Hanford Site 100 Area Assessment Plan
Volume I: Columbia River Aquatic Resources

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For

The Hanford Natural Resource Trustee Council

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EXECUTIVE SUMMARY

HANFORD SITE 100 AREA ASSESSMENT PLAN
VOLUME I: COLUMBIA RIVER AQUATIC RESOURCES

This document is the first volume of the Hanford Site 100 Area Assessment Plan. The goal of an assessment plan is to determine the injury to natural resources caused by the release of hazardous substances, and ultimately to restore and further protect these resources from future exposure. This document represents the first phase of a comprehensive process to examine injuries from Hanford Site 100 Area releases. During this first phase, only current injuries to aquatic resources in the Columbia River will be investigated. Investigation of past injuries or injuries to other natural resources from 100-Area releases will not be included in this phase, but may be addressed at a later date at the discretion of the trustees.

This volume of the Assessment Plan was prepared by the U.S. Fish and Wildlife Service's Upper Columbia River Basin Field Office at the direction of the Hanford Natural Resource Trustee Council (HNRTC). The HNRTC is comprised of representatives from state, federal, and tribal natural resource agencies who are currently participating in the assessment process. It is designed to be in general accordance with the Natural Resource Damage Assessment (NRDA) Regulations, 43 CFR Part 11, promulgated by the U.S. Department of the Interior. The Hanford 100 Area assessment is a public process, and represents a HNRTC joint effort. The participating natural resource trustees are responsible for making decisions regarding the assessment process.

This first volume of the Assessment Plan includes the Columbia River and associated aquatic system from River Mile 385, located in the Hanford Reach, out to the Pacific coast. No data were located indicating exposure of aquatic resources to Hanford-derived contaminants in the portion of the Hanford Reach between Priest Rapids Dam and River Mile 385. Therefore, River Mile 385 has been established as the upstream boundary of the Assessment Area. The Assessment Area was evaluated in three sections; River Mile 385 to McNary Dam, McNary Dam to the mouth of the Columbia River, and coastal areas near the mouth of the Columbia River. This phase focuses primarily on the first segment of the Assessment Area (River Mile 385 to McNary Dam), since this is the area of documented current exposure.

The HNRTC decided to proceed with the Assessment Plan based on the presence of hexavalent chromium in groundwater at concentrations that exceed aquatic life criteria. These exceedences have been documented such that they meet the NRDA definition of injury to groundwater. Elevated hexavalent chromium concentrations are also known to be reaching the Columbia River via groundwater transport. This volume of the Assessment Plan focuses on the most recent contaminant data available from the 100 Area and the Columbia River to document current exposure and potential injury scenarios.

The methods used to confirm exposure of a natural resource to a hazardous substance in the Assessment Area include (1) comparisons of groundwater and surface water contaminant data from the Assessment Area to State of Washington and federal water quality criteria that protect human health and the environment, (2) comparisons of sediment contaminant data from the Assessment Area to sediments from reference or background sites, and (3) comparisons of contaminant residue data in aquatic biota from the Assessment Area to aquatic biota residue data from reference or background sites.

The data reviewed for this volume of the Assessment Plan confirms that aquatic resources (water, biological, geological, and cultural) in different segments of the Columbia River have been and currently are being exposed to hazardous substances (radionuclides, metals, and organic compounds) released from the 100 Area. Three hazardous substances have been identified as being of primary concern to aquatic biological resources in the Columbia River because of the areal extent of contamination, the number of elevated concentrations detected, and the number of natural resources exposed. These include hexavalent chromium, strontium-90, and possibly tritium.

Several potential investigative approaches are presented in this volume to evaluate injury of aquatic resources in the Columbia River. Investigations presented in this document could be used to (1) establish groundwater cleanup criteria, (2) establish/confirm a pathway for contaminants to reach a receptor, and (3) document injury from hazardous substance releases from the 100 Area.

There may be additional injuries to natural resources from 100-Area releases that were not addressed in this volume of the Assessment Plan, but may be addressed by additional volumes. These additional injuries include (1) past injuries to Columbia River aquatic resources, (2) current or past injuries in other aquatic systems (lakes), (3) current or past injuries to terrestrial resources, and (4) any cumulative injuries among the natural resource systems or arising from the additive effect of other sources of contamination not addressed in this volume. The HNRTC will prioritize additional phases (Assessment Plan volumes) based on presence of known or suspected injury to natural resources, importance of natural resources potentially impacted, ability to influence remedial decisions, and availability of funds. Additional volumes will be developed on an as-needed basis. Investigation of injury due to other Hanford Site releases (e.g., from 200 and 300 Areas) will be addressed as appropriate under separate NRDA assessments.

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PART I: GENERAL INFORMATION

I. INTRODUCTION

The goal of an assessment plan is to determine the injury to natural resources caused by releases of hazardous substances, and ultimately to restore and further protect these resources from future exposure. This document is the first volume of the Hanford Site 100 Area Assessment Plan (Assessment Plan) and represents part of a comprehensive process to examine injuries from 100-Area releases. During this first phase, only current injuries to aquatic resources in the Columbia River will be investigated. Investigation of past injuries from100-Area releases will not be included in this phase, but may be addressed at a later date at the discretion of the trustees.

This volume of the Assessment Plan was prepared by the U.S. Fish and Wildlife Service's (USFWS) Upper Columbia River Basin Field Office, including the Moses Lake Suboffice, at the direction of the Hanford Natural Resource Trustee Council (HNRTC). The HNRTC is made up of representatives from state, federal and tribal natural resource trustees who are currently participating in the assessment process. These include the State of Washington, represented by Washington Department of Fish and Wildlife and Washington Department of Ecology (Ecology); the State of Oregon, represented by Oregon Department of Energy; U.S. Department of the Interior, represented by the USFWS and the Bureau of Land Management; the U.S. Department of Energy (DOE), represented by the Richland Operations Office; the Yakama Indian Nation; the Nez Perce Tribe; and the Confederated Tribes of the Umatilla Indian Reservation. Additional agencies who have trust responsibilities in the Hanford area, but are not represented on the HNRTC include the U.S. Department of Commerce, represented by National Oceanic and Atmospheric Administration, and the U.S. Department of Defense. The Confederated Tribes of the Warm Springs Reservation are also a potential Trustee in the Hanford area. The U.S. Department of Energy and the U.S. Department of Defense represent potentially responsible parties (PRPs) as well as Trustees.

The Assessment Plan is designed to be in general accordance with the Natural Resource Damage Assessment (NRDA) Regulations, 43 CFR Part 11, promulgated by the U.S. Department of the Interior. The HNRTC has agreed to follow these regulations as technical guidance in attaining restoration of any injured or potentially injured natural resources. To the extent possible, the HNRTC will address natural resource damage concerns during the remedial action process.

I.A SCOPE OF VOLUME I OF THE ASSESSMENT PLAN

The nature of contamination at Hanford, the cleanup process, and the role and relationship of the trustee agencies with DOE are complex. Hazardous substances continue to be released and migrate towards the Columbia River. The cleanup of these contaminants is not expected to be complete for decades. During the cleanup period known injuries and potential injuries to natural resources will continue to occur, including injuries which may result from the cleanup itself. Also during this period, information on past injuries may be reduced, masked or lost.

In an effort to address urgent risks, DOE, the Environmental Protection Agency (EPA), and Ecology are planning and implementing a number of interim cleanup decisions. The consequences of these decisions may have an impact on natural resources, at least during the several-decade interim. There is currently an opportunity to shape these decisions and incorporate information on (1) potential injuries to natural resources, (2) steps to protect the resources, and (3) restoration for lost resources.

The U.S. Department of Energy, as a responsible party and a trustee, must ensure that the cleanup is carried out and that all injured or lost resources are documented and restored. The State of Washington also has two roles, regulator and trustee, and must ensure that the cleanup (1) is protective of human health and the environment, (2) is in compliance with the regulations, and (3) fully restores the resources. These two agencies, together with the other Trustees, have established a cooperative working relationship through the HNRTC, which serves as a forum for promoting all of the participants' trustee roles.

This phase of the assessment will include only the aquatic resources associated with the Columbia River system. The purpose of this phase of the assessment is to investigate **current** exposure pathways and potential injury to these resources as they are impacted by releases from the 100 Area. Investigation of past injuries to aquatic resources from 100-Area releases will not be included in this phase, but may be addressed at a later date at the discretion of the HNRTC. Assessment of other systems, such as terrestrial systems and aquatic systems associated with lakes in the Hanford region, and potential injury to their associated natural resources from 100-Area releases may be addressed by additional volumes to this Assessment Plan. Hazardous substance releases from other areas of the Hanford Site have been documented as potentially impacting the Columbia River system (CRCIA 1998). For example, tritium concentrations greater than the drinking water standards have been documented in groundwater beneath the 200 and 300 Areas, extending as far as the Columbia River. Uranium and trichloroethylene concentrations greater than the drinking water standards have also been documented in groundwater beneath the 300 Area in the vicinity of the Columbia River. In addition to having potential direct impacts to natural resources, these substances may have cumulative effects along with 100-Area derived contaminants. Investigation of past and present injury to Columbia River aquatic resources due to other Hanford Site releases (e.g., from 200 and 300 Areas) will not be addressed in this plan, but may be addressed in additional assessments.

The Hanford 100 Area assessment is intended to be a public process, and represents a joint effort between natural resource trustees with funding currently provided by DOE. The participating natural resource trustees and DOE (represented on the HNRTC), will be jointly responsible for making decisions regarding this assessment process. All data will be generated and analyzed in a cooperative manner at the discretion of the HNRTC and their delegated work groups. Data will be available to all Trustees and regulators, and as applicable, are intended for use in the design and implementation of remedial processes and restoration projects on Hanford 100-Area sites.

I.B NATURAL RESOURCE DAMAGE ASSESSMENT PROCESS

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) allows for multiple processes for environmental cleanup and restoration. Two such processes commonly implemented at National Priorities List (NPL) sites include the remedial investigation and feasibility study (RI/FS) process of EPA, and the NRDA process of the natural resource trustees. The NRDA process allows for investigation of potential injuries to natural resources that may still be occurring after remedial actions have been completed, or that occur outside designated NPL sites. In addition, the process allows for the investigation of past injury. This phase of the assessment will address 100-Area releases that are responsible for current injuries to those resources associated with the Columbia River aquatic system, including groundwater, surface water, biota, geologic, and cultural resources. The following describes the NRDA process in general.

In CERCLA it is stated that parties that have released hazardous substances into the environment shall be liable for damages for injury to, destruction of, or loss of natural resources caused by the releases. State and federal agencies and affected tribal governments are empowered to obtain monetary compensation from PRPs for damages to the natural resources for which they have trust responsibilities. These agencies and governments are referred to as "natural resource trustees." The compensation must then be used toward restoration of the affected natural resources. Natural Resource Damage Assessment is the process by which natural resource injury and damages are assessed.

Injury means a measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a hazardous substance. This includes the loss of services that the injured resource would have produced had the release not occurred. An injured resource includes a receptor of direct injury or a resource that serves as a pathway of injury to another resource. For this assessment, injured resources may include aquatic biota or cultural resources located within the aquatic system, or resources such as groundwater, surface water, or sediment that may serve as pathways of injury to other aquatic resources. According to 43 CFR § 11.62(f), biological injury includes any of the following conditions: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunction, physical deformation, or a measured concentration of a contaminant of concern that exceeds an established action level or criterion in the resource.

Service means the physical and biological functions performed by a resource for another resource. This may include ecological and/or human use services. Human uses and services are listed in 43 CFR § 11.71, and include but are not limited to habitat quality, food, recreation, flood control, groundwater recharge, waste assimilation, and other such functions. Cultural use of natural resources is recognized in recent scientific literature as being part of natural resource valuation (e.g., Peterson and Lubchenko 1997). In 43 CFR § 11.83 some of the monetary values are listed, such as existence and bequest values and the time required for the resources and their services to be fully returned to their baseline conditions.

Damages means the amount of money sought by the natural resource trustees as compensation for injury, destruction, or loss of natural resources.

The procedures for performing a NRDA are provided in 43 CFR, Part 11. Two types of assessments, Type A and Type B, are identified and requirements for each are discussed in 43 CFR § 11.31(c-d). Type A assessment procedures were designed to address injuries that result from minor releases and releases of short durations, and were designed primarily for coastal and marine environments. Type B assessment procedures require that a confirmation of exposure be prepared, and that quality assurance/quality control plans be developed for injury and pathway investigations. After review of § 11.34-11.36, the HNRTC determined that Type B procedures are more appropriate for the Hanford site than the more simplified Type A procedures.

There are four major components in conducting a NRDA, including the Preassessment Screen (PAS), Assessment Plan, Assessment (injury determination, injury quantification and damage determination), and the Post-Assessment or Report of Assessment. The process usually begins after the completion of the CERCLA remedial action to clean up the hazardous substance release.

The trustees first prepare the **PAS** to determine whether a discharge or release of hazardous substances has the potential to cause injury and warrants conducting a full-scale NRDA.

If the determination is made to proceed with the NRDA, the **Assessment Plan** is prepared. The Assessment Plan is essentially the work plan for the NRDA, and typically includes a series of injury and pathway investigations that will be conducted as part of the assessment. It also includes information that assures that the NRDA is proceeding in a cost-effective manner and that various requirements of the regulations are being met. The

Trustees are required to provide an opportunity for public review of and comment on the Assessment Plan. If deemed appropriate, public comments are addressed and/or incorporated into the Plan.

The Assessment Plan can be, and is often presented in a phased approach that reflect the three phases of the actual **Assessment** (Type B Method):

Injury determination involves determining whether injury to one or more of the natural resources has occurred, and that the injury resulted from the release of a hazardous substance based upon the exposure pathway and the nature of the injury.

Injury quantification involves determining and quantifying the extent of the injuries and the reduction of services provided by the natural resources. The services provided may include such things as wildlife habitat, recreation, ceremonial use, erosion control, or ecological functions.

Damage determination is the phase during which the value of specific injured resources and the services provided by the resources is determined, and the monetary compensation for injury is calculated. Included is a restoration and compensation determination plan that lists a number of possible alternatives for restoration, rehabilitation, and/or replacement of the injured natural resources and related services. Damages include the cost of the assessment, the monetary compensation for injury, and the cost of restoration.

The final component is the **Post-Assessment**, in which a **Report of Assessment** is prepared and made available to the public. The Report of Assessment consists of supporting documentation and the results of the studies performed during the injury determination, quantification, and damage determination phases of the assessment. The PRPs are presented with a demand in writing for a specific amount, representing the damages due to the Trustees. An account is established for the damage assessment awards. Finally, a Restoration Plan is developed and implemented.

The goal of the NRDA process is to restore, replace, or rehabilitate the affected natural resources and money recovered must be used in restoration. In some instances, some of the components and phases are not conducted or completed due to settlements reached with the PRPs.

Injury vs. Risk (NRDA vs. Superfund)
The NRDA process is often compared to the RI/FS ecological risk assessment process. In a broad sense they are similar. Both are part of CERCLA and both measure the effects of a contaminant on an organism, however, there are important differences. The NRDA process involves documenting injuries to a natural resource resulting from a release or spill of a hazardous substance, whereas risk assessment estimates or predicts the adverse effects of contaminants, and is one of the earlier steps in the site remediation process.

During the RI phase, a baseline risk assessment is performed to estimate the probability of health or ecological problems occurring if no cleanup is conducted at a site. The FS looks at possible remedial actions for cleanup. These techniques are evaluated and compared and the final candidate cleanup options are presented. At federal facilities such as Hanford, the facility is responsible for notifying natural resource trustees of the RI/FS process and associated risk assessment procedures. Early trustee coordination in the process may alleviate many natural resource damage concerns.

It is important to understand that the RI/FS process estimates the potential risk from a hazard. The RI/FS process is an educated prediction using data collected during monitoring, the remedial investigation, and from published research results and available modeling techniques. The NRDA process, on the other hand, typically provides more site specific injury information. The RI/FS results are used to assess the impacts and begin cleanup in order to limit potential threat to the public. Natural resource issues not addressed in the RI/FS process, and ultimately in the Record of Decision (ROD), can be addressed in the NRDA process. In general, the earlier the trustees get involved in the EPA remedial process, the greater the opportunity for natural resource issues to be dealt with as part of remedial planning, and thus address the NRDA goal of restoration during this process.

The Hanford RI/FS Process

At the Hanford Site, Qualitative Risk Assessments (QRAs) have typically been conducted in conjunction with either the RI phase or during Limited Field Investigations (LFIs). Figure 1 summarizes the Hanford Past Practice RI/FS process. Currently, QRAs are not conducted to produce stand-alone reports. Instead risk may be addressed in Remedial Design Reports, where cleanup levels are established, and in close out reports, which demonstrate compliance with the cleanup levels. Although cleanup is already progressing, the baseline risk assessment has not yet been conducted in the 100 Area. This remains to be conducted when individual sites are cleaned up, prior to finalizing land use restrictions.

The Hanford Injury Assessment Process

The Hanford trustees believe that it is more protective of natural resources and more cost-effective to address natural resource injuries early in the Superfund process rather than at the completion of the remedial action(s). Due to circumstances specific to Hanford, the trustees have an opportunity to integrate natural resource restoration into the cleanup process to restore the resources. These circumstances allow for an approach that differs from the formal NRDA process. The trustees will follow the substance and rigor of the NRDA regulations rather than the step-by-step approach of the NRDA process.

If successful, the Hanford injury assessment process will provide a full accounting of injured resources and foster appropriate restoration of those resources. If this approach does not fully address natural resource injuries, the injury information generated during this informal process can be used in a formal NRDA. Two departures from the formal NRDA process are: (1) a PAS has not been prepared prior to this Assessment Plan, and (2) a lead trustee has not currently been appointed.

Hanford Past Practice RI/FS (RFI/CMS) Process

The process is defined as a combination of interim cleanup actions (involving concurrent characterization), field investigations for final remedy selection where interim actions are not clearly justified, and feasibility/treatability studies.

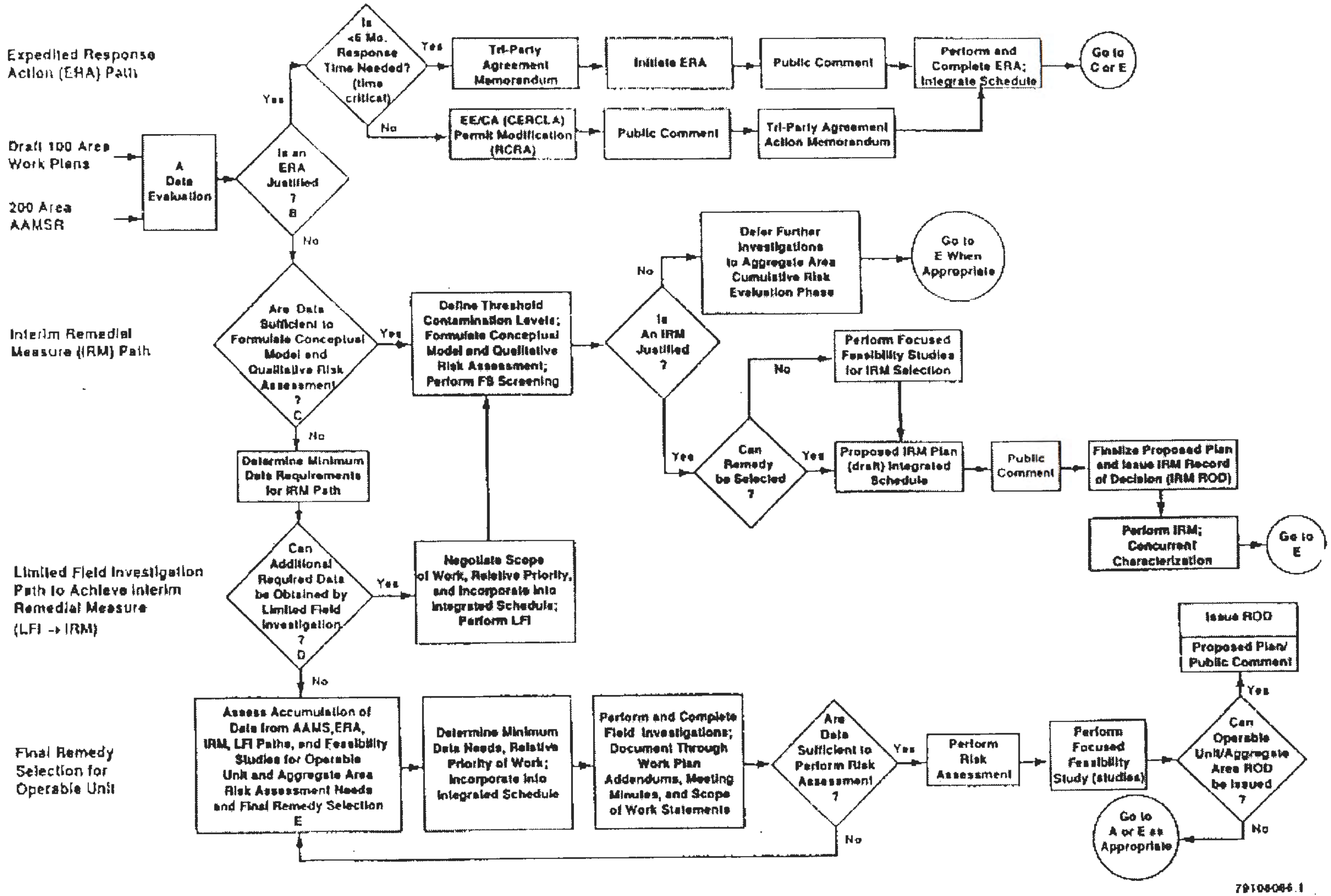


Figure 1. Hanford Past-Practice RI/FS Process.

The HNRTC approach is to create a multi-phased injury assessment process. Each phase of the injury assessment will be planned and implemented through separate volumes as part of a comprehensive Hanford Site Injury Assessment. The trustees will prioritize additional phases based on:

a. Presence of known or suspected injury to natural resources due to a release of hazardous substance
b. Ranking of natural resources potentially impacted
c. Ability to influence remedial actions
d. Availability of funds.

Each volume will focus on natural resources grouped by categories such as type, geography, exposure pathway, and/or cleanup area. The Injury Assessment Plan volumes and subsequent injury pathways studies will be prepared following the substance of the requirements in 43 CFR Part 11.

I.C SITE HISTORY: HANFORD SITE AND 100 AREA

Hanford Area

The Hanford Site (Site) is a 560 square-mile facility located along the Columbia River in south central Washington, north and west of the cities of Richland, Kennewick and Pasco (known as the Tri-Cities; Figure 2). In addition to urban and industrialized areas of the Tri-Cities, which supports a population of more than 100,000, the Site is surrounded primarily by agricultural and grazing land. The Hanford facility was established during World War II to produce plutonium for nuclear weapons. Operated by DOE, it was the first nuclear production facility in the world. Although production was discontinued in 1987, DOE facilities are still located throughout the Site, as well as in the city of Richland. Current operations at the Site consist primarily of environmental restoration, waste management, and science and technology.

The Hanford area landscape is dominated by semi-arid lands with drought-resistant grasses and cold desert shrubs that provide habitat for a variety of wildlife species. The southwestern portion of the Site includes a 120 square-mile area designated as the Arid Lands Ecology Reserve (ALE) (Figure 3), managed by the USFWS as a research natural area.

The North Slope is the approximately 140 square-mile portion of the Site located north of the Columbia River. Approximately 47 square miles of the western portion of the North Slope is designated as Saddle Mountain National Wildlife Refuge (Figure 3), federally managed by USFWS under permit with DOE. The remaining 93 square miles to the east is known as the Wahluke Slope State Wildlife Management Area (Figure 3), managed by Washington Department of Fish and Wildlife, also under permit with DOE. In addition to their wildlife habitat aspects, these areas have served and continue to serve as buffer

Figure 2. Hanford Area in South Central Washington State

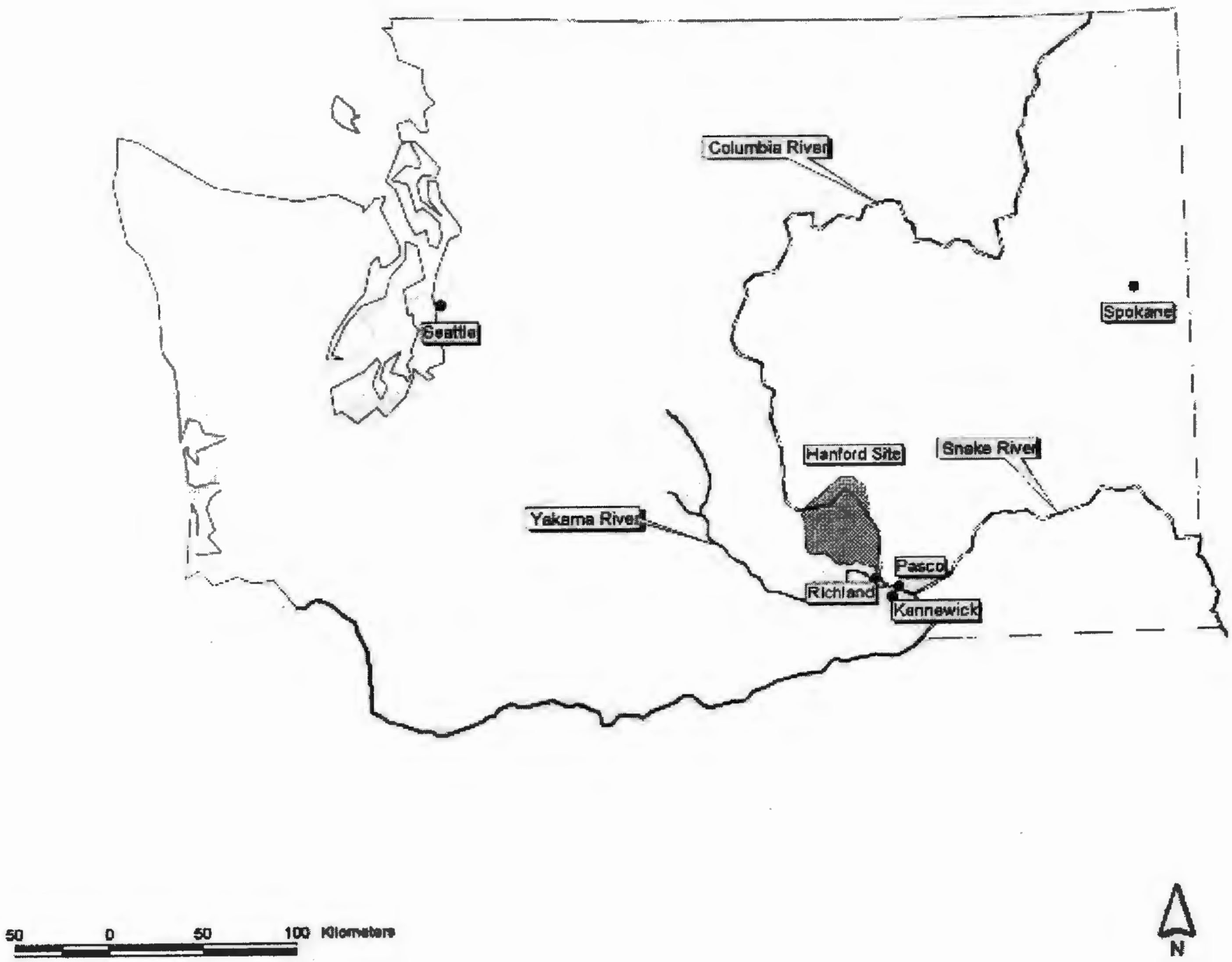
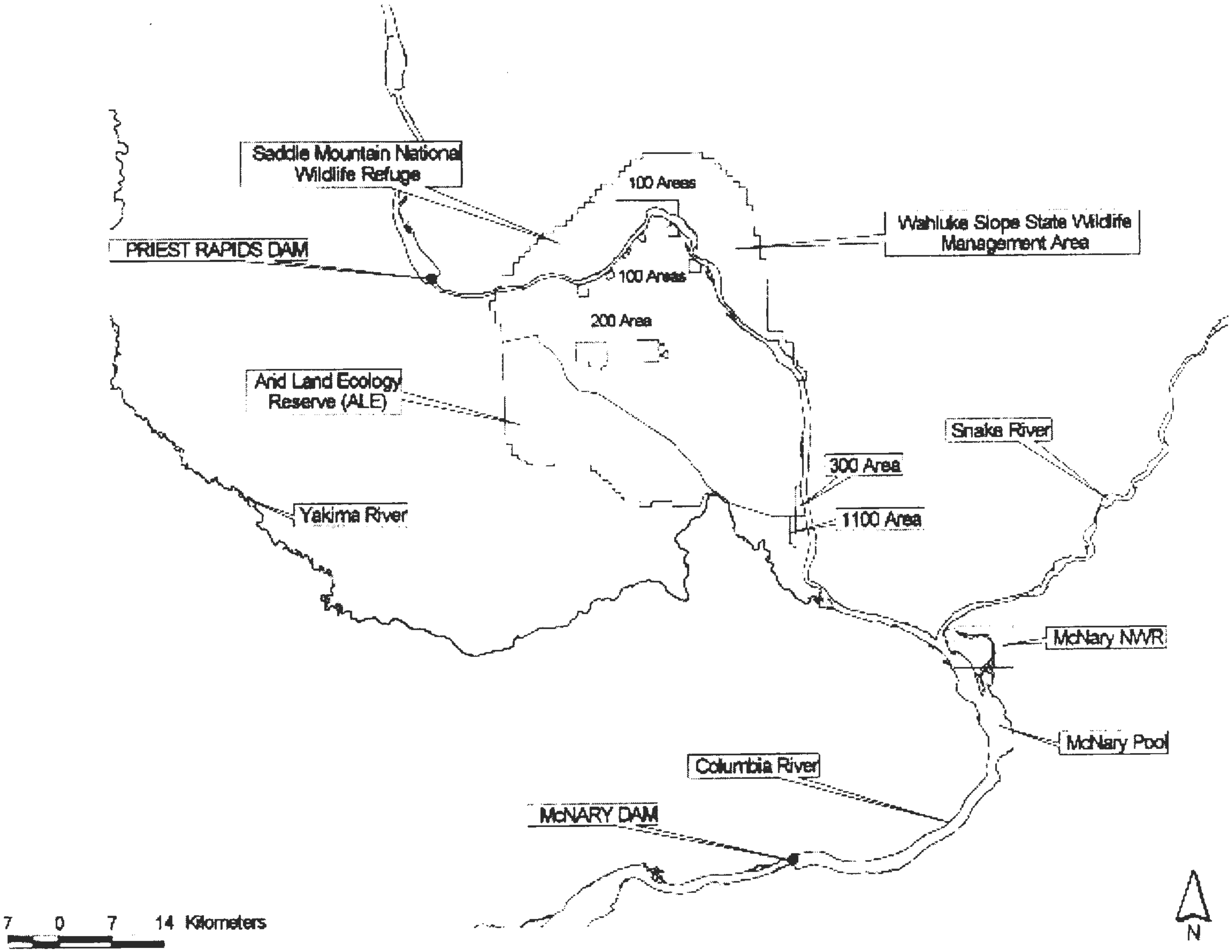


Figure 3. Hanford Site



zones to isolate the reactor areas and operations, as well as areas restricted by military use, from the public. Ten U.S. Army sites, including seven anti-aircraft emplacements, and three Nike missile positions were located on the North Slope until closure in the 1960's. Many of the remaining army facilities were torn down or decommissioned in the mid-1970's and a no further action ROD was signed for the North Slope in February 1996. However residual contamination in the landfills and other hazardous waste sites in this area may pose a threat to the environment.

The 51-mile stretch of Columbia River between Priest Rapids Dam and the head of McNary Pool (Figure 3) is known as the Hanford Reach, and is considered the last unimpounded stretch of the river within the United States, with the exception of the stretch below Bonneville Dam and the Columbia River estuary. Large quantities of water from this section of river were used for reactor cooling water during the years of plutonium production. The river provides Site facility drinking water, and serves as a source of water for communities downstream of the Site. Recreational uses of the Hanford Reach include hunting, fishing, boating, water skiing and swimming. The Hanford Reach is currently being considered for designation as a National Wild and Scenic River. The Columbia River in the vicinity of the Site is used extensively for crop irrigation.

Tribal History

The Hanford area has an extensive history of tribal existence and cultural influence. Since time immemorial, the First Americans have been a part of the natural ecosystem of the Columbia Basin, including Hanford, the Hanford Reach, and the area to be studied as part of this assessment. Archaeological records show that use and occupation of parts of Hanford extend back at least 11,000 years. From generation to generation, knowledge concerning the use of indigenous plants as foods and natural and spiritual medicines has been passed down by tribal elders. To this day, they continue to teach that spiritual value is inherent in all natural resources, from the waters which give life, the foods that provide sustenance, the language and place names that provide continuity between generations and recognition of the ancestral homelands, to the landscape that provides wholeness and shelter for all life forms. Natural resources remain an integral and inseparable part of tribal culture.

Following the coming of Europeans, use of the area by indigenous peoples was severely curtailed, but not extinguished. The Yakama Indian Nation and the Confederated Tribes of the Umatilla Indian Reservation, in the Treaties of 1855, ceded the land on which Hanford sits to the United States, expressly reserving rights to hunt, fish, and gather natural foods and medicines. The Tribes never ceded the right to practice their traditional and ancient spirituality throughout their ancestral lands. The Nez Perce Tribe also retains the right to fish in usual and accustomed places along the Hanford Reach. The area that encompasses the Hanford reserve continued to provide the Yakama, Umatilla and Nez Perce peoples, as well as the Wanapum people, with traditional foods, medicines, and materials that were harvested throughout the year.

In 1943, with the establishment of Hanford, the government restricted the ability of the Tribes to exercise the rights guaranteed them under the treaties. Under the terms of the treaties and the doctrine of trust responsibility established through many U.S. Supreme Court decisions over the last 200 years, the Tribes consider Hanford to be a legally protected place to exercise treaty-reserved rights. As such, the Tribes view all of Hanford as a cultural reserve with abundant natural resources and valuable habitats as well as many sites of significant historical and spiritual importance to the Yakama, Umatilla, and Nez Perce peoples.

Cultural uses and resources in the Hanford area include the cultural use of natural resources, the cultural significance of the Hanford landscape, and individual sites and cemeteries. From the tribal perspective, the Big River, N'chi'wana, remains the lifeblood of tribal culture and traditions, as it has been for generations upon generations. The river sustains and nourishes many related peoples, including the salmon, the deer, the eagle, the human, the sagebrush, etc. Proximity - in spirit, heart, and mind - to and with the atwana (river), shapes tribal perspectives. The Columbia River and environs contains buried ancestors, material culture, artifacts, and numerous cultural sites that help define the cultural services provided to the tribes by the river.

Site Operations and NPL Designation

Operation of nuclear reactors and ancillary facilities on the Site resulted in the production and disposal of large quantities of solid, liquid and gaseous wastes containing hazardous substances. Wastes were introduced to soil, groundwater and the Columbia River through disposal, discharges, and unplanned releases. Due to these releases of hazardous substances to the environment, the Site was evaluated according to the EPA's Hazard Ranking System in 1988 and added to the NPL in 1989 under authorities granted by CERCLA (1980), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. Four separate areas within the Site were listed as NPL sites, including the 100 Area, 200 Area, 300 Area and 1100 Area (Figure 3). This Assessment Plan focuses on 100-Area releases and their impacts to the Columbia River aquatic environment.

The 100 Area is located in the north-central part of the Site along the southern and parts of the northern shoreline of the Columbia River (Figure 3). Nine reactor sites are located in 100 Area. All reactors were used for plutonium production, and have been decommissioned or are in the process of being decommissioned. Eight reactors were designed for direct cooling, utilizing Columbia River cooling water that was pumped through the reactors and discharged back into the river during the years of reactor operation. The ninth reactor, N reactor, was designed with a closed-loop cooling system. This system utilized cooling water from the river that was first purified then re-circulated through the reactors to produce steam. Excess cooling water was discharged to a crib near the river shoreline. Table 1 lists the nine reactors and their period of operation.

Table 1. Hanford 100 Area production reactors.

Reactor	Period of Operation
B	1944-1946 1948-1968
D	1944-1967
F	1945-1965
H	1949-1965
DR	1950-1964
C	1952-1969
K West	1955-1970
K East	1955-1971
N	1963-1987

In addition to direct discharges to the Columbia River, large quantities of solid and liquid wastes were discharged to facility structures such as cribs, unlined trenches, and retention basins, or directly to the soil. As a result of these and other disposal practices, as well as unplanned releases, hazardous substances associated with reactor facility operations were introduced to the soils in reactor facility areas, and in some cases, to groundwater beneath the contaminated soil areas. As part of the NPL listing, operable units (OUs) were designated to organize cleanup efforts and address contaminated areas with similar types of waste sites. Seventeen OUs, including 11 source OUs and 6 isolated units (IUs) (Figure 4), were designated in the 100 Area in the vicinity of reactor facilities to address contaminant sources. Five OUs (Figure 4) were designated to address contamination of groundwater beneath the source OUs due to migration of hazardous substances from the soils above. Table 2 describes contaminants of concern (COC) or contaminants of potential concern (COPC) and potentially exposed media for the 100 Area source OUs and IUs, based on information provided in available CERCLA documents. This table describes the general nature of contamination originating from the source OUs, with a focus on contamination that has potentially impacted the underlying groundwater, and is not intended to be a complete characterization of the source OUs.

Figure 4. Hanford 100 Area Operable Units

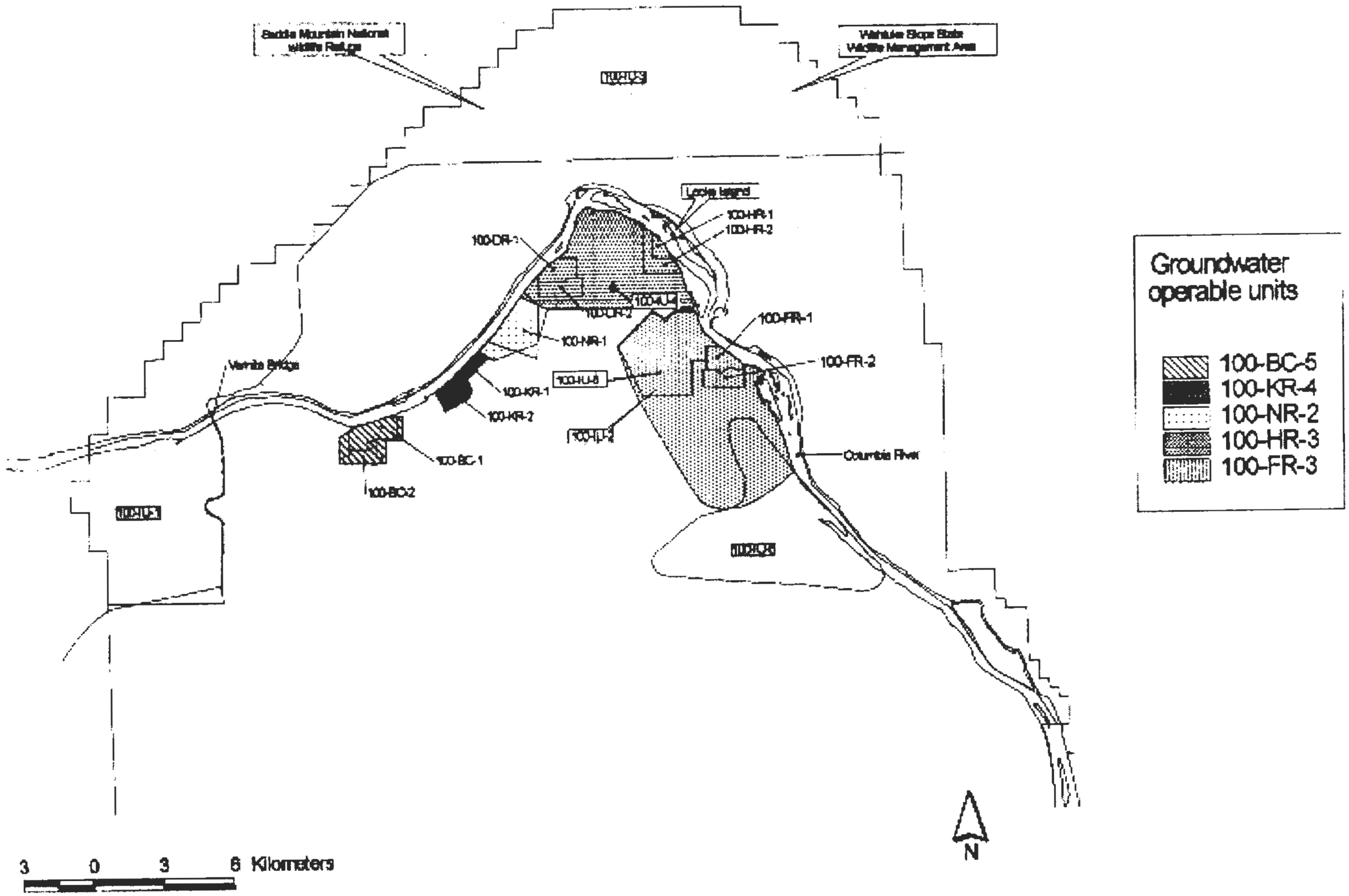


Table 2. Hanford 100 Area source operable units.

Operable Unit	Description
100-BC-1	B reactor plant facility wastes, and B and C reactor cooling retention basin wastes; high priority radioactive liquid waste disposal sites; Sb, Ba, Cr, Hg, Pb, semi-volatile organics, radionuclides; releases to soil, groundwater (100-BC-5) and Columbia River.
100-BC-2	Includes original 100-BC-3 and 100-BC-4 OUs; radioactive liquid waste and solid waste from C reactor operations resulting in soil and groundwater (100-BC-5) contamination.
100-KR-1	High priority radioactive liquid waste disposal sites, solid waste disposal sites; Cr, Hg, TCE radionuclides; releases to soil and Columbia River; groundwater impact (100-KR-4).
100-KR-2	Includes K-East and K-West reactors.
100-NR-1	Includes N-springs riverbank seeps and associated contaminated soils; principal COC include Cr, Cu, Pb, Ni, Zn, radionuclides (including Sr-90), petroleum hydrocarbons; contaminated soils/debris at liquid waste disposal sites, solid waste surface disposal areas, unplanned releases (UPRs); soil exposure, groundwater exposure (100-NR-2), surface water exposure (N-springs).
100-DR-1	As, Cr, pesticides, PCBs, semi-volatile organics and radionuclides; releases to soil and Columbia River.
100-DR-2	Cr, radionuclides; releases to soil.
100-HR-1	H reactor plant facility wastes, and retention basins for 300 Area liquid process and chemical wastes; As, Cr, Pb, Zn, fluoride, semi-volatile organics and radionuclides; releases to soil.
100-HR-2	Cd, Pb, Hg, fluoride, radionuclides; high priority solid waste burial grounds; soil exposure.
100-FR-1	As, Ba, Cd, Cr, Cu, Pb, Hg, Ag, Se, Zn, chlordane, PCBs, radionuclides; high priority radioactive liquid waste disposal sites, solid waste disposal sites; soil and groundwater (100-FR-3) exposure.
100-FR-2	Primarily solid waste burial grounds; soil and groundwater (100-FR-3) exposure.
100-IU-1	Riverland Rail Yard; COC included aldrin, dieldrin, 2,4-D and petroleum contaminated soil; COC cleaned up to below Model Toxics Control Act (MTCA) residential cleanup standards; no identified groundwater contamination.
100-IU-2	White Bluffs Townsite; COPC include hydrocarbons, Pb, TCE; no current evidence of groundwater contamination by hydrocarbons or Pb; TCE contamination of groundwater (DOE 1996); groundwater contamination from 100-IU-2 monitored through 100-FR-3 OU.
100-IU-3 *	Wahluke Slope; COC included asbestos-containing materials, organic solvents, petroleum products, paints, grease, DDT and petroleum contaminated soils; COC cleaned up to below MTCA residential cleanup standards; no identified groundwater contamination.
100-IU-4	Sodium dichromate barrel landfill; primary COC was Cr; COC cleaned up to below MTCA residential cleanup standards; no identified groundwater contamination.
100-IU-5	White Bluffs pickling acid cribs; COC included spent nitric and hydrofluoric acids; COC cleaned up to below MTCA residential cleanup standards; no identified groundwater contamination.

Operable Unit	Description
100-IU-6	Hanford Townsite; COPC include hydrocarbons, Pb; no evidence of groundwater contamination from 100-IU-6 sources.

* 100-IU-3 is located on the North Slope, which is part of the 100 Area delisted from the NPL on July 8, 1998. There have been no identified impacts to the Columbia River system from North Slope waste sites.

Contaminated groundwater currently serves as the primary pathway of exposure of the aquatic environment. Therefore, groundwater contamination issues present the most immediate concern for potential injury to aquatic resources. Groundwater OUs include contaminated groundwater underlying the specified source OUs, the adjacent groundwater, saturated soils, surface water and aquatic biota impacted by the respective reactor area operations (Ayres 1994). Figure 4 shows groundwater OU locations relative to source OUs. Table 3 describes COC or COPC identified in groundwater, and identified discharges to the aquatic environment. Information was taken from Peterson et al. (1996) for 100-BC-5, 100-KR-4, 100-HR-3, and 100-FR-3 OUs. The COC listed are based on concentrations elevated above EPA's maximum contaminant levels (MCL). Information for the 100-NR-2 OU was taken from Borghese (1997).

Table 3. Hanford 100 Area groundwater operable units.

Operable Unit	Description
100-BC-5	Includes contaminated groundwater underlying the 100-BC-1 and 100-BC-2 OUs; primary concern for groundwater is liquid waste from source OUs; elevated COPC in groundwater include Cr, Fe, Sr-90 and tritium; the proposed plan for interim decision (*DOE/RL-94-112 Draft A*) reports no COC at levels that warrant interim actions (DOE 1994a).
100-KR-4	Includes contaminated groundwater underlying 100-KR-1 and 100-KR-2 OUs; primary COC is hexavalent Cr; also Al, Fe, Mn, Ni, Se, carbon-14, Sr-90, gross beta, tritium, TCE; groundwater contamination with discharge to Columbia River.
100-NR-2	Includes contaminated groundwater underlying 100-NR-1 OU; groundwater COC include Sr-90, tritium, Cr, Mn, TPH; primary COC for Columbia River Sr-90 and tritium; groundwater discharge to Columbia River (N-springs).
100-HR-3	Includes contaminated groundwater underlying 100-HR-1, 100-HR-2, 100-DR-1, 100-DR-2 and 100-IU-4 OUs, and the portion of the 600 area lying in between the 100-H and 100-D/DR areas; primary COC is hexavalent Cr; COPC include Sr-90, tritium, technetium-99, fluoride; groundwater contamination with discharge to Columbia River.
100-FR-3	Includes contaminated groundwater underlying 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-5OUs; COPC include TCE, Cr, Mn, Sr-90, tritium; TCE contamination of groundwater, soil gas; Limited Field Investigation report (*DOE/RL-95-99 Rev. 0*) states that TCE levels in 100-FR-3 groundwater OU are low risk to humans and environment (DOE 1996).

I.D REMEDIAL ACTIVITIES IN THE HANFORD 100 AREA

In anticipation of the NPL listing, DOE, EPA and Ecology entered into a Federal Facility Agreement and Consent Order, referred to as the Tri-Party Agreement (TPA), in May 1989. The TPA established a procedural framework and schedule for developing, implementing, and monitoring remedial response actions at Hanford. Numerous remedial activities have been implemented to address hazardous waste sites in the 100 Area to date. Operable unit-specific LFIs have been conducted to characterize contamination in soils, facility structures, solid waste debris and groundwater. Operable unit-specific QRAs were also conducted to evaluate current and potential effects of contaminants from the respective OUs on both human and ecological receptors. The U.S. Department of Energy has performed a 100 Area wide Phase 1 and 2 Feasibility Study, and a Phase 3 Source Waste Site Feasibility Study as part of the CERCLA process. In many cases, results of such investigations, QRAs, and feasibility studies have indicated that expedited response actions or interim remedial measures (IRM) are warranted for specific OUs in order to accelerate remediation, or to protect humans or the environment from immediate threats due to contamination. Numerous investigative reports, QRAs, conceptual site models (CSM) for contamination at specific OUs, proposed plans for IRM or interim decisions, and plans for mitigation or cleanup have been published regarding 100-Area OUs. In some cases an interim action ROD has been established. It is important to note that no baseline ecological risk assessment has been completed for the 100 Area, as stated in section I.B. Table 4 provides a summary of remedial activities for groundwater OUs, which will most directly affect the aquatic system.

Table 4. Remedial activities in groundwater operable units.

Operable Unit	**Remedial Activity**
100-BC-5	Published QRA and CSM; proposed plan for interim decision reports no COC at levels that warrant interim actions (DOE 1994a).
100-HR-3 and 100-KR-4	Published QRAs and CSMs for both OUs; DOE has initiated an (IRM) in both HR-3 and KR-4 OUs in response to significant levels of Cr in groundwater near Columbia River. Remedial action is pumping and treating groundwater for Cr removal. Interim action ROD has been issued.
100-NR-2	Published QRA and CSM; expedited response action for N-Springs; plan for IRM to pump and treat groundwater for Sr-90 removal, reduce flow of contaminated groundwater into Columbia River, and recover petroleum from existing wells.
100-FR-3	Published QRA and CSM; LFI report specified TCE levels in 100-FR-3 groundwater OU are low risk to humans and environment (DOE 1996).

I.E TRUSTEE COORDINATION WITH REMEDIAL ACTIVITIES

The HNRTC was established as a collaborative working group under a Memorandum of Agreement (MOA) among the seven participating natural resource trustees, with the intent of facilitating "*coordination and cooperation of the Trustees in their efforts in restoring, and minimizing impacts to, natural resources injured as a result of, or during clean up of, releases associated with the Hanford Site*" (DOE 1995). The MOA states the HNRTC objectives as follows:

- X *To help ensure that natural resource values are fully considered in decision-making related to the Hanford Site.*
- X *To integrate, to the extent practicable, natural resource restoration into remedial actions taken at the Hanford Site; and to minimize resource injury during remedial action.*
- X *To encourage the development and implementation of sitewide natural resource planning which supports mitigation, restoration, and management goals, and encompasses good stewardship practices.*
- X *To provide the Department of Energy and regulatory agencies the information necessary to achieve objectives 1-3 above* (DOE 1995).

The HNRTC has initiated a series of aquatic resources investigations complementing this Assessment Plan and assisting in the remedial process for the 100-HR-3 and 100-KR-4 groundwater OUs. All aspects of these investigations will be approved by the HNRTC or its designated working groups. Three initial investigations will be conducted as part of an inter-agency agreement between USFWS and DOE to address potential aquatic resource injury due to contamination of the Columbia River system by chromium (Cr). Information obtained from these investigations will be available for use in remedial design and the final ROD for the 100-HR-3 and 100-KR-4 OUs, and possibly other Hanford Site OUs where Cr contamination of groundwater is of concern. These investigations and any additional investigations will also serve to identify potential injury occurring to natural resources associated with the river system from exposure to hazardous substances released from the 100 Area.

II. TRUSTEE AUTHORITY OVER NATURAL RESOURCES

Under Section 107(f) of CERCLA, 42 U.S.C. § 9607(f), the United States, Indian Tribes, and/or States are authorized to recover damages for injury to, destruction of, or loss of natural resources resulting from a release of hazardous substances from a facility. These sovereign entities are authorized to act as trustees for natural resources within their trusteeship. For the United States, natural resource trusteeship has been delegated to specific federal officials in Executive Order 12580 and the National Contingency Plan, 40 CFR § 300.600.

Under the National Contingency Plan, "where there are multiple trustees, because of coexisting or contiguous natural resources or concurrent jurisdictions, they should coordinate and cooperate in carrying out" their trustee responsibilities, 40 CFR § 300.615. Each trustee may have co-trustee authority over natural resources listed within the trusteeship of the other trustees. The Hanford 100 Area Assessment is an example of a multiple-trustee situation where trustees coordinate through the HNRTC. Participating natural resource trustees include the State of Washington, the State of Oregon, the U.S. Department of the Interior, DOE, the Yakama Indian Nation, the Nez Perce Tribe, and the Confederated Tribes of the Umatilla Indian Reservation. Other trustees not currently represented on the HNRTC include U.S. Department of Commerce and the U.S. Department of Defense. The Confederated Tribes of the Warm Springs Reservation also have potential Trustee interests in the Hanford area.

III. RELEASE OF HAZARDOUS SUBSTANCES

Hazardous substances continue to be released into the Columbia River aquatic system from sources originating in the 100 Area via groundwater movement. These sources include, but are not limited to, the source waste sites associated with the nine reactor areas of the 100 Area, and the corresponding groundwater contaminant plumes. The nature of these waste sites and the mechanisms by which hazardous substances were introduced to soil, groundwater, and surface water are described in the various CERCLA documents pertaining to source and groundwater OUs of the 100 Area.

Through the CRCIA (1998) process, a list of more than 600 potential contaminants was compiled and subjected to a multilevel screening process to identify those contaminants that have been detected in the Columbia River/Hanford area, and those of potential risk to human health and the Columbia River ecosystem. Twenty COC determined to be of Hanford origin, plus direct irradiation, were identified in soil, sediment, groundwater within 150 meters of the Columbia River, and in the Columbia River (CRCIA 1998). Of the 20 COC, 18 are hazardous substances, including antimony (Sb), Arochlor 1248 (PCB), arsenic (As), cesium (Cs)-134, Cs-137, chlordane, Cr, cobalt (Co)-60, copper (Cu), diesel fuel, europium (Eu)-152, Eu-154, lead (Pb), manganese (Mn), mercury (Hg), silver chloride, strontium (Sr)-90, and zinc (Zn) (nitrate/nitrite and phosphate are not considered hazardous substances). Two additional contaminants, carbon tetrachloride and fluoride, were identified in groundwater greater than 150 meters from the river. Since the CRCIA process was not limited to the 100 Area, it is likely that some of these contaminants originated from Hanford areas other than the 100 Area.

Section VI of this document presents 16 contaminants (plus gross alpha and beta) derived from the Hanford 100 Area that are identified as COC to aquatic resources, based on documented exposure of specific aquatic resources to each contaminant listed. In this assessment, a resource is considered to be exposed to a specific contaminant if current data exists demonstrating concentrations of the contaminant detected in that resource above the criteria described in Section VI (typically above an established MCL, or above background levels).

Seven of the COC identified in the CRCIA process, including Cs-137, Cr, Co-60, Cu, Eu-152, Eu-154, and Sr-90, are also identified in Section VI as being COC to aquatic resources based on exposure. Contaminants of concern that are identified in the CRCIA process, but not listed in Section VI of this Assessment Plan, potentially originated from (1) an area other than 100 Area, or (2) from the 100 Area, but none of the data reviewed during the confirmation of exposure process indicated current exposure of an aquatic resource to the contaminants based on the criteria used. In addition, it should be noted that the criteria used in CRCIA to screen for COC are focused on prediction of risk, rather than exposure (i.e., different criteria potentially identify different COC). Similarly, the COC identified in Section VI, but not in the CRCIA process, were likely identified due to the different criteria used.

This assessment will focus on those Hanford 100 Area-derived contaminants to which, based on available data, aquatic resources have been exposed. In addition to having direct effects on the environment, these contaminants identified in the aquatic system may have effects due to interactions with other hazardous or non-hazardous compounds, or may form new hazardous compounds or decay products that are released into the environment as they undergo physical, chemical, or biological processes.

IV. DESCRIPTION OF ASSESSMENT AREA AND NATURAL RESOURCES

The Columbia River aquatic system includes a large variety of natural resources that are important to the respective natural resource trustees, and which may have been exposed to, and potentially injured as a result of, releases from the Hanford 100 Area. These natural resources may include any resource associated with the aquatic system, and fall under the general categories of groundwater, surface water, geologic, biological, and cultural resources. Exposure of aquatic resources to hazardous substances from the 100 Area potentially occurs both directly (e.g., releases into groundwater) or via an aquatic pathway (e.g., exposure of aquatic biota from groundwater seeps into the river). Therefore, the Hanford 100 Area Assessment Area (Assessment Area) that is defined for the purpose of assessing injury to aquatic resources due to Hanford 100-Area releases must include a geographic range that takes into account aquatic exposure pathways, and all resources exposed.

Section IV.A below geographically defines the Assessment Area, and identifies the portion of the Assessment Area where there is current exposure of natural resources to hazardous substances. Section IV.B provides a brief description of the natural resources associated with that portion of the Assessment Area. Through processes such as CRCIA (1998), detailed characterizations of the Columbia River (primarily the Hanford Reach) and associated natural resources have been performed. Since extensive summaries of Columbia River resources are available, this Assessment Plan will reference CRCIA (1998) and other documents as necessary for detailed descriptive information.

IV.A GEOGRAPHIC DESCRIPTION OF ASSESSMENT AREA

For this Assessment Plan, the Assessment Area includes the Columbia River and associated aquatic system from River Mile 385, located in the Hanford Reach, out to the Pacific coast. This area is consistent with the extent of demonstrated exposure. As described in section VI.A, no data were located indicating exposure of aquatic resources to Hanford-derived contaminants in the portion of the Hanford Reach between Priest Rapids Dam and River Mile 385. This section is provided in order to support the conclusion that no exposure is occurring here. However, available data did indicate exposure downstream from River Mile 385, as described in section VI.B. Therefore, River Mile 385 has been established as the upstream boundary of the Assessment Area. In addition, concentrations of hazardous substances originating in the Hanford Area have in the past been documented in sediment and marine biota out as far as the Pacific Ocean (Wells 1994). For the purposes of this assessment, the Assessment Area will be evaluated in three sections, including two segments of the Columbia River (River Mile 385 to McNary Dam and McNary Dam to the mouth of the Columbia River), and coastal areas near the mouth of the Columbia River. In addition, the river segment between Priest Rapids Dam and River Mile 385 will be evaluated as a background area. This Assessment Plan will focus primarily on the first segment of the Assessment Area (River Mile 385 to McNary Dam), since this is the area of documented current exposure, as presented in Section VI.

Priest Rapids Dam to River Mile 385
This river segment is not considered part of the Assessment Area, but will be evaluated as a background area. As presented in section VI.A, data evaluated indicates that no aquatic resource exposure to Hanford-derived contaminants is occurring here. This segment therefore represents similar aquatic habitat characteristics to those of the first segment of the Assessment Area, without the impacts from 100-Area releases that are documented in the first segment of the Assessment Area.

River Mile 385 to McNary Dam
The uppermost river segment of the Assessment Area begins at River Mile 385, approximately 3 miles downstream from Vernita Bridge, and includes the portion of the Hanford Reach that flows through the Site and ends at McNary Dam. This segment includes McNary Pool, the impoundment formed behind McNary Dam, which serves as a trap for sediments carried downstream from the Site. Data indicates that current exposure is occurring in this segment and therefore it will be the focus of this assessment.

McNary Dam to Mouth of Columbia River
The second river segment of the Assessment Area begins at McNary Dam and extends downstream to the mouth of the Columbia River. The uppermost stretch of this river segment, from McNary Dam downstream to Bonneville Dam, is primarily impounded water, due to the presence of John Day Dam, The Dalles Dam, and Bonneville Dam.

This stretch includes a series of particulate traps and sinks formed by the impoundments. The lower stretch of river (from Bonneville Dam out to the mouth) is characterized by unimpounded water, with tidal influence near the mouth of the river. None of the data reviewed indicates current exposure of aquatic resources to Hanford-derived contaminants in this segment, therefore it will not be a focus of this assessment.

Coastal Areas
The coastal areas for this Assessment Plan are defined as the geographic areas along the Oregon seacoast that were monitored by Oregon Health Department for Hanford-derived radionuclides from 1962-1993, including the Columbia River estuary (OHD 1994). These geographic areas are consistent with the sampling areas within which aquatic resource exposures to contaminants of Hanford origin were documented up until the mid-1980's (OHD 1994). Since Hanford-derived contaminants have not been detected in these areas since the mid-1980's, further efforts to describe these geographic areas and associated resources will not be undertaken in this Assessment Plan. More detailed descriptions can be found in OHD (1994).

IV.B DESCRIPTION OF NATURAL RESOURCES

Groundwater Resources
Hanford Site groundwater consists of an unconfined upper (or suprabasalt) aquifer generally located in the Hanford geologic formation, an underlying semi-confined aquifer in the Ringold geologic formation, and a confined aquifer located within Columbia River basalts. In many places the unconfined aquifer is connected with the semi-confined aquifer beneath it. Confined aquifer water movement is generally in the direction of the Columbia River, with some hydraulic communication with the semi-confined and unconfined aquifers. Neitzel et al. (1996) reports a potential for significant groundwater leakage between the confined and unconfined systems. Groundwater moves in the unconfined aquifer from elevated recharge areas west of the Site, towards the river to the north and east. Discharge of the unconfined aquifer is primarily to the Columbia River. The Yakima River (Figure 3) to the southwest serves as a recharge source. In addition to natural recharge, groundwater in the Hanford area is affected by artificial recharge, including excess irrigation, industrial processing and waste water disposal. Neitzel et al. (1996) reported that artificial aquifer recharge from wastewater disposal (estimated at a total volume of 4.44×10^{11} gallons) at the Site has been significantly greater than natural recharge from 1944 to the time of the report.

Groundwater within the 100 Area along the Hanford Reach ranges in depth from 0 meters (near the river) to 30 meters (inland from the river). The water table is generally located within the Hanford or Ringold geologic formations. The relationship between groundwater and the Columbia River creates a complex hydrology in this area. Typically the direction of groundwater movement is towards the river. During high river stages (river level above groundwater level) groundwater moves away from the river.

Surface Water Resources
The primary surface water resource in the Assessment Area is the Columbia River. The Hanford Reach of the Columbia River extends fifty-one miles from Priest Rapids Dam, through the Site and down to McNary Pool, the impoundment formed by McNary Dam. Although it is impacted by the presence of Priest Rapids Dam and six other dams upstream, the Hanford Reach is considered the only unimpounded stretch of the Columbia River in the United States, with the exception of the reach below Bonneville Dam and the Columbia River estuary. Mean river discharge in the Hanford Reach is greatest during spring runoff from April through June and is lowest from September through October. Flows in the Hanford Reach fluctuate significantly due to operations at mid-Columbia River hydroelectric projects and water storage practices. In addition to hydroelectric power production and irrigation, uses of Columbia River water include a drinking water source for communities downstream of the Hanford Reach, a drinking water and industrial water source for Hanford onsite facilities, and recreational activities such as fishing, hunting, boating, and various water sports. The Columbia River also provides an extensive aquatic habitat for fish, wildlife, and aquatic organisms.

Riverbank springs (groundwater seepage into the Columbia River) in the first segment of the Assessment Area occur both naturally, due to releases of water which is stored in riverbanks during high river stages, and artificially due to groundwater recharge from wastewater disposal. The springs are relatively small and flow is intermittently influenced by river level fluctuations (Neitzel et al. 1996).

The Columbia River riparian zone includes the largest wetland habitat on the Hanford Site. These areas include willows, grasses, aquatic macrophytes and other wetland plants, and provide habitat for waterfowl and wetland and riparian based wildlife. Water levels fluctuate greatly in these areas, primarily due to management of water levels at Priest Rapids Dam just upstream (Neitzel et al. 1996).

Geologic Resources (Soils/Sediments)
The Columbia River provides outflow to the Pacific Ocean from the Pasco Basin of the Columbia River Plateau. The basin has received fluvial, lacustrine and glacialfluvial sediment accumulations as a result of geologic events. The uppermost sedimentary layer covering much of the Site is known as the Hanford formation, consisting primarily of sand and gravel from the last ice age (CRCIA 1998). Of the fifteen soil and sediment types identified on the Site, CRCIA (1998) reports the most important soils and sediments associated with the Columbia River as follows:

X Rupert Sand - coarse, sandy alluvial deposits overlain by windblown sand.
X Burbank Loamy Sand - loamy sand over gravel.
X Ephrata Stony Loam - medium-textured soil over gravel; topographic hummocks containing boulders.
X Ephrata Sandy Loam - medium-textured soil over deep gravel deposits.
X Riverwash Soil - small areas of sand, gravel and boulder deposits in wet, periodically flooded areas; overflowed islands and shoreland.

X Dune Sand - hills and ridges of sand-sized particles; drift into river during strong winds.

These types of soils and sediments, originating from the Site, exist in the Columbia River and along its shorelines throughout the Hanford Reach.

Biological Resources

The Columbia River system along the Hanford Reach supports a large variety of biota, including birds, mammals, fish, aquatic organisms, amphibians, reptiles, and vegetation, existing in both aquatic and riparian habitats. Summaries are provided in CRCIA (1998) of the dominant vegetation, mammals, birds, amphibians, and reptiles in the riparian community, as well as the existing taxonomic groups of aquatic vegetation, benthic invertebrates, and fish species in the aquatic community. In addition, CRCIA (1998) provides a list of 368 species that occur in the Hanford Reach.

Fickeisen et al. (1980) reports waterfowl, shorebird, fish-eating bird, upland game bird, passerine, and raptor use of the Hanford Reach to include nesting and brood rearing, wintering and staging of migrating populations, and feeding/fishing. Mammals potentially occurring in the area include deer, mice, shrew, fur-bearers, muskrats, bats, coyote, raccoon, skunk, and bobcat (CRCIA 1998). Table 5 lists endangered, threatened, and candidate bird and mammal species that potentially exist or intermittently occur in the first segment of the Assessment Area.

Table 5. State and federal listed endangered, threatened, and candidate birds and mammals.

SPECIES	Washington State Status (as of 7/99)	Federal Status (Date listed)
Peregrine falcon (*Falco peregrinus*)	Endangered	*
American white pelican (*Pelecanus erythrorhynchus*)	Endangered	--
Sandhill crane (*Grus canadensis*)	Endangered	--
Bald eagle (*Haliaeetus leucocephalus*	Threatened	Threatened (6/95)
Ferruginous hawk (*Buteo regalis*)	Threatened	--
Aleutian Canada goose (*Branta canadensis leucopareia*)	Threatened	Threatened (12/90)
Common loon (*Gavia immer*)	Candidate	--
Snowy plover (*Charadrius alexandrinus*)	Endangered	--
Pygmy rabbit (*Brachylagus idahoensis*)	Endangered	--

* Delisted 8/99

Forty-four fish species in the Hanford Reach, including migrating chinook and sockeye salmon and steelhead trout, are identified in CRCIA (1998). Table 6 lists endangered, threatened, proposed, and candidate species of fish, amphibians, and aquatic organisms known to occur in, spawn in, or migrate through the first segment of the Assessment Area.

Table 6. State and federal listed endangered, threatened, proposed, and candidate fish, amphibians, and aquatic organisms.

SPECIES	Washington State Status (as of 7/99)	Federal Status (Date listed)
Upper Columbia River Steelhead (*Oncorhynchus mykiss*)	Candidate	Endangered (8/97)
Middle Columbia River Steelhead (*O. mykiss)*	Candidate	Threatened (3/99)
Snake River Steelhead (*O. mykiss)*	Candidate	Threatened (8/97)
Upper Columbia River Spring Chinook Salmon (*O. tshawytscha*)	Candidate	Endangered (3/99)
Chinook Salmon, Snake River fall and spring/summer populations (*O. tshawytscha*)	Candidate	Threatened (4/92)
Columbia River Chum Salmon (*O. keta*)	Candidate	Threatened (3/99)
Snake River Sockeye salmon (*O. nerka*)	Candidate	Endangered (11/91)
Sea run cutthroat trout (*O. clarki clarki*)	--	Proposed as Threatened (4/99)
Bull trout (*Salvelinus confluentus*)	Candidate	Threatened (6/98)
River lamprey (*Lampetra ayresi*)	Candidate	--
Leopard dace (*Rhinichthys falcatus*)	Candidate	--
Mountain sucker (*Catostomus platyrhynchus*)	Candidate	--
Columbia spotted frog (*Rana pretiosa*)	Candidate	--
California floater (*Andonta californiensis*)	Candidate	--
Great Columbia River spire snail (*Lithoglyphus columbianus*), also known as Columbia pebble snail (*Fluminicola columbianus*)	Candidate	--

Table 7 lists endangered, threatened, and sensitive species of plants potentially associated with the Columbia River aquatic system in the first segment of the Assessment Area.

Table 7. State and federal listed endangered, threatened, and sensitive plants.

SPECIES	Washington State Status (as of 1/99)	Federal Status (Date listed)
Columbia yellowcress (*Rorippa columbiae)*	Threatened	--
Northern wormwood (*Artemisia campertris ssp borealis var wormskioldii)*	Endangered	--
Columbia milk-vetch (*Astragalus columbianus)*	Threatened	--
Shining flatsedge (*Cyperus bipartitus)*	Sensitive	--
Hoover's desert-parsley (*Lomatium tuberosum)*	Threatened	--
Ute ladies'-tresses (*Spiranthes diluvialis)*	--	Threatened (1/92)
Dwarf evening primrose (*Oenothera pygmaea*)	Threatened	--

Cultural Resources

In general, any of the above listed resources may serve as a cultural resource to tribes. Since 43 CFR Part 11 does not define cultural resources and their uses and services, it is left to the participating tribes, including the Yakama, Umatilla, and Nez Perce peoples, to determine how they will be defined. More than 10,000 years of tribal occupation have left extensive archaeological deposits along the river shores as well as many inland areas. Attachment to land and water means that sacred sites are not always confined or precisely located, and are numerous and diverse in form. They also include the cultural and physical factors of the landscape and the landforms themselves, which provide the context within which tribal life ways are practiced, and which are culturally defined through legends, events, and customs as sacred places or areas of tribal historical significance. In this light, the Hanford Reach and adjacent areas are a cultural landscape whose elements cannot be separated.

Cultural Resources also include Traditional Cultural Properties, which are properties that have traditional cultural significance and/or are associated with cultural practices or beliefs that are rooted in a community's history and are important in maintaining the continuing cultural identity of the community (National Register Bulletin #38). The identification of such properties is not dependent on physical evidence, and may not have been recorded in terms of metes and bounds, but depend on the identification by the affected community. For the Assessment Area, tribes associate the area in general with beliefs about their origin, their cultural history, and the nature of the world. Tribal members continue to go to specific locations to perform ceremonial activities in accordance with traditional religious rules. They also make widespread use of foods and medicines, and barter and exchange items gathered across the area. The act and method of gathering, processing, using, and exchanging these items can all carry important cultural significance. The tribes identify all of the Assessment Area as a traditional cultural property due to its subsistence, spiritual, ancestral, and social importance.

Natural resources are treated with due respect and utilized only after appropriate ritual. Landforms are likewise culturally defined through legends, events, or customs as sacred places or areas of tribal historic significance.

Water is the respected entity of cultural and religious beliefs for the Columbia Basin tribes.

> *Since time immemorial, before the coming of the People, Water stepped forward and said, "I shall be life-giving to all - to plants and to animals and to Man." Ever since that day, Water has kept its promise.*

The oral history tells of the Creator creating the People from the land, with the water becoming the life-blood of the body, and the wind becoming the breath of life. The Unwritten Law tells the People to be the caretaker of these resources. This belief is one of religious stewardship.

> *During religious services, Water is acknowledged as a life-blood of the "beautiful land" on which we walk, as we are part of this land. Water has its place in the peoples' spiritual way of life. Water is the sustenance of our life. Water is the gift of survival for the people, and is included in our worship and daily ritual.*

Water is the interconnection between land and all life forms, including biota with sustenance, medicinal, food, implement, decorative, and teaching uses. The plants and animals given life by water are also part of the Columbia Basin religions. Water is a single resource, whether occurring as groundwater, seeps, springs, streams, rivers, wetlands, soil moisture, precipitation, recharge, snowpack, drainage waters, or any other forms. Clean water is vital to the health and welfare of the Native Peoples, and it is a civic and religious duty to protect the environmental quality and integrity of all surface and groundwater. All waters have cultural and religious significance and provide cultural and religious services. The religious, cultural, personal, and ecological significance of water guides the appropriate use, management, and protection of water resources.

V. PRELIMINARY LIST OF SERVICES PROVIDED BY NATURAL RESOURCES

The natural resources in the Assessment Area provide a wide variety of services to the Trustees and the public whose interest they protect. The NRDA regulations require that each service addressed in the assessment be linked to a potential natural resource injury.

The following is a preliminary list of services potentially provided by the natural resources in the Assessment Area. The list addresses generally those resources occurring in the first segment, although these services may apply to any area where the resources occur. Only those resources associated with the aquatic (i.e., Columbia River) system, including, groundwater, surface water, biota, geologic, and cultural resources will be addressed. Once a full assessment of injuries has been made, the specific services provided by individual resources will be identified, and a more detailed list of services lost, or reduction of services, may be completed. In addition, the value of lost or reduced services may be determined in the damage determination phase of the assessment.

Groundwater provides:
X Drinking water
X Domestic, commercial, municipal, and industrial uses
X Surface water recharge
X Wetland recharge
X Habitat for hyporheic zone invertebrates
X Other

Surface water provides:
X Habitat for fish and wildlife
X Recreation, including sport fishing, hunting, boating, contact recreation, and wildlife observation
X Transportation
X Groundwater discharge
X Provisions for wildlife habitat
X Subsistence and personal use
X Commercial fishing
X Other

Biota provides:
X Subsistence fishing, hunting, and gathering
X Recreational hunting, fishing, and wildlife observation
X Food chain services (aquatic and terrestrial)
X Habitat for trustee species including shelter and breeding areas
X Species diversification and ecosystem balance
X Scientific assessment and research
X Education
X Flood control (wetlands)
X Waste assimilation
X Other

Geologic resources (soils, sediments, and minerals) provide:
X Medium for vegetative growth and related services, such as gardening,

agriculture, gathering, rangeland, forestry and timber production, wildlife habitat, and erosion control

X Provisions for terrestrial, riparian, and aquatic ecosystems

X Recreation (including hunting and trapping, gathering), camping, picnicking, wildlife observation

X Land use (public and traditional)

X Other

In general, cultural services that may be provided by water, biota, air, and geology might include:

X Ceremonial drinking water

X Habitat for sacred, medicinal, and subsistence plants

X Habitat for subsistence animals, birds, and fish

X Sacred ground for worship

X Sacred meeting places

X Burial grounds

X Other

In addition to the above attributes, many people derive pleasure from knowing that the natural resources exist and are available for future use. Natural resources can also provide cultural and spiritual values to certain members of the public.

VI. SUMMARY CONFIRMATION OF EXPOSURE TO AQUATIC RESOURCES

The purpose of this section is to confirm, with the use of existing site-specific data, that natural resources in the Assessment Area have been in physical contact with hazardous substances and/or with media containing hazardous substances.

The methods used to confirm exposure of a natural resource to a hazardous substance in the Assessment Area are (1) comparisons of groundwater and surface water contaminant data from the Assessment Area to State of Washington and federal water quality criteria that protect human health and the environment, (2) comparisons of sediment contaminant data from the Assessment Area to sediments from reference or background sites, and (3) comparisons of contaminant residue data in aquatic biota from the Assessment Area to aquatic biota residue data from reference or background sites. The reference or background sites are assumed to be unimpacted by hazardous substance releases from the 100 Area. The comparison of contaminant residue data for sediment and biota from the Assessment Area to reference or background sites is necessary because there are no federal criteria for sediments or biological resources.

The HNRTC decided to proceed with the Assessment Plan based on concentrations of hexavalent chromium, abbreviated as Cr (VI), exceeding aquatic life criteria in groundwater/pore water, which meets the definition of injury to groundwater. Hexavalent chromium is known to be toxic to salmonid species, including chinook salmon. A major chinook salmon spawning area occurs in/near areas of documented contaminated groundwater/pore water (Figure 5).

Concentrations of some of the other hazardous substances released to the environment have declined significantly due to (1) the cessation of reactor operations, (2) a decline in cooling water disposal/discharge, (3) implementation of pollution control devices, (4) implementation of various response actions, (5) enforcement of environmental laws, and (6) natural decay of radionuclides. Therefore, the HNRTC's ability to fully document exposure to natural resources since the establishment of Hanford and the nuclear reactor operations may be limited. This Assessment Plan focuses on the most recent contaminant data available from the 100 Area and the Columbia River to document current exposure and potential injury scenarios. All data reviewed for this Assessment Plan were provided by the HNRTC.

Although considerable data exist on past exposures of natural resources to hazardous substances released from the 100 Area, no methodologies to quantify those exposures or injuries will be presented in this document.

VI.A PRIEST RAPIDS DAM TO RIVER MILE 385

Groundwater Resources

No data were provided or located on groundwater contaminant concentrations for the Priest Rapids Dam to River Mile 385 portion of the Assessment Area to indicate groundwater exposure to hazardous substances released from groundwater from the 100 Area. Based on the information provided by the HNRTC, there is no evidence that groundwater resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this stretch of river.

Surface Water Resources

No data were provided or located on surface water contaminant concentrations for the Priest Rapids Dam to River Mile 385 portion of the Assessment Area to indicate surface water exposure to hazardous substances released from groundwater from the 100 Area. Based on the information provided by the HNRTC, there is no evidence that surface water resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this stretch of river.

Biological Resources

There are data on radionuclide concentrations in fish collected in this area indicating exposure to releases of radionuclides from the 100 Area. However, the likely explanation to the presence of radionuclides in fish collected from this stretch of river is the upstream migration of these fish from the river adjacent to the 100 Area (Dauble et al. 1992; Poston 1994).

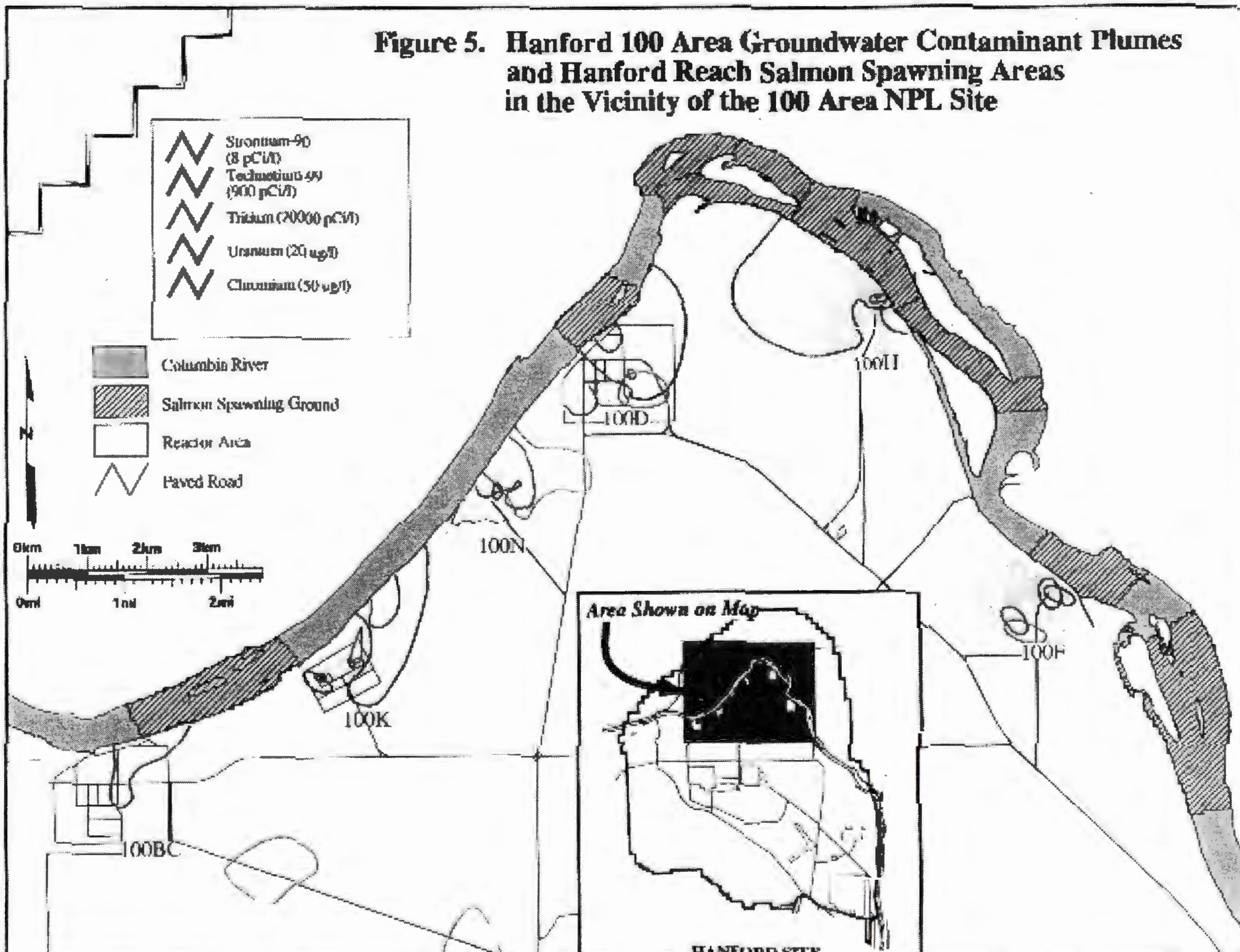


Figure 5. Hanford 100 Area Groundwater Contaminant Plumes and Hanford Reach Salmon Spawning Areas in the Vicinity of the 100 Area NPL Site

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Geologic Resources
No data were provided or located on sediment contaminant concentrations for the Priest Rapids Dam to River Mile 385 portion of the Assessment Area to indicate sediment exposure to hazardous substances released from groundwater from the 100 Area. Based on the information provided by the HNRTC, there is no evidence that geologic resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this stretch of river.

Cultural Resources
Other than fish migrating from downstream areas, no data confirming exposure of cultural resources in the Priest Rapids Dam to River Mile 385 portion of the Assessment Area to hazardous substances released from groundwater from the 100 Area were provided or located. Based on the information provided by the HNRTC, there is no evidence that cultural resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this stretch of river.

VI.B RIVER MILE 385 TO MCNARY DAM

Considerable information will be presented in this section documenting exposure, injury, or potential injury to a variety of natural resources in the Hanford Reach of the Columbia River from releases of numerous hazardous substances from the 100 Area. Table 8 summarizes the hazardous substances that have been documented to currently be exposing and/or potentially causing injury to natural resources in the Columbia River. This table also identifies data gaps, where there was insufficient information to conclude either presence or absence of natural resource exposure to hazardous substances. These areas may warrant collection of additional information to either confirm or rule out natural resource exposure, if the Trustees determine that such information is important in the assessment process.

Groundwater Resources
Groundwater is the primary medium by which contaminants in the 100 Area are discharged to the Columbia River (Peterson et al. 1996).

Considerable groundwater data exists for the Hanford Site including the 100 Area that documents exposure of groundwater to radionuclides, metals, and organic compounds (Table 8). Exposure was confirmed by comparing groundwater data to State of Washington and U.S. EPA water quality standards for the protection of human health and the environment. The majority of the groundwater data reviewed were from documents specific to the 100 Area.

Table 8. Aquatic resources summary of exposure matrix for the Hanford 100 Area.

Resource	**Cr (VI)**	**H-3**	**Sr-90**	**Co-60**	**Tc-99**	**Gross alpha**	**Gross beta**	**TCE**	**Al**	**Cu**	**C-14**	**U-tot**	**Cs-137**	**Eu-152/154/155**
Groundwater	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	N	N
Surface water	Y	Y	Y	N	N	Y	Y	N	N	N	N	N	N	N
Sediment	Y[1]	N	Y	Y	N	?	?	N	N	Y	N	Y	Y	Y
Aquatic inverts	Y	Y	Y	?	?	Y	Y	?	?	Y	?	Y	Y	Y
Fish														
Embryo	Y	Y	Y	?	?	Y	Y	?	?	?	?	?	?	?
Alevin	Y	Y	Y	?	?	Y	Y	?	?	?	?	?	?	?
Juvenile/ adult	Y	Y	Y	?	?	?	?	?	?	Y	N	N	Y	N
Aquatic/riparian birds														
Embryo	N	N	Y	N	?	?	?	N	N	N	N	N	N	N
Juvenile/ adult	N	Y	Y	?	?	?	?	N	N	?	?	?	Y	?
Cultural	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = Sufficient information exists to suspect/document aquatic resource exposure at this time.
N =Data reviewed does not indicate that aquatic resources are currently being exposed to releases of hazardous substances from the 100 Area.
? = Indicates data gap; sufficient data does not exist to conclude the presence/absence of exposure at this time.
[1]= Documented exposure of this resource to both Cr and Cr (VI); Cr concentrations exceed 95% UTL (Weiss 1993).

As summarized by Peterson et al. (1996), the source of the groundwater contamination in the 100 Area is from "significant leakage" of coolant water from underground piping and retention basins associated with reactor operations. From 1949 to 1971, large volumes of Columbia River water were used to cool the 100-Area's single-pass reactors. Sodium dichromate was added to the water to provide corrosion protection for piping. When the sodium dichromate disassociated, Cr (VI) was formed. While in the reactor, impurities in the water were activated by the intense neutron flux, creating short- and long-lived radionuclides. The coolant water was then discharged to retention basins for thermal and radioactive cooling. After cooling, the water was then discharged to the Columbia River.

Under the retention basins, mounding of groundwater, up to 8 meters, occurred from leakage of cooling water from retention basins and underground piping. Riverbank seepage of coolant water created springs along the shoreline adjacent to the 100 area. After reactor shutdown, the groundwater mounds dissipated quickly. However, significant amounts of contaminants present in the coolant water remain in the sediments that overlie the normal water table. According to Peterson et al. (1996) it can be expected that continued releases of hazardous substances to the groundwater and the Columbia River will continue for many years.

Considerable groundwater contamination has been documented from the 200 and 300 Area OUs (e.g., tritium, trichloroethylene (TCE), and uranium). Although groundwater monitoring data from these areas have documented that some of these hazardous substances are entering the Columbia River, inclusion of these data from these OUs and assessing potential cumulative effects to aquatic resources in the Columbia River are beyond the scope of this plan.

Exposure Assessment of Groundwater Resources

Data exist that document exceedences of the Primary MCL for State of Washington or federal Ambient Water Quality Criteria (AWQC) and Drinking Water Standards for numerous specific radionuclides, including tritium, Sr-90, carbon-14 (C-14), and technetium-99 (Tc-99) or total beta radiation (Peterson et al. 1996), for metals including Cr (VI) and aluminum (Al), and for the organic compound TCE. With the exception of uranium and radon, there are no federal Primary MCLs established for radionuclides on a pCi/l basis. Rather, the MCL is based upon an annual dose not to exceed 4 mrem/yr. There are interim and/or secondary standards based on a pCi/l concentration for easier interpretation of measured field results. For this assessment, the secondary standard/interim standard will be used. The MCL acronym will be used for consistency with the literature reviewed. With respect to ecological receptors, there is no agreed upon radionuclide concentration or dose that is considered to protect against injury. There are, however, guidelines or recommended exposure limits designed to protect populations of aquatic and terrestrial organisms. For example, draft radiological protection standards (10 CFR, subpart F) (DOE written communication) provides three specific dose limits for biota. They are 1 rad/day for aquatic organisms, 1 rad/day for terrestrial plants, and

0.1 rad/day for terrestrial animals. These standards are partially based on International Atomic Energy Agency guidelines (IAEA 1992) and the International Commission on Radiological Protection (ICRP 1972). The ICRP (1972) stated that:

> *"Although the principal objective of radiation protection is the achievement and maintenance of appropriately safe conditions for activities involving human exposure, the level of safety required for the protection of all human individuals is thought likely to be adequate to protect other species. The Commission therefore believes that if man is adequately protected then other living things are also likely to be sufficiently protected."*

The ICRP modified the preceding statement as follows:

> *"The Commission believes that the standard of the environment control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of a non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species."*

Based on the definition of injury under Department of the Interior NRDA regulations, harm to individual organisms would constitute injury.

The two radionuclides with the highest concentrations, largest number of samples with drinking water exceedences, greatest documentation and/or potential to expose various natural resources in the Columbia River, and greatest areal extent of contamination in groundwater were tritium and Sr-90 (Table 8). There are eight Sr-90 plumes and four tritium plumes identified in the 100 Area (Peterson et al. 1996; Peterson et al. 1997) (Figure 5). Concentrations of tritium and/or Sr-90 above MCLs were documented at 100-BC-5, 100-FR-3, 100-HR-3, 100-NR-2, and 100-KR-4. Concentrations of Tc-99 exceeded the MCL at 100-HR-3. Concentrations of C-14 exceeded the human health MCL at 100-KR-4. Table 9 compares maximum concentrations of the various radionuclides and their respective MCLs.

DOE (1998) stated that "...groundwater entering the river could reach an aquatic and riparian ecological receptor through direct uptake of Sr-90 in contaminated food and water. Ecological receptors may contact contaminants in groundwater seeps that may be present when the Columbia River is at low stage and in sediment pore water at the groundwater/river bottom interface. While the Sr-90 concentration in pore water and its potential impact to ecological receptors is not entirely known, no significant adverse impacts have been identified at this time. More information must be obtained to determine whether Sr-90 concentrations are causing short- or long-term impacts to these receptors..."

Table 9. Comparison of maximum radionuclide concentrations detected in groundwater from the Hanford 100 Area and MCLs.

Radionuclide	Max Conc. (pCi/l)	MCL[1] (pCi/l)
Sr-90	6,089	8
H-3	111,000	20,000
C-14	32,000	2,000
Tc-99	4,980	900
U-Tot	257	44
Gross Beta	9,379	50
Gross alpha	206	15

[1] Concentration assumed to yield an annual dose of 4 mrem/yr. However, EPA is reevaluating the MCL for tritium. The MCL may increase to greater than 60,000 pCi/l.

DOE (1998) went on to state "...the 100-NR-1/100-NR-2 CMS [Corrective Measures Study] concluded that no groundwater contaminants of concern are above ecological remedial action goals based on EPA's AWQC for the protection of aquatic life. However, AWQC standards have not been established for Sr-90. Concentrations of Sr-90 are known to be elevated in groundwater and seeps. Therefore, it is possible that concentrations of Sr-90 are also high in the pore water where aquatic receptors could be exposed. Further evaluation of potential impacts to aquatic and riparian resources is considered a vital part of the proposed interim action."

The metal with the greatest areal extent of groundwater contamination is Cr (VI). There are four Cr (VI) plumes in the 100 Area (Peterson et al. 1996; Peterson et al. 1997). Other metals (e.g., Al, iron (Fe)) occasionally are reported with elevated concentrations. The source of the Al may be from alum, which was used as a flocculant in cooling systems. The Fe may be from well casings. The highly elevated concentrations of Cr (VI) in groundwater at 100-HR-3 and 100-KR-4 caused DOE to implement an accelerated response action at these sites. Hexavalent chromium concentrations above the EPA ecological and/or human health MCLs (11 Φg/l and 100 Φg/l, respectively) have been reported at 100-HR-3, 100-KR-4, 100-BC-5, 100-FR-3, 100-D/DR, and 100-N (Peterson et al. 1996; DOE 1994). The State of Washington MCL for Cr is 50 Φg/l.

Groundwater collected from aquifer sampling tubes, meant to represent pore water, has also been collected and analyzed for Cr (VI) in areas of known salmon spawning habitats (e.g., 100 Area). Concentrations of Cr (VI) in excess of the 11 Φg/l MCL for the protection of aquatic life was reported near 100-B/C, 100-K, 100-H, and 100-F. The maximum concentration (>600 Φg/l) was collected near 100-D/DR (Peterson et al. 1998).

These data provide evidence of, or potential for, exposure and potential injury of aquatic resources (e.g., groundwater, spawning gravels and salmon embryo/alevins) to hazardous substances released from the 100 Area.

Surface Water Resources

There are data confirming exposure of surface water resources to hazardous substances released from the 100 Area (Table 8). Surface water resources in the 100 Area consist of the Columbia River and seeps and springs along the southern shore of the Columbia River. The source of the seeps and springs are upwelling groundwater plumes from the 100 Area. The source of the hazardous substances in the groundwater is previous reactor operations in the 100 Area. Some of the seeps have been shown to provide a pathway for contaminated groundwater to reach the Columbia River. Exposure of surface water to hazardous substances was confirmed by comparing surface water data to State of Washington and/or EPA water quality standards for the protection of human health and the environment. Currently, there are no agreed upon aquatic life criteria standards for radionuclides established to compare surface water quality data from the Hanford site.

Most water quality data for the Columbia River indicate that hazardous substances entering the river from groundwater and seeps are diluted to below MCLs relatively quickly because of the large volumes of water in the river. However, there may be a short-term impairment of surface water quality from Sr-90 in areas adjacent to locations where contaminated groundwater enters the Columbia River, especially near the 100-N reactor site (CRCIA 1998).

Several springs have been identified in the 100 Area that are contributing high concentrations of radionuclides, especially tritium and Sr-90, to the Columbia River. According to DOE (1994b) discharges of Sr-90 from the N Springs may potentially affect aquatic biota in the Columbia River. Springs in the 100-N Area and 100-H Area discharge water containing gross beta radiation exceeding the State of Washington MCL of 50 pCi/l (DOE 1994; Peterson and Johnson 1992). Exceedences of the tritium MCL have been documented in springs at the 100-B and the 100-N reactor sites. Exceedences of the Sr-90 MCL have been documented at 100-N, 100-D, 100-K, and 100-H reactor sites (Peterson and Johnson 1992) (Table 10). According to Peterson and Johnson (1992), concentrations of Sr-90 are increasing at some springs (e.g., 100-K and 100-H).

Metal analysis of water samples from the Columbia River, though limited, revealed no upriver/downriver trend between the two sampling locations of Vernita Bridge and Richland Pumphouse (Dirkes et al 1993). However, the reporting limit for Cr was above the 11 Φg/l aquatic life criteria.

Concentrations of Cr (VI) exceeding the State of Washington MCL of 50 Φg/l and the federal MCL and aquatic life criteria were detected in seeps at 100-B/C, 100-K, 100-D,

Table 10. Comparison of maximum radionuclide concentrations detected in seeps from the Hanford 100 Area and water quality MCLs.

Radionuclide	Max Conc. (pCi/l)	MCL[1] (pCi/l)
Sr-90	10,900	8
H-3	30,900	20,000
Gross Beta	24,000	50

[1] Concentration assumed to yield an annual dose of 4 mrem/yr.

and 100-H. The highest concentration of Cr (VI) was 124 Φg/l and was found at 100-D (Peterson and Johnson 1992).

Biological Resources

To assess exposure, biological resources were compared to background data (when available). Current exposure of biological resources in the Columbia River to radionuclides from the 100 Area is from two sources: radionuclide-contaminated groundwater entering the Columbia River and longer-lived radionuclides deposited in sediments during reactor operations. Data exists documenting or identifying the potential for exposure of biological resources to various radionuclides (Table 8).

Considerable data exist documenting past exposure of biological resources to various radionuclides from past reactor operations to the present. The majority of the radionuclides present in reactor effluents were the result of "neutron activation" of elements dissolved in the cooling water or present on the surface of piping or fuel elements. On occasion, the failure of the aluminum or zirconium fuel-element jackets would allow cooling water to come into direct contact with the fuel elements (Foster 1970).

Concentrations of many radionuclides have decayed to below reportable concentrations. Watson et al. (1970) reported that phosphorus-32 (P-32) was not detectable in water samples from the Columbia River seven days after reactor shutdown. The authors also reported that after five weeks chromium-51 (Cr-51) was not detectable and zinc-65 (Zn-65) was present, but at very low concentrations. Cushing et al. (1981) reported that there was a rapid decrease in fission-produced radionuclides to low or below-detection concentrations in various species of aquatic biota within 18-24 months after cessation of all reactor operations and concomitant discharges. Watson et al. (1970) reported that Cr-51 accounted for 50% of the radioactivity in Columbia River water, but was not readily accumulated in biota. However, Zn-65 and P-32, which accounted for 1-2% of the radioactivity in water, was much more biologically available. Watson and Davis (1957) found that 60-90% of the radioactivity in mountain whitefish *(Prosopium williamsoni)* was attributable to P-32.

Exposure Assessment of Biological Resources

Fishery resources:
White sturgeon (*Acipenser transmontanus*) have been collected in the past to assess radionuclide exposure/accumulation. Dauble et al. (1992) collected 27 sturgeon from the Hanford Reach/McNary Pool and compared radionuclide concentrations in these sturgeon to sturgeon collected from Lake Roosevelt, Washington, and the Columbia River near The Dalles and Bonneville, Oregon. The authors found that currently there is little evidence of accumulation of radionuclides (Cs-137, Co-60, Sr-90) in sturgeon above reference site concentrations.

Adult fall chinook salmon (*Onchyrynchus tshawytscha*) were collected in 1988 to address potential accumulation of radionuclides in this species. Concentrations of Cs-137 and Sr-90 were typically low and/or not definitive (Poston 1994).

Concentrations of radionuclides in other species of fish, common carp *(Cyprinus carpio*), mountain whitefish, and bass (*Micropterus spp.*) indicate that there are no discernable differences in the concentrations of radionuclides in fish tissue between this segment of the Columbia River and reference sites. However, maximum tissue concentration of Sr-90 in bass and whitefish were typically found near the 100 Area (Poston 1994).

Blanton (pers. comm.) found that sculpins (*Cottus spp.*) collected near N-Springs had higher mean concentration of Sr-90 than sculpins from the Vernita area (Table 11). Compared to migratory or more mobile fish species, sculpins with limited home-ranges may be exposed to higher radiation levels than more mobile fish species.

Table 11. Comparisons of mean Sr-90 concentrations in sculpins from Columbia River near N-Springs and Vernita, 1997 (from Blanton pers. comm).

Sculpins (pCi/g)	
Vernita	N-Springs
0.0152	0.754

Another likely exposure scenario of fishery resources potentially indicative of injury, would be embryo and/or alevin exposure to radionuclides in spawning substrates near or adjacent to the 100 Area. Presently, there are no data available on exposure of salmonid embryo/alevins to radionuclides entering the Columbia River via groundwater. However, available sculpin residue data and salmon spawning data do confirm the potential for exposure, and potential injury to, fishery resources from radionuclides released from the 100 Area.

Concentrations of radionuclides in fish do not currently exceed human health standards of 4 mrem/yr. Currently, it is estimated that the Maximally Exposed Individual (MEI) (does not account for subsistence use) would be exposed to a dose of 0.02 mrem/yr through fish consumption in the Hanford Reach of the Columbia River. The primary contributors to the dose are Sr-90 and Cs-137 (Woodruff et al. 1992). According to Foster (1970) the MEI dose to humans (sport anglers) from consuming fish from the Hanford Reach during the 1960's was 17% of the acceptable exposure limit. The radionuclide primarily responsible for the dose was P-32. Based on this information, it is very unlikely that human consumption guidelines, based on recreational anglers, are exceeded in the Assessment Area.

Macro-invertebrate Resources:
Various aquatic invertebrates have been collected and analyzed for the presence of radionuclides. In 1990, a clam shell collected from the 100-N area had approximately 260 pCi/g Sr-90 (Woodruff et al. 1992). Cushing (1993) reported on concentrations of three radionuclides (Sr-90, Co-60, and Cs-137) in caddisfly larvae from the Columbia River adjacent to the 100-H and 100-N and from the Vernita Bridge area (reference area). Only one sample had detectable concentrations of radionuclides (Sr-90 0.57 pCi/g dw). This sample was collected adjacent to 100-N.

Vegetative Resources:
Cushing (1993) reported that concentrations of Co-60, Cs-137, and Sr-90 in periphyton from the Columbia River adjacent to the 100-N and 100-H areas and the Vernita Bridge area (reference area) were all below detection.

Reed canary grass (*Phalaris arundinacea*) has been found to accumulate Sr-90 in the Hanford Reach. The highest concentrations (50 pCi/g) were typically found in samples collected near 100-N. Concentrations of Sr-90 decrease both upstream and downstream from 100-N (Rickard and Price 1990). The authors concluded that there was a relationship between concentrations of Sr-90 in grass samples and Sr-90 releases to the Columbia River. Reed canary grass is an important food item of the Canada goose during early spring (Rickard and Price 1990).

Antonio et al. (1993) reported that Hanford-derived radionuclides (tritium, Sr-90, Co-60) were accumulating in shoreline plants. Some of the plants collected include Asparagus (*Asparagus officinalus*), reed canary grass, onion (*Allium spp.*), chokecherry (*Prunus virginiana*), etc. Apparently, the roots of the plants were in contact with contaminated groundwater/seep water. The largest concentrations of radionuclides, when compared to background concentrations, were found in plants near the 100-N Area, Hanford Townsite, and north of the 300 Area. These data confirm that plant resources are in contact with hazardous substances released from the 100 Area.

Avian Resources:
Data on exposure to water-dependent or riparian bird species is limited. Past studies have documented elevated concentrations of Sr-90 in Canada goose (*Branta canadensis*) egg shell fragments (Foster 1970; Rickard and Price 1990). Concentrations of Sr-90 in eggshell fragments collected from an island from the Hanford Reach (Plow Island, 0 = 1.45 pCi/g) was about twice as high as eggshells from a reference island on the Snake River (New York Island 0.85 pCi/g). Shell fragments from Bridgeport, Washington,

contained a mean concentration of 0.99 pCi/g Sr-90. During the early spring, female geese forage along the shoreline consuming food items, primarily plant matter, containing elevated concentrations of Sr-90. Some Sr-90 is then deposited in the eggshell. After hatching, the female and young also forage along the shoreline potentially being exposed to elevated concentrations of Sr-90. There has been very little research conducted on the effects of chronic radiation exposure in avian populations, especially wild populations. The minimum chronic dose at which effects on reproduction or mortality would manifest does not seem to be well established for birds (IAEA 1992).

From 1971 through 1988, 453 waterfowl were collected from the Hanford Reach for radionuclide (potassium-40 (K-40) and Cs-137) analysis. The purpose of the monitoring program was to assess potential human exposure to radionuclides. Both radionuclides were detected in waterfowl muscle (Eberhardt et al. 1989). Median concentrations of Cs-137 in waterfowl muscle collected in the river were typically less than 0.05 pCi/g. Median concentrations of K-40 were typically less than 3.0 pCi/g.

Exposure of avian resources to releases from the 100 Area have been documented or suspected. Unfortunately, not enough data exist to determine the potential for injury. Additional investigations may be necessary.

Geologic Resources

Sediment samples have been collected from the mainstem of the Columbia River to McNary Dam and from springs in the 100 Area through various surveillance programs. Routine sediment sampling in the Hanford Reach did not begin until 1989 (Woodruff et al. 1992). Numerous radionuclides and heavy metals have been detected in sediment samples documenting exposure (Table 8). Most radionuclides now present are intermediate to long-lived isotopes. Short-lived isotopes have long since decayed (Sula 1980).

<u>Exposure Assessment of Geologic Resources</u>

Weiss (1993) conducted sediment sampling ($n = 44$) in the Columbia River from the Vernita Bridge (background) area to the Hanford Townsite. Man-made radionuclides were detected in all samples except four from the Hanford Townsite area. The only man-made radionuclide detected in background sediment samples was Cs-137 (0.14 pCi/g). Typically the greatest number of man-made radionuclides and highest concentrations were found from 100-D to the 100-F slough. Table 12 provides a summary of radionuclide varieties and maximum concentrations detected in Columbia River sediments from the 100 Area.

Table 12. Maximum concentrations of man-made radionuclides detected in Hanford Reach sediments (from Weiss 1993).

Radionuclide	Max. Conc. (pCi/g)
Cs-137	4.6
Eu-152	1.8
Eu-154	0.2
Eu-155	0.8
Co-60	0.4
Np-237	0.6
Am-241	0.2
Mg-54	0.06
Pu-239/240	0.07
Sr-90	0.4

Peterson and Johnson (1992) reported that concentrations of Sr-90 in all sediment samples (n = 27) collected from seeps in the 100 Area exceeded the background concentration of 0.026 pCi/g. Concentrations of Sr-90 in seep sediments from the 100 Area ranged from $1x10^{-1}$ to $1x10^{2}$ pCi/g.

Wells (1994) summarized radionuclide sediment data from the Vernita Bridge to the Columbia River estuary and continental shelf. Early investigations found that deep sediments in McNary Pool contained considerably higher concentrations of radionuclides than surface sediments (Tables 13 and 14) and sediments from the Hanford Reach. The reason for the higher concentrations in the McNary Pool deep sediments compared to the Hanford Reach sediments was due to the fact that radionuclides readily adsorb to fine silts and clays that are deposited behind McNary Dam. There are few areas within the Hanford Reach where fine silts and clays are deposited in the mainstem of the Reach. Within the Hanford Reach, the highest concentrations of radionuclides in sediments are typically found in depositional areas near 100-D, 100-F, 100-H, and the Hanford Townsite.

Table 13. Maximum concentrations of man-made radionuclides detected in McNary Pool surface sediments (from Wells 1994).

Radionuclide	Max. Conc. (pCi/g)
Cs-137	1.2
Eu-152	0.98
Co-60	0.5
Am-241	<0.003
Pu-239/240	0.002
Sr-90	0.064

Table 14. Maximum concentrations of man-made radionuclides detected in McNary Pool deep sediments (from Wells 1994).

Radionuclide	Max. Conc. (pCi/g)
Cs-137	5.1
Eu-152	9.6
Co-60	1.6
Am-241	<0.02
Pu-239/240	0.12
Sr-90	--
Ni-63	4.4

A unique situation occurs in the Hanford Reach with respect to Co-60 contamination of metal flakes or "specks" (Sula 1980; Cooper and Woodruff 1993). Apparently, Co-60 - contaminated metal flakes from reactor cooling systems were deposited along the Hanford Reach. The specks are typically associated with coarse sediments along the shoreline and islands in the Hanford Reach.

Sula (1980) estimated that there were approximately 0.003 specks per square meter of sediment. By 1993, the number of specks declined to 0.000008 specks per square meter (Cooper and Woodruff 1993). The explanation for the vast reduction in the number of Co-60 - contaminated flakes has been primarily contributed to radioactive decay. In the 13 years between studies, it was estimated that 82% of the Co-60 would have decayed to stable Nickel-60 (Cooper and Woodruff 1993; Wells 1994).

Five heavy metals (As, Cr, Cu, Pb, and Zn) have been found to be contaminating sediments in the Columbia River near the 100 Area. (i.e., exceed the 95% Upper Threshold Limit (UTL)) (Weiss 1993). Sediments that contain concentrations of metals greater than the 95% UTL value derived from Hanford soils are considered to be contaminated (DOE 1993). Three of the metals (As, Pb, and Zn) are not considered to be site-derived because elevated concentrations (i.e. >95% UTL) were found in Vernita area sediments. For this investigation, Vernita served as the background site. The two remaining metals (Cr and Cu) are considered or suspected of being site-derived because concentrations in sediments in the Columbia River near the 100 Area exceeded the 95% UTL, and concentrations of both metals did not exceed the 95% UTL in the Vernita area. Concentrations of Cr and Cu decreased to below the 95% UTL at the Hanford Townsite (Weiss 1993). Table 15 summarizes metal concentrations in Hanford Reach of the Columbia River sediments.

Table 15. Comparison of maximum metal concentrations (mg/kg), and respective 95% UTL (from Weiss 1993).

	Vernita	100 Area	Hanford Townsite	95% UTL
As	9.4	10.7	<95% UTL	9.0
Cr	<95% UTL	131.0	<95% UTL	28.0
Cu	<95% UTL	69.6	<95% UTL	30.0
Pb	57.7	59.8	<95% UTL	14.9
Zn	226.0	454.0	293.0	79.0

Cultural Resources

Based on the evaluation of the preceding aquatic resource categories, it is assumed that cultural resources in the Columbia River are also being exposed to hazardous substances released from the 100 Area. The cultural resources and services provided by this river segment and its surroundings are numerous. This segment includes sacred geographies and landforms, places where religious history was made, many sacred foods and medicines, and is an integral part of the homeland and life ways. Tribal beliefs hold that there is no part of this segment that is unimportant to its indigenous peoples, and no biotic or abiotic resources that are unimportant.

Since natural resources (e.g., groundwater) have been exposed above regulatory standards, then the cultural uses of those resources have been impaired. Additionally, tribal uses based on exposures and health effects may also have been impaired at concentrations *below* regulatory standards because tribal members receive more exposure than the suburban residents that the regulatory standards were designed to protect. Depending on the contaminant and the pathway of exposure, tribal members may receive 2-100 times more exposure than suburban residents because their lifestyle puts them in closer contact with the environment (Harris and Harper 1997). Thus, a lower concentration would cause an equivalent level of exposure to tribal members. Since regulatory standards are used as one demonstration of exposure or potential injury to a natural resource, tribally-relevant equivalents of the regulatory standard (some fraction of the regulatory standard) could also be evidence of exposure and potential injury.

Exposure of natural resources (including groundwater) below regulatory standards but above detection limit or background also impairs cultural use, as well as inheritance and bequest value. Therefore, from a tribal perspective, the cultural utility of natural resources is impaired at *any detectable concentration*. This is a separate determination from human exposure received during cultural or lifestyle activities. As a screening criterion, the areal extent and duration of any amount of contamination could provide a threshold determination of exposure and potential injury of cultural resources of either abiotic media, biota, or physical cultural resources such as grave sites or archaeological sites.

VI.C MCNARY DAM TO MOUTH OF COLUMBIA RIVER

Groundwater Resources

No data were provided or located for groundwater contaminant concentrations for the McNary Dam to the Mouth of the Columbia River portion of the Assessment Area. Based on the information provided by the HNRTC, there is no evidence that groundwater resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Surface Water Resources

The Oregon Health Division monitored surface water quality in the Columbia River from McNary Dam to the Oregon Coast from 1963 to 1993 (OHD 1994). During the 1960's, gross beta concentrations at The Dalles Dam approached 600 pCi/l. Historically, the most common radionuclides detected were Cr-51, Zn-65, and P-32. From 1989 to 1993, the average beta concentration was only 5 pCi/l, **considered** background for Oregon surface waters. At the conclusion of this report period, there was no radioactivity of Hanford origin detectable in the Columbia River in Oregon. Based on the information provided by the HNRTC, there is no evidence that surface water resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Biological Resources

Fishery Resources:

The State of Oregon did not issue any fish consumption advisories in the Columbia River as a result of Hanford operations (OHD 1994). There are no known advisories issued by the State of Washington. At the conclusion of the study period, there was no radioactivity of Hanford origin detectable in Columbia River fishery resources in Oregon (OHD 1994). Based on the information provided by the HNRTC, there is no evidence that fishery resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Aquatic plant resources:

Radionuclides were not detected in aquatic vegetation or algae after 1977. Peak concentrations of Zn-65 were observed during the early 1960's (OHD 1994). At the conclusion of this report period, there was no radioactivity of Hanford origin detectable in Columbia River aquatic plant resources in Oregon (OHD 1994). Based on the information provided by the HNRTC, there is no evidence that aquatic plant resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Geologic Resources

During the 1960's and early 1970's, Zn-65 and Co-60 were commonly found in Columbia River sediments (OHD 1994). By the late 1980's concentrations of these radionuclides were low or below detection in Columbia River sediments. Other radionuclides observed in the past were Cr-51, and scanadium-46. At the conclusion of this report period, there was no radioactivity of Hanford origin detectable in the Columbia River in Oregon (OHD 1994). Based on the information provided by the HNRTC, there is no evidence that aquatic plant resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Cultural Resources
Based on the information provided by the HNRTC and the evaluation of the preceding aquatic resource categories, there is no evidence that cultural resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

VI.D COASTAL AREAS

Groundwater Resources
No data were provided or located on groundwater contaminant concentrations for the Coastal Areas portion of the Assessment Area. Based on the information provided by the HNRTC, there is no evidence that groundwater resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Surface Water Resources
At the conclusion of this report period, there was no radioactivity of Hanford origin detectable in the Columbia River estuary in Oregon (OHD 1994). Based on the information provided by the HNRTC, there is no evidence that surface water resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Biological Resources
At the conclusion of this report period, there was no radioactivity of Hanford origin detectable in biota from the Columbia River estuary in Oregon (OHD 1994). Based on the information provided by the HNRTC, there is no evidence that biological resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Geologic Resources
At the conclusion of this report period, there was no radioactivity of Hanford origin detectable in the Columbia River estuary in Oregon (OHD 1994). Based on the information provided by the HNRTC, there is no evidence that geologic resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

Cultural Resources
Based on the information provided by the HNRTC and the evaluation of the preceding

aquatic resource categories, there is no evidence that cultural resources are currently being exposed to Hanford-derived radionuclides or other Hanford-derived hazardous substances in this portion of the Assessment Area.

VII. CONCLUSIONS

The data reviewed for this Assessment Plan confirms that aquatic resources (water, biological, geological, and cultural) in certain segments of the Columbia River have been and currently are being exposed to hazardous substances (radionuclides, metals, and organic compounds) released from the 100 Area (Table 8). In addition, exposure pathways from groundwater and surface (seep) water to terrestrial resources in the 100 Area were identified. However, it is beyond the scope of this document to address terrestrial resources in any great detail.

Although numerous hazardous substances have been discussed, the substances of primary concern to aquatic biological resources in the Columbia River are Cr (VI), Sr-90, and possibly tritium. Continued evaluations may determine other hazardous substances of concern. Although aquatic resources are currently being exposed to other hazardous substances of potential concern (Table 8), the three substances previously identified are of *most* concern because of the areal extent of contamination, the number of elevated concentrations detected, and the number of natural resources exposed. Currently, the only portion of the Assessment Area where releases of hazardous substances from the Hanford 100 Area are confirmed or suspected of exposing and/or causing injury to aquatic resources is River Mile 385 to McNary Dam.

Prior to addressing other areas in this portion of the Assessment Area (e.g., sloughs and backwaters), the primary focus of any investigation to confirm injury should be on locations adjacent to the 100 Area where contaminated groundwater enters the Columbia River (seeps and pore water). Contaminated seeps and pore water in areas downstream of contaminated groundwater plumes provide the greatest potential for injury to natural resources associated with releases of hazardous substances from the 100 Area. If injury to aquatic biological resources is occurring, it would occur in areas of highest contaminant concentrations first. Resident fish species (i.e., sculpin), early life stage fish (salmon embryo/alevins), or possibly macroinvertebrates inhabiting the river in/near contaminated seeps and pore water may provide for the most sensitive testing. One of the most sensitive species/life-stages to evaluate injury to aquatic biological resources would be the egg/alevin stage of the chinook salmon inhabiting pore water at groundwater release sites.

In addition, semi-aquatic/terrestrial wildlife species that may be exposed to hazardous substances released from the 100 Area (e.g., Sr-90) via seeps should also be assessed.

VIII. TECHNICAL SUPPORT SERVICES

During the process of this assessment large quantities of data will potentially be generated. Because the assessment involves natural resource injury investigations, the nature of the data may be very different from previous data collected at Hanford, and may not be accommodated by existing Hanford databases. In addition, it is expected that new Geographic Information System (GIS) coverages will be developed for the natural resource information generated. It is therefore important to establish data management and mapping strategies specific to the needs of this assessment.

VIII.A DATABASE MANAGEMENT

An environmental database designed specifically for natural resource injury data may be developed for Trustee use during this assessment. Specific database needs have yet to be evaluated by the Trustees, but may include compatibility with, or incorporation of, existing Hanford environmental databases. General data management objectives may include compiling existing exposure or injury data (such as the data evaluated during the confirmation of exposure process), compiling and managing data acquired during injury investigations or biomonitoring activities, and organizing natural resource information to support injury studies. A process for development and management of such a database will be established by the HNRTC.

VIII.B MAPPING OF THE ASSESSMENT AREA

Maps provided in this Assessment Plan were produced from GIS coverages developed by the USFWS Upper Columbia River Basin Field Office, technical staff at Bechtel Hanford Inc., USFWS Region 1 realty division, and the U.S. Geological Survey Spokane Office. These coverages may be used with currently established GIS repositories to map biological information gathered during this assessment process. Further development and management of GIS repositories for this assessment will be determined by the HNRTC.

PART II: POTENTIAL INJURY DETERMINATION/CLEANUP CRITERIA AND PATHWAYS STUDIES

I. INTRODUCTION

The objective of the first phase of this assessment is to determine which, if any, aquatic natural resources in the Columbia River may have been exposed and potentially injured as a result of releases of hazardous substances from the 100 Area. Several potential investigative approaches will be presented to evaluate injury of aquatic resources in the Columbia River. However, it should be pointed out that a pathway from groundwater/springs to terrestrial resources has been established in the Summary of Exposure section of this document. In fact, DOE (1998) identified Sr-90 as potentially being a concern for riparian wildlife receptors in the 100-N Area. Given this fact, risk managers will need to take this information into account before final groundwater remedial decisions can be made in the 100 Area. The investigations that will be presented could be used to (1) establish groundwater cleanup criteria, (2) establish/confirm source-receptor contaminant pathways, and (3) document injury from hazardous substance releases from the 100 Area. The investigations presented should not be viewed as an all-inclusive list, or as complete study plans. If any of these investigations were to be selected in the future for implementation, much more detailed study plans would need to be developed.

II. PATHWAY INVESTIGATIONS

II.A PORE WATER

One investigation that should be conducted would be to monitor Cr (VI) concentrations in aquifer sampling tubes on a much more frequent basis (i.e., monthly). This information would allow other investigators to more accurately reconstruct salmon embryo/alevin exposure scenarios under laboratory and field conditions. Additional aquifer sampling tubes could be installed to monitor additional contaminants (e.g., Sr-90 and tritium).

II.B SEEPS/SPRINGS

Upwelling groundwater, sediments, plants, invertebrates (aquatic and terrestrial), small mammals, avian species could be collected at numerous sites in the 100 Area to measure contaminant exposure and uptake to determine if a seep/spring-terrestrial pathway exists in these areas. This investigation could also be used to develop wildlife exposure scenarios and contaminant accumulation rates for use in developing injury determination investigations/cleanup criteria for riparian/terrestrial wildlife species.

would measure contaminant exposure, mortality rates, hatching rates, occurrence of deformities, etc. The advantage of this approach is that uncontrollable environmental or man-made variables would be drastically reduced.

III.B RESIDENT FISH (SCULPIN) INVESTIGATION

Field Approach

Battelle-PNL and the Washington Department of Health conducted an investigation measuring accumulation of various radionuclides in sculpin from the N-springs (Blanton pers. comm.). This investigation only included two sites, a reference area and one treatment area. The investigators documented accumulation of Sr-90 in sculpins one order of magnitude greater than in fish from the reference site. This investigation should be expanded to include additional spring/seep areas of various Sr-90 concentrations to include a continuum of exposures. These data could then be used to develop dose-response relationships in the field. Sculpins should be collected from each treatment area and the reference site for residue chemistry and histopathological examination. Unfortunately with this approach, it cannot be determined with certainty which hazardous substance(s) are responsible for the health effect, if one is noted. Therefore, establishing cleanup criteria or establishing injury to an aquatic resource from a hazardous substance may be difficult.

Laboratory Approach

Sculpins from a reference location could be brought to a mobile or permanent laboratory facility and chronically exposed (>90 d) to a range of Sr-90 concentrations. This investigation would determine dose-response and cause-and-effect relationships between dose and several health endpoints. After these relationships are established, additional sculpins could be exposed, under laboratory conditions, to groundwater from the 100 Area (the selection of a groundwater well should be based on Sr-90 concentrations). After exposure, the sculpins could be analyzed for contaminant residues and health effects to determine if they are consistent with laboratory and field results. This type of investigation could be used to establish groundwater cleanup criteria that is protective of resident fish species.

III.C RESIDENT FISH (SCULPIN) EARLY-LIFE STAGE INVESTIGATION

Another possible component of this investigation would be to expose early life-stage sculpins to Sr-90 and groundwater to assess developmental effects. A whole groundwater component is essential to determine if there are significant additive, antagonistic, or synergistic effects from hazardous and nonhazardous substances in groundwater before establishing cleanup criteria. A similar series of investigations using early life-stage chinook salmon should also be conducted. This would allow for comparative toxicity between the two species to be established. This information could then be used to ensure the cleanup criteria are protective of the most sensitive species tested.

III.D ADDITIONAL INVESTIGATIONS

Upper Columbia River Steelhead Spawning Surveys (Annual)
The Upper Columbia River population of the steelhead is federally listed as endangered. Recently, steelhead have been documented to spawn in the Hanford Reach adjacent to the 100 Area. For the purposes of establishing protective cleanup criteria for groundwater in the 100 Area, spawning surveys should be conducted to determine where this species spawns near the 100 Area. In addition, spring/summer surveys for 0-age steelhead should also be conducted to determine if successful reproduction has occurred.

Steelhead Toxicity/Avoidance testing
Since Upper Columbia River steelhead spawning activities have been recently documented near the 100 Area, additional investigations need to be conducted to determine toxicity of Cr (VI) and Sr-90 in whole groundwater, using rainbow trout as a surrogate species for steelhead. Field and laboratory investigations identical to those conducted for chinook salmon should be conducted for Cr, Sr-90, and whole groundwater to determine the relative sensitivity of steelhead to chinook salmon. In addition, if the steelhead spawning surveys indicate that steelhead are not utilizing spawning habitat near areas with potential groundwater-contaminant upwelling, an avoidance investigation could be conducted to determine if contaminants in groundwater from the 100 Area cause steelhead to avoid potential spawning habitat near the 100 Area. If it is determined that steelhead are more sensitive to groundwater contamination than chinook, based on either toxicity or avoidance behavior, cleanup standards must be established that are protective of this endangered species.

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APPENDIX I: LIST OF ACRONYMS AND ABBREVIATIONS

2,4-D	2,4-Dichlorophenoxyacetic acid (pesticide)
Al	Aluminum
ALE	Arid Lands Ecology Reserve
Am-241	Americium-241
As	Arsenic
AWQC	Ambient Water Quality Criteria
Ba	Barium
C-14	Carbon-14
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Cd	Cadmium
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
Co-60	Cobalt-60
COC	Contaminants of concern
COPC	Contaminants of potential concern
Cr	Chromium
Cr (VI)	Hexavalent chromium
Cr-51	Chromium-51
CRCIA	Columbia River Comprehensive Impact Assessment
Cs-134	Cesium-134
Cs-137	Cesium-137
CSM	Conceptual Site Model
Cu	Copper
DDT	1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane (pesticide)
DOE	U.S. Department of Energy
dw	dry weight basis
EPA	U.S. Environmental Protection Agency
Eu-152/154/155	Europium-152/154/155
Fe	Iron
GIS	Geographic Information System
H-3	Tritium
Hg	Mercury
HNRTC	Hanford Natural Resource Trustee Council
IRM	Interim Remedial Measures
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IU	Isolated units
K-40	Potassium-40
LFI	Limited Field Investigation
MCL	Maximum contaminant level
MEI	Maximally Exposed Individual
Mg-54	Magnesium-54
mg/kg	milligrams per kilogram

Mn	Manganese
MOA	Memorandum of Agreement
mrem/yr	millirem per year
MTCA	Model Toxics Control Act
Ni	Nickel
Ni-63	Nickel-63
Np-237	Neptunium-237
NPL	National Priorities List
NRDA	Natural Resource Damage Assessment
OHD	Oregon Health Department
OU	Operable unit
P-32	Phosphorus-32
PAS	Preassessment Screen
Pb	Lead
PCB	Polychlorinated biphenyls
pCi/g	picocuries per gram
pCi/l	picocuries per liter
PRP	Potentially Responsible Party
Pu-239/240	Plutonium-239/240
QRA	Qualitative Risk Assessment
rad/day	rad (radiation absorbed dose) per day
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
Sb	Antimony
Se	Selenium
Sr-90	Strontium-90
Tc-99	Technetium-99
TCE	Trichloroethylene
TPA	Tri-Party Agreement
Φg/l	micrograms per liter
UPR	Unplanned release
USFWS	U.S. Fish and Wildlife Service
UTL	Upper Threshold Limit
U-tot	Uranium, total
Zn	Zinc
Zn-65	Zinc-65

APPENDIX II – RESPONSES TO PUBLIC REVIEW COMMENTS

June 17, 1999 Public Meeting Comments and Comment Responses

Comment #1 -- Who will be reviewing the study?

Response – Members of the Council provide technical experts from their agencies to review and comment on the proposed studies as they are being developed.

Comment #2 – What type of peer review will the proposed plan go through?

Response – We are looking internally for a review from the participating Council members. In addition, to a Council review, experts in the U.S. Fish and Wildlife Service and National Biological Resource Division of the U.S. Geological Service have reviewed the Chromium study design and procedures and signed off on a Quality Assurance Project Plan.

Comment #3 – Are there heavy metals in the Columbia River above Hanford coming down from Idaho?

Response – Yes. One of the documents the Council provided to U.S. Fish and Wildlife Service to review was the *Screening Assessment and Requirements for a Comprehensive Assessment: Columbia River Comprehensive Impact Assessment*. The assessment identified several upstream non-Hanford contaminants of concern, such as copper, zinc, lead and mercury. However, Hanford does contribute to these contaminant loads.

Comment #4 – Will there be another public meeting based on the lack of attendance and public notice at this meeting?

Response – No. The comment period ran from June 7 to July 31. During that time period no additional requests to hold a public meeting were received by the Council.

U.S. Environmental Protection Agency's (EPA) July 6, 1999 Comment Letter

Comment – The subject document states that a "number of interim cleanup decisions have been made in the 100 Area NPL site" and "more than likely, most of these interim actions will be deemed final remedies". However, due to ongoing efforts to identify better treatment technologies and recently completed treatability studies "the existing interim cleanup decisions related to the cleanup of the groundwater in the 100 Area to protect the Columbia River are not considered final remedies" (see attached letter for more detail).

Response – The Hanford Natural Resource Trustee Council agrees with EPA's comment and has revised the second paragraph of Section I.A accordingly.

Jean Eggers Fuller's July 20, 1999 Comment Letter

Comment – "Richland and Hanford land originally belonged to the Walla Walla and their chiefs, so they should have some say in the outcome of Hanford" (see attached letter for more detail).

Response – The Hanford Site 100 Area Assessment Plan was prepared by the U.S. Fish and Wildlife Service for the Hanford Natural Resource Trustee Council (HNRTC). The HNRTC is comprised of designated federal, state and tribal trustees for natural resource located within the Hanford Site. The tribal trustees include the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), which in turn includes the Walla Walla. As such, the Walla Walla do have some say in the outcome of Hanford, at least with regard to the natural resources addressed by the Assessment Plan and other trustee activities. The CTUIR representative on the HNRTC is Mr. J.R. Wilkinson. Mr. Wilkinson can be reached at 541-278-5205.

John Strand's July 28, 1999 Comment Letter

Comment #1 – "I think that it would be better to conduct the studies in a mobile laboratory located along side the Columbia River. I see this approach is being considered for Phase II. If pathogens were or are an issue, then well water might have to be used" (see attached letter for more detail).

Response – Phase II of the study will be conducted in the Pacific Northwest National Laboratory's Hanford Site aquatics laboratory, which sits along side the Columbia River (a mobile laboratory was determined to be too risky with regard to the long term continuous operation required by the study). Phase II will involve the mixing of Hanford Site chromium contaminated groundwater with Columbia River water, the same mixing which occurs in the river gravel beds where the salmon spawn.

Comment #2 – "I don't think that using Chinook salmon from the McNenny State Fish Hatchery in Spearfish is the best approach. I think it would have been better to work with stock of fish inhabiting the Hanford Reach".

Response – The fisheries biologists planning for and conducting the Phase I study recommended using the McNenny salmon eggs. The fisheries biologists reviewing the plan for the trustees agreed with this recommendation. The eggs provided by McNenny were certified "disease free", a certification that the biologists stated was more critical to the success of the study than using non-certified Hanford Reach salmon eggs (no Hanford Reach "disease free" eggs were available for the Phase I study). Certified "disease free" salmon eggs from the Priest Rapids hatchery will be available for the Phase II study.

Comment #3 – "There appear to be some inconsistencies in the properties of the experimental water that you will use" (i.e., varying water hardnesses) (see the attached letter for more detail).

Response – Experimental Hanford River water will have a hardness of 80 mg/L and this is the water that will be used during the experimental and exposure portion of Task 1 and Task 3. Prior to and after the experiment it would be desirable to continue to use the 80-mg/L water, but technically it was not possible. The trade off was using the disease free McNenny eggs. After the eggs were exposed and water hardened, they were returned to the McNenny Hatchery and McNenny water (360 mg/L) was used for incubation. In Task 3, the eggs, alevins, and fry were held in Jackson spring water (150-mg/L hardness) until the experiment was started. The fry were acclimated to Hanford Experimental water for 5 days before the test was initiated.

Comment #4 – How did you determine that four replicates for each test concentration were enough? Is there a statistical basis for this design?

Response – Three replicates is a minimum in terms of having sufficient degrees of freedom to perform statistical analyses of significant differences. The fourth replicate gives additional degrees of freedom, adds power to the analyses, and provides an extra replicate in case one of the four replicates is lost. The effect of additional replication on increased statistical power drops off after four replications. Five or more experimental units in a 120-day laboratory study increases the cost beyond the benefit.