

5.14 Cumulative Impacts

This section presents a discussion of cumulative impacts on the human environment from past, current, and reasonably foreseeable future actions in the Hanford area in conjunction with the actions proposed in the HSW EIS. DOE endeavored to take into consideration all Hanford Site and nearby actions that might make an important contribution to cumulative impacts.

The Council on Environmental Quality Assessment of Cumulative Impacts

In 40 CFR 1508.7, the Council on Environmental Quality (CEQ) defines cumulative impact as:

“...the impact on the environment from the incremental impact of the action when added to other past, present, and reasonably future actions regardless of what agency (federal or non-federal) or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.”

In CEQ 1997a, the CEQ states:

“The continuing challenge of cumulative effects analysis is to focus on important cumulative issues....”

Past onsite actions that might lead to present-day or future cumulative impacts considered in this assessment include:

- operation of fuel fabrication facilities, reactors, and product separation facilities
- operation of research and development facilities
- management of liquid waste, including tank storage
- disposal of liquid radioactive waste in cribs, ponds, and ditches
- leaks and spills of liquid waste on the ground
- management of spent nuclear fuel
- storage of strontium, cesium capsules, and other radioactive materials
- retrievable storage of TRU waste
- disposal of solid radioactive wastes in trenches and caissons
- stabilization of the Plutonium Finishing Plant
- operation of the ETF, the LERF, the State-approved land disposal system, and the TEDF
- conduct of RCRA/CERCLA remediation projects including operation of the ERDF
- disposal of Navy reactor compartments
- operation of a commercial LLW disposal site by US Ecology, Inc.
- operation of the Columbia Generating Station by Energy Northwest.

Past offsite actions that were considered consists of those of a nearby commercial nuclear fuel fabrication plant and commercial waste treatment facilities.

Current onsite actions that were considered include:

- continued operation of research and development facilities
- preparations for treatment and disposal of tank waste
- continuation of RCRA/CERCLA remediation projects and operation of ERDF
- continued management of TRU waste (including retrieval), LLW, and MLLW
- continued management of spent nuclear fuel
- continued storage of strontium, cesium capsules, and other radioactive materials
- continued stabilization of the Plutonium Finishing Plant
- continued operation of the ETF, the LERF, the State-approved land disposal system, and the TEDF
- disposal of Navy reactor compartments
- operation of the commercial LLW disposal site by US Ecology, Inc.
- operation of the Columbia Generating Station by Energy Northwest.

Current offsite activities that were considered consist of those of the nearby commercial nuclear fuel fabrication plant and commercial waste treatment facilities.

In addition to the activities proposed in the HSW EIS, reasonably foreseeable future onsite activities that were considered include:

- continued operation of research and development facilities
- disposal of tank waste and closure of tank waste sites
- continued management of spent nuclear fuel
- continued storage of strontium, cesium capsules, and other radioactive materials
- continuation of RCRA/CERCLA remediation projects and operation of ERDF
- continued stabilization of the Plutonium Finishing Plant
- continued operation of the ETF, the LERF, the State-approved land disposal system, and the TEDF
- decommissioning and disposition of Hanford's surplus reactors and chemical processing facilities
- continued disposal of Navy reactor compartments
- continued operation of the commercial LLW disposal site by US Ecology, Inc.
- continued operation of the Columbia Generating Station by Energy Northwest.

Reasonably foreseeable future offsite activities that were considered consist of those of the nearby commercial nuclear fuel fabrication plant and commercial waste treatment facilities.

As evidenced by the data presented elsewhere in Section 5 and in the Hanford annual environmental reports, for most resource and potential impact areas, the cumulative impacts from implementation of the HSW EIS alternative groups for the Hanford Only, Lower Bound, and Upper Bound waste volumes, or for the No Action Alternative for the Hanford Only and Lower Bound waste volumes, when added to impacts of the other cited actions, would be small to negligible.

5.14.1 Land Use

Consistent with past NEPA actions, land within the 200 Areas has already been committed for Industrial-Exclusive use, including waste disposal (DOE 1999). Radionuclides are present in the soil from past discharges, disposal actions, or tank leaks. Because of their chemical characteristics and very long half-lives (for example, cesium-135 with a half-life of 2.3 million years), some radionuclides are held in the soil indefinitely.

Waste previously disposed of in the solid waste disposal facilities currently occupies 130.5 ha (322 ac) of the Hanford Site. As discussed in Section 5.1, additions to the commitment of land area for waste disposal would range from about 19.2 ha (47 ac) for the Hanford Only waste volume as disposed of in any of the configurations of Alternative Groups D or E to 79.6 ha (197 ac) for the Upper Bound waste volume estimate as disposed of in Alternative Group B (see Section 5.1). Waste management activities through 2046 (Upper Bound waste volume) would be expected to require up to a total of 427 ha (1050 ac) for waste storage, treatment, and disposal facilities and for capping materials. Of this total, 210 ha (519 ac) would be permanently committed for disposal of wastes in Alternative Group B (largest requirements). This amount would represent about 4.2 percent of the 5000 ha (12,350 ac) within the area previously designated for long-term waste management activities in the *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS) (DOE 1999).

5.14.2 Air Quality

As discussed in Section 5.2, air quality standards at the Hanford Site boundary would not be approached or exceeded as a result of implementing any of the actions described here or in combination with other reasonably foreseeable actions at the Hanford Site (see Section 5.2). This is due in large part to the current and projected:

- low density and intensity of pollutant emitting activities on the Hanford Site and in neighboring areas of south-central Washington
- relatively low population density in the region (minimizing the contribution of urban impacts on the region's air quality)
- substantial distances between the project activities and the Hanford Site boundary
- atmospheric dispersion conditions at Hanford that are generally favorable and meteorological conditions that could lead to a severe atmospheric stagnation event are of low-to-moderate frequency (and typically of short duration).

Quantification of cumulative non-radiological impacts for criteria pollutants was based on data presented in the Tank Waste Remediation System EIS and is shown in Table 5.150 (DOE and Ecology 1996). The maximum impacts from Hanford Solid Waste Program activities are presented in Table 5.151 for comparison.

Table 5.150. Cumulative Air Quality Impacts for Criteria Pollutants

Sources	Maximum Average Concentration ($\mu\text{g}/\text{m}^3$)			
	Particulate (PM_{10})	Nitrogen Oxide (NO_2)	Sulfur Oxide (SO_2)	Carbon Monoxide (CO)
Hanford Site baseline	3	3	19	3
Hanford remedial action	43	40	5	26
Environmental Restoration Disposal Facility	33	Negligible	Negligible	Negligible
Tank Waste Remediation System alternative	98	2.2	27	2500
Standard ^(a)	150 (24 hour)	100 (Annual)	365 (24 hour)	10,000 (8 hour)
(a) 40 CFR 50.				

Table 5.151. Largest Criteria-Pollutant Impacts for HSW Operations Among the Alternative Groups and the No Action Alternative

Alternative Group	Hanford Only and Lower Bound Waste Volumes				Upper Bound Waste Volume			
	24-hr PM_{10}	1-hr SO_2	8-hr CO	Annual NO_2	24-hr PM_{10}	1-hr SO_2	8-hr CO	Annual NO_2
Alternative Group A, $\mu\text{g}/\text{m}^3$	69	81	470	0.72	74	98	590	0.80
Alternative Group B, $\mu\text{g}/\text{m}^3$	71	130	800	1.0	90	180	1110	1.1
Alternative Group C, $\mu\text{g}/\text{m}^3$	60	79	460	0.77	61	80	470	0.77
Alternative Group D, $\mu\text{g}/\text{m}^3$	61	84	500	0.79	62	84	500	0.85
Alternative Group E, $\mu\text{g}/\text{m}^3$	60	93	530	0.89	62	95	530	0.89
No Action Alternative, $\mu\text{g}/\text{m}^3$	57	86	460	0.85	Not applicable			
(a) Standards are: 24-hour PM_{10} = 150 $\mu\text{g}/\text{m}^3$, 1-hour SO_2 = 1,000 $\mu\text{g}/\text{m}^3$, 8-hour CO = 10,000 $\mu\text{g}/\text{m}^3$. Annual NO_2 = 100 $\mu\text{g}/\text{m}^3$								

It should be noted that the values presented in Tables 5.150 and 5.151 are maximums that would occur at different times and locations and may not be additive.

5.14.3 Ecological, Cultural, Aesthetic, and Scenic Resources

Cumulative impacts as they pertain to ecological, cultural, aesthetic, and scenic resources in general on the Hanford Site can be found in the HCP EIS, which is incorporated by reference (DOE 1999). There, it was concluded that the potential for cumulative impacts to biological resources could best be

evaluated by determining the amount of *Hanford Site Biological Resources Management Plan* (BRMaP) Level III and Level IV resources that could be affected.

The HSW EIS does not consider any change in land use designated by the HCP EIS Record of Decision (64 FR 61615). The HCP EIS took a long-term look at the resources that would be required for the major reasonably foreseeable projects. Capping on the Central Plateau and complete conversion of the Industrial-Exclusive to industrial areas were two of the impacts assumed at that time. The HCP EIS contains the distribution of BRMaP Levels II, III, and IV resources for the DOE preferred alternative—prior to the 24 Command Fire. BRMaP mitigation would have been required for those areas that were designated Level III or Level IV. Assuming that the pre-fire condition represents the edaphic potential of the burned areas, the HCP EIS identified 44,183 ha (109,179 ac) in Conservation (Mining) and 5,064 ha (12,323 ac) in Industrial-Exclusive as BRMaP Level III resources, out of a site resource base of 148,080 ha (365,914 ac). These areas contain no BRMaP Level IV resources. In the HCP EIS, Conservation (Mining) was chosen for 30 percent of the site, while Preservation was chosen for 53 percent of the site.

Field surveys conducted during 2002 for each of the areas in which any of the HSW EIS alternative groups might be implemented identified the near PUREX disposal facility site (up to 24.5 ha [60 ac]) as mature shrub-steppe habitat that could qualify under BRMaP Level III and require mitigation. Isolated element occurrences in Area C might also qualify as Level III or Level IV but would need to be re-examined nearer the time of the planned disturbance (see Section 5.5).

The activities described in this EIS would take place in areas that are, and will be for the foreseeable future, dedicated to industrial type uses. However, the presence of the Hanford Reach Monument with its relatively low-density use and the portions of the Hanford Site designated for preservation/conservation would result in large areas remaining in a natural state.

Surveys of areas to be used in implementing each of the alternative groups did not disclose the presence of cultural resources (see Section 5.7). However, changes to the viewshed of the Hanford 200 Areas would occur as a result of activities evaluated in this EIS as well as other programs at Hanford. As facilities are closed and barriers are placed on waste disposal facilities, the visual appearance of waste disposal facilities would likely become more similar to the to pre-Hanford Site condition. Future uses of the Central Plateau are likely to include structures and activities consistent with its designation for Industrial-Exclusive use in the HCP EIS (DOE 1999). However, most areas of the viewshed on the Hanford Site are expected to remain in a near natural state due to designation of approximately 80,000 ha (200,000 ac) of the site as a national monument (65 FR 37253) and of many other major areas of the site for preservation/conservation (DOE 1999).

5.14.4 Geologic Resources

Geologic resources consisting of sand, gravel, silt/loam, and perhaps basalt would be required in the construction of Modified RCRA Subtitle C Barriers for any of the alternative groups and for the Hanford barrier to cover immobilized low-activity waste (ILAW) as disposed of in the No Action Alternative. The expected quantities of these resources were presented in Section 5.10. The resources would be obtained

from Area C identified in the HCP EIS (DOE 1999) as Conservation (Mining). In areal extent, the requirements would at most (Alternative Group B) amount to about 10 percent of Area C designated for borrow-pit materials.

This HSW EIS does not consider any change in land use designated by the HCP EIS ROD (64 FR 61615). The HCP EIS took a long-term look at the resources that would be required for the major reasonably foreseeable projects. Capping on the Central Plateau and complete conversion of the Industrial-Exclusive to industrial areas were two of the impacts assumed at that time. Appendix D of the HCP EIS discussed using 36.1 million cubic meters (47.3 million cubic yards) of fine textured soils and developing a basalt source that could yield 15.3 million cubic meters (20 million cubic yards) of basalt riprap. A maximum of 90 ha (222 ac) of area C would be used for geologic resource development, out of the 44,183 ha (109,179 ac) reserved by the HCP EIS for Conservation (Mining). In the HCP EIS, Conservation (Mining) was chosen for 30 percent of the site, while Preservation was chosen for 53 percent of the site.

5.14.5 Socioeconomics

If a number of the projects being considered for Hanford were undertaken simultaneously, the activity levels and the workers needed to support the activities could temporarily strain community infrastructure. The impact of any of the HSW EIS alternative groups or the No Action Alternative would be small (300 to 400 workers out of 15,000 workers at the Hanford Site, see Section 5.6). The current projected baseline for Hanford shows declining employment beginning in about 2005. If this baseline is maintained and other considerations remain equal, most existing components of community infrastructure would be adequate to accommodate population growth of about 2,000 residents associated with any of the HSW EIS alternative groups in the long run. However, a projected 7,000 new residents are expected move into the area to support construction of the Hanford tank waste treatment plant. These new arrivals and any early arrival of the up to about 2,000 new residents related to the Hanford solid waste program in the Tri-Cities area could challenge the capacities of the local real estate markets, the transportation network, and the primary and secondary education facilities.

In addition, other projects are expected to be underway at Hanford in the near term, such as operations at the Hazardous Materials Management and Emergency Response (HAMMER) facility; cleanup of several older reactors and other buildings; and actions to remediate the K Basins, the vadose zone, and the groundwater on the site. These additional projects could increase Hanford employment by a few hundred workers during the period 2003 to 2010 and, therefore, might also affect the socioeconomic context against which the effects of any LLW, MLLW, and TRU waste-related activity under the proposed action would need to be judged (see Section 5.6).

While the increases in workers (300 to 400) mentioned above would be in addition to the existing Hanford workforce of about 15,000, that work force is anticipated to temporarily increase (from activities other than those associated with Hanford solid waste), then generally decline after about 2005, and finally continue to decline throughout the period of analysis (see Section 5.6, Figure 5.22). Overall employment may even decline at a faster rate than presently forecasted depending on the success of accelerated site

cleanup. However, the impact of implementing any of the Hanford solid waste alternative groups would be a small addition to cumulative socioeconomic impacts.

5.14.6 Public Health

Although large amounts of various chemicals have been used during Hanford operations over the years, the breadth and depth of documented, quantitative information regarding these chemicals is very limited when compared with the amount of information available about radioactive materials. However, as shown in Section 5.11, hazards from releases of chemicals to the atmosphere have been calculated to be very small for all the alternative groups and would not be expected to add measurably to cumulative impacts regardless of their magnitude.

As was shown in Section, 4.5.3.2, Figure 4.19, a number of chemicals, principally from past liquid discharges to the ground, are found in the groundwater at Hanford. Again, there is only fragmentary data on the source quantities and transport to groundwater of these chemicals. In one case, however, it was estimated that the inventory of nitrate in groundwater beneath the 200 Areas exceeded 90,000 tonnes (100,000 tons) (ERDA 1975). The inventory of nitrate in Hanford solid waste is on the order of 6.2 tonnes (6.8 tons), which is small relative to other sources of this chemical at Hanford. In addition to the minimal impacts reported for chemicals in Section 5.3, this suggests that the impacts of other chemicals in Hanford solid waste would not contribute substantially to the cumulative impacts of existing chemicals in groundwater.

Cumulative impacts for the atmospheric, surface water, and groundwater pathways, which could lead to potential radiological impacts on the public, are presented in the following subsections (also see Section 5.11).

5.14.6.1 Atmospheric Pathway

A summary of cumulative radiological impacts on public health due to radiological air emissions from past, current, and reasonably foreseeable future activities at Hanford is provided in Table 5.152. Examples of past activities include operation of the fuel fabrication plants, reactors, the PUREX Plant and other fuel processing facilities; the Plutonium Finishing Plant; and research facilities. Current activities include site cleanup, waste disposal, and tank waste stabilization; reasonably foreseeable future activities include continuation of site cleanup, waste disposal, immobilization of both high-level and low-activity waste, and related activities.

The cumulative population dose since the startup of Hanford operations was estimated to be 100,000 person-rem (DOE 1995). The number of inferred latent cancer fatalities (LCFs) since Hanford startup from such a population dose would amount to about 60, essentially all of which would be attributed to a dose received in the 1945 to 1952 time period.

For perspective, since startup of the Hanford Site, the population of interest (assuming an average population within 80 km [50 mi] of 380,000 and an individual dose of 0.3 rem/yr [NCRP 1987]) would have received about 6 million person-rem from naturally occurring radiation sources (that is, natural background), from which about 4000 LCFs could be inferred.

Table 5.152. Cumulative Population Health Effects in the Hanford Environs from Atmospheric Pathways due to Hanford Site Activities^(a)

Source of Impacts	Dose Person-rem	Latent Cancer Fatalities ^(b)
Past Hanford operations (DOE 1995)	100,000	60
Ongoing and Proposed Operations		
Hanford operations (1997–2046) (Poston et al. 2001) ^(c)	15	0
Columbia generating station (30 yr) (DOE 1996b)	21	0
HSW EIS—atmospheric releases		
Alternative Groups A, C, D, & E—range ^(d)	0.15–0.24	0
Alternative Group B—range ^(d)	0.19–0.29	0
No Action Alternative—range ^(e)	0.10–0.12	0
Reasonably Foreseeable Operations		
Plutonium Finishing Plant stabilization (DOE 1996b)	140 ^(f)	0
K Basin fuel treatment and storage (DOE 1996a)	120 ^(f)	0
TWRS phased implementation alternative (DOE and Ecology 1996)	400 ^(f)	0
Cumulative total	100,696.3 ^(g)	60
Perspective		
Cumulative natural background dose—100 yr, 1946–2046	12,000,000	7,000

(a) Assumes constant population of about 380,000.
(b) Assumes six inferred LCFs per 10,000 person-rem. Values less than 0.5 were rounded to zero.
(c) Assumed to continue at the 2000 population dose rate.
(d) Range based on Hanford Only and Upper Bound waste volumes.
(e) Range based on Hanford Only and Lower Bound waste volumes.
(f) Value based on previous NEPA analyses.
(g) For the solid waste program, this number includes only the value of 0.3 person-rem from Alternative Groups A, B, C, D, or E, Upper Bound waste volume activities.

If the entire Hanford sitewide contribution to population dose from all exposure pathways were to remain at calendar-year 2000 levels (Poston et al. 2001) through the period ending in 2046, the estimated collective population dose would be about 36 person-rem. No LCFs would be expected from such a population dose.

This estimated level was based on a 0.3-person-rem/yr population dose from DOE facilities at Hanford and a 0.7-person-rem/yr population dose from Energy Northwest’s Columbia Generating Station for 30 years of operation (DOE 1996b). The largest contribution from solid waste management alternative groups to the total population dose of 36 person-rem would be about 0.3 person-rem (see Section 5.11).

Vitrification of the Hanford tank wastes could contribute up to about 400 person-rem to the cumulative, collective population dose (DOE and Ecology 1996). The cumulative, collective population dose from Plutonium Finishing Plant activities could be up to 140 person-rem (DOE 1996b). Similarly, remediation of K Basins could be up to 120 person-rem (DOE 1996a). No other activities are foreseen that would add substantially to these doses, and the total dose from these activities through the period ending in 2046 would not be expected to result in any LCFs.

Again for perspective, the doses to the local population from naturally occurring radioactive sources would result in about an additional 6 million person-rem for the 50-year period ending in 2046, from which about 4000 LCFs also would be inferred. Thus, over about 100 years from the start of the Hanford operations to the year 2046, about 7000 LCFs might have resulted from naturally occurring sources. To this number of LCFs resulting from natural sources would be the inference that Hanford operations might have added about 60 LCFs as a result of airborne releases of radioactive material mainly during the 1945 to 1952 time period.

5.14.6.2 Surface Water Pathway

Past impacts associated with the water pathway were principally associated with contamination of Columbia River water that was used as once-through coolant for the eight Hanford production reactors. Various elements present in the incoming water were made radioactive during their passage through one or more of these reactors.^(a) In addition, some of the corrosion products that formed in the plants' piping were made radioactive and entered the water. Fuel element failures (slug ruptures) also exposed the fuel to cooling water and added contaminants to the water. On an average annual basis, the principal radionuclides contributing to a potential dose were phosphorous-32, chromium-51, zinc-65, arsenic-76, and neptunium-239. Contamination also occurred as a result of adding water-conditioning agents, with hexavalent chromium as the principal contaminant.

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- (a) A ninth reactor, N Reactor, did not use once-through cooling. Past discharges to nearby trenches is a source for seepage of some contaminants into the river.
 - (b) Before 1971, higher doses would have been experienced by those individuals making recreational use of the Columbia River, consuming food crops grown with irrigation water derived from the river, consuming fish and waterfowl inhabiting the river, and consuming seafood harvested from along the Washington and Oregon coast. Due to the number of pathways and uncertainties in numbers of individuals involved, this aspect has not been quantified on a collective basis for the 1944 to present time period. Estimates of maximum and average representative individual doses may be found in Farris et al. (1994). Doses from 1971 to present were estimated from the maximally exposed individual (MEI) doses taken from annual reports and, consequently, are substantially higher than would be expected for individuals with typical dietary habits (for example, the annual per capita dose for 1999 was reported as 0.0007 mrem, and the MEI dose was reported as 0.008 mrem, thus the MEI dose overestimates the per capita dose by a factor of about 10.)

An estimate of the collective population dose to the nearest downstream users of the Columbia River (Richland, Pasco, and Kennewick, Washington) from 1944 to present would amount to about 3000 person-rem, most of which occurred before 1971 at which time the last reactor that used once-through cooling was shut down. This estimate was based on the dose to people who drank water supplied by municipal water plants and estimates of the populations for Richland (after startup of its water treatment plant in late 1963), Pasco, and Kennewick, and included a nominal amount of time for people who engaged in boating and swimming in the Columbia River.^(b) From 1971 to present, the collective population dose was estimated to be less than 400 person-rem. From a collective dose of 3000 person-rem, 2 LCFs could be inferred. The collective population drinking water dose for 2001 from the surface water pathway was determined to be 0.0024 person-rem (Poston et al. 2001). If that annual dose were to continue over 10,000 years, the total from all future Hanford activities might amount to 27 person-rem. The addition of radionuclides from the disposal of Hanford solid waste over that period was less than or equal to 0.3 person-rem in the Tri-Cities. Neither the current projection of drinking water dose nor that projected from disposal of Hanford solid waste would add substantially to the past cumulative population dose derived from the Columbia River of 3400 person-rem.

The presence of contaminants in surface water as a result of inflow of groundwater and a discussion of the cumulative impacts of contaminants in the groundwater, itself, are included in the next subsection.

5.14.6.3 Groundwater Pathway

Cumulative groundwater impacts are examined in the context of existing sources of contamination in the soil, vadose zone, and groundwater. The following contaminants have been consistently detectable in soil on the Hanford Site: strontium-90, cesium-137, uranium-238, plutonium isotopes (238, 239, 240), and americium-241. Contaminants in the vadose zone include cobalt-60, strontium-90, technetium-99, cesium-137, europium isotopes (152, 154), uranium isotopes (234, 235, 238), and plutonium isotopes (239, 240). Contaminants in the vadose zone also include non-radioactive materials including metals, volatile organics, semivolatile organics, and inorganics (Poston et al. 2002). Current contamination of the groundwater and vadose zone is due primarily to past liquid waste disposal practices involving hazardous chemicals and radionuclides. The existing level of contamination in the groundwater would exceed Federal Drinking Water Standards if it were a source of drinking water as defined in the standards (Poston et al. 2002). Hazardous chemical contaminants that would exceed this benchmark include nitrate, carbon tetrachloride, trichloroethene, and chromium, and radiological contaminants that exceed the standards include tritium, iodine-129, strontium-90, technetium-99, and uranium. Concentrations of these radionuclides and hazardous chemicals currently in groundwater are shown in Section 4.5.3.1, Figures 4.18 and 4.19, respectively.

Action alternatives analyzed in this EIS would not cause the dose from drinking groundwater at 1 km from the disposal facilities to exceed the DOE 4-mrem-per-year benchmark public drinking water limit (see Section 5.11.2.1). Analysis of the preferred alternative also indicated the dose from drinking groundwater at the disposal facility boundary would not exceed the DOE limit (see Section 5.11.2.1.4). By the time the waste constituents from the action alternatives are predicted to reach groundwater (hundreds of years) the waste constituents would not superimpose on existing plumes and would not exceed the benchmark dose, because the existing groundwater contaminant plumes will have migrated out of the unconfined aquifer by then.

Radionuclides leached from wastes disposed of in HSW disposal facilities could eventually be transported through the vadose zone to groundwater. For this analysis, it was assumed that an individual drilled a well through the vadose zone to the groundwater and used the groundwater as a source of drinking water. As an indication of cumulative Hanford groundwater impacts, the annual dose to an individual drinking 2 liters of that water per day and taking into account all wastes intentionally or unintentionally disposed of on the Hanford Site since the beginning of operations and waste forecast to be disposed of through 2046^(a) was calculated for technetium-99, iodine-129, and uranium isotopes using the System Assessment Capability (SAC) (Kincaid et al. 2000) software and data. Technetium-99, iodine-129, and uranium were selected for analysis because they are expected to be the dominant contributors to risk in the future. Carbon-14 was omitted from this cumulative assessment based on prior analyses (Kincaid et al. 1998) that showed it to be less mobile and not substantially influencing cumulative results. The distribution coefficients assigned to carbon-14 in solid waste for that analysis were substantially greater than those assigned to uranium and iodine-129, and, consequently, carbon-14 would not be expected to release from solid waste deposits into groundwater during this 10,000-year assessment.

The more limited data available for chemical inventories in solid waste disposals would not support a SAC analysis on the same scale as the initial assessment conducted for radionuclides. However, based on available information, chemicals in solid waste do not appear to be as important in terms of human health impacts as the key radionuclides—technetium-99, iodine-129, and uranium. Carbon tetrachloride and chromium in Hanford solid waste are not expected to add substantially to impacts of those substances from other Hanford sources, that is, liquid discharge sites and unplanned releases. For further discussion of the potential impacts from hazardous chemical constituents in Hanford solid waste, see Volume I, Sections 5.3.2 and 5.3.5.

(a) ILAW from treating tank waste was not included in the original SAC or initial assessment. Initially the SAC was tasked to address a 1000-year period; however, technetium-99 and iodine-129 would not release from the ILAW form to the water table within that time period. An approximation of the drinking water doses combining SAC and ILAW results for technetium-99, iodine-129, and uranium is shown as a function of time in Figures 5.38 through 5.43. Melters and naval reactor compartments also were not included as sources of radioactive releases in the original SAC assessment. They, like ILAW, were assumed to not release any activity during the initial 1000-year post-closure period. Both of these waste types are encased in substantial steel containment and contain substantially lower inventories of technetium-99 and uranium than ILAW; therefore, they would not contribute to groundwater contamination and were not simulated.

A SAC analysis of hypothetical future impacts was conducted based on conservative assumptions (that is, absence of active institutional controls and cessation of barrier maintenance). The SAC analysis of the initial assessment for 10,000 years completed for the HSW EIS was comprised of two simulations: a stochastic analysis^(a) and a deterministic analysis.^(b)

Liquid Discharge of Carbon Tetrachloride

Groundwater modeling has been performed in support of the Hanford Carbon Tetrachloride Innovative Treatment Remediation Demonstration (ITRD) Program (Truex et al. 2001). Simulations, as part of this study, of the liquid discharge sites receiving carbon tetrachloride were based on an assumption that approximately 65 percent, 30 percent, 10 percent, and 1 percent of the source could reach the groundwater. Approximately 1 to 2 percent of the original carbon tetrachloride inventory is estimated to now exist in the plume based on averaged groundwater measurements (Ebasco Services, Inc. 1993). Other model parameters varied in Truex et al. (2001) included porosity, soil/water equilibrium partition coefficient (K_d), and abiotic degradation rate (K_a). The analysis revealed that a breakpoint for cleanup requirements lies between 1 and 10 percent of the initial discharge inventory reaching groundwater. If 1 percent of the inventory reaches groundwater, no cleanup is likely to be required, whereas if 10 percent of the inventory eventually reaches groundwater, some cleanup may be necessary. Therefore, an estimate of the initial inventory that may ultimately reach groundwater is important in determining the need for site cleanup. The study also showed that better definition of K_d , K_a , and porosity would aid in refining estimates of the compliance boundary concentrations. Truex et al. (2001) concluded, "...if 1% of the discharged CT [carbon tetrachloride] is all that ever reaches groundwater, then it is likely the highest concentration of CT to arrive at the compliance boundary will not exceed the compliance concentration."

LLBG Disposal of Carbon Tetrachloride

The presence of carbon tetrachloride in the aquifer underlying the 200 West Area is a direct result of the disposal of liquid waste streams containing carbon tetrachloride. The mean value inventory of carbon tetrachloride shows approximately 813,000 kg being released to liquid discharge sites in the 200 West Area. For comparison, all of the carbon tetrachloride in HSW is reported to be in "stored" solid waste; none is reported in "buried" solid waste, and the total inventory reported to be stored through 1997 was approximately 5000 kg. Storage is taking place in the radioactive mixed waste storage facilities (primarily CWC) and in retrievably stored TRU waste trenches in the 218-W-3A, 218-W-4B, and 218-W-4C LLBGs. While there is no record of past disposals, some carbon tetrachloride might have been disposed of in HSW; however, it is likely that the amount, its rate of release, and its potential impact on groundwater would not be substantial compared with that of past releases to liquid discharge facilities.

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- (a) Stochastic Analysis: Set of calculations performed using values randomly selected from a range of reasonable values for one or more parameters; in contrast, see deterministic analysis. In the HSW EIS, the median result from a set of stochastic calculations was reported.
- (b) Deterministic Analysis: A single calculation using only a single value for each of the model parameters. A deterministic system is governed by definite rules of system behavior leading to cause and effect relationships and predictability. Deterministic calculations do not account for uncertainty in the physical relationships or parameter values.

The stochastic analysis included 25 realizations. Each realization represents a possible combination of the uncertain parameters. Using a cumulative performance measure, such as cumulative dose at a point of interest, a single realization can be identified as the median response for the stochastic problem. The single deterministic calculation was performed using the median value for each input parameter. Results of the 25 stochastic simulations, with the median result case highlighted, are provided in Volume II, Appendix L. The result of the deterministic calculation using median inputs is reported in this section as well as in Volume II, Appendix L for comparison to the stochastic cases. For additional information on the SAC calculation process, see Volume II, Appendix L to this EIS and the initial assessment report (Bryce et al. 2002). The SAC is the next generation methodology intended to update and improve the 1998 Composite Analysis completed by Kincaid et al. (1998). Using the dose predicted in the ILAW performance assessment (Mann et al. 2001) the influence of ILAW disposal has been added to that predicted in the initial assessment median-inputs case simulated with SAC. Thus, the cumulative impact shown below for selected points is achieved by superimposing the published ILAW impact on the simulated initial assessment results. The inventories simulated using the SAC tool for this EIS are shown in Table L.1 in Volume II, Appendix L and represent the combination of solid waste, liquid discharge and unplanned release, tank waste, and commercial low-level waste inventories addressed in the cumulative assessment.

1-km Line of Analysis

A line of analysis approximately 1 km from an operational area or waste disposal site was used in the 1998 composite analysis (Kincaid et al. 1998), the initial assessment completed with the SAC (Bryce et al. 2002), and in the simulations supporting this HSW EIS. The travel distance between the source and the uptake location is consistent with the groundwater model grid (that is, 375 m) and the longitudinal dispersivity (that is, 95 m) used in the sitewide groundwater model. In general, the rule of thumb for selecting an appropriate longitudinal dispersivity is to use approximately 10 percent of the mean travel distance of interest. A 1-km travel distance implies a 100-m longitudinal dispersivity. To control model stability and artificial dispersivity, the model grid Peclet number (that is, grid spacing/longitudinal dispersivity = 375 m/95 m) is typically selected to be no greater than 4 for finite element models. The existing model for the cumulative impacts was not configured to produce results at a 100-m travel distance. To achieve results at a 100-m line of analysis for the cumulative impacts would require development of a local-scale model based on an approximate grid size of 40 m and longitudinal dispersivity of 10 m.

Concentration profiles over time for technetium-99, iodine-129, and uranium from all Hanford sources at a line of analysis approximately 1 km (0.6 mi) southeast of the 200 East Area are shown in Figure 5.44. Maximum concentrations for each of the radionuclides occur in the near term.

Concentrations of technetium-99, iodine-129, and uranium are 1600, 0.90, and 1.1 pCi/L, respectively. The technetium-99 and iodine-129 concentrations are above or near the benchmark drinking water standards of 900 pCi/L and 1 pCi/L, respectively. The uranium concentration, approximately 3.3 µg/L, is below its benchmark drinking water standard of 30 µg/L. The cumulative impact for technetium-99, iodine-129, and uranium from all Hanford sources is provided in Figure 5.45. This is the annual dose

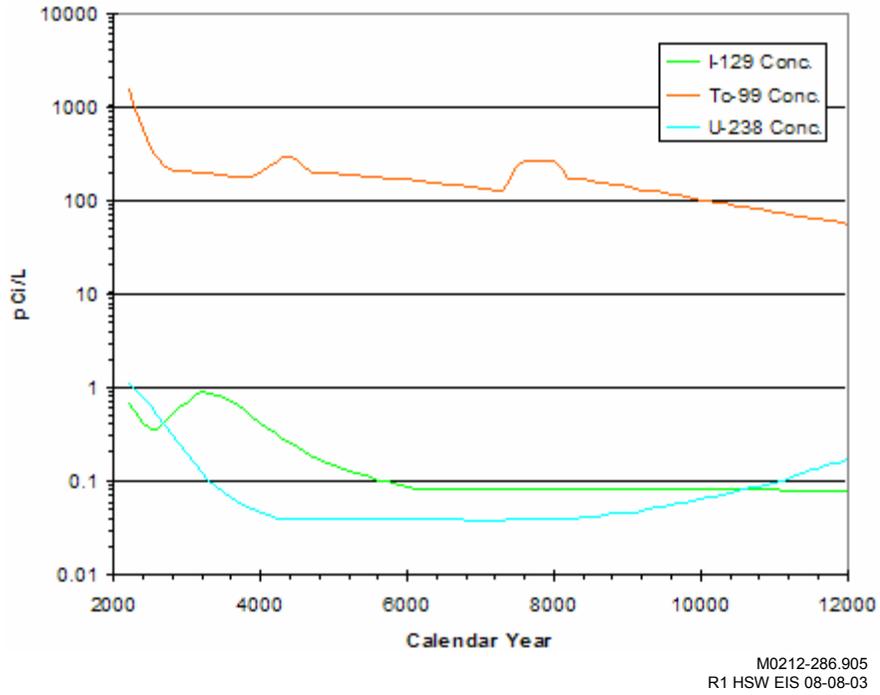


Figure 5.44. Concentrations of Technetium-99, Iodine-129, and Uranium in Groundwater Southeast of the 200 East Area from All Hanford Sources

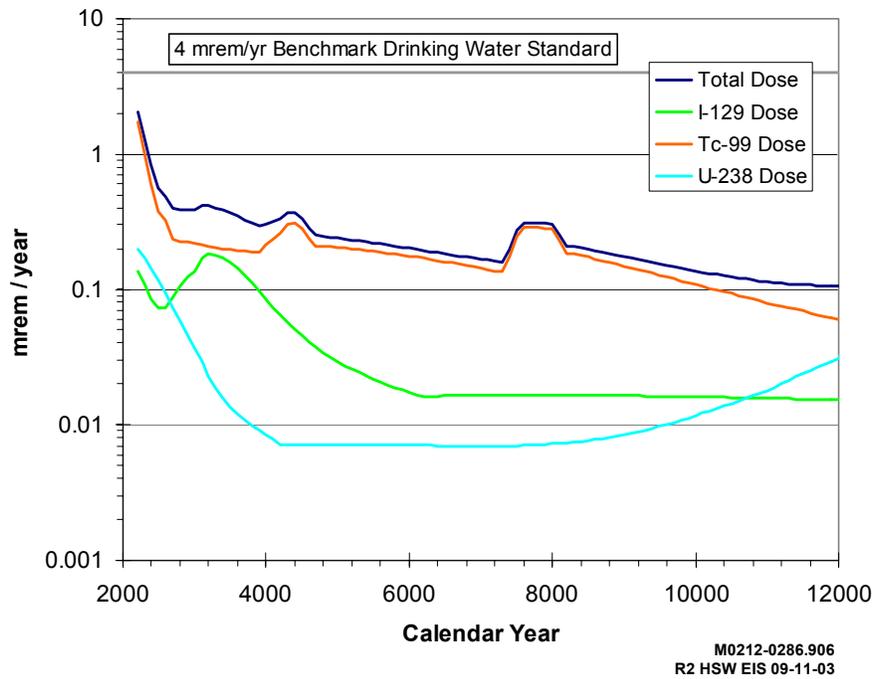


Figure 5.45. Hypothetical Drinking Water Dose from Technetium-99, Iodine-129, and Uranium in Groundwater Southeast of the 200 East Area from All Hanford Sources

resulting from a 2-L/d drinking water scenario for each of the radionuclides. The values of maximum dose for technetium-99, iodine-129, and uranium corresponding to the maximum concentrations are 1.7, 0.18, and 0.20 mrem/yr.

The annual dose exhibits a peak of approximately 2 mrem/yr. This peak appears to be related to releases from past liquid discharge sites in the 200 East Area. Additional, but lower, peaks of approximately 0.4 mrem/yr appear in approximately years 4400 and 7600. Releases of technetium-99 from HSW disposal facilities in the 200 West Area are responsible for the peak in approximately year 4400. Tank waste residuals releasing technetium-99 in the 200 East Area from a 1-percent residual volume and a salt cake waste are responsible for the last peak. The underlying long-term dose declines to 0.1 mrem/yr by 10,000 years post closure. This dose is related to long-term releases from HSW and other miscellaneous waste, which, when combined, account for approximately 0.07 mrem/yr, and from ILAW, which accounts for approximately 0.04 mrem/yr.

Based on uncertainty in the groundwater conceptual model and resulting direction of groundwater flow, the ILAW contribution to the cumulative result may be approximately four times larger when groundwater flows to the northeast rather than the southeast. The resulting cumulative 2-L/d drinking water dose from ILAW for technetium-99, iodine-129, and uranium would be approximately 0.2 mrem/yr at 10,000 years post closure for this northeast groundwater flow case. Somewhat higher contributions than shown here from HSW and other sources (that is, 0.07 mrem/yr) may also occur because of uncertainty in the groundwater conceptual model used in the SAC; however, groundwater model uncertainty as it relates to the HSW contributions is addressed in Section 5.3 and Volume II, Appendix G. It should be noted that the ILAW release and associated dose impacts play a role in the last several thousand years only and do not substantially influence the peaks that occur earlier.

The cumulative dose from all Hanford sources and that portion attributed to solid waste at the line of analysis southeast of the 200 East Area are shown in Figure 5.46. Differences in the two curves (that is, the slope of the curves) are attributed to somewhat different distribution coefficient (K_d) values used in the simulation of HSW EIS groundwater impact analysis and in this cumulative assessment. The more rapid release and migration of uranium in the evaluation of solid waste disposal alternatives enables uranium to influence the long-term solid waste contribution between 8,000 and 12,000 A.D. This uranium influence is not seen in the initial assessment simulated with SAC because of the use of somewhat higher distribution coefficients to represent median or central tendency behavior. More details can be found later in this section.

Figure 5.47 shows the concentrations of technetium-99, iodine-129, and uranium from all Hanford sources from Columbia River water at the City of Richland pumping station. This location is downriver from all groundwater plumes of Hanford origin, and reveals the substantial dilution and dispersion that occurs because of the relatively large discharge of the Columbia River as compared with that of the unconfined aquifer underlying Hanford. Although groundwater simulations continued through the year 12,050 A.D. (10,000 years post closure; see Figure 5.47), the river simulations were terminated at the year 9900 A.D. due to the software design constraints of the river model. Thus, river model forecasts are not available for the final 2000 years of the 10,000-year post-closure period. However, as is apparent from

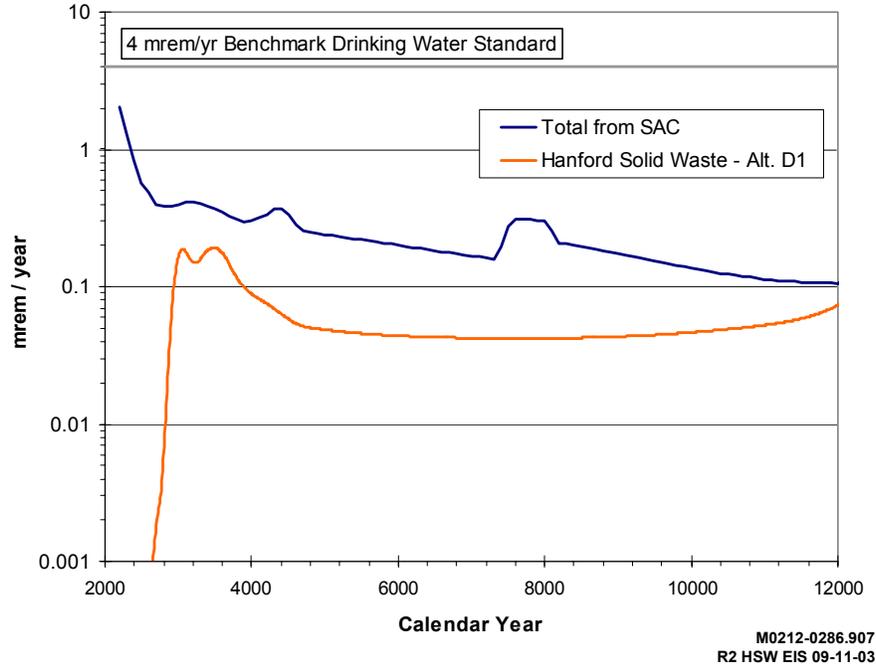


Figure 5.46. Hypothetical Total Drinking Water Dose from Groundwater for All Hanford Sources and the Hanford Solid Waste Contribution at the Line of Analysis Southeast of the 200 East Area

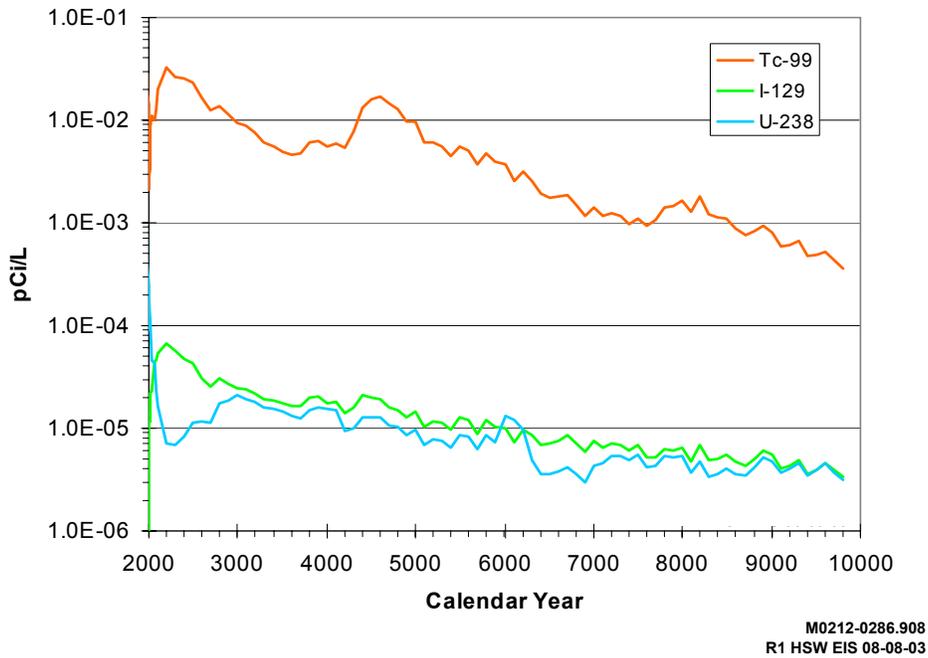


Figure 5.47. Concentrations of Technetium-99, Iodine-129, and Uranium in the Columbia River at the City of Richland Pumping Station from All Hanford Sources

the simulation results achieved, trends seen in the groundwater system near the Central Plateau appear somewhat later and at much reduced concentrations in the Columbia River at the City of Richland location.

A corresponding plot of the drinking water dose for technetium-99, iodine-129, and uranium is provided in Figure 5.48. While having a much more variable appearance caused by river discharge variability, the peaks seen in technetium-99 plots at the 200 East Area location are also present in Figure 5.48. Dose from Hanford-origin uranium and iodine-129 also exhibits a temporal variability caused by variability in Columbia River discharge. However, the peaks are subdued and delayed because these elements are sorbed and migrate more slowly than groundwater and non-sorbed elements, such as technetium. Concentration and annual dose values are approximately five orders of magnitude lower at the city of Richland compared with those predicted at the 200 East Area.

Figure 5.48 reveals the drinking water dose to a human from technetium-99, iodine-129, and uranium using water concentrations calculated near the City of Richland pumping station in the Columbia River never gets above 1.0×10^{-4} , or 0.0001, mrem/yr in the median inputs analysis. This location is downriver from all groundwater plumes of Hanford origin. The peak median dose from technetium-99 for the year 2000 through 9900 A.D. was approximately 3.5×10^{-5} , or 0.000035, mrem/yr. For the same period, the peak median dose from iodine-129 was approximately 1.5×10^{-5} , or 0.000015, mrem/yr. For uranium, the peak median dose was approximately 5×10^{-5} , or 0.00005, mrem/yr. These peaks occur at different times based on the sorption of each radionuclide. These results of dose analyses are presented as annual radiation dose.^(a)

Figure 5.49 shows the cumulative dose from all Hanford sources and that portion attributed to solid waste at the City of Richland pumping station. By the end of this analysis, 8000 years after site closure, the contribution from solid waste will be increasing slightly while the cumulative dose from all sources will be decreasing, and the overall dose from the three radionuclides is estimated to be less than 1×10^{-5} mrem/yr for the median-inputs case. An examination of the contribution of solid waste compared with the total annual dose reveals that initially less than one percent of the total is from solid waste; by calendar year 3500 the solid waste contribution will be approximately 6 percent of the total dose, and by calendar year 10,000 the solid waste contribution will be approximately 20 percent of the total dose. However, the contribution from solid waste is never above 1.0×10^{-6} , or 0.000001, mrem/yr at the City of Richland pumping station.

The stochastic capability of SAC was employed to evaluate the relative role in overall release of different waste types including solid waste, past liquid discharges, tank wastes, and facilities including canyon buildings. The variability in the stochastic results is due to variability in the inventory, release,

(a) The National Council on Radiation Protection and Measurements continues to hold that a dose of 1 mrem/yr is a dose “below which efforts to reduce the radiation exposure to the individual are unwarranted (Section 17 of NCRP 1993)” (NCRP 2002). Regardless, in this HSW EIS, doses are reported as calculated, however small they may be. Thus doses will be seen that are several to many orders of magnitude below 1 mrem/yr, and while these may be useful for comparative purposes, they should not be construed as having any physical meaning in terms of detriment to health.

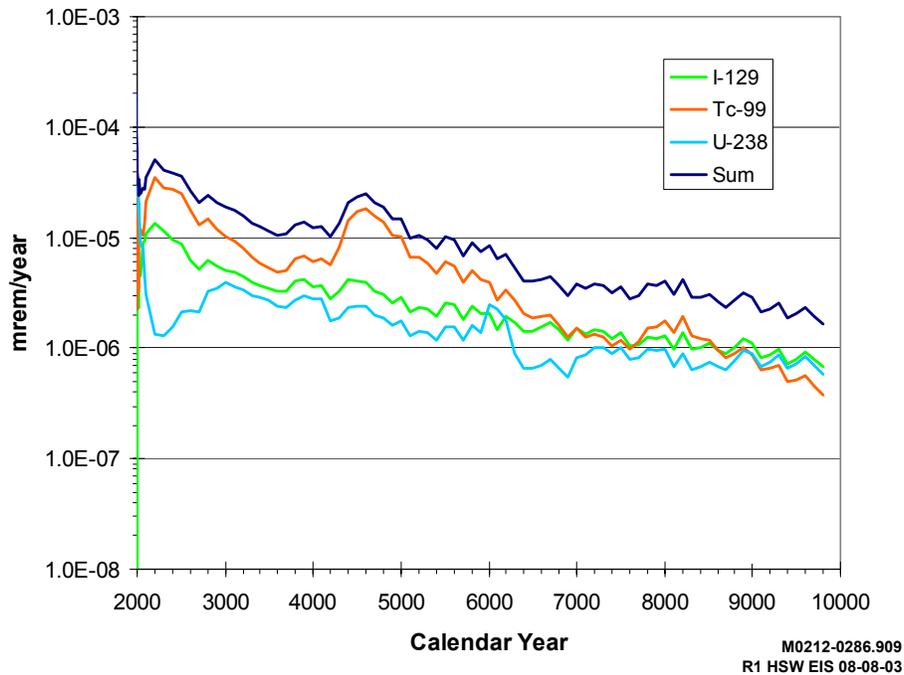


Figure 5.48. Drinking Water Dose from Technetium-99, Iodine-129, and Uranium in the Columbia River at the City of Richland Pumping Station from All Hanford Sources

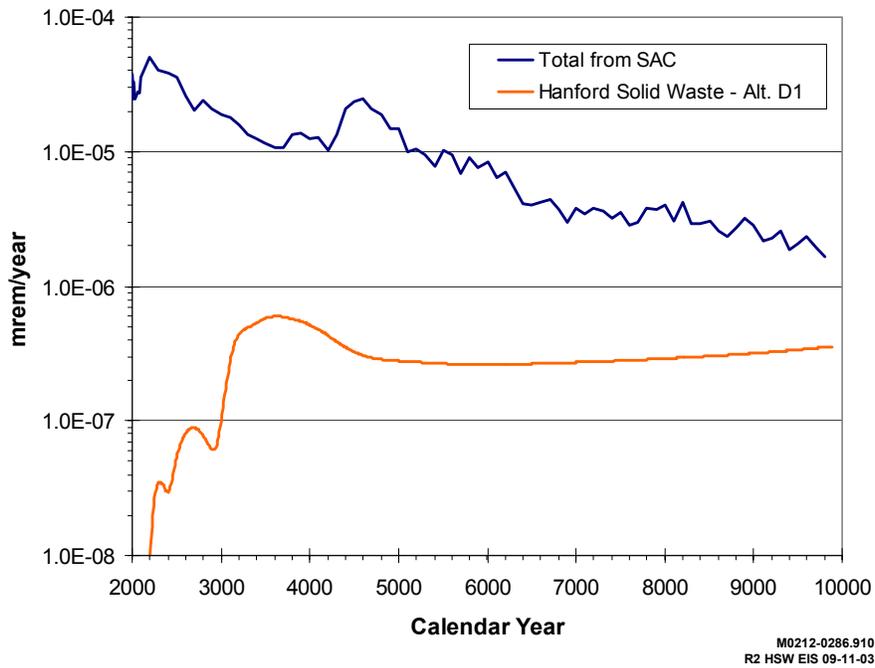


Figure 5.49. Hypothetical Total Drinking Water Dose from All Hanford Sources and the Hanford Solid Waste Contribution in the Columbia River at the City of Richland Pumping Station

and transport of technetium-99, iodine-129, and uranium. The human dose calculations use fixed inputs. These results include all waste releases (for example, releases from cribs, ponds, solid waste, past tank leaks, future tank losses, tank residuals, unplanned releases) that were considered in the initial assessment performed by Bryce et al. (2002). For reasons discussed previously, ILAW was analyzed separately and the results were added to the SAC analysis. The melters and naval reactor compartments would not contribute to the totals within 10,000 years (see the first footnote in Section 5.14.6.3 regarding ILAW, melters, and navy wastes).

In the SAC simulation, cumulative releases to groundwater from HSW, excluding ILAW disposed of in the Central Plateau, ranged from approximately 300 to 450 Ci for technetium-99 over the 10,000-year analysis period. This compares with releases to groundwater ranging from approximately 1500 to 2300 Ci of technetium-99 for all Hanford wastes except ILAW. Thus, the contribution to technetium-99 releases to groundwater from HSW, excluding ILAW, would amount to at most 20 percent of the cumulative release from all Hanford sources. The ILAW cumulative release of technetium-99 for the base case (Mann et al. 2001) used in this analysis was approximately 86 Ci by the end of the 10,000-year, post-closure period. Thus, the contribution from HSW, including ILAW, for technetium-99 would amount to, at most, 25 percent of the cumulative release. The majority of technetium-99 releases from wastes other than ILAW were predicted to occur from liquid discharge sites (cribs, ponds, trenches) used in the past and from unplanned releases on the plateau and from off-plateau waste sites.

For uranium, releases from HSW, excluding ILAW, to groundwater are much lower in the SAC simulation. No realizations showed any release of uranium to groundwater from these wastes in the 200 East Area, and only 5 of 25 realizations show any release of uranium to groundwater from these wastes in the 200 West Area. Thus, in an average (or median) sense, deposits of HSW, excluding ILAW, would release no uranium to groundwater over the 10,000-year period of analysis. This compares with a median release of approximately 84 Ci and a range of releases to groundwater from the 25 realizations of between approximately 10 and 300 Ci of uranium for all Hanford wastes except ILAW. Of the five stochastic realizations exhibiting non-zero uranium release from HSW, excluding ILAW, in the 200 West Area, the cumulative release ranged from 0 to approximately 90 Ci. Hence, the contribution of HSW, excluding ILAW, to overall uranium release to groundwater lies between 0 and 90 Ci, but the majority of the realizations showed no release. As a consequence, the contribution of HSW, excluding ILAW, to uranium releases to groundwater would amount to between 0 and 30 percent of the cumulative release from all Hanford sources except ILAW, and likely would be zero. The majority of uranium releases from wastes other than ILAW was predicted to occur from liquid discharge sites (for example, cribs, ponds, and trenches) used in the past and from unplanned releases on the plateau and from off-plateau waste sites. The ILAW cumulative release of uranium for the base case (Mann et al. 2001) was less than 1 Ci by the end of the 10,000-year post-closure period. Accordingly, the contribution from HSW including ILAW would amount to about 1 percent of the cumulative median release of uranium from all Hanford sources after 10,000 years.

Cumulative releases to groundwater from HSW disposed of in the Central Plateau, excluding ILAW, ranged from 0 to approximately 2.2 Ci for iodine-129 over the period of analysis. This compares with releases to groundwater ranging from approximately 0.1 to 8.8 Ci of iodine-129 for all Hanford wastes except ILAW. The contribution to iodine-129 releases to groundwater from HSW, excluding ILAW,

would amount to, at most, 25 percent of the cumulative release from all Hanford sources. With the exception of commercial low-level radioactive waste, iodine-129 releases from solid waste disposal facilities were predicted to be on par with those from tank sites and only half of those from liquid discharge and unplanned release sites. The ILAW cumulative release of iodine-129 for the base case (Mann et al. 2001) was approximately 0.07 Ci by the end of the 10,000-year post-closure period. This is a nominal amount given the existing iodine-129 plume in groundwater and the forecast releases of other waste forms.

The SAC cumulative and HSW EIS alternative-specific (see Volume II, Appendix G) simulations of uranium migration and fate that appear in this EIS differ in the relative roles of technetium-99 and uranium at times nearing the end of the 10,000-year, post-closure period analyzed because distribution coefficients for uranium in the two analyses differ. The SAC produces results where technetium-99 is the dominant radionuclide throughout the post-closure analysis period. However, the HSW EIS alternative-specific approach, which is applied to generate comparative analyses of the 33 alternative groups, predicts that uranium becomes dominant towards the end of the post-closure analysis. The distribution coefficients of the linear sorption isotherm model were assigned a value of 0.6 mL/g in the HSW EIS alternative-specific approach and a value of 3 mL/g for release models and 0.8 mL/g for transport models in the median-value SAC simulation. The value used in the HSW EIS alternative-specific approach is a more conservative, lower value that causes more rapid migration at higher contaminant levels. The values used in the SAC are median values somewhat higher than the conservative value, and they result in slower migration and lower contaminant concentrations. As a result, the SAC assessment predicts that the median response will be dominated by technetium-99 with uranium making a contribution in the latter portion of the 10,000-year, post-closure period. The HSW EIS alternative-specific simulation of alternative groups shows uranium dominating in the last few thousand years because its mobility is greater in that model. The range of K_d applied for uranium in the stochastic SAC model includes the nominal value used in the HSW EIS alternative-specific simulation, and some realizations of the stochastic model exhibit the greater uranium mobility and contribution to dose seen in the HSW EIS alternative-specific results. However, for the purpose of reporting cumulative impacts using the SAC assessment, the median stochastic result is provided.

Leaching of radionuclides from wastes disposed of in HSW disposal facilities and their transport through the vadose zone, to groundwater, and then to the Columbia River also would lead in the long term to small additional collective doses to downstream populations. The collective dose from HSW for all action alternatives was calculated to range from about 0.2 person-rem for the total population of the cities of Richland, Kennewick, and Pasco, Washington, to about 0.6 person-rem for a hypothetical population of a city the size of Portland, Oregon, that might draw water from the Columbia River in the vicinity of Portland. No LCFs would be inferred from such population doses (see Section 5.11.2.1).

To provide some perspective on the preceding material on groundwater impacts that might be associated with disposal of HSW, impacts as a result of using water from various sources for the three principal groundwater related scenarios—drinking-water dose, dose to the resident gardener, and dose to the resident gardener with a sauna/sweat lodge—are presented in Table 5.153.

Table 5.153. Radiological Impacts (principally from uranium) in Various Sources of Water on, Near, or Downstream of the Hanford Site

Source of Water	Dose Scenario		
	Drinking Water (2 L/day) mrem/yr	Resident Gardener mrem/yr	Resident Gardener with Sauna/Sweat Lodge ^(a) mrem/yr
Sources of Water not Impacted by Hanford Groundwater			
Portland, OR municipal (Bull Run) water ^(b)	0.006	0.007	6
Columbia River upstream of the Hanford Site at Priest Rapids ^(c)	0.092	0.11	96
Yakima River at Benton City ^(d)	0.19	0.23	200
Yakima Barricade well ^(e)	0.45	0.54	470
Well - Mathews Corner, Franklin Co. ^(f)	1.3	1.6	1,400
Benton City municipal water system ^(g)	2.6	3.1	2,700
Hanford Groundwater and Sources of Water Downgradient from Hanford Groundwater			
Highest doses attributable to HSW - hypothetical wells in the 200 Areas - action alternatives ^(h)	0.42	1.4	200
Highest doses attributable to HSW - hypothetical wells near the Columbia River - action alternatives ^(h)	0.064	0.22	7.4
Highest doses attributable to HSW - hypothetical wells in the 200 Areas - No Action Alternative ^(h)	0.98	3.3	480
Highest doses attributable to HSW - hypothetical wells near the Columbia River - No Action Alternative ^(h)	0.039	0.12	14
Columbia River downstream of the Hanford Site at the Richland pump house ^(c)	0.10 ⁽ⁱ⁾	0.12	110 ⁽ⁱ⁾
Columbia River - Franklin County across from the Richland pump house ^(k)	0.15	0.18	160
<p>(a) Water containing natural uranium (with 1:1 ratio of U-234 to U-238) at the MCL of 30 µg/L would yield about 4,000 mrem/yr in the sauna/sweat lodge scenario. Where the ratio is larger than 1, as is often the case for groundwater, the dose would be higher than 4,000 mrem/yr.</p> <p>(b) July–December 1977 composite sample (Cothorn and Lappenbusch 1983). In 1985 Portland began to use the Columbia South Shore well field to supplement their water supply. It was used exclusively for a few days in 1996 because of turbidity in Bull Run water (see discussion at http://www.water.ci.portland.or.us/groundwater.htm). Because of the high rainfall and recharge in the region of the well field, it is believed unlikely that contamination of Hanford origin could have any impact on the quality of Portland municipal water.</p> <p>(c) 6-year average measurement (Poston et al. 2002).</p> <p>(d) Single measurement sample collected March 2003.</p> <p>(e) 7-year average measurement. Hanford Environmental Information System Database. Fluor Hanford, Inc.</p> <p>(f) 5-year average measurement. Hanford Environmental Information System Database. Fluor Hanford, Inc.</p> <p>(g) Average of 10 measurements 1959 (Junkins et al. 1960), single measurement 2003.</p> <p>(h) Values given are exclusive of background which may be approximated by the Yakima Barricade values.</p> <p>(i) To which HSW was determined to add up to about 6.0×10^{-7}, or 0.0000006, mrem/yr from Tc-99 and I-129 in about the year 4000 A.D.</p> <p>(j) To which HSW was determined to add less than 0.001 mrem/yr from uranium in the year 12,000 A.D.</p> <p>(k) Poston et al. (2002).</p>			

Of interest are the relatively large doses to the gardener with sauna/sweat-lodge even when the drinking water dose is less than the DOE 4-mrem/yr benchmark drinking water standard. This is attributed to the inhalation of uranium in the hot, moist air of the sauna/sweat lodge. Also of interest is the dose in this scenario for naturally occurring uranium is about twice that for doses associated with HSW for like masses of material. This difference is attributed to the reduction in the ratio of uranium-234 to uranium-238 in Hanford solid waste compared with that occurring naturally.

5.14.6.4 Transportation

Transportation impacts associated with transporting radioactive wastes and materials including that to and from the Hanford Site have been addressed in other NEPA documents. Table 5.154, based on DOE (2002a) and this EIS, provides cumulative impact information from those analyses and analyses performed for the HSW EIS.

Table 5.154. Cumulative Transportation Impacts

Category	Workers LCFs ^(a)	General Population, LCFs ^(a,b)	Traffic Fatalities
Representative Past and Reasonably Foreseeable Actions (Excluding HSW) Involving Transport of Radioactive Materials			
Historical DOE shipments	0 (0.20)	0 (0.14)	Not Listed
Sodium-bonded Spent Nuclear Fuel	0 (<0.001)	0 (<0.001)	0 (<0.001)
Surplus plutonium disposition	0 (0.036)	0 (0.040)	0 (0.053)
Waste Management PEIS	10	12	36
Waste Isolation Pilot Plant	0 (0.47)	4 (3.5)	5
Cruiser and submarine reactor plant disposal	0 (0.003)	0 (0.003)	0 (0.0095)
Spent nuclear fuel and high-level waste – Oregon & Washington	0 (<0.055)	0 (<0.021)	0 (0.049)
General transport of radio-pharmaceuticals, commercial LLW, etc.	198	174	22
Transport of Hanford Solid Wastes			
Alternative Groups A, C, D, and E – onsite, nearby treatment, and treatment at ORR	0 (0.038)	0 (0.43)	0 (0.084)
Alternative Group B – onsite and nearby treatment	0 (0.064)	1 (0.86)	0 (0.068)
No Action Alternative – onsite	0 (0.012)	0 (0.14)	0 (0.050)
Incoming and offsite shipments (Upper Bound waste volume) ^(c)	1 (0.74)	8 (8.2)	2 (2.3)
Incoming and offsite shipments, WA and OR impacts only – included in the above (Upper Bound waste volume)	0 (0.096)	1 (1.1)	1 (0.52)
TRU Waste Shipments from Hanford to WIPP			
Alternative Groups A – E (Upper Bound waste volume)	0 (0.30)	5 (4.8)	1 (0.56)
No Action Alternative	0 (0.15)	2 (1.6)	0 (0.28)
(a) Assumes 6 LCFs per 10,000 person-rem.			
(b) For the HSW EIS, the numbers consist of inferred fatalities from radiation exposure and vehicular emissions.			
(c) In the final HSW EIS, all offsite transport is addressed, including the entire transportation route for offsite waste sent to Hanford.			

In addition, this EIS presents a discussion of transportation of wastes that are within the scope of this HSW EIS to and from the Hanford Site (see Section 5.8).

The information in Table 5.154 indicates that the cumulative transportation impacts associated with any of the HSW EIS alternative groups are small relative to transport of radioactive material in general. For perspective, it may be noted that several million traffic fatalities from all causes would be expected nationwide during the period 1943 to 2047 (DOE 2002a).

5.14.7 Worker Health and Safety

The cumulative Hanford worker dose since the startup of activities at Hanford is about 90,000 person-rem (DOE 1995), to which would be added approximately 1000 person-rem from spent fuel management (DOE 1996a); 8200 person-rem from tank waste remediation (DOE and Ecology 1996); 730 person-rem for Plutonium Finishing Plant stabilization (DOE 1996b); and 765 to 873 person-rem through the year 2046 from the management of Hanford solid waste, ILAW, and WTP melters (Hanford Only waste volume for Alternative Group A to either the Hanford Only or Lower Bound volume for the No Action Alternative, [see Section 5.11]). Thus, for about 100 years of Hanford operations, approximately 40 LCFs would be inferred among workers, none of which would be attributable to Hanford solid waste program activities. Because of DOE restrictions on worker dose and rigorous application of the ALARA principle, the cumulative collective worker dose associated with all future Hanford Site restoration activities would not be expected to add substantially to the collective worker dose to date.