos feed by filtering plankton and fine particulate organic matter from the water and by actively grazing the periphyton community. Both feeding methods mean they are integrating other organisms likely to be concentrators of contaminants. Collection and

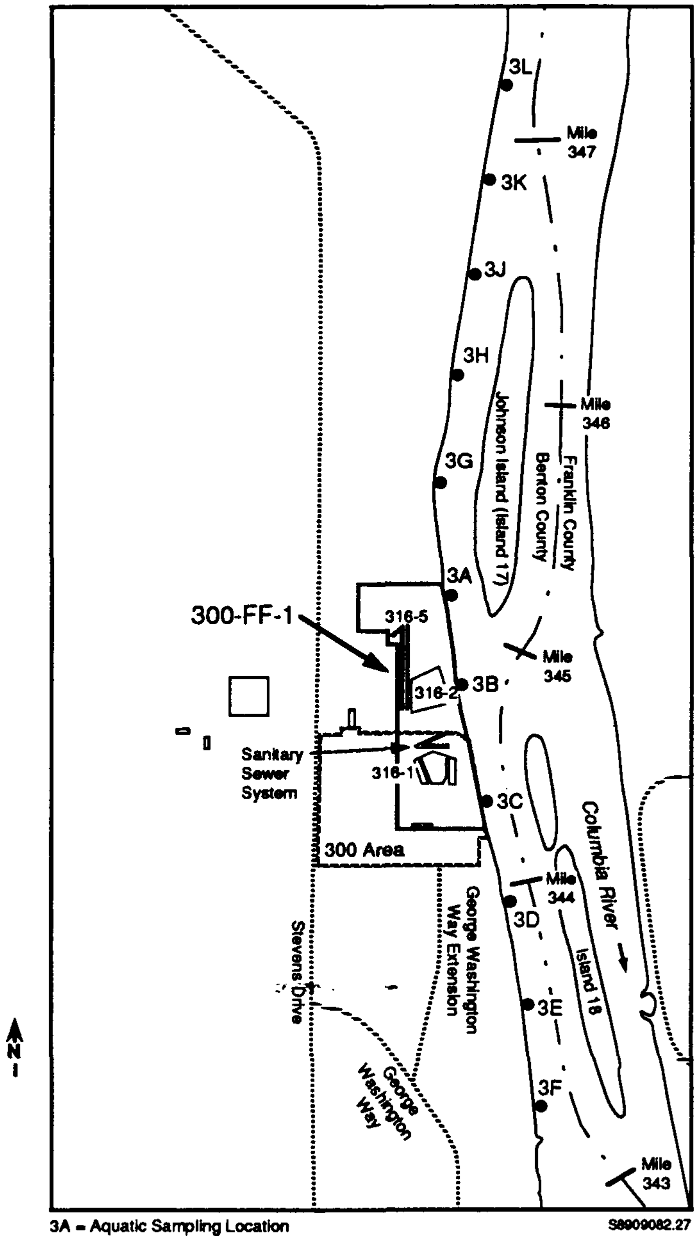


Figure 43. Proposed Locations of Sampling Stations for Aquatic Biota Investigations.

analysis methods for the rock benthos are described in Section 5.3.7.1.2. Isolated back-water areas in the 300-FF-5 operable unit will be sampled to examine contamination levels in the soft bottom macroinvertebrates inhabiting this substrate. These organisms feed by ingesting the mud substrate or by filter feeding from the water column. For the rock benthos, it means that they are integrating other organisms or material likely to be contaminated. The soft bottom benthos will be sampled either by dredging with Ekman or Ponar grab samplers from boats or by retrieving via underwater divers. Organisms will be removed by filtering through graduated screens. Oven-dried weights will be obtained before contaminant analysis.

Special attention will be paid during the benthos collection to the occurrence of two species that are candidates for inclusion as threatened and endangered species: the giant Columbia River limpet and the great Columbia River spire snail. The endangered (State of Washington) persistent sepal yellow cress also may occur in the riparian zone, and its occurrence will be noted, if found.

4. Fish--Fish are mobile; thus, contamination levels detected in any fish collected in the vicinity of the 300-FF-5 operable unit may not necessarily be derived from that area. Fish from the 300-FF-5 operable unit will be collected and analyzed primarily to provide background contamination levels for use by others who will evaluate organisms (birds) and men that use fish as a food source. It is unlikely any species that can truly be called resident will be identified, although obviously small species (such as minnows) will not range as far as larger species. A variety of methods will be used to sample fish in the vicinity of the 300 Area, including gill nets (if slack-water conditions are found), beach seines for smaller species, and electro-fishing techniques for larger species. Particular attention will be paid to species known to be utilized by man.

5.3.7.1.2 Measure Distribution of Contamination and Evaluate Effects. Sampling under this task is designed to assess the distribution of contaminants emanating from activities in the 300-FF-5 operable unit and to determine, if necessary, the effects of these contaminants by establishing permanent sampling stations. The organisms/communities that will be sampled are periphyton, rock benthos, and suckers. Sampling these organisms/communities will be done at 11 permanent sampling transects, extending from the shoreline toward the middle of the Columbia River. Because of daily water-level fluctuations that occur from Priest Rapids Dam operations, care must be taken to ensure that samples for periphyton and rock benthos are collected from substrates that have not been exposed to the air during the period before sample collection. Because of water-level fluctuations, all samples will be collected in the morning before the daily water levels increase. This will ensure that subsamples are not exposed to the air before sampling.

Eleven sampling transects will be established in the Columbia River to evaluate contamination and potential effects of contamination on the aquatic biota (see Figure 43). Transect 3A will be located above potential groundwater input of uranium in the 300-FF-5 operable unit and will essentially be the control station. Transect 3F will be located well below the 300-FF-5 operable unit. Transects 3B, 3C, 3D, and 3E will be located equidistantly between 3A and 3F and will allow the establishment of interim sources of contamination and/or effects. A series of trenches located north of the 300 Area are a potential source of uranium contamination by groundwater. Five transects will be established at equal distances between transect 3A and a point opposite those trenches to evaluate potential contamination of transect 3A from the trenches. These transects will be designated as 3G, 3H, 3J, 3K, and 3L (see Figure 43).

Periphyton and rock benthos will be sampled from natural substrates along these transects by retrieving rocks by wading or with underwater divers. Rocks will be selected from each transect, beginning next to the shoreline and extending into the river for a minimum of 20 m horizontally or to a depth of 3 m, whichever is reached first. They will be collected at this depth because it is unlikely that organisms farther out from shore would be exposed to high-enough concentrations of any contaminant to be detectable or show effects.

1. Periphyton--Ten representative rocks will be collected from each transect, and two samples will be collected from each of the ten rocks. The first sample will be a qualitative sample for contaminant analysis and species composition, and the second will be an areal sample for analysis of biomass and chlorophyll α content. The 10 qualitative samples will be pooled into a composite sample. A small subsample will be removed from the composite for microscopic analysis of species composition. The remainder will be divided into two subsamples, one for analysis of chemical contaminants and the other for determination of radionuclide concentrations. Each of the 10 separate areal samples for biomass and chlorophyll α content will be analyzed separately to determine the mean standing crop of periphyton for each transect. Oven-dried weights will be obtained before analyses.

2. Rock benthos--Ten representative rocks will be collected from each transect to determine species composition and standing crop. Invertebrates and debris will be scrubbed from each rock separately into a bucket, and the entire sample returned to the laboratory for processing. In the laboratory, all benthic macroinvertebrates will be picked, counted, and identified. This analysis will furnish data on the species composition and the number of each taxa per rock. Oven-dried weights will be obtained to determine biomass of each taxa per rock. A second set of 10 representative rocks will be collected, and the organisms scrubbed and pooled into a composite sample for contaminant analysis. The composite sample will be divided into two parts, one for chemical contaminant analysis and the other for determination of radionuclide concentrations.

3. Suckers--Beach seines or other suitable methods will be used to collect fish near in-shore regions. Suckers graze on periphyton and, therefore, integrate this trophic level. Also, they restrict their movements to a small portion of the river. The composite sample from each transect will be divided into two separate subsamples, one for chemical contaminant analysis and one for determination of radionuclide concentrations.

5.3.7.2 Riparian Zone Plants. The objective of the biota investigations is to evaluate the biological and ecological significance of the contamination levels present in riparian zone biota collected along the Columbia River shoreline in the vicinity of the 300-FF-5 operable unit.

The objective of sampling riparian zone plants is to detect the presence and distribution of chemical contaminants that may have moved from disposal sites in the 300 Area through groundwater and/or surface (springs) runoff toward the Columbia River.

The sampling strategy for the 300-FF-5 operable unit riparian zone is to compare hazardous material concentrations in plants and animals collected upstream from the operable unit and that are presumably unaffected by the chemical contaminants of the 300-FF-5 operable unit (background levels) with those living close to the operable unit (most likely affected) and those living downstream (mildly affected, if at all).

Riparian zone plants can accumulate contaminants from contaminated river water, from contaminated sediments washed onto the shoreline and deposited in the riparian zone, or by root contact with contaminated groundwater before it enters the Columbia River.

Riparian plants (such as reed canary grass, mulberry trees, and willow shrubs) can be used to detect groundwater pathways of contamination. They are especially useful in situations where the depth to groundwater is relatively shallow (<20 ft) and groundwater flow is along narrow channels in heterogeneous substrates. In special cases, plant sampling is much more cost effective than well drilling. Groundwater seepage into the Columbia River is seldom present as distinct streamlets even when the river flow is low. Plants have an advantage by being able, in some cases, to reach the groundwater flow before it enters the river and, thus, it is not greatly diluted by mixing with river water. Plants also have the capacity to "bioaccumulate" certain radionuclides (e.g., ^{90}Sr) in their stems and leaves, allowing more realistic estimates of the amounts likely to be ingested by herbivorous animals.

Plants will be collected at 12 stations (Figure 44). Four sampling stations will be established upstream from the operable unit, four stations along the river boundary of the unit, and four stations downstream from the operable unit. The upstream sampling locations are chosen to identify a true background level. Downstream stations are chosen to identify the extent of contamination that might have been carried downstream. At least three samples of leaves and stems will be sampled at three locations at each station. Samples will be taken during the growing season over a 2-wk period. The species selected will be representative of those at each sampling station. Also,

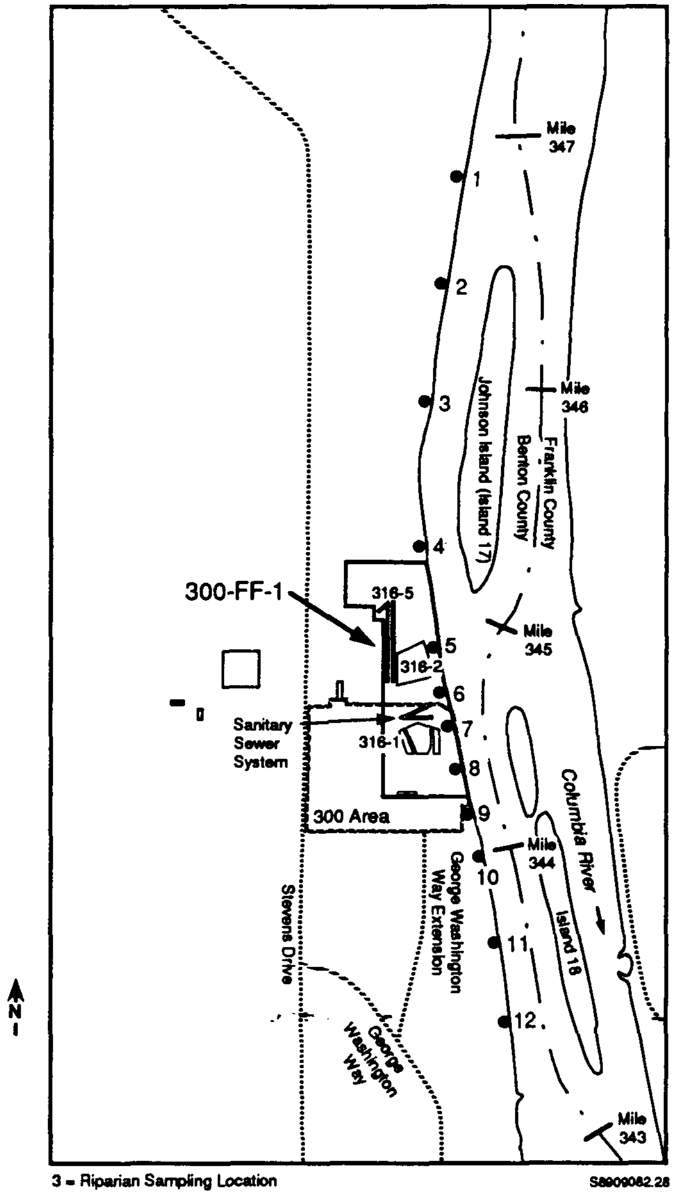


Figure 44. Proposed Locations of Sampling Stations for Riparian Biota Investigations.

asparagus plants will be sampled wherever they occur between stations 1 and 12 at the appropriate season of the year because these are collected and eaten as food by people. Vegetation associated with the seeps will be sampled where they occur between stations 1 and 12.

The stems and leaves will be cut into decimeter lengths and air dried in paper bags for several weeks. Approximately 200 g of dried plant material will be cut at each location within each sampling site. One hundred grams of dried plant tissue will be radiochemically analyzed by gamma scan. Ten grams of dried plant material will be analyzed by x-ray fluorescent spectrometry for a suite of mineral elements, including zinc, copper, chromium, iron, aluminum, cadmium, and uranium. Plant tissues will not be analyzed for the presence of hazardous organic materials. The remainder of the collected and dried plant material will be archived for further chemical analyses as deemed appropriate.

It is recommended that plant sampling be conducted in the riparian zone in conjunction with sampling of animals. Contaminants accumulated by riparian zone plants are likely to be a different set than those likely to occur in animals. Sometimes animals may exhibit contaminants that may be difficult to trace to sources because of animal mobility. Therefore, it is recommended that herbivorous animals with limited mobility be sampled in the riparian zone (e.g., meadow mice and cottontail rabbits).

The distribution of asparagus in the immediate vicinity of the 300-FF-5 operable unit and 1,000 m downstream of the 300 Area south fence will be mapped.

5.3.7.3 Vertebrates. The objectives of vertebrate sampling are to detect the presence and distribution of hazardous chemical materials, primarily organic compounds disposed to the ground in the 300-FF-5 operable unit, in the tissues of wild animals that inhabit the riparian zone or have access to forage plants in this zone and to document the use of the operable unit by protected and/or human food-chain vertebrate species.

As described in Section 2.2, a number of wildlife species frequent the riparian zones of the Columbia River and forage on plants. If contaminants are detected in plant tissues, they can be transferred to herbivorous animals [such as cottontail rabbits, deer, meadow mice (voles), and Canada geese]. These animals are a link in a food web that could lead to humans or to carnivores (such as the bald eagle, a threatened species).

To attribute these contaminants to the immediate source of the 300-FF-5 operable unit rather than from other adjacent operable units, it is necessary to monitor animals that do not move far from the unit (such as the cottontail rabbit and the meadow mouse). Both animals are herbivores and eat riparian zone plants.

Small mammals residing in the riparian zone at each of the 12 sampling stations will be collected by trapping. Up to five animals per station will be collected. On collection, animals will be killed and placed in plastic bags labelled by specimen identification number, station, date, species, and weight. Specimens will be skinned and eviscerated on return to the laboratory. Skins will be bagged and labelled by specimen identification number, station, date, and species. Guts and contents will be discarded. Specimens will be stored in a freezer at -60°F to preserve any volatile organics.

Skins and skinned, eviscerated carcasses will be analyzed for gamma-emitting radionuclides by gamma scan. Skin analysis will indicate superficial contamination (e.g., from mammal runways), while whole body counts will indicate systemic contamination. Following gamma scan, carcasses will be pooled according to collection location and homogenized. Homogenate will be divided into three fractions and labelled as to collection location. One of the three fractions will be used to assess the presence of manmade organic compounds in body tissues using capillary gas chromatography or other appropriate methodology approved by the EPA. The second fraction will be ashed and the ash analyzed for heavy metals by x-ray fluorescent spectrometry. The third fraction will be archived in a freezer at -60°F. Visual sampling methods will be used at the appropriate times of year to identify whether protected species or those important to the human food chain utilize the area.

5.3.8 Task 8--Data Evaluation

Data collected during the remedial investigation will be evaluated continuously to document progress versus cost and to rescope future investigations. The data evaluation process will be specific for each potential exposure pathway and remedial investigation task. Results of individual remedial investigation task evaluations will be reported as part of the monthly reporting process. Potential exposure pathway evaluations will be produced as part of the annual remedial investigation reports or when a major remedial investigation task is complete.

Data evaluation will be performed for all remedial investigation tasks included within the scope of the 300-FF-5 operable unit, as well as those interrelated tasks undertaken as part of the operable unit investigations (300-FF-1, 300-FF-2, and 300-FF-3). Data evaluations will be performed for the following tasks:

- Task 2--Geologic Investigation
- Task 3--Soil Investigation
- Task 4--Groundwater Investigation
- Task 5--Surface-Water and Sediment Investigation
- Task 7--Biota Investigations.

The information developed in the data evaluation task will be used to develop a baseline risk assessment and to identify remedial action alternatives. A summary of individual remedial investigation task evaluations follows.

5.3.8.1 Geologic Data Evaluation. Stratigraphic horizons will be delineated in the sediments in the 300-FF-5 operable unit. This will be done using geophysical techniques and by observation and analysis of sediment samples collected from wells. This work will provide the basis for distinguishing different strata within the aquifer as they affect groundwater flow and contaminant transport. Both physical and chemical properties of the samples will be used in this interpretation.

Surface geophysical surveys will be used to attempt to locate the top of basalt and contacts between major lithofacies, and to provide some indication of the location and depth of a hypothesized hydrologic barrier along the Columbia River. Because the techniques proposed are developmental in nature, their successful application is in question. These questions can be answered only by making some trial applications under actual field conditions.

Physical appearance and laboratory analyses of sediment samples collected from wells will be used to delineate stratigraphic horizons across the site. These interpretations will provide the basis for conceptual groundwater flow models for the 300-FF-5 operable unit.

5.3.8.2 Soil Data Evaluation. Physical and chemical characteristics of background soils (Task 3; from both the vadose zone and upper unconfined aquifer) from throughout the 300-FF-5 operable unit will be evaluated. Physical properties of soils will be evaluated to provide data input for baseline risk assessments (such as porosity, moisture content, hydraulic conductivity, and particle size). Chemical characteristics of background soils will be developed, evaluated, and used to compare with contaminated soil data gathered as part of the source operable unit investigations.

Chemical characterization of background soils will be consistent with the analytical parameters listed in Table 35. In addition, selected samples will be analyzed for chemical characteristics, including cation exchange capacity, mineralogy, and calcium carbonate content. Besides establishing background soil compositions for both the vadose zone and upper unconfined aquifer, unconfined aquifer soils also will be evaluated to determine the extent of contamination due to the flow of contaminated groundwater. Sorption and desorption studies will be evaluated to provide an indication of contaminant mobility through the aquifer sediments. Background soil conditions (physical and chemical characteristics) will be established for portions of 300-FF-5 consistent with known source operable units. In other words, a background soil characterization will be provided for soils in 300-FF-1, as well as each of the other source operable units located within the geographic boundaries of 300-FF-5.

5.3.8.3 Groundwater Data Evaluation. Data gathered during Task 4--Groundwater Investigation will be evaluated to establish water quality conditions within the 300-FF-5 operable unit. Background water quality conditions may vary within the 300-FF-5 operable unit. For this reason, upgradient water quality will be established for each of the source control operable units located within the geographic boundaries of 300-FF-5. Once background conditions are established, statistical comparisons can be made to identify contaminated zones within 300-FF-5. These evaluations will be used to determine the nature and extent of groundwater contamination.

The locations and multiple completion depths of selected wells will allow two key questions to be answered. First, is the source of part of the groundwater contamination beneath the 300 Area from disposal sites to the west and north of 300-FF-5; second, what is the vertical extent of contamination in the unconfined aquifer and is the upper confined aquifer contaminated?

Physical properties of the groundwater system also will be evaluated to estimate flow rates and directions. Of particular importance in the groundwater investigations is the interaction of groundwater and surface water. Interactions of groundwater and surface water along the boundary of 300-FF-5 represent a major unknown in terms of assessing baseline risk as part of the groundwater and surface-water pathways.

The shallow groundwater near the bank of the Columbia River represents an accessible source of contamination for riparian plants and animals. In addition, near-shore wells would provide an upper bound for the concentrations of hazardous substances entering the Columbia River. Finally, evaluations will be made, where possible, to distinguish between groundwater contamination and direct river discharge as the source of contamination.

5.3.8.4 Surface-Water and Sediment Data Evaluation. Surface-water hydrologic data will be evaluated to provide technically defensible inputs to the baseline risk assessment for the surface-water pathway (Task 5). In addition, surface-water flow conditions will be evaluated to refine schedules for identified sampling activities (i.e., spring mapping and sampling).

Radiation surveys will be conducted to assess radiation levels at known discharge locations and riverbank springs, and will be used to guide future sampling efforts as input to the baseline risk assessment.

Locations, elevations, and relative flows of seeps along the 300-FF-5 operable unit riverbank will be plotted, and relative water quality data will be evaluated to determine whether a preferential groundwater discharge pathway to the river exists.

In addition, surface-water concentrations will be used to evaluate dilution of groundwater discharges at the groundwater/surface-water interface. These data will then be used as input to assess environmental pathways along riparian areas.

Near-shore surface-water and sediment quality data will be statistically compared with background values to determine the contaminants being contributed to these environmental media by the 300-FF-5 operable unit. Data will then be plotted against distance along the river to estimate the length of the contaminant plumes in the water column and sediments. In addition, the near-shore surface-water and sediment data evaluations will be used to identify potential indicator species to use in surface-water transect investigations.

5.3.8.5 Biota Data Evaluations. Results of the biota investigations (Task 7) will be evaluated to assess the potential for uptake of radioactive and hazardous materials by flora and fauna. Biological data gathered in the 300-FF-5 operable unit will be compared with background data from control populations outside 300-FF-5. Results of these evaluations will be used to evaluate potential impacts on endangered, threatened, or economically important species. Results of these evaluations also will be used to assess any significant impacts to the human food chain as part of the preliminary baseline risk assessment.

5.3.9 Task 9--Baseline Risk Assessment

The objective of the baseline risk assessment task is to provide an evaluation of potential harm to human health and/or the environment by the actual or possible release of hazardous substances from a waste site in the absence of remedial action. The results of the risk assessment are used to determine whether remedial action is necessary and provide justification for cleanup levels. The assessment will be developed in accordance with EPA (1986b) and will be divided into four subtasks:

- Task 9a--Contaminant Identification
- Task 9b--Exposure Assessment
- Task 9c--Toxicity Assessment
- Task 9d--Risk Characterization.

Figure 45 illustrates the interrelationships between the four subtasks in the 300-FF-5 risk assessment.

The baseline risk assessment will consist of the following specific activities:

- identify the concentrations and quantity of hazardous substances present in air, soil, groundwater, surface water, river sediments, and biota based on the results of characterization

- identify and describe the mechanisms for environmental fate and transport within different environmental media (such as groundwater, surface water, and atmosphere) and the physical, chemical, and biological degradation processes that affect transport

- identify and describe the potential exposure pathways and the extent of actual or expected exposure

- identify the potential human and environmental receptors

- evaluate and describe the extent of expected impacts and the potential for such impacts occurring (i.e., risk characterization)

- compare the results of the exposure assessment with acceptable levels of exposure based on regulatory and/or toxicological information.

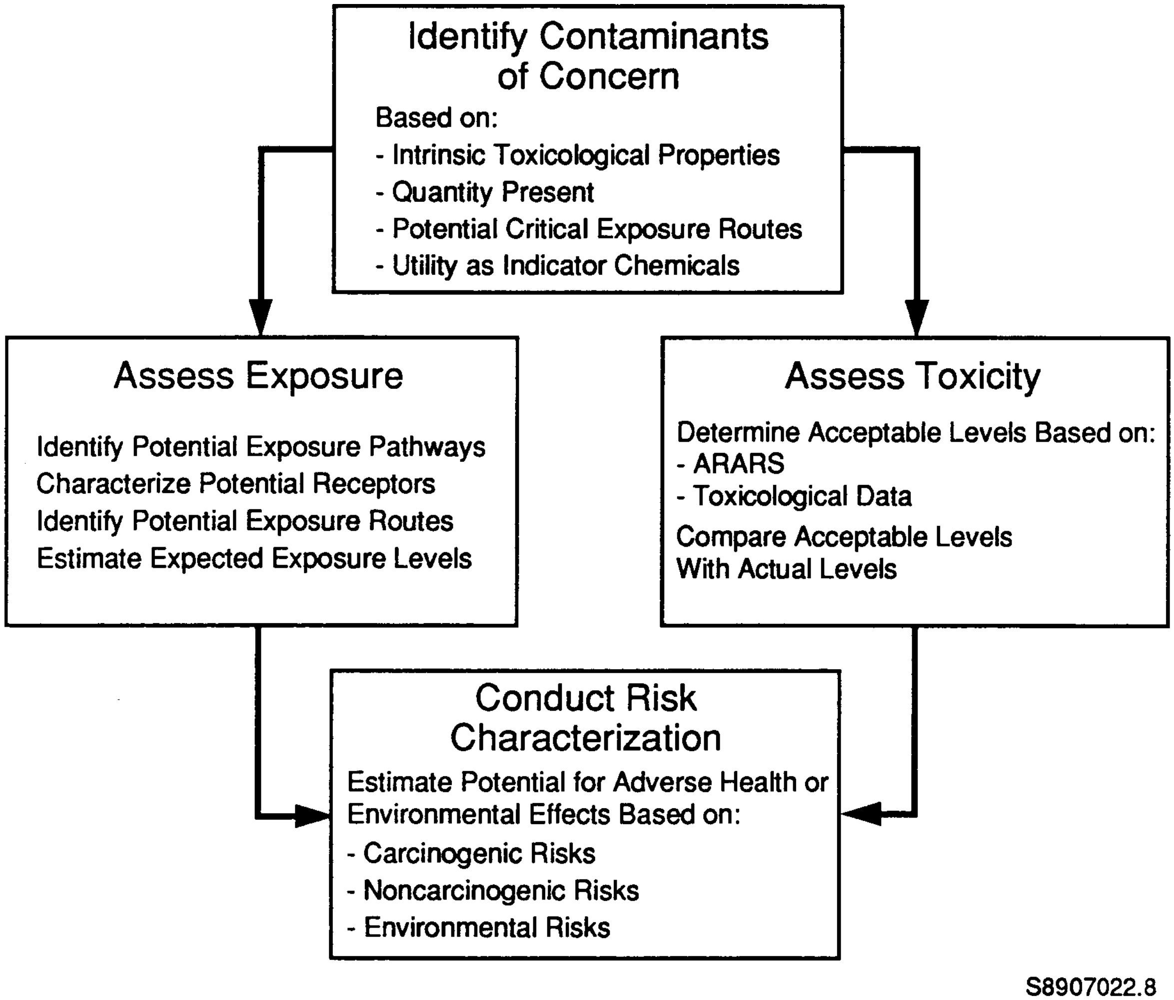


Figure 45. Risk Assessment Process.

Wastes from the source term operable units (300-FF-1, 300-FF-2, and 300-FF-3) affect the 300-FF-5 groundwater operable unit. Because of this interaction, lines of communication will be established and maintained with the RI/FS efforts at the other operable units located above the 300-FF-5 operable unit. This communication will enable new information pertinent to the 300-FF-5 risk assessment to be identified as it is obtained from the various field investigations. Once information from other remedial investigations is obtained, it will be incorporated into the 300-FF-5 risk assessment so that an overall assessment of the risk to the public and the environment can be made.

5.3.9.1 Task 9a--Contaminant Identification. The first component of the risk assessment process is to identify the contaminants of concern present in groundwater of the 300-FF-5 operable unit. The objective of contaminant identification is to screen the field of contaminants identified in the remedial investigation to provide a list of contaminants for which the subsequent risk assessment activities are focused. Target contaminants will be selected on the basis of their intrinsic toxicological properties, presence in large quantities, and/or presence in potentially important exposure pathways (such as drinking water sources).

If the number of contaminants of concern identified in the 300-FF-5 operable unit is high, it may be useful to further narrow the list by identifying indicator species that pose the greatest risk to human health or environmental degradation. The number of contaminants that makes it necessary to identify indicator species will be determined during the remedial investigation as part of this subtask. If indicator species are used, they will be carefully selected by focusing on those substances in the 300-FF-5 operable unit that are the most toxic, abundant, mobile, persistent; have the greatest tendency to bioaccumulate; and for which the best information is available. A detailed methodology for selecting indicator species is provided in EPA (1986b).

5.3.9.2 Task 9b--Exposure Assessment. The objective of the exposure assessment subtask is to use measured or predicted environmental concentrations to estimate human and environmental exposures. Estimating present and future exposure to contaminants in the 300-FF-5 operable unit requires identification and characterization of the potential or actual exposure pathways, potential or actual transport pathways, and potentially exposed populations.

The first step of the exposure assessment involves identifying exposure pathways. Each exposure pathway consists of four elements: (1) a source and mechanism for release to the environment, (2) environmental transport media (such as groundwater and surface water), (3) a potential location for receptor contact with a transport medium (such as surface water; i.e., exposure point), and (4) an exposure route at the contact point (such as drinking water ingestion or crop irrigation and food consumption). For contaminants in 300-FF-5, some of the exposure assessments will be done with contaminants measured in the transport media (such as measured groundwater concentrations).

Data gathered during the preliminary assessment/site inspection, environmental monitoring activities, remedial investigations for the other operable units, and any other available data sources will be used to identify the potential release sources and release mechanisms from the sources. As the release mechanism(s) for contaminants are identified or postulated, the transport pathways for the released constituents also will be identified. In addition to starting from source concentrations, the measured concentrations of contaminants in different environmental media will be used as starting points for transport and exposure analyses.

The next element of the exposure assessment will consist of identifying the potential locations for exposure and routes of exposure to humans and environmental populations at those locations. Existing exposure locations will be identified and future locations will be postulated. Different populations for which a potential for exposure exists will be identified and characterized for the population exposures, and maximally exposed individuals will be identified for worst-case scenarios. Characterization of a population involves determining the number of individuals in the population, the demographics of each population group, and the potential exposure routes to populations and individuals. Determining routes for exposure includes identifying and characterizing activities and food consumption for which short- and long-term exposures to contaminants can occur.

The last element of the exposure assessment is to determine the fate and transport of the contaminants in the exposure pathways and to estimate the expected exposure levels. The fate and transport modeling will consider the environmental transport of contaminants through the different pathways (groundwater, overland, surface water, atmospheric) and mechanisms for transfer of contaminants from one transport medium to another (e.g., sorption, volatilization). Initial concentrations for the transport modeling will include source concentrations, as well as concentrations in different transport media (such as groundwater). After potential exposure pathways are determined, measured or predicted environmental concentrations for each contaminant of concern or indicator species will be estimated at each of the identified exposure locations. The environmental concentrations and information on exposure routes will then be used to estimate the amount of contaminant that the various receptors potentially could intake (i.e., dose rate), including the extent and duration of the exposure.

5.3.9.3 Task 9c--Toxicity Assessment. The objective of the toxicity assessment subtask is to evaluate the nature and extent of health and environmental hazards associated with exposure to contaminants from the 300-FF-5 operable unit. The final product of the toxicity assessment is a qualitative index of toxicity for each contaminant derived by comparison of predicted concentrations and exposures with available ARARs (dose limits and maximum concentrations).

Available contaminant-specific ARARs (e.g., maximum contaminant levels, 25 mrem/yr effective dose equivalent, all pathways) will be used as acceptable levels for human exposure unless exposure at the ARAR level results in a risk greater than 10^{-6}. Acceptable levels for contaminants for which no contaminant-specific ARARS are available will be based on reference doses for noncarcinogens and cancer potency factors for carcinogens. These reference doses and cancer potency factors are available from toxicity profiles published by the EPA and the Agency for Toxic Substances and Disease Registry (Barsotti et al. 1988). For contaminants that have no ARARs, reference doses, or cancer potency factors, acceptable exposure levels will be developed if toxicological data are available in the literature.

Acceptable levels for environmental receptors will consist of contaminant toxicity levels for various species of fish and wildlife, which are available in the literature. The levels of contaminants in environmental receptors will be determined by measured or predicted concentrations of contaminants in plants and animals along various exposure pathways.

5.3.9.4 Task 9d--Risk Characterization. The final component of the risk assessment process consists of characterizing the risk to various receptors from exposure to contaminants from the 300-FF-5 operable unit. The risks include carcinogenic, noncarcinogenic, and environmental. This characterization is done by evaluating the results of the exposure and toxicity assessments to estimate the potential or actual risks resulting from contaminant release from the 300-FF-5 operable unit.

Potential human risks from the 300-FF-5 operable unit will be assessed by comparing acceptable contaminant exposure levels with actual or predicted levels. For noncarcinogens, the goal will be exposure, such that the sum of fractions of actual or predicted exposure versus the reference dose is less than one. The goal for exposure to carcinogens will be a lifetime risk of contracting cancer between 10^{-7} to 10^{-4}.

The risks associated with environmental contaminants will be evaluated by considering the effects of contaminant exposures on indigenous species, food chain, and habitat. All these factors affect environmental quality in the vicinity of the 300-FF-5 operable unit and its associated exposure pathways.

The baseline risk assessment will include a summary of risks associated with the 300-FF-5 operable unit, data associated with each step of the risk assessment process, estimated uncertainty of the various transport and exposure components, assumptions made during the assessment, and distribution of risk across different segments of the population and environment. The results of the baseline risk assessment will be used to determine whether the 300-FF-5 operable unit poses an actual or potential threat to human health and/or the environment.

The results of the baseline risk assessment will provide the basis for documenting the decision for choosing the no-action alternative or performing remedial action. If remedial action is selected as the preferred alternative for hazards at the 300-FF-5 operable unit, remedial alternatives will be assessed as part of the feasibility study. Risks will be determined for each of the remedial alternatives, but this risk evaluation is beyond the scope of the current effort.

5.3.10 Task 10--Preliminary Site Characterization Summary Reports

The purpose of preliminary site characterization summary reports is to summarize site data at the completion of each field sampling and analysis phase. The reports will include information on physical and chemical characteristics of each study area and the nature and extent of contamination in each of the various media. Reports will be disseminated during the remedial investigation so that information is available to interested parties before the completion of the remedial investigation and draft remedial investigation report. Information included in the reports will be used to identify ARARs, initiate the risk assessment process, and evaluate remedial alternatives in the feasibility study.

It is currently estimated that three technical reports will be prepared during the remedial investigation. Each report will provide new information for each area of investigation (e.g., groundwater, surface water, biota, and human receptors) since the previous summary report was issued. In addition, a report that summarizes quality assurance activities (such as surveillances, audits, and change instructions) will be prepared at the end of each investigative phase or annually.

5.4 PHASE I FEASIBILITY STUDY--REMEDIAL ALTERNATIVES DEVELOPMENT

Section 3.4 presented preliminary lists of media-specific general response actions and remedial technologies and their associated process options that are potentially applicable to the 300-FF-5 operable unit. These lists were based on a review of the environmental data from this unit and the 300-FF-1 operable unit that lies above 300-FF-5. Based on the additional data collected during the remedial investigation, this section (5.4) addresses the steps that will be taken to develop remedial action alternatives for this operable unit.

5.4.1 Task 1--Development of Remedial Action Objectives

Section 3.4 described the general basis to be used for developing preliminary remedial action objectives. During the remedial investigation, further characterization of the operable unit will identify, quantify, and locate those contaminants of concern that will form the basis for further developing the remedial action objectives. The potential risk to human health and the environment will be determined for each contaminant in each medium. This risk assessment will provide further refinement of the basis for selecting the contaminants of concern and the associated exposure pathways and receptors. From this risk assessment, the remedial action objectives will be further developed with respect to defining acceptable residual concentrations for each contaminant in each medium.

5.4.2 Task 2--Development of General Response Actions

Preliminary general response actions for the 300-FF-5 operable unit were identified in Section 3.4. Those response actions are medium specific and describe the general activities that are expected to satisfy each of the remedial action objectives. Since the response actions relate directly to the remedial action objectives, any substantial changes in these objectives, as a result of data generated during the remedial investigation, will require that the response actions be revised.

5.4.3 Task 3--Identification of Potential Remedial Technologies

This task will be conducted in the manner described in Section 5.4.3 of the 300-FF-1 Work Plan.

5.4.4 Task 4--Evaluation of Process Options

This task will be conducted in the manner described in Section 5.4.4 of the 300-FF-1 Work Plan. Because the process options will be evaluated for remediation of media specific to this operable unit, the effort will be conducted independently but cognizant of the efforts in the other operable units in the 300 Area. Also, because of the large extent of the operable unit and the possibility that the groundwater is contaminated by more than one unique source term, consideration will be given to technologies that are applicable to only a portion of a medium within the operable unit.

5.4.5 Task 5--Assembly of Remedial Alternatives

In this task, applicable technologies using representative process options will be linked together to address each general response action. In developing these alternatives, consideration will be given to the combination of several treatment process options to achieve an acceptable level of treatment and to further treat secondary waste streams. Also, consideration will be given to the level of application of each portion of the alternative. For example, an activated carbon adsorption process to remove organic compounds from the groundwater may be applied to the entire groundwater plume or only that portion of the groundwater contaminated by organic compounds. In general, alternatives will be medium specific at this point. However, process options that are applied to separate media may be combined at this time into a single alternative if they clearly interact substantially in achieving a treatment objective. For example, an alternative that treats river sediments by in situ stabilization will have no influence on the performance of groundwater extraction wells and subsequent waste-water treatment steps. Therefore, these alternatives would not be combined.

5.4.6 Task 6--Identification of Action-Specific Applicable or Relevant and Appropriate Requirements

Preliminary action-specific ARARs were identified in Section 3.2.3. These will be reexamined and revised as necessary after the remedial action alternatives have been screened to eliminate options that are not desirable.

5.4.7 Task 7--Reevaluation of Data Needs

This task will be conducted in the manner described in Section 5.4.7 of the 300-FF-1 Work Plan.

5.4.8 Task 8--Phase I Feasibility Study Report--Remedial Alternatives Development Summary

This task will be conducted in the manner described in Section 5.4.8 of the 300-FF-1 Work Plan.

5.5 PHASE II FEASIBILITY STUDY--REMEDIAL ALTERNATIVES SCREENING

The screening of alternatives follows the development of alternatives and precedes the detailed analysis of alternatives. The objective of alternatives screening is to eliminate those alternatives that are clearly inferior to the others, thus reducing the field of potential alternatives. The intention of this task is to preserve all of the viable options. If only a few alternatives have been developed, this screening step may not be needed, in which case all of the alternatives would be evaluated in detail. Three distinct steps are conducted during the screening of alternatives:

1. The alternatives selected in Phase I are further refined, based on the quantities or areas of environmental media affected, the sizes and capacities of process options, and other pertinent factors obtained from the remedial investigation.

2. The refined alternatives are evaluated on a general basis to determine their effectiveness, implementability, and cost.

3. The alternatives best able to meet the remedial action objectives are retained for detailed analysis in Phase III of the feasibility study, which is described in Section 5.7.

5.5.1 Task 1--Refinement of Remedial Action Objectives

This task will be conducted in the manner described in Section 5.5.1 of the 300-FF-1 Work Plan.

5.5.2 Task 2--Definition of Remedial Alternatives

This task will be conducted in the manner described in Section 5.5.2 of the 300-FF-1 Work Plan. While media interactions considered in this task will concentrate on those media within the operable unit, consideration also will be given to the potential effects of source control actions being considered for adjacent operable units, in addition to the 300-FF-1 operable unit.

5.5.3 Task 3--Screening Evaluation

This task will be conducted in the manner described in Section 5.5.3 of the 300-FF-1 Work Plan.

5.5.4 Task 4--Verification of Action-Specific Applicable or Relevant and Appropriate Requirements

This task will be conducted in the manner described in Section 5.5.4 of the 300-FF-1 Work Plan.

5.5.5 Task 5--Reevaluation of Data Needs

This task will be conducted in the manner described in Section 5.5.5 of the 300-FF-1 Work Plan.

5.5.6 Task 6--Phase II Feasibility Study Report-- Remedial Alternatives Screening Summary

Each step of the alternatives screening process will be summarized in a report. This interim report will later become integrated into the final RI/FS report. Because of the need for defensibility, all procedures for evaluating, screening, and defining the alternatives will be well documented. The reasoning and judgments that were applied to each decision will be clearly presented. The report will include the following types of information:

- chemical- and/or risk-based remedial action objectives associated with the alternatives
- modifications required for media-specific alternatives to ensure acceptably low risk from multiple-pathway exposures and interactions among source and groundwater remediation strategies
- definition of each alternative, including extent of remediation, volume of contaminated material, size of major technologies, process parameters, cleanup time frames, transportation distances, and any other special considerations
- notation of which processes are represented by which alternatives remaining in the screening process
- screening evaluation summaries for each alternative
- comparison of screening evaluations among alternatives.

5.6 REMEDIAL INVESTIGATION--TREATABILITY INVESTIGATION

The purpose of the treatability investigation is to provide the process information needed to conduct a detailed analysis of all alternatives and to ensure with reasonable certainty that the remedial action alternatives ultimately selected will achieve the remedial action objectives. The treatability investigation includes both the acquisition of additional characterization data for the operable unit and the performance of treatability studies for individual processes. Treatability studies generally take the form of bench-scale and/or pilot-scale tests. Treatability studies will be conducted for a process when it has been determined that there is insufficient information to determine the size, performance, and operational requirements of a full-scale system. These investigations will be accomplished by conducting the following three tasks.

5.6.1 Task 1--Treatability Investigation Work Plan

Two types of work plans will be developed for conducting the treatability investigation:

- a comprehensive treatability investigation plan
- individual treatability study plans for each process.

The comprehensive treatability investigation plan will serve as an overall guide in establishing the required individual treatability studies, overall cost, schedule, and additional site characterization requirements necessary to obtain all necessary technology-related data. The individual treatability study plans will detail those activities that will be conducted to obtain the necessary data for each process by conducting the treatability study. The development of both types of plans will include planning for individual treatability studies and preparing the comprehensive treatability investigation plan.

A literature search will be conducted to identify additional data needs. The objectives of the survey will be the following:

- determine whether the performance of those processes under consideration have been sufficiently documented on similar wastes, considering the scale (e.g., bench, pilot, or full).

- determine what site and process information is needed to determine the relative costs, applicability, removal efficiencies, operations and maintenance requirements, and implementability of the candidate technologies

- determine testing requirements for bench- and/or pilot-scale treatability studies.

The literature search will include a review of data from any ongoing treatability studies being conducted at the Hanford Site for other operable units within the 300 Area.

Once the site characterization needs and individual treatability studies have been identified, the comprehensive treatability investigation plan will be developed to provide the necessary data in a timely manner and at a reasonable cost. This plan will identify all additional site characterization data that need to be collected for the candidate technologies, all treatability tests that need to be conducted, and all site material and sample requirements needed to conduct the tests. A schedule will be prepared that provides for obtaining all necessary site characterization data, site materials and samples, test materials, permits, equipment, and analytical services. A preliminary cost estimate also will be provided for each activity specified in the plan.

After approval of this comprehensive treatability investigation plan, an individual treatability study plan will be prepared for each process to be tested. The development of each plan will include the following steps:

- determine the scale of the test
- identify key parameters to be varied and evaluated and criteria to be used to evaluate the tests
- determine specifications for test samples and the means for obtaining these samples
- determine the test equipment, materials, and procedures to be used in the treatability test
- identify where and by whom the tests and any analytical services will be conducted, as well as any special procedures and permits required to transport samples, residues, and conduct the tests
- identify the methods required for residue management and disposal
- identify any special quality assurance/quality control needed for the tests
- identify any special safety training or procedures that will be needed for the tests.

Determining the scale of the test will be the first step in developing a treatability investigation work plan for a specific technology because the study has a major influence on the cost, schedule, and complexity of the test. Establishing the scale involves several difficulties: scaling the results to the expected full-scale process; finding data to design, construct, and operate the equipment at the minimum acceptable scale; and obtaining the necessary quantities of site materials for the test. For most treatment technologies, bench-scale tests will be sufficient for obtaining the necessary data to evaluate a full-scale process. However, for some technologies (e.g., as in situ treatment technologies and containment or barriers technologies), it may be necessary to conduct pilot-scale tests to obtain the data needed to conduct a satisfactory evaluation of the technology. Furthermore, if insufficient data are available to design the pilot test, bench-scale tests will have to be conducted first. The scale of the test also will be influenced by the difficulty in obtaining the sample volume necessary for conducting the test.

The range of each key parameters that will be evaluated in the tests will be specified. Some of these parameters (such as pH or temperature) will be varied over a range specified by the process. Other parameters (such as the level of dissolved solids in the groundwater and soil composition) will be varied over a range determined by site characteristics and the effects of any pretreatment steps. In addition, key performance criteria (such as contaminant removal efficiency or leaching rate) will be established for the test plan.

The specifications for the samples to be evaluated will consider the range of the key parameters expected for the process, the range of variation of site-specific parameters, and any special considerations that may affect the process performance.

For example, a precipitation/coagulation process for removing copper from water could conceivably be performed using uncontaminated groundwater spiked with varying quantities of chromium(VI) and principal dissolved solids (such as calcium) and aluminum. An ion exchange process, on the other hand, may need actual waste water that has been filtered following pretreatment using a precipitation/coagulation process.

The equipment, materials, and test procedures will be specified for each individual treatability study as required to obtain the necessary data. In determining what equipment and test procedures are required, particular attention will be given to those identified in the literature search. The equipment and procedures also will be consistent with approved testing methods used by the EPA. Particular attention will be given to the methods and accuracy required for measuring key performance variables (such as effluent contaminant concentration) to ensure that the sensitivity of the analytical methods and equipment matches the sensitivity required to compare results to the test criteria.

Two important considerations in developing each individual treatability study plan are where and by whom the tests will be conducted. If the test is to be offsite or at the 300-FF-5 operable unit, special permits may be necessary for either constructing and operating equipment or transporting wastes and residues offsite. Similarly, when the work is conducted by a subcontractor, equipment, test, and sample analysis will need to be negotiated with respect to the treatability study test plan.

Management and disposal requirements for residues produced during the test will be determined. The quantity, composition, and location of the waste may influence treatability study plans. Management of the residues may be an important consideration in determining where and at what scale the tests are to be conducted.

Quality assurance/quality control plans will be reviewed to determine any special requirements necessary for each individual treatability study. Special consideration will be given to the ability to detect and reliably measure contaminants at the concentrations required by the criteria, as well as the potential for contamination of samples during collection, storage, and analysis.

Health and safety plans will be reviewed to determine whether any special training or procedures will be needed. Health and safety considerations will be given to both waste handling and test operations.

The information gathered during the literature search and the development of individual treatability study plans will be used to assemble a comprehensive treatability investigation work plan. This plan also will be used to supplement this 300-FF-5 Work Plan, the Sampling and Analysis Plan, and the Health and Safety Plan, where appropriate. The comprehensive treatability investigation work plan will include a description of the technology, background on site information relevant to each technology requiring a treatability study, and documentation of missing data. The comprehensive treatability investigation work plan will contain the following types of information:

- project description and site background
- summary of individual treatability studies
- schedule
- cost.

The project description and site background section will summarize appropriate information on site characteristics, contaminant levels, allowable levels, and the remedial action alternatives that are relevant to the technologies being investigated in the treatability study. The section summarizing treatability tests will contain brief descriptions of each test, including the approximate scale of the test (bench or pilot scale), and whether there are any special requirements for the test that could impact the overall schedule for the plan. A preliminary cost estimate will be generated by fiscal year based on the schedule and expected cost for conducting each test.

A separate plan also will be prepared for each treatability study and will provide the detail necessary for conducting the tests. Each plan will include the following sections:

- project description and site background
- remediation technology description
- test objectives
- description of equipment and materials
- test procedures
- test plan for parameters to be tested
- sampling plan
- analytical methods
- data management
- data analysis and interpretation
- reporting of results
- health and safety
- quality assurance
- residuals management
- schedule
- cost.

Each of these sections will incorporate documentation of the information developed during the previous activities as described above.

5.6.2 Treatability Investigation Implementation

Implementation of the individual treatability study plans will generally begin following approval of the comprehensive treatability investigation plan. Each individual plan will be prepared and implemented according to the comprehensive plan schedule. Some of the activities involved in preparing individual treatability study plans will need to be conducted during the development of the comprehensive plan for cases where they are expected to have a significant impact on the schedule or costs. Such activities include acquiring site characterization data or large samples of groundwater, establishing lead times for procurement of major equipment, and identifying special permitting requirements. These activities will be identified and specific activities carried out when approved.

5.6.3 Task 3--Remedial Investigation Report

The results of the individual treatability studies will be documented in the remedial investigation report for each treatability study conducted. The remedial investigation report will include the following types of information:

- description of the technology
- key parameters needed to evaluate the technology
- objectives of the treatability study
- equipment, test procedures, and methods of measurement of key parameters
- test procedure
- test results
- interpretation of test results
- conclusions.

The first five sections of the remedial investigation report will simply be composed of the corresponding sections in the respective treatability study work plans. The test results section will present the test data obtained and will summarize the overall performance of the tests. The section on interpretation of test results will present the data in a reduced form, as necessary, to predict the performance of the technology if it were applied on a full scale to the waste or waste sites. In addition, the section will discuss the uncertainties related to instrument accuracy and detection limits. The conclusions section will summarize the impacts and uncertainties of the results on the performance and design requirements of the technology for its application to the 300-FF-5 operable unit. This section also will draw conclusions regarding any pretreatment or posttreatment requirements that are expected and that may affect the requirements or performance of other technologies that would be combined in a remedial action alternative.

5.7 PHASE III FEASIBILITY STUDY-- REMEDIAL ALTERNATIVES ANALYSIS

On completion of all treatability studies and acquisition of all necessary site characterization data, each alternative will be fully developed based on all available information. An independent detailed analysis of each alternative will then be conducted against specific criteria (e.g., ability to meet cleanup objectives in a prescribed time frame). Finally, a comparison of all alternatives will be made to evaluate the relative performance of all the alternatives for each evaluation criterion. These activities will be accomplished in the following three tasks.

5.7.1 Task 1--Definition of Remedial Alternatives

Those alternatives that were identified during the initial screening phase will be reviewed and further developed, as appropriate, to allow consistent application of evaluation criteria for each technology. Factors that will be addressed in this task include the following:

- changes in the volume or nature of contaminated media identified through additional site characterization
- changes in the combinations of technologies comprising each alternative, based on treatability data that indicate different performance than expected and thus requiring the addition, removal, or substitution of specific technologies in the alternatives
- changes in the capacities and sizes of specific equipment to be used to achieve the desired objectives of the alternative.

The information developed to further refine each alternative will consist of integrated process flow diagrams and flowsheets, preliminary design calculations based on parameters determined from treatability studies, and literature and preliminary site layouts, as appropriate. All alternatives will be composed of combinations of media-specific alternatives needed to address the entire 300-FF-5 operable unit. All assumptions, uncertainties, and constraints identified for each alternative will be defined.

5.7.2 Task 2--Detailed Analysis of Remedial Alternatives

This task will be conducted in the manner described in Section 5.7.2 of the 300-FF-1 Work Plan.

5.7.3 Task 3--Comparison of Remedial Alternatives

This task will be conducted in the manner described in Section 5.4.3 of the 300-FF-1 Work Plan, except that the combination of media-specific alternatives will be accomplished in Task 1, as described in Section 5.7.1 herein.

5.7.4 Task 4--Feasibility Study Report

This task will be conducted in the manner described in Section 5.7.4 of the 300-FF-1 Work Plan.

6.0 PROJECT SCHEDULE

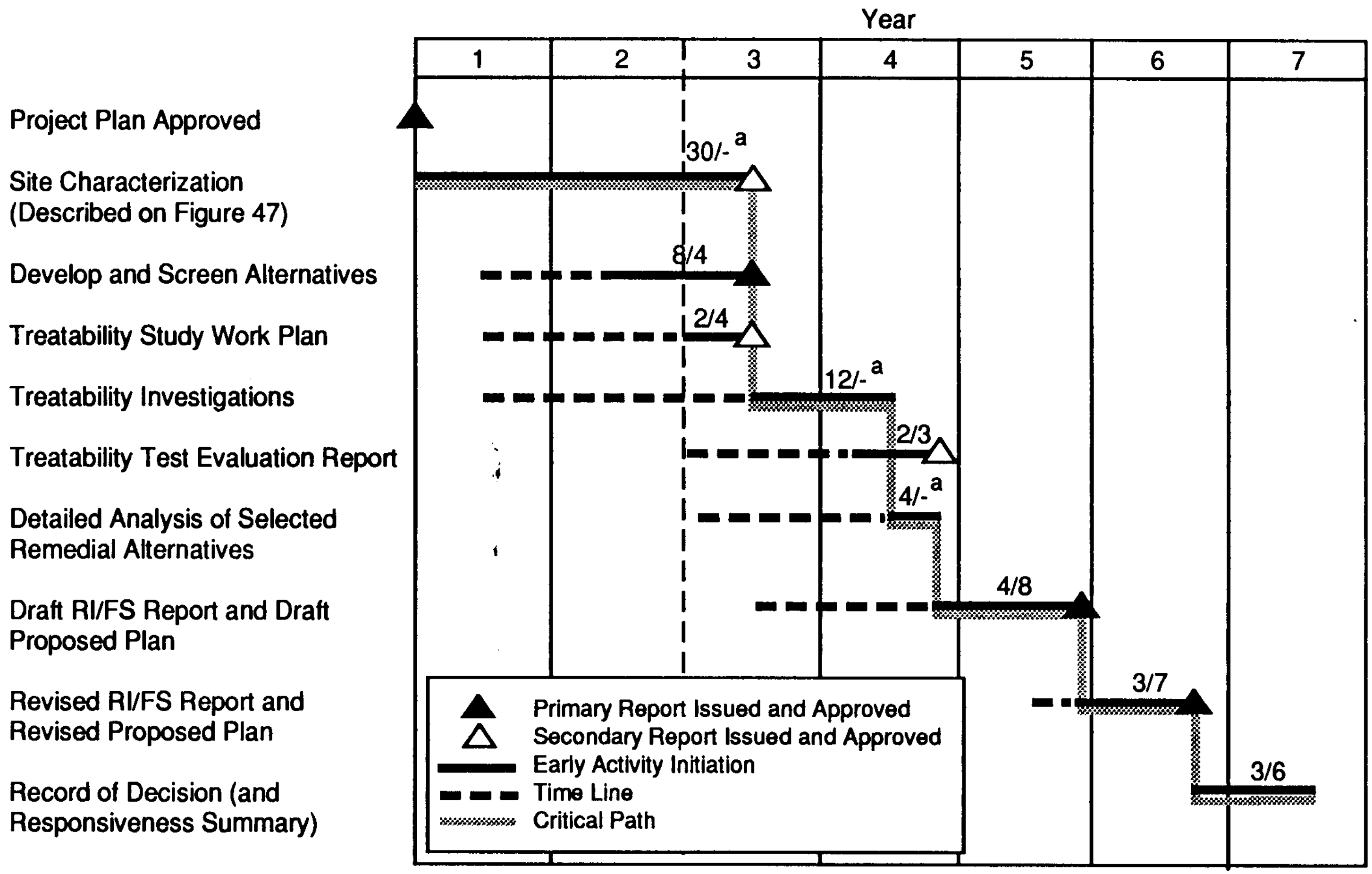
The overall schedule for the 300-FF-5 operable unit is shown in Figure 46. The schedule summarizes the basic remedial investigation, treatability studies, feasibility study, and reports that support a Record of Decision. Two sets of numbers, separated by a slash (/), are given for each activity: the first number is the estimated number of months needed for accomplishing the technical work, including report writing, and the second number is the review and revision period (also in months) for a primary or secondary report. These reports are those support documents identified in the Tri-Party Agreement (1989). Overall, the review period varies between 6 and 8 mo for a primary report and 3 to 4 mo for a secondary report. The institutional involvement during these reviews is report specific and is based on a combination of the following sequenced activities:

- DOE Field Office review
- document revision
- DOE Headquarters review
- document revision
- EPA/state review
- document revision
- document held for dispute resolution
- document printing and issuance
- public review.

Figure 46 also displays the critical path. While a few months' flexibility can exist along this path, it is important to recognize that a basic sequencing of activities is a natural part of the CERCLA process. For example, a significant amount of site characterization data must be collected before the development and screening of remedial alternatives are possible or the treatability studies begin in earnest. In like manner, the detailed analysis of remedial alternatives depends on having completed the site characterization, treatability investigation, and remedial alternative screening activities. Drafting and finalizing the RI/FS reports, Proposed Plan, Record of Decision, and Responsiveness Summary take up the remaining schedule.

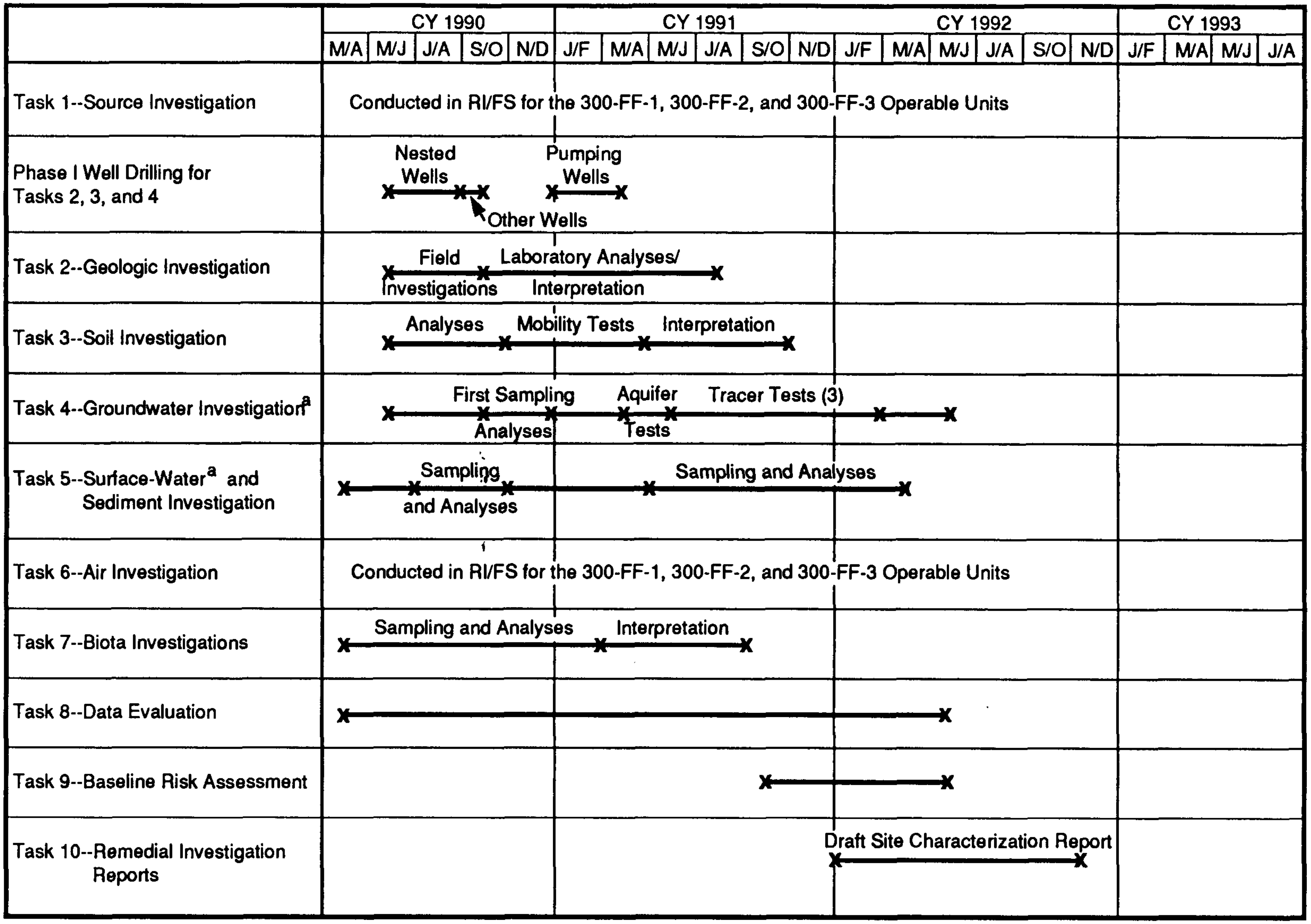
The overall schedule shown in Figure 46 should be viewed as an initial planning effort. This is because many variables exist that could impact the schedule, including resource commitments, site characterization findings, availability of suitable treatability data, dispute resolution processes, plus Federal/state/public interactions.

Figure 47 summarizes the principal soil, groundwater, surface-water and sediment, air, and biota investigations to be conducted over the 30-mo site characterization. As characterization findings develop, then the treatability studies (work plan, investigations, and evaluation report) and feasibility study (remedial alternative development, screening, and detailed analyses) can be planned in detail. Presently, Chapter 5.0 of this work plan addresses the basic tasks to be completed in support of treatability and feasibility studies. Once site characterization is under way, specific task schedules can then be developed.



NOTE: 8/4 = 8 mo technical work; 4 mo review, revision, etc.
[a] Results issued in Draft Remedial Investigation/Feasibility /Study (RI/FS) Report.

Figure 46. General Activity Schedule Supporting the Record of Decision for the 300-FF-5 Operable Unit.



NOTE: The scheduling of activities within each task will vary based on resource allocations, study findings, and institutional agreements. S8907022.C

[a]Water-level measurements are collected throughout task duration.

RI/FS = Remedial Investigation/Feasibility Study.

Figure 47. Preliminary Proposed Schedule for Implementing Remedial Investigations Within the 300-FF-5 Operable Unit.

7.0 PROJECT MANAGEMENT

Administrative control of the 300-FF-5 operable unit RI/FS is described in Attachment 5--Project Management Plan of the 300-FF-1 Work Plan. That plan describes measures to control project files, costs and schedules, correspondence, and meetings.

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ATTACHMENT 1

SAMPLING AND ANALYSIS PLAN FOR THE 300-FF-5 OPERABLE UNIT

ATTACHMENT 1

SAMPLING AND ANALYSIS PLAN FOR THE 300-FF-5 OPERABLE UNIT

This Sampling and Analysis Plan generally addresses the sampling goals, methods to reach these goals, sampling locations, sampling frequency, and protocols. Specific sampling locations and frequencies and several environmental investigation instructions required to begin field operations will be developed. It is inappropriate to attempt to include completely independent Field Sampling and Quality Assurance Project Plans at this planning stage that provide for all necessary and presently unknown investigative contingencies and options. Specific and detailed plans for each investigation will be written before sampling begins.

This Sampling and Analysis Plan for the 300-FF-5 operable unit contains the Field Sampling Plan (Part 1) and the Quality Assurance Project Plan (Part 2). The Field Sampling Plan is composed of field sampling activities described in Section 5.3 of the 300-FF-5 Work Plan. Listed below are the tasks that contain field sampling activities. Only those activities with an identified field component in the 300-FF-5 Work Plan are included in the Field Sampling Plan. The Quality Assurance Project Plan discusses the quality control and quality assurance practices during the remedial investigation.

Work plan section	Task	Title
5.3.2	2	Geologic investigation
5.3.3	3	Soil investigation
5.3.4	4	Groundwater investigation
5.3.5	5	Surface-water and sediment investigation
5.3.7	7	Biota investigations

PART 1

FIELD SAMPLING PLAN

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LIST OF FIGURES

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PART 1

FIELD SAMPLING PLAN

1.0 TASKS 2, 3, AND 4--GEOLOGY, SOIL, AND GROUNDWATER INVESTIGATIONS

1.1 DRILLING, SOIL SAMPLING, AND WELL INSTALLATION

1.1.1 Sampling Objectives

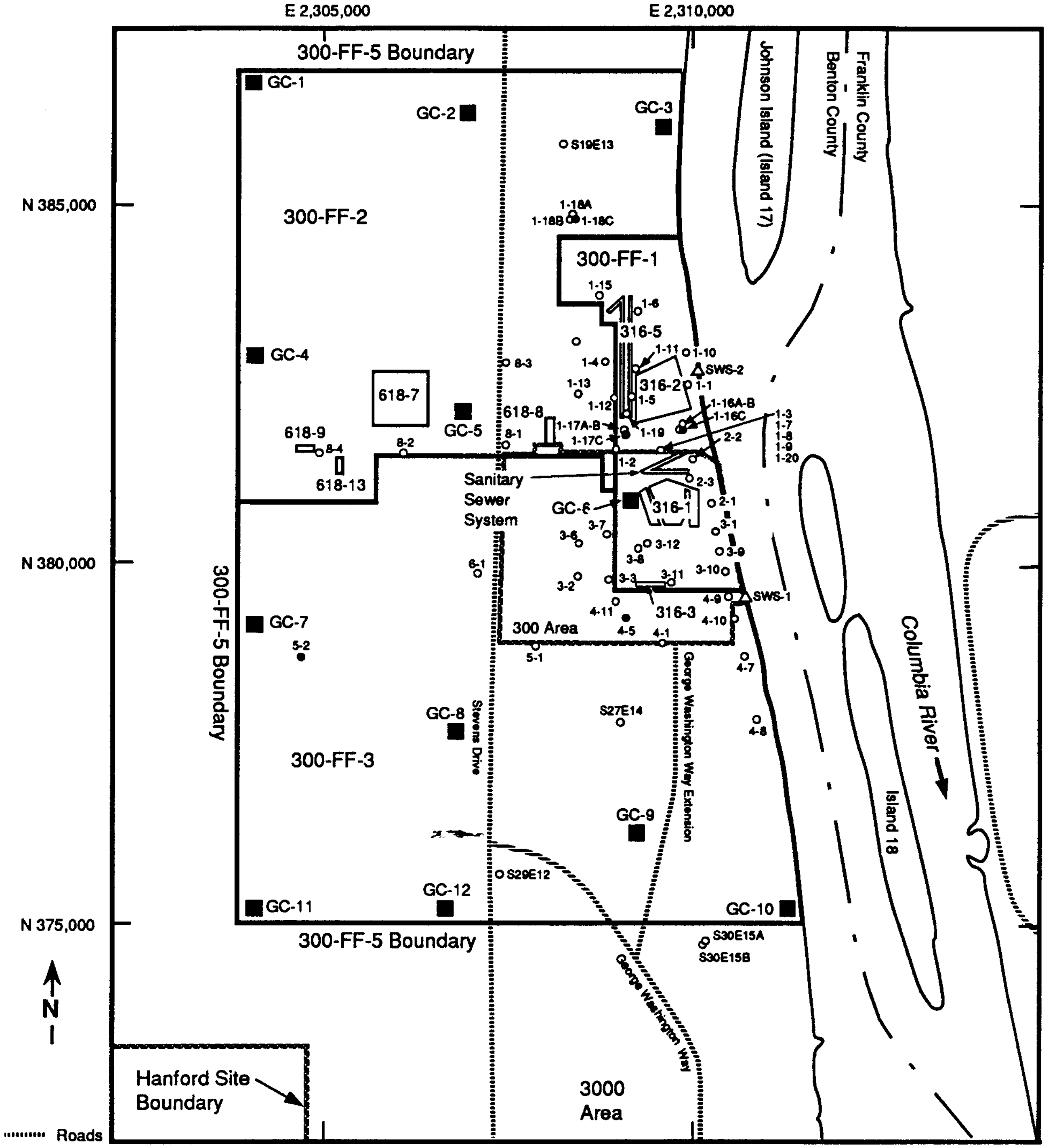
The purposes of these tasks are to drill and install groundwater monitoring wells. During the drilling phase, sediment samples will be collected and analyzed for selected physical properties and chemical constituents listed in Table 29 in the 300-FF-5 Work Plan. There will be three phases of drilling, as described in Task 4--Groundwater Investigation (Section 5.3.4 of the 300-FF-5 Work Plan).

1.1.2 Sample Locations and Frequencies

Locations of boreholes and wells to be drilled in Phase I are shown in Figures 1 and 2. Well design and sampling data are presented in Table 1, and Figure 3 presents the monitoring well designs for the three design types used in this project. Water-level monitoring wells are shown in Figure 4. Sampling frequencies are given in Table 2. The rationale for the location of proposed sample locations and frequencies is presented in Section 5.3.4 of the 300-FF-5 Work plan. Sampling frequencies for geologic samples are presented in Tables 31 and 32 of the 300-FF-5 Work Plan.

1.1.3 Sample Designations

Wells will be designated in accordance with the system currently in use at the Hanford Site (McGhan et al. 1985). The following codes will be used to designate soil samples: XX.X to the nearest tenth of a foot of depth penetration, where X is a variable number; MS = metals and radiation analysis; AS = nonmetallic ion analysis; VS = volatile organics analysis; TS = physical analysis; LB = samples for laboratory adsorption-desorption tests; and R = archive. These codes will be combined to provide designations such as 15.0-MS.



○ 1-12	Well Location and Number (Wells Prefixed by 399- or 699- as Appropriate)
△ SWS-1	Surface-Water Monitoring Station
○	Unconfined Aquifer Well
●	Confined Aquifer Well
■	New Geologic Characterization Borehole

Figure 1. Locations of Proposed Geologic Characterization Boreholes.

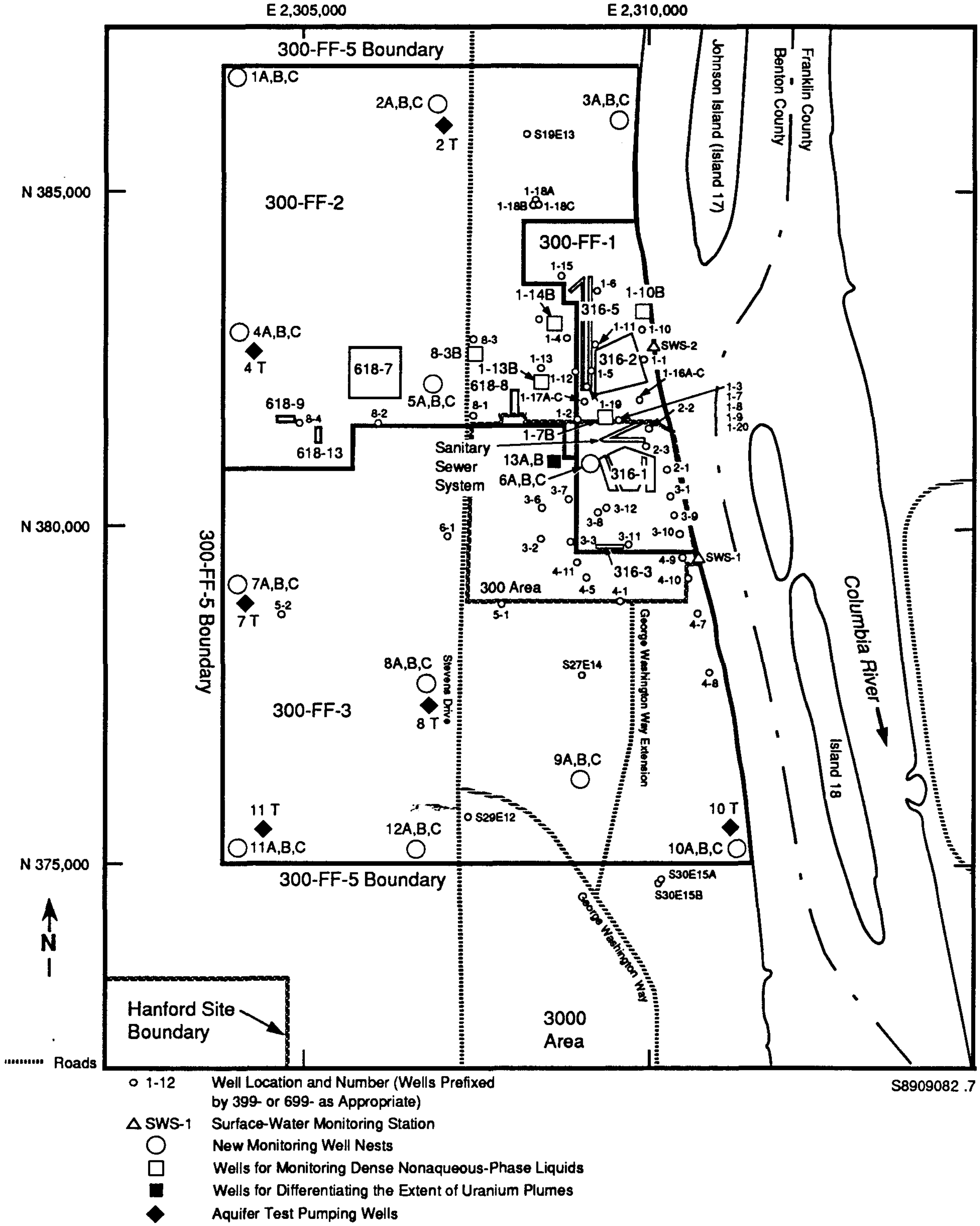


Figure 2. Proposed Locations and Primary Purposes for Phase I Monitoring Wells and Aquifer Test Pumping Wells.

Table 1. Detailed Borehole, Groundwater Monitoring, and Test Well Design and Rationale for Phase I. (Sheet 1 of 6)

Proposed monitoring well	Aquifer/ zone examined	Construction material[a]	Estimated screened interval [depth[b] (elevation) in feet below land surface]	Estimated screen length in feet and slot size[c]	Estimated total depth to be drilled (ft)	Primary (underlined) and other purposes[d] of monitoring wells	Proposed drilling technique[e]	Physical testing[f]	Water chemistry testing[g]
GC-1	Unconfined	Temporary carbon steel	NA	NA	120	NA	B	See wells with "C" suffix	None
GC-2	"	NA	NA	NA	120	NA	B	"	"
GC-3	"	NA	NA	NA	115	NA	B	"	"
GC-4	"	NA	NA	NA	110	NA	B	"	"
GC-5	"	NA	NA	NA	120	NA	B	"	"
GC-6	"	NA	NA	NA	112	NA	B	"	"
GC-7	"	NA	NA	NA	110	NA	B	"	"
GC-8	"	NA	NA	NA	120	NA	B	"	"
GC-9	"	NA	NA	NA	125	NA	B	"	"
GC-10	"	NA	NA	NA	120	NA	B	"	"
GC-11	"	NA	NA	NA	115	NA	B	"	"
GC-12	"	NA	NA	NA	120	NA	B	"	"

Table 1. Detailed Borehole, Groundwater Monitoring, and Test Well Design and Rationale for Phase I. (Sheet 2 of 6)

Proposed monitoring well	Aquifer/ zone examined	Construction material[a]	Estimated screened interval [depth[b] (elevation) in feet below land surface]	Estimated screen length in feet and slot size[c]	Estimated total depth to be drilled (ft)	Primary (underlined) and other purposes[d] of monitoring wells	Proposed drilling technique[e]	Physical testing[f]	Water chemistry testing[g]
1A	Top of unconfined	SS or FRE	50 to 65 (345 to 330)	15, #20	See wells with "C" suffix	<u>A</u>, B, G, I	A, D	See wells with "C" suffix	A, B, C
2A	"	"	40 to 55 (345 to 330)	15, #20	"	<u>A</u>, B, G, I	A, D	"	A, B, C
3A	"	"	30 to 45 (340 to 325)	15, #20	"	<u>A</u>, B, G	A, D	"	A, B, C
4A	"	"	35 to 50 (345 to 330)	15, #20	"	<u>A</u>, B, G, I	A, D	"	A, B, C
5A	"	"	45 to 60 (345 to 330)	15, #20	"	<u>A</u>, B, G	A, D	"	A, B, C, D
6A	"	"	50 to 65 (345 to 330)	15, #20	"	<u>A</u>, F, B, H	A, D	"	A, B, C, D
7A	"	"	35 to 50 (345 to 330)	15, #20	"	<u>A</u>, B, F, G, I	A, D	"	A, B, C
8A	"	"	40 to 55 (345 to 330)	15, #20	"	<u>A</u>, B, F, G, I	A, D	"	A, B, C
9A	"	"	45 to 60 (345 to 330)	15, #20	"	<u>A</u>, B, F	A, D	"	A, B, C
10A	"	"	40 to 55 (345 to 330)	15, #20	"	<u>A</u>, B, F, G	A, D	"	A, B, C
11A	"	"	30 to 45 (350 to 335)	15, #20	"	<u>A</u>, B, F, G, I	A, D	"	A, B, C
12A	"	"	40 to 55 (350 to 335)	15, #20	"	<u>A</u>, B, F, G, I	A, D	"	A, B, C

Table 1. Detailed Borehole, Groundwater Monitoring, and Test Well Design and Rationale for Phase. (Sheet 3 of 6)

Proposed monitoring well	Aquifer/ zone examined	Construction material[a]	Estimated screened interval [depth[b] (elevation) in feet below land surface]	Estimated screen length in feet and slot size[c]	Estimated total depth to be drilled (ft)	Primary (underlined) and other purposes[d] of monitoring wells	Proposed drilling technique[e]	Physical testing[f]	Water chemistry testing[g]
1B	Bottom of unconfined	SS or FRE	110 to 120 (280 to 270)	10, #8	See wells with "C" suffix	<u>A</u>, C, E, G, I, J	A, D	See wells with "C" suffix	A, B, C
2B	"	"	110 to 120 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, I, J	A, D	"	A, B, C
3B	"	"	105 to 115 (275 to 265)	10, #8	"	<u>A</u>, C, E, G, J	A, D	"	A, B, C
4B	"	"	100 to 110 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, I, J	A, D	"	A, B, C
5B	"	"	110 to 120 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, J	A, D	"	A, B, C, D
6B	"	"	102 to 112 (275 to 265)	10, #8	"	<u>A</u>, C, E, G, H, J	A, D	"	A, B, C, D
7B	"	"	100 to 110 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, I, J	A, D	"	A, B, C
8B	"	"	110 to 120 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, I, J	A, D	"	A, B, C
9B	"	"	115 to 125 (275 to 265)	10, #8	"	<u>A</u>, C, E, G, J	A, D	"	A, B, C
10B	"	"	110 to 120 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, J	A, D	"	A, B, C
11B	"	"	105 to 115 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, I, J	A, D	"	A, B, C
12B	"	"	110 to 120 (280 to 270)	10, #8	"	<u>A</u>, C, E, G, I, J	A, D	"	A, B, C

Table 1. Detailed Borehole, Groundwater Monitoring, and Test Well Design and Rationale for Phase I. (Sheet 4 of 6)

Proposed monitoring well	Aquifer/ zone examined	Construction material[a]	Estimated screened interval [depth[b] (elevation) in feet below land surface]	Estimated screen length in feet and slot size[c]	Estimated total depth to be drilled (ft)	Primary (underlined) and other purposes[d] of monitoring wells	Proposed drilling technique[e]	Physical testing[f]	Water chemistry testing[g]
1C	Confined	SS or FRE	140 to 200 (200 to 190)	10, #10	202	A, D, G, I, J	A, D	Y	A, B, C
2C	"	"	180 to 190 (200 to 190)	10, #10	192	A, D, G, I, J	A, D	Y	A, B, C
3C	"	"	170 to 180 (200 to 190)	10, #10	182	A, D, G, J	A, D	Y	A, B, C
4C	"	"	170 to 180 (210 to 200)	10, #10	182	A, D, G, I, J	A, D	Y	A, B, C
5C	"	"	170 to 180 (220 to 210)	10, #10	182	A, D, G, J	A, D	Y	A, B, C
6C	"	"	170 to 180 (225 to 215)	10, #10	182	A, D, G, J	A, D	Y	A, B, C
7C	"	"	180 to 190 (200 to 190)	10, #10	192	A, D, G, J	A, D	Y	A, B, C
8C	"	"	190 to 200 (195 to 185)	10, #10	202	A, D, G, J	A, D	Y	A, B, C
9C	"	"	190 to 200 (200 to 190)	10, #10	202	A, D, G, J	A, D	Y	A, B, C
10C	"	"	190 to 200 (195 to 185)	10, #10	202	A, D, G, J	A, D	Y	A, B, C
11C	"	"	180 to 190 (200 to 190)	10, #10	192	A, D, G, J	A, D	Y	A, B, C
12C	"	"	190 to 200 (200 to 190)	10, #10	202	A, D, G, J	A, D	Y	A, B, C

Table 1. Detailed Borehole, Groundwater Monitoring, and Test Well Design and Rationale for Phase I. (Sheet 5 of 6)

Proposed monitor-ing well	Aquifer/ zone examined	Construction material[a]	Estimated screened interval [depth[b] (elevation) in feet below land surface]	Estimated screen length in feet and slot size[c]	Estimated total depth to be drilled (ft)	Primary (under-lined) and other purposes[d] of monitoring wells	Proposed drilling technique[e]	Physical testing[f]	Water chemistry testing[g]
13A	Top of unconfined	SS or FRE	50 to 65 (345 to 330)	15, #20	67	E, B, F, H	A, C, or E	N	A, B, C, D
13B	Bottom of unconfined	"	100 to 110 (295 to 285)	10, #8	112	E, C, J	A, C, or E	S	A, B, C, D
1-7B	"	"	110 to 120 (273 to 263)	10, #8	122	E, C, J	A, C, or E	S	A, B, C, D
1-10B	"	"	100 to 110 (272 to 262)	10, #8	112	E, C, J	A, C, or E	S	A, B, C, D
1-13B	"	"	110 to 120 (275 to 265)	10, #8	122	E, C, J	A, C, or E	S	A, B, C, D
1-14B	"	"	105 to 115 (275 to 265)	10, #8	117	E, C, J	A, C, or E	S	A, B, C, D
8-3B	"	"	110 to 120 (282 to 272)	10, #8	122	E, C, J	A, C, or E	S	A, B, C, D
2T	Bottom of unconfined aquifer	Carbon steel with stainless steel tele-scoping well screen	60 to 120 (330 to 270)	60, #10-50	120	L	E	NA	None; use adjacent well nest data
4T	"	"	40 to 110 (350 to 280)	70, #10-50	110	L	E	"	"
7T	"	"	40 to 185 (340 to 270)	70, #10-50	110	L	E	"	"
8T	"	"	50 to 120 (340 to 270)	70, #10-50	120	L	E	"	"
10T	"	"	50 to 120 (340 to 270)	70, #10-50	120	L	E	"	"
11T	"	"	42 to 112 (335 to 265)	70, #10-50	112	L	E	"	"

Table 1. Detailed Borehole, Groundwater Monitoring, and Test Well Design and Rationale for Phase I. (Sheet 6 of 6)

NOTE: Test wells will have 30 ft of 20-in.-diameter temporary conductor casing for the purpose of providing a surface seal. The actual test well shall consist of 16-in.-diameter driven steel casing (A53, Grade B) with a drive shoe. The screened interval shall be determined by the project geohydrologist, but probably will be screened the entire length of the unconfined aquifer. The screen shall consist of 16-in.-diameter telescoping stainless steel wire-wrap well screen, with variable slot sizes (from 10 to 20 slot, depending on the grain size of the formation material). The screen will be exposed by pulling back the 16-in.-diameter carbon steel casing. The top of the screen will be approximately 5 to 10 ft below the top of the aquifer to eliminate problems with cascading water during pumping.

[a]All monitoring wells will be 2.0-in.-inside-diameter casing and screen with flush threads conforming to F480 (ASTM 1988a) thread dimensions for schedule-40 well casing and monitoring pipe. SS = All monitoring wells will be constructed of either 316 (or 304) stainless steel schedule-40 casing and equivalent wire-wrap screen. FRE = Schedule-40 fiberglass-reinforced epoxy casing and 316 stainless steel well screen. All screened sections shall have welded bottom caps or plates. Seals across the M3 confining layer shall consist of a rigid seal, such as a high-solids bentonite or a cement grout slurry composed of water mixed with Portland cement (C150; ASTM 1988b) with 1% to 3% (by volume) sodium bentonite, bounded by 2- to 5-ft-thick layers of high-solids bentonite in the form of viscous slurries or bentonite pellets or large chips. Seals between A- and B-suffix wells shall be composed of bentonite slurries and pellets, chips, or bentonite sleeves, where practical. Bentonite pellets placed below the water table shall be placed through a 2-in.-diameter polyvinyl chloride pipe tremie. Surface seals at least 10 ft above the water-table surface shall be a cement grout slurry like that placed opposite the M3 layer.

[b]The feet below ground surface designation is subject to change, based on field observations of geologic strata penetrated.

[c]Slot size may vary, depending on grain-size distribution of unit penetrated. Filter pack required: #8 slot channel pack screen should contain 40- to 60 mesh quartz sand and be packed outside with 10- to 20-mesh sand; #10 slot screen use 10- to 20- or 16- to 30-mesh, rounded quartz sand; #20 slot screen use 10- to 20 or 8- to 12-mesh sieve size rounded quartz sand. All filter pack will be installed at least 2 ft above the top of the screen. In addition, a secondary filter will be placed on the filter pack and will consist of a 0.5- to 1.0-ft layer of 20- to 40-mesh sand, and upon it a 0.5- to 1.0-ft-thick layer of 40- to 140-mesh sand.

[d]A = Water quality sampling point and continuous geologic log of the M3 and underlying sediments.
B = Define flow direction in top of unconfined aquifer and hydraulic head.
C = Define flow direction in bottom of the unconfined aquifer and hydraulic head.
D = Define flow direction in the confined aquifer and hydraulic head.
E = Determine the extent of trichloroethene and 1,2-dichloroethene in the bottom of the unconfined aquifer and possible presence of dense nonaqueous-phase liquids.
F = Differentiate between multiple sources of uranium contamination.
G = Define plumes entering the 300-FF-5 operable unit.
H = Use as tracer test sampling well.
I = Observation well for aquifer tests during Phase I.
J = Slug test well.
K = Continuous geologic log from ground surface to the top of the M3 layer.
L = Pumping well for aquifer tests.

[e]A = Becker with casing driven into M3 layer.
B = Becker with driven casing to the top of the Ringold Formation; then mud rotary wireline core.
C = Becker without driven casing in the unconfined aquifer only.
D = Cable tool (both core barrel and hard tool) with driven casing through M3 layer and basalt only.
E = Cable tool (both core barrel and hard tool) with driven casing through unconfined aquifer only.

[f]See Section 5.3.2 in the 300-FF-5 Work Plan for proposed sampling. Y = Yes; N = No; S = Some limited testing.

[g]A = Water chemistry testing during the first round of sampling of all new wells will consist of the WAC 9903 list. Many existing wells also will be tested to provide a complete picture of the distribution of constituents in the 300-FF-5 operable unit.
B = Special sampling, in addition to the WAC 9903 list, will include for all wells isotopic analyses of uranium to differentiate between sources of uranium in the 300-FF-5 operable unit.
C = High-sensitivity volatile organic analyses by gas/electron chromatography and gas chromatography/flame ionization detection to determine the extent and possible source areas of trichloroethene and 1,2-dichloroethene.
D = Tracer sampling of bromide to determine contaminant pathways and rate of transport. Primarily existing wells will be used.

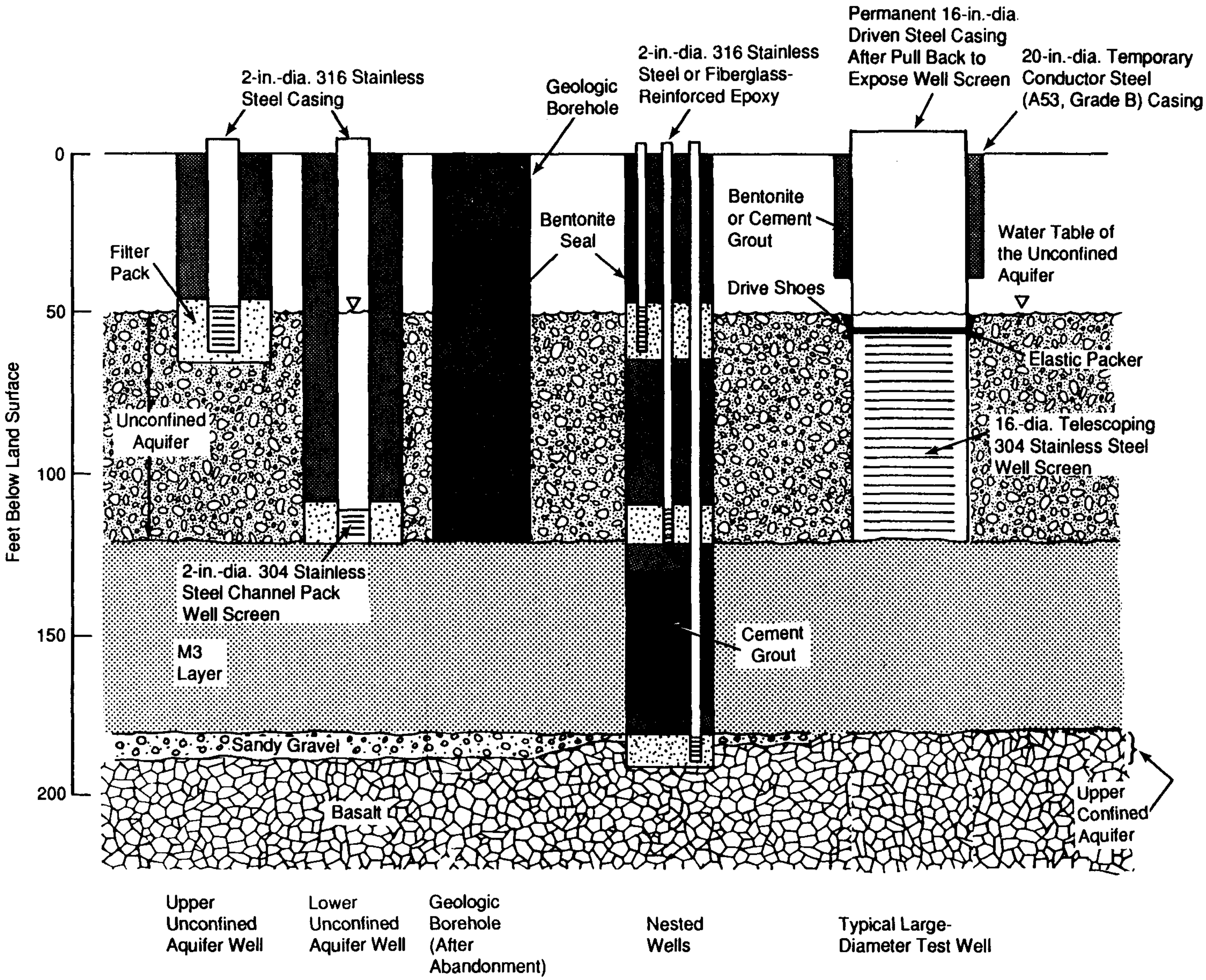


Figure 3. Designs for Monitoring Wells to be Constructed in the 300-FF-5 Operable Unit During Phase I.

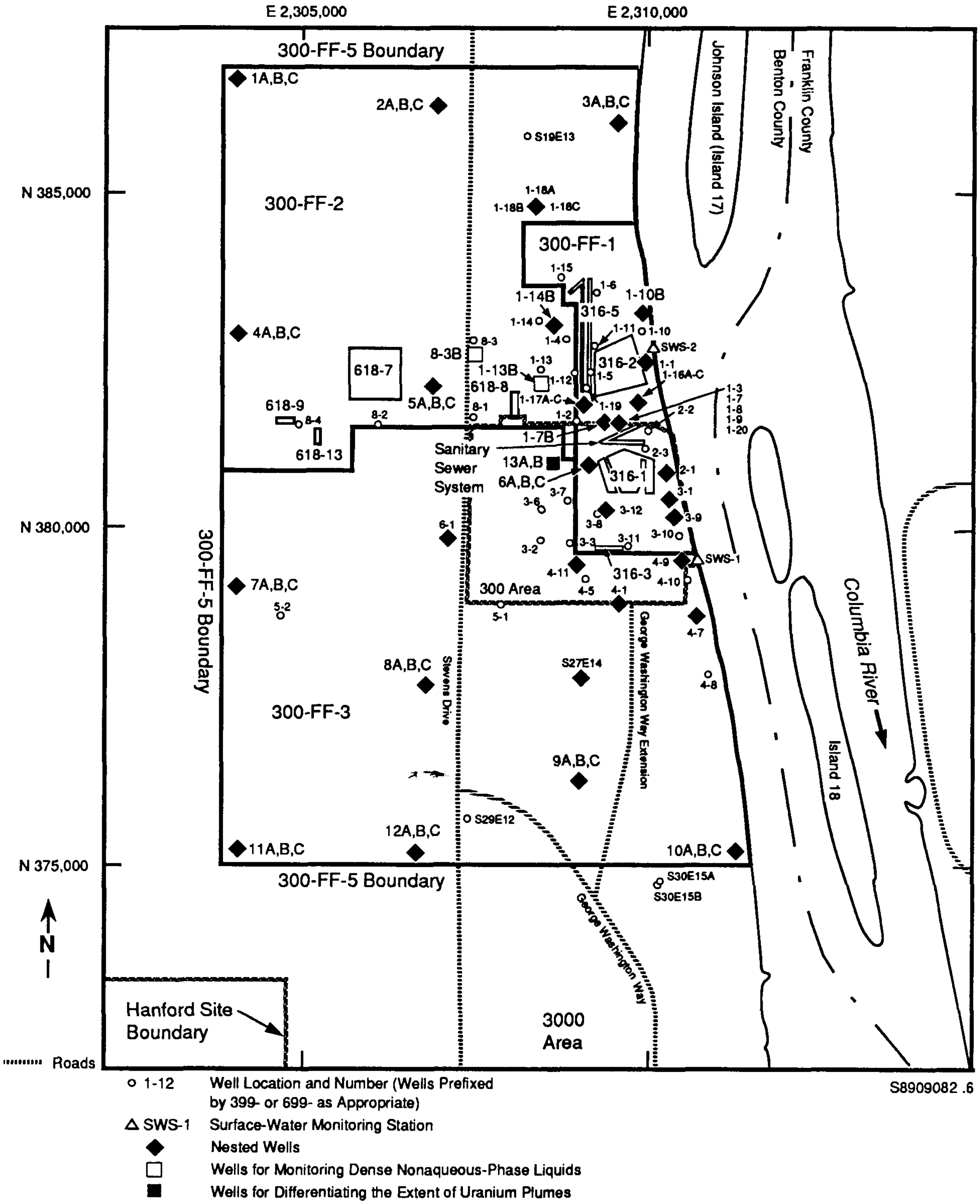


Figure 4. Proposed Locations for Phase I Water-Level Monitoring Wells.

Table 2. Sampling Parameters for Subsurface Geologic Drilling in the 300-FF-5 Operable Unit.

Geologic formation	
Pathway	Source → soil → groundwater → surface water
Type of sample	Drilling sediment
Locations	Phase I well sites
Number of samples (estimated)	720 (160 analyzed, 560 archived)
Constituents	Various (lithology, physical parameters, geochemistry, contaminants)
Frequency	Collected for each well at 5-ft-depth intervals and at stratigraphic changes

1.1.4 Sampling and Equipment Procedures

All drilling, sampling, field screening analyses, and installations shall be performed in accordance with approved procedures, as described in Part 2--Quality Assurance Project Plan. Drilling to obtain high-quality samples for characterizing the geologic and hydrologic characteristics of sediment and rock will consist of 12 boreholes (see Figure 1). These 12 boreholes will be drilled by the air-rotary (e.g., Becker) method or an approved equal through the Hanford formation. Sampling will consist of cuttings collected at the surface. The samples will be disturbed. After penetrating the Hanford formation, temporary, threaded or welded 4-in.-diameter casing will be set inside the 6-in.-inside-diameter air-rotary drill pipe. A thick bentonite slurry will be tremied into the annulus between the inside of the drill pipe and the 4-in. casing in 10-ft lifts as the drill pipe is progressively pulled out of the borehole. The bentonite slurry will serve as a seal to minimize fluid losses during subsequent mud rotary drilling, and will facilitate easy removal of the 4-in. casing after drilling and sampling are completed. After all of the drill pipe has been removed and the annular space sealed, mud rotary drilling with continuous wireline core sampling will continue through the fine- to coarse-grained Ringold Formation to the top of the M3 layer but will not penetrate it. (See Section 2.2.2 in the 300-FF-5 Work Plan for a discussion of the M3 layer.) Wireline core sampling is proposed to obtain undisturbed samples for laboratory analysis (see Section 5.3.2.3 of the 300-FF-5 Work Plan). Once the M3 layer is encountered, coring will cease. The core sampling assembly will be removed, and a high-solids (at least 20%) bentonite grout will be pumped into the drill as it is pulled out. This will seal the borehole up to the bottom of the 4-in. casing. The remaining wireline drill rod will be removed, and a tremie pipe will be set into the well near the bottom of the 4-in. casing. Then, as the 4-in. casing is removed, more high-solids bentonite grout will be pumped through the tremie pipe to fill the void inside the 4-in. casing. At the surface, a small-diameter, 2-ft-deep, concrete marker will be placed at ground surface, with a brass monument marker set into the concrete. These 12 geologic characterization boreholes will each be located approximately 25 ft downgradient of the each of the 12 new groundwater nested monitoring well locations (see Figure 2).

Each of these nested well locations, in conjunction with the nearby characterization boreholes, will serve as a reference source for geology, water chemistry, and hydrology in the 300-FF-5 operable unit. The nested wells will be logged, instrumented, and sampled.

These 12 nested well boreholes will be completed with three 2-in.-inside-diameter monitoring wells in each borehole. Installation of these monitoring wells and sampling of these boreholes will be accomplished in the following manner. The wells will be drilled by the air-rotary (e.g., Becker) method with continuously driven temporary casing or an approved equal through the coarse sediments of the Hanford and Ringold Formations to the top of the M3 layer. Sampling will consist of cuttings collected at the surface. The samples will be disturbed, but the basic character of the sediments will be identifiable and correlatable with the nearby characterization boreholes. After penetrating to the top of the M3 layer, the temporary casing will be driven at least 5 ft into the M3 layer. If the M3 layer is not present and basalt is encountered instead, then drilling must cease, and only two 2-in.-diameter monitoring wells will be constructed in the borehole.

If the M3 layer is present, the air-rotary drill rod and bit will be withdrawn from the borehole. The water shall be pumped from inside the 12-in. casing to prevent contamination of the confined aquifer and to determine if an adequate seal had been achieved by drilling into the M3 layer. If an adequate seal has been achieved, the water level in the well should rise at less than a few inches an hour. If no leakage is apparent, then drilling can proceed; if not, a bentonite slurry (approximately 5 gal) must be tremied into the borehole and the casing driven an additional 2 to 3 ft into the M3 layer, then tested again. Within the 12- to 14-in.-diameter casing still in the borehole, an 8-in. casing will be set, and drilling will continue through the M3 layer using the cable-tool method. Sampling of the M3 layer will be accomplished by either continuous core barrel drilling or split-barrel sampler. The 8-in. casing will be driven to the top of basalt. Drilling will continue approximately 10 ft into the upper basalt flow. Drill cuttings of the basalt will be collected and analyzed by X-ray fluorescence to distinguish between the Goose Island and Martindale flows. If the Goose Island flow is encountered first and the water level in the well is not substantially higher than the unconfined aquifer, drilling will continue into the basalt until the permeable flow top of the Martindale flow is encountered. If the Martindale flow is encountered, drilling will stop.

After drilling to the desired total depth, a 6- to 12-in. layer of filter pack will be placed in the bottom of the borehole to form the granular envelope around the well screen. Next, a 10-ft section of 2-in.-inside-diameter, 304 or 316 stainless steel well screen or channel pack will be set in the borehole and backfilled with the appropriate size filter pack to at least 2 ft above the top of the screen (see Table 1 footnotes). The 2-in.

casing above the screen must be capped at the surface during all completion operations to prevent filter pack and other materials from entering the inside of the 2-in. casing. A 1-ft-thick finer grained secondary filter material will be placed on top of the filter pack. This fine sand, if set opposite the overlying M3 layer, will form an effective barrier to the migration of bentonite slurries into the filter pack. After placing the secondary filter, a 6- to 12-in. layer of bentonite pellets should be tremied to the top of the secondary filter material as the 8-in. casing is pulled from the borehole. The pellet should be allowed to swell for at least 2 h. Next, a slurry, consisting of a high-solids (at least 20%) bentonite or cement grout, will be pumped through the tremie into the borehole as the 8-in. casing is completely pulled from the borehole. The borehole should be filled to within 2 to 5 ft of the top of the M3 layer. After the bentonite layer has set for approximately 12 to 24 h, the annulus should be bailed or pumped down approximately 20 ft, and measurements should be taken every hour for a period of 24 h to determine if water levels are rising or declining. If water levels are rising significantly, then adequate hydraulic isolation has not been achieved. If water levels remain static, then hydraulic isolation should be satisfactory. If water-level conditions appear satisfactory, bentonite pellets should be tremied to fill the remaining borehole to the top of the M3 layer as the 12- or 14-in. casing is pulled back to the top of the M3 layer.

Next, the second 10-ft stainless steel monitoring well screen and casing riser are set without a sediment trap or a sand base. By maintaining the bottom of the well screen equal to the top of the M3 layer detection of dense nonaqueous-phase liquids is more effective. Filter pack, secondary filter, bentonite pellets, and bentonite grout (cement grout should not be used in the saturated zone of the unconfined aquifer) are placed in the same manner as for the deepest monitoring well in this borehole nest. Bentonite pellets should extend to within 15 ft of the highest annual water level, so that the top of the third screen is never below water. This will ensure that this 15-ft screened interval will allow floating nonaqueous-phase liquids to be detected. The only exception to this is if a 1-ft-thick or greater layer of silt is encountered; then, the bottom of the well screen may be set as little as 5 ft into the saturated zone, with the bottom of the well screen equal to the top of the silt or clay layer. As the last 21 ft of 12-in. casing are removed, a cement grout slurry should be used to seal the annulus. A 4- by 4-ft concrete pad, 6 in. thick, will be poured around the surface of the well nest. A brass monument marker and a protective stainless steel or anodized aluminum housing shall be set into the concrete pad. Protective steel posts will be placed around each well nest.

All three of the proposed drilling methods [i.e., Becker (dual-wall reverse-air rotary), cable tool (hard tool), and mud-rotary wireline core] require the addition of fluids to be successful. Unlike most air-rotary techniques, the use of additives (mud, surfactant, water, etc.) is not needed or desirable. A major advantage of the air-rotary technique, besides its ability to rapidly drill through coarse gravels and cobbles, is that air is the only element introduced. However, as with all air-rotary techniques, the pressurized air contains (even after filtering) small quantities of oil used to lubricate the compressors. Because the Becker method is a dual-wall reverse-air method, relatively little air is introduced at operating pressures needed for drilling to approximately 120 ft as proposed for the 300 Area. The cable-tool (hard-tool) technique requires the addition of water to the borehole in the vadose zone to create a wet paste of the drill cuttings so they can be bailed from the borehole. The mud-rotary method requires the use of bentonite added to water or organic polymers added to water to make drilling muds. Only pure bentonite muds without additives (e.g., diesel oil) will be used.

1.1.5 Sample Handling and Analysis

An onsite geologist will maintain a field log and a well log for each installation. These logs will be handled in accordance with procedures described in Part 2--Quality Assurance Project Plan and the Data Management Plan.

Field screening analysis will be performed for combustible organics, ionizable organics, and alpha, beta, and gamma radiation, and recorded in a field log. Where contamination is determined or suspected from these screening surveys, quantitative analyses will be performed for contaminant content, and laboratory sorption/desorption tests will be performed on samples. Nine sediment samples per well will be taken by core barrel (or other "undisturbed" sampling technique) for laboratory analysis of physical characteristics (grain-size distribution, bulk density, bulk porosity, water content, and hydraulic conductivity).

Before completion, all wells will be geophysically logged for natural-gamma activity. In addition, wells may be logged with calibrated natural-spectral-gamma, neutron-neutron, and gamma-gamma probes if warranted and if available. These logs will be corrected for borehole environmental effects (such as variation in well diameter, borehole fluid, and casing thickness). The borehole geologic logs will assist with stratigraphic analysis, evaluation of formation physical characteristics, and determination of distribution of selected radioactive contaminants in the soil column.

Samples for laboratory analysis will be properly preserved and transported to a laboratory under chain-of-custody procedures described in Part 2--Quality Assurance Project Plan.

1.2 GROUNDWATER SAMPLING

1.2.1 Sampling Objective

This activity will better determine the extent of groundwater contamination attributable to the 300-FF-5 operable unit and will confirm the nature of such contamination.

1.2.2 Sample Locations and Frequencies

All Phase I groundwater monitoring wells installed (see Figure 1) and existing wells in the monitoring network will be sampled initially in Phase I. Based on these data, a subset of the analyses conducted on the first samples will be determined and analyzed quarterly for one year. Samples will be collected from the top of the unconfined aquifer (59 wells), the bottom of the unconfined aquifer (16 wells), and from the upper confined aquifer (18 wells). (Additional details on number of water samples are contained in Table 3.)

Table 3. Water Samples to be Taken in the 300-FF-5 Operable Unit.

Water	
Pathway	Groundwater → surface water
Type of sample	Groundwater
Locations	Phase I new well sites; preexisting monitoring wells within and adjacent to the operable unit
Number of samples (estimated)	93 initially; <93 quarterly
Constituents	Contract Laboratory Program target compound list (Section 1.2.5) initially; reduced list, based on initial analyses, will be analyzed quarterly for one year

Water levels (piezometric head) will be measured on all wells before sampling. In addition, water levels will be measured hourly at approximately 20 well locations and in approximately 50 wells within and adjacent to the 300-FF-5 operable unit. In addition to the permanent river-gauging station, SWS-1, a permanent river-gauging station will be installed in the Columbia River at or near the existing temporary station, SWS-2 (see Figure 1) to hourly monitor changes in river level. As adequate data are obtained, wells will be phased into and out of the continuous water-level monitoring network to acquire wide areal coverage on groundwater-level response throughout the operable unit.

1.2.3 Sample Designations

Groundwater samples will be designated by well code, constituent code, constituent name, customer number, sponsor, laboratory performing analysis, sample size, bottle type, date and time, and responsible person performing the collection.

1.2.4 Sampling Equipment and Procedures

All groundwater sampling equipment and procedures used for this activity shall be specified in approved procedures, as described in Part 2--Quality Assurance Project Plan.

1.2.5 Sample Handling and Analysis

Several parameters will be measured immediately onsite: static water level, water temperature, pH, and specific conductivity. These measurements will be performed in accordance with approved procedures. Results will be recorded, according to procedures specified in Part 2--Quality Assurance Project Plan and the Data Management Plan.

Samples obtained for laboratory analysis will be properly preserved and transported to the designated laboratory. Such samples will be analyzed for the parameters listed in Table 4. This list will be modified as additional data are obtained. Chain-of-custody procedures, as described in Part 2--Quality Assurance Project Plan, will be followed. Location of sources of volatile organics will be distinguished on the basis of not only the concentration distribution, but also on the unique ratios of degradation and parent isomers. For example, the results from two studies of perchloroethene, trichloroethene, and dichloroethene isomers in the 300 Area indicate that the ratios of perchloroethene, trichloroethene, and trans- and cis-1,2, dichloroethene were different for the top of the unconfined aquifer versus the bottom of the unconfined aquifer (Fruland et al. 1989, Smith et al. 1989). The source of the perchloroethene and trichloroethene in the top of the unconfined aquifer appears to be very new because neither the cis nor trans isomers of dichloroethene are present above detection limits (set at 20 to 40 parts per trillion, respectively). The trichloroethene in the bottom of the unconfined aquifer is much older, based on the much greater dominance of the cis isomer over the trans isomer and the parent isomer, trichloroethene. This is one example of how two plumes can be differentiated. The source of the trichloroethene in the top of the unconfined aquifer is 316-5 (the process trenches). If additional wells were available like those proposed for the 300-FF-5 operable unit, it might be possible to identify the source of trichloroethene contamination in the bottom of the confined aquifer. Also, other sources of contamination could be identified by their unique distribution of isomers. Results from other studies in the open literature (Schalla et al. 1984, 1986; Vogel and McCarthy 1985; Wilson et al. 1983) indicate similar results for degradation and identification of source areas.

Table 4. Contract Laboratory Program Target Compound List. (Sheet 1 of 4)

Volatiles	CAS[a] number
Chloromethane	74-87-3
Bromomethane	74-83-9
Vinyl chloride	75-01-4
Chloroethane	75-00-3
Methylene chloride	75-09-2
Acetone	67-64-1
Carbon disulfide	75-15-0
1,1-Dichloroethene	75-35-4
1,1-Dichloroethane	75-34-3
1,2-Dichloroethene (total)	540-59-0
Chloroform	67-66-3
1,2-Dichloroethane	107-06-2
2-Butanone	78-93-3
1,1,1-Trichloroethane	71-55-6
Carbon tetrachloride	56-23-5
Vinyl acetate	108-05-4
Bromodichloromethane	75-27-4
1,2-Dichloropropane	78-87-5
1,3-Dichloro-1-propene (z)	10061-01-5
Trichloroethene	79-01-6
Dibromochloromethane	124-48-1
1,1,2-Trichloroethane	79-00-5
Benzene	71-43-2
trans-1,3-Dichloropropene	542-75-6
Bromoform	75-25-2
4-Methyl-2-pentanone	108-10-1
2-Hexanone	591-78-6
Tetrachloroethene	127-18-4
Toluene	108-88-3
1,1,2,2-Tetrachloroethane	79-34-5
Chlorobenzene	108-90-7
Ethyl benzene	100-41-4
Styrene	100-42-5
Xylenes (total)	1330-20-7
Semivolatiles	**CAS[a] number**
Phenol	108-95-2
bis(2-Chlorethyl) ether	111-44-4
2-Chlorophenol	95-57-8
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
Benzyl alcohol	100-51-6
1,2-Dichlorobenzene	95-50-1
2-Methylphenol	95-48-7

Table 4. Contract Laboratory Program Target Compound List. (Sheet 2 of 4)

Semivolatiles (contd)	CAS[a] number
bis(2-Chloroisopropyl) ether	39635-32-9
4-Methylphenol	106-44-5
N-Nitroso-di-n-dipropylamine	621-64-7
Hexachloroethane	67-72-1
Nitrobenzene	98-95-3
Isophorone	78-59-1
2-Nitrophenol	88-75-5
2,4-Dimethylphenol	105-67-9
Benzoic acid	65-85-0
bis(2-Chloroethoxy) methane	111-91-1
2,4-Dichlorophenol	120-83-2
1,2,4-Trichlorobenzene	120-82-1
Naphthalene	91-20-3
4-Chloroaniline	106-47-8
Hexachlorobutadiene	87-68-3
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7
2-Methylnaphthalene	91-57-6
Hexachlorocyclopentadiene	77-47-4
2,4,6-Trichlorophenol	88-06-2
2,4,5-Trichlorophenol	95-95-4
2-Chloronaphthalene	91-58-7
2-Nitroaniline	88-74-4
Dimethylphthalate	131-11-3
Acenaphthylene	208-96-8
2,6-Dinitrotoluene	606-20-2
3-Nitroaniline	99-09-2
Acenaphthene	83-32-9
2,4-Dinitrophenol	51-28-5
4-Nitrophenol	100-02-7
Dibenzofuran	132-64-9
2,4-Dinitrotoluene	121-14-2
Diethylphthalate	84-66-2
4-Chlorophenyl-phenyl-ether	7005-72-3
Fluorene	86-73-7
4-Nitroaniline	100-01-6
4,6-Dinitro-2-methylphenol	534-42-1
N-nitrosodiphenylamine	86-30-6
4-Bromophenyl-phenylether	101-55-3
Hexachlorobenzene	118-74-1
Pentachlorophenol	87-86-5
Phenanthrene	85-01-8
Anthracene	120-12-7
Di-n-butylphthalate	84-74-2
Fluoranthene	206-44-0

Table 4. Contract Laboratory Program Target Compound List. (Sheet 3 of 4)

Semivolatiles (contd)	CAS[a] number
Pyrene	129-00-0
Butylbenzylphthalate	85-68-7
3,3′-Dichlorobenzidine	91-94-1
Benzo(a)anthracene	56-55-3
Chrysene	218-01-9
bis(2-Ethylhexyl)phthalate	117-81-7
Di-n-octylphthalate	117-84-0
Benzo(b)fluoranthene	205-99-2
Pesticides/polychlorinated biphenyls	**CAS[a] number**
Benzo(k)fluoranthene	207-08-9
Benzo(a)pyrene	50-32-8
Indeno (1,2,3-cd)pyrene	193-39-5
Dibenz(a,h)anthracene	53-70-3
Benzo(g,h,i)perylene	191-24-2
Alpha-BHC	319-84-6
Beta-BHC	319-85-7
Delta-BHC	319-86-8
Gamma-BHC (Lindane)	58-89-9
Heptachlor	76-44-8
Aldrin	309-00-2
Heptachlor epoxide	1024-57-3
Endosulfan I	959-98-8
Dieldrin	60-57-1
4,4′-DDE	72-55-9
Endrin	72-20-8
Endosulfan II	33213-65-9
4,4′-DDD	72-54-8
Endosulfan sulfate	1031-07-8
4,4′-DDT	50-29-3
Methoxychlor	72-43-5
Endrin ketone	53494-70-5
Alpha-Chlordane	5103-71-9
Gamma-Chlordane	5103-74-2
Toxaphene	8001-35-2
Aroclor-1016	12674-11-2
Aroclor-1221	11104-28-2
Aroclor-1232	11141-16-5
Aroclor-1242	53469-21-9
Aroclor-1248	12672-29-6
Aroclor-1254	11097-69-1
Aroclor-1260	11096-82-5

Table 4. Contract Laboratory Program Target Compound List. (Sheet 4 of 4)

Analyte[b]	Radionuclides[c]	Inorganic anions[c]
Aluminum	Gamma scan	Bicarbonate
Antimony	Gross alpha	Carbonate
Arsenic	Gross beta	Chloride
Barium	Iodine-129	Fluoride
Beryllium	Isotopes	Nitrate (as NO_3^-)
Cadmium	Plutonium	Phosphate
Calcium	Strontium-90	Sulfate
Chromium	Technetium-99	
Cobalt	Tritium	
Copper	Uranium	
Cyanide		**Other[c]**
Iron		
Lead		Alkalinity/acidity
Magnesium		Ammonia-N
Manganese		Biological oxygen demand
Mercury		Chemical oxygen demand
Nickel		Dissolved oxygen
Potassium		Hardness
Selenium		Total organic carbon
Silver		Total organic halogen
Sodium		Total dissolved solids
Thallium		Total suspended solids
Vanadium		
Zinc		

[a]From American Chemical Society system for compounds.
[b]Analyses will be for dissolved metals only.
[c]These parameters are not part of the Contract Laboratory Program target compound list but will be analyzed.

1.3 GEOHYDROLOGIC TESTING

1.3.1 Aquifer Testing

Aquifer tests will be conducted at each new well location after completion and development to assist in determination of aquifer characteristics (transmissivity and storage coefficient). Tests will be conducted by pumping from large-diameter wells constructed near each nested well installation on the western margin of 300-FF-5. Because of known high transmissivities in the 300-FF-5 area, the large-diameter pumping test wells will be located within 50 ft, as possible, of the nested well monitoring installations to ensure a measurable response in these installations from pumping of the test wells. Water levels will be monitored in the completed well nests during and after pumping. The large-diameter test wells will be pumped for a period of not less than 8 h. Specific plans will be prepared for each aquifer test and for the disposal of withdrawn water.

1.3.2 Tracer Tests

Three tracer tests are planned for Phase I. The purposes of these tests are to determine flow velocities, hydraulic conductivity, and dispersivity, and to provide data to calibrate the transport model in the eastern half of the 300-FF-5 operable unit. Essentially, a conservative tracer (i.e., chloride, bromide) will be released into 316-5 (the process trenches) as a single pulse and tracked by extracting water samples from the network of monitoring wells available. Flow velocities will be determined using arrival times of peak concentration correlated with water-level data. Potassium bromide was selected as the tracer because the bromide does not adsorb onto soils, and will enable determination of longitudinal dispersion (Levy and Chambers 1987). Also, potassium bromide has a solubility of 5.35×10^5 mg/L at 0°C, making it possible to produce the desired source concentrations in the field (Weast and Astle 1979).

The tracer tests will be conducted during periods of low and high river stage. One tracer test will be initiated just before the beginning of the high river stage in April. This test will provide valuable information on flow velocity and pathways when the river produces predominantly southern flow within the unconfined aquifer. This will slow the flow velocities along the longest pathway from the process trenches. The second tracer test will be conducted during the late summer months to reflect the shortest and most rapid easterly pathway. The third tracer test will be conducted during the fall to demonstrate flow velocities and pathways that are more typical of the predominantly southeasterly flow pattern.

The bromide tracer will be introduced into 316-5 as an instantaneous (10-min) pulse from a tanker truck. 316-5 is 20 ft wide and 1,500 ft long, but it is expected that most of the tracer solution will enter in a distance as little as one third of the length of the trenches. The source concentration will be between 1,000 to 10,000 p/m. Tracking each of these single-pulse plumes will be accomplished by sampling wells on a daily basis following introduction of the pulse. This is necessary because groundwater velocities near 316-5 may be as high as 100 ft/d and are known to average 35 ft/d during the summer months (Cline et al. 1985). Subsets of 12 to 30 wells of the 50 monitoring wells in the eastern half of 300-FF-5 will be sampled to determine the changing configuration of the plume. After the first 3 wk of daily sampling, the sampling frequency will be modified based on changes in the plume configuration. Based on the current knowledge of the groundwater flow patterns and velocities, each of these tracer tests will last between 90 and 120 d.

To provide an adequate data set for interpretation of the flow directions in the unconfined aquifer, particularly during tracer tests, continuous hourly water-level measurements will be collected in approximately 20 monitoring well locations and at 2 river-gauging stations. Each well will be equipped with a multiple-channel data logger and one to three transducers (three for multiple-horizon wells). Each data logger will be equipped with electrical solar panels for recharging batteries and a radio telemetry system for transmitting the data to the project office.

1.3.3 Wave Propagation Analysis

Wave propagation analysis will consist of time-series analysis between the water levels of river-gauging stations in the Columbia River and water levels in approximately 10 wells in the 300 Area. The influence of the daily cycle of surface-water fluctuations on the rate of change in water levels (wave propagation) in groundwater monitoring wells will be evaluated, using the cyclic evaluation technique (Ferris 1952) to provide additional information on aquifer transmissivity and storativity. The work will be coordinated with similar measurements made under Task 5--Surface-Water and Sediment Investigation. The principal objective of this analysis is to utilize time-lag data to identify geohydrologic properties (such as hydraulic conductivity, transmissivity, and storativity). Secondary objectives of this analysis are to estimate hydraulic diffusivity of materials in the 300 Area and to aid in establishing boundary conditions for numerical modeling. The analyses involve cross-correlation of river water levels with groundwater levels to identify the lag time. The lag time or response time in the monitored well is determined by the hydraulic properties of the sediments between the well and the river.

2.0 TASK 5--SURFACE-WATER AND SEDIMENT INVESTIGATION

2.1 SAMPLING OBJECTIVES

The goal of the surface-water and sediment investigation is to assess the impact of past facility operations and waste disposal activities in the 300-FF-5 operable unit on the quality of Columbia River water and sediment. The objectives of the investigation are to identify and characterize, to the extent possible, the distribution and levels of contaminants present in Columbia River water and sediment and in riverbank springs and sediment in the immediate vicinity of the operable unit. Information obtained will be used to evaluate health risks and, if necessary, remedial action alternatives.

2.2 SAMPLING LOCATIONS AND FREQUENCIES

Surface-water and sediment sampling locations are dependent, to a certain degree, on results of the groundwater investigation sampling activities (Section 5.3.4 of the 300-FF-5 Work Plan) and initial surface-water sampling (Section 5.3.5 of the 300-FF-5 Work Plan). The sampling locations, to the extent possible, are described in Table 5. Table 5 also includes the desired sampling period, estimated maximum number of samples, field measurements to be performed on specific samples, and laboratory analyses to be performed. It is not expected that sampling will be routinely conducted. Sampling will coincide with low-flow conditions, during which maximum environmental contaminant concentrations are expected.

2.3 SAMPLE DESIGNATIONS

Each sample will be identified with a unique code, traceable from sample scheduling through the receipt of the analytical result and final reporting, and described to enable sample location and type identification. Documentation logged during sample collection shall be maintained according to approved procedures, as described in Part 2--Quality Assurance Project Plan and the Data Management Plan.

2.4 SAMPLING EQUIPMENT AND PROCEDURES

All water and sediment sampling equipment and procedures shall be specified in approved procedures, as described in Part 2--Quality Assurance Project Plan. Standard methods shall be referenced, as appropriate. All procedures shall be developed and approved prior to the start of any sampling activities.

2.5 SAMPLE HANDLING AND ANALYSIS

Sample handling requirements and analytical methods shall be in accordance with Part 2--Quality Assurance Project Plan. Special requirements during sample collection, handling, and transport of the samples to the laboratory shall be specified on appropriate sample collection logs and addressed before field sampling activities begin.

Table 5. Surface-Water and Sediment Sampling Locations and Frequencies. (Sheet 1 of 2)

Task/subtask	Media	Locations	Sample period	Estimated maximum number of samples	Field measurements	Laboratory analysis
Riverbank springs	Water	As located/surveyed along operable unit shoreline control--groundwater data	Low-flow conditions; typically August-November	10	Temperature, pH, conductivity, nitrate	- Table 4, plus tritium, ^{90}Sr, and U-isotopic
			- Followup/model verification	10		- Second sample set analysis dependent on groundwater results and initial spring sample results
	Sediment	Within flow of spring/seeps identified above	Low-flow conditions; typically August-November	10	NA	- ^{90}Sr, uranium, gamma scan - Others to be determined on groundwater sediment results
Near-shore river--Phase I	Water	Adjacent to 300-FF-5--Surface-water monitoring stations 1 and 2) (SWS-1 and SWS-2)	Duration of study	NA	Continuous water-level recordings - Systems exist at SWS-1 and SWS-2; takeover/continue operations	NA
	Water	Vicinity of springs as defined above--site-specific Location illustrated in Figure 5	Low-flow conditions; typically August-November	4/Spring, ~40	Temperature, pH, conductivity, nitrate	Table 4, plus tritium ^{90}Sr, and U-isotopic
Near-shore river--Phase II	Water	Vicinity of active seeps--expanded initial protocol as warranted	Low-flow conditions typically August-November	100	Temperature, pH, conductivity, nitrate - install downstream river-gauging station	To be determined based on results of groundwater sampling, riverbank spring sampling, Phase I river sampling, and groundwater projections

Table 5. Surface-Water and Sediment Sampling Locations and Frequencies. (Sheet 1 of 2)

Task/subtask	Media	Locations	Sample period	Estimated maximum number of samples	Field measurements	Laboratory analysis
Near-shore river--Phase II (contd)	Water	Vicinity of groundwater plume entry; exact locations dependent on contaminant location/extent (Figure 6)	Low-flow conditions; typically August-November	100	Temperature, pH, conductivity, nitrate	To be determined based on results of groundwater sampling, riverbank spring sampling, Phase I river sampling, and groundwater projections
	Sediment	At each near-shore water sampling transect/spring location	Low-flow conditions, typically August-November	30	NA	To be determined based on results of groundwater sampling, riverbank spring sampling, Phase I river sampling, and groundwater projections
Transect river water	Water	Upstream and downstream of operable unit	Low-flow conditions, typically August-November	120 20 stations/ transect 3 depths/ station 2 transects	Temperature, pH, conductivity, nitrate, distance to sample station, water depth, current velocity	To be determined based on results of groundwater sampling, riverbank spring sampling, Phase I river sampling, and groundwater projections

NA = Not applicable.

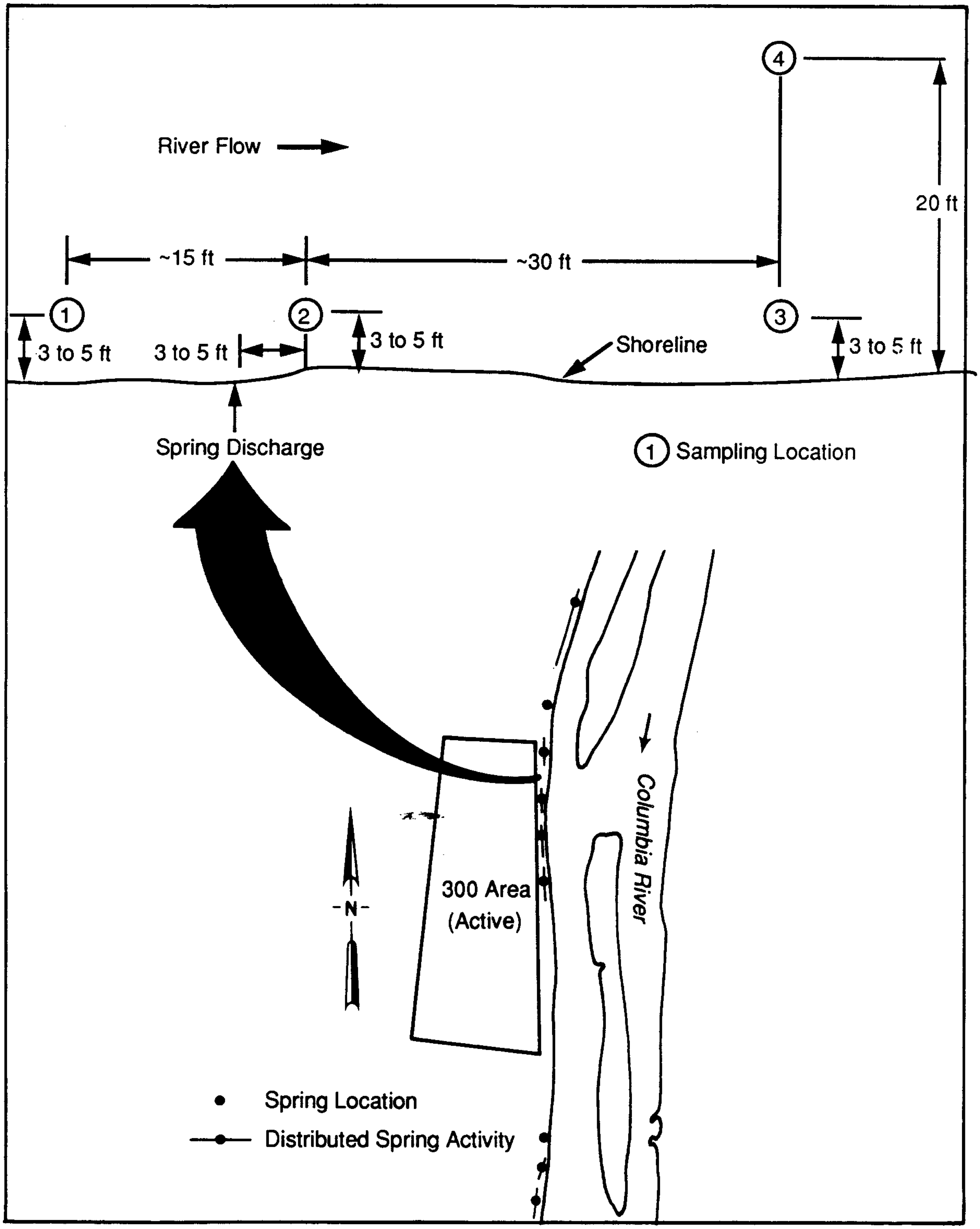


Figure 5. Near-Shore River Water Sampling Locations Relative to Spring Discharge.

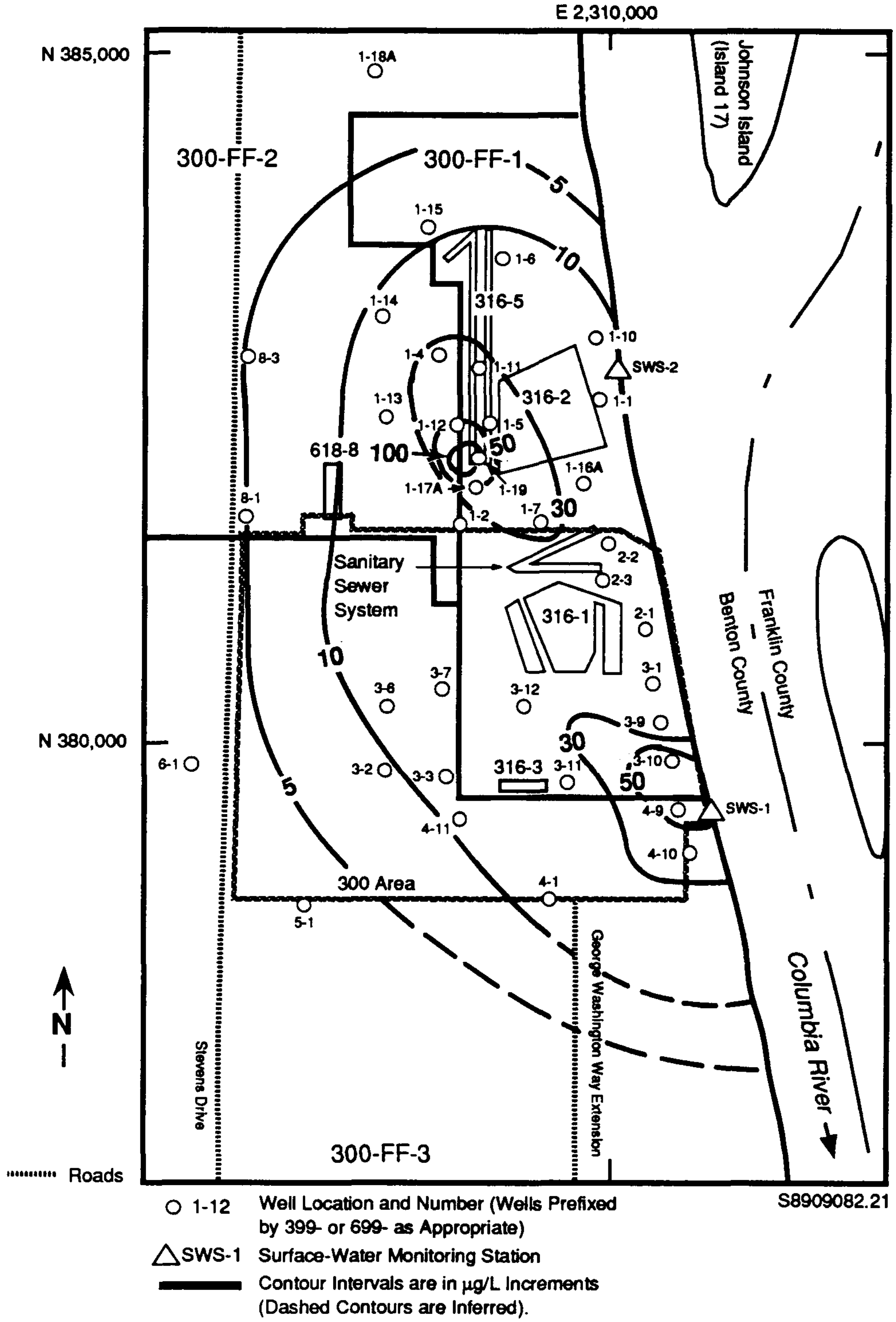


Figure 6. Distribution of Uranium in the Unconfined Aquifer in the 300-FF-5 Operable Unit

3.0 TASK 7--BIOTA INVESTIGATIONS

This section begins with Task 7--Biota Investigations since air investigations (Task 6) are discussed in the 300-FF-1 Work Plan.

Biota investigations will concentrate on three major categories of biota: aquatic biota, riparian vegetation, and wildlife. The sampling program will select certain species from each group (such as periphyton and rock benthos or reed canary grass and cottontail rabbits). These species will be used to (1) determine baseline contaminant conditions, (2) investigate the entry of contaminants into a food web that leads to humans or threatened species, and (3) provide the most logical means of measuring bioaccumulated contaminants or biological effects of contaminants from site cleanup activities.

3.1 AQUATIC BIOTA

3.1.1 Sampling Objectives

The aquatic biota to be sampled include periphyton, macrophytes, benthos, and fish.

Periphyton is a closely adhering mixture of algae, bacteria, fungi, and other microscopic heterotrophs that form matlike communities on rocks and other solid objects. Periphyton's large surface-to-volume ratio makes it an excellent accumulator of waterborne contaminants, such as radionuclides (Cushing 1967, Watson et al. 1970, Cushing et al. 1981).

Macrophytes, in addition to reed canary grass, are important in pathway transfer of contaminants. They accumulate radionuclides and stable compounds through roots and leaves. Their occurrence may be spotty, so they will be collected as they are found in the vicinity of the sampling locations.

Benthos will include both rock benthos, macroscopic invertebrates inhabiting the surface of rocks at the bottom of the river, and soft bottom benthos, macroscopic invertebrates living in mud or silt. Benthos are stationary communities and good indicators of habitat contamination. Rock benthos include filter feeders and grazers; soft bottom benthos both filter feed and ingest mud. Soft bottom habitats are found only where water flow is slow and fine sediments settle; they may not be present at the established sampling locations. The in-shore regions of the river from above to below 300-FF-5 will be surveyed for soft bottom habitats and sampled accordingly.

Special attention will be paid during benthos collection to the occurrence of two species that are candidates for inclusion as threatened and endangered species: the giant Columbia River limpet and the great Columbia River spire snail.

Fish are mobile, but important vectors in pathway transfer of contaminants. Suckers will be sampled because of their lower mobility and their location in the food chain.

3.1.2 Sampling Locations and Frequencies

Sampling locations around 300-FF-5 are shown in Figure 7. Sampling for this subtask will be at transects 3D and 3F located below the two main springs. Similar samples collected at transect 3H will serve as background. Samples will be collected semiannually. These include 11 shoreline locations. Sampling frequencies are shown on Table 6 and in Section 5.3.7.1. of the 300-FF-5 Work Plan.

3.1.3 Sample Designations

Any areas where evidence of biological uptake of hazardous substances are found will be described by locational coordinates and types of species impacted. (See Table 6 and the Section 5.3.7.1 of the 300-FF-5 Work Plan.)

3.1.4 Sampling Equipment and Procedures

This assessment will be performed by biologists having field experience at the Hanford Site. The procedures and equipment are detailed in Part 2--Quality Assurance Project Plan.

3.1.5 Sample Handling and Analysis

Notes will be maintained in a field notebook and handled in accordance with Part 2--Quality Assurance Project Plan and the Data Management Plan.

3.2 RIPARIAN PLANTS

3.2.1 Sampling Objectives

Trees growing near the shoreline of the Columbia River have roots deep enough to intercept groundwater before it enters the river. Some of the contaminants in the groundwater are available for root uptake. Deer, which browse on tree leaves, are hunted and then consumed by humans, so there is a potential food chain pathway of contaminants to humans.

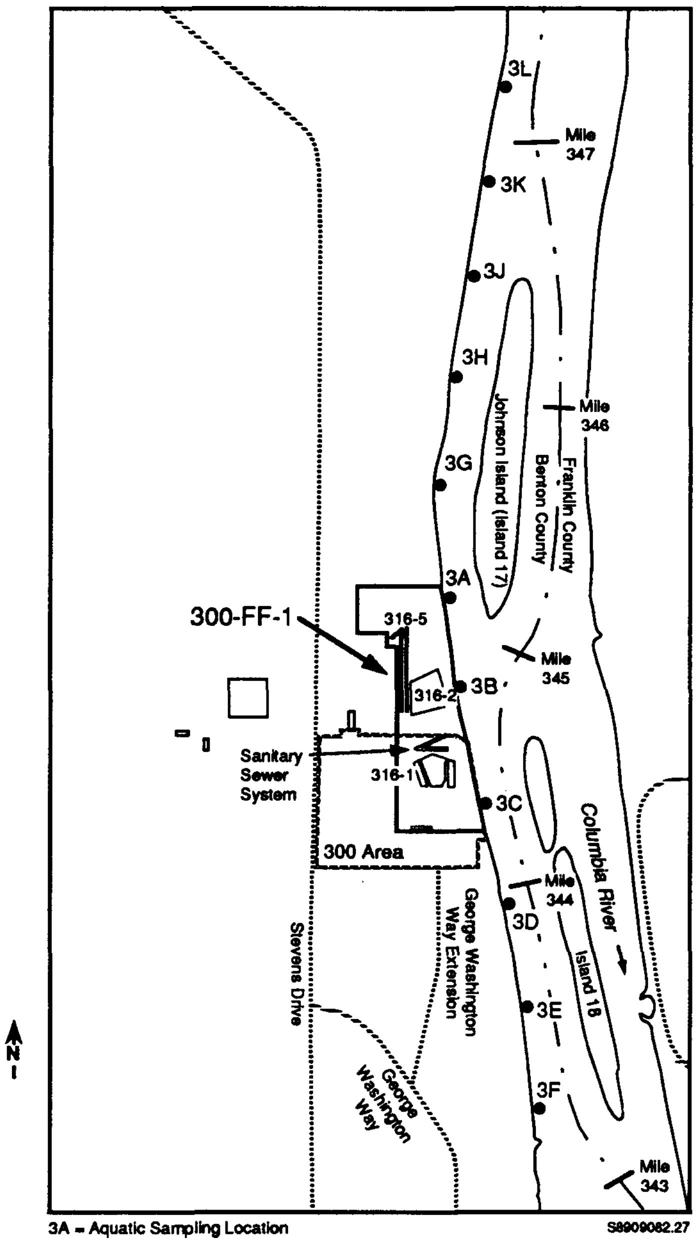


Figure 7. Aquatic Biota Sampling Stations for the 300-FF-5 Operable Unit.

Table 6. Sampling Parameters for Contaminant Distribution and Effects on Aquatic Biota in the 300-FF-5 Operable Unit. (Sheet 1 of 2)

Periphyton	
Pathway	Water → periphyton → invertebrates → fish/birds
Type of sample	Whole matlike community
Locations	Transects 3A through 3L (see Figure 7)
Number of samples	Ten average rocks at each location (Figure 8)
Constituents	Uranium, metals
Time/frequency	Bimonthly over 12 mo
Macrophytes	
Pathway	Water → macrophytes → geese, ducks (food)
Type of sample	Stems, leaves
Locations	Transects 3A through 3L (see Figure 7)
Number of samples	10 from each location where they occur
Constituents	Uranium, metals
Time/frequency	May and October, two-time sampling
Rock benthos	
Pathway	Water/sediment → periphyton/detritus/plankton → benthos → fish/birds
Type of sample	Whole bodies
Locations	Transects 3A through 3L (see Figure 7)
Number of samples	Ten representative with macroinvertebrates from each location (Figure 9)
Constituents	Uranium, metals
Time/frequency	Bi-monthly over 12 mo

Table 6. Sampling Parameters for Contaminant Distribution and Effects on Aquatic Biota in the 300-FF-5 Operable Unit. (Sheet 2 of 2)

Soft bottom benthos	
Pathway	Water/sediment → infaunal invertebrates → fish
Type of sample	Whole bodies or selected tissues
Locations	Soft bottom habitats between sites 3A and 3D (see Figure 7)
Number of samples	Specific for each species
Constituents	Uranium, metals
Time/frequency	May and October, two-time sampling
Suckers	
Pathway	Water/sediment → periphyton/detritus/plankton → small invertebrates → suckers → fish/great blue heron
Type of sample	Whole bodies
Locations	Transects 3A through 3L (see Figure 7)
Number of samples	Number depends on size of individuals
Constituents	Uranium, metals
Time/frequency	Bi-monthly over 12 mo

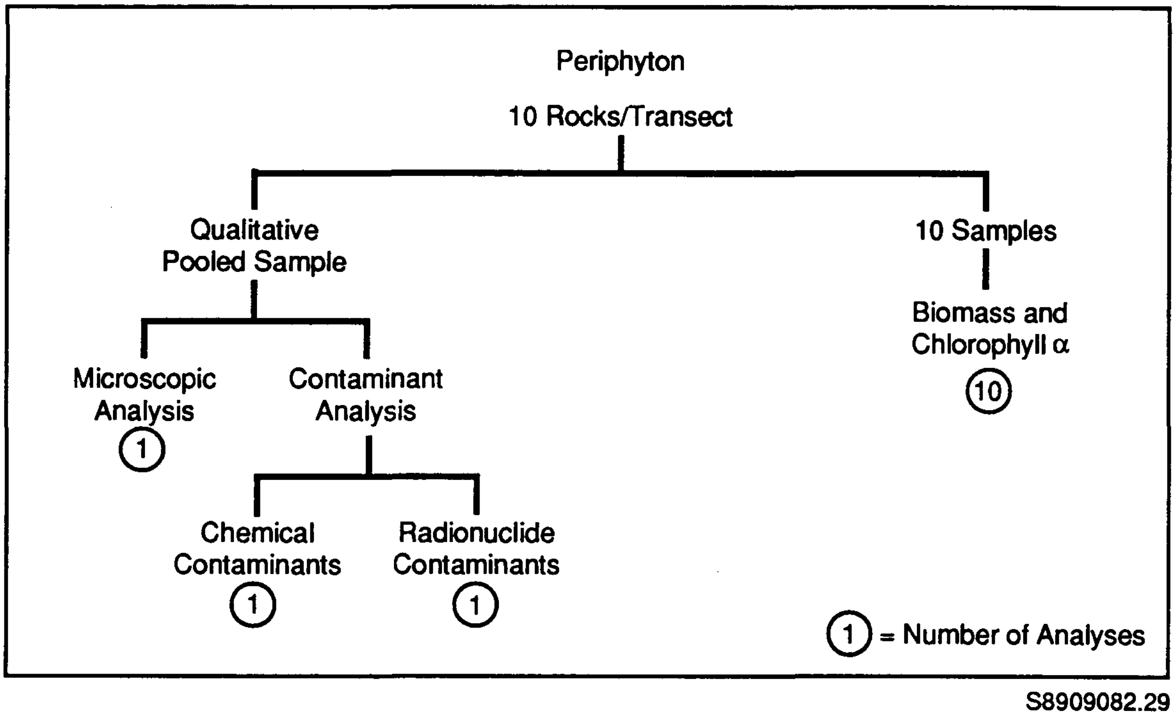


Figure 8. Sampling Flow Diagram for Periphyton Analyses.

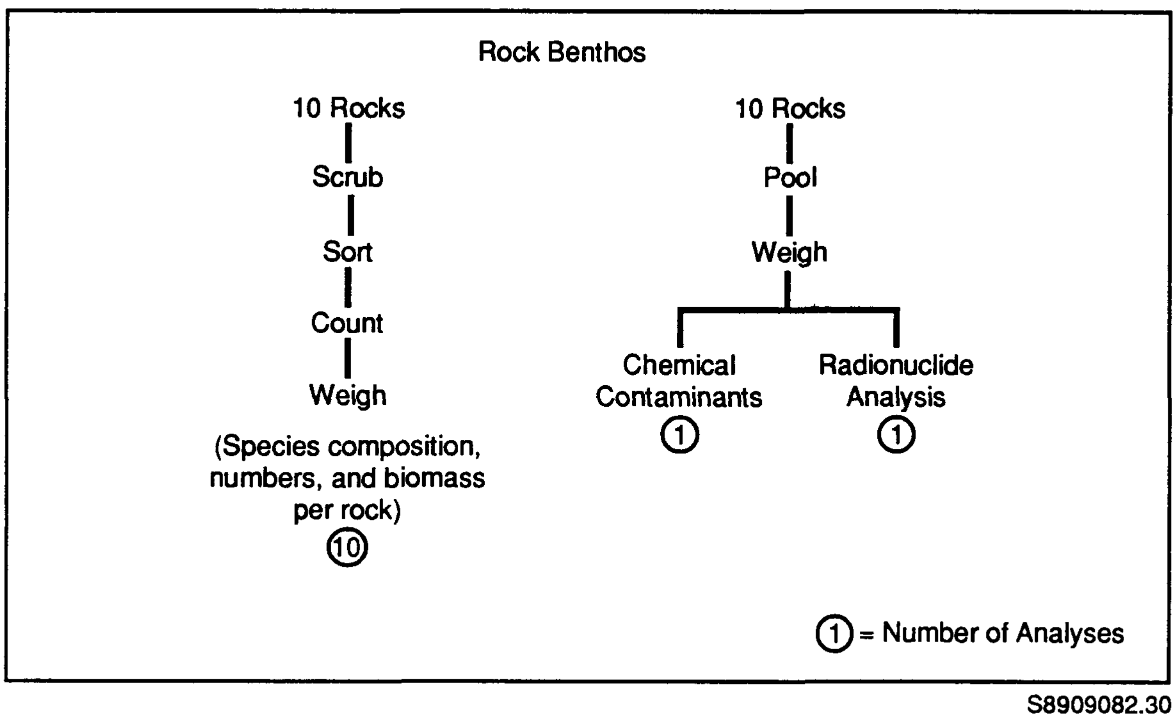


Figure 9. Sampling Flow Diagram for Rock Benthos Analyses.

Reed canary grass is a common riparian grass along the Columbia River that can accumulate contaminants from surface water, sediments, and spring seeps. This grass is eaten by cottontail rabbits, meadow mice, and Canada geese. Asparagus grows wild in the riparian zone and it is harvested and eaten by the local population.

3.2.2 Sampling Locations and Frequencies

Sampling locations around 300-FF-5 are shown in Figure 10. These include 12 shoreline locations. Sampling frequencies are shown on Table 7.

3.2.3 Sample Designations

All locations used as biotic sampling stations will be surveyed and the samples will be identified by these locations and the type of biota sampled (see Table 7).

3.2.4 Sampling Equipment and Procedures

This assessment will be performed by biologists having field experience at the Hanford Site. The procedures and equipment are detailed in Part 2--Quality Assurance Project Plan.

3.2.5 Sample Handling and Analysis

Notes will be maintained in a field notebook and handled in accordance with Part 2--Quality Assurance Project Plan and the Data Management Plan.

3.3 RIPARIAN WILDLIFE

3.3.1 Sampling Objectives

Cottontail rabbits have access to the riparian zone along the Columbia River where they eat plants. Contaminants that could be expected in riparian plants are radionuclides and metals, substances that could be ingested by the cottontails. Cottontails are prey for owls, eagles, and hawks, notably the state-endangered Ferruginous hawks that nest on the Hanford Site. Cottontails are also game animals killed and eaten by humans.

Meadow mice (moles) are also riparian zone inhabitants. They have small home ranges and spend their entire lives in limited areas. They are herbivores that eat green plants daily, and are expected to be a good measure of the biological availability of contaminants in their environment.

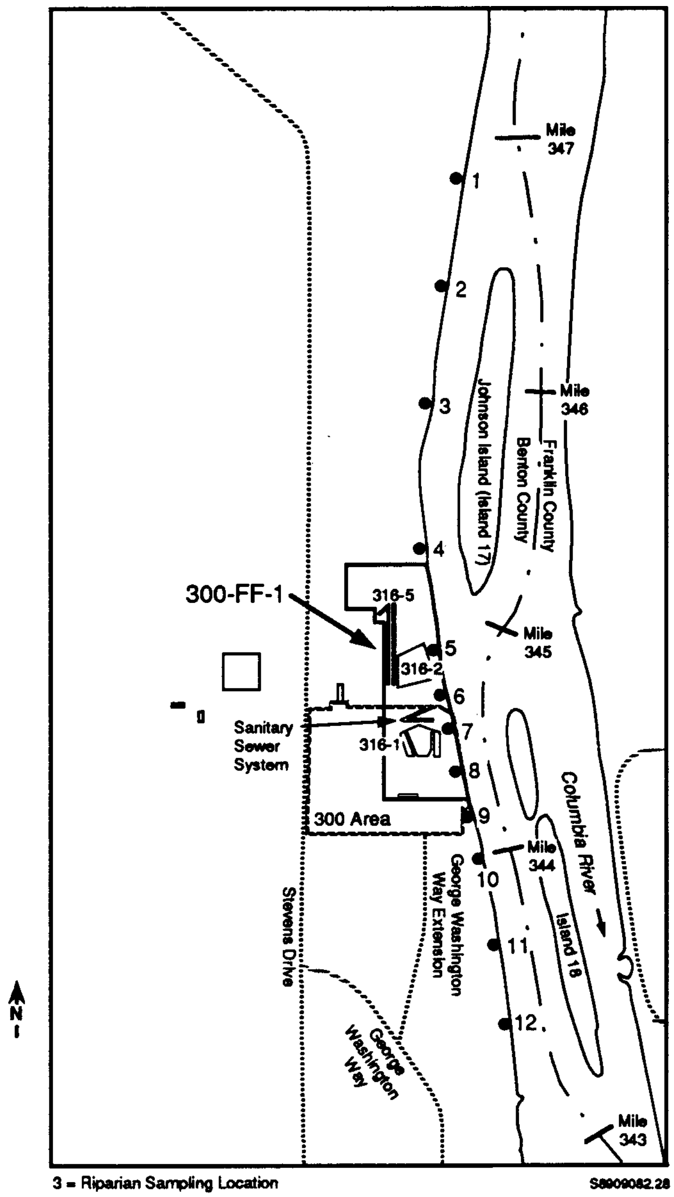


Figure 10. Riparian Biota Sampling Stations for the 300-FF-5 Operable Unit.

Table 7. Sampling Parameters for Riparian Plants in the 300-FF-5 Operable Unit.

Vegetation	
Pathway	Groundwater → trees → deer (forage) → man
Type of sample	Stems, leaves
Locations	Stations 1 through 12 (see Figure 10)
Number of samples	9 from each location (total of 108)
Constituents	Radionuclides, metals
Time/frequency	May; one-time sampling
Reed canary grass	
Pathway	Groundwater/surface water → reed canary grass → geese (food), deer (food), gamebirds (seeds), small mammals → predators (threatened or endangered species)
Type of sample	Shoots, stems, leaves
Locations	At each spring between stations 1 through 12 (see Figure 10)
Number of samples	3 from each location
Constituents	Radionuclides, metals
Time/frequency	May; one-time sampling

3.3.2 Sampling Locations and Frequencies

Sampling locations around 300-FF-5 include 12 shoreline stations (see Figure 10). Sampling frequencies are shown in Table 8 and in Section 5.3.7.1 of the 300-FF-5 Work plan.

3.3.3 Sample Designations

Any areas where evidence of biological uptake of hazardous substances are found will be described by locational coordinates and types of species impacted. (See Table 8 and Section 5.3.7.1 of the 300-FF-5 Work Plan.)

Table 8. Sampling Parameters for Riparian Wildlife in the 300-FF-5 Operable Unit.

Cottontail rabbits and meadow mice	
Pathway	Cottontails, meadow mice → birds of prey, man
Type of sample	Skin, whole body
Locations	Stations 1 through 12 (see Figure 10)
Number of samples	Total of 60
Constituents	Radionuclides, metals, organics
Time/frequency	May or June; one-time sampling

3.3.4 Sampling Equipment and Procedures

This assessment will be performed by biologists having field experience at the Hanford Site. The procedures and equipment are detailed in Part 2--Quality Assurance Program Plan.

3.3.5 Sample Handling and Analysis

Notes will be maintained in a field notebook and handled in accordance with Part 2--Quality Assurance Program Plan and the Data Management Plan.

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PART 2

QUALITY ASSURANCE PROJECT PLAN

QUALITY ASSURANCE PROJECT PLAN FOR PHASE I ENVIRONMENTAL INVESTIGATIONS IN THE 300-FF-5 OPERABLE UNIT

Revision -0-

Westinghouse Hanford Company
Environmental Engineering and Technology Function
Richland, Washington

Approved by:

US EPA Unit Manager ______________________________ Date: __________

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State of Washington Department of
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PART 2

QUALITY ASSURANCE PROJECT PLAN

1.0 PROJECT DESCRIPTION

1.1 PROJECT OBJECTIVE

The primary objective of remedial investigations for source and groundwater operable units is to define the extent and location of hazardous chemical and radioactive contamination in the environment. Data resulting from these investigations will be evaluated to determine the most feasible options for remediation.

1.2 BACKGROUND INFORMATION

The 300-FF-5 groundwater operable unit underlies the 300 Area of the Hanford Site as shown on Figure 1. Detailed background information regarding the history and present use of the unit is provided in Chapter 2.0 of the 300-FF-5 Work Plan.

1.3 QUALITY ASSURANCE PROJECT PLAN SCOPE AND RELATIONSHIP TO WESTINGHOUSE HANFORD COMPANY'S QUALITY ASSURANCE PROGRAM PLAN

This Quality Assurance Project Plan (QAPP) summarizes the general policies, methods organization, and activities necessary to achieve site characterization data quality objectives for the 300-FF-5 operable unit. Chapter 1.0 of the 300-FF-5 Work Plan provides a discussion of the different phases of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedial investigation/feasibility study (RI/FS) processes. The QAPP is a part of the Sampling and Analysis Plan prepared specifically for this unit investigation and has been prepared in compliance with EPA (1988) and the overall quality assurance program requirements of Westinghouse Hanford Company (Westinghouse Hanford). All plans or procedures referenced in the QAPP are available for regulatory review. A task-by-task description of the work to be accomplished in the 300-FF-5 operable unit can be found in Chapter 5.0 of the 300-FF-5 Work Plan. This 300-FF-5 QAPP complies with the formatting requirements of EPA (1983; QAMS-005/80). In addition, Chapters 15.0, 16.0, 17.0, and 18.0 have been added to this QAPP to provide additional control in areas not addressed in EPA (1983; QAMS-005/80).

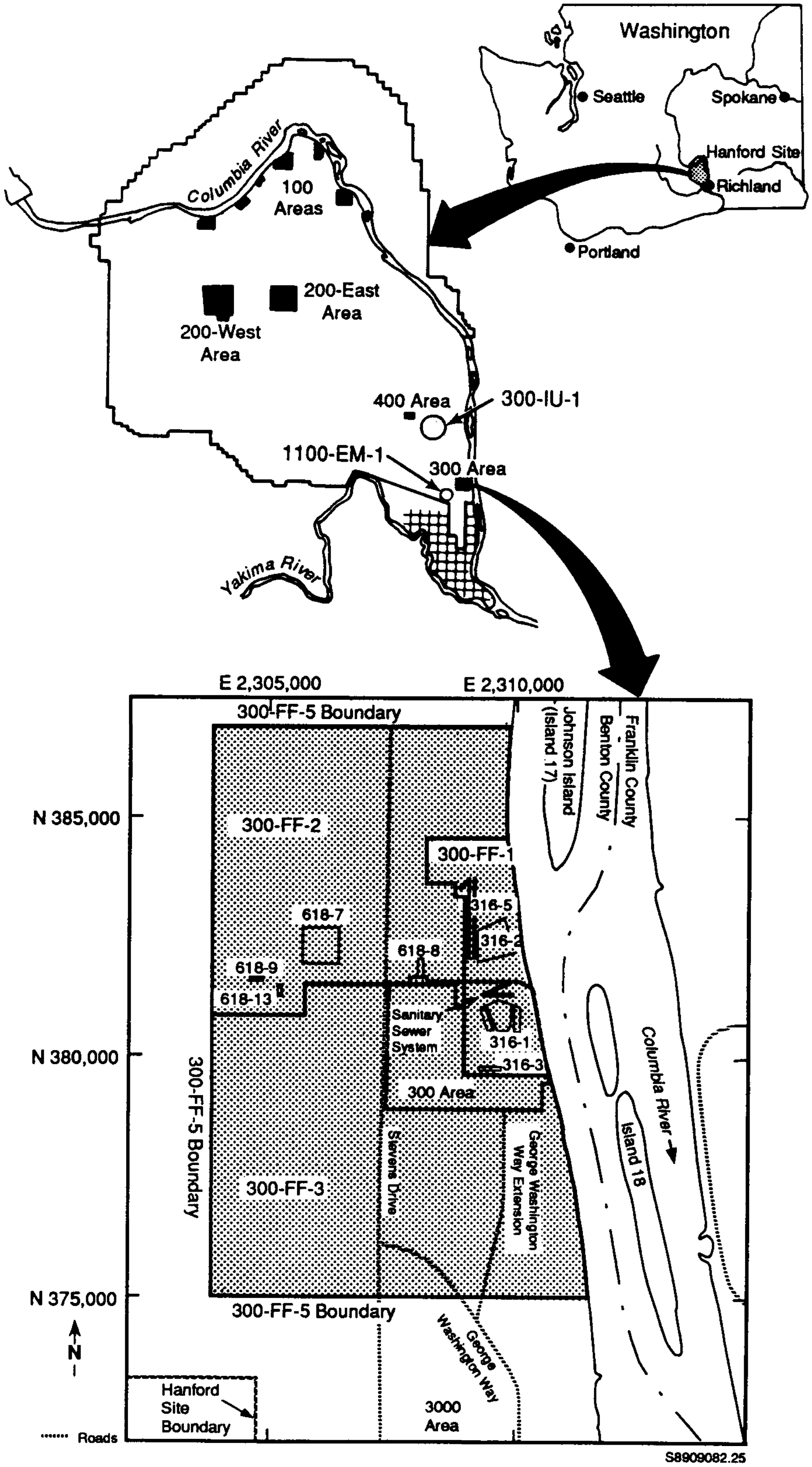

Figure 1. Location of the 300-FF-5 Operable Unit on the Hanford Site.

1.4 DISCUSSION OF ACTIVITIES

The investigations that will be conducted in the 300-FF-5 operable unit will be subdivided into discrete phases and a number of smaller individual tasks. Since the results of the task activities in an individual phase may significantly affect the technical activities planned for subsequent phases, this QAPP shall undergo mandatory review after completion of each phase, or at least annually, and shall be updated or modified to accommodate any required revisions in the scope of work. This version of the 300-FF-5 QAPP applies specifically to the site characterization phase of the remedial investigation.

1.4.1 Site Characterization

Representative tasks for site characterization activities are listed and briefly described below. Detailed comprehensive discussions of each of the tasks specific to the 300-FF-5 operable unit are contained in Chapter 5.0 of the 300-FF-5 Work Plan. Sampling procedures applicable to the project-specific tasks described here are discussed in Chapter 4.0 of this QAPP. Sample analyses will be conducted as described in Chapters 3.0 and 7.0 of this QAPP. A description of the 300-FF-5 operable unit can be found in Chapter 2.0 of the 300-FF-5 Work Plan.

1.4.1.1 Task 1--Source Investigation. This task is addressed in the 300-FF-1 Work Plan and those work plans to be developed for the 300-FF-2 and 300-FF-3 operable units.

1.4.1.2 Task 2--Geologic Investigation. This task entails a comprehensive review of all pertinent existing geologic data. In addition, new data collected as part of the remedial investigation of associated groundwater units and data collected during the drilling of additional groundwater monitoring wells and from any applicable geophysical surveys will be reviewed.

1.4.1.3 Task 3--Soil Investigation. The soil investigation task involves subsurface soil sampling and analysis and sorption studies to evaluate soils contaminant transport characteristics.

1.4.1.4 Task 4--Groundwater Investigation. This task will require compilation of the geohydrologic database and the preparation of working files. Monitoring wells will be installed at selected locations; well installation will be accompanied by soil sampling, analysis, and physical testing activities. Newly installed wells and river-gauging stations will be geodetically surveyed. A groundwater sampling program will be initiated using the monitoring wells and gauging stations. Water-level measurements will be recorded and aquifer tests will be performed on a selected number of wells.

1.4.1.5 Task 5--Surface-Water and Sediment Investigation. This task involves the collection and compilation of hydrologic data. Riverbank surveys will be conducted, involving reconnaissance, surface (seep) water sampling, analysis, and geodetic surveying. Water and sediments from near the shore and from cross-river transects will be sampled and analyzed. Potable water supplies also may be sampled.

1.4.1.6 Task 6--Air Investigation. This task is addressed in the 300-FF-1 Work Plan and those work plans to be developed for the 300-FF-2 and 300-FF-3 operable units.

1.4.1.7 Task 7--Biota Investigations. An evaluation of biota for evidence of toxic uptake and a qualitative species survey will be conducted. Riparian and aquatic biota will be sampled and analyzed for selected contaminants.

1.4.1.8 Task 8--Data Evaluation. This task is addressed in the 300-FF-1 Work Plan and those work plans to be developed for the 300-FF-2 and 300-FF-3 operable units.

1.4.1.9 Task 9--Baseline Risk Assessment. This task is addressed in the 300-FF-1 Work Plan and those work plans to be developed for the 300-FF-2 and 300-FF-3 operable units.

1.4.1.10 Task 10--Preliminary Site Characterization Summary Report. This task is addressed in the 300-FF-1 Work Plan and those work plans to be developed for the 300-FF-2 and 300-FF-3 operable units.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 TECHNICAL LEAD RESPONSIBILITIES

The Environmental Engineering and Technology Function of Westinghouse Hanford has primary responsibilities for conducting this investigation. Organizational charts are included in Attachment 5--Project Management Plan for the 300-FF-1 operable unit that define personnel assignments and individual Westinghouse field team structures applicable to the various types of tasks included in site characterization activities.

External participant contractors or subcontractors shall be evaluated and selected for certain portions of task activities at the direction of the technical lead in compliance with standard Westinghouse Hanford or Westinghouse Hanford-approved procedures for supplier evaluation and procurement. Major participant contractor and subcontractor resources are listed in Figure 2-2 of the 300-FF-1 Project Management Plan. All contractors' plans and procedures shall be approved prior to use, and shall be available for regulatory review after Westinghouse Hanford approval. All analytical procedures shall be reviewed and approved by the Westinghouse Hanford Analytical Laboratories organization.

2.2 ANALYTICAL LABORATORIES

All analyses shall be performed in compliance with Westinghouse Hanford-approved laboratory quality assurance plans and analytical procedures and shall be subject to Westinghouse Hanford procurement, as well as internal and external quality auditing and surveillance controls. As additional capabilities in hazardous sample analysis are developed and approved, laboratory procedures will be prepared and updated in compliance with test planning, performance, and evaluation. For participant contractors and subcontractors, applicable quality requirements shall be invoked as part of the approved documentation on preparation, review, and approval of purchase orders, or via requirements on obtaining services via work orders. Services of alternate laboratories may be procured for the performance of split sample analysis. If such an option is selected, the laboratory quality assurance plan and applicable analytical procedures must be approved prior to their use. Data that will be used as the basis for decision making require that the analysis of samples in laboratories meets specific quality assurance/quality control requirements. To meet these requirements, Federal- or state-lead site investigations have the option of using mobile laboratories, the Contract Laboratory Program, which is established by the U.S. Environmental Protection Agency (EPA), or a non-Contract Laboratory Program-equivalent laboratory that meets the data quality objectives of the site investigation.

2.3 OTHER SUPPORT CONTRACTORS

Selection and procurement of all other contracted field activities shall be in compliance with the procurement procedures discussed in Sections 2.1 and 2.2 of this QAPP. All work shall be performed in compliance with Westinghouse Hanford-approved quality assurance plans and/or procedures, subject to internal and external quality auditing and surveillance controls. Applicable quality requirements shall be invoked as part of the approved procurement documentation or work order.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENTS

Analytical data based on sampling activities will be obtained and evaluated to characterize the nature and extent of radioactive and hazardous contamination and to determine the most feasible options for remediation. The analytical levels available to support remedial investigation data collection activities are defined in EPA (1987) and are reproduced in Table 30 in the 300-FF-5 Work Plan. The analytical data collected during this remedial investigation will be obtained at the analytical levels described as follows:

Level III: Level III analyses will be performed on all analytes. All analyses shall be performed onsite or offsite by Westinghouse Hanford, participant contractor, or subcontractor laboratories appropriately equipped to perform the contracted analyses, based on the results of Level I radiation screening as described below. Analytical detection limits, precision, and accuracy shall be specified in the analytical method, which shall be reviewed and approved in compliance with standard or Westinghouse Hanford or Westinghouse Hanford-approved procurement control and/or procedure control procedures prior to use.

Level I: Soil samples shall undergo field screening to determine gross alpha and beta/gamma radiation. Samples exhibiting radioactivity greater than 200 counts/min will be automatically routed to an appropriately equipped and qualified laboratory for analysis. Screening shall be performed by qualified Westinghouse Hanford, participating contractor, or subcontractor radiation protection technologists as specified in governing procedures.

Data quality objectives for the 300-FF-5 operable unit are summarized in Tables 1 and 2 and are also discussed in Chapter 4.0 of the 300-FF-5 Work Plan. As noted in Section 4.6 of EPA (1987), data quality objectives for precision, accuracy, representativeness, completeness, and comparability (PARCC) are difficult to establish at the outset of an investigation. Where data quality objectives can be established, however, they must be based on the expected end use of the data. Where standard reference methods are provided, minimum guidelines are available that may be used in the preparation of analytical methods appropriate for this investigation. Table 2 provides general guidelines and reference sources for method detection limits, precision, and accuracy as available for each analyte of interest.

Table 1. Data Quality Objectives. (Sheet 1 of 2)

Measurement parameter	Accuracy	Precision	Completeness
Water chemistry	see Table 2	see Table 2	see Table 2
Hydrologic testing			
Flow rate	±10%	±10%	80% per log cycle
Depth to water (testing)	±0.04 ft	±0.04 ft	80% per log cycle
Well diameter	±0.01 ft	±0.01 ft	100%
Distance between wells	±5%	±5%	100%
Well depth	±1 ft	±0.1 ft	100%
Time	<10 min ±5 s >10 min ±1%	±5 s	100%
Depth to water (sampling)[a]	±0.02 ft	±0.02 ft	100%
Surveyed casing elevation[a]	±0.04 ft	±0.02 ft	100%

Table 1. Data Quality Objectives. (Sheet 2 of 2)

Measurement parameter	Accuracy	Precision	Completeness
Sediment/soil analysis			
Scale(s)	±0.02 g	±1%[b]	100%
Caliper(s)	±0.025 mm	±1%[b]	100%
Pressure gauge	±0.01 bar	±1%[b]	100%
Hydrometer	±1 g colloids/L	±2%[b]	100%
Biota sampling			
Radionuclides, metals	See Table 2	See Table 2	See Table 2

[a]Relative to National Geodetic Vertical Survey or Hanford facility datum.
[b]Of full scale.

Groundwater analyses of potential or existing drinking water sources may require detection limits beyond the standard Contract Laboratory Program detection limits. Proactive efforts to identify constituents that may require enhanced analytical methods will be taken as early as possible and throughout the project. When these situations occur, the required detection limits shall be specified in the analytical laboratory subcontract or work order. Once individual laboratory statements of work are negotiated and procedures are developed and approved in compliance with Westinghouse Hanford or Westinghouse Hanford-approved procurement control procedures, Table 2 shall be revised to reference approved detection limit, precision, and accuracy criteria as project requirements.

Goals for data representativeness are addressed qualitatively by the specification of sampling locations and intervals within the Field Sampling Plan for this operable unit. Objectives for completeness for this investigation shall require that contractually or procedurally established requirements for precision and accuracy be met for at least 90% of the total number of requested determinations. Failure to meet this criterion shall be documented as a nonconformance subject to corrective action. Approved analytical procedures shall require that standard reporting techniques and units be used wherever possible to facilitate the comparability of data sets in terms of precision and accuracy. The comparability of data shall be controlled through the use of Westinghouse Hanford Environmental Investigation Instructions, Westinghouse Hanford technical procedures, or Westinghouse Hanford-approved subcontractor-developed procedures for conducting technical investigations.

Table 2. Analytical Level, Method Selection, Detection Limit, Precision, and Accuracy Guidelines for the 300-FF-5 Operable Unit. (Sheet 1 of 2)

Category of analysis	Analyte of interest	Analytical level[a]	Standard or reference method	Analytical method	Minimum detectable concentration (in soil)	Precision (soil)	Accuracy (soil)	Minimum detection limit (in water)	Precision (water)	Accuracy (water)
Radiation screening	Gross alpha	I	NA	b	NA	NA	NA	NA	NA	NA
	Gross beta/gamma	I	NA	b	NA	NA	NA	NA	NA	NA
Organic vapor screening	All volatile organics	I	NA	b	NA	NA	NA	NA	NA	NA
Radionuclides	Gross alpha	III	9310[c]	b	d	d	d	d	d	d
	Gross beta	III	9310[c]	b	d	d	d	d	d	d
	^{235}U	III	NA	b	d	d	d	d	d	d
	^{238}U	III	NA	b	d	d	d	d	d	d
Metals	Aluminum	III	6010[c]	b	d	d	d	d	d	d
	Antimony	III	6010[c]	b	d	d	d	d	d	d
	Beryllium	III	6010[c]	b	d	d	d	d	d	d
	Cadmium	III	6010[c]	b	d	d	d	d	d	d
	Chromium	III	6010[c]	b	d	d	d	d	d	d
	Copper	III	6010[c]	b	d	d	d	d	d	d
	Iron	III	6010[c]	b	d	d	d	d	d	d
	Lead	III	7420 or 7421[c]	b	d	d	d	d	d	d
	Manganese	III	7460 or 7461[c]	b	d	d	d	d	d	d
	Mercury	III	7470 or 7471[c]	b	d	d	d	d	d	d
	Nickel	III	6010[c]	b	d	d	d	d	d	d
	Silver	III	6010[c]	b	d	d	d	d	d	d
	Zinc	III	7950 or 7951[c]	b	d	d	d	d	d	d

Table 2. Analytical Level, Method Selection, Detection Limit, Precision, and Accuracy Guidelines for the 300-FF-5 Operable Unit. (Sheet 2 of 2)

Category of analysis	Analyte of interest	Analytical level[a]	Standard or reference method	Analytical method	Minimum detectable concentration (in soil)	Precision (soil)	Accuracy (soil)	Minimum detection limit (in water)	Precision (water)	Accuracy (water)
Ions	Ammonium	III	D-4327[e]	b	1 µg/g	e	e	500 µg/L	e	e
	Fluoride	III	D-4327[e]	b	1 µg/g	e	e	500 µg/L	e	e
	Nitrate (as NO_3^-)	III	NA	b	c	d	d	d	d	d
	Nitrite	III	NA	b	c	d	d	d	d	d
Volatile organics	1,2-Dichloroethene	III	8240[c]	b	d	d	d	d	d	d
	Methylene chloride	III	8240[c]	b	d	d	d	d	d	d
	Tetrachloroethylene	III	8240[c]	b	d	d	d	d	d	d
	Trichloroethene	III	8240[c]	b	d	d	d	d	d	d
Polychlorinated biphenyls	Arochlor 1248	III	8080[c]	b	d	d	d	d	d	d
Other	Cation exchange capacity	III	9080 or 9081[c]	b	d	d	d	d	d	d
	pH (soil)	III	9045[c]	b	d	d	d	d	d	d
	pH (water)	III	NA	b	d	d	d	d	d	d

[a]Analytical levels are as defined in Section 4.3.1 of EPA (1987).
[b]Analytical methods shall be approved Westinghouse Hanford Company (Westinghouse Hanford) or Westinghouse-Hanford approved participant contractor procedures. All procedure reviews and approvals shall be in compliance with applicable Westinghouse Hanford procedure control or procurement procedures.
[c]Standard methods are from EPA (1986).
[d]Minimum requirements for method detection levels, precision, and accuracy will be method specific and shall be negotiated and established in the procedure review and approval process.
[e]Standard methods are from ASTM (1987).
NA = Not applicable.

4.0 SAMPLING PROCEDURES

All procedures required for site characterization sampling activities shall be developed, prepared, and approved in accordance with Westinghouse Hanford procedures or Westinghouse Hanford-approved procedures for procedure preparation, review, and approval prior to the start of any sampling activities. Classes of procedures related to sampling are identified in Table 3. Sampling activities in support of the tasks delineated in Section 1.4.1 of this QAPP will be conducted in accordance with appropriate established procedures delineated in Table 4.1 of the 300-FF-1 QAPP. Participating contractor or subcontractor quality assurance plans and procedures shall be reviewed, approved, and maintained as project quality records. All approved procedures shall be available for regulatory review on request by direction of the Westinghouse Hanford technical lead.

Table 3. Sampling and Investigative Procedures for Phase I Investigations in the 300-FF-5 Operable Unit. (Sheet 1 of 2)

Procedure subject[a]	Source sampling and analysis	Surface soil sampling and analysis	Vadose zone soil sampling and analysis	Seismic refraction survey	Groundwater sampling and analysis
Field log books	X	X	X	X	
Records management	X	X	X	X	X
Preparation of health and safety plans	X	X	X	X	
Chain of custody	X	X	X		
Soil and sediment sampling	X	X	X		
Field decontamination of drilling equipment	X		X		
Decontamination of equipment for RCRA/CERCLA sampling	X	X	X		
Natural-gamma geophysical logging	X		X		
Hanford geotechnical library control sample archiving	X		X		X
Activity reports of operations	X		X		
Geologic logging	X		X		
Borehole/site reclamation and verification	X		X		
Borehole/site reclamation activity reports	X		X		

Table 3. Sampling and Investigative Procedures for Phase I Investigations in the 300-FF-5 Operable Unit. (Sheet 2 of 2)

Procedure subject[a]	Source sampling and analysis	Surface soil sampling and analysis	Vadose zone soil sampling and analysis	Seismic refraction survey	Groundwater sampling and analysis
Surveying[b]	X	X	X	X	
Laboratory analysis[b]	X	X	X		X
Seismic refraction procedure[c]				X	
Underground utility location[c]	X	X			
Underground pipe leak detection[c]		X			
Soil probe installation and monitoring[c]		X			
Additional geophysical logging:[c] •neutron-epithermal-neutron •gamma-gamma •high-resolution spectral gamma			X		

NOTE: Level I radiation screening procedures shall be as specified by standard Westinghouse Hanford Company (Westinghouse Hanford) radiological protection operating procedures.

[a]Procedures are Westinghouse Hanford Environmental Investigation Instructions (EIIs) (Brown 1989) unless participant contractor or subcontractor procedures are indicated. All procedures listed are directly applicable to the performance or documentation of task activities. Other administrative EIIs that are applicable to all tasks address the following subjects:

- •Preparation of EIIs
- •Desk instruction preparation
- •Deviations from EIIs
- •Dosimetry
- •Lock and tag requirements
- •Pest control.

[b]All participant contractor and subcontractor procedures shall be reviewed and approved by Westinghouse Hanford before use; approved procedures are retained in project quality records and are available for regulatory review on request at the direction of the technical lead. Laboratory analytical procedures are further defined in Chapters 3.0 and 7.0 of this Quality Assurance Project Plan.

[c]Procedures will be developed by Westinghouse Hanford participating organizations, participant contractors, or subcontractors in compliance with the procurement control, procedure control, and test control requirements promulgated by Westinghouse Hanford. All procedures will be reviewed and approved by Westinghouse Hanford before use and shall be available on request at the direction of the Westinghouse Hanford technical lead.

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act.
RCRA = Resource Conservation and Recovery Act.

Any additional activities that will be specifically required for this portion of the investigation shall be documented, reviewed, and approved prior to use. Documentation requirements shall be addressed within individual procedures, Chapter 15.0 of this QAPP, and/or the 300-FF-5 Data Management Plan, as appropriate. Analytical procedures are discussed in detail in Chapter 7.0 of this QAPP and were noted in Table 2.

Should deviations from established technical procedures be required to accommodate unforeseen field situations, they may be authorized by the field team leader or his designee in accordance with change control procedures (Section 15.4 of this QAPP). Changes initiated from the field may be approved by the appropriate field team leader via radio or telephone communication and will be documented as required by Westinghouse Hanford procedures or Westinghouse Hanford-approved procedures governing change control. Other types of procedure change requests shall be documented as required by the Westinghouse Hanford or Westinghouse Hanford-approved procedure governing their preparation.

5.0 CHAIN OF CUSTODY AND FIELD DOCUMENTATION

All samples obtained during the course of this investigation shall be controlled as required by the Westinghouse Hanford or Westinghouse Hanford-approved procedures for chain of custody from the point of origin to the analytical laboratory and/or the location of storage or archival. Laboratory chain-of-custody procedures shall be reviewed and approved as required by Westinghouse Hanford procurement control procedures, and shall ensure the maintenance of sample integrity and identification throughout the analytical process. At the direction of the technical lead, requirements for return of residual sample materials after completion of analysis shall be defined in accordance with procedures defined in the procurement documentation to subcontractor or participant contractor laboratories. Chain-of-custody forms shall be initiated for returned residual samples as required by the approved procedures applicable within the participating laboratory. Results of analyses shall be traceable to original samples through the unique code or identifier specified by Part I--Field Sampling Plan. Results shall be controlled as permanent project quality records as required by standard Westinghouse Hanford procedures and the 300-FF-5 Data Management Plan.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

Calibration of all measuring and test equipment, whether in existing inventory or purchased for this investigation, shall be controlled as required by calibration programs in compliance with standard Westinghouse Hanford or Westinghouse Hanford-approved procedures.

All calibration of laboratory measuring and test equipment shall meet the minimum requirements of EPA (1986), as modified by proposed rules contained in the Federal Register (1989). Such requirements shall be invoked wherever required through standard Westinghouse Hanford or Westinghouse Hanford-approved procurement control procedures.

7.0 ANALYTICAL PROCEDURES

Laboratory and field analytical methods or procedures for each analytical level identified in Chapter 3.0 of this QAPP shall be selected or developed and approved prior to use in compliance with test planning, performance, and evaluation, and/or procurement control requirements. As noted in Section 4.6 of EPA (1987), universal goals for precision, accuracy, representativeness, completeness, and comparability (PARCC parameters) cannot be practically specified at the outset of an investigation. Where standard reference methods are available, however, minimum guidelines are provided that may be used in the preparation of analytical methods appropriate for this investigation.

Table 2 provided general guidelines and reference sources for laboratory method detection limits, precision, and accuracy as available for each analyte of interest and sorted by the required analytical level. Analytes noted as being level III shall require the use of the approved procedure(s) noted in EPA (1986). Where guidelines are not available, statistical guidelines appropriate for determining precision and accuracy shall be developed, included in procedures, and submitted for Westinghouse Hanford review and approval. The guidance provided in Appendix A in this QAPP may be used in such situations as appropriate for the development of procedural guidelines. Once individual laboratory statements of work are negotiated and procedures are approved in compliance with appropriate Westinghouse Hanford or Westinghouse Hanford-approved requirements, Table 2 shall be revised to include actual method references, approved detection limits, precision, and accuracy criteria as project requirements.

All analytical procedures approved for use in this site characterization shall require the use of standard reporting techniques and units wherever possible to facilitate the comparability of data sets in terms of precision and accuracy. All approved procedures shall be retained in the project quality assurance records, and shall be available for regulatory review when requested at the direction of the Westinghouse Hanford technical lead.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Analytical data from sampling activities will be used primarily to determine the presence and amounts of analytes of interest in the sampled locations or intervals. Field team leaders shall be responsible for the preliminary examination and validation of data collected in the field. Analytical laboratories shall be responsible for the examination and validation of analytical results to the extent appropriate for the analytical level. The requirements discussed in this chapter shall be invoked, as appropriate, in procurement documentation prepared in compliance with standard Westinghouse Hanford or Westinghouse Hanford-approved procedures. Major participant contractor and subcontractor key individuals and positions are delineated in the Project Management Plan for the 300-FF-1 operable unit.

Figure 2 presents the overall data reduction, validation, review, and reporting flow scheme for this project. The following sections briefly describe the data reduction, validation, and reporting procedures that will be used. Also, many specific data validation methods are described in Chapter 12.0 of this QAPP as part of the required internal quality control.

8.1 DATA MANAGEMENT PROCEDURES

All data generated shall be managed in accordance with the 300-FF-5 Data Management Plan.

8.2 PROCESS FOR HANDLING UNACCEPTABLE OR SUSPECT DATA

During initial data screening, data verification, and data review activities of field- and laboratory-generated data, when unacceptable or suspect data (including outliers) are discovered, they must be evaluated to determine their cause, possible impact on previously reported results, and if necessary, to develop remedial action for the immediate problem as well as to prevent its recurrence. This investigation must be documented, distributed, and placed in the permanent project files. As a minimum, the project manager, sample collection task leader, sample analysis task leader, and quality engineer must be copied on the distribution. If the evaluation indicates that the cause was noncompliance with an established procedure or requirement, a report will be generated in accordance with Westinghouse Hanford or Westinghouse Hanford-approved procedures for controlling deviations from quality assurance requirements and established procedures. If the evaluation indicates that the cause was nonconformance of an item with documented specifications or requirements, a report will be generated in accordance with Westinghouse Hanford or Westinghouse Hanford-approved procedures for controlling nonconformances. If the evaluation indicates that suspect data have been included in the Hanford Environmental Information System (see 300-FF-5 Data Management Plan), it must be flagged to indicate its suspect status.

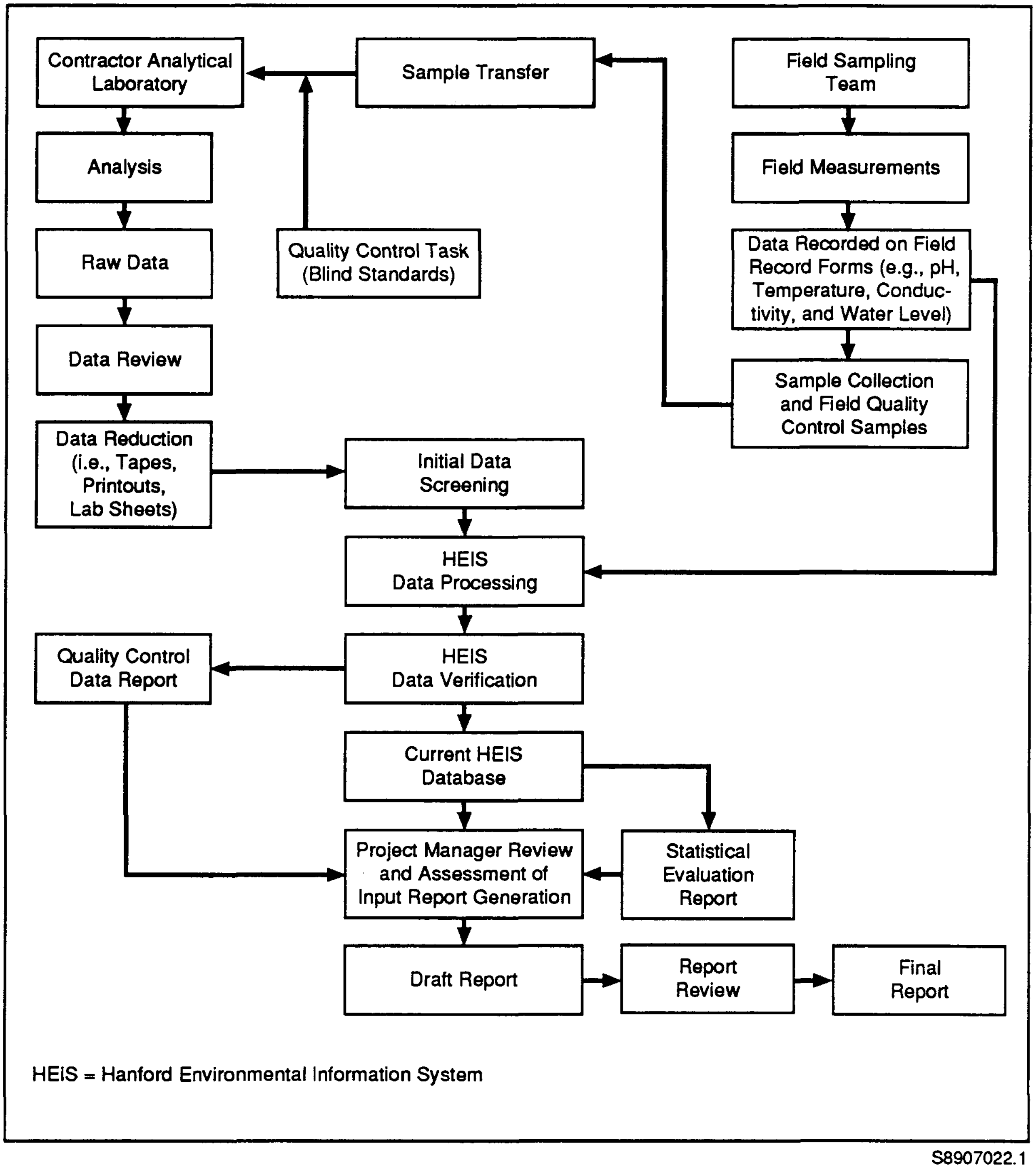

Figure 2. Data Flow Scheme.

9.0 INTERNAL QUALITY CONTROL

The principal functions of a sampling and analysis program are to obtain reliable and representative environmental samples and to provide validated data using reliable analytical methods. To achieve such functions, a program to assess both field and laboratory data must be instituted. The program presented in this section establishes the type and frequency of quality control checks, both field sampling and laboratory.

9.1 SUMMARY OF QUALITY CONTROL CHECKS

A summary of the quality control checks instituted is shown in Table 4.

Table 4. Summary of Quality Control Checks.

Data characteristic	Sample type	Frequency
Field/transport contamination	Field blank	1 per 20 samples
Field/transfer contamination	Field blank	1 per 20 samples
Laboratory contamination	Laboratory (reagent) blank	1 per batch
Accuracy	Blind standards	Variable, depending on constituent
	Split samples (optional)	Variable
Precision (field variability)	Field duplicates	1 per 20 samples or 1 per sample event
Precision (laboratory variability)	Laboratory replicates	1 per batch
	Split samples (optional)	Variable
Container contamination	Empty container	1 per lot

In response to the specific data quality needs of this site characterization, the internal quality control checks performed by analytical laboratories for level III analyses shall meet the minimum requirements of EPA (1986), as modified by Federal Register (1989). Quality control checks performed by analytical laboratories of level IV analyses shall meet the quality assurance/quality control requirements of the Contract Laboratory Program protocols. The requirements of this section shall be invoked in procurement documents or work orders in compliance with Westinghouse Hanford or Westinghouse Hanford-approved procedures.

Definitions of the sample types provided in Table 4 are as follows:

- Field Blank--A blank that is prepared, handled, and analyzed in the same manner as normal carrying agents, except that it is not exposed to the material to be selectively captured. Field blanks are used to evaluate ambient conditions. Equipment blanks and trip blanks are two specific types of field blanks.

- Laboratory Blank--A blank used as a baseline for the analytical portion of a method. For example, a blank consisting of a sample from a batch of absorbing solution used for normal samples, but processed through the analytical system only, and used to adjust or correct routine analytical results.

- Blind Standard--A standard submitted whose composition is known by the submitter, but not by the analyst. A blind standard is one way to test the proficiency of a measurement process.

- Duplicates--Duplicates are two (or more) samples collected independently at a sampling location during a single act of sampling. Field duplicates are disguised so that the laboratory personnel performing the analysis are not able to determine which samples are duplicates. Duplicates are used to measure sample variance.

- Replicates--Replicates are single samples divided into two equal parts for the purpose of analysis. These samples are often referred to as "splits." Field replicates are treated and numbered identically to pay samples so that laboratory personnel performing the analysis are not able to determine which samples are replicates.

10.0 PERFORMANCE AND SYSTEM AUDITS

Acceptable performance for this project is defined as compliance with the requirements of the 300-FF-5 Work Plan, this QAPP, its implementing procedures and appendices, and associated plans, such as, but not limited to, the Field Sampling Plan or the Data Management Plan.

All activities addressed by this QAPP are subject to planned audits of project performance and systems adequacy. System audits, consist of a careful evaluation of field and laboratory quality assurance and quality control procedures. This project will be reviewed annually by the internal audits group for inclusion into the annual audit schedule. Audits are planned and performed in accordance with standard Westinghouse Hanford or Westinghouse Hanford-approved quality assurance procedures and internal audit procedures. Audit personnel are qualified in accordance with Westinghouse Hanford or Westinghouse Hanford-approved quality assurance and quality assurance audit personnel qualification procedures.

Performance audits are conducted to determine the accuracy of the total measurement system or its component parts. Surveillances are performance audits of narrow and focused scope. They will be utilized in lieu of performance audits, since a better perspective of project control can be determined by examining a project's component parts than by looking at overall control systems. Overall control systems will be addressed by the systems audits discussed above. Surveillances are typically performed by the project's quality engineer or designee. Surveillances performed on environmental projects can be placed into three basic groups: compliance, real-time, and data traceability surveillances. Compliance surveillances are performed to ensure that a specific requirement, or set of requirements, is being implemented. Real-time surveillances are performed during the work or analysis process to ensure that specific standardized procedures are being followed. Data traceability surveillances are performed to ensure that the resultant project data are traceable through the analysis process, through sample handling and transportation, and back to the actual date, time, location, individual, and technique used to collect the sample.

Surveillances shall be performed in accordance with standard Westinghouse Hanford or Westinghouse Hanford-approved procedures. Quarterly surveillance plans will be developed, identifying the requirements of this QAPP and supporting project planning documents and specifications to be verified during the upcoming quarter.

Discrepancies observed during an audit or surveillance that cannot be quickly corrected within procedure allowances shall be documented as deficiencies or nonconformances. Chapter 13.0 of this QAPP discusses corrective actions for the dispositioning of deficiencies and nonconformances. The results of surveillances and audits will be made available to project and line management, as well as to individuals contacted.

11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratory that directly affects the quality of the analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime. A preventive maintenance schedule will be developed for all field equipment. Laboratories shall be responsible for performing or managing the maintenance of their analytical equipment. Maintenance requirements, spare parts lists, and instructions shall be included in individual methods or laboratory quality assurance plans, subject to Westinghouse Hanford approval.

Requirements for the preventive maintenance of participant contractor and subcontractor equipment shall be passed on via procurement documents or work orders in compliance with standard Westinghouse Hanford or Westinghouse Hanford-approved procedures.

12.0 PROCEDURES TO ASSESS DATA QUALITY

A data validation report, summarizing the precision and accuracy of the analyses, shall be prepared at least quarterly by the analytical laboratory. The data validation report shall compare actual analytical results with the objectives stated in Chapter 3.0 of this QAPP. If the stated objectives for a particular parameter are not met, the situation shall be evaluated, and limitations or restrictions on the use(s) of such data shall be established. The summary report shall be reviewed and approved by the technical lead, who may direct additional sampling activities if the objectives for data precision, accuracy, and completeness have not been met. The approved report shall be routed to permanent project quality records and also shall be included within the report that will be prepared for submittal to the lead regulatory agency at the end of site characterization activities.

Table 2 provided general guidelines and reference sources for method detection limits, precision, and accuracy, as available, for each analyte of interest and sorted by the required analytical level. Where guidelines are not available, statistical guidelines appropriate for determining precision and accuracy shall be developed, included in procedures, and submitted for Westinghouse Hanford review and approval. The guidance provided in Appendix A of this QAPP may be used in such situations as appropriate for the development of procedural guidelines.

13.0 CORRECTIVE ACTION

Corrective actions may be identified during audits and surveillances or as a result of reported nonconformances or deficiencies. The technical lead and cognizant task leader shall be informed of all necessary corrective actions in accordance with Chapter 10.0 of this QAPP. The technical lead and cognizant task leader notifications of needed corrective actions in response to nonconformances or deficiencies is discussed below.

Corrective action must be initiated by the technical lead or cognizant task leader when deviations from procedural requirements or construction specifications occur or when quality control checks reveal that an instrument system is operating outside the range defined for acceptable operation. The need for corrective action may be revealed by observations of measurement system response, during data reasonableness checks (brief comparison of newly collected data against observed historical trends), when discrepancies are noted during instrument calibration, or during data analysis.

13.1 ACCEPTABLE OPERATING RANGES

Instruments or equipment found to be operating outside acceptable operating ranges must be investigated. Acceptable operating ranges are defined in measuring and test equipment listing required by the procedure for controlling calibrations that was discussed in Chapter 6.0 of this QAPP. A calibration discrepancy must be initiated in accordance with Westinghouse Hanford or Westinghouse Hanford-approved procedures for calibration control, when it is determined that measurement and testing equipment is not within calibration and data have been collected.

13.2 DEVIATIONS FROM PROCEDURES

Unplanned deviations from procedural requirements, either technical or administrative, must be documented by completing a report in accordance with Westinghouse Hanford or Westinghouse Hanford-approved deficiency reporting procedures. Any staff member may initiate such a report. The report must identify the requirement deviated from, the cause of the deviation, whether any results were impacted, and the corrective action to remedy the immediate problem and to prevent recurrence.

Planned deviations, documented (including justification) and approved by the technical lead in advance, do not require development of a report.

13.3 NONCONFORMANCES AND DEFICIENCIES

For materials found to be in nonconformance with specifications, a report must be generated in accordance with the Westinghouse Hanford or Westinghouse Hanford-approved procedure for controlling nonconformances and the item(s) must be dispositioned in accordance with standard procedures. Such nonconforming materials must be segregated or tagged to identify their status as nonconforming, pending disposition. Copies of all reports of nonconformances shall be forwarded to the technical lead and the cognizant task leader.

Unplanned deviations from procedures, plans, specifications, or related documents must be documented via a report in accordance with the Westinghouse Hanford or Westinghouse Hanford-approved procedure for controlling deviations from quality assurance requirements and established procedures. Potentially impacted data must be segregated or flagged pending evaluation of the deficiency's impact on the data and final disposition of the report. Copies of all reports of deficiencies shall be forwarded to the technical lead and the cognizant task leader.

Planned deviations from procedures, plans, specifications, or related documents are discussed in Chapter 4.0 of this QAPP.

14.0 QUALITY ASSURANCE REPORTS

As previously stated in Chapters 10.0 and 13.0 of this QAPP, project performance shall be regularly assessed by auditing and surveillance processes. Surveillance, deficiency, nonconformance, audit, and corrective action documentation shall be routed to the project manager as well as to project records on completion or closure of the activity. A report summarizing all audit, surveillance, and instruction change authorization activity, as well as any associated corrective actions, shall be prepared by the quality coordinator at the completion of site characterization or once annually, whichever is sooner. The report(s) shall be submitted to the technical lead for incorporation into the final report prepared at the end of each phase of the investigation. The final report shall include an assessment of the overall adequacy of the total measurement system with regard to the data quality objectives of the investigation.

Significant problems uncovered by project personnel must be reported to line management immediately for resolution. Significant problems involving data quality, sample integrity, or well construction must be thoroughly documented.

Line management must be included on the distribution of all audit reports. Significant problems encountered in day-to-day operations must be reported to line management immediately by the project manager.

15.0 RECORDS AND DOCUMENT CONTROL

In accordance with Article XXXVI (Tri-Party Agreement 1989), all records of sampling, analysis, investigations, and monitoring conducted during this work shall be maintained for a minimum of 10 yr after termination of the agreement. In addition, all records will be disposed of in accordance with the agreement.

15.1 RECORDS CONTROL

Project records must be controlled in accordance with the Westinghouse Hanford or Westinghouse Hanford-approved records system procedure. A records inventory and disposition schedule/file index must be prepared and submitted for review and approval by the quality engineer and records specialist.

15.2 RECORDS CHECKOUT

When records identified in the project file index are removed from their specified location, a checkout card that identifies who removed the document, its title or identification, and when the document was removed, must be placed in the file from which the document was removed. On return of the document, the checkout card will be removed and the borrower's name lined through.

15.3 QUALITY ASSURANCE PROJECT PLAN CONTROL

Distribution and control of this QAPP must be conducted in accordance with standard document control procedures. Modifications to this QAPP must be made in accordance with Section 9.3 of the Tri-Party Agreement (1989).

15.4 TECHNICAL PROCEDURE CONTROL

Technical procedures shall be developed, distributed, and controlled in accordance with Westinghouse Hanford or Westinghouse Hanford-approved procedures. Modifications to any of these procedures must be performed in accordance with standard Westinghouse Hanford procedures or Westinghouse Hanford-approved procedures and instructions for document change control.

16.0 PROCUREMENT CONTROL

16.1 PURCHASE REQUISITIONS AND SUBCONTRACTS

Procurements of items and subcontracted services are controlled by Westinghouse Hanford or Westinghouse Hanford-approved procedures covering the preparation, review, and approval of purchase requisitions.

16.2 WORK ORDERS AND WORK PACKAGE AUTHORIZATIONS

Work package authorizations or work orders to individuals or groups outside the project organization must be generated and issued in accordance with Westinghouse Hanford or Westinghouse Hanford-approved procedures for obtaining services via work orders. As appropriate, a letter of instruction or statement of work must accompany each work order or work package authorization.

17.0 STAFF TRAINING

Staff performing activities affecting quality will be issued documented training assignments, including applicable administrative and technical procedures in accordance with Westinghouse Hanford or Westinghouse Hanford-approved procedures for training and indoctrination unless training on the procedure to be utilized has already been documented. The project manager must evaluate the training history of project contributors to determine the staff's training status before utilizing these staff for activities affecting quality. Project-specific technical training (e.g., training on the technical procedures) will be assigned by the technical lead if an evaluation of a staff member's training records indicate additional project-specific training is necessary. This evaluation must be documented whether project-specific training is assigned or not.

Briefings must be documented following standard Westinghouse Hanford or Westinghouse Hanford-approved procedures on indoctrination and training.

When each staff member has completed the assigned training, the training assignment(s) must be returned to the project manager (or radiation protection technologist supervisor as discussed above) who assigned the training. The applicable manager or supervisor will sign and date the bottom of the assignment, indicating that assigned training has been completed, and will ensure that a copy is placed into an individual's training records.

18.0 SOFTWARE CONTROL

18.1 SOFTWARE DEVELOPMENT

Computer code development, modification, and application activities must be performed in accordance with Westinghouse Hanford or Westinghouse Hanford-approved software control procedures. The following types of activities shall be procedurally controlled:

- Determination of software requirements
  - provides for identification and classification of software into one of three functional categories: (1) engineering/scientific software, (2) support software, and (3) system-maintained software
  - provides the preplanning of software activities
- Software configuration management
  - provides configuration control measures of software released for testing and/or use
- Conversion testing, verification, and/or validation of software
  - provides for the verification, validation, and/or conversion testing of developed or modified software
- Software application control
  - provides control for client-reported application runs
- Control of databases
  - provides for revision and change control of databases.

A thorough discussion of the project-specific database requirements can be found in the 300-FF-5 Data Management Plan.

18.2 ADDITIONAL SOFTWARE ACTIVITIES

Software utilized in the field or by a laboratory shall be controlled in accordance with the Westinghouse Hanford or Westinghouse Hanford-approved procedures for software control. The aspects of commercial software to be controlled shall include, but shall not be limited to, the following:

- Conversion testing, verification, and validation
- Control of client-reported application runs, including the traceability of software-generated results to the specific version of the software used to generate the results.

Quality requirements and specifications for controlling the software of subcontractors shall be passed to the subcontractor via a statement of work or work order in accordance with the procurement control requirements of Chapter 16.0 of this QAPP.

19.0 REFERENCES

ASTM, 1987, *1988 Annual Book of ASTM Standards*, American Society for Testing and Materials, Philadelphia, Pennsylvania.

Brown, L. C., 1989, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Revision #10, Westinghouse Hanford Company, Richland, Washington.

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

EPA, 1983, *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80*, EPA-600/4-83-004, Office of Monitoring Systems and Quality Assurance, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1987, *Data Quality Objectives for Remedial Response Activities - Development Process*, OSWER Directive 9355.0-7B, EPA/540/G-87/003, Office of Emergency and Remedial Response and Office of Waste Programs, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, OSWER Directive 9355.3-01, EPA/540/G-89/004, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

Federal Register, 1989, "Part II, Environmental Protection Agency, 40 CFR Parts 260, 261, 262, 264, 265, 268, and 270, Hazardous Waste Management System; Testing and Monitoring Activities," *Federal Register*, Vol. 54, No. 13, January 23, 1989.

Tri-Party Agreement, 1989, *Hanford Federal Facility Agreement and Consent Order Between the U.S. Environmental Protection Agency, the U.S. Department of Energy, and the State of Washington Department of Ecology, May 15, 1989*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

APPENDIX A

RECOMMENDED STATISTICAL METHODS FOR ASSESSING PRECISION, ACCURACY, AND COMPLETENESS

1.0 SCOPE

This appendix discusses various statistical methods and standard formulae suitable for inclusion in Westinghouse Hanford Company, participant contractor, or subcontractor laboratory analytical procedures for environmental investigations. Such methods are routinely used to assess the precision, accuracy, and completeness of measurement data within individual analytical procedures (EPA 1979). The information provided by this appendix is intended for guidance only. All methods selected or proposed by an individual analytical laboratory for the assessment of data precision, accuracy, and completeness are subject to review and approval prior to use.

2.0 STATISTICAL METHODS AND FORMULAE

2.1 CENTRAL TENDENCY AND DISPERSION

Methods for determining central tendencies and dispersion of data may include determination of various statistical values. The arithmetic mean, $\bar{X}$, is the average of the sum of a set of n values divided by n

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where n = number of items in the sample or test

X_i = ith measurement, or the ith smallest measurement of a set of measurements arranged in ascending order.

Range simply refers to the difference between the highest and lowest values reported for a sample (EPA 1979). The standard deviation, σ, is the square root of the variance of the population

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} X_i^2 - \left(\sum_{i=1}^{N} X_i\right)^2 |n}{N}}$$

where N = population size (if finite) or lot size.

The standard deviation estimate, S, is the most widely used measure to describe the dispersion of a set of data, and is expressed as follows:

$$S = \sqrt{\frac{\sum_{i=1}^{N} X_i^2 - \left(\sum_{i=1}^{N} X_i\right)^2 |n}{-1}}$$

The relative standard deviation, RD, is the ratio of the standard deviation of a set of numbers to their mean, expressed as a percentage; it relates the standard deviation (or precision) of a set of data to the size of the numbers

$$CV = RD\ (\%) = 100 \frac{S}{\bar{X}}$$

where CV = coefficient of variation.

Skewness, K, is a measure of the asymmetry of a frequency distribution

$$K = \frac{(X_i - \bar{X})^3}{n\sigma^3}$$

The geometric mean is a measure of central tendency for data from a positively skewed distribution (log normal)

$$\bar{X}_g = n\sqrt{(X_1)(X_2)\ \ldots\ (X_n)}$$

$$\bar{X}_g = \text{antilog} \frac{\sum_{i=1}^{n} \log X_i}{n}$$

where $\bar{X}_g$ = geometric mean of sample measurements.

2.2 ASSESSMENT OF DATA QUALITY

Accuracy may be interpreted as the measure of the bias in a measurement system. Bias is a systematic error due to the experimental method that causes measured values to deviate from true values. Accuracy is the degree of agreement of a measurement (or the average of a set of measurements with identical parameters) with an accepted reference or true value. Accuracy may be expressed as (1) the difference between the measurement (X) with the reference value (T) (i.e., X-T) or (2) the difference between the two values as a percentage of the reference value (i.e., 100(X-Y)/Y) or simply as the ratio X/T. For the purposes of environmental investigations, precision may be interpreted as a measure of relative agreement or reproducibility between individual measurements made with a common set of parameters or conditions. Precision is normally expressed in terms of the standard deviation, but also may be expressed as the relative standard deviation (coefficient of variation) or range (maximum value minus minimum value; see the discussion in Section 2.1). Relative error, RE, refers to the mean error of a series of measured data values as a percentage of the true value, X_t

$$RE\ (\%) = 100 \frac{|X - \bar{X}|}{X_t}$$

For the purposes of environmental investigations, comparability is an expression of the relative confidence with which one data set may be compared with another. Confidence limits are discussed in Section 2.4. Completeness may be interpreted as a measure of the amount of data actually obtained from a measurement system against the amount that would be expected under correct normal conditions, and is expressed as follows:

$$\text{Completeness (\%)} = \frac{\text{Number of valid analyses (for each parameter)}}{\text{Number of samples analyzed (for each parameter)}} \; 100$$

For the purposes of environmental investigations of the Hanford Site, completeness is defined as an objective of meeting established requirements for precision and accuracy for at least 80% of the requested determinations.

2.3 SIGNIFICANCE TESTS

Significance tests refer to the various statistical means of checking distribution hypotheses. Such tests include the Student-t test, the χ squared test, the paired t test, and the F test, and should be selected to suit the types of hypotheses. Detailed discussions of these types of tests may be found in standard statistics texts, such as Lapin (1983) or Miller and Freund (1965).

2.4 CONFIDENCE LIMITS

Confidence limits refer to the boundaries of a value interval with a designated probability (the confidence coefficient) of including some defined parameter of the sample population. The confidence coefficient is the probability that the value interval has of including the sample population values. The confidence coefficient is normally expressed as a percentage; for a given sample size, the distance between the confidence limits increases as the coefficient increases. The guidelines, tables, formulae, and figures of Appendix E from EPA (1987) are recommended references for the establishment of confidence limits.

2.5 TESTING FOR OUTLIERS

Statistical tests are recommended for the screening of data sets for unusually large or small data values for elimination prior to the analysis or processing of data. The guidelines, tables, formulae, and figures of Appendix F from EPA (1987) are recommended for selection of appropriate methods.

3.0 REFERENCES

EPA, 1979, *Handbook for Analytical Quality Control in Water and Wastewater Laboratories*, EPA/600/4-79/019, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA, 1987, *Data Quality Objectives for Remedial Response Activities - Development Process*, OSWER Directive 9355.0-7B, EPA/540/G-87/003, Office of Emergency and Remedial Response and Office of Waste Programs, U.S. Environmental Protection Agency, Washington, D.C.

Lapin, L. L., 1983, *Probability and Statistics for Modern Engineering*, Brooks/Cole Publishing Company, Monterey, California.

Miller, I. and J. E. Freund, 1965, *Probability and Statistics for Engineers*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

ATTACHMENT 2

HEALTH AND SAFETY PLAN FOR THE 300-FF-5 OPERABLE UNIT

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LIST OF FIGURES

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ATTACHMENT 2

HEALTH AND SAFETY PLAN FOR THE 300-FF-5 OPERABLE UNIT

1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

1.1 INTRODUCTION

The 300 Area, located north of Richland, Washington contains the reactor fuel fabrication facilities and research and development laboratories. The 300-FF-5 operable unit includes the groundwater under the 300 Area. Contaminants in the groundwater are related to the types and quantities of hazardous chemicals and radiological substances used and disposed in the 300 Area.

This Health and Safety Plan (HASP) is, therefore, written as a supplement to the 300-FF-1 HASP, since that operable unit has been the major source of groundwater contamination. Other than this introductory material and Sections 1.1 through 1.3, the material in this supplementary HASP is numbered to coincide with that in the 300-FF-1 HASP.

1.1.1 Purpose

The purpose of this HASP is to establish overall policies and procedures to protect workers and the public from potential hazards associated with the 300-FF-5 operable unit and operations conducted to support the remedial investigation/feasibility study (RI/FS).

1.1.2 Scope

This HASP is provided as a supplement to the 300-FF-1 HASP and, therefore, contains only the additional requirements associated with the groundwater RI/FS work in the 300-FF-5 operable unit. All relevant requirements of the 300-FF-1 HASP, including the general work safety practices, apply to this work. Subcontractors may develop their own HASP that is specifically tailored to their operations, but it must be at least as restrictive as this HASP. Site-specific safety and health procedures will be developed using a Job Hazard Breakdown, a Job Safety Analysis, or Safe Operating Procedures for each site covered by this HASP. These procedures will address, at a minimum, the following:

- tasks to be accomplished
- potentially hazardous radioisotopes, toxic chemicals, and physical hazards at the site
- personnel
- specific protective equipment requirements and hazard mitigation
- site-specific detail regarding air and exposure monitoring
- site-specific emergency procedures.

1.1.3 Description of the 300-FF-5 Operable Unit

The 300-FF-5 operable unit is the groundwater under the 300 Area and considers all sources of contaminants in and around the 300 Area that contribute to groundwater contamination. In addition to the principal sources associated with the 300-FF-1 operable unit, there are also groundwater contamination sources in the 300-FF-2, 300-FF-3, and 300-IU-1 operable units. Figure 1 shows the location of the 300-FF-1, 300-FF-2, and 300-FF-3 surface operable units in relation to the 300 Area and the 300-FF-5 operable unit. The location of the 300-IU-1 operable unit relative to the 300 Area is shown in Figure 2 of the 300-FF-5 Work Plan. Chapter 3.0 in the 300-FF-1 HASP and Tables 2, 3, and 4 in Chapter 2.0 of the 300-FF-5 Work Plan identify contaminant sources within the 300-FF-1, 300-FF-2, 300-FF-3, and 300-IU-1 operable units.

1.2 DESIGNATED SAFETY PERSONNEL

Site safety personnel are identified by position and their duties described in Section 1.2 of the 300-FF-1 HASP.

1.3 MEDICAL SURVEILLANCE

Medical requirements for all personnel engaged in site activities for the 300-FF-5 RI/FS are described in Section 1.3 of the 300-FF-1 HASP.

1.4 TRAINING

Training requirements for all personnel engaged in site activities for the 300-FF-5 RI/FS are described in Sections 1.4 and 1.5 of the 300-FF-1 HASP. Specific training requirements for boat operators and divers are noted in Section 4.3.9 of this HASP.

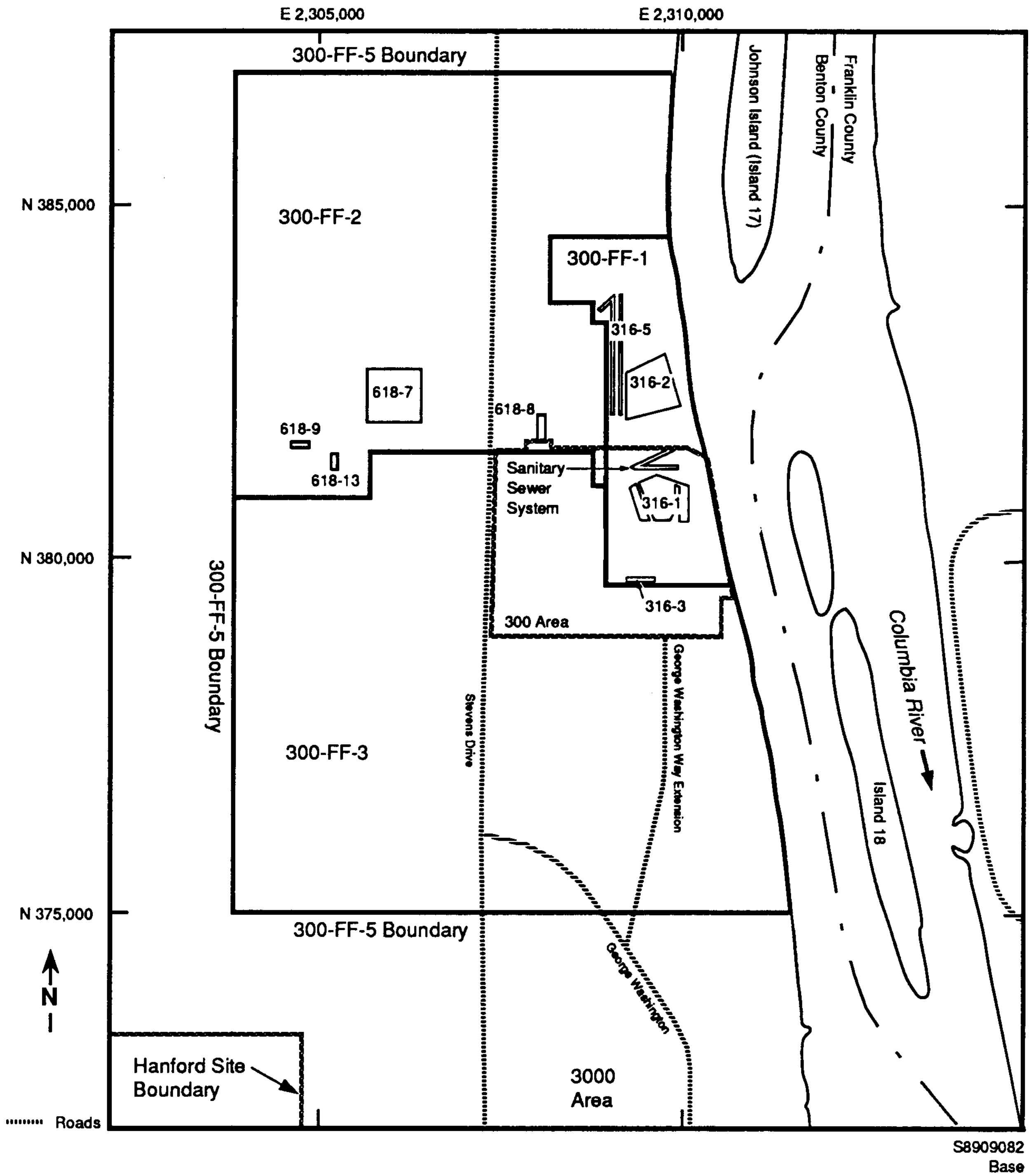

Figure 1. Relationship of the 300-FF-5 Operable Unit to the 300-FF-1, 300-FF-2, and 300-FF-3 Operable Units.

2.0 GENERAL PROCEDURES

General safety procedures for site activities for the 300-FF-5 RI/FS are described in Chapter 2.0 of the 300-FF-1 HASP. Those procedures cover safety considerations associated with specific tasks, personal protective equipment, decontamination, and emergencies. A special treatment of confined space entry is also presented.

3.0 SITE BACKGROUND

Descriptions of sources of hazardous materials that may be encountered in the 300-FF-5 operable unit are presented in Chapter 3.0 of the 300-FF-1 HASP and in Chapter 2.0 of the 300-FF-5 Work Plan. The source operable units that may contribute to contamination found in the 300-FF-5 operable unit are 300-FF-1, 300-FF-2, 300-FF-3, and 300-IU-1.

4.0 SCOPE OF WORK AND POTENTIAL HAZARDS

There are three major objectives associated with the 300-FF-5 operable unit:

- to further characterize the nature and extent of contamination in the groundwater and to evaluate contaminant movement into the accessible surface-water environment
- to identify and characterize the distribution and levels of contaminants present in the sediments and water of the Columbia River
- to conduct biological sampling
- determine baseline contaminant conditions
- determine pathways to man or threatened species
- provide the most reasonable chance of detecting bioaccumulated contaminants from site cleanup activities.

This work is necessary to accurately assess the impact of past facility operations and waste disposal activities on the groundwater quality in the 300-FF-5 operable unit.

4.1 WORK TASKS

The following environmental sampling work will be accomplished for the 300-FF-5 operable unit:

- Water and sediment samples will be collected from active springs or seepage areas at near-shore river locations adjacent to the 300-FF-1 operable unit and in the river at transect locations established along the operable unit. Also, radiation surveys will be conducted of exposed shoreline along the operable unit, including islands located in that stretch of the river. Sample collection involves work along the river and from boats, and possible diving operations using self-contained underwater breathing apparatus (SCUBA).

- Columbia River water samples will be collected at the intakes to the City of Richland municipal water supply and the 300 Area water supply.

- Groundwater samples will be taken from wells in the 300-FF-5 operable unit. Additional wells will be installed at new locations and/or will be screened at different depths at existing locations to further characterize groundwater contamination and migration. Soil samples will be collected during drilling.

- Biota investigations will be conducted and will involve three types of samples:

- wildlife feeding on river vegetation
- near-river terrestrial vegetation
- aquatic vegetation.

- Soil gas analysis will be conducted to evaluate any volatiles emanating from the groundwater. Sampling requires driving a stainless steel pipe into the ground with a post driver and using a sampling pump to draw the gases up through the pipe for subsequent analysis.

4.2 POTENTIAL HAZARDS

The one significant chemical contaminant, in addition to those presented in the 300-FF-1 HASP, is hexone (a.k.a. methyl isobutyl ketone or MIBK) and its degradation product, 2-butanone (a.k.a. methyl ethyl ketone or MEK) disposed in 316-4 in the 300-IU-1 operable unit. The waste inventory for 316-4 is shown in Table 1. The allowable exposure limits and hazards associated with these chemicals are shown in Table 2. Material Safety Data Sheets are provided in Appendix A.

Table 1. Estimated Nonradiological Chemical Waste Inventory for 316-4.

Total volume of liquids disposed: 200 m^3	
Chemical	Quantity (kg)
Uranium	2,000
Nitrate	1,000
Methyl isobutyl ketone	3,000

Table 2. Potential Chemical Hazards.

Substance	Threshold limit value time-weighted average (p/m)	Immediately dangerous to life or health (IDLH) (p/m)	Monitoring sampling	Primary hazards and symptoms
Hexone (MIBK)	50	3,000	HNU/OVA	Irritation of eyes, nose, and throat
2-Butanone (MEK)	200	3,000	HNU/OVA	Irritation of eyes, nose; headaches

HNU = A type of monitoring instrument.
OVA = Organic vapor analyzer.

Potential hazards associated with RI/FS tasks for the 300-FF-5 operable unit include the following:

- External and internal exposure to ionizing radiation via breaks in the skin barrier, inhalation, and ingestion
- Exposure to toxic contaminants from water, soil, and sediment samples through absorption, inhalation, and/or ingestion
- Electrical shock/electrocution from derricks or other equipment contacting overhead electrical lines or shorting of ungrounded electrical equipment
- Mechanical and overhead hazards during drilling operations, resulting in slips, trips, falls, bumps, cuts, pinch points, falling objects, crushing injuries, etc; slips and falls also may occur during sediment and water sampling and boat activities due to steep grades, uneven terrain, or slippery surfaces.

- Thermal stress caused by excessive exposure to heat and cold
- Drowning or hypothermia during diving and boating operations.

4.3 ASSESSMENT AND MITIGATION OF POTENTIAL HAZARDS

4.3.1 Ionizing Radiation (External, Internal)

The Radiation Work Procedure provides the specific measures necessary to minimize radiation exposure to personnel during onsite activities based on sampling and monitoring. External contamination will be controlled through the use of personal protective clothing. Internal contamination will be controlled through the use of full-face, air-purifying respirators.

An initial radiation survey of the site will be conducted to determine if there is any surface contamination present. If necessary, water mist will be sprayed as necessary to maintain control of the spread of dirt, dust, and associated contamination.

During borehole geophysical logging, all nonessential personnel will be kept at least 50 ft away from the logging unit. The operators will be experienced and will use time, distance, and shielding to minimize exposure to probe sources, and will wear dosimeters to monitor their radiation exposure.

A wind direction indicator will be posted during sampling activities. To the extent feasible, personnel will be positioned upwind of any site activity to prevent the inhalation of dust. The radiation protection technologist may stop the work until the wind subsides if airborne contamination levels exceed an 8-h derived air concentration. Respirators will be worn as necessary to protect workers from airborne radioactive materials in contaminated dust.

Radiation protection technologists will monitor any soil or equipment before it is removed from the controlled area.

4.3.2 Chemical Exposure (Inhalation, Ingestion, Absorption)

Baseline sampling and chemical analysis of toxic contaminants in the surface soil and in the air will be conducted at proposed drill sites prior to other tasks. Periodic or special monitoring for chemical hazards will be based on recommendations from the Hanford Environmental Health Foundation following baseline sampling.

To the extent feasible, personnel will be positioned upwind of any site activity to prevent the inhalation of airborne chemical contaminants. Respirators will be worn, as necessary, to protect workers from respirable toxic chemicals. Wearing of contact lenses with respirators shall not be permitted.

To prevent ingestion of any toxic materials, eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material will be prohibited within the controlled area.

Contaminant concentrations in existing wells in and around the 300 Area indicate that contaminant levels are generally low. Although these levels may exceed drinking water standards for some contaminants, the airborne chemical concentrations associated with this water are not likely to exceed occupational exposure standards. Sampling from existing wells will be conducted in accordance with established procedures for monitoring well and groundwater sample collection. Sampling from new wells also may be conducted under this plan after baseline sampling has confirmed that contaminant levels are below occupational exposure limits and site monitoring has determined that no significant levels of contaminants are present in the vicinity of the well.

Contaminant levels in soil samples from drilling operations may contain higher contaminant levels. Wells will not be drilled into known waste disposal structures (such as trenches or cribs), but may be installed immediately downgradient from such sites. Respiratory protection will be used when working with such soil samples until monitoring shows that such protection is not required.

Protective clothing and gloves will be worn, as necessary, to prevent contact with chemical contaminants. Impermeable gloves will be required when handling soil samples.

4.3.3 Noise

Noise levels from equipment and operations will be measured and hearing protection used when required. Drilling may generate operating noise levels as high as 100 dBA near the drilling rig. When continuous noise levels make routine communication difficult without raising one's voice (>85 dBA), hearing protection shall be worn. Hearing protection also shall be worn for high-intensity impact noise (>120 dBA).

4.3.4 Electrical Hazards

Electrical shock hazards during site activities will be controlled by separation of operations from overhead power lines, grounding and bonding of fixed electrical equipment, use of ground-fault-interruption circuits (GFI) for 120-V temporary wiring and insulation of conductors. The GFIs will be tested and insulation of conductors will be inspected at scheduled intervals.

Required clearances between derricks and overhead power lines will be maintained in accordance with 29 CFR 1926.550. As a rule of thumb, the horizontal distance between a derrick and the nearest overhead power lines must be no less than the height of the derrick.

No personnel will be near cranes or drilling rigs during electrical storms.

4.3.5 Mechanical Hazards

Mechanical guarding and other safety devices will be used to control mechanical hazards. All equipment will be inspected to verify that appropriate guards are functional and used. Residual hazards will be controlled by training and physical separation of personnel from the hazards. Trained operators with drilling knowledge and experience will be assigned to the drilling team. Nonessential personnel will not be permitted in the immediate vicinity of operations where mechanical hazards are present. Untrained personnel who must be present in the vicinity of operations where mechanical hazards are present will be briefed on the hazards and accompanied by trained personnel.

All proposed drilling locations will be cleared with the Westinghouse Hanford Company landlord prior to operations to ensure that any underground services or structures are not affected.

Eye protection will be provided and used during operations where eye hazards (such as flying particulate matter) are present. Personnel will not wear contact lenses in eye-hazardous areas or operations. If personnel require corrective lenses, they will be provided with prescription safety glasses or goggles that are to be worn over their glasses. A portable eyewash unit will be provided onsite.

Climbing hazards may occur during various activities on the site. Occasionally, it is necessary for one of the drilling crew to climb the derrick to service the rig, untangle cables, or perform other maintenance activities. Climbing activities also may be involved in biological sampling along the riverbank. Lifelines and safety belts or a harness will be used when climbing activities are at elevations over 10 ft above ground surface. Safety nets are required where lifelines are impractical (29 CFR 1926.951).

4.3.6 Heat Stress

Personnel working outdoors may be subject to heat stress during the summer. Cool drinking water will be available onsite, and personnel will be encouraged to increase their use of salt on foods during hot periods. Site personnel will be trained to recognize symptoms of heat stress.

Heat stress monitoring requirements, symptoms of heat stress, and control measures are specified in the 300-FF-1 HASP.

4.3.7 Cold Hazards

Hypothermia is the cooling of the body's core temperature below approximately 97°F. Work outdoors during cold weather has the potential to cause hypothermia. Workers will wear appropriate levels of clothing to provide insulation and protection from the cold. Breaks from work will be taken in heated trailers during cold periods. The symptoms and treatment of hypothermia are provided in the 300-FF-1 HASP.

As the outdoor temperature drops below 20°F, there is an increasing danger of freezing exposed flesh within 1 min, depending on wind speed. Workers will be warned to avoid skin contact with cold surfaces below 20°F.

Cold water diving presents a high risk of hypothermia due to the higher specific heat and thermal conductivity of water resulting in higher heat transfer rates. Individuals may not be able to judge the degree to which they have been affected and it is harder to detect symptoms while diving. It is, therefore, important for individual divers to be aware of any loss of dexterity or grip strength, uncontrolled shivering, difficulty in performing routine tasks, confusion, or a tendency to repeat tasks or procedures, all of which are indicative of the onset of hypothermia. The dive must be terminated if any of these symptoms are noted.

Divers will be encouraged to avoid alcoholic beverages and increase their protein and carbohydrate consumption during cold diving operations. The standard 1/4- or 3/8-in. foam neoprene wet suit with a hood is usually suitable for dives in water at 40 to 60°F for no more than 60 min. Variable volume dry suits are recommended for longer dives at these temperatures. Wet suits shall be maintained in good condition to ensure a good fit and to minimize the flushing of water in and out of the suit. A second neoprene hood may be worn over the normal hood to minimize heat loss from the head. Insulating socks, gloves, and knitted cap also may be used to minimize heat loss.

The diver is also susceptible to hypothermia on exiting the water due to fatigue and evaporative cooling. The diver's suit should be flushed with warm water, if possible, and a dry, warm changing area should be provided (NOAA 1979).

4.3.8 Fire Hazards

The work site will be kept orderly and free of debris (such as tumbleweeds). Accumulations of combustible materials (such as decontamination materials) in the controlled area will be minimized. Two approved 20-lb A-B-C-rated fire extinguishers and two shovels will be provided and situated for easy access from within and outside the controlled area. Smoking is restricted to buildings or cleared sites outside the restricted zone. The location of the nearest fire hydrant will be shown in the emergency plan.

4.3.9 Boating and Diving

Some water and sediment sampling is expected to require boating and diving activities. Drowning, hypothermia, and other forms of exposure are specific to marine operations. The relatively harsh and changeable environment normally associated with marine operations can magnify the hazards to which workers are exposed.

Boat operators will be required to have a valid U.S. Coast Guard Auxiliary Certificate or Power Squadron Certificate and will comply with all U.S. Coast Guard safety and registration requirements. Personal flotation devices must be provided and used by all occupants of the boat.

Boat operators will leave a float plan with a responsible staff member before departing on any boat trip. This float plan should contain a description of the boat, number of passengers, destination and proposed route, estimated time of return, and other pertinent information.

Divers will be certified by a national certifying organization and must be trained in first aid and cardiopulmonary resuscitation. A minimum of 10 dive days within the past 12 mo is required to maintain diving proficiency and remain on an active dive list. Two of these dive days should have been completed within the past 3 mo. If a diver is currently a certified diver but cannot meet these requirements, the diver must be checked out by the Senior Dive Officer (29 CFR 1910.410).

All divers must receive a special medical examination to ensure that their physical condition does not pose a hazard during diving. A medical reexamination must be conducted prior to subsequent diving following a diving-related injury or illness.

Diving will be conducted within the time-depth limits of no decompression. Control of hypothermia is covered above. No diving will be conducted when there is ice along the edge of the river. All diving will be conducted in compliance with established safe diving practices procedures. These procedures will be maintained by the senior dive officer and should include the following:

- 29 CFR 1910.410
- Dive plans and safety procedures developed prior to the dive, which include consideration of environmental conditions and unusual hazards
- Emergency procedures for fire, equipment failure, adverse environmental conditions, medical illness, and injury
- Check list for dive team assignments and responsibilities
- Equipment operating procedures and inspection check lists
- Briefing and debriefing check lists for dives
- Decompression and treatment tables.

5.0 ENVIRONMENTAL AND PERSONNEL MONITORING

During the conduct of site activities, monitoring for contaminants at likely personnel exposure points shall be performed. These monitoring activities are discussed in Chapter 5.0 of the 300-FF-1 HASP.

6.0 PERSONAL PROTECTIVE CLOTHING AND RESPIRATORY PROTECTION

Personnel performing work on the site shall use appropriate protective clothing and equipment to minimize exposure to hazardous materials. Levels of protective equipment are described in Chapter 6.0 of the 300-FF-1 HASP.

7.0 SITE CONTROL

The site shall be controlled in such a manner so as to prevent entry of unauthorized personnel onto the site. Control measures are discussed in Chapter 7.0 of the 300-FF-1 HASP.

For drill sites outside the 300 Area that are accessible to the public, the Hanford Patrol will be informed of their locations, the normal work hours, and the personnel to contact should the need arise. Access roads will be posted and the site periodically checked to prevent unauthorized entry into controlled areas.

8.0 DECONTAMINATION PROCEDURES

Procedures for decontaminating personnel, sampling and monitoring equipment, respiratory equipment, and heavy equipment are described in Chapter 8.0 of the 300-FF-1 HASP.

9.0 CONTINGENCY AND EMERGENCY RESPONSE PLANS

Communication and procedures for various emergency scenarios are provided in Chapter 9.0 of the 300-FF-1 HASP.

The Hanford Fire Department has been designated as emergency responder for spill stabilization, and their HazMat Response Team has been specifically trained to carry out that activity. The Hanford Fire Department has developed its own training programs to meet the requirements of 29 CFR 1920.120, and they also provide trained emergency medical technicians, depending on the nature of the emergency.

The site team leader will notify all necessary emergency responders. The site safety and health officer and/or field manager will provide the necessary details regarding the nature of the emergency.

Emergency Phone Numbers	
Hanford Emergency Response	811
Richland Emergency Services	911
PNL Emergency Response	375-2400
Kadlec Hospital Emergency Decontamination	946-4611
Poison Control Center	1-800-542-5842
National Response Center	1-800-424-8802
CHEMTREC	1-800-424-9300
Chemical Emergency Preparedness Program	1-800-535-0202
RCRA/Superfund Hotline	1-800-424-9346
TSCA Hotline	1-202-554-1404
Safe Drinking Water Act Hotline	1-800-426-4791

EMERGENCY NUMBERS ARE TO BE
VERIFIED IMMEDIATELY PRIOR
TO ANY SITE ACTIVITIES

The nearest first-aid station is located in the 3706 Building in the 300 Area. Other first-aid facilities on the Hanford Site are shown in Figure 9-1 of the 300-FF-1 HASP. Normally, seriously injured workers are transported to the hospital by Hanford Fire Department ambulance. The nearest hospital is the Kadlec Medical Center:

Kadlec Medical Center
888 Swift Blvd.
Richland, Washington 99352
Phone Number (509) 946-4611

10.0 REFERENCE

NOAA, 1979, *NOAA Diving Manual, Diving for Science and Technology, Second Edition*, J. W. Miller (ed.), National Oceanographic and Atmospheric Administration, Office of Ocean Engineering, U.S. Department of Commerce, Washington, D.C.

APPENDIX A

MATERIAL SAFETY DATA SHEETS

MATERIAL SAFETY DATA SHEET OHS14460

OCCUPATIONAL HEALTH SERVICES, INC.
450 SEVENTH AVENUE, SUITE 2407
NEW YORK, NEW YORK 10123
(800) 445-MSDS (212) 967-1100

EMERGENCY CONTACT:
JOHN S. BRANSFORD, JR. (615) 292-1180

SUBSTANCE IDENTIFICATION

CAS-NUMBER 78-93-3
RTEC-NUMBER EL6475000

SUBSTANCE: METHYL ETHYL KETONE

TRADE NAMES/SYNONYMS:
BUTANONE: 2-BUTANONE: ETHYL METHYL KETONE: METHYL ACETONE: 3-BUTANONE: MEK: RCRA U159: STCC 4904243: UN 1193: C4H8O: OHS14460

CHEMICAL FAMILY:
KETONE, ALIPHATIC

MOLECULAR FORMULA: C-H3-C-H2-C-O-C-H3MOLECULAR WEIGHT: 72.12

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=3 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=1 FIRE=3 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: METHYL ETHYL KETONE PERCENT: 100

OTHER CONTAMINANTS: NONE

EXPOSURE LIMIT:
METHYL ETHYL KETONE:
200 PPM (590 MG/M3) OSHA TWA; 300 PPM (885 MG/M3) OSHA STEL
200 PPM (590 MG/M3) ACGIH TWA; 300 PPM (885 MG/M3) ACGIH STEL
200 PPM (590 MG/M3) NIOSH RECOMMENDED 10 HOUR TWA

5000 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY
SUBJECT TO SARA SECTION 313 ANNUAL TOXIC CHEMICAL RELEASE REPORTING

PHYSICAL DATA

DESCRIPTION: COLORLESS LIQUID WITH AN ACETONE-LIKE ODOR.

BOILING POINT: 176 F (80 C) MELTING POINT: -123 F (-86 C)

SPECIFIC GRAVITY: 0.8054 EVAPORATION RATE: (ETHER=1) 2.7

SOLUBILITY IN WATER: 27.5% VAPOR DENSITY: 2.5

VAPOR PRESSURE: 100 MMHG @ 25 C ODOR-THRESHOLD: 10 PPM

OTHER SOLVENTS (SOLVENT - SOLUBILITY):
ALCOHOL, ETHER, BENZENE, ACETONE, OILS

MATERIAL SAFETY DATA SHEET OHS14460 (contd)

OTHER PHYSICAL DATA
VISCOSITY: 0.40 CPS @ 25 C

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD
DANGEROUS FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL A CONSIDERABLE DISTANCE TO A SOURCE OF IGNITION AND FLASH BACK.

VAPOR-AIR MIXTURES ARE EXPLOSIVE ABOVE FLASH POINT.

FLASH POINT: 16 F (-9 C) (CC) UPPER EXPLOSION LIMIT: 11.4% @ 200 F

LOWER EXPLOSION LIMIT: 1.4% @ 200 F AUTOIGNITION TEMP.: 759 F (404 C)

FLAMMABILITY CLASS (OSHA): IB

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, HALON, WATER SPRAY OR ALCOHOL FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR ALCOHOL FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FIREFIGHTING:
MOVE CONTAINER FROM FIRE AREA IF POSSIBLE. COOL FIRE-EXPOSED CONTAINERS WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM STORAGE TANK ENDS. FOR MASSIVE FIRE IN STORAGE AREA, USE UNMANNED HOSE HOLDER OR MONITOR NOZZLES, ELSE WITHDRAW FROM AREA AND LET FIRE BURN. WITHDRAW IMMEDIATELY IN CASE OF RISING SOUND FROM VENTING SAFETY DEVICE OR ANY DISCOLORATION OF STORAGE TANK DUE TO FIRE (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4, GUIDE PAGE 26).

EXTINGUISH ONLY IF FLOW CAN BE STOPPED; USE WATER IN FLOODING AMOUNTS AS FOG, SOLID STREAMS MAY NOT BE EFFECTIVE. COOL CONTAINERS WITH FLOODING QUANTITIES OF WATER. APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING VAPORS, KEEP UPWIND.

WATER MAY BE INEFFECTIVE (NFPA FIRE PROTECTION GUIDE ON HAZARDOUS MATERIALS, EIGHTH EDITION).

ALCOHOL FOAM (NFPA FIRE PROTECTION GUIDE ON HAZARDOUS MATERIAL, EIGHTH EDITION).

TRANSPORTATION

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49CFR172.101:
FLAMMABLE LIQUID

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49CFR172.101 AND SUBPART E:

MATERIAL SAFETY DATA SHEET OHS14460 (contd)

FLAMMABLE LIQUID

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49CFR173.119
EXCEPTIONS: 49CFR173.118

TOXICITY

METHYL ETHYL KETONE:
350 PPM EYE-HUMAN IRRITATION; 80 MG EYE-RABBIT IRRITATION; 500 MG/24 HOURS SKIN-RABBIT MODERATE IRRITATION; 402 MG/24 HOURS SKIN-RABBIT MILD IRRITATION; 13,780 UG/24 HOUR OPEN SKIN-RABBIT MILD IRRITATION; 100 PPM/5 MINUTES INHALATION-HUMAN TCLO; 38 GM/M3 INHALATION-MAMMAL LC50; 40 GM/M3/2 HOURS INHALATION-MOUSE LC50; 6480 MG/KG SKIN-RABBIT LD50; 2737 MG/KG ORAL-RAT LD50; 4050 MG/KG ORAL-MOUSE LD50; 607 MG/KG INTRAPERITONEAL-RAT LD50; 616 MG/KG INTRAPERITONEAL-MOUSE LD50; 2000 MG/KG INTRAPERITONEAL-GUINEA PIG LDLO; MUTAGENIC DATA (RTECS); REPRODUCTIVE EFFECTS DATA (RTECS).
CARCINOGEN STATUS: NONE.

METHYL ETHYL KETONE IS AN EYE, SKIN, AND MUCOUS MEMBRANE IRRITANT AND CENTRAL NERVOUS SYSTEM DEPRESSANT. IT MAY ENHANCE THE NEUROTOXIC EFFECTS OF N-HEXANE OR METHYL N-BUTYL KETONE, AND PREDISPOSE THE LIVER TO INJURY FROM HEPATOTOXINS. PERSONS WITH A HISTORY OF CHRONIC SKIN OR RESPIRATORY DISEASE MAY BE AT AN INCREASED RISK FROM EXPOSURE.

HEALTH EFFECTS AND FIRST AID

INHALATION:
METHYL ETHYL KETONE:
IRRITANT/NARCOTIC. 3000 PPM IMMEDIATELY DANGEROUS TO LIFE OR HEALTH.

ACUTE EXPOSURE- INHALATION OF VAPOR CONCENTRATIONS OF 100-200 PPM CAUSED MILD NOSE AND THROAT IRRITATION; 300-500 PPM WAS OBJECTIONABLE AND CAUSED THROAT IRRITATION, HEADACHE, AND NAUSEA; 3,300 PPM WAS MODERATELY IRRITATING; AND MOMENTARY EXPOSURE TO 33,000 AND 100,000 PPM PRODUCED INTOLERABLE IRRITATION OF THE NOSE AND THROAT. WORKERS EXPOSED TO 90-270 PPM/4 HOURS SHOWED SHORTENED TIME ESTIMATIONS IN MEN AND INCREASED THE VARIATION IN TIME ESTIMATION TESTS IN WOMEN. EXTREMELY HIGH CONCENTRATIONS MAY CAUSE COUGHING AND SHORTNESS OF BREATH, AND CENTRAL NERVOUS SYSTEM DEPRESSION WITH HEADACHE, LIGHTHEADEDNESS, NAUSEA, VOMITING, DIZZINESS, INCOORDINATION, AND NARCOSIS. GUINEA PIGS EXPOSED TO 10,000 PPM DEVELOPED IRRITATION RAPIDLY, AND NARCOSIS DEVELOPED AFTER AFTER 5 HOURS; 33,000 PPM/200 MINUTES PRODUCED NARCOSIS AND DEATH; AND 100,000 PPM/55 MINUTES PRODUCED NARCOSIS AFTER 10 MINUTES. ODOR AND IRRITATION ARE GENERALLY SUFFICENT TO PREVENT OVEREXPOSURE. METHYL ETHYL KETONE MAY ENHANCE THE NEUROTOXIC EFFECTS OF N-HEXANE AND METHYL N-BUTYL KETONE.

CHRONIC EXPOSURE- WORKERS EXPOSED VIA INHALATION AND SKIN CONTACT TO 300-600 PPM COMPLAINED OF NUMBNESS IN THE ARMS AND FINGERS; ONE WORKER COMPLAINED OF NUMBNESS IN THE LEGS AND A TENDENCY FOR THEM TO GIVE WAY. SEVERAL CASES OF PERIPHERAL NEUROPATHY, INCLUDING OPTIC NEURITIS DUE TO METABOLITES, HAVE BEEN REPORTED IN WORKERS. PERIPHERAL NEUROPATHY HAS NOT BEEN INDUCED IN ANIMALS BY METHYL ETHYL KETONE ALONE. HOWEVER, IT HAS BEEN DEMONSTRATED IN HUMANS AND ANIMALS THAT METHYL ETHYL KETONE POTENTIATES THE NEUROTOXIC EFFECTS OF N-HEXANE AND METHYL N-BUTYL KETONE. EXPOSURE RELATED EFFECTS ON THE LIVER AND BRAIN HAVE BEEN REPORTED IN RATS AT EXPOSURES UP TO 5000 PPM. OFFSPRING OF PREGNANT RATS EXPOSED TO 1,000 OR

MATERIAL SAFETY DATA SHEET OHS14460 (contd)

3,000 PPM EXHIBITED ACAUDIA, IMPERFORATE ANUS, BRACHYGNATHIA, AND FETAL DEVELOPMENTAL RETARDATION. THE SAME INVESTIGATORS REPEATED THE STUDY AND 3,000 PPM PRODUCED SLIGHT MATERNAL TOXICITY AND SLIGHT FETOTOXICITY, BUT NO EMBRYO TOXICITY OR TERATOGENICITY WERE SEEN.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:
METHYL ETHYL KETONE:
IRRITANT.
ACUTE EXPOSURE- CONTACT WITH LIQUID OR CONCENTRATED VAPORS MAY CAUSE DERMATITIS. DIRECT CONTACT WITH THE LIQUID MAY CAUSE EXTREME THICKENING OF THE FINGERNAILS, WITH PERMANENT DESTRUCTION OF THE NAIL BEDS. APPLICATION OF A LETHAL DOSE TO RABBIT SKIN PRODUCED ERYTHEMA, EDEMA, AND NECROSIS. LIVER AND INTESTINAL CONGESTION WERE ALSO REPORTED.
CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE DEFATTING OF THE SKIN PRODUCING A DRY, SCALY, FISSURED DERMATITIS. WORKERS EXPOSED VIA SKIN CONTACT AND INHALATION TO 300-600 PPM COMPLAINED OF NUMBNESS IN THE ARMS AND FINGERS; ONE WORKER COMPLAINED OF NUMBNESS IN THE LEGS AND A TENDENCY FOR THEM TO GIVE WAY. REPEATED CONTACT WITH METHYL ETHYL KETONE AND TETRAHYDROFURAN PRODUCED BILATERAL PARESTHESIA AND LOSS OF MUSCLE STRENGTH IN A WORKER. SYMPTOMS PERSISTED FOR 2 MONTHS FOLLOWING CESSATION OF EXPOSURE.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
METHYL ETHYL KETONE:
IRRITANT.
ACUTE EXPOSURE- EXPOSURE TO VAPOR CONCENTRATIONS OF 200 PPM CAUSED IRRITATION AND A BURNING SENSATION OF THE EYELIDS; 3,300 PPM PRODUCED MODERATE IRRITATION; AND 10,000 PPM WAS INTOLERABLE TO HUMANS. DIRECT CONTACT OF THE LIQUID WITH THE EYES CAUSED PAINFUL IRRITATION AND TEMPORARY CORNEAL INJURY IN RABBITS, GRADED 5 ON A SCALE OF 1-10. IN GUINEA PIGS, 10% VAPOR FOR 30 MINUTES CAUSED TEMPORARY CORNEAL OPACITY WHICH CLEARED WITHIN 8 DAYS.
CHRONIC EXPOSURE- REPEATED OR PROLONGED EXPOSURE MAY CAUSE CONJUNCTIVITIS. A CASE OF OPTIC NEURITIS WAS REPORTED AS A RESULT OF SYSTEMIC POISONING FOLLOWING REPEATED INHALATION EXPOSURE.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
METHYL ETHYL KETONE:
NARCOTIC.
ACUTE EXPOSURE- INGESTION MAY CAUSE IRRITATION OF THE GASTROINTESTINAL TRACT WITH ABDOMINAL SPASMS, NAUSEA, VOMITING, AND POSSIBLY CENTRAL NERVOUS SYSTEM DEPRESSION, INCLUDING NARCOSIS. ADMINISTRATION OF A LETHAL DOSE TO RATS PRODUCED CONGESTED AND HEMORRHAGIC LUNGS, AND CONGESTION OF THE LIVER, ALIMENTARY TRACT, AND PERITONEAL WALL. ANIMAL STUDIES SHOW THAT METHYL ETHYL KETONE POTENTIATES THE HEPATOTOXIC AND NEPHROTOXIC EFFECTS OF CHLOROFORM, AND MAY POTENTIATE THE HEPATOTOXIC EFFECTS OF CARBON

MATERIAL SAFETY DATA SHEET OHS14460 (contd)

TETRACHLORIDE.
CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID- REMOVE BY GASTRIC LAVAGE OR EMESIS AND CONSIDER USING ACTIVATED CHARCOAL. DO NOT PERFORM GASTRIC LAVAGE OR EMESIS ON AN UNCONSCIOUS PERSON. MAINTAIN BLOOD PRESSURE AND RESPIRATION. GIVE OXYGEN IF RESPIRATION IS SHALLOW OR ANOXIA IS PRESENT. (DREISBACH, HANDBOOK OF POISONING, 12TH ED.) TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY. LAVAGE AND OXYGEN MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL.

ANTIDOTE:
NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY SECTION

REACTIVITY:
STABLE UNDER NORMAL TEMPERATURES AND PRESSURES.

INCOMPATIBILITIES:
METHYL ETHYL KETONE:
- CHLOROFORM: VIGOROUS, EXOTHERMIC REACTION IN THE PRESENCE OF A BASE.
- CHLOROSULFONIC ACID: MIXING IN CLOSED CONTAINER MAY RESULT IN INCREASED TEMPERATURE AND PRESSURE.
- HYDROGEN PEROXIDE, NITRIC ACID: PRODUCES SHOCK AND HEAT SENSITIVE OILY PEROXIDE.
- ISOPROPANOL: ACCELERATES PEROXIDATION OF THE ALCOHOL PRODUCING AN EXPLOSIVE PRODUCT.
- OLEUM: MIXING IN CLOSED CONTAINER MAY RESULT IN INCREASED TEMPERATURE AND PRESSURE.
- OXIDIZERS (STRONG): POSSIBLE FIRE AND EXPLOSION HAZARD.
- PLASTICS: MAY BE ATTACKED.
- POTASSIUM TERT-BUTOXIDE: IGNITION REACTION.
- RESINS: MAY BE ATTACKED.
- RUBBER: MAY BE ATTACKED.

DECOMPOSITION:
THERMAL DECOMPOSITION PRODUCTS MAY INCLUDE TOXIC OXIDES OF CARBON.

POLYMERIZATION:
HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

STORAGE-DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE ENVIRONMENTAL PROTECTION AGENCY.

STORAGE

STORE IN ACCORDANCE WITH 29 CFR 1910.106.

BONDING AND GROUNDING: SUBSTANCES WITH LOW ELECTROCONDUCTIVITY, WHICH

MATERIAL SAFETY DATA SHEET OHS14460 (contd)

MAY BE IGNITED BY ELECTROSTATIC SPARKS, SHOULD BE STORED IN CONTAINERS WHICH MEET THE BONDING AND GROUNDING GUIDELINES SPECIFIED IN NFPA 77-1983, RECOMMENDED PRACTICE ON STATIC ELECTRICITY.

STORE AWAY FROM INCOMPATIBLE SUBSTANCES.

DISPOSAL

DISPOSAL MUST BE IN ACCORDANCE WITH STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE, 40CFR 262. EPA HAZARDOUS WASTE NUMBER U159.

CONDITIONS TO AVOID

MAY BE IGNITED BY HEAT, SPARKS OR FLAMES. CONTAINER MAY EXPLODE IN HEAT OF FIRE. VAPOR EXPLOSION HAZARD INDOORS, OUTDOORS OR IN SEWERS. RUN-OFF TO SEWER MAY CREATE FIRE OR EXPLOSION HAZARD.

SPILLS AND LEAKS

SOIL-RELEASE:
DIG HOLDING AREA SUCH AS LAGOON, POND OR PIT FOR CONTAINMENT.

ABSORB BULK LIQUID WITH FLY ASH, CEMENT POWDER, SAWDUST, OR COMMERCIAL SORBENTS.

AIR-RELEASE:
APPLY WATER SPRAY TO KNOCK DOWN VAPORS.

WATER-SPILL:
LIMIT SPILL MOTION AND DISPERSION WITH NATURAL BARRIERS OR OIL SPILL CONTROL BOOMS.

USE SUCTION HOSES TO REMOVE TRAPPED SPILL MATERIAL.

OCCUPATIONAL-SPILL:
SHUT OFF IGNITION SOURCES. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. NO SMOKING, FLAMES OR FLARES IN HAZARD AREA! KEEP UNNECESSARY PEOPLE AWAY; ISOLATE HAZARD AREA AND DENY ENTRY.

REPORTABLE QUANTITY (RQ): 5000 POUNDS
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES THAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS SUBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE AND THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF THIS SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE CENTER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE METROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

MATERIAL SAFETY DATA SHEET OHS14460 (contd)

PROTECTIVE EQUIPMENT SECTION

VENTILATION:
PROVIDE LOCAL EXHAUST OR GENERAL DILUTION VENTILATION TO MEET PUBLISHED EXPOSURE LIMITS. VENTILATION EQUIPMENT MUST BE EXPLOSION-PROOF.

RESPIRATOR:
THE FOLLOWING RESPIRATORS AND MAXIMUM USE CONCENTRATIONS ARE RECOMMENDATIONS BY THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, NIOSH POCKET GUIDE TO CHEMICAL HAZARDS OR NIOSH CRITERIA DOCUMENTS; OR DEPARTMENT OF LABOR, 29CFR1910 SUBPART Z.
THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE AND BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION.

METHYL ETHYL KETONE:
1000 PPM- ANY POWERED AIR-PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE.
ANY CHEMICAL CARTRIDGE RESPIRATOR WITH FULL FACEPIECE AND ORGANIC VAPOR CARTRIDGE.

3000 PPM- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH CHIN-STYLE OR FRONT- OR BACK-MOUNTED ORGANIC VAPOR CARTRIDGE.
ANY SUPPLIED-AIR RESPIRATOR OPERATED IN CONTINUOUS FLOW MODE.
ANY SELF-CONTAINED BREATHING APPARATUS WITH A FULL FACEPIECE.
ANY SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE.

ESCAPE- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH CHIN-STYLE OR FRONT- OR BACK-MOUNTED ORGANIC VAPOR CANISTER.
ANY APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE DEMAND OR OTHER POSITIVE PRESSURE MODE.

SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES TO PREVENT EYE CONTACT WITH THIS SUBSTANCE. CONTACT LENSES SHOULD NOT BE WORN.

AUTHORIZED BY- OCCUPATIONAL HEALTH SERVICES, INC.

CREATION DATE: 09/28/84 REVISION DATE: 04/12/89

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MATERIAL SAFETY DATA SHEET OHS14550

OCCUPATIONAL HEALTH SERVICES, INC.
450 SEVENTH AVENUE, SUITE 2407
NEW YORK, NEW YORK 10123
(800) 445-MSDS (212) 967-1100

EMERGENCY CONTACT:
JOHN S. BRANSFORD, JR. (615) 292-1180

SUBSTANCE IDENTIFICATION

CAS-NUMBER 108-10-1
RTEC-NUMBER SA9275000

SUBSTANCE: METHYL ISOBUTYL KETONE

TRADE NAMES/SYNONYMS:
HEXONE; 4-METHYL-2-PENTANONE; ISOBUTYL METHYL KETONE; ISOPROPYL ACETONE; 2-METHYL-4-PENTANONE; MIBK; MIK; U161; UN 1245; M-213; OHS14550

CHEMICAL FAMILY:
KETONE, ALIPHATIC

MOLECULAR FORMULA: C6-H12-O MOLECULAR WEIGHT: 100.18

CERCLA RATINGS (SCALE 0-3): HEALTH=2 FIRE=3 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=0

COMPONENTS AND CONTAMINANTS

COMPONENT: METHYL ISOBUTYL KETONE PERCENT: 100

OTHER CONTAMINANTS: NONE

EXPOSURE LIMIT:
METHYL ISOBUTYL KETONE:
50 PPM (200 MG/M3) OSHA TWA; 75 PPM (300 MG/M3) OSHA STEL
50 PPM (200 MG/M3) ACGIH TWA; 75 PPM (300 MG/M3) ACGIH STEL
50 PPM (200 MG/M3) NIOSH RECOMMENDED 10 HOUR TWA

5000 POUNDS CERCLA SECTION 103 REPORTABLE QUANTITY
SUBJECT TO SARA SECTION 313 ANNUAL TOXIC CHEMICAL RELEASE REPORTING

PHYSICAL DATA

DESCRIPTION: COLORLESS LIQUID WITH A FAINT PLEASANT KETONIC AND CAMPHOR ODOR

BOILING POINT: 244 F (118 C) MELTING POINT: -120 F (-80 C)

SPECIFIC GRAVITY: 0.800 EVAPORATION RATE: (BU ACETATE=1) 1.6

SOLUBILITY IN WATER: 1.9% VAPOR DENSITY: 3.5

VAPOR PRESSURE: 15.7 MMHG @ 20 C

OTHER SOLVENTS (SOLVENT - SOLUBILITY):
ETHER, ETHANOL, ACETONE, BENZENE, CHLOROFORM, MOST ORGANIC SOLVENTS

MATERIAL SAFETY DATA SHEET OHS14550 (contd)

FIRE AND EXPLOSION DATA

FIRE AND EXPLOSION HAZARD
DANGEROUS FIRE HAZARD WHEN EXPOSED TO HEAT OR FLAME.

VAPOR-AIR MIXTURES ARE EXPLOSIVE ABOVE FLASH POINT.

VAPORS ARE HEAVIER THAN AIR AND MAY TRAVEL A CONSIDERABLE DISTANCE TO A SOURCE OF IGNITION AND FLASH BACK.

FLASH POINT: 64 F (18 C) (CC)

UPPER EXPLOSION LIMIT: 8.0%

LOWER EXPLOSION LIMIT: 1.2%

AUTOIGNITION TEMP.: 840 F (448 C)

FLAMMABILITY CLASS (OSHA): IB

FIREFIGHTING MEDIA:
DRY CHEMICAL, CARBON DIOXIDE, HALON, WATER SPRAY OR ALCOHOL FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FOR LARGER FIRES, USE WATER SPRAY, FOG OR ALCOHOL FOAM (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4).

FIREFIGHTING:
MOVE CONTAINER FROM FIRE AREA IF POSSIBLE. COOL FIRE-EXPOSED CONTAINERS WITH WATER FROM SIDE UNTIL WELL AFTER FIRE IS OUT. STAY AWAY FROM STORAGE TANK ENDS. FOR MASSIVE FIRE IN STORAGE AREA, USE UNMANNED HOSE HOLDER OR MONITOR NOZZLES, ELSE WITHDRAW FROM AREA AND LET FIRE BURN. WITHDRAW IMMEDIATELY IN CASE OF RISING SOUND FROM VENTING SAFETY DEVICE OR ANY DISCOLORATION OF STORAGE TANK DUE TO FIRE (1987 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.4, GUIDE PAGE 26).

EXTINGUISH ONLY IF FLOW CAN BE STOPPED; USE FLOODING AMOUNTS OF WATER AS A FOG, SOLID STREAMS MAY BE INEFFECTIVE. COOL CONTAINERS WITH FLOODING AMOUNTS OF WATER, APPLY FROM AS FAR A DISTANCE AS POSSIBLE. AVOID BREATHING VAPORS, KEEP UPWIND.

WATER MAY BE INEFFECTIVE (NFPA FIRE PROTECTION GUIDE ON HAZARDOUS MATERIALS, EIGHTH EDITION).

ALCOHOL FOAM (NFPA FIRE PROTECTION GUIDE ON HAZARDOUS MATERIAL, EIGHTH EDITION).

FIRE FIGHTING PHASES: USE DRY CHEMICAL, ALCOHOL FOAM, OR CARBON DIOXIDE; WATER MAY BE INEFFECTIVE, BUT WATER SHOULD BE USED TO KEEP FIRE-EXPOSED CONTAINERS COOL. IF A LEAK HAS NOT IGNITED, USE WATER SPRAY TO DISPERSE AND PROTECT MEN ATTEMPTING TO STOP A LEAK. WATER SPRAY MAY BE USED TO FLUSH SPILLS AWAY FROM EXPOSURES AND TO DILUTE SPILLS TO NONFLAMMABLE MIXTURES (NFPA 49, HAZARDOUS CHEMICALS DATA, 1975).

TRANSPORTATION

MATERIAL SAFETY DATA SHEET OHS14550 (contd)

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49CFR172.101:
FLAMMABLE LIQUID

DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS 49CFR172.101 AND SUBPART E:
FLAMMABLE LIQUID

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49CFR173.119
EXCEPTIONS: 49CFR173.118

TOXICITY

METHYL ISOBUTYL KETONE:
200 PPM/15 MINUTE EYE-HUMAN IRRITATION; 500 MG/24 HOUR SKIN-RABBIT MILD IRRITATION; 40 MG EYE-RABBIT SEVERE IRRITATION; 500 MG/24 HOURS EYE-RABBIT MILD IRRITATION; 23,300 MG/M3 INHALATION-MOUSE LD50 ; 2080 MG/KG ORAL-RAT LD50; 2671 MG/KG ORAL-MOUSE LD50; 1600 MG/KG ORAL-GUINEA PIG LD50; 400 MG/KG INTRAPERITONEAL-RAT LD50; 268 MG/KG INTRAPERITONEAL-MOUSE LD50; 800 MG/KG INTRAPERITONEAL-GUINEA PIG LD50; 1396 MG/KG UNREPORTED-MAMMAL LD50.
CARCINOGEN STATUS: NONE.

METHYL ISOBUTYL KETONE IS AN EYE, SKIN AND MUCOUS MEMBRANE IRRITANT AND CENTRAL NERVOUS SYSTEM DEPRESSANT. POISONING MAY AFFECT THE LIVER, KIDNEYS, AND NERVOUS SYSTEM.

HEALTH EFFECTS AND FIRST AID

INHALATION:
METHYL ISOBUTYL KETONE:
IRRITANT/NARCOTIC.
3000 PPM IMMEDIATELY DANGEROUS TO LIFE OR HEALTH.

ACUTE EXPOSURE- VAPOR CONCENTRATIONS OF 100 PPM MAY CAUSE HEADACHE AND NAUSEA. EXPOSURE TO 200 PPM IS IRRITATING TO THE EYES AND RESPIRATORY TRACT. EXPOSURE TO CONCENTRATIONS FROM 100 TO 500 PPM MAY ALSO PRODUCE GASTROINTESTINAL EFFECTS SUCH AS NAUSEA, VOMITING, LOSS OF APPETITE AND DIARRHEA. HIGH CONCENTRATIONS MAY CAUSE CENTRAL NERVOUS SYSTEM DEPRESSION WITH LIGHTHEADEDNESS, DIZZINESS, DULLNESS, INCOORDINATION, ATAXIA, UNCONSCIOUSNESS AND COMA. EXPOSURE OF RATS TO 4000 PPM FOR 4 HOURS CAUSED DEATH, WHILE 2000 PPM FOR 4 HOURS WAS NOT LETHAL.

CHRONIC EXPOSURE- WORKERS EXPOSED TO 80-500 PPM FOR 30 MINUTES PER DAY COMPLAINED OF THROAT IRRITATION, WEAKNESS, LOSS OF APPETITE, HEADACHE, NAUSEA, AND VOMITING. FEW WORKERS EXPERIENCED INSOMNIA, SOMNOLENCE, HEARTBURN, INTESTINAL PAIN AND SLIGHT LIVER ENLARGEMENT. RATS EXPOSED TO 100 PPM FOR 90 DAYS RESULTED IN HEAVIER LIVERS AND KIDNEYS WITH REVERSIBLE NEPHROSIS OF THE KIDNEYS. EXPOSURE OF RATS TO 20-30 PPM FOR 4 HOURS PER DAY FOR 4 AND 1/2 MONTHS CAUSED DISTURBANCES IN CONDITIONED REFLEXES, INTERFERENCE WITH DETOXIFYING FUNCTION OF THE LIVER AND ELEVATED EOSINOPHIL COUNT. MINIMAL DISTAL AXONAL CHANGES RESULTED FROM EXPOSURE TO 1500 PPM FOR 5 MONTHS.

FIRST AID- REMOVE FROM EXPOSURE AREA TO FRESH AIR IMMEDIATELY. IF BREATHING HAS STOPPED, PERFORM ARTIFICIAL RESPIRATION. KEEP PERSON WARM AND AT REST. TREAT SYMPTOMATICALLY AND SUPPORTIVELY. GET MEDICAL ATTENTION IMMEDIATELY.

SKIN CONTACT:

MATERIAL SAFETY DATA SHEET OHS14550 (contd)

METHYL ISOBUTYL KETONE:
IRRITANT.
ACUTE EXPOSURE- VAPOR MAY CAUSE IRRITATION WITH REDNESS. 500 MG APPLIED TO RABBIT SKIN PRODUCED MODERATE IRRITATION WITH TRANSIENT ERYTHEMA.
CHRONIC EXPOSURE- REPEATED OR PROLONGED SKIN CONTACT MAY CAUSE DEFATTING OF THE SKIN WITH PRIMARY IRRITATION AND DESQUAMATION. APPLICATION OF 10 ML FOR 7 DAYS TO RABBIT SKIN CAUSED DRYING AND FLAKING.

FIRST AID- REMOVE CONTAMINATED CLOTHING AND SHOES IMMEDIATELY. WASH AFFECTED AREA WITH SOAP OR MILD DETERGENT AND LARGE AMOUNTS OF WATER UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

EYE CONTACT:
METHYL ISOBUTYL KETONE:
IRRITANT.
ACUTE EXPOSURE- VAPOR CONCENTRATIONS OF 200 PPM ARE IRRITATING TO THE EYES. DIRECT CONTACT WITH LIQUID MAY CAUSE PAIN AND IRRITATION. EXPOSURE TO HIGH CONCENTRATIONS MAY CAUSE LACRIMATION OR SALIVATION.
CHRONIC EXPOSURE- REPEATED OR PROLONGED CONTACT MAY CAUSE CONJUNCTIVITIS.

FIRST AID- WASH EYES IMMEDIATELY WITH LARGE AMOUNTS OF WATER OR NORMAL SALINE, OCCASIONALLY LIFTING UPPER AND LOWER LIDS, UNTIL NO EVIDENCE OF CHEMICAL REMAINS (APPROXIMATELY 15-20 MINUTES). GET MEDICAL ATTENTION IMMEDIATELY.

INGESTION:
METHYL ISOBUTYL KETONE:
NARCOTIC.
ACUTE EXPOSURE- MAY CAUSE COUGHING, GASTROENTERITIS, AND CENTRAL NERVOUS SYSTEM DEPRESSION WITH HEADACHE, DIZZINESS, DULLNESS AND VOMITING.
CHRONIC EXPOSURE- NO DATA AVAILABLE.

FIRST AID: IF PERSON IS CONSCIOUS, GIVE LARGE AMOUNTS OF WATER IMMEDIATELY. REMOVE BY EMESIS OR GASTRIC LAVAGE. DO NOT MAKE AN UNCONSCIOUS PERSON VOMIT OR DRINK ANYTHING. GIVE ACTIVATED CHARCOAL. GIVE OXYGEN IF RESPIRATION IS DEPRESSED. MAINTAIN AIRWAY AND BLOOD PRESSURE. GET MEDICAL ATTENTION. (DREISBACH, HANDBOOK OF POISONING, 11TH ED.) LAVAGE OR OXYGEN MUST BE ADMINISTERED BY QUALIFIED MEDICAL PERSONNEL.

ANTIDOTE:
NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY AND SUPPORTIVELY.

REACTIVITY SECTION

REACTIVITY:
STABLE UNDER NORMAL TEMPERATURES AND PRESSURES.

INCOMPATIBILITIES:
METHYL ISOBUTYL KETONE:
OXIDIZERS (STRONG): VIGOROUS REACTION.
POTASSIUM TERT-BUTOXIDE: VIOLENT REACTION.
REDUCING MATERIALS: VIGOROUS REACTION.

DECOMPOSITION:
THERMAL DECOMPOSITION PRODUCTS MAY INCLUDE TOXIC OXIDES OF CARBON.

MATERIAL SAFETY DATA SHEET OHS14550 (contd)

POLYMERIZATION:
HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

STORAGE-DISPOSAL

OBSERVE ALL FEDERAL, STATE AND LOCAL REGULATIONS WHEN STORING OR DISPOSING OF THIS SUBSTANCE. FOR ASSISTANCE, CONTACT THE DISTRICT DIRECTOR OF THE ENVIRONMENTAL PROTECTION AGENCY.

STORAGE

STORAGE: PROTECT AGAINST PHYSICAL DAMAGE. OUTSIDE OR DETACHED STORAGE IS PREFERABLE. INSIDE STORAGE SHOULD BE IN A STANDARD FLAMMABLE LIQUIDS STORAGE ROOM OR CABINET. SEPARATE FROM OXIDIZING MATERIALS (NFPA 49, HAZARDOUS CHEMICALS DATA, 1975).

DISPOSAL

DISPOSAL MUST BE IN ACCORDANCE WITH STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE, 40CFR 262. EPA HAZARDOUS WASTE NUMBER U161.

CONDITIONS TO AVOID

MAY BE IGNITED BY HEAT, SPARKS OR FLAMES. CONTAINER MAY EXPLODE IN HEAT OF FIRE. VAPOR EXPLOSION HAZARD INDOORS, OUTDOORS OR IN SEWERS. RUN-OFF TO SEWER MAY CREATE FIRE OR EXPLOSION HAZARD.

SPILLS AND LEAKS

OCCUPATIONAL-SPILL:
SHUT OFF IGNITION SOURCES. STOP LEAK IF YOU CAN DO IT WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. FOR SMALL SPILLS, TAKE UP WITH SAND OR OTHER ABSORBENT MATERIAL AND PLACE INTO CONTAINERS FOR LATER DISPOSAL. FOR LARGER SPILLS, DIKE FAR AHEAD OF SPILL FOR LATER DISPOSAL. NO SMOKING, FLAMES OR FLARES IN HAZARD AREA! KEEP UNNECESSARY PEOPLE AWAY; ISOLATE HAZARD AREA AND DENY ENTRY.

REPORTABLE QUANTITY (RQ): 5000 POUNDS
THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA) SECTION 304 REQUIRES THAT A RELEASE EQUAL TO OR GREATER THAN THE REPORTABLE QUANTITY FOR THIS SUBSTANCE BE IMMEDIATELY REPORTED TO THE LOCAL EMERGENCY PLANNING COMMITTEE AND THE STATE EMERGENCY RESPONSE COMMISSION (40 CFR 355.40). IF THE RELEASE OF THIS SUBSTANCE IS REPORTABLE UNDER CERCLA SECTION 103, THE NATIONAL RESPONSE CENTER MUST BE NOTIFIED IMMEDIATELY AT (800) 424-8802 OR (202) 426-2675 IN THE METROPOLITAN WASHINGTON, D.C. AREA (40 CFR 302.6).

MATERIAL SAFETY DATA SHEET OHS14550 (contd)

PROTECTIVE EQUIPMENT SECTION

VENTILATION:
PROVIDE LOCAL EXHAUST OR GENERAL DILUTION VENTILATION TO MEET PUBLISHED EXPOSURE LIMITS. VENTILATION EQUIPMENT MUST BE EXPLOSION-PROOF.

RESPIRATOR:
THE FOLLOWING RESPIRATORS AND MAXIMUM USE CONCENTRATIONS ARE RECOMMENDATIONS BY THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, NIOSH POCKET GUIDE TO CHEMICAL HAZARDS OR NIOSH CRITERIA DOCUMENTS; OR DEPARTMENT OF LABOR, 29CFR1910 SUBPART Z.
THE SPECIFIC RESPIRATOR SELECTED MUST BE BASED ON CONTAMINATION LEVELS FOUND IN THE WORK PLACE AND BE JOINTLY APPROVED BY THE NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH AND THE MINE SAFETY AND HEALTH ADMINISTRATION.

METHYL ISOBUTYL KETONE (HEXONE):

500 PPM- ANY CHEMICAL CARTRIDGE RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE.
ANY SUPPLIED-AIR RESPIRATOR.
ANY SELF-CONTAINED BREATHING APPARATUS.

1000 PPM- ANY POWERED AIR-PURFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE(S).
ANY CHEMICAL CARTRIDGE RESPIRATOR WITH A FULL FACEPIECE AND ORGANIC VAPOR CARTRIDGE(S).

1250 PPM- ANY SUPPLIED-AIR RESPIRATOR OPERATED IN A CONTINUOUS FLOW MODE.

2500 PPM- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONT OR BACK-MOUNTED ORGANIC VAPOR CANISTER.
ANY SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE.
ANY SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE.
ANY SUPPLIED-AIR RESPIRATOR WITH TIGHT-FITTING FACEPIECE OPERATED IN CONTINUOUS FLOW MODE.

3000 PPM- ANY SUPPLIED-AIR RESPIRATOR WITH A HALF-MASK AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

ESCAPE- ANY AIR-PURIFYING FULL FACEPIECE RESPIRATOR (GAS MASK) WITH A CHIN-STYLE OR FRONT OR BACK-MOUNTED ORGANIC VAPOR CANISTER.
ANY APPROPRIATE ESCAPE-TYPE SELF-CONTAINED BREATHING APPARATUS.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN PRESSURE DEMAND OR OTHER POSITIVE PRESSURE MODE.

SUPPLIED-AIR RESPIRATOR WITH FULL FACEPIECE AND OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE IN COMBINATION WITH AN AUXILIARY SELF-CONTAINED BREATHING APPARATUS OPERATED IN PRESSURE-DEMAND OR OTHER POSITIVE PRESSURE MODE.

CLOTHING:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE (IMPERVIOUS) CLOTHING AND EQUIPMENT TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH THIS SUBSTANCE.

GLOVES:
EMPLOYEE MUST WEAR APPROPRIATE PROTECTIVE GLOVES TO PREVENT CONTACT WITH THIS SUBSTANCE.

MATERIAL SAFETY DATA SHEET OHS14550 (contd)

EYE PROTECTION:
EMPLOYEE MUST WEAR SPLASH-PROOF OR DUST-RESISTANT SAFETY GOGGLES TO PREVENT EYE CONTACT WITH THIS SUBSTANCE. CONTACT LENSES SHOULD NOT BE WORN.

AUTHORIZED BY- OCCUPATIONAL HEALTH SERVICES, INC.

CREATION DATE: 11/12/84 REVISION DATE: 04/12/89

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ATTACHMENT 3

PROJECT MANAGEMENT PLAN
FOR THE 300-FF-5 OPERABLE UNIT

ATTACHMENT 3

PROJECT MANAGEMENT PLAN FOR THE 300-FF-5 OPERABLE UNIT

The purpose of a Project Management Plan is to define the administrative and institutional tasks necessary to support remedial investigation/ feasibility study activities in accordance with the Comprehensive Environmental Response, Compensation and Liability Act. The Project Management Plan for the 300-FF-1 operable unit, presented in Attachment 5 of the 300-FF-1 Work Plan, is applicable to the 300-FF-5 remedial investigation/feasibility study project in total. Therefore, the 300-FF-5 operable unit remedial investigation/feasibility study will be managed according to that Project Management Plan and is not repeated in this attachment. Essentially, Westinghouse Hanford Company has the lead on the project and directs the project for the U.S. Department of Energy.

ATTACHMENT 4

DATA MANAGEMENT PLAN FOR THE 300-FF-5 OPERABLE UNIT

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ATTACHMENT 4

DATA MANAGEMENT PLAN FOR THE 300-FF-5 OPERABLE UNIT

1.0 INTRODUCTION AND OBJECTIVES

An extensive amount of data will be generated over the next several years in connection with the remedial investigation/feasibility study (RI/FS) process that will be conducted to evaluate and remediate hazardous waste sites at the Hanford Site. The quality of the data must be very high and suitable for its intended use because they will be used to evaluate the need, select the method(s), and support the full remediation of the waste sites as agreed on by the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), State of Washington Department of Ecology (Ecology), and interested parties. Thus, a comprehensive plan for the management of this extensive amount of data is essential.

This plan describes a two-component data management system (DMS) for accessing and tracking the receipt, storage, and control of validated data, records, documents, correspondence, and other associated information. These components include the following:

- a computer-based component
- an administrative component to handle, store, and protect physical records and samples.

Since an all-inclusive DMS is not available for supporting the RI/FS work planned at the Hanford Site over the next several years, such a DMS is now being developed. This Data Management Plan outlines the following:

- types of data and information that are expected to be collected
- available computer-based and administrative components
- plans for developing any needed interim administrative components
- plans for developing a comprehensive computer-based component that integrates selected existing and expected computer databases
- plans for establishing an information repository for maintaining the official paper-copy (hard-copy) records and physical samples associated with each operable unit.

Procedures for the system will be developed for directing project-authorized personnel as to the manner in which data are received, stored, tracked, amended, and disseminated so that a record of control is always maintained. These procedures will be developed to ensure that the integrity of the data is maintained. The procedures will be provided in a detailed data system procedures manual that describes how data can be entered, accessed, processed, and amended so that a record of use and changes or modifications to the data is maintained. Those who have a need to obtain access to the database will be allowed, as described in the Hanford Federal Facility Agreement and Consent Order between the DOE, EPA, and Ecology (Tri-Party Agreement 1989).

The data system procedures manual will include the procedures necessary for handling and tracking the information that must be maintained in the official (hard-copy) administrative record for each operable unit, as well as physical paper-copy records and archived physical samples associated with each unit. The manual will also include procedures for operation and control of the computer-based component of the system. Existing procedures will be either modified or used, or new procedures will be developed, to address records management for the following general subject areas:

- congressional inquiries and hearings
- remedial planning, investigation, and feasibility studies
- remedial design and implementation
- Federal and state agency coordination
- community relations
- imagery (photographs, maps, illustrations, etc.)
- enforcement activities
- contracts
- financial records.

An Environmental Data Management Plan has been submitted to the DOE-Richland Operations Office. Work is under way to identify requirements and responsibilities for managing environmental data and to develop a data system procedures manual.

The computer-based component for technical data is the Hanford Environmental Information System (HEIS) being developed by Pacific Northwest Laboratory (PNL). The HEIS will be used to manage the extensive amount of data that will be collected and generated during the RI/FS and site-remediation processes. The HEIS is a computer-based information system that is designed to receive, store, and provide for access to quality-assured data concerning Hanford Site environmental and regulatory issues. As shown in Figure 1, the HEIS is an integrated database designed to integrate existing operational databases and provide facilities for data being gathered as part of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) processes.

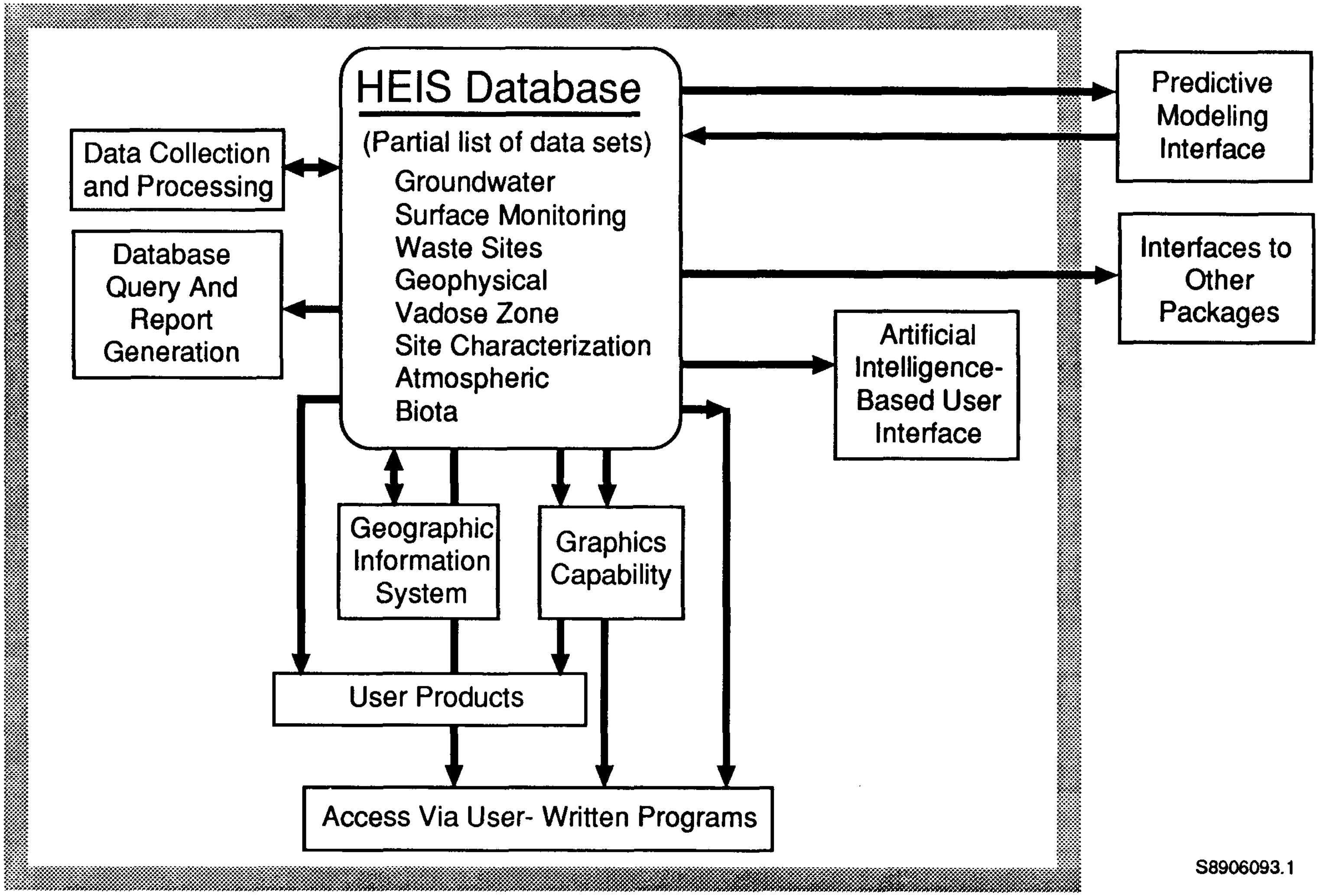

Figure 1. Framework of the Hanford Environmental Information System.

The HEIS will provide the following:

- a relational database
- a geographic information system (GIS)
- integrated graphics support
- comprehensive user-access capabilities
- access by personal computers via existing networks
- security of the databases.

The computer-based component will be able to list and locate paper records and physical samples. The HEIS will maintain much of the various types of raw site (operable unit) data, verified program and summary data, and results of approved analytical computer programs. The results of such analyses will be stored separately from the original data files.

The ability to enter data into raw data files will be restricted so as to maintain control of validated data. Any changes required to validate data will be procedurally controlled to restrict qualified data from being inadvertently or intentionally altered. All changes will be documented and maintained in the system.

The official hard-copy records (administrative record, as well as other official paper-copy records) and archived physical samples will be maintained in designated areas that will be specified in the data system procedures manual. The designated areas will be designed such that they will meet all applicable protection and security requirements. Backup record copies will be maintained as necessary.

2.0 TYPES OF DATA TO BE COLLECTED AND ANALYZED

Records and types of data to be tracked during the RI/FS process at the Hanford Site are shown in Table 1. Raw data represent the actual field and laboratory measurements or observations that will be made during the RI/FS processes. Summary data represent the first-order analyses of the raw data. Program tracking includes information that is programmatic or administrative in nature, and represents the data that are required for the conduct of a project. However, program tracking does not include field or laboratory data.

To the extent possible, validated data gathered during RI/FS processes will be kept separate from other Hanford Site project data. However, many of the ongoing Hanford Site projects will provide data that will be useful for the Hanford Site RI/FS. Data will be stored such that they may be accessed for analyses, the results of which will be stored separately.

A reference collection of applicable EPA, Ecology, DOE, and Hanford Site contractor documents, drawings, and correspondence will be maintained to support site characterization and remedial investigation activities. The applicable or relevant and appropriate requirements (ARARs) drawn from Federal

Table 1. Types of Remedial Investigation/Feasibility Study Information and Data to be Collected.

Site characterization	
Raw data/sample analyses	Groundwater samples Sediment samples Surface-water samples Atmospheric samples Personnel exposure monitoring records Geophysical information Biota samples Site descriptive information (topography, geologic and ecological features) Pilot/bench test data Engineering design data
Summary data	Analytical results of environmental media by time, location, depth, containment, etc. Health risk assessment results Engineering test results Graphic information system outputs
Sampling/analyses/data handling	Sampling schedule Sample collection procedures Field/laboratory notebooks Analyses scheduling Laboratory quality assurance/quality control Calibration tracking Instrument coordination Data entry procedures Data reduction, validation, storage, and transfer procedures
Program tracking	
Project management	Project schedule and milestones Project costs Equipment, personnel, and supplies scheduling Document tracking Subcontracts Project quality assurance/quality control procedures
Personnel	Personnel training and qualifications Occupational exposure records Personnel health and safety records
Compliance/regulatory	Applicable or relevant and appropriate requirements (ARARs)/screening levels Guidance document tracking Compliance issues Problem resolution

and state requirements and standards also will be kept and updated in a timely manner. Compliance requirements also will be maintained and updated periodically.

3.0 DATA MANAGEMENT PLAN SCOPE RELATIVE TO OTHER REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLAN COMPONENTS

The DMS will receive and control validated data obtained through implementation of the RI/FS project plan for the 300-FF-5 operable unit, Field Sampling Plan (FSP), and Health and Safety Plan (HASP). The Quality Assurance Project Plan (QAPP) provides the specific procedural direction and control for obtaining and analyzing samples in conformance with requirements to ensure quality data and results of analyses. The FSP provides the detailed logistical methods to be employed in selecting the location, depth, frequency of collection, etc., of media to be sampled and the methods to be employed to obtain samples of the selected media for cataloging, shipment, and analyses. The data that result from the analyses will be entered into the DMS for subsequent control and tracking. In a similar manner, data from field and bench tests of potential remedial techniques will be entered into the DMS. Procedural control for such testing will be found in the QAPP. Specific directions and logistical methods to be employed for field and bench testing will be provided prior to treatability investigation (remedial investigation) activities. Site and personnel health data needed to ensure worker safety will be specified in the HASP, which will also specify the manner in which these data are to be obtained. Personnel health records will be protected as required by the Privacy Act and secured in such a way that only authorized personnel will have access to these data.

4.0 PROCEDURAL CONTROL

The DMS will be procedurally regulated by the data system procedures manual to be developed.

5.0 IDENTIFICATION OF EXISTING DATABASE SYSTEMS

Several databases are in use at the Hanford Site. These databases were developed for a variety of different purposes and uses. However, much of the information and data-handling capabilities associated with these databases is directly useful to RI/FS evaluation of the various operable units located on the Hanford Site. A listing of some of the existing databases that are available is provided in Table 2. Other databases may be incorporated into the system as warranted, depending on their utility in serving the needs of RI/FS execution.

Table 2. Existing Hanford Databases. (Sheet 1 of 2)

Database name	Information type
Hanford Ground Water Data Base (HGWDB)	Contains chemical and radionuclide analytical results for groundwater and sediment samples
Program Data and Management System (PDMS)	Contains chemical and radionuclide analytical results of air, surface-water, oil, vegetation, wildlife and foodstuffs samples
Waste Information Data System (WIDS)	Contains information on the physical and environmental characteristics of waste units at the Hanford Site (radioactive and hazardous chemicals)
Sample Preparation System (SPS)	Generates labels, reports, etc., for sampling preparation, and contains information on facilities, locations, time of sampling, and chain-of-custody information
BWIP Technical Data System (BTDS)	Contains information on hydrologic conditions and some geologic data for the Hanford Site. Also contains site characterization, hydrologic, hydrochemistry, stratigraphic, and constituent data
Warehouse Inventory Management System (WIMS)	Keeps track of all hazardous material purchased at the Hanford Site
Flow Gemini-Environmental Information System [Hanford Environmental Health Foundation's (HEHF) Occupational Hazardous Materials Exposure/Monitoring System (HEX)]	Contains information associated with onsite monitoring of exposures to hazardous materials for Hanford workers
Flow Gemini-Occupational Health Information System (HEHF's Medical Information Tracking System)	Contains employee medical information

Table 2. Existing Hanford Databases. (Sheet 2 of 2)

Database name	Information type
Material Safety Data Sheet (MSDS) System	Contains information on chemicals found at Hanford. Currently this is a manual system operated by HEHF, but it is in the process of being computerized. This effort is being coordinated with the Superfund Amendments and Reauthorization Act Title III Right-To-Know Program at the Hanford Site
Occupational Radiation Exposure (ORE)	Contains personnel respiratory protection, fitting, work restriction, and radiation exposure information
Quality Control Blind Standards Data Base (QCBSDB)	Contains results on spiked samples, replicate samples, and interlaboratory comparisons
Training Records Information System (TRIS)	Contains records on individual employee training records
Westinghouse Hanford Commitment Tracking (WCT) System	Tracks commitments through completion.

Westinghouse Hanford Company (Westinghouse Hanford) maintains an Environmental Resource Center (ERC) that contains copies of environmental and pertinent Federal and state regulations, documents that have been prepared and submitted to Ecology and EPA pertaining to the regulations, and correspondence in support of environmental matters. The ERC contains RCRA permit applications and closure plans, as well as RI/FS project plans for individual Hanford Site operable units. Other information, such as environmental laws, DOE orders, corporate policies, and case histories, also will be added. A computer-based indexing system is being developed that will allow rapid identification of appropriate documents, copies of which may be obtained from the ERC files. The ERC will contain copies of all correspondence with Ecology and EPA. This will include primary, as well as secondary, documents.

6.0 EVALUATION OF EXISTING DATABASE SYSTEMS

In general, the databases in use on the Hanford Site were designed for specific purposes. They are not integrated to cover expected RI/FS needs. These existing databases will provide supplementary, historical data to support the RI/FS process. The scope of each database identified in Table 2 is discussed separately in the following paragraphs.

The Hanford Ground Water Data Base (HGWDB) is used to generate the annual groundwater monitoring at Hanford report. It also contains the Hanford Site's RCRA compliance monitoring program's groundwater monitoring data.

The Program Data and Management System (PDMS) is generally used by the Hanford Site to generate the annual surface environmental monitoring at Hanford report. The PDMS is an overall database for tracking routine and special air, surface-water, soil, vegetation, wildlife, and foodstuff samples from the Hanford Site.

The Waste Information Data System (WIDS) was set up specifically to handle hazardous waste site information. The WIDS contains data on the general physical and environmental characteristics associated with the waste units located on the Hanford Site. The WIDS serves as the official Hanford Site waste units identification and tracking system.

The Sample Preparation System (SPS) was set up to generate labels for sample bottles and to track sample status at the analytical laboratories. The SPS can generate reports on samples collected, samples currently at an analytical laboratory, and samples with results overdue from the laboratory.

The BWIP Technical Data System (BTDS) was being prepared for the Basalt Waste Isolation Project (BWIP) to contain information on hydrologic conditions and some geologic data at the Hanford Site. The BTDS was intended to handle data obtained from wells in hydrologic units in the basalt strata, giving Lambert coordinates, water pressure, and other similar well information. The BTDS also was designed to handle site characterization, hydrologic, hydrochemistry, stratigraphic, and constituent data. There is some overlap between the capabilities of the HGWDB and the BTDS. The BTDS is not intended for shallow wells in the unconfined aquifer and is not available to users.

The Warehouse Inventory Management System (WIMS) is a database established to track, from receipt of material to its shipment to the customer, all stock items and to forward costing data to the Financial Data System. For the purpose of safe storage and transportation, hazardous materials are identified within WIMS. The system will be used in conjunction with the Material Safety Data Sheet system and the Superfund Amendments and Reauthorization Act (SARA) Title III program.

The Flow Gemini-Environmental Information System, managed by the Hanford Environmental Health Foundation (HEHF), is commonly referred to as the HEX system. It is set up to contain information associated with onsite monitoring of exposures to hazardous materials of Hanford Site employees.

The Flow Gemini-Occupational Health Information System (HEHF's Medical Information Tracking System) contains the confidential employee medical evaluation and history information. The HEHF medical surveillance program will need to be given directions from the HASP for each operable unit as to the specific elements that will need to be tracked for the specific individuals involved with its characterization. Once this is done, the HEHF Medical Information Tracking System will contain all of this information.

The Material Safety Data Sheet (MSDS) system contains information on chemicals found at the Hanford Site. The system is part of the worker "right-to-know" program at the Hanford Site.

The Occupational Radiation Exposure (ORE) database system contains personnel respiratory protection fitting and qualifications, work restrictions, and radiation exposure information for all Hanford Site employees. Access to individual employee's records must be tightly controlled to comply with the Privacy Act.

The Quality Control Blind Standards Data Base (QCBSDB) contains information associated with quality control spiked samples, replicate sampling, and interlaboratory comparison results for the Hanford Site RCRA program.

The Training Records Information System (TRIS) contains training records for Westinghouse Hanford employees. The TRIS can be adjusted to include all contractor personnel working on a particular operable unit.

The Westinghouse Hanford Commitment Tracking (WCT) System is an automated database used to identify and track commitments through to their completion and to provide weekly reports showing the current status of each open commitment (i.e., the number of calendar days until it is due or the number of calendar days it is past due), as well as statistics on Westinghouse Hanford performance in meeting these commitments in a timely manner.

Chapter 3 of EPA's Office of Solid Waste and Emergency Response Directive 9355.3-01 (EPA 1988) addresses data management procedures. The contents of Table 3-11 of Section 3.5.1 (EPA 1988), which provides an outline of the file structure necessary for a superfund site, were used as a list of elements necessary for a DMS. Table 3 (herein) shows a listing of these elements and a brief discussion of how the various components of the DMS will address them.

The previous discussions have addressed the existing systems that can be used to provide a historical basis for the RI/FS work. However, there are several data management needs identified in Table 1 for which there is no currently operated or historical database. These include the following:

- pilot- and bench-scale testing data
- applicable or relevant and appropriate requirement (ARAR) screening
- cost tracking

- calibration tracking
- instrument coordination
- quality assurance/quality control tracking
- field and laboratory notebook tracking
- document tracking (both site-specific documents and guidance documents)
- treatment/alternative screening.

The Environmental Data Management Plan addresses the above-noted needs. Initial development of the HEIS will focus on these needs in the order listed.

Table 3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency's Draft Guidance Directive and Current Historical Hanford Site Databases. (Sheet 1 of 3)

File structure/data needs	Applicable database system
Congressional inquiries and hearings Correspondence Transcripts Testimony Published hearing records	None available. These will have to be addressed by written procedures.
Discovery Initial investigation Preliminary assessment Site inspection report Hazard ranking system data	Waste Information Data System.
Remedial planning Correspondence Work plans for remedial investigation/feasibility study Remedial investigation/feasibility study reports Health and safety plan Quality assurance/quality control plan Record of decision/responsiveness summary	The Commitment Control System is presently available to track correspondence. Health and safety plans and quality assurance/quality control plans will be included in each work plan that will be developed for each operable unit. The information pertinent to the development of the remedial investigation/feasibility study report will be tracked by the Hanford Environmental Information System (HEIS).

Table 3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency's Draft Guidance Directive and Current Historical Hanford Site Databases. (Sheet 2 of 3)

File structure/data needs	Applicable database system
Remedial implementation Remedial design reports Permits Contractor work plans and progress reports U.S. Army Corps of Engineers agreements, reports, and correspondence	All these items will be tracked by the Data Management System.
State and other agency coordination Correspondence Cooperative agreement/Superfund state contract Interagency agreements Memorandum of understanding with the state	Parts of these may be able to be tracked by the Hanford Environmental Compliance Report. A record file system also is being developed at the Hanford Site to track many of these items. These will be managed within the Data Management System.
Community relations Interviews Correspondence Community relations plan List of people to contact (e.g., local officials, civic leaders, environmental groups) Meeting summaries Press releases News clippings Fact sheets Comments and responses Transcripts Summary of proposed plan Responsiveness summary	There is no known system at the Hanford Site available to electronically track community relations information. This information can be handled manually in accordance with the Community Relations Plan, or tracking can be added to the Data Management System, if desired.
Imagery Photographs Illustrations Other graphics	The HEIS will have Geographic Information System capabilities.

Table 3. Analysis of Data Needs as Specified in the U.S. Environmental Protection Agency's Draft Guidance Directive and Current Historical Hanford Site Databases. (Sheet 3 of 3)

File structure/data needs	Applicable database system
Enforcement Status reports Cross-reference to any confidential enforcement files and the person to contact Correspondence Administrative orders	The Hanford Environmental Compliance Report and Environmental Compliance Tracking System will be used to contain the compliance status information by operable unit. Any administrative orders that are formally produced also can be tracked in the Data Management System designed to track formal documents.
Contracts Site-specific contracts Procurement packages Contract status notifications List of contractors	Other than existing project management software systems available at the Hanford Site, there is no known electronic system available to track contract information such as this. This information can be handled manually by procedures, or the Data Management System can track it.
Financial transactions Cross-reference to other financial files and the person to contact Contractor cost reports Audit reports	The financial operations for the cleanup of a Federal facility is different from the normal U.S. Environmental Protection Agency-funded Superfund process. The financial information that needs to be tracked for compliance purposes can be tracked manually or by the Data Management System.
Technical data Geophysical data Soil column analytical data Summarized/analyzed data	The HEIS is being developed to handle technical data gathered as part of the RI/FS process.

7.0 REFERENCES

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, OSWER Directive 9355.3-01, EPA/540/G-89/004, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

Tri-Party Agreement, 1989, *Hanford Federal Facility Agreement and Consent Order Between the U.S. Environmental Protection Agency, the U.S. Department of Energy, and the State of Washington Department of Ecology, May 15, 1989*, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

ATTACHMENT 5

COMMUNITY RELATIONS PLAN FOR THE 300-FF-5 OPERABLE UNIT

ATTACHMENT 5

COMMUNITY RELATIONS PLAN FOR THE 300-FF-5 OPERABLE UNIT

A Community Relations Plan has been developed for the Hanford Site (CRP 1989). A decision was made to develop a single Community Relations Plan because community relations activities are interrelated for all of the operable units. The site-wide plan discusses background information, community involvement history, and community Hanford Site concerns. The Community Relations Plan is a cooperative program of the U.S. Department of Energy-Richland Operations Office, U.S. Environmental Protection Agency-Region X, and State of Washington Department of Ecology. The Community Relations Plan will be implemented for all community relations activities associated with the 300-FF-5 Work Plan.

REFERENCE

CRP, 1989, *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order*, Prepared by: Washington State Department of Ecology, United States Environmental Protection Agency, and United States Department of Energy, August 1989.