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Revision 0

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100-NR-2 Study Area Ecological Risk Assessment Sampling and Analysis Plan

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

United States Department of Energy
P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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CONCURRENCE PAGE

Title: 100-NR-2 Study Area Ecological Risk Assessment Sampling and Analysis Plan

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Acronyms and Abbreviations

AA	alternative action
AEA	alpha energy analysis
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CVP	cleanup verification package
DOE	U.S. Department of Energy
DOE-RL	DOE Richland Operations Office
DQO	data quality objective
DR	decision rule
DS	decision statement
DWMP	Drinking Water Monitoring Plan
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
FY	fiscal year
GPS	global positioning system
HEIS	Hanford Environmental Information System
ICP	inductively coupled plasma
ICP-MS	inductively coupled plasma-mass spectrometry
LWDF	liquid waste disposal facility
MCL	maximum contaminant level
OU	operable unit
PCB	polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PSQ	principal study question
QA	quality assurance
QC	quality control
RCBRA	River Corridor Baseline Risk Assessment
ROD	record of decision
SAP	sampling and analysis plan
SESP	Surface Environmental Surveillance Project
SOP	standard operating procedure
SOW	statement of work
SVOA	semivolatile organic analyte
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOA	volatile organic analyte
WAC	Washington Administrative Code

Metric Conversion Chart

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
Inches	25.4	millimeters	millimeters	0.039	inches
Inches	2.54	centimeters	centimeters	0.394	inches
Feet	0.305	meters	meters	3.281	feet
Yards	0.914	meters	meters	1.094	yards
Miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
Acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
Ounces	28.35	grams	grams	0.035	ounces
Pounds	0.454	kilograms	kilograms	2.205	pounds
Ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
Teaspoons	5	milliliters	milliliters	0.033	fluid ounces
Tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
Cups	0.24	liters	liters	0.264	gallons
Pints	0.47	liters	cubic meters	35.315	cubic feet
Quarts	0.95	liters	cubic meters	1.308	cubic yards
Gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
Picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

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1.0 Introduction

This sampling and analysis plan (SAP) presents the rationale and strategy for ecological sampling and analysis activities in fulfillment of a requirement in the 100-NR-1 and 100-NR-2 Interim Remedial Action Record of Decision (ROD) (EPA/ROD/R-99/112). The Interim ROD calls for the U.S. Department of Energy (DOE) to "conduct an evaluation of aquatic and riparian receptor impacts from contaminant discharges at the groundwater/river interface...." Therefore, this SAP identifies the sampling activities in the 100-NR-2 Area riparian and near-shore aquatic environment soil, sediment, water, and biota to evaluate protectiveness of human health and ecological receptors. Contaminant sources are from one source operable unit (OU) (100-NR-1) and a groundwater OU (100-NR-2), which are associated with the 100-N Area of the Hanford Site. To evaluate protectiveness, contaminant concentrations in abiotic and biotic media will be compared to endpoint criteria specified by Washington State regulations, DOE technical guidance, or as supported by the scientific literature.

The sampling and analysis strategy presented in this SAP was developed in the *100-NR-2 Groundwater Operable Unit Ecological Risk Assessment Data Quality Objectives Summary Report* (WMP-23141). Section 1.0 of this SAP provides background information about the project, a discussion of previous sampling within the 100-NR-1 and 100-NR-2 OUs, the list of contaminants of potential ecological concern (COPECs), and a summary of the 100-N ecological data quality objectives (DQOs). Section 2.0 provides the Quality Assurance Project Plan, which articulates the field work and data management quality assurance (QA) requirements. Section 3.0 of this SAP is the Field Sampling Plan (FSP), which provides the field sampling details and supporting logic. Section 4.0 discusses health and safety considerations. The 100-N Area ecological risk assessment supported by this SAP will be integrated with the Hanford Site Risk Assessment Integration document currently under development by DOE Richland Operations Office (DOE-RL).

1.1 Background

The Hanford Site became a federal facility in 1943 when the U.S. Government took possession of the land to produce nuclear materials for defense purposes. The Hanford Site's production mission continued until the late 1980s, when the mission changed from producing nuclear materials to cleaning up the radioactive and hazardous waste that had been generated during the previous years. In 1989, the 100 Area (encompassing the former plutonium production reactors along the Columbia River) was one of four areas at the Hanford Site that was placed on the National Priorities List under the authority of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Placement on the National Priorities List initiated the CERCLA process that would lead to cleanup of contaminated areas on the Hanford Site.

The 100-N Area is located in south-central Washington, in the northern part of the Hanford Site along the southern shore of the Columbia River (Figure 1.1). The 100-N Reactor was constructed during 1958 to 1963. The reactor began producing plutonium for nuclear weapons in April 1964, and began generating steam for electrical power at the Washington Public Power Supply System Hanford Generating Plant in 1966. Both continued to operate until 1986 when the reactor was shut down for safety upgrades. In 1988, DOE placed the reactor in cold standby, and in 1991, DOE issued an order to prepare N Reactor for decontamination and decommissioning (DOE/RL-96-91; DOE/RL-97-1047).

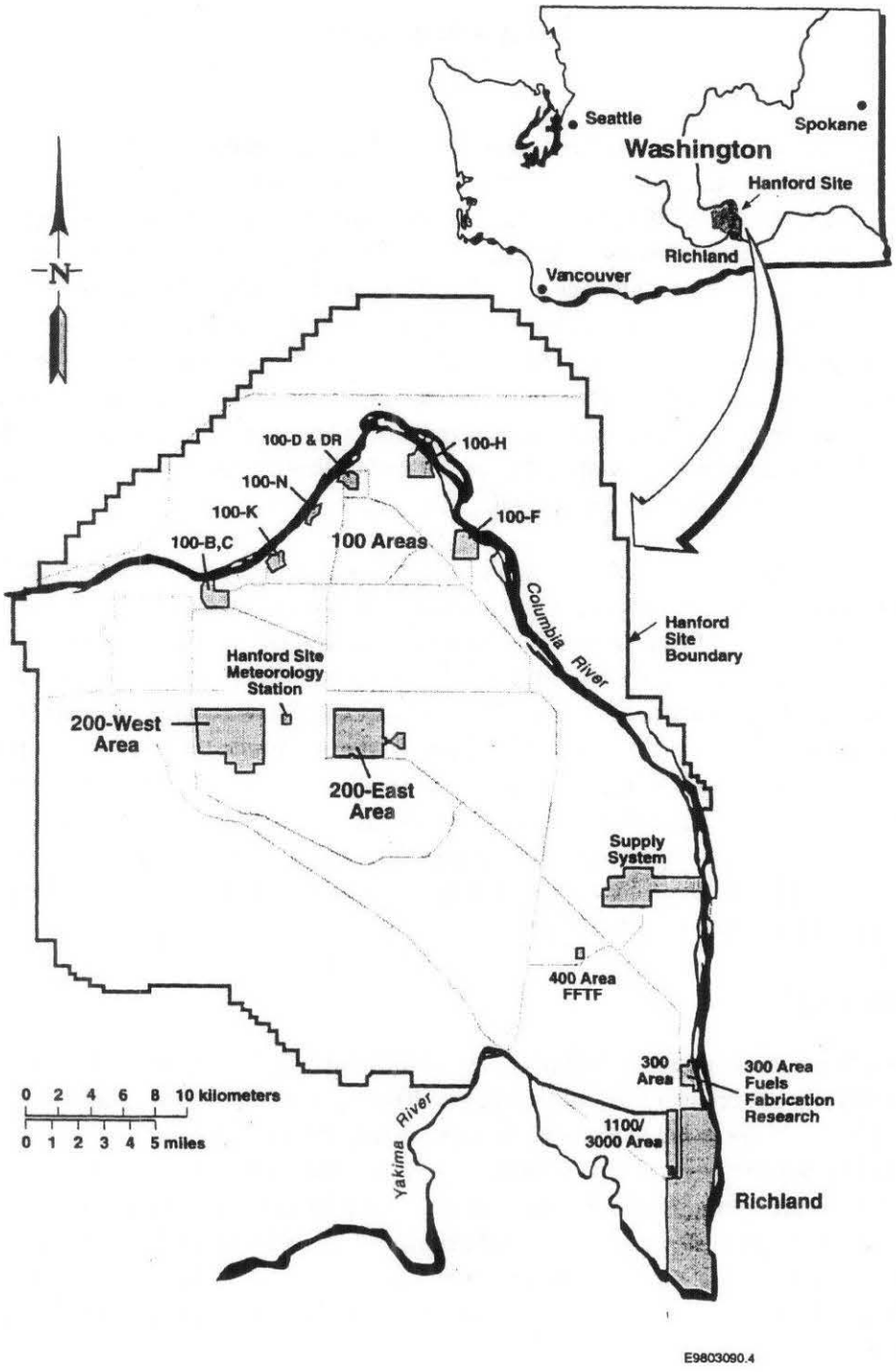

Figure 1.1. Hanford Site Map

The N Reactor was unique among the nine Hanford Site production reactors in its use of a heat-exchange cooling system that greatly reduced the release of contaminants to the river environment in comparison with the eight other single-pass reactors. The primary coolant (deionized water) was passed through the N Reactor multiple times (roughly 100 cycles, based on a 1% continuous replacement), which resulted in higher radionuclide accumulations in the reactor coolant in comparison with the single-pass

reactors. During operation, contaminated cooling water, and other related sources, was directed to the 1301-N and the 1325-N liquid waste disposal facilities (LWDF). Although the direct discharge of radionuclides and chemicals to the Columbia River was minimal, substantial volumes of contaminated water were discharged to the LWDF. As a result, contaminants were dispersed through the soil column beneath the LWDF, reaching the riverbank springs along the 100-N Area shoreline. Production operations at the N Reactor ceased in 1985, with a dramatic decrease in the volume of water discharged to the LWDF and, thus, greatly reduced discharge volumes to the 100-N Area riverbank.

The soil column waste sites (100-NR-1 OU) are considered potential sources for groundwater contamination. Waste sites for the 100-N Area are tabulated by waste category in the 100-NR-1 Corrective Measures Study (DOE/RL-95-111), including radionuclides, petroleum hydrocarbons, inorganics, burn pits, and miscellaneous waste.

On September 1, 1995, a pump-and-treat interim remedial action was initiated to remove strontium-90 from groundwater. Approximately 1.6 curies of strontium-90 has been removed from groundwater by the pump-and-treat system from the start of operations until June 2004.

1.1.1 100-NR-1 and 100-NR-2 Operable Units Background

One source OU (100-NR-1) and a groundwater OU (100-NR-2) are associated with the 100-N Area of the Hanford Site. The 100-NR-1 OU contains the dual-purpose nuclear reactor and the associated infrastructure that supported reactor operations.

The 100-NR-1 OU encompasses an area of approximately 405 hectares (over 1,000 acres). Within this area, a total of 114 known or suspected surface and subsurface soil contamination sites were identified (EPA/ROD/R-99/112). Thirty-three of these sites were eliminated in the Corrective Measures Study (CMS) because they were either never contaminated or will be addressed through a process other than through the interim remedial action (EPA/ROD/R-99/112). The principal contaminants of concern for the 100-NR-1 source sites are radionuclides, petroleum hydrocarbons and metals.

The groundwater OU (100-NR-2) consists of all the contaminated groundwater beneath and in proximity to the 100-NR-1 OU boundary. Contaminants in groundwater (i.e., that exceed or have previously exceeded a maximum contaminant level [MCL]) include strontium-90, tritium, petroleum hydrocarbons, nitrate, sulfate, manganese, and iron.

1.1.2 Status of 100-N Area Remediation

Remediation of waste sites in the 100 Areas was prioritized so that sites with the greatest potential to impact groundwater, sites closest to the Columbia River, and sites that contributed the most to surface radiation exposure would be remediated first (DOE/RL-96-17). Some low-priority sites were included in the initial phase of remediation because of their close proximity to the high-priority sites. A more detailed summary/description of the 100-NR-1 sources can be found in the interim ROD (EPA/541/R-99/112).

100-NR-1. In the 100-N Area, remedial action activities under CERCLA authority began in 1996. An interim action ROD, addressing the most significant soil and groundwater contamination first, was issued in 1999 (EPA/541/R-99/112). Interim 100-NR-1 cleanup actions conducted to date consist of removal of radioactively contaminated soils beneath the two most significant radiological sources

(116-N-1 and 116-N-3 cribs) to a depth of approximately 4.6 meters (15 feet) below ground surface. Removal actions at 116-N-3 are complete and excavation work at 116-N-1 is nearing completion. The current status of removal actions is documented in cleanup verification package (CVP) reports that are updated monthly. Cleanup of the remaining subsurface soil and surface sites will occur in the future in order of priority as established by the regulatory agencies. The structures and buildings associated with the 100-NR-1 OU currently have a CERCLA Removal Action Memorandum (dated February 6, 1999) to authorize cleanup of these sties.

Prior cleanup actions consisted primarily of removal of contaminated soil at diesel and fuel oil spill sites and removal of floating product using an interceptor trench near the shoreline and extraction of floating product from monitoring wells. The interceptor trench was approximately 150 meters (492 feet) long and was located near well 199-N-96A (Figure 1.2). At the present time, a small amount of floating product has been observed in only one well (199-N-18). However, residual petroleum hydrocarbons, and microbial degradation and reaction products, are still present in the aquifer in the area impacted by past spills (shaded area between well 199-N-18 and the shoreline shown in Figure 1.2). For example, groundwater samples from well 199-N-18 are anoxic with dissolved iron concentrations up to 25,000 ppb. The latter occurrence is attributed to biochemical reducing conditions in the near-surface aquifer impacted by the past diesel and fuel oil spill(s).

In addition to the above, sediment near the shoreline contaminated with strontium-90 during operations were covered with rip rap (large boulders) to prevent contact by potential human and ecological receptors. The boulder-covered strip along the central 100-N shoreline serves as a useful reference point in the field for locating where the highest concentrations of the strontium-90 plume intersect the Columbia River.

100-NR-2. A pump-and-treat system has been in operation since 1995 to address the portion of the aquifer beneath 100-NR-1 that is contaminated with strontium-90 and tritium from past soil column disposal activities (liquid waste disposal sites 116-N-1 and 116-N-3, Figure 1.2). The pump-and-treat system has removed approximately 1.6 curies of strontium-90 to date. While the flux of contaminated groundwater to the river has been reduced, elevated concentrations of strontium-90 in porefluid near the shoreline are relatively unchanged. Treatability testing to address this near-shore portion of the contaminated aquifer is proposed to begin in fiscal year (FY) 2006 (see the River Corridor Baseline Risk Assessment [RCBRA] web page, http://bhi-erc.com/projects/risk/risk_library.htm, *Evaluation of Strontium-90 Treatment Technologies for the 100-NR-2 Groundwater Operable Unit, October 2004*). However, the extent of implementation of any treatment in this critical near-shore zone will in part depend on the outcome of the 100-NR-2 ecological risk assessment supported by this SAP. The risk assessment is scheduled to be completed by October 2005.

1.1.3 Subsurface Conditions and Groundwater

The soil column underlying the 100-N Area and extending to groundwater consists of lithologic materials belonging to the Hanford formation. The Hanford formation consists predominantly of medium dense to dense sand and gravel, with varying amounts of silt, cobble, and boulders. The approximate depth to groundwater near the 116-N-1 and 116-N-3 cribs is 19 and 22 meters (62 to 72 feet), respectively. Net groundwater flow is to the northwest toward the Columbia River. The nearby river and other factors such as atmospheric pressure influence groundwater elevations in wells within the stream bank storage zone along the river.

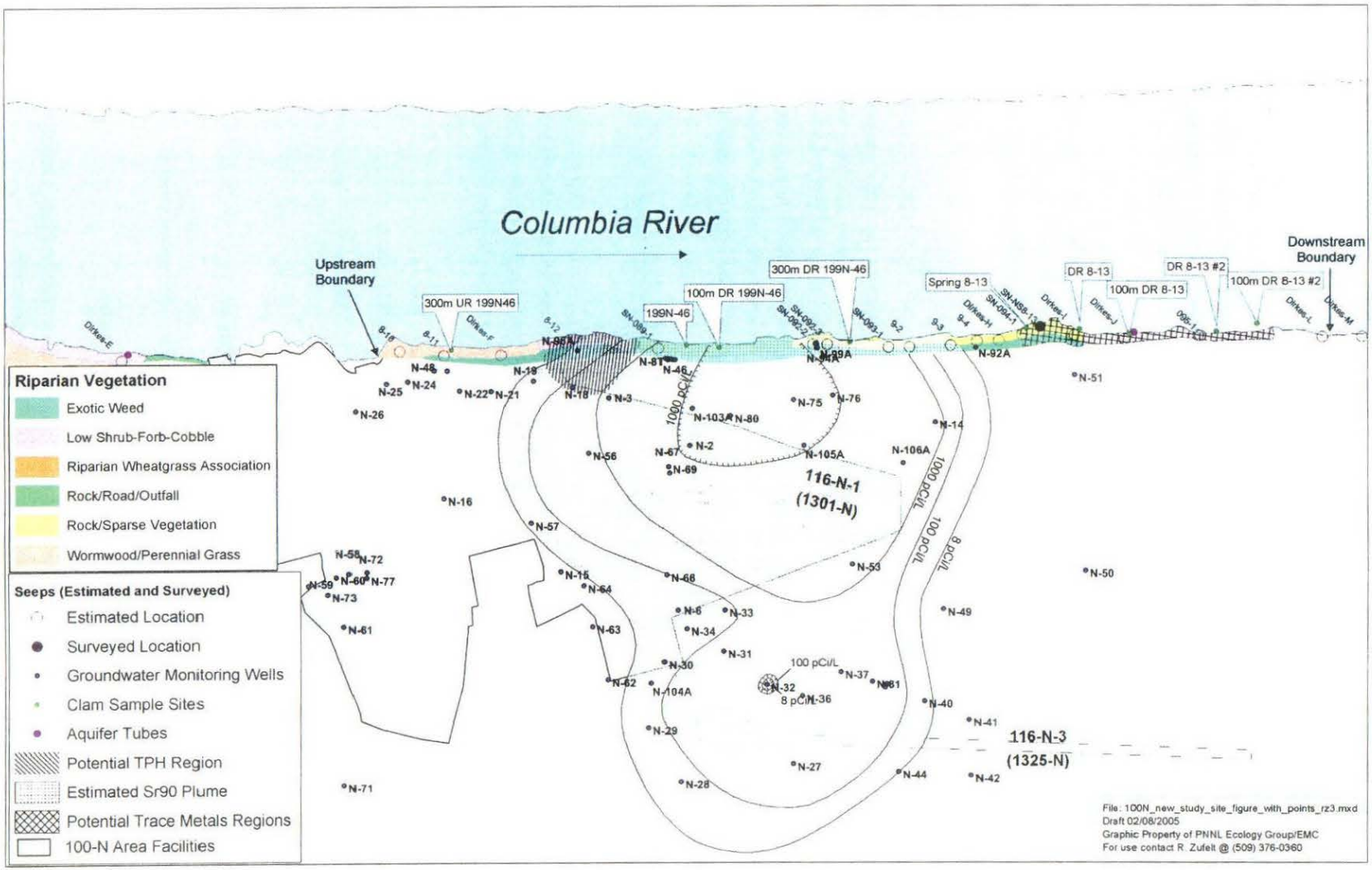

Figure 1.2. 100-NR-2 Study Area Depicting Existing Sample Locations, Sample Media, and Regions

As previously indicated, contaminants in the soil and groundwater in the 100-N Area are from the liquid waste disposal sites and burial grounds associated with reactor operations. Many contaminants are retained in the vadose zone and aquifer from the large-volume discharges to the liquid waste sites (e.g., adsorbed strontium-90 on aquifer solids). Although the large-volume discharges have ceased, infiltration of natural precipitation is assumed to carry some of the residual mobile contaminants through the vadose zone beneath the remediated waste sites to groundwater. Contaminants entering the aquifer from the vadose zone under current conditions should be near the top of the aquifer. Due to changes in river stage in response to seasonal river stage variations and release of water from the upstream Priest Rapids Dam, water table fluctuations cause changes in contaminant water concentrations in near-shore wells. In the fall, the river is at it lowest flow rate and the river stage becomes relatively stable. Contaminant concentrations in the groundwater near the shoreline also tend to stabilize during this time because of the stable river stage. This creates a time of maximum exposure to human and ecological receptors in the near-shore area because the undiluted groundwater flowing into the river is more accessible than at other times during the year.

1.1.4 Previous Investigations in the 100-N Area

Previous investigations involving ecological sampling in the vicinity of the 100-N aquatic and riparian zone were recently summarized in *Evaluation of Aquatic and Riparian Receptor Impacts at the 100-N Area: Literature and Data Review*, PNNL-SA-3949 (available on the RCRBA web site, http://bhi-erc.com/projects/risk/risk_library.htm). Groundwater monitoring for the 100-N Area is ongoing as part of the Hanford Site Groundwater Performance Assessment Project. Results are reported annually and are available electronically via the internet at http://groundwater.pnl.gov/. The identification of contaminants of potential concern (COPCs) is presented in Section 1.2.

1.2 Contaminants of Potential Ecological Concern

This sampling and analysis plan is focused on ecological risk of COPECs in the riparian and near-shore aquatic zones of the 100-N Area. The DQO process for the 100-NR-2 OU identified a list of COPCs from the interim action ROD (Table 1.1). These were evaluated against a set of exclusion criteria to determine if they should be retained as a refined list of COPCs or excluded from further consideration. The specific COPC exclusion rationales are summarized as follows:

- Short-lived radionuclides with half-lives less than 3 years
- Naturally occurring isotopes that were not created as a result of Hanford Site operations
- Contaminants not detected, or detected at very low levels
- Naturally occurring elements present in background concentrations
- Constituents that would be neutralized and/or decomposed in the soil environment
- Chemicals in the gaseous state that cannot accumulate in soil media
- Chemicals that are not persistent in the soil environment because of chemical instability volatilization, biological degradation, or other natural mitigating features.

The remaining COPCs were further evaluated for inclusion as COPECs, by considering their potential to exist in the riparian and near-shore aquatic environments. The three principal transport pathways considered include transport by wind (or water) erosion and deposition, biota transport, and migration through the vadose zone into the groundwater and transport to riparian and near-shore river receptors. The groundwater transport pathway was judged to be the most significant route for this study. The rationale for the assignment of COPECs to specific media in this study is based on numerous factors such as origin and source of the contaminant, mobility/solubility in the environment, and the potential to accumulate in biota. These considerations as they apply to specific media are described in the 100-NR-2 DQO for each COPEC, with a screening rationale for a screening approach to determine if further sampling of biota is warranted. A final listing of 17 COPECs is provided in Table 1.2. The sampling design in Chapter 3 of this document includes reconnaissance efforts that involved additional review of these COPECs as it pertains to the SAP.

This process provides a cost-effective screening-level approach for evaluating the exposure pathways identified in the DQO summary report (WMP-23141) and provides the basis for subsequent sampling. Details of the sampling design are discussed in the text and provided in tables in Section 3.0, "Field Sampling Plan."

1.2.1 Groundwater Screening of COPECs

A screening of groundwater data was conducted for 73 wells occurring within an 800-meter (2,625-foot) radius around the N-1301 crib. The data were collected from 1980 to date (Fall 2004). Mercury, technetium-99, and possibly silver were either absent or had insignificant historical concentrations. These constituents may be candidates for removal from the analyte list in case the estimated cost of the sampling and analysis effort exceeds available resources. Polychlorinated biphenyls (PCBs) may also be considered as a potential candidate for removal based on the absence of detects for Aroclor 1254 and Aroclor 1260 in groundwater.

Also, a review of the Hanford Site groundwater monitoring report (PNNL-14187) indicated there are two constituents (dissolved iron and nitrate) that exceed their MCLs but were not included in the COPC list. The dissolved iron exceedances are associated with the diesel spill as discussed previously. Iron and nitrate will be analyzed as part of the group measurements for metals (inductively coupled plasma [ICP]) and anions (ion chromatography) in surface water and aquifer tube samples and included in the impact evaluation.

1.2.2 COPEC Modifications and Considerations

For 2005 sampling, the entire list of COPECs will be retained; however, some samples will be limited to a reduce number of COPECS for technical reasons. These include:

- Gamma surveys will be conducted across the entire riparian zone. No gamma emitters have been retained as COPEC. In the event that hot stops are detected, soil samples will be taken at those spots for gamma spectral analysis.

Table 1.1. List of Contaminants of Potential Concern from the Interim Record of Decision

Radioactive Contaminants of Potential Concerns			
Americium-241 Antimony-125 Cesium-137 Cobalt-60	Europium-152 Europium-154 Plutonium-239/240 Strontium-90	Technetium-99 Thorium-232 Tritium (H-3)	Uranium-233/234 Uranium-235 Uranium-238
Inorganic Contaminants of Potential Concern			
Antimony Arsenic Barium Cadmium	Chromium (III) Chromium (VI) Lead	Manganese Mercury Nickel	Selenium Vanadium Zinc
Organic Chemical Contaminants of Potential Concern			
Carbon tetrachloride Chloroform	Hydrazine PCBs	Tetrachloroethylene	TPH

PCB = Polychlorinated biphenyl.
TPH = Total petroleum hydrocarbon.

Table 1.2. 100-NR-2 Groundwater Operable Unit Area Final List of Contaminants of Potential Ecological Concern

Radionuclides[a]	
Strontium-90 Technetium-99 Uranium-233/234[b]	Uranium-235[b] Uranium-238[b]
Inorganics (Metals)[c]	
Antimony Arsenic Barium Cadmium Chromium (VI) Lead Manganese	Mercury Nickel Selenium Vanadium Uranium Zinc
Organics	
PCBs	TPH (Diesel)

(a) Gamma surveys will also be conducted across the Riparian area.
(b) Uranium will be analyzed as a metal and a natural distribution of isotopes will be assumed for dose calculations.
(c) Iron and nitrate will be included in surface water and aquifer tube samples.
PCB = Polychlorinated biphenyl, 21 selected congeners.
TPH = Total petroleum hydrocarbon.

- Four isotopes of uranium were identified in the DQO – uranium-233, -234, -235, and -238. Uranium-233 and uranium-234 are generally inseparable by alpha spectroscopy and are considered as uranium-233/234 if the presence of uranium-233 is suspect. Because of their long half-lives

($>10^5$ years) and low specific activity, uranium is a chemical hazard rather than a radiological hazard. For this sampling plan, uranium will be measured as a trace metal by ICP analyses and no isotopic analyses for uranium are planned.

- The presence of a rust deposit in the vicinity of a suspected diesel fuel oil spill may require some additional sampling for iron in this area. Diesel fuel oil contaminants will be sampled in riparian soil, but only in this area and the immediate vicinity. Because of the extremely low likelihood of detecting petroleum hydrocarbons in biota, no biota samples will be analyzed for total petroleum hydrocarbons (TPHs). Because TPHs are relatively insoluble in water, seep or aquifer tube water will not be analyzed for TPH unless TPH is found in soil or sediment associated with the riparian or near-shore river environment.

- PCBs are a complex mixture of persistent organic compounds that were used as commercial preparations called Aroclors. Aroclors are designated by the average percentage of chlorination in the PCB mixture. As a COPEC, PCBs will be analyzed as Aroclor 1254 and 1260 (54% and 60% chlorine respectively) and 21 specific congeners.

1.2.3 Surveillance Sampling of Metals at 100-N, 1997

In 1997, a collaborative sampling effort between the Washington State Department of Energy and Pacific Northwest National Laboratory (PNNL) was initiated to evaluate radiological (PNNL-11933) and trace metal contamination (PNNL-11795) at 100-N. A review of the metals data in water transect samples collected close to the cobble and sediment samples suggests that chromium may be elevated within the strontium-90 plume and downstream of the plume.

1.2.4 Reconnaissance Sampling Spring 2004

In March, 2004, reconnaissance sampling of 100-N springs seep water, clams, and onions was conducted to supplement existing data for the shoreline area (Appendix A). Metals were observed in spring water near caisson 813 at concentrations exceeding Columbia River surface water collected at Vernita. Concentrations of uranium, arsenic, barium, chromium, manganese, nickel, and selenium were higher for 100-N Area riverbank spring water samples compared to the Columbia River background surface water samples collected at Vernita. In the area of the flowing seeps, clams accumulated chromium at levels exceeding levels observed at the background location upstream of the Vernita Bridge. Clams also accumulated strontium-90 in their shells in the near-shore river area adjacent to well N-46 in the central part of the known strontium-90 plume.

Rust deposits were also observed along the shoreline cobble upstream of the strontium-90 plume in an area adjacent to a documented diesel fuel oil spill. It is not certain that there is a relationship between the oil spill and the rust deposits.

These observations along with other environmental data examined 100-N (PNNL-SA-39495) suggest three general regions in the study area: 1) a suspected diesel contamination region upstream of well 199N-96A, 2) a strontium-90 plume region that is well defined by groundwater and surface surveillance monitoring, and 3) region where metals including chromium may be elevated. These three study areas are graphically depicted in Figure 1.2 and further described in Section 3.0

1.3 Data Quality Objectives

The EPA's DQO process (EPA/600/R-96/055) was used to support the development of this SAP. The DQO process is a strategic planning approach that provides a systematic procedure for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section presents a summary of the key outputs resulting from the implementation of the seven-step DQO process. For additional details, refer to the DQO summary report (WMP-23141).

1.3.1 Statement of the Problem

The purpose of the DQO summary report (WMP-23141) was to define the scope and data needs to support an ecological risk assessment at the 100-N Area of the Hanford Site. This SAP describes the samples and data collection processes that are needed to support these objectives.

Table 1.3 presents the principal study questions (PSQs), alternative conclusions (ACs), and resulting decision statements (DSs) associated with the problem statement. It also provides a qualitative assessment of the consequences of implementing an incorrect AC. This assessment takes into consideration the environment (flora/fauna) and economic ramifications. The severity of the consequences is expressed as low, moderate, or severe.

1.3.2 Inputs Needed to Develop Decision Rules

Decision rules (DRs) are developed for the DSs in the form of "IF...THEN..." statements that incorporate the parameters of interest, the scale of the decision, the action levels, and the ACs that would result from resolving the DSs. Table 1.4 presents the information needed to formulate the DRs. This information includes the alternative considerations identified in DQO Step 2, the decision units from DQO Step 4, the statistical parameters of interest, and the action levels for the COPECs (WMP-23141).

1.3.3 Decision Rules

The output of DQO Step 5 and the previous DQO steps are combined into "IF...THEN" DRs that incorporate the parameter of interest, the scale of decision making, the action level, and the actions that would result from resolution of the decision (WMP-23141). The DRs are listed in Table 1.5.

1.3.4 Error Tolerance and Decision Consequences

The factors that were taken into consideration to make this selection were determined in DQO Step 2 and included the qualitative consequences of an inadequate sampling design and the accessibility of the site if resampling is required. For decisions that carry potentially severe consequences of erroneous alternative conclusions, and for which the sampled media is not accessible for resampling after remediation, statistically rigorous sampling designs that can be proven to accurately estimate the entire population within acceptable error limits are normally employed.

When the consequences of erroneous alternative conclusions are moderate or low, and when resampling may be performed after remediation, sampling designs relying on methods to (1) minimize

variability associated with the population and (2) target key areas or individuals in the populations may be considered. These designs take into consideration prior knowledge of the population to be sampled and use systematic approaches and stratification techniques to minimize sampling errors. The use of systematic sampling and stratification of the population of interest in designing sampling is intended to allow resources and funding to be focused on the most important questions. For this DQO, these approaches are termed judgmental in that they may introduce bias in the sampling biota. Table 1.6 provides a summary of the information used to support the selection between a statistical versus a judgmental sampling design for each DS.

Table 1.6 indicates that non-statistical, judgmental sampling designs are proposed for all of the alternative consequences in this DQO process because of the low and moderate consequences of potentially inadequate sampling designs.

Systematic grid and biased sampling designs were developed for this application. These sampling designs are based on prior knowledge of the area of concern, review of existing information regarding contaminant concentrations in the abiotic and biotic sampling media, and the physical and biological characteristics of the available habitat found at the 100-N Area. Each of the sampling designs is applied according to the type and nature of the media being sampled.

1.3.5 Sample Design Summary

The proposed sampling design for the 100NR-2 study area is discussed in detail in Section 7 of the DQO (WMP-23141). The main features are described here and documented in Table 1.7 and in Section 3 of the document. Two ecological zones have been identified for sampling within the 100-NR-2 study area. These zones include the riparian and near-shore aquatic zones. Reconnaissance surveys, including surveys for special status species, radionuclide surveys in the riparian zone, and conductivity surveys within the near-shore river, will be performed prior to any sampling. Samples will consist of abiotic and biotic media.

Abiotic media will include soil and groundwater sample collection in both zones and surface water within the near-shore aquatic zone. Biotic media collection will include the sampling of appropriate resident species (i.e., key receptor species of plants and animals) within each zone.

A variety of sampling methods are required to ensure that the proper characterization data are collected from abiotic and biotic media within the 100-N Area. The sampling methods are described in detail in the FSP (Section 3.0). The sample design objectives, methods, features, and bases are presented in Table 1.7.

Table 1.3. Summary Principal Study Questions, Alternative Conclusions, and Decision Statements

PSQ-AA#	Alternative Conclusions	Consequence if Alternative Conclusion is Wrong	Severity of the Consequence (Low/Moderate/Severe)
Riparian Environment			
PSQ #1 – Are riparian receptors exposed to radiologically contaminated soil or groundwater?			
1-1	Yes, receptors are being exposed to radiologically contaminated soil or groundwater.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
1-2	No, receptors are not being exposed to radiologically contaminated soil or groundwater.	Potential exposure of receptor species	Moderate to Severe
DS #1 – Determine if riparian receptors are exposed to radiologically contaminated soil or groundwater.			
PSQ #2 – Are riparian receptors exposed to chemically contaminated soil or groundwater?			
2-1	Yes, receptors are being exposed to chemically contaminated soil or groundwater.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
2-2	No, receptors are not being exposed to chemically contaminated soil or groundwater.	Potential exposure of receptor species	Moderate to severe
DS #2 – Determine if riparian receptors are exposed to chemically contaminated soil or groundwater.			
PSQ #3 – Are riparian receptors radiologically contaminated?			
3-1	Yes, receptors are radiologically contaminated.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
3-2	No, receptors are not radiologically contaminated.	Potential radiological contamination of receptor species	Moderate to severe
DS #3 – Determine if riparian receptors are radiologically contaminated.			
PSQ #4 – Are riparian receptors chemically contaminated?			
4-1	Yes, receptors are chemically contaminated.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
4-2	No, receptors are not chemically contaminated.	Potential chemical contamination of receptor species	Moderate to severe
DS #4 – Determine if riparian receptors are chemically contaminated.			
PSQ #5 – Are riparian receptors adversely affected?			
5-1	Yes, receptors are adversely affected.	The degree of the effects needs to be assessed. Unnecessary costs may be incurred.	Low to moderate
5-2	No, receptors are not adversely affected.	Adverse effects would go unrecognized and there would be potentially affected receptor species	Moderate to severe
DS #5 – Determine if riparian receptors are adversely affected.			

Table 1.3. (contd)

PSQ-AA#	Alternative Conclusions	Consequence if Alternative Conclusion is Wrong	Severity of the Consequence (Low/Moderate/Severe)
PSQ #6 – Is the adverse affect (if any) to riparian receptors acceptable?			
6-1	Yes, the adverse effects are acceptable.	Adverse effects would go unrecognized and there would be unacceptably affected receptor species.	Moderate to severe
6-2	No, the adverse effects are not acceptable.	Unnecessary costs may be incurred.	Low to moderate
DS #6 – Determine if the adverse effects to riparian receptors are acceptable.			
Near-Shore Aquatic Environment			
PSQ #7 – Are near-shore aquatic receptors exposed to radiologically contaminated groundwater upwelling, sediment, or surface water?			
7-1	Yes, receptors are being exposed to radiologically contaminated groundwater upwelling, sediment, or surface water.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
7-2	No, receptors are not being exposed to radiologically contaminated groundwater upwelling, sediment, or surface water.	Potential exposure of receptor species	Moderate to severe
DS #7 – Determine if riparian receptors are exposed to radiologically contaminated groundwater upwelling, sediment, or surface water.			
PSQ #8 – Are near-shore aquatic receptors exposed to chemically contaminated groundwater upwelling, sediment, or surface water?			
8-1	Yes, receptors are being exposed to chemically contaminated groundwater upwelling, sediment, or surface water.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
8-2	No, receptors are not being exposed to chemically contaminated groundwater upwelling, sediment, or surface water.	Potential exposure of receptor species	Moderate to severe
DS #8 – Determine if near-shore aquatic receptors are exposed to chemically contaminated groundwater, sediment, or surface water.			
PSQ #9 – Are near-shore aquatic receptors radiologically contaminated?			
9-1	Yes, the near-shore aquatic receptors are radiologically contaminated.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
9-2	No, the near-shore aquatic receptors are not radiologically contaminated.	Potential radiological contamination of receptor species	Moderate to severe
DS #9 – Determine if near-shore aquatic receptors are radiologically contaminated.			

Table 1.3. (contd)

PSQ-AA#	Alternative Conclusions	Consequence if Alternative Conclusion is Wrong	Severity of the Consequence (Low/Moderate/Severe)
PSQ #10 – Are near-shore aquatic receptors chemically contaminated?			
10-1	Yes, the near-shore aquatic receptors are chemically contaminated.	Unnecessary remedial actions may be taken, and unnecessary costs may be incurred	Low
10-2	No, the near-shore aquatic receptors are not chemically contaminated.	Potential chemical contamination of receptor species	Moderate to severe
DS #10 – Determine if near-shore aquatic receptors chemically contaminated.			
PSQ #11 – Are near-shore aquatic receptors adversely affected?			
11-1	Yes, the near-shore aquatic receptors are adversely affected.	The degree of the effects will need to be assessed. Unnecessary costs may be incurred.	Low to moderate
11-2	No, the near-shore aquatic receptors are not adversely affected.	Adverse effects would go unrecognized and there would be potentially affected receptor species	Moderate to severe
DS #11 – Determine if near-shore aquatic receptors are adversely affected.			
PSQ #12 – Is the adverse affect (if any) to near-shore aquatic receptors acceptable?			
12-1	Yes, the adverse effects are acceptable.	Adverse effects would go unrecognized and there would be unacceptably affected receptor species.	Moderate to severe
12-2	No, the adverse effects are not acceptable.	Unnecessary costs may be incurred.	Low to moderate
DS #12 – Determine if the adverse effects to near-shore receptors are acceptable.			

Table 1.4. Inputs Needed to Develop Decision Rules

DS #	COPECs	Statistical Parameter of Interest	Decision Units[a]	Action Levels	Alternative Conclusions for Principal Study Questions
1	Radiological COPECs	95% UCL of the mean, average, or maximum detected value, as appropriate	*Riparian* Soil Groundwater	Calculated radiological exposures to biota through RESRAD-BIOTA, comparison with the reference area	Yes, receptors are being exposed to radiologically contaminated soil or groundwater, or no they are not.
2	Chemical COPECs	95% UCL of the mean, maximum detected values, or detected value, as appropriate	*Riparian* Soil Groundwater	WAC Table 749-3 values, Ambient Water Quality Criteria, literature search values, and comparison with the reference area	Yes, receptors are being exposed to chemically contaminated soil or groundwater, or no they are not.
3	Radiological COPECs	95% UCL of the mean, average, or maximum detected value, as appropriate	*Riparian* Flora Fauna	Contaminants in the biota tissue samples are compared with tissue concentrations from reference areas	Yes, receptors are radiologically contaminated, or no they are not.
4	Chemical COPECs	95% UCL of the mean, average, or maximum detected value, as appropriate	*Riparian* Flora Fauna	Contaminants in the biota tissue samples are compared with literature search values or tissue concentrations from reference areas	Yes, receptors are chemically contaminated, or no they are not.
5	Radiological and Chemical COPECs	95% UCL of the mean, average, or maximum detected value, or visual observation as appropriate	*Riparian* Soil Groundwater Flora Fauna	Calculated radiological exposures to biota through RESRAD-BIOTA, WAC Table 749-3 values, Ambient Water Quality Criteria, literature search values, and comparison with the reference areas, results of the weight of evidence determination	Yes, receptors are adversely affected, or no, they are not.
6	Radiological and Chemical COPECs	95% UCL of the mean, average, or maximum detected value, or visual observation as appropriate	*Riparian* Soil Groundwater Flora Fauna	TBD in Risk Assessment with input from Tri-Party Agency Decision Makers	Yes, the adverse effects are acceptable, or no they are not.
7	Radiological COPECs	95% UCL of the mean, average, or maximum detected value, as appropriate	*Near-Shore Aquatic* Groundwater upwelling Sediment Surface Water	Calculated radiological exposures to biota through RESRAD-BIOTA, comparison with the reference area	Yes, receptors are being exposed to radiologically contaminated groundwater, sediment or surface water or no they are not.

Table 1.4. (contd)

DS #	COPECs	Statistical Parameter of Interest	Decision Units[a]	Action Levels	Alternative Conclusions
8	Chemical COPECs	95% UCL of the mean, maximum detected values, or detected value, as appropriate	*Near-Shore Aquatic* Groundwater upwelling Sediment Surface Water	Ambient Water Quality Criteria, literature search values, and comparison with the reference area	Yes, receptors are being exposed to chemically contaminated groundwater, sediment, or surface water or no they are not.
9	Radiological COPECs	95% UCL of the mean, average, or maximum detected value, as appropriate	*Near-Shore Aquatic* Flora Fauna	Contaminants in the biota tissue samples are compared with tissue concentrations from reference areas	Yes, the near-shore aquatic receptors are radiologically contaminated, or no they are not.
10	Chemical COPECs	95% UCL of the mean, average, or maximum detected value, as appropriate	*Near-Shore Aquatic* Flora Fauna	Contaminants in the biota tissue samples are compared with tissue concentrations from reference areas	Yes, the near-shore aquatic receptors are chemically contaminated, or no they are not.
11	Radiological and Chemical COPECs	95% UCL of the mean, average, or maximum detected value, or visual observation as appropriate	*Near-Shore Aquatic* Groundwater upwelling Sediment Surface Water Flora Fauna	Calculated radiological exposures to biota through RESRAD-BIOTA, Ambient Water Quality Criteria, literature search values, and comparison with the reference areas, results of the weight of evidence determination	Yes, the near-shore aquatic receptors are adversely affected, or no they are not.
12	Radiological and Chemical COPECs	95% UCL of the mean, average, or maximum detected value, or visual observation as appropriate	*Near-Shore Aquatic* Groundwater upwelling Sediment Surface Water Flora Fauna	TBD in Risk Assessment with input from Tri-Party Agency Decision Makers	Yes, the adverse effects are acceptable, or no they are not.

(a) Specific biota selected for sampling are identified in Step 7 of the DQO and in the Field Sampling Plan, Section 3.0.

DS = Decision statement.
COPEC = Contaminant of potential ecological concern.
UCL = Upper confidence limit.

Table 1.5. Decision Rules

DR #		Decision Rule
1		If the activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the Riparian soil or groundwater results in a RESRAD-BIOTA estimated radiological exposure that exceeds the exposures in the reference area, then the receptors are being exposed to radiologically contaminated media. Otherwise, they are not radiologically contaminated.
2		If the concentrations (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the Riparian soil or groundwater exceed Ambient Water Quality Criteria, literature search values, or concentrations in the reference area, then the receptors are being exposed to chemical media. Otherwise, they are not chemically contaminated.
3		If the activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the samples from the Riparian flora[a] or fauna[a] exceeds the values from the reference area, then the receptors are radiologically contaminated. Otherwise, they are not radiologically contaminated.
4		If the concentration (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the samples from the Riparian flora[a] or fauna[a] exceed the literature search values or biota tissue concentrations in the reference area, then receptors are chemically contaminated. Otherwise, they are not chemically contaminated.
5	a	If the activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the samples from the Riparian soil, groundwater, flora[a] or fauna[a] results in a RESRAD-BIOTA estimated radiological exposure that exceeds the exposures in the reference area, and visual observations support an unfavorable weight of evidence determination, then the receptors are adversely affected. Otherwise, they are not adversely affected.
	b	If the concentration (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the samples from the Riparian soil, groundwater, flora[a] or fauna[a] exceed the literature search values, biota tissue concentrations in the reference area, and visual observations support an unfavorable weight of evidence determination, then the receptors are adversely affected. Otherwise, they are not adversely.
6		If the results of the Ecological Risk Assessment indicate that there are adverse effects on the Riparian receptors, the Tri-Party Agency decision makers will review the risk assessment and determine whether the adverse effects are acceptable, or not.
7		If the activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the Near-Shore aquatic groundwater upwelling, sediment, or surface water results in a RESRAD-BIOTA estimated radiological exposure that exceeds the exposures in the reference area, then the receptors are being exposed to radiologically contaminated media. Otherwise, they are not radiologically contaminated.
8		If the concentrations (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the Near-Shore aquatic groundwater upwelling, sediment, or surface water exceed Ambient Water Quality Criteria, literature search values, or concentrations in the non-contaminated reference area, then the receptors are being exposed to chemically contaminated media. Otherwise, they are not chemically contaminated.
9		If the activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the samples from the Near-Shore aquatic flora[a] or fauna[a] exceed the values from the reference area, then the receptors are radiologically contaminated. Otherwise, they are not radiologically contaminated.

Table 1.5. (contd)

DR #		Decision Rule
10		If the concentration (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the samples from the Near-Shore River flora[a] or fauna[a] exceed the literature search values, or biota tissue concentrations in the reference area, then the receptors are chemically contaminated. Otherwise, they are not chemically contaminated.
11	a	If the activity (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of radionuclides within the samples from the Near-Shore River groundwater upwelling, sediment, surface water, flora[a] or fauna[a] results in a RESRAD-BIOTA estimated radiological exposure that exceeds the exposures in the reference area, and visual observations support an unfavorable weight of evidence determination, then the receptors are adversely affected. Otherwise, they are not adversely affected.
	b	If the concentration (as estimated by the 95% UCL on sample mean, average, or maximum detected value, as appropriate) of chemical constituents within the samples from the Near-Shore River groundwater upwelling, sediment, surface water, flora[a] or fauna[a] exceed the literature search values, biota tissue concentrations in the reference area, and visual observations support an unfavorable weight of evidence determination, then the receptors are adversely affected. Otherwise, they are not adversely affected.
12		If the results of the Ecological Risk Assessment indicate that there are adverse effects on the Near-Shore aquatic receptors, the Tri-Party Agency decision makers will review the risk assessment and determine whether the adverse effects are acceptable, or not.

(a) Specific biota selected for sampling are identified in Step 7 of the DQO and in the Field Sampling Plan, Section 3.0.

Table 1.6. Justification for Sampling Design

DS#	PSQ Summary	Alternative Consequence Summary		Consequence Severity (High, Moderate, Low)	Resampling Access After Remediation (Accessible or Not)	Preliminary Sample Design Basis (Statistical, Judgmental)
1	Are riparian receptors exposed to radiologically contaminated soil or groundwater?	1	Yes, receptors are being exposed to radiologically contaminated soil or groundwater.	Low	Y	Judgmental
		2	No, receptors are not being exposed to radiologically contaminated soil or groundwater.	Moderate to severe	Y	
2	Are riparian receptors exposed to chemically contaminated soil or groundwater?	1	Yes, receptors are being exposed to chemically contaminated soil or groundwater.	Low	Y	Judgmental
		2	No, receptors are not being exposed to chemically contaminated soil or groundwater.	Moderate to severe	Y	
3	Are riparian receptors radiologically contaminated?	1	Yes, receptors are radiologically contaminated.	Low	Y	Judgmental
		2	No, receptors are not radiologically contaminated.	Moderate to severe	Y	
4	Are riparian receptors chemically contaminated?	1	Yes, receptors are chemically contaminated.	Low	Y	Judgmental
		2	No, receptors are not chemically contaminated.	Moderate to severe	Y	
5	Are riparian receptors adversely affected?	1	Yes, receptors are adversely affected.	Low to moderate	Y	Judgmental
		2	No, receptors are not adversely affected.	Moderate to severe	Y	
6	Is the adverse effect (if any) to riparian receptors acceptable?	1	Yes, the adverse effects are acceptable.	Moderate to severe	Y	Judgmental
		2	No, the adverse effects are not acceptable.	Low to moderate	Y	
7	Are near-shore aquatic receptors exposed to radiologically contaminated groundwater upwelling, sediment, or surface water?	1	Yes, receptors are being exposed to radiologically contaminated groundwater upwelling, sediment, or surface water.	Low	Y	Judgmental
		2	No, receptors are not being exposed to radiologically contaminated groundwater upwelling, sediment, or surface water.	Moderate to severe	Y	
8	Are near-shore aquatic receptors exposed to chemically contaminated groundwater upwelling, sediment, or surface water?	1	Yes, receptors are being exposed to chemically contaminated groundwater.	Low	Y	Judgmental
		2	No, receptors are not being exposed to chemically contaminated groundwater.	Moderate to severe	Y	

Table 1.6. (contd)

DS#	PSQ Summary	Alternative Consequence Summary		Consequence Severity (High, Moderate, Low)	Resampling Access After Remediation (Accessible or Not)	Preliminary Sample Design Basis (Statistical, Judgmental)
9	Are near-shore aquatic receptors radiologically contaminated?	1	Yes, the near-shore aquatic receptors are radiologically contaminated.	Low	Y	Judgmental
		2	No, the near-shore aquatic receptors are not radiologically contaminated.	Moderate to severe		
10	Are near-shore aquatic receptors chemically contaminated?	1	Yes, the near-shore aquatic receptors are chemically contaminated.	Low	Y	Judgmental
		2	No, the near-shore aquatic receptors are not chemically contaminated.	Moderate to severe		
11	Are near-shore aquatic receptors adversely affected?	1	Yes, the near-shore aquatic receptors are adversely affected.	Low to moderate	Y	Judgmental
		2	No, the near-shore aquatic receptors are not adversely affected.	Moderate to severe		
12	Is the adverse effect (if any) to near-shore aquatic receptors acceptable?	1	Yes, the adverse effects are acceptable.	Moderate to severe	Y	Judgmental
		2	No, the adverse effects are not acceptable.	Low to moderate		

(a) Treatment technologies for contaminated groundwater may include, but will not be limited to, existing pump-and-treat technology, passive barriers, phytoremediation, or combinations of these.
DS = Decision statement.
PSQ = Principal study question.

Table 1.7. Sampling Design Methodology, Objectives, Features, and Basis

Riparian					
Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Reconnaissance Surveys					
Literature reviews and scoping surveys	Determine locations, abundance and availability of sampling populations. Determine rigor of COPEC data.	Abiotic and biotic sampling populations.	Review existing information and maps. Conduct scoping surveys for visual observations and mapping reconnaissance.	Initial activity to focus and refine the sampling design.	NA
Radiological field surveys	Land-based radiological survey to characterize external radiological exposure.	Review pertinent radiological survey reports. Survey for beta/gamma emitters in riparian surface soils.	Review past radiological surveys and thermoluminescent dosimetry. Conduct systematic grid surveys for radiological measurements in riparian zone.	Provide systematic assessment of spatial extent of radiological contamination in riparian soils. Identify any "hot spots" with respect to both beta and gamma-emitting radionuclides. Collect comparable data consistent with surveys at other OUs along river corridor for baseline risk assessment. (100/300 Area Component of RCBRA, 100 B/C pilot)	NA
Visual and analytical survey of suspected TPH contamination	Identify and evaluate spatial extent of TPH contamination.	Suspected TPH contamination.	Rapid assay and assessment technique based on rust coloration in soil/water and on rocks at shoreline.	Identify additional sampling locations	NA
Survey of special status species/habitat and key receptor species	Determine presence in study zone.	Special status species, key receptors.	Surveys conducted when species most likely to be present (season). Survey appropriate habitat.	Identifies and locates species of regulatory significance. Identifies and locates receptor species.	Table 3.3
Select reference location	Assess suitability of reference location.	Match presence of receptors and abiotic media with 100-NR-2 study site.	Evaluate reference sties used for other environmental programs and baseline risk assessments.	Provides point of comparison for COPEC concentrations in study area and biological measurements.	NA

Table 1.7. (contd)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Abiotic Sampling					
Soil sampling	Characterize COPECs, levels, and distribution within riparian environment.	Soil concentrations of 100-NR-2 COPECs.	1. Systematic sampling of soils adjacent to receptors, based on groundwater contaminant plume information and existing contaminant data.	Characterize spatial distribution of COPECS in study area. Evaluate contaminant distribution in the soil column. Contaminant levels in soil can be compared against benchmarks (e.g., WAC 749-3) Verify whether visual observations of rust correspond with elevated TPH concentrations.	Table 3.4
			2. Targeted sampling based on ground-based survey results indicating potential radiological contamination or on groundwater contaminant plume information and existing contaminant data.	Provides exposure measurements (quantitative and qualitative) to compare with potential ARARs/cleanup levels. Populate existing data gaps for specific COPECs.	Table 3.4
Groundwater - shallow aquifer tubes and seeps	Characterize the groundwater/river mixture within riparian environment. Provide data to refine sampling design (identify where receptors may have elevated exposure to 100-NR-2 COPECs). Provide data to support evaluation of pump-and-treat operations or alternative treatment technologies.	Water (hyporheic zone) concentrations of 100-NR-2 COPECs.	Samples collected from shallow drive points 30+ cm. Samples collected during low-flow conditions to represent highest exposure scenario to plants in riparian zone. Specific sampling locations based on information and decisions made during reconnaissance surveys. Consider sampling along transects at intermittent seeps based on river water conductivity surveys.	Sampling transects along primary and intermittent seep captures hyporheic flow of mixed groundwater and river water. Measures groundwater COPECs in region accessible to riparian receptors. Sampling transects at intermittent seep based on professional judgment (spatial relationship to known and suspected contaminant sources.	Table 3.5

Table 1.7. (contd)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Soil sampling at selected reference site	Gather information to characterize reference contaminant levels and distribution within similar riparian environment for comparison with results for 100-NR-2 study area.	Soil concentrations of 100-NR-2 COPECs.	Same as for 100-NR-2 study area. Evaluate existing library of soil contaminant information available for selected reference sites.	Evaluate reference contaminant levels and distribution in the soil column.	Table 3.4
Groundwater - shallow aquifer tubes and seeps at selected reference site	Gather comparative information to characterize contaminant levels and distribution within riparian environment for comparison with results for 100-NR-2 study area.	Ambient water concentrations of COPECs at reference site.	Supplement and evaluate existing database of contaminant information available for reference sites. Provide data for potential application to weight of evidence evaluations.	Sampling along primary and intermittent seep transects captures hyporheic flow of mixed groundwater and river water. Measures groundwater COPECs in reference area.	Table 3.6
Biotic Sampling					
Key ecological receptor sampling at 100-NR-2	Characterize accumulation of COPECs in key ecological receptors.	Phase I ecological receptors within the 100-NR-2 study region.	Systematically selected receptor species for 100-NR-2 based on technical criteria (screening guild, proximity to source terms, habitat and season factors). Reconnaissance surveys will identify sampling locations. Stratify sampling by vegetation/ soil characteristics in study region. Stratify sampling of ecological receptors based on screening guilds (functional groups of species). Default to opportunistic sampling based on availability and abundance of biota using professional judgment.	Key receptor species selected according to distinct groupings (guilds or functional types based on life history characteristics), as described in WAC 173-340. Terrestrial guilds identified in the DQO process (Table 3-3) are consistent with guidance in WAC 173-340. Design is consistent with general EPA screening guidelines for assessing biological condition (using key entities and their attributes)	Table 3.6

Table 1.7. (contd)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Key ecological receptor sampling at 100-NR-2 (contd)			Number of samples to meet analytical mass requirements and/or statistical data needs. Capture biological health metrics based on screening-level assessments for selected receptors.		
Key ecological receptor sampling at reference area	Gather comparative riparian biota in reference area for comparison with COPEC and biological condition results for 100-NR-2 study area.	Phase I ecological receptors within the reference area.	Systematically selected receptor species for 100-NR-2 based on technical criteria (screening guild, proximity to source terms, habitat and season factors). Provide data for potential application to weight of evidence evaluations.	Same as 100-NR-2 study area sampling of riparian biota (includes coincident soil sampling).	Table 3.6
Near Shore Aquatic					
Reconnaissance Surveys					
Literature review and site characterization surveys	Determine locations, abundance and availability of sampling populations.	Abiotic and biotic sampling populations.	Review existing information and maps. Site visits for visual observations and mapping reconnaissance.	Initial activity for refinement of the sampling design (spatial mapping of strata, key receptor species distributions, etc.)	NA
Screen areas for groundwater upwelling (field-based conductivity surveys)	Characterize areas within study region with active upwelling of shallow groundwater.	Conductivity values indicating shallow groundwater upwelling.	Conductivity surveys using systematic grid sampling of areas where shallow groundwater is upwelling. Samples collected from riverbank seepage or from surface water (6.0 cm above the surface of the riverbed).	Provides relatively continuous characterization data to describe shallow groundwater upwelling. Complements other OU surveys along river corridor. Low cost and rapid technique.	NA
Identifying special status species	Determine presence of special status species and assess suitability of habitat in study zones.	Special status species within study region.	Surveys conducted when species most likely to be present. Surveys assess habitat quality and habitat availability to address potential presence of species.	Identifies and locates special status species that need to be considered.	Table 3.7

Table 1.7. (contd)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Select reference location	Assess suitability of reference location.	Match presence of receptors and abiotic media with 100-NR-2 study site.	Evaluate reference sites used for other environmental programs and baseline risk assessments.	Provides point of comparison for COPEC concentrations in study area and biological measurements.	Literature review, interview site environmental scientists, visit candidate sites.
Abiotic Sampling					
Surface and groundwater aquifer tube sampling in shallow river bottom	Characterize 100-NR-2 COPECs found in near-shore groundwater upwelling and surface water.	Ambient water concentrations of 100-NR-2 COPECs (i.e., a combination of shallow-groundwater and river water where ecological receptors may be exposed).	Systematic sampling along the river's edge. Systematically sample each site 0.25 m (water depth) below the line of persistent periphyton. Sample during low and steady flow conditions to represent maximum shallow-groundwater exposure scenarios. Initial activity leads to further insight of stratified sampling designs for contaminant exposures in aquatic environment.	Sampling identifies distributions of contaminants along the river's edge. Drive point samples 10.0 cm deep represent maximum depth of macroinvertebrates observed in mid-Columbia River Provides evidence to support a relationship between concentrations of COPECs in the water and selected sentinel biota. Provides data to support evaluation of pump-and-treat operations.	Table 3.9
Sediment	Characterize 100-NR-2 COPECs found in near-shore sediment.	Ambient sediment concentrations of 100-NR-2 COPECs where ecological receptors may be exposed.	Opportunistically sample each site between 0.0 m and 0.25 m (water depth) beginning at the line of persistent periphyton. Sample sediment for benthic flora and fauna to a depth of 10.0 cm.	Provides evidence to support a relationship between concentrations of COPECs in the water and selected sentinel biota. Provides COPECs and ambient sediment quality data needed as input to model potential ecological risk to receptors.	Table 3.8

Table 1.7. (contd)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Biotic Sampling					
Key ecological receptor sampling at 100-NR-2 PHASE I: (clams, periphyton, milfoil, fish)	Characterize radioactive and chemical accumulation in ecological receptors.	Concentrations of COPECs in ecological receptors within the 100-NR-2 study region.	Use one particular organism and key aquatic receptor that is nearly ubiquitous in the near-shore aquatic environment to identify concentrations of COPECs. Stratify sample sites by the biological, physical, and/or hydrological conditions present in the study region. Stratify sample sites by the biological, physical, and/or hydrological conditions present in the study region. Stratify ecological receptor sampling based on screening guilds (functional groups of species). Systematically select species present near 100-N that best meet sentinel species technical criteria. Phased approach developed for screening potential impacts of contaminant exposure and impacts to other guilds (see Fig. 7.1 of the DQO).	Provides data to describe the spatial extent (x and y dimensions) and level (ecosystem-wide) of accumulation of COPECs in biota. PHASE I: (clams, periphyton, milfoil, fish) Key receptor species selected according to distinct groupings (guilds or functional types based on life history characteristics), as described in WAC 173-340. Samples will be analyzed for groundwater contaminants (Table 1.2) and, as appropriate, biological health metrics in accordance with Table 3-2 of the DQO summary report. Design consistent with general screening guidelines for assessing biological condition (using key entities and their attributes) established by EPA.	Table 3.10
Key ecological receptor sampling at 100-NR-2 PHASE II: (crayfish, juv. suckers, carp, mallard, kingbird/bufflehead)	Conduct screening-level assessments of biological conditions of ecological receptors.	Biological condition of ecological receptor populations within the study region.	Systematically select receptors present near 100-NR-2 for sentinel species technical considerations, and which possess measurable attributes that can be used to assess their biological condition. Stratify by geo-physical, hydrological, and/or biological properties of the study region for comparison with reference areas.	Data describe additional assessment endpoints (based on measurable attributes of key receptors) for weight of evidence evaluation for risk assessment Design consistent with general screening guidelines for assessing biological condition (using key entities and their attributes) established by EPA.	NA (TBD)

Table 1.7. (contd)

Sample Collection Methodology	Sampling Objectives	Population	Key Features of Design	Basis for Sampling Design	Reference Table for Sampling[a]
Key ecological receptor selection/sampling in reference site	Sample an area similar to study area without 100-NR-2 COPECs.	Population mirrors sample populations identified for riparian zone.	Same as study area.	Provides data needed for establishing a biological assessment endpoint (tissue residues) for weight of evidence evaluation for risk assessment	

(a) Details concerning number of samples and sampling locations are found in tables of Section 3 of this document.
NA = Not applicable

2.0 5535Quality Assurance Project Plan

This section identifies the organizations participating in the implementation of this SAP and discusses specific roles and responsibilities of the staff performing the work.

2.1 Project Management

This section addresses the basic areas of project management and will ensure that the project has a defined goal, that the participants understand the goal and the approach to be used, and that the planned outputs have been appropriately documented.

2.1.1 Project/Task Organization

The project will be managed by Fluor Hanford, Inc. through the Groundwater Remediations Project, which has an assigned project manager and task leads. Flour Hanford, Inc. may subcontract portions of this work to qualified subcontractors in accordance with the requirements of this SAP. PNNL will be responsible for collection, packaging, and shipment of soil and biota samples to the laboratory. The sampling task lead will provide oversight for all sampling and field analytical measurements. Lane Environmental will provide logistical support as requested by Fluor Hanford, Inc. Radiological control, health and safety, and waste support will be obtained from the Fluor Hanford and Battelle staff responsible for all field activities. QA assessments will be performed on sample collection and analysis activities.

2.1.2 Project Schedule

A *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) commitment (Ecology et al. 1989) was established for the evaluation of risk posed to aquatic and riparian receptors at the 100-NR-2 Groundwater OU by October 2005. The information from the DQO summary report (WMP-23141) and any subsequent sampling data will be used to support the Tri-Party Agreement milestone. Table 2.1 presents the tentative schedule for the completion of the task activities associated with developing and implementing the 100-NR-2 study, associated reconnaissance surveys and sampling program, performance of laboratory analyses, performance of a data quality assessment, and evaluation and reporting of investigation results.

2.1.3 Quality Objectives and Criteria for Measurement Data

The detection limits and precision and accuracy requirements for each of the analyses to be performed are summarized in Table 2.2 and 2.3. These requirements were derived as part of Step 3 in the DQO process (WMP-23141).

Table 2.1. Schedule for Field Sampling Activities

Tier	Sampling Activities	Sampling Dates	Data Evaluation Dates	Data Summary Time/Date
I	Riparian Reconnaissance Type 1 (LARAD/Beta)	February-March 2005	~March 31, 2005	~April 30, 2005
I	Riparian Reconnaissance Type 2 (TPH region)	February 2005	~ February 1, 2005	~ February 15, 2005
I	Riparian Reconnaissance Type 3 (Sample Media)	February 2005	~February 31, 2005	~ February 15, 2005
I	Riparian Reconnaissance Type 4a (T&E birds)	February-June 2005	~August 30, 2005	~October 31, 2005
I	Riparian Reconnaissance Type 4b (T&E plants)	April-September 2005	~September 30, 2005	~October 31, 2006
I	Aquatic Reconnaissance Type 1 (Conductivity)	February 2005	~February 31, 2005	~ February 15, 2005
	Aquatic Reconnaissance Type 2 (Sample Media)	February 2005	~ February 1, 2005	~February 15, 2005
I	Aquatic Reconnaissance Type 3 (T&E's birds, mollusks, fish)	February-March 2005	~September 30, 2005	~October 31, 2005
II	Riparian - Phase I Sampling (Soil, Water, Soil Biota, Plants, Mammals)	May-June 2005	~August 31, 2005	~October 31, 2005
II	Aquatic - Phase I Sampling (Sediment, Water, Macrophytes, Benthic Invertebrates, Fish)	February-March 2005	~August 31, 2005	~October 31, 2005

LARAD = Laser Assisted Radiological Survey
T&E = Threatened and Endangered Species
TPH = Total petroleum hydrocarbon.

2.1.4 Special Training Requirements/Certification

Training or certification requirements needed by sampling personnel shall be in accordance with the requirements of 29 CFR 1910.120 and site wide radiological work procedures. Field personnel will typically have completed the following training before starting work:

- Occupational Safety and Health Administration 40-hour hazardous waste worker training and supervised 24-hour hazardous waste site experience
- Eight-hour hazardous waste worker refresher training (as required)
- Hanford general employee radiation training
- Radiological worker training.

Table 2.2. Analytical Performance Requirements (Radionuclides)

Contaminants of Potential Ecological Concern	CAS #	Preliminary Action Level[a] Rural-Residential 15 mrem/yr[b] (pCi/g)	Name/Analytical Technology	Target Required Quantitation Limits Biota (pCi/g)	Soil (pCi/g)	Water (pCi/L)	Precision Water	Accuracy Water	Precision Soil	Accuracy Soil
Radionuclides										
Strontium-90	10098-97-2	4.5	Total radioactive strontium – GPC	--	1	2	±30%	70-130[c]	±30%	70-130[c]
Technetium-99	14133-76-7	15[d]	Technetium-99 – liquid scintillation	--	15	15	±30%	70-130[c]	±30%	70-130[c]

(a) The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits).
(b) The radiological cleanup criteria for the rural-residential exposure scenario is 15 mrem/yr above background. These numerical values are limiting for both human health and ecological receptors. Therefore, the ecological values are not listed on this table.
(c) Accuracy criteria for associated batch laboratory control sample percent recoveries. Except for GEA analysis, additional analysis-specific evaluations so preformed for matrix spikes, tracers, and carriers as appropriate to the method. Precision criteria for batch laboratory replicate sample analyses.
(d) The RAG is below the target required quantitation limit. The value presented is the target required quantitation limit.
CAS = Chemical Abstract Services.
GEA = Gamma energy analysis.
GPC = Gas proportional counter.
RAG = Risk Assessment Guideline

Table 2.3. Analytical Performance Requirements (Metals and Organics)

COCs	CAS #	Preliminary Action Level[a]	Name/Analytical Technology	Target Required Quantitation Limits			All Media	
		Method B[b] and Eco Screening Values (mg/kg)		Biota (mg/kg dry wt.)	Soil Low Conc. (mg/kg)	Water[c] Low Conc. (µg/L)	Precision (%)	Accuracy (%)
Antimony	7440-36-0	NA	EPA 1638	--	--	0.02	± 25[d]	75-125[d]
		5	EPA 200.8/200.7	0.01	0.03	--	± 25[d]	75-125[d]
Arsenic	7440-38-2		EPA 1638 – ICP-MS	--	--	0.05	± 25[d]	75-125[d]
		10	EPA 200.8/200.7	0.1	0.1	--	± 25[d]	75-125[d]
Barium	7440-39-3		EPA 1638	--	--	0.01	± 25[d]	75-125[d]
		102	EPA 200.8/200.7	0.1	0.2	--	± 25[d] ± 25[d]	75-125[d] 75-125[d]
Cadmium	7440-43-9	0.00059	Metals – 1638 – ICP-MS	--	--	0.05	± 25[d]	75-125[d]
		4	EPA 200.8/200.7	0.01	0.02	--	± 25[d]	75-125[d]
Chromium (total)	7440-47-3	0.096	Metals – 1638 – ICP-MS	--	--	0.02	± 25[d]	75-125[d]
		42	EPA 200.8/200.7	0.08	0.06	--	± 25[d]	75-125[d]
Chromium VI	18540-29-9	0.010	Chromium (hexavalent) – 7196 – colorimetric	--	--	0.3	± 25[d]	75-125[d]
Lead	7439-92-1	0.0011	Metals – 1638 – ICP-MS	--	--	0.005	± 25[d]	75-125[d]
		50	EPA 200.8/200.7	0.03	0.05	--	± 25[d]	75-125[d]

Table 2.3. (contd)

COCs	CAS #	Preliminary Action Level[a] Method B[b] and Eco Screening Values (mg/kg)	Name/Analytical Technology	Target Required Quantitation Limits Biota (mg/kg dry wt.)	Soil Low Conc. (mg/kg)	Water[c] Low Conc. (µg/L)	All Media Precision (%)	Accuracy (%)
Manganese	7439-96-5	512	Metals – 1638 – ICP-MS	--	--	0.01	± 25[d]	75-125[d]
		1,100	EPA 200.8/200.7	0.02	2.0	--	± 25[d]	75-125[d]
Mercury	7439-97-6	0.000012	– EPA 1631 – CVAF (Mod)	--	--	0.0002	± 25[d]	75-125[d]
			EPA 245.5 – CVAA (Mod)	--	0.005	N/A	± 25[d]	75-125[d]
		0.1	EPA 245.6 – CVAA (Mod)	0.005	--	--	± 25[d]	75-125[d]
Nickel	7440-02-0	0.083	Metals – 1638 – ICP-MS	--	--	0.05	± 25[d]	75-125[d]
		30	EPA 200.8/200.7	0.05	0.05	--	± 25[d]	75-125[d]
Selenium	7782-49-2	5.0	Metals – 1638 – ICP-MS	--	--	0.5	± 25[d]	75-125[d]
		0.3	EPA 200.8	0.2	0.4	--	± 25[d]	75-125[d]
			EPA 270.3 HGAA	0.02	0.02	--	± 25[d]	75-125[d]
Vanadium	7440-62-2	TBD	EPA 1638 – ICP			0.1	± 25[d]	75-125[d]
		2	EPA 200.8/200.7	1	0.5		± 25[d]	75-125[d]
Uranium	7440-61-1	5	EPA 200.8 – ICP	0.01	0.06	0.01	± 25[d]	75-125[d]
Aroclor-1254	11097-69-1	0.5[e]	PCBs-8082-GC	--	0.0165	--	± 25[d]	75-125[d]
		0.65	EPA – 645 – GC	0.001	--	--	± 25[d]	

Table 2.3. (contd)

COCs	CAS #	Preliminary Action Level[a]	Name/Analytical Technology	Target Required Quantitation Limits			All Media	
		Method B[b] and Eco Screening Values (mg/kg)		Biota (mg/kg dry wt.)	Soil Low Conc. (mg/kg)	Water[c] Low Conc. (µg/L)	Precision (%)	Accuracy (%)
Aroclor-1260	11096-82-5	0.5[e]	PCBs-8082-GC	--	0.0165	--	± 25[d]	75-125[d]
		0.65	EPA – 645 – GC	0.001	--	--		
Total Petroleum Hydrocarbon (diesel)	68476-34-6	200	Ecology 3510 -8000 – GC	NA	25	50	± 25[d]	75-125[d]

(a) The preliminary action level is the regulatory or risk-based value used to determine appropriate analytical requirements (e.g., detection limits).
(b) WAC 173-340 Method B soil values for direct exposure.
(c) The RAG is below the target required quantitation limit. The value presented is the target required quantitation limit.
(d) Accuracy criteria for associated batch matrix spike percent recoveries. Evaluation based on statistical control of laboratory control samples also performed. Precision criteria for batch laboratory replicate matrix spike analyses or replicate sample analysis.
(e) Compliance is based on the sum of all aroclors detected.

CAS = Chemical Abstract Services.
COC = Contaminant of concern.
CVAA = Cold vapor atomic absorption.
CVAF = Cold vapor atomic fluorescence
EPA = U.S. Environmental Protection Agency.
GC = Gas chromatograph.
ICP = Inductively coupled plasma.
ICP-MS = Inductively coupled plasma mass spectrometer.
NA = Not applicable.
PCB = Polychlorinated biphenyls.
RAG = Risk Assessment Guideline
WAC = Washington Administrative Code.

2.1.5 Documentation and Records

At the direction of the project lead, all data packages and/or validation reports shall be subject to technical review before submittal to regulatory agencies or inclusion in reports/technical memoranda. Data shared with regulatory agencies or stakeholder groups prior to technical review will be qualified as data under review and subject to revision. When appropriate, electronic access shall be through computerized databases (e.g., Hanford Environmental Information System [HEIS]). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989).

2.2 Measurement/Data Acquisition

The following subsections present the requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory quality control (QC). The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

2.2.1 Sampling Process Design

Sampling design, documentation, sample preservation, shipment, and chain-of-custody requirements comply with "Guidance for the Data Quality Objectives Process" ((EPA/600/R-96/055)(QA/G-4)200 as revised; "EPA Requirements for Quality Assurance Project Plans" (EPA/240/B-01/003)(EPA QA/R-5) March 2001, as revised, and "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods: (EPA/SW-846 as amended).

The FSP in Section 3.0 presents additional details, summary tables, and figures that address sampling procedures, sampling locations, sampling frequencies, and analytical methods.

2.2.2 Sampling Methods Requirements

Sampling methods, documentation, sample preservation, shipment, and chain-of-custody requirements comply with "Guidance for the Data Quality Objectives Process" ((EPA/600/R-96/055)(QA/G-4)200 as revised; "EPA Requirements for Quality Assurance Project Plans" (EPA/240/B-01/003)(EPA QA/R-5) March 2001, as revised, and "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods: (EPA/SW-846 as amended).

The sampling procedures that will be used during implementation of this SAP are outlined in the FSP in Section 3.0.

2.2.3 Sample Handling and Custody Requirements

The sample handling and custody requirements comply with "Guidance for the Data Quality Objectives Process" ((EPA/600/R-96/055)(QA/G-4)200 as revised; "EPA Requirements for Quality Assurance Project Plans" (EPA/240/B-01/003)(EPA QA/R-5) March 2001, as revised, and "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods: (EPA/SW-846 as amended).

2.2.4 Analytical Methods Requirements

Analytical parameters and methods are listed in Table 2.2 and 2.3. Laboratory-specific standard operating procedures (SOPs) for the analytical methods are in place or will be prepared as necessary.

2.2.4.1 Field Analysis

Field screening and radiological surveys used for site characterization or sample collection will be performed in accordance with applicable procedures in the subcontractors' or manufacturers' manuals.

2.2.4.2 Laboratory Analysis

The standard fixed laboratory analyses will be used for all verification samples and will be performed in accordance with the reference methods identified in Table 2.2 and 2.3 and the associated laboratory SOPs. The standard fixed laboratory statement of work (SOW) and SOPs will also be available prior to analysis.

2.3 Quality Control Requirements

QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. When performing this field sampling effort, care shall be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity.

The QC procedures must be followed in the field and laboratory to ensure that reliable data are obtained. The QC parameters are evaluated through laboratory checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks. Acceptance criteria have been established for each of these parameters based on guidance from EPA (SW-846; EPA 530/SW-86-055, OSWER-9950.1). When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and affected data are flagged in the database.

2.3.1 Field Quality Control

Field QC requirements are used to monitor and ensure the quality of the field results. Field QC samples will be collected during fieldwork to monitor the performance of sample collection and measure the effects of sampling bias or variability. Field sampling QC samples are amenable to abiotic media, including water, sediment, and soil.

Field QC requirements will consist of the following:

- ***Equipment blanks.*** Equipment blanks will be collected for soil and water samples. One equipment blank consisting of clean silica sand will be collected and submitted for offsite analysis. The equipment blank for soil and water will be collected by pouring silica sand and deionized water, respectively, over the surfaces of a set of soil sampling equipment prior to use and collecting the blank media in clean sample jars for analyses. The sample results will be used to evaluate the cleanliness of the sampling equipment and the decontamination procedure.

- ***Field duplicate samples.*** One field duplicate sample will be collected from the same media as the primary sample and will be uniquely numbered. The field duplicate provides information concern-

ing the homogeneity of the media and may also provide an evaluation of the precision of the analysis process. Field duplicates can be collected for abiotic media, provided sufficient mass is available.

2.3.2 Fixed Laboratory Quality Control

Laboratory QC requirements will be performed as specified in the analytical services SOW for the selected laboratory and will consist of a laboratory method blank, laboratory control sample, matrix spike, and laboratory duplicate or matrix spike duplicate. Table 2.2 and 2.3 summarize laboratory QC requirements.

2.3.3 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

All onsite environmental instruments shall be tested, inspected, and maintained in accordance with PNNL or subcontractor procedures and documented.

2.3.4 Instrument Calibration and Frequency

All onsite environmental instruments shall be calibrated in accordance with PNNL or subcontractor procedures. Tags will be attached to all field screening and onsite analytical instruments, noting the date when the instrument was last calibrated and the calibration expiration date.

2.3.5 Data Management

Data resulting from the implementation of this SAP will be managed and stored by PNNL or subcontractors in accordance with applicable procedures. The contract laboratories report analytical results electronically. The results are loaded into the HEIS database. Field-measured parameters are entered manually or through electronic transfer. All validated reports and supporting analytical data packages shall be subject to final technical review by qualified reviewers (before their submittal to regulatory agencies or inclusion in reports or technical memoranda) at the direction of the project task lead. Electronic data access, when appropriate, shall be through environmental information systems computerized databases (i.e., HEIS). Where electronic data are not available, hard copies will be provided in accordance Section 9.6 of the Tri-Party Agreement (Ecology et al. 1989). Preliminary data and report briefings/distributions (subject to technical review) to EPA and the Washington State Department of Ecology will be provided as requested.

2.3.6 Field Documentation

The field documentation requirements and procedures are presented in the FSP (Section 3.0).

2.4 Assessment/Oversight

2.4.1 Assessments and Response Actions

The surveillance and assessments to verify compliance with the requirements outlined in this SAP can be requested as needed, project work packages, the project quality management plan, and procedures and regulatory requirements. Deficiencies shall be reported to project management. When appropriate, corrective actions will be taken by the task lead in accordance with DOE-RL-96-68.

2.4.2 Reports to Management

Management shall be made aware of all deficiencies identified by self-assessments. Identified deficiencies shall be reported to the Fluor Hanford Project Manager.

2.5 Data Validation and Usability

2.5.1 Data Review, Validation, and Verification Requirements

Data verification and validation are performed on analytical data sets, primarily to confirm that sampling and chain-of-custody documentation is complete, sample numbers can be tied to the specific sampling location, samples were analyzed within the required holding times, and analyses met the data quality requirements specified in the sampling and analysis instruction.

A minimum of 5% of all data will be validated. Onsite measurements and quick-turnaround analysis data will not undergo a formal validation. The QA/QC processes used in SOPs will be followed to ensure usable data. These include the use of blanks, duplicates, splits, and measurement of known standards. The data will be reviewed by analytical personnel and the project team. QC data are evaluated against the criteria listed in the project QA plan, and data flags are assigned when appropriate. If necessary, the laboratory may be asked to check calculations or reanalyze a sample, or the media may be resampled. The validated data results, including applicable qualifiers, shall be entered into the HEIS database.

2.5.2 Reconciling Results with Data Quality Objectives

A data quality assessment shall be performed on the resulting analytical data in accordance with EPA's *Guidance for Data Quality Assessment* (EPA QA/G-9). The data quality assessment is a scientific and statistical evaluation of the data set to determine if the data are the right type, quality, and quantity to support the intended use. This evaluation includes the following:

- Reviewing the DQOs, including study objectives, statistical hypotheses, decision error, and sample design
- Reviewing analytical data, including data packages, QA reports, calculating statistical-based quantities, and graphical representation
- Selecting and performing statistical hypothesis tests
- Verifying the assumptions of the statistical hypothesis tests
- Determining corrective actions
- Drawing conclusions from the data
- Interpreting and communicating the test results.

3.0 Field Sampling Plan

This field sampling plan (FSP) identifies and describes sampling and analysis activities that will be conducted to resolve decision rules identified in the DQO process (Table 1.5). In some sampling zones, the occurrence of a COPEC in an abiotic exposure media may trigger future sampling in biota. Tables presented in the FSP describe the suite of analyses and associated media across sampling zones.

The 100-NR-2 study area includes geographically distinct areas and sampling media—riparian and near-shore aquatic environments with associated biota. There also are geographically distinct areas of suspected and/or known contamination as indicted in Section 1.2.4 and Figure 1.2. In addition, ecological sampling activities may be limited by the abundance and availability of biota related to available habitat and seasonality of the organisms. To address these issues and provide data representing ecological exposure, the sampling strategy outlined for this FSP involves a tiered approach (Table 3.1). The first tier of sampling includes the acquisition of reconnaissance survey data and information to target suspected hot spots for contaminants and evaluate the presence and abundance of ecological receptors. The second tier involves targeted contaminant sampling of the ecological receptors and associated environment (soil, sediment, and water) at the 100-NR-2 study area and at similar habitats at a selected reference area upstream from Hanford operations.

Table 3.1. Features of Tiered Approach to Characterization and Sampling at the 100-NR-2 Study Area

Tiers of Sampling	Objectives	Measurement Attributes	Assessment Endpoints
I Reconnaissance Activities	Identify Key Receptors and Special Status Species	• existing data • new site surveys	• presence/absence • habitat assessment
	Identify Spatial Extent and Levels of COPECs in Study Region Environment	• existing data and reconnaissance surveys of COPECs in ambient soil and water • existing data for COPECs in selected media and sentinel species	• use spatial extent and distribution of reconnaissance data to focus sampling
II Field Sampling Activities	Conduct Ecological Exposure Screening (Phases I, II, III)	• COPECs in tissues of key receptors in key guilds • COPECs in ambient soil and water	• comparison to reference samples • comparison to potential ARARs/benchmarks
	Conduct Biological Condition Screening	• selected attributes of condition in key receptors in selected guilds	• comparison to reference samples

Potential ARAR = Applicable or relevant and appropriate requirement.
COPEC = Contaminant of potential ecological concern.

The FSP defines sampling objectives (Section 3.1), sampling design (Section 3.2), and describes the planned sampling for two ecological zones: riparian (Section 3.3), and near-shore river (Section 3.4). Administrative matters include sample handling (Section 3.5), environmental measurements (Section 3.6), sample management (Section 3.7), and waste management (Section 3.8). Figure 3.1 depicts the riparian and aquatic sampling zones and the extent of the study area.

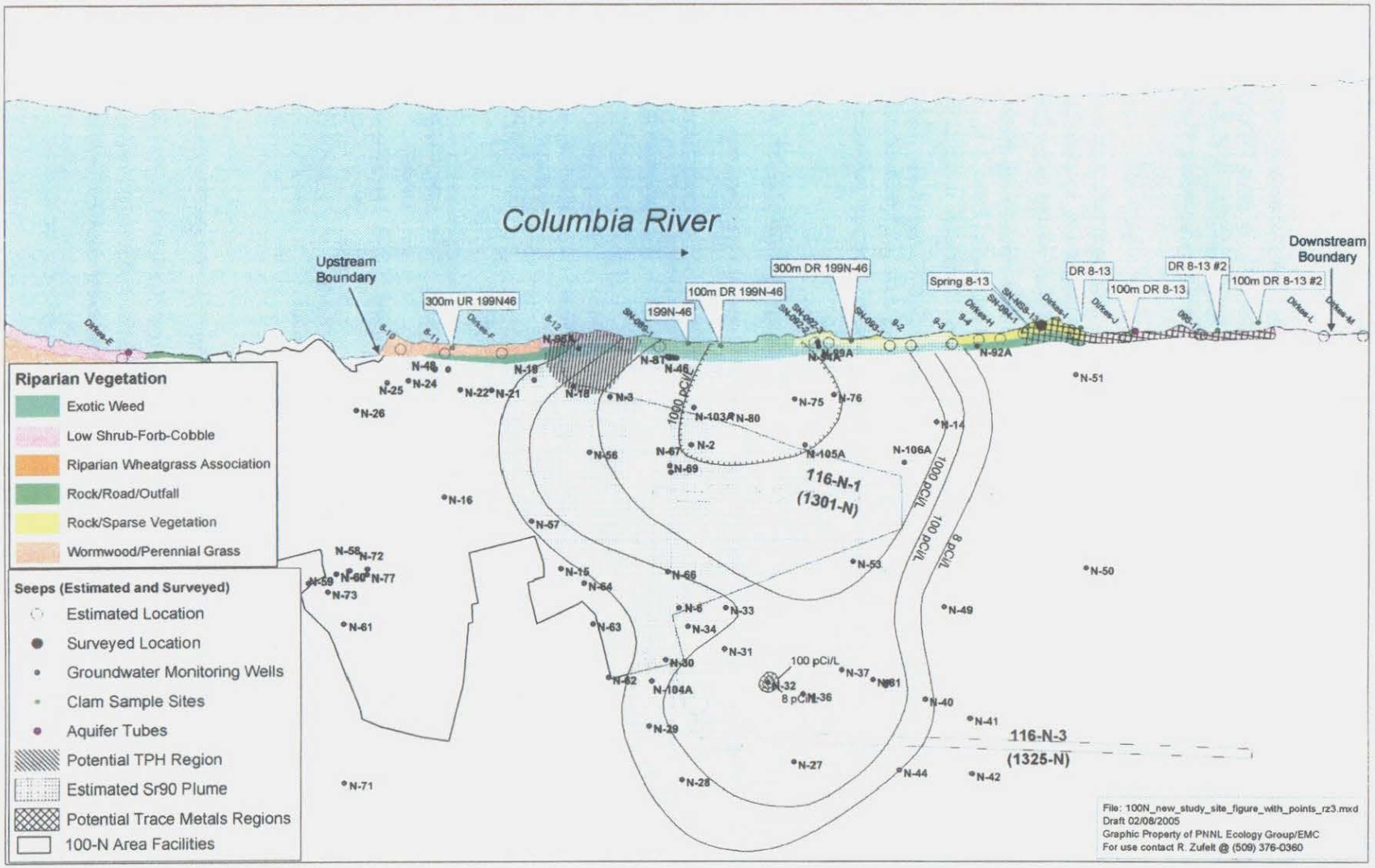

Figure 3.1. Main Ecological Sampling Zones and Upstream and Downstream Extents of 100-NR-2 Ecological Assessment Study Area

3.1 Sampling Objectives

The objective of the FSP is to clearly identify the sampling and analysis activities needed to resolve the DRs identified in Step 5 of the DQO process (Table 1.5). The intent of sampling is to provide information needed to evaluate impacts of contaminant discharges at the groundwater/river interface at 100-N on aquatic and riparian receptors. The specific objectives include sampling riparian soil, shallow groundwater (seep water), near-shore river water, sediment, key receptor species in riparian and near-shore aquatic habitats found adjacent to the 100-N Area, and documenting the presence or absence of special status species in these areas. These objectives and bases for sampling are described in the Table 1.7 of this SAP. The FSP is based on the sampling design proposed in Step 7 of the DQO summary report and presents this design using figures and tables to identify sampling locations, total number of samples to be collected, sampling procedures to be implemented, analyses to be performed, and sample container requirements.

3.2 Sampling Design

The approach for this study is to 1) collect survey data (Tier I) and samples (Tier II) in the two main ecological zones (riparian and near-shore aquatic zones) that are affected by the 100-NR-2 Groundwater OU, and 2) collect comparable data and samples at a suitable reference site. Samples will be collected in areas of known or suspected contamination and under conditions where potential uptake by biota is expected to be maximized (e.g., during the growing season for riparian plants, during low river stage for riparian and near-shore river zone sampling).

Three sampling regions with specific contaminant interest are identified in the 100-NR-2 study area: the strontium-90 plume, the suspected diesel contaminant regions, and a region where trace metals may be elevated. The documented strontium-90 plume lies in the center of the study area. It is a critical area with respect to characterizing baseline ecological conditions for follow-on assessments of alternative treatment technologies that address strontium discharge to the river. In addition to the strontium plume, a suspected diesel contaminant region lies at the upstream end of the estimated strontium plume, and a downstream region exists where reconnaissance sampling indicated elevated levels of metals including chromium (Figure 3.1). Sampling of abiotic media and key ecological receptors will be conducted in the riparian and aquatic habitats present in these three regions. Similar habitats will be identified and sampled at the selected reference sites.

3.2.1 Ecological Screening Approach Using Guilds and Trophic Levels

Key receptor species within the riparian and near-shore aquatic ecosystem are selected for the distinct groupings (guilds), as described in the DQO. Using this conceptual model of ecological exposure and transport, a phased screening approach then is prescribed based on trophic level and for animals on their primary dietary patterns relative to the sources of contamination suspected in the riparian and near-shore aquatic environments within the 100-NR-2 study area (Figure 3.2). If concentrations of COPECs are not detected in the lower-order trophic levels and food-chain pathways identified in an initial screening (Phase I shown in Figure 3.2), then exposure in higher order trophic levels is not expected, with the exception of contaminants known to biomagnify.

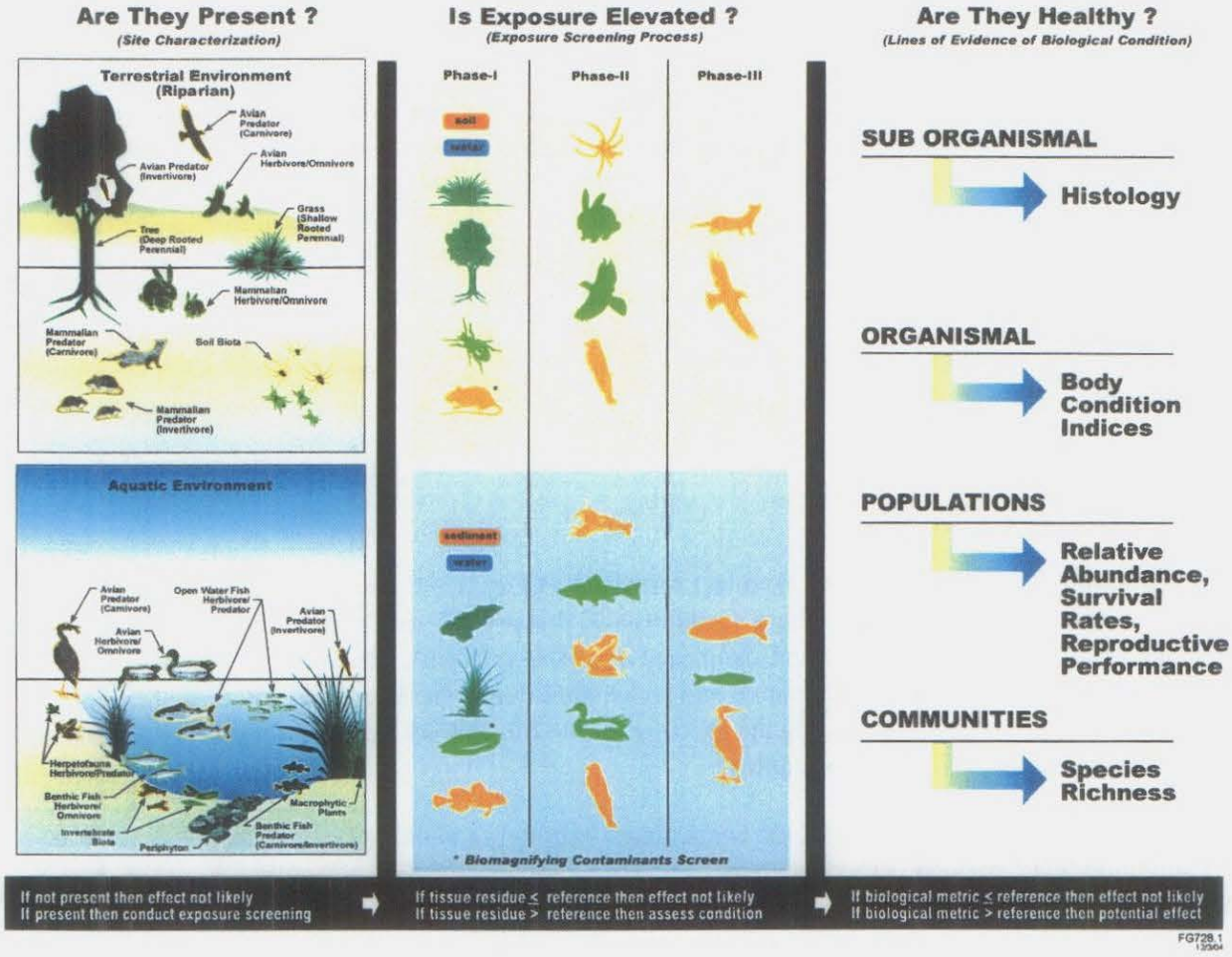

Figure 3.2. Ecological Guilds Identified for Terrestrial and Near-Shore Aquatic Environments on the Hanford Site and Phased Sampling for Guild Exposure Screening

3.2.2 Sampling Design Elements

A variety of sampling design alternatives may be required to assure that representative characterization data are collected from the regions, media and receptors identified. A critical aspect of sampling is to identify and separate spatial and temporal components. That is, if biological receptors or abiotic media are known to exhibit temporal and spatial patterns, then sampling locations and times must be adjusted to account for that variability. Therefore, judgmental and opportunistic data collection designs are appropriate. The 100-NR-2 study area will be stratified by known environmental patterns (e.g., vegetation cover types or river bottom substrate types) and known contaminant patterns. The sampling elements that will be applied for the 100-NR-2 Ecological Risk Assessment include the following:

- **Reference Site Selection** – A reference site is a location that closely resembles the study site with respect to terrain, hydrologic regime, soil types, vegetation, and wildlife. The reference site should be geographically separate from the influence of COPECs associated with the 100-NR-2 study (Table 1.2). For this study, an upstream reference site will be identified for each sampling zone. Sampling at the reference sites will be comparable to that conducted within the 100-NR-2 zones.

Information from reconnaissance surveys and existing data will be used to help select reference areas. Because the 100-NR-2 study area lies within the Hanford Reach of the Columbia River (a free-flowing stretch of this river system), shoreline areas along reservoirs behind dams are not considered to be acceptable reference sites. The primary area upstream of Hanford operations that may be sampled as a reference includes the stretch of the Hanford Reach from just below Priest Rapids Dam to just above the 100-B/C Area.

- **Reconnaissance Surveys** – Reconnaissance surveys including visual observations, conductivity measurements, radiological survey, mapping, and review of existing data and literature will be conducted for each primary study zone as indicated in Table 1.7. These surveys will provide information to determine appropriate sampling locations, abundance, availability of sampling populations, and the presence/absence of special status species. This initial field activity for each zone is needed to refine the sampling design. Conductivity measurements will be used to locate persistent and intermittent seeps within the near-shore river zone and areas where upwelling of groundwater occurs within the Columbia River bottom. Land-based radiological surveys will identify areas that have elevated levels of gamma emitters and beta emitters (e.g., strontium-90).

- **Systematic Sampling and Surveys** – Systematic sampling (and survey) is based on a specified pattern with samples taken at regular intervals along that defined pattern. This method is used to assure that the target population is fully and uniformly represented in the sample. The regular assignment of locations to the sample provides assurance that the sample truly represents the overall characteristics of the target population. To make systematic sampling a probability-based design, the initial unit for the first sample of a sample of size n is chosen at random, then the remaining (n-1) units are chosen so all n are located according to the pattern.

  Samples may be selected in one, two, or three dimensions if the population characteristic of interest has a spatial component. Sampling along a line or transect represents sampling in one dimension. Sampling every node on a grid laid over an area of interest is sampling two dimensions. Sampling representative of a depth profile at a sampling node would represent three-dimensional sampling.

- **Stratified Sampling** – Stratified sampling is a sampling design in which prior information about the population is used to determine groups (called strata) that are sampled independently. Each possible sampling population member must belong to exactly one stratum. A stratified sampling design can also be used to obtain estimates for desired subpopulations or to ensure that important subpopulations have a sufficient number of sampling units in the samples. One of the most common uses of stratification is to account for spatial variability by defining geographic strata. Sampling by spatial strata may also be useful when study results need to be reported separately for particular geographic areas or regions. Spatial strata identified to be used in this study include vegetation cover types, substrate type of the near-shore river bottom, river depth, and topography. An additional level of stratification included for this field sampling plan is the geographic distribution of known and suspected contamination along the shoreline and near-shore river environment.

A combination of stratified and systematic sampling designs is applied in this field sampling plan to minimize variability and provide representative samples for the populations of interest at the 100-NR-2 study area. The systematic sampling design is well suited for combination with the stratified sampling method to provide uniform sampling (grids or transects).

The sample design objectives, methods, features, and bases presented in Table 1.7 are discussed in the following subsections.

3.2.3 Sampling Procedures and Sampling Locations

In general, the sampling locations will be distributed along transects selected across the study area and in the reference site in an effort to characterize residual chemical and radionuclide concentrations. All sample collection locations will be surveyed using a global positioning system (GPS) and sample-specific coordinates will be recorded.

Table 3.2. Methods for Survey/Sample Collection

Survey/Sampling Media	Description
Soil	Direct reading radiological survey detectors for beta and gamma detection
	Characterization soil, stainless steel trowel, and samples from 0 to 30 cm[a]
	Rooting zone soil, stainless steel trowel, samples from 0 to 10 cm and from 11 to 30 cm[a]
Sediment	Grab samples
Periphyton	Teflon scraper, filter paper[a]
Surface water	Six centimeters above river bed, polyethelene tubing, peristaltic pump
Groundwater/river water mixture	Aquifer tubes/stainless steel drive points at 10-cm depth in matrix substrate, polyethelene tubing, peristaltic pump[a]
Plants	Stainless steel snipping shears or stainless steel scissors[a]
Invertebrates	Pitfall traps along transect within each sample site, hand-pick aquatic macroinvertebrates[a]
Small mammals	Live traps systematically placed along transects within each sample site[a]
Fish	Boat-based electrofisher[a]

(a) *Procedures and Guidance for Sampling to Support Assessment of Onsite Ecological Impacts* (Public Safety and Resource Protection Project).

3.3 Riparian

Sampling and survey in the riparian zone includes the Tier 1 reconnaissance surveys and Tier 2 sampling of abiotic media and biotic receptors in the riparian habitat. Sampling will be targeted to provide information in the three regions of known and suspected contamination.

3.3.1 Tier I – Riparian Reconnaissance Surveys

In addition to the background literature review four types of reconnaissance surveys are planned for the 100-NR-2 study area.

1. **Receptor/Scoping Survey.** These surveys will involve visual review of the site to assess the physical conditions at potential sampling locations and verify the presence and relative abundance of key receptor species.

2. **Land-Based Radiological Exposure.** These surveys will be used to characterize levels of beta and gamma-emitting radionuclides across the study region. This survey will provide information similar to data planned for collection in the 100/300 Area Component RCBRA surveys at other OUs along the river corridor. Reconnaissance of existing radiological surveys and thermoluminescent dosimeter measurements will be performed to assist in the final study design. Radiological surveys of the riparian zone will be conducted along transect lines parallel to the shoreline forming a grid the entire length of the study area using GPS-linked detectors.

3. **Suspected Diesel/TPH Survey.** Perform ground-based visual inspection of the soil and water surfaces found in the riparian zone will be performed to look for evidence of potential diesel (TPH) contamination in shoreline areas adjacent to groundwater monitoring well N-18 (diesel has been detected in groundwater sampling of this well). Several small soil samples will be collected at the high water mark based on observations at the site (e.g., presence of oil sheen on water, iron oxide accumulation), and screened by placing a sub-sample into a bottle of water and looking for the development of an oil sheen. Soil samples will be returned to the laboratory to be further screened for hydrocarbons if the field screening tests indicate the presence of hydrocarbons.

4. **Special Status Species.** Special status species (federal or state threatened or endangered, and species of concern or candidate species) that may be found in the riparian zone within the 100-NR-2 Area shoreline are shown in Table 3.3.

   Existing information will be reviewed to determine if any of these special status species have been previously documented to occur within the 100-NR-2 riparian study zone. Field-based surveys will be conducted to identify the presence of federal or State threatened or endangered species within the 100-NR-2 study area. In addition, habitat conditions that appear suitable for the threatened or endangered species will also be recorded in the appropriate field record survey forms or laboratory record books.

   In particular, field surveys will be performed for awned halfchaff sedge (*Lipocarpha [= Hemicarpha] aristulata*), grand redstem (*Ammannia robusta*), lowland toothcup (*Rotala ramosior*), and persistent sepal yellowcress (*Rorippa columbiae*) during the summer and early fall. Surveys for the bald eagle (*Haliaeetus leucocephalus*) will be conducted during the Phase I sampling efforts (between February and February 2005). Surveys for the sandhill crane (*Grus canadensis*) will be conducted during the March 2005. Field collection staff will be trained to identify special status species that may occur in the river and habitat conditions that are suitable for them. Any special status species that are observed during reconnaissance surveys will be noted and coordinate locations will be recorded as feasible.

Table 3.3. Special Status Species (Federal or Washington State) That May be Found Near 100-NR-2 Riparian Study Zone

Common Name	Scientific Name	Federal	State
Plants			
awned halfchaff sedge	*Lipocarpha (= Hemicarpha) aristulata*		Threatened[a]
grand redstem	*Ammannia robusta*		Threatened[a]
lowland toothcup	*Rotala ramosior*		Threatened[a]
persistent sepal yellowcress	*Rorippa columbiae*	SOC[b]	Threatened[a]
Canadian St. John's wort	*Hypericum majus*		Sensitive
shining flatsedge	*Cyperus bipartitus (rivularis)*		Sensitive
Birds			
bald eagle[c]	*Haliaeetus leucocephalus*	Threatened[a]	Threatened[a]
sandhill crane	*Grus canadensis*		Endangered[d]
golden eagle	*Aquila chrysaetos*		Candidate
Lewis woodpecker[b]	*Melanerpes lewisii*		Candidate
peregrine falcon[a,d]	*Falco peregrinus*	SOC	Sensitive
merlin	*Falco columbarius*		Candidate
northern goshawk[a,b]	*Accipter gentiles*	SOC	Candidate
Invertebrates			
Columbia River tiger beetle[c]	*Cicindela columbica*		Candidate

(a) Species likely to become endangered in the foreseeable future.
(b) Species of concern (SOC) that are not currently listed or candidates under the *Endangered Species Act of 1973*, but are of conservation concern within specific U.S. Fish and Wildlife Service regions.
(c) Currently under review for change in status (delisting).
(d) Species in danger of extinction within all or a significant portion or its range.

3.3.2 Tier II – Riparian Abiotic Sampling

Soil and shallow groundwater in the riparian zone will be sampled in each of the three contaminant regions identified in this FSP (Figure 3.2). Soils will be sampled both systematically to characterize the contaminant zones and in the rooting zone of receptor plant species. Aquifer tubes will be installed to collect shallow groundwater samples in selected locations within the riparian environment.

3.3.2.1 Riparian Soil Sampling

Soil sampling in the riparian zone is intended to characterize contaminant levels and distribution within the riparian environment (Table 3.4). Soil sampling locations may be added or modified if indications of contaminant hot spots are found during the radiological surveys. The stratified design based on hot spot identification will be complemented by a systematic sampling design. Sampling of soil adjacent to plant receptor species will default to opportunistic sampling as necessary, according to the abundance and availability of plant populations.

Table 3.4. Riparian Soil Sampling Locations and Analytes in Phase I

Sample Type and Sample Region	Radionuclides[a]		Metals		Organic Compounds	
	Strontium-90	Technetium-99	Metals ICP	Mercury CVAA	Polychlorinated Biphenyls	TPH (Diesel)
Soil Characterization Samples						
Suspected Diesel Contamination	4	4	4	4	4	8[b]
Strontium Plume	4	4	4	4	4	1
Elevated Metals Area	4	4	4	4	4	1
Reference Site[c]	2	2	2	2	2	
Soil Samples Associated with Plant Receptors (Root Zone)[d]						
Suspected Diesel Contamination						[e]
Strontium Plume	6	6	6	6		
Elevated Metals Area	6	6	6	6		
Reference Site[c]	4	4	4	4		

(a) Gamma scans if survey indicates elevated gamma emitters; 6 to 10 sample sites.
(b) Samples to be collected systematically within suspected areas and upstream and downstream for comparison based on reconnaissance data.
(c) Data will be supplemented with other COPEC characterization data for reference sites.
(d) These samples will be collected in association with plant samples collected in the riparian zone (see Table 3.8).
(e) No plant samples will be collected for TPH analysis and as a result no rooting zone soils will be collected in the suspected diesel contaminant region

COPEC = Contaminant of potential ecological concern.
CVAA = Cold vapor atomic absorption.
ICP = Inductively coupled plasma.
TPH = Total petroleum hyrdrocarbon.

Sample media may be difficult to locate in these areas because of the presence of interfering materials such as large rip rap boulders or road construction. If sampling conditions are poor, the best available samples will be collected. Four samples of soil (where available) will be collected along transects in each of the three contaminant areas. Soil samples may be collected between rocks in rip rap zones, if necessary.

3.3.2.2 Riparian Shallow Groundwater Sampling

Aquifer tubes will be installed in selected regions of the three contaminant regions to sample the mixture of river and shallow groundwater at a depth representative of the plant root zone. These will allow characterization of 100-NR-2 COPECs that may contribute to exposure of ecological receptors in the riparian zone (Table 3.5).

Table 3.5. Shallow Groundwater Sampling (Aquifer Tubes) for Locations and Analytes in the Riparian Zone

Sample Type and Sample Zone	Radionuclides		Metals		Organic Compounds	
	Strontium-90	Technetium-99	Metals ICP	Mercury CVAA	Polychlorinated Biphenyls[a]	TPH (Diesel)
Suspected Diesel Contamination	1	1	1	1		1
Strontium Plume	1	1	1	1		
Elevated Metals Area	1	1	1	1		
Reference Site[a]	1	1	3	1		

(a) Data will be supplemented with other COPEC characterization data for reference sites.
COPEC = Contaminant of potential ecological concern.
CVAA = Cold vapor atomic absorption.
ICP = Inductively coupled plasma.
TPH = Total petroleum hydrocarbon.

3.3.3 Riparian Biota Sampling

The sampling design for the riparian biota will be stratified based on data gathered through reconnaissance surveys within the river shoreline and the riparian zone. Because linear hydrocarbons do not accumulate in biota, no efforts are planned to investigate TPH concentrations in biota. Key receptor sampling will be focused along transects established in the strontium-90 plume and in the areas where elevated metal concentrations have been detected (Table 3.6) and at the selected reference sites. However, the design will default to opportunistic sampling if biota are not available along or within the vicinity of these transects. Phase I sampling of key receptors will include deer mice (*Peromyscus maniculatus*), soil invertebrates (beetles), reed canary grass (*Phalaris arundinaceae*), and mulberry (*Morus alba*). All sampling locations will be identified and mapped using a GPS unit. The number of samples will be set to meet analytical mass requirements and statistical data needs. Media-appropriate biological health metrics will be measured as a screening-level assessment during the first year of sample collection.

3.3.3.1 Plants

The potential plant species selected for sampling in the riparian zone are representative of several plant functional types including shallow- and deep-rooted perennial vegetation. Potential species that may be sampled include mulberry, coyote willow (*Salix exigua*), northern wormwood (*Artemisia campestris*), sweet clover (*Melilotus alba* or *M. officinalis*), and reed canary grass. Because contaminant concentration data have been collected previously for mulberry and reed canary grass, these two species are preferred "target species" for sampling and analysis, if available. Plant sampling for COPECs in the riparian zone will be based on abundance and availability of target plant populations (Table 3.6). Tissue of the key plant species identified for each of the sampling areas will be collected at or in the vicinity of

the sampling transects. At each of the riparian transect sampling locations, vegetation samples will be collected and composited by species for that location. Three replicate samples of each species will be collected along each transect in areas where elevated levels of strontium-90 and metals are suspected. Identical sampling methods will be employed in similar habitat at the reference locations.

Table 3.6. Riparian Biota Sampling Locations and Analytes, Phase I

Sample Type and Sampling Zone	Radionuclides		Metals		Organic Compounds	
	Strontium-90	Technetium-99	Metals ICP	Mercury CVAA	Polychlorinated biphenyls	TPH (Diesel)
Soil Invertebrates						
Suspected Diesel Contamination	3	3	3	3		
Strontium Plume	3	3	3	3		
Elevated Metals Area	3	3	3	3		
Reference Site[a]	2	2	2	2		
Mice						
Suspected Diesel Contamination					3	
Strontium Plume	3	3	3	3	3	
Elevated Metals Area	3	3	3	3	3	
Reference Site[a]	2	2	2	2	2	
Reed Canary Grass (shoots)						
Suspected Diesel Contamination						
Strontium Plume	3	3	3	3		
Elevated Metals Area	3	3	3	3		
Reference Site[a]	2	2	2	2		
Mulberry Tree (shoots)						
Suspected Diesel Contamination						
Strontium Plume	3	3	3	3		
Elevated Metals Area	3	3	3	3		
Reference Site[a]	2	2	2	2		

(a) Data will be supplemented with other COPEC characterization data for reference sites.
COPEC = Contaminant of potential ecological concern.
CVAA = Cold vapor atomic absorption.
ICP = Inductively coupled plasma.
TPH = Total petroleum hydrocarbon.

Sampling methods will be appropriate for each species. For the woody perennial species, only shoot material will be collected (includes both woody stems and leaves). For specified herbaceous or semi-woody target species, vegetative tissue (shoots and leaves) samples will be collected. Vegetative material

will be clipped using stainless steel shears. Plant material will be bagged for transport and analysis. Sampling constraints or protocols will be species and contaminant specific.

General conditions of plants will be observed in the field at each sampling location. Plants will be inspected for overall vigor and, where appropriate, screening-level health measures may be collected and entered into field logbooks. If elevated levels of COPECs are indicated, subsequent sampling may include the collection of health metrics for plants.

3.3.3.2 Riparian Invertebrates

Pitfall traps will be used to capture invertebrates in riparian areas for COPEC analysis (Table 3.6). Pitfall traps will be used to capture ground-dwelling invertebrates such as darkling beetles to satisfy the soil biota guild specified in WAC 173-340-7493. Pitfall traps may also capture amphibians, small reptiles, or shrews. These samples may be retained for analysis if minimum sample size criteria are met. Pitfall traps will be operated for a minimum of five nights. One composite sample will be taken from each location, and aliquots of that sample may be taken to perform the analyses of the various COPECs. Each trap location will be recorded using a GPS unit. Sample weights required for laboratory analysis will be collected in accordance with the laboratory-specific SOWs. Collection of health metrics is not planned for invertebrates.

3.3.3.3 Small Mammal Sampling

Deer mice may be present in the riparian area where adequate vegetation exists. These mice are omnivores, but are considered representative of the mammalian predator guild (as recommended in WAC 173-340-7490 et seq.) because the riparian study area is too small to support upper trophic-level predators in numbers that could support sampling design requirements. Mice also satisfy the sentinel organism criteria as defined in the DQO process (WMP-23141).

Samples will be collected using live traps placed along a sampling transect (trap line) that lies parallel to the shoreline and within the riparian vegetation (Table 3.6). Typically, two trap lines, each usually consisting of seven Sherman live traps (3 inches wide by 3.5 inches high by 9 inches length) will be placed parallel with the edges of the buffer areas. If the extent of riparian habitat is insufficient, then the number or placement of traps may be modified to provide systematic sampling of the available habitat. Such adjustments will be made as a function of the size of the area and type of the plant community trapped. Exact locations for each trap will be recorded using a GPS unit.

Identical trapping methods will be employed in similar habitat at the reference locations. The line spacing, and trap spacing may be varied to maintain comparable trapping efforts between sites and ensure that results are comparable between the areas of concern and reference locations.

Because of the analytical mass requirements, whole-body tissues will be composited for the radionuclide analysis. However, samples from individual organisms will be analyzed for trace metals and organic COPECs. Organisms collected for COPEC analysis will be inspected for biological health metrics as shown in Figure 3.2.

3.4 Near-Shore Aquatic Zone

Sampling and surveys in the near-shore zone include Tier I reconnaissance surveys and Tier II sampling of abiotic media and biotic receptors in the aquatic habitats present in the study area. Sampling will be focused to provide information in the three regions of known or suspected contamination and at the selected reference site.

Abiotic and biotic sampling in the near-shore river zone of the 100-NR-2 study area study will be scheduled to coincide with the low flows of the river that occur in winter and late summer. Low river flow corresponds to maximum availability and minimal dilution of contaminated groundwater. Sampling locations in the near-shore river zone will be selected based on the identification of known or suspected contaminant zones as discussed previously, and reconnaissance surveys to identify the areas along the shore and in the riparian zone that are most likely to contain COPECs. In effect, the reconnaissance surveys provide information to stratify the sampling area according to detection of contamination. The rationale for the assignment of COPECs to specific media is described in Section 1.2 and reflected in the subsequent sampling tables. Figure 3.3 illustrates three potential sampling areas based on the current available information regarding riverbank seeps, wells, biota, and contaminant releases associated with historic operations at the 100-N Area. The specific sampling sites may be adjusted based on the 2005 reconnaissance surveys.

3.4.1 Near-Shore River Reconnaissance Surveys

In addition to the literature reviews, three types of reconnaissance surveys are planned for the near-shore river zone at 100-N:

1. **Receptor/Scoping Survey.** These surveys will involve visual review of both the 100-NR-2 study area and potential reference site areas to assess the physical conditions at potential sampling locations and verify the presence and relative abundance of key receptor species. Reference sites will be selected for each type of sampling based on the criteria listed in Section 3.3.2.

2. **Conductivity Surveys** – Conductivity surveys will be conducted in February during stable low flow river conditions (<75 CFS determined at Priest Rapids Dam) to map the spatial extent of groundwater upwelling in the near-shore zone. Conductivity (measurement of water samples for specific conductance) reconnaissance will be used to select the final locations for primary and secondary transect samples. Two methods are available for use. The primary method is to position a conductivity sensor on a staff and position the probe along the river bottom at defined intervals along the shoreline and into the river at a depth of no greater than 2 meters. In the event of equipment failure, water samples will be collected near the river bottom by using a peristaltic pump and Tygon® tubing with the sample inlet positioned <6 centimeters above the river bottom. The specific conductance of the river water will be measured using a hand-held meter (Myron L Ultrameter). All conductivity measures will be located with a GPS system and downloaded into a portable field data logger.

   Conductivity measurements will be taken at 10-meter increments along the shoreline along the study site. At known seepage sampling sites and sample sites that indicate elevated conductivity, additional conductivity measurements will be taken along a primary transect situated perpendicular to the shoreline and extending out into the river at water depths of 0.5, 1.0, and 2.0 meters. These primary transects will be bounded with additional secondary transects at 5 meters upstream and 5 meters

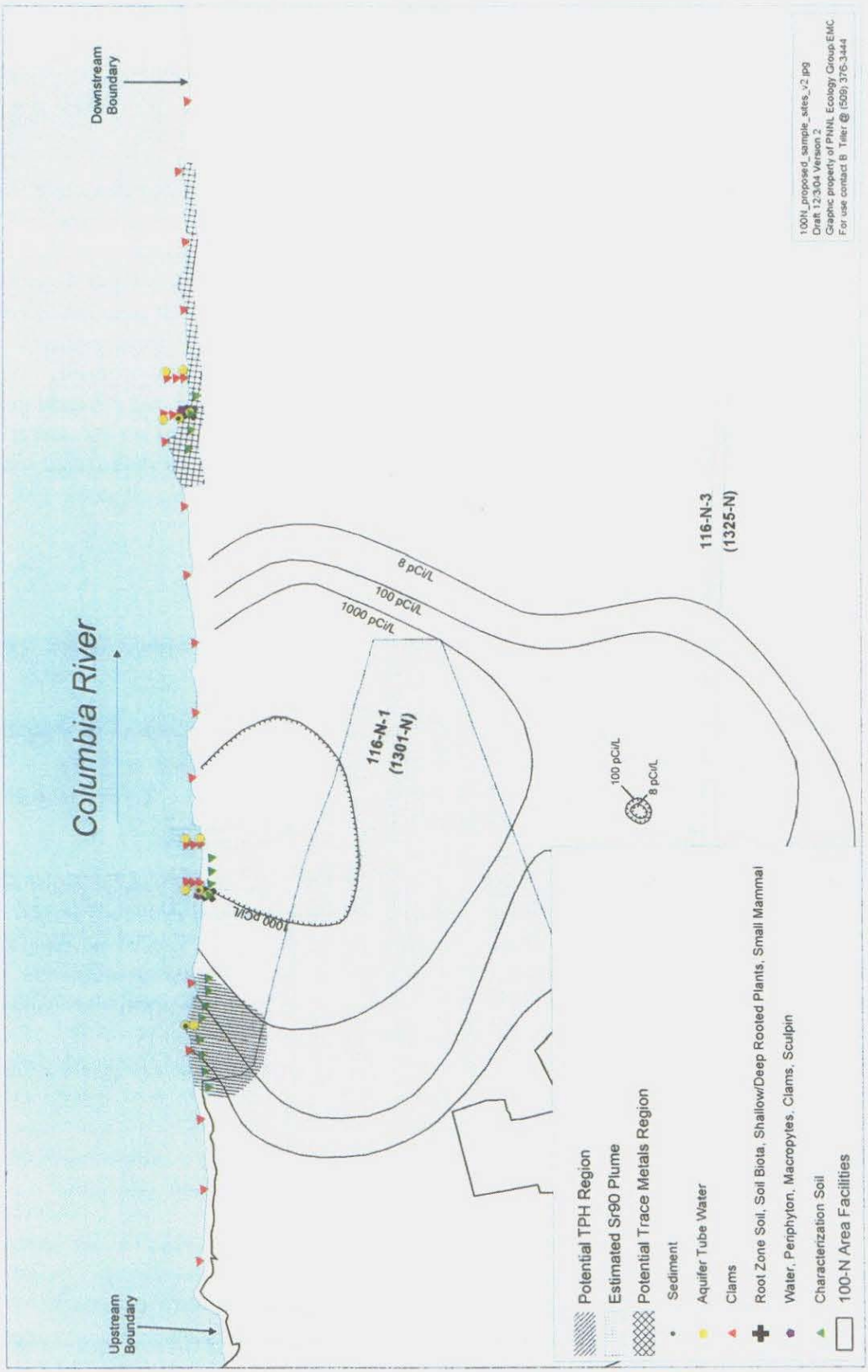

Figure 3.3. Proposed Sampling Regions and Sample Locations at 100-NR-2 Study Area

downstream of the primary transect to better define the spatial boundary of the groundwater discharge. Secondary transects will be established as long as conductivity readings exceed river background by 10 microseimens/cm.

3. **Special Status Species Reconnaissance** – Special status species (federal or state threatened or endangered, and species of concern or candidate species) that may be found in the near-shore aquatic zone within the 100-NR-2 Area shoreline are shown in Table 3.7.

   Existing information will be reviewed to determine if any of these special status species have been previously documented to occur within the 100-NR-2 near-shore aquatic study zone. Field-based surveys will be conducted to identify the presence of federal or state threatened or endangered species within the 100-NR-2 study area. In addition, habitat conditions that appear suitable for the threatened or endangered species will also be recorded in the appropriate field record survey forms or laboratory record books.

Table 3.7. Special Status Species (Federal or Washington State) That May be Found Near 100-NR-2 Near-Shore Aquatic Study Zone

Common Name	Scientific Name	Federal	State
Birds			
American white pelican	*Pelecanus erythrorhychos*		Endangered[a]
common loon[a]	*Gavia immer*		Sensitive
western grebe	*Aechmorus occidentalis*		Candidate
Fish and Other Aquatic Vertebrates			
bull trout[b]	*Salvelinus confluentus*	Threatened[c]	Candidate[d]
spring-run Chinook salmon	*Oncorhynchus tshawytscha*	Endangered[a]	Candidate[d]
steelhead	*Oncorhynchus mykiss*	Endangered[a]	Candidate[d]
mountain sucker[e]	*Catastomus platyrhynchus*		Candidate
leopard dace[e]	*Rhinichthys flacatus*		Candidate
river lamprey[e]	*Lampetra ayresi*	SOC[e]	Candidate
Invertebrates			
Idaho spring snail	*Pyrgulopsis idahoensis*	Endangered	New Species[d]
giant Columbia River limpet (Shortfaced lanx)	*Fisherola* (= *Lanx*) *nuttalli*		Candidate
Columbia River pebble snail[e]	*Fluminicola* (= *Lithoglyphus*) *columbiana*	SOC[e]	Candidate
California floater[e]	*Anadonta californeinsis*	SOC[e]	Candidate

(a) Species in danger of extinction within all or a significant portion or its range.
(b) Reported, but seldom observed on the Hanford Site.
(c) Species likely to become endangered in the foreseeable future.
(d) Species that are believed to qualify for threatened or endangered species status, but for which listing proposals have not been prepared.
(e) Species of concern (SOC) that are not currently listed or candidates under the *Endangered Species Act of 1973*, but are of conservation concern within specific U.S. Fish and Wildlife Service regions.

In particular, field surveys will be performed for spawning steelhead trout (*Onchorhyncus omykiss*) in the study region (four surveys conducted 1 month apart from March through May 2005). Surveys for other special status fish and lamprey will be conducted during the Phase I sampling efforts (between February and February 2005), as well as the benthic community surveys for the Idaho Springsnail (*Pyrgulopsis idahoensis*) and other special status mussels and snails (see Table 3.7). Field collection staff will be trained to identify special status species that may occur in the river and habitat conditions that are suitable for them.

3.4.2 Abiotic Sampling

Abiotic sampling in the near-shore river zone includes sediment, surface water, and shallow groundwater (interstitial pore water sampled using aquifer tubes) collected from, at, or in the river substrate. The selection of sampling locations will be determined by review of information from reconnaissance investigations and will include process knowledge, estimated groundwater plumes, riverbank spring surveillance data, and water conductivity measurements along the shoreline.

3.4.2.1 Sediment Sampling

Sediment samples will be collected in association with in-river sampling of ecological receptors (see Section 3.4.2.4) in areas identified by conductivity surveys as having relatively higher conductivity and within the known strontium-90 plume. Sampling will also be conducted in the area where elevated metals have been detected (i.e., chromium concentrations in water, sediment, and clams) (PNNL-SA-39495; PNNL-14687; spring 2004 reconnaissance sampling; Appendix A). Opportunistic sampling will be conducted because in some cases, parts of the river bottom within the study area are dominated by cobble and rocks and do not contain enough fine-grained material or sediment to provide a sample. Analyses will be performed for radionuclides, metals, and polychlorinated biphenyls (PCBs) (Table 3.8). Sediment collected within the vicinity of the suspected diesel contamination area will be analyzed for TPH. Sampling at the reference site will follow the same protocols.

3.4.2.2 Shallow Groundwater Sampling in Near-Shore Aquatic Zone

Aquifer tubes will be installed to evaluate the strontium-90 plume and the area where elevated metals have been detected (Table 3.9). Samples are collected using a peristaltic pump to pull water from polyethylene tubing installed into the shallow aquifer and into appropriate sampling containers. Existing aquifer tube arrays in the study location may be sampled. However, plans are to install four aquifer tube pairs at selected locations. Based on results of the reconnaissance survey for diesel oil in the riparian zone, additional shallow water aquifer tubes may be installed during a second stage of sampling in FY 2006 to determine the fate of TPH that may enter the river via groundwater.

Primary emphasis will be placed on gathering data to evaluate shallow groundwater within the strontium-90 plume area. Aquifer tubes will be installed at four locations as determined by the conductivity surveys and the review of historic data to determine the best locations to characterize areas of highest exposure. Sample points will be located at 10-centimeter depth (biotic zone) into the matrix substrate.

Table 3.8. Locations and Analysis of Sediment Samples

Sampling Regions	Radionuclides		Metals		Organic Compounds	
	Strontium-90	Technetium-99	Metals ICP	Mercury CVAA	Polychlorinated Biphenyls	TPH (Diesel)
Suspected Diesel Contamination	2					2
Strontium Plume	3	3	3	3	3	
Chromium Site	3	3	3	3	3	
Reference Site[a]	1	1	3	1	1	

(a) Data will be supplemented with existing COPEC characterization data for reference sites.
COPEC = Contaminant of potential ecological concern.
CVAA = Cold vapor atomic absorption.
ICP = Inductively coupled plasma.
TPH = Total petroleum hydrocarbon.

Table 3.9. Sample Region, Number, and Analysis of Shallow Groundwater Aquifer Tube Samples and Surface Water Samples

Sample Type and Sample Zone	Radionuclides		Metals		Organic Compounds	
	Strontium-90	Technetium-99	Metals ICP	Mercury CVAA	Polychlorinated Biphenyls	TPH (Diesel)
Aquifer Tube Sampling						
Suspected Diesel Area	1[a]	1	1			1
Strontium Plume	4	4	4	4		
Elevated Metals Area	4	4	4	4		
Reference Site	3	3	3	3		
Surface Water Sampling	3	3	3	3		

(a) One aquifer tube at 10-centimeter depth in matrix substrate.
CVAA = Cold vapor atomic absorption.
ICP = Inductively coupled plasma.
TPH = Total petroleum hydrocarbon.

Sampling planned for the elevated metals area will be conducted using four shallow groundwater aquifer tubes at 10-centimeter depth (biotic zone) into the matrix substrate. These will be installed at the point of maximum chromium discharge or accumulation as determined by reconnaissance on conductivity and other supporting data from clams, well monitoring, aquifer tube, and seep water samples. Three shallow groundwater aquifer tubes will be installed at the selected reference site based on conductivity data and physical conditions.

3.4.2.3 Surface Water Samples

Surface water samples will also be collected within 6 centimeters of the substrate in coordination with each aquifer tube sampling site. River water sampling consists of grab samples collected from just above the river bottom for analysis of COPECs, anions (primarily nitrate), temperature, dissolved oxygen, and specific conductivity. The sampling provides a measure of surface water quality where the highest potential for groundwater upwelling occurs. River water will be collected from near the river bottom by using a peristaltic pump and Tygon® tubing with the sample inlet positioned <6 centimeters above the river bottom. COPECs to be analyzed include metals and radionuclides. Samples will be collected at low river stage to reflect maximum exposure in the identified contaminant regions and at the reference sites.

3.4.3 Near-Shore Aquatic Biota Sampling

Key biological receptors identified for the 100-NR-2 Phase I sampling include periphyton, milfoil (or other macrophyte as available), Asiatic clams, and sculpin (see Figure 3.3). Asiatic clam sampling was included in the reconnaissance sampling in spring 2004 and will be supplemented with an effort to spatially define the strontium-90 plume and region where metals are elevated. Samples of periphyton, clams and milfoil are collected by hand; electroshocking is used to collect sculpin. Clam samples will be processed to provide whole body soft tissue and shell samples. Because of the small size of clams and sculpins, multiple organisms may need to be collected and processed to provide sufficient tissue for compositing to meet analytical detection requirements. During these sampling activities, biological condition will be measured as appropriate for the species samples and are discussed for each receptor below. Key receptors will be sampled at the reference sites following the same protocols used in the 100-NR-2 study area.

3.4.3.1 Sculpin

Sculpin best represent the aquatic vertebrate predator guild and serve as a sentinel organism in this study design. Sculpins will be sampled for COPECs and for screening health metrics (Table 3.10, Figure 3.2). Sculpin are believed to have a relatively limited home range and are strict benthic species. Sculpin will be collected in triplicate at the vicinity of the well N-46 seep and near the point of maximum chromium concentrations. Sample concentrations of strontium-90 and PCBs will be based on whole body (minus the portion of liver removed for trace metal analysis). Trace metal concentrations will be analyzed in liver tissue samples.

3.4.3.2 Milfoil

Milfoil samples will be collected in triplicate from the vicinity of the well N-46 and near the point of maximum chromium concentrations (Table 3.10). Sample concentrations will be obtained for bulk samples of stems and leaves.

Table 3.10. Near-Shore Aquatic Biota Sampling Regions, and Analytes, Phase I

Sample Type and Sampling Region	Radionuclides		Metals		Organic Compounds	
	Strontium-90	Technetium-99	Metals ICP	Mercury CVAA	Polychlorinated Biphenyls	TPH (Diesel)
Sculpin						
Suspected Diesel Area					2	
Strontium Plume	2[(a)]	2[(a)]	2	2	2	
Elevated Metals Area	2[(a)]	2[(a)]	2	2	2	
Reference Site[(b)]	2	2	2	2	2	
Milfoil						
Suspected Diesel Area						
Strontium Plume	3	3	3	3		
Elevated Metals Area	3	3	3	3		
Reference Site[(b)]	2	2	2	2		
Clams						
Characterization of 100-NR-2 Study Area (Systematic Sampling)	15		15			
Suspected Diesel Area						
Strontium Plume	6					
Elevated Metals Area			6	6		
Reference Site[(b)]						
Periphyton						
Suspected Diesel Area						
Strontium Plume	3	3		3	3	
Elevated Metals Area		3	3	3	3	
Reference Site[(b)]	5	5	5	5	3	

(a) Samples may be composited to acquire sufficient mass.
(b) Combined with other reference site COPEC characterization data.
COPEC = Contaminant of potential ecological concern.
CVAA = Cold vapor atomic absorption.
ICP = Inductively coupled plasma.
TPH = Total petroleum hydrocarbon.

3.4.3.3 Clams

Clam samples will be collected to support the delineation of strontium-90 and chromium in the vicinity of well N-46 and the point of maximum chromium concentrations in clams (Table 3.10). Both soft tissue composite samples and shells (strontium-90 analyses specifically) will be processed for contaminant analysis. The sampling design is to establish 2 transects extending perpendicular from the river shoreline located in each of two sampling regions: one set where strontium-90 is elevated, and one set where trace metals are elevated. Sample points for clams will be established at depths of 0.25, 1, and

2 meters at each transect. Systematic sampling of clams will be conducted at 100-meter intervals from the upper study boundary moving downstream to the southern boundary of the study site.

During the collection of biota for COPEC analysis, measurements will be taken to help assess the overall health of the clams. These measurements for clams include demographics, densities, and histology. In addition, other macroinvertebrates within 0.1-meter radius plots will be collected in the strontium-90 and trace metal regions where highest exposure scenarios are expected. Macroinvertebrate summaries will include: the numbers of each species per sample, species richness, and species diversity.

3.4.3.4 Periphyton

Periphyton is at the base of the aquatic food web in the Columbia River, and they may provide COPEC concentrations that can be used to model dose. This may be important for receptors such as suckers and crayfish. It is difficult to separate biomass from sediment contamination as well as simply obtaining sufficient mass. As such, it is difficult to assume comparable results are obtained between samples. However; periphyton communities are sessile and on a gravimetric basis, have a large surface to volume ratio. Periphyton will be sampled (as feasible) in the area of elevated metals and within the strontium-90 plume area (Table 3.10).

3.4.3.5 Key Receptor Phase II Biota Sampling

On the basis that reconnaissance sampling was collected in spring 2004 and that past studies and monitoring have established that particular COPECs accumulate in aquatic biota, opportunistic sampling for Phase 2 biota is planned in FY 2005. The decision to sample Phase 2 biota will involve an assessment of the spatial distribution upwelling (reconnaissance conductivity assessment), trophic relationships between the species for which COPEC data is in hand, the established potential for the COPECs of interest to biomagnify through the food chain, and a subjective assessment of the likelihood that a Phase 2 species may obtain a significant exposure from consuming contaminated biota. Tentative candidates for Phase 2 sampling include king birds (avian invertivore), mallards (aquatic avian herbivore), carp (which are known to consume clams), and juvenile suckers (benthic herbivore)

3.5 Sample Handling, Shipping, and Custody Requirements

All field sample handling, shipping, and custody requirements will be consistent with established procedures (see Section 2.0). Sample transportation shall be in compliance with applicable regulations for packaging, marking, labeling, and shipping of hazardous materials, hazardous substances, and hazardous waste mandated by the U.S. Department of Transportation (49 Code of Federal Regulations [CFR] 171-177) in association with the International Air Transportation Authority, DOE requirements, and applicable program-specific implementing procedures. Sample custody during laboratory analysis is addressed in the applicable laboratory SOPs. Laboratory custody procedures will ensure that sample integrity and identification are maintained throughout the analytical process.

3.6 Sampling and Onsite Environmental Measurement Procedures

Procedures for field measurements are specified in the subcontractor's or manufacturer's manuals. The sampling and onsite environmental measurement procedures to be implemented in the field will be consistent with established established procedures.

3.7 Sample Management

Sample management activities shall be consistent with established PNNL procedures. All data will be entered into HEIS

3.8 Management of Investigation-Derived Waste

Waste generated by sampling activities will be managed consistent with an established waste management plan. Unused samples and associated laboratory waste for analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. In accordance with 40 CFR 300.440, Remedial Project Manager approval is required before returning unused samples or waste from offsite laboratories.

4.0 Health and Safety

All field operations will be performed consistent with PNNL health and safety requirements and the requirements of the *Hanford Site Radiological Control Manual* (DOE/RL-96-109). Where necessary, a work planning package will be prepared that will further control site operations. The work planning package will include, as appropriate, a job hazard analysis, and/or a site-specific health and safety plan, and applicable radiological work permits.

The sampling procedures and associated activities will implement as low as reasonably achievable practices to minimize the radiation exposure to the sampling team, consistent with the requirements defined in the *Hanford Site Radiological Control Manual* (DOE/RL-96-109).

5.0 References

29 CFR 1910. "Occupational Safety and Health Standards." *Code of Federal Regulations*, as amended.

40 CFR 300. "National Oil and Hazardous Substances Pollution Contingency Plan." *Code of Federal Regulations*, as amended.

49 CFR 171. "General Information, Regulations, and Definitions." *Code of Federal Regulations*, as amended.

49 CFR 172. "Office of Hazardous Materials Transportation Color Tolerance Charts and Tables." *Code of Federal Regulations*, as amended.

49 CFR 173. "Shipper's--General Requirements for Shipments and Packaging." *Code of Federal Regulations*, as amended.

49 CFR 174. "Carriage by Rail." *Code of Federal Regulations*, as amended.

49 CFR 175. "Carriage by Aircraft." *Code of Federal Regulations*, as amended.

49 CFR 176. "Carriage by Vessel." *Code of Federal Regulations*, as amended.

49 CFR 177. "Carriage by Public Highway." *Code of Federal Regulations*, as amended.

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PNNL-14687. 2004. *Hanford Site Environmental Report for Calendar Year 2003.* TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

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Appendix A

Data Supporting Study Region Designation

Appendix A

Data Supporting Study Region Designation

Past studies have provided data that support the designation of a strontium-90 and chromium study region at the 100-NR-2 Operable Unit. These include the spring 2004 reconnaissance sampling conducted by Pacific Northwest National Laboratory (PNNL) at the site, the 1997 collaborative study by the Washington State Department of Health (DOH) and PNNL, and supporting metals characterization conducted by PNNL in 1997. Past diesel fuel oil spills in an area upstream of the study area and the measurement of diesel fuel oil in groundwater wells in that area support the designation of a diesel study region (DOE 1997 Corrective Measures Document). This appendix provides the data from these studies to support the designation of these study regions in the data quality objective and sampling and analysis plan.

A.1 Spring Reconnaissance

In March 2004, PNNL under direction from U.S. Department of Energy (DOE) with concurrence of Washington State Department of Ecology and U.S. Environmental Protection Agency, conducted reconnaissance sampling of selected biota and seeps at the 100-N Area. Clams collected during this survey indicated an accumulation of chromium at the downstream section of the study site (Figure A.1).

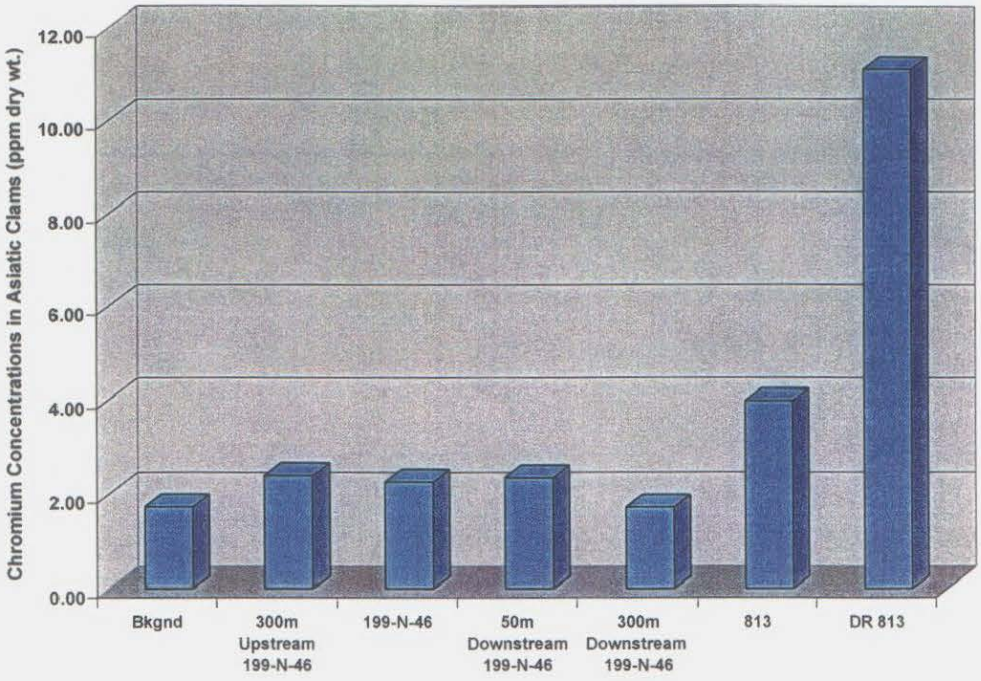

Figure A.1. Chromium Concentrations in Asiatic Clams (soft tissue) Collected During March 2004

Clam shell samples were collected on March 24 and 25, 2004 and analyzed for technetium-99 and Strontium-90. All technetium-99 results were below the detection limit of 0.36 pCi/g. The highest concentration of strontium-90 was found in a clam shell collected from the 199N-46 spring site (Table A.1). Results from samples collected from two new sites located immediately downstream of caisson 199N-46 (50 meters downstream caisson 199N-46 and caisson 8-13) showed that elevated Sr-90 concentrations continue down river for at least 50 meters but do not appear to be elevated 300 meters downstream of 199N-46. Shallow-groundwater seepage was not visually apparent at these two sites. The highest Sr-90 concentrations previously reported in clam shell samples collected along the Hanford Reach of the Columbia River occurred near 199N-46 and was 383 pCi/g wet wt., approximately 100 times greater than the maximum background levels (0.37 pCi/g wet wt.) reported to date (PNNL 14687).

A.2 1997 Washington State Department of Health/Pacific Northwest National Laboratory Study

This study focused on radiological characterization of the riparian-near shore river area at 100-N. As reported by DOH, Site 3 was located near 100N-46 and the primary seep historically containing elevated levels of strontium-90 (Van Verst et al. 1998; http://sesp.pnl.gov/Reports/11933.pdf). The sampling in 1997 for river water, seep water, and sediment identified this area as an area of elevated strontium-90 (Table A.2; Van Verst et al. 1998). Sampling sites upstream of Site 3 are Sites 1 and 2, sites downstream of Site 3 are Sites 4 and 5). Clearly, the 1997 study showed that biotic and abiotic media contained elevated concentrations at Site 3 adjacent to the 100N-46 well site.

Table A.1. Strontium-90 in clam shells collected from the 100-N shoreline and a reference location near the Vernita Bridge, March 24-25, 2004.

Sample Number	Location	Concentration (pCi/g wet wt.)	Propagated Error (2σ)	Minimum Detectable Amount
B18X40	Background	0.194	0.045	0.0478
B18X45	100-N Spring 199N-46	50.5	7.3	0.107
B18X48	100-N Spring 50 m DR 199N-46	9.57	1.4	0.0314
B18X52	100-N Spring Caisson 8-13	0.34	0.058	0.03
B18X55	100-N Spring DR Caisson 8-13	0.239	0.044	0.0244
B18X56	100-N Spring DR Caisson 8-13 Duplicate	0.282	0.05	0.0224

A.3 1997 Metals Sampling at 100-N Area

Environmental samples were also collected during the DOH/PNNL study for metals characterization. While this study was a companion study for the 100-N radiological sampling, the reporting of sample sites is reversed. Relative to Site 3 (N-46 well area), the downstream samples were designated as Sites 1 and 2 and the upstream sample sites were designated as Sites 4 and 5 (opposite of the DOH designation). Sediment data indicates elevated chromium in the seep found at Site 3 and in the downstream sector of the 100-N Area (Table A.3). Water samples also suggested an elevation of chromium at and downstream of the Site 3 groundwater seep (N-46 well area) (Table A.4).

A.4 References

PNNL-11933. 1998. *Survey of Radiological Contaminants in the Near-Shore Environment at the Hanford Site 100-N Reactor Area.* SP Van Verst, CL Albin, GW Patton, ML Blanton, TM Poston, AT Cooper, and EJ Antonio, Pacific Northwest National Laboratory, Richland, Washington.

PNNL-14687. 2004. *Hanford Site Environmental Report for Calendar Year 2003.* TM Poston, RW Hanf, RL Dirkes, and LF Morasch (eds.), Pacific Northwest National Laboratory, Richland, Washington.

Table A.2. Results of Radiochemical Analysis of 100-N Area Near-Shore Samples

Sample Location[a]	Collection Date	Sr-90				H-3				Cs-137				Co-60			
		DOH		PNNL		DOH		PNNL		DOH		PNNL		DOH		PNNL	
		Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error
River Water (pCi/L)																	
Site 1a	09/08/97	1.1	0.8	0.101	0.0363	53	38	37.3	9.59	0.6	0.9	0.568	1.26	-0.2	0.8	-0.397	1.06
Site 2a	09/08/97	0.3	0.6			38	38			0.1	0.4			0.3	0.5		
Site 2b	09/08/97	0.1	0.6	0.128	0.0414	107	41	63.9	11.6	-0.1	0.9	-0.153	1.51	0.7	0.7	-0.745	1.16
Site 2c	09/08/97	0.3	0.6			84	39	61.3	11.3	0.3	0.9			0.7	0.8		
Site 2d	09/08/97	0.04	0.63			89	40	63.2	11.4	-1	1			-0.4	0.8		
Site 2e	09/08/97	-0.05	0.58			31	37	61.2	11.4	0.3	0.8			-0.2	0.8		
Site 3a	10/29/97	13	2			153	42			0	1			-0.1	0.9		
Site 3a	03/30/98	12	1.3			-62	33			0.1	0.9			0.8	0.7		
Site 3a	09/08/97	3.8	1	3.87	0.741	90	39	67.7	11.8	0.6	1	0.354	1.15	-0.07	0.85	0	1.09
Site 3b	09/08/97	6.6	1.1	4.55	0.869	84	39	73.1	12.2	-0.2	0.9	-0.388	1.25	0.4	0.8	-0.876	1.37
Site 3c	09/08/97	4.1	1	3.76	0.701	55	38	71.9	12.1	-0.02	0.94	-0.547	0.954	0.7	0.8	-1.11	1.46
Site 3d	09/08/97	0.9	0.7	1.36	0.264	93	39	65.5	11.6	0.2	0.8	1.16	0.958	0.1	0.8	-0.0856	1.11
Site 4a	09/08/97	0.8	0.7	0.723	0.151	65	38	65.7	11.6	-0.7	0.9	0.479	1.26	0.4	0.8	0.407	0.921
Site 5a	09/08/97	0.9	0.5	0.231	0.0602	1160	70	998	90.2	0	0.9	0.0459	1.06	0.5	0.9	0.0744	1.17
Site 5b	09/08/97			0.297	0.0702			227	24.8			-0.904	1.13			0.819	0.968
Site 5c	09/08/97			0.299	0.0733			320	32.6			0.934	1.04			1.19	0.851
Site 5d	09/08/97			0.294	0.069			312	31.8			1.16	1.62			1.23	1.48
Vernita				0.094	0.037			25.5	7.95								
Riverbank Spring Water (pCi/L)																	
Site 3	09/09/97	6110	80			13700	300			-1	1			1	1		
Site 3	11/03/97			9870	1850			13700	1100			0.352	1.49			0.0742	1.77
Site 4/5	11/03/97			0.591	0.134			18900	1480			0.718	0.848			2.15	1.65
Sediment (pCi/g dry)																	
Site 1	09/09/97			0.0847	0.0197							0.246	0.0368			0.103	0.0237
Site 3	09/09/97			46.7	8.53							0.0911	0.0215			0.0489	0.0187
Site 5	09/09/97			0.0135	0.00546							0.369	0.0473			1.05	0.117
Vernita	08/18/97			0.0108	0.0055							0.361	0.0466			0.0086	0.0117

Table A.2. (contd)

Sample Location[a]	Collection Date	Sr-90				H-3				Cs-137				Co-60			
		DOH		PNNL		DOH		PNNL						DOH		PNNL	
		Result	Error	Result	Error			Result	Error	Result	Error			Result	Error	Result	Error
Sculpin (pCi/g wet)																	
Shoreline	09/11/97			0.754	0.145							0.0128	0.0249			0.023	0.023
Vernita	09/11/97			0.0152	0.00901							0.0089	0.0478			0.034	0.050
Clam Shells (pCi/g)																	
Site 1	09/09/97	1.5	0.3							0.002	0.009			0.004	0.009		
Site 5	09/08/97	0.13	0.17							-0.001	0.01			0.008	0.01		
Vernita	09/11/97	0.4	0.3							0.011	0.009			0.003	0.005		
Caddis Fly (pCi/g)																	
Site 3	09/11/97	64.5	1.2							39	9.3			0.25	0.055		
Site 5	09/08/97	0.007	0.035							-0.002	0.008			0.004	0.009		
Vernita	09/23/97	0.02	0.05							0.007	0.009			0	0.01		
Milfoil (pCi/g)																	
Site 1	09/09/97			0.0577	0.0151							0.0951	0.0809			0.034	0.046
Site 5	09/09/97	0.07	0.03	0.161	0.0339					0.012	0.01	0.122	0.0581	0.005	0.005	0.122	0.056
Vernita	09/11/97			0.0533	0.0146							0.159	0.0735			0.0006	0.042
Reed Canary Grass (pCi/g)																	
Site 1	09/09/97	0.18	0.04			470	170			0.05	0.04			0.06	0.03		
Site 3	09/09/97	33.3	0.4			470	185			0.02	0.02			0.01	0.02		
Site 5	09/08/97	0.035	0.029			530	170			0.04	0.03			0.03	0.03		
Vernita	09/11/97	0.24	0.04			135	190			0.047	0.026			0.001	0.015		
Periphyton (pCi/g)																	
Site 1	09/09/97	-0.04	0.22							0.22	0.028			0.036	0.007		
Site 3	09/08/97	0.99	0.44							0.201	0.018			0.195	0.01		
Site 5	09/09/97	0.11	0.15							0.174	0.018			0.132	0.013		
Vernita	09/09/97	0.02	0.16							0.138	0.016			0.0002	0.0073		

(a) Sampling sites upstream of Site 3 (then-46 Well area) are Sites 1 and 2, sites downstream of Site 3 are Sites 4 and (Van Verst et al. 1998).
DOH = Washington State Department of Health.
PNNL = Pacific Northwest National Laboratory.

Table A.3. Trace Metal Concentrations in Sediment at 100-N Area (µg/g dry wt)

Site[a]	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Silver	Thallium	Zinc
100-N Station 1	0.96	12	1.4	2.2	69	40	0.080	34	60	1.8 U	0.36	1.3	330
100-N Station 3 A	0.45	3.5	1.4	0.50	33	21	0.020	19	17	1.8 U	0.20	0.51	130
100-N Station 3 B Riverbank Spring	1.1	4.2	1.4	3.3	100	43	0.20	39	52	1.8 U	0.56	1.2	370
100-N Station 5	0.16	1.8	0.34	0.33	14	7.2	0.060	7.3	7.1	1.8 U	0.070	0.18	50
Priest Rapids (Median)	0.80	6.9	1.1	4.3	68	39	--	36	36	0.12	0.34	1.5	450

(a) Relative to Site 3 (N-46 well area), the downstream samples were designated as Sites 1 and 2 and the upstream sample sites were designated as Sites 4 and 5.

Table A.4. Near-Shore Water Mini-Transect Trace Metal Concentrations (µg/L)

Location[a]	Depth (m)[b]	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Selenium	Silver	Thallium	Zinc
100 N Station-1A	0.3	0.28	0.80	0.08 U	0.020 J	0.60	0.86	0.00051	0.18	0.18	0.4 U	0.01 U	0.037	2.6
100 N Station -1B	1.5	0.28	0.64	0.08 U	0.050	0.64	1.0	0.00090	0.47	0.50	0.4 U	0.01 U	0.036	4.5
100 N Station -1C	1.5	0.27	0.61	0.08 U	0.020 J	0.26	0.76	0.00052	0.17	0.14	0.4	0.01 U	0.036	2.2
100 N Station -1D	2	0.29	0.70	0.08 U	0.017 J	0.28	0.84	0.00046	0.16	0.14	0.4 U	0.01 U	0.040	2.5
100 N Station -2	0.3	0.27	0.73	0.08 U	0.021 J	0.20 J	0.92	NA	0.21	0.18	0.4 U	0.01 U	0.042	2.8
100 N Station -3A	0.3	0.52	0.66	0.08 U	0.034	0.20 J	0.97	0.00044	0.26	0.14	0.4 U	0.017	0.049	3.6
100 N Station -3B	0.6	0.38	0.58	0.08 U	0.034	0.24 J	0.86	0.0017	0.24	0.21	0.4 U	0.011 J	0.042	2.6
100 N Station -3C	1.5	0.36	0.67	0.08 U	0.026 J	0.19 J	0.86	0.00060	0.20	0.22	0.4 U	0.012 U	0.037	3.3
100 N Station -3D	2	0.34	0.64	0.08 U	0.026 J	0.24	0.85	0.00049	0.12	0.16	0.4 U	0.01 U	0.040	2.6
100 N Station -4A	0.3	0.33	0.69	0.08 U	0.027 J	0.21 J	0.88	NA	0.13	0.14	0.4 U	0.01 U	0.038	2.4
100 N Station -4B	0.6	0.30	0.65	0.08 U	0.030 J	0.15 J	0.85	NA	0.17	0.16	0.4 U	0.01 U	0.038	2.5
100 N Station -4C	1.1	0.28	0.62	0.08 U	0.031 J	0.32	0.88	NA	0.22	0.25	0.4 U	0.01 U	0.040	3.0
100 N Station -4D	1.5	0.30	0.65	0.08 U	0.029 J	0.19 J	0.85	NA	0.24	0.17	0.4 U	0.01 U	0.037	2.4
100 N Station -5	0.3	0.28	0.64	0.08 U	0.025 J	0.20 J	0.86	NA	0.11	0.16	0.4 U	0.01 U	0.037	2.4

J = Estimated, concentration very near the detection limit.
NA = Not analyzed.
U = Undetected.
(a) Relative to Site 3 (N-46 well area), the downstream samples were designated as Sites 1 and 2 and the upstream sample sites were designated as Sites 4 and 5.
(b) Depth designates the depth of the water column where the samples were collected. Samples were collected <10 cm off the bottom.

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