



**Final
Hanford Site Solid
(Radioactive and Hazardous)
Waste Program
Environmental Impact
Statement
Richland, Washington**

**Volume I
Sections 1 through 7**

U.S. Department of Energy
Richland Operations Office
Richland, Washington

Cover Photographs:

- 1. Hanford workers preparing to retrieve and repackage TRU waste drums**
- 2. Drums of transuranic waste in a retrievable storage trench**
- 3. A partial aerial view of Hanford's Low Level Burial Grounds**
- 4. Waste Receiving and Processing Facility inspection and repackaging glove boxes**
- 5. Hanford's Mixed Low-Level Waste disposal facility**
- 6. Placing TRU waste into a TRUPACT shipping container for shipment to the Waste Isolation Pilot Plant**

RESPONSIBLE AGENCY:

U.S. Department of Energy, Richland Operations Office

COVER SHEET**TITLE:**

Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement, Richland, Benton County, Washington (DOE/EIS-0286F)

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ABSTRACT:

The Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS) provides environmental and technical information concerning U.S. Department of Energy (DOE) proposed waste management practices at the Hanford Site. The HSW EIS updates analyses of environmental consequences from previous documents and provides evaluations for activities that may be implemented consistent with the Waste Management Programmatic Environmental Impact Statement (WM PEIS) Records of Decision (RODs). Waste types considered in the HSW EIS include operational low-level radioactive waste (LLW), mixed low-level waste (MLLW), immobilized low-activity waste (ILAW), and transuranic (TRU) waste (including TRU mixed waste). MLLW contains chemically hazardous components in addition to radionuclides. Alternatives for management of these wastes at the Hanford Site, including the alternative of No Action, are analyzed in detail. The LLW, MLLW, and TRU waste alternatives are evaluated for a range of waste volumes, representing quantities of waste that could be managed at the Hanford Site. A single maximum forecast volume is evaluated for ILAW. The No Action Alternative considers continuation of ongoing waste management practices at the Hanford Site and ceasing some operations when the limits of existing capabilities are reached. The No Action Alternative provides for continued storage of some waste types. The other alternatives evaluate expanded waste management practices including treatment and disposal of most wastes. The potential environmental consequences of the alternatives are generally similar. The major differences occur with respect to the consequences of disposal versus continued storage and with respect to the range of waste volumes managed under the alternatives. DOE's preferred alternative is to dispose of LLW, MLLW, and ILAW in a single, modular, lined facility near PUREX on Hanford's Central Plateau; to treat MLLW using a combination of onsite and offsite facilities; and to certify TRU waste onsite using a combination of existing, upgraded, and mobile facilities. DOE issued the Notice of Intent to prepare the HSW EIS on October 27, 1997, and held public meetings during the scoping period that extended through January 30, 1998. In April 2002, DOE issued the initial draft of the EIS. During the public comment period that extended from May through August 2002, DOE received numerous comments from regulators, tribal nations, and other stakeholders. In March 2003, DOE issued a revised draft of the HSW EIS to address those comments, and to incorporate disposal of ILAW and other alternatives that had been under consideration since the first draft was published. Comments on the revised draft were received from April 11 through June 11, 2003. This final EIS responds to comments on the revised draft and includes updated analyses to incorporate information developed since the revised draft was published. DOE will publish the ROD(s) in the *Federal Register* no sooner than 30 days after publication of the Environmental Protection Agency's Notice of Availability of the final HSW EIS.

Reader's Guide

The Reader's Guide includes the following:

- **Contents**
- **List of Figures**
- **List of Tables**
- **Acronyms/Abbreviations**
- **Glossary of Terms**
- **Glossary of Terms Related to Radioactivity, Radiation Dose, and Exposure**
- **Units of Measure**
- **Reference Citations**

The final HSW EIS is based on the revised draft HSW EIS. Substantive changes (additions, deletions, and modifications) to the document are indicated with "change bars" in the margins of the affected pages. These change bars indicate additional or revised information since the publication of the revised draft HSW EIS, including information based on revised analyses, and in response to public comments. Changes that were editorial in nature are not indicated.

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Acronyms/Abbreviations

AADT	annual average daily traffic
AEA	Atomic Energy Act
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
ALE	Fitzner/Eberhardt Arid Lands Ecology (Reserve)
ANSI	American National Standards Institute
APL	Accelerated Process Line
ARAR	applicable or relevant and appropriate requirement
ATG	Allied Technology Group, Inc.
BCAA	Benton Clean Air Authority
BCF	bioconcentration factor
BDAT	best demonstrated available technology
BHI	Bechtel Hanford, Inc.
BLS	Bureau of Labor Statistics
BNSF	Burlington Northern and Santa Fe Railway
BPA	(U.S. Department of Energy) Bonneville Power Administration
BRMiS	Hanford Site Biological Resources Mitigation Strategy
BRMaP	Hanford Site Biological Resources Management Plan
BWIP	Basalt Waste Isolation Project
C3T	cleanup, constraint, and challenges team
CAA	Clean Air Act
CAIRS	Computerized Accident/Incident Reporting System
Cat 1	Category 1 low-level waste (Hanford Site)
Cat 3	Category 3 low-level waste (Hanford Site)
CBC	Columbia Basin College
CCP	Comprehensive Conservation Plan
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFEST	Coupled Fluid, Energy, and Solute Transport (computer code)
CFR	Code of Federal Regulations
CH	contact-handled
Ci	curie(s)
CNSS	Council of the National Seismic System
CO	carbon monoxide
CRCIA	Columbia River Comprehensive Impact Assessment
CRD	Comment Response Document

CSB	Canister Storage Building
CWC	Central Waste Complex
D&D	decontamination and decommissioning
dB	decibel(s)
dBA	A-weighted decibel(s)
DCG	derived concentration guide
DEIS	Draft Environmental Impact Statement
D _l	longitudinal dispersivity
DOE	U.S. Department of Energy
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-RL	U.S. Department of Energy, Richland Operations Office
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
D _t	transverse dispersivity
DWS	drinking water standard
EA	environmental assessment
ECAMP	Ecological Compliance Assessment Management Plan
ECEM	Ecological Contaminant Exposure Model (computer code)
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EDNA	environmental designation for noise abatement
EH	U.S. Department of Energy Office of Environment, Safety and Health
EHQ	environmental hazard quotient
EIS	environmental impact statement
EM	U.S. Department of Energy Office of Environmental Management
EMI	environmental management integration
EMSL	Environmental and Molecular Sciences Laboratory
ENCO	enterprise companies
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
ERDA	U.S. Energy Research and Development Administration
ER	environmental restoration
ERDF	Environmental Restoration Disposal Facility
ERPG	Emergency Response Planning Guideline
ERTC	Effluent Retention and Treatment Complex
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
ETF	200 Area Effluent Treatment Facility
FEMA	Federal Emergency Management Agency
FFS	focused feasibility study
FFTF	Fast Flux Test Facility

FH	Fluor Hanford, Inc.
FONSI	finding of no significant impact
FR	<i>Federal Register</i>
FRAMES	Framework for Risk Analysis in Multimedia Environmental Systems (computer code)
FTE	full-time equivalent (or full-time employee)
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GC	U.S. Department of Energy Office of General Counsel
GIS	geographic information system
GOCO	government-owned contractor-operated
GPS	global positioning system
GTC3	greater than Category 3 low-level waste (Hanford Site)
GTCC	greater than Class C low-level waste (NRC)
HAMMER	Hazardous Materials Management and Emergency Response Facility (Volpentest Training and Education Center)
HCP EIS	Hanford Comprehensive Land-Use Plan Environmental Impact Statement
HCRC	Hanford Cultural Resources Case
HCRL	Hanford Cultural Resources Laboratory
HDPE	high-density polyethylene
HDW EIS	Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes Environmental Impact Statement
HEHF	Hanford Environmental Health Foundation
HEPA	high-efficiency particulate air
HIC	high-integrity container
HLW	high-level (radioactive) waste
HMS	Hanford Meteorology Station
HPMP	Hanford Performance Management Plan
HPPE	high-density polyethylene
HSRAM	Hanford Site Risk Assessment Methodology
HSSWAC	Hanford Site solid waste acceptance criteria
HSW	Hanford solid waste within Hanford Solid Waste Program
HSW EIS	Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement
HTWOS	Hanford Tank Waste Operating System
HW	hazardous waste
HWMA	Washington State Hazardous Waste Management Act
HWMP	Hanford Waste Management Program
HWVP	Hanford Waste Vitrification Project
Hz	hertz

ICRP	International Commission on Radiological Protection
IDF	integrated disposal facility
IDLH	Immediately Dangerous to Life and Health
ILAW	immobilized low-activity waste
IPABS	Integrated Planning, Accountability and Budgeting System
ISCST3	Industrial Source Complex Short-Term Model, version 3 (computer code)
ISO	International Standards Organization
ISS	interim safe storage
K_d	distribution coefficient for partitioning of contaminants in soil
LCF	latent cancer fatality
LC50	chemical concentration reported to be lethal to 50 percent of the exposed organisms after some period of exposure, usually a few hours to a few days
LD50	dose reported to be lethal to 50 percent of the exposed organisms after some period of exposure, usually a few hours to a few days
LDR	Land Disposal Restriction
LEPC	Local Emergency Planning Committee
LERF	Liquid Effluent Retention Facility
LIGO	Laser Interferometer Gravitational-Wave Observatory
LLBG	Low Level Burial Ground
LLW	low-level (radioactive) waste
LLW MA	low-level waste management area
LMF	lined modular facility
LOA	line of analysis
LOEC	lowest observed effects concentration
LOEL	lowest observed effects level
LOS	level of service
LWC	lost workday case
LWD	lost workday
M&O	management and operations
MASS2	Modular Aquatic Simulation System 2 (computer code)
MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MEI	maximally exposed individual
MEK	methyl ethyl ketone
MEPAS	Multimedia Environmental Pollutant Assessment System
MLLW	mixed low-level waste
MMEDE	Multimedia-Modeling Environmental Database Editor (computer code)
MMI	Modified Mercalli Intensity
MT	metric ton(s) (tonnes)
MTCA	Model Toxics Control Act
MTG	minimum technology guidance
MTU	metric tons of uranium

NAAQS	National Ambient Air Quality Standards
National Register	National Register of Historic Places
NCRP	National Council on Radiation Protection and Measurements
NDA	non-destructive assay
NDE	non-destructive examination
ND	not detected
NE	no emissions
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NIOSH	National Institute for Occupational Safety and Health
NM	not measured
NMFS	National Marine Fisheries Service
NO ₂	nitrogen dioxide
NOA	Notice of Availability
NOAEL	no observed adverse effects level
NOC	Notice of Construction
NOE	Notice of Extension
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	U.S. Nuclear Regulatory Commission
NS	no standard
NTS	Nevada Test Site
NWPF	new waste processing facility
NWS	National Weather Service
OAR	Oregon Administrative Rule
OCF	offsite commercial facility
OFM	Office of Financial Management
ORP	(U.S. Department of Energy) Office of River Protection
ORR	(U.S. Department of Energy) Oak Ridge Reservation
OSHA	U.S. Occupational Safety and Health Administration
PA	performance assessment
PCB	polychlorinated biphenyl
pCi	picocurie(s)
PEIS	Programmatic Environmental Impact Statement
PEL	permissible exposure level
PFP	Plutonium Finishing Plant
PHMC	Project Hanford Management Contract
PM	particulate matter
PM ₁₀	particulate matter with aerodynamic diameters 10 µm or smaller
PNNL	Pacific Northwest National Laboratory
ppm	parts per million

PSD	prevention of significant deterioration
Pu	plutonium
PUREX	Plutonium-Uranium Extraction Facility
R	roentgen
R&D	research and development
RADTRAN	Radioactive Transportation Risk Analysis (computer code)
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
RCW	Revised Code of Washington
REIS	Regional Economic Information System
R _f	contaminant retardation factors
RfD	reference dose
RH	remote-handled
RIMS	Regional Input-Output Modeling System (computer code)
RL	(U.S. Department of Energy) Richland Operations Office
ROD	Record of Decision
RPP	River Protection Project
SA	safety analysis
SAC	System Assessment Capability (computer code)
SALDS	State-Approved Land Disposal Structure
SC	species of concern
SCAPA	Subcommittee on Consequence Assessment and Protective Actions
SEIS	Supplemental Environmental Impact Statement
SEPA	State (of Washington) Environmental Policy Act
SERC	State Emergency Response Commission
SI	Le Système International d'Unites (International System of Units [metric system])
SIP	state implementation plan
SLD	shallow land disposal
SNF	spent nuclear fuel
SO ₂	sulfur dioxide
SR	State Route
SRS	(U.S. Department of Energy) Savannah River Site
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases (computer code)
STP	site treatment plan
SWB	standard waste box
SWBG	solid waste burial ground
SWIFT	Solid Waste Integrated Forecast Technical (report)
SWITS	Solid Waste Information and Tracking System
SWOC	Solid Waste Operations Complex

T&E	threatened and endangered (biological species designation)
TCP	traditional cultural property
TD	temperature difference
TEDE	total effective dose equivalent
TEDF	200 Area Treated Effluent Disposal Facility
TEEL	Temporary Emergency Exposure Limit
TI	Transportation Index
TLV	threshold limit value
TNC	The Nature Conservancy (of Washington)
TPA	Tri-Party Agreement (Hanford Federal Facility Agreement and Consent Order)
TRAGIS	Transportation Routing Analysis Geographic Information System (computer code)
TRC	total recordable case
TRIGA	Test Reactor and Isotope Production General Atomics
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter-II
TRUSAF	Transuranic Storage and Assay Facility
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and/or disposal
TSP	total suspended particulates
TWRS	Tank Waste Remediation System
UPR	unplanned release
UO ₃	uranium trioxide
USC	United States Code
USGS	U.S. Geological Survey
UW	University of Washington
UWGP	University of Washington Geophysics Program
VADER	VADose zone Environmental Release (computer code)
VOC	volatile organic compound
WAC	Washington Administrative Code
WDFW	Washington State Department of Fish and Wildlife
WDOH	Washington State Department of Health
WESF	Waste Encapsulation and Storage Facility
WHC	Westinghouse Hanford Company
WIF	well intercept factor
WIPP	Waste Isolation Pilot Plant
WIPP SEIS2	Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement
WM	waste management
WM PEIS	Waste Management Programmatic Environmental Impact Statement
WNHP	Washington Natural Heritage Program

WRAP
WSU-TC
WTP

Waste Receiving and Processing Facility
Washington State University – Tri-Cities Branch Campus
waste treatment plant

Glossary of Terms

anadromous – Migrating up rivers from the sea to breed in fresh water.

aromatic – Of, related to, or containing the six-carbon ring typical of the benzene series and related organic groups also, “having an aroma”.

bioconcentration factor (BCF) – The ratio of the tissue concentration of an aquatic organism to the water concentration where uptake is limited to water alone, usually derived in an experimental setting.

borrow pit – The excavation site used to obtain geological resources (such as sand, gravel, basalt rocks, or fine sediments).

caisson – As used in the HSW EIS, these structures are reinforced cylindrical steel and concrete underground vaults 2.4 m (8 ft) in diameter and 3-m (10-ft) high designed to store remote-handled waste in the Low Level Burial Grounds.

candidate species – Plants and animals with a status of concern, but about which more information is needed before they can be proposed for listing as threatened species or endangered species. A state candidate species is one that is being reviewed for possible listing as a state endangered, threatened, or sensitive species as specified by the Washington State Department of Fish and Wildlife. See also endangered species, threatened species, and species of concern.

cap – A cap used to cover a radioactive burial ground with soil, rock, vegetation, or other materials as part of the facility closure process. The cap is designed to reduce migration of radioactive and hazardous materials in the waste by infiltration of water or by intrusion of humans, plants, or animals from the surface. In this EIS, the modified RCRA Subtitle C barrier was selected to use as a cap for LLW and MLLW disposal grounds. (Also called “cover cap” and “barrier” in this EIS.)

capping – As applied to radioactive and mixed-waste disposal facilities, the process of covering a burial ground with soil, rock, vegetation, or other materials as part of the facility closure process.

carcinogen – A substance that can cause cancer.

cask – A heavily shielded container used to store or ship radioactive materials.

Category 1 low-level waste – Low-level radioactive waste containing radionuclide concentrations within the maximum limits defined for this waste type in the HSSWAC. These limits are site-specific, and they define the lowest activity category of low-level radioactive waste. Category 1 wastes typically do not require special packaging or treatment for disposal by shallow land burial.

Category 3 low-level waste – Low-level radioactive waste containing radionuclide concentrations greater than those defined for Category 1 waste, but within the maximum limits defined for Category 3 waste in

the HSSWAC. These limits are site-specific, and are established using the performance assessment for a particular disposal facility. Category 3 wastes typically require special packaging or treatment for disposal by shallow land burial.

characterization – See waste characterization.

chemical oxidation – Oxidation of a material by adding chemicals such as peroxide, ozone, persulfates, or other oxidizing material. Commonly used for oxidation of organic constituents.

chemical reduction – Reduction of a material by adding chemicals such as sulfites, polyethylene glycol, hydrosulfide, or ferrous salts. Commonly used for the reduction of hexavalent chromium to the trivalent state. In all these cases, the reduced forms of the contaminant are much less mobile in the environment because of their low solubility and high adsorption to soils. Microbiological reduction of these waste constituents also has been found to occur naturally in sediment and aquifer environments and with addition of chemical food sources to enhance the microbe growth rates reductive biological remediation is becoming more economical.

cleanup – The term cleanup refers the full range of projects and activities being undertaken to address environmental and legacy waste issues associated with the Hanford Site.

closure – As applied to radioactive and hazardous waste disposal facilities, the process of site stabilization and placement of caps or other barriers to provide long-term confinement of the waste.

contact-handled (CH) waste – Generally, packaged waste whose external surface dose rate does not exceed 200 mrem/hr and does not create a high radiation area (>100 mrem/hr at 30 cm). See also remote-handled waste.

crib – An underground structure designed to receive liquid waste that can percolate into the soil directly and/or after traveling through a connected tile field.

criteria pollutants – Six pollutants (carbon monoxide, suspended particulates of specified sizes, sulfur dioxide, lead, nitrogen oxide, and ozone) known to be hazardous to human health or structures and for which the U.S. Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards under the Clean Air Act (40 CFR 50).^(a)

cullet – Small pieces of glass (similar in size to pea-gravel) formed when hot molten glass is quenched in a water bath.

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

(a) 40 CFR 50. “National Primary and Secondary Ambient Air Quality Standards.” Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/40cfr50_01.html

dangerous waste – Solid waste designated in WAC 173-303-070^(a) through WAC 173-303-100 as dangerous or extremely hazardous waste, or mixed waste.

deactivation – As applied to waste treatment, the removal of the hazardous characteristics of a waste due to its ignitability, corrosivity, and or reactivity.

decibel – A standard unit of sound pressure. The decibel is a value equal to 10 times the logarithm of the ratio of a sound pressure squared to a standard reference sound-pressure level (20 micropascals) squared.

decommissioning – Officially remove from service or demolish a facility.

decontamination – Final actions taken to reduce the potential health and safety impacts of DOE-contaminated facilities, including activities to stabilize, reduce, or remove radioactive and hazardous materials. Includes the removal, reduction, or neutralization of radionuclides and/or hazardous materials from contaminated facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

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. Typically, deterministic calculations are based on best estimates of the involved parameters. See stochastic analysis.

disposal – As generally used in this document, placement of waste with no intent to retrieve. Statutory or regulatory definitions of disposal may differ.

dose – The accumulated radiation or hazardous substance delivered to the whole body, or a specified tissue or organ, within a specified time interval, originating from an external or internal source. See also terms related to radiation exposure and dose.

edaphic – Of, or relating to, the soil.

effluent – Airborne and liquid wastes discharged to the environment.

element occurrence – An element occurrence of a plant community is one that meets the minimum standards set by the State of Washington Natural Heritage Program (WNHP) for ecological condition, size, and the surrounding landscape. Element occurrences are generally considered to be of significant conservation value from a state and/or regional perspective.

endangered species (Federal) – Plants or animals that are in danger of extinction throughout all or a significant portion of their ranges and have been listed as endangered by the U.S. Fish and Wildlife

(a) WAC 173-303. “Dangerous Waste Regulations.” Washington Administrative Code, Olympia, Washington. Online at: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=chapterdigest&chapter=173-303>

Service or the National Marine Fisheries Service, following the procedures set out in the Endangered Species Act and its implementing regulations (50 CFR 424).^(a)

endangered species (State) – Washington State defines endangered species as any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state (WAC 232-12-297).^(b) See also candidate species and threatened species.

eolian – Pertaining to, caused by, or carried by the wind.

ERPG-1 – The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

ERPG-2 – The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

ERPG-3 – The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

Evolutionarily Significant Unit (ESU) – A distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

Federal species of concern – Species whose conservation standing is of concern to the U.S. Fish and Wildlife Service but for which status information still is needed.

fluvial – Produced by the action of flowing water.

french drain – A rock-filled encasement with an open bottom to allow seepage of liquid waste into the ground.

generator – Within the context of this document, generators refer to organizations within DOE or managed by DOE whose act or process produces low-level waste, mixed low-level waste, or transuranic waste.

graded approach – A process by which the level of analysis, documentation, and actions necessary to comply with a requirement are commensurate with 1) the relative importance to safety, safeguards, and

(a) 50 CFR 424. “Listing Endangered and Threatened Species and Designating Critical Habitat.” Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/50cfr424_01.html

(b) WAC 232-12-297. “Endangered, threatened, and sensitive wildlife species classification.” Washington Administrative Code, Olympia, Washington. Online at: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=232-12-297>

security; 2) the magnitude of any hazard involved; 3) the life cycle stage of a facility; 4) the programmatic mission of a facility; 5) the particular characteristics of a facility; and 6) any other relevant factor.

greater than Category 3 (GTC3) low-level waste – Low-level radioactive waste that exceeds the maximum radionuclide concentrations as defined for Category 3 low-level waste. See also Category 3 waste.

Hanford Federal Facility Agreement And Consent Order – See Tri-Party Agreement.

hazardous waste – Waste that contains chemically hazardous constituents regulated under Subtitle C of the Resource Conservation and Recovery Act (RCRA), as amended (40 CFR 261)^(a) and regulated as a hazardous waste and/or mixed waste by the EPA. May also include solid waste designated by Washington State in WAC 173-303-070^(b) through WAC 173-303-100 as dangerous or extremely hazardous waste, or mixed waste. See also mixed low-level waste.

high-integrity container (HIC) – A container that provides additional confinement for remote-handled Category 3 LLW and some contact-handled Category 3 LLW and is typically constructed of concrete or other durable material.

high-level (radioactive) waste (HLW) – High-level waste is the highly radioactive waste material resulting from the processing of spent nuclear fuel, including liquid waste produced directly in processing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations, and other highly radioactive material that is determined, consistent with existing law, to require isolation.

immobilization – Placing the waste within a material such as concrete or a glass to immobilize (reduce dispersability and leachability of) the radioactive or hazardous components within the waste. See also stabilization.

immobilized low-activity waste (ILAW) – The solidified low-activity waste from the treatment and immobilization of Hanford tank wastes. See also low-activity waste.

in-trench grouting – In-trench grouting involves placing the waste on a cement pad or on spacers, installing reinforcement steel and forms around the waste, and covering the waste with fresh concrete to encapsulate the waste within a concrete barrier.

lacustrine – Of or pertaining to lakes.

(a) 40 CFR 261. “Identification and Listing of Hazardous Waste.” Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/40cfr261_01.html

(b) WAC 173-303. “Dangerous Waste Regulations.” Washington Administrative Code, Olympia, Washington. Online at: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=chapterdigest&chapter=173-303>

land disposal restrictions – The restrictions and requirements for land disposal of hazardous or dangerous waste as specified in 40 CFR 268 (RCRA) and WAC 173-303-140 (Washington State Dangerous Waste Regulations).

land-use designations:

Industrial-Exclusive – An area suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, non-radioactive wastes, and related activities.

Conservation (Mining) – An area reserved for the management and protection of archeological, cultural, ecological, and natural resources. Limited and managed mining (for example, quarrying for sand, gravel, basalt, and topsoil for governmental purposes only) could occur as a special use (i.e., a permit would be required) within appropriate areas. Limited public access would be consistent with resource conservation. This designation includes related activities.

latent cancer fatality (LCF) – A cancer death postulated to result from, and occurring some time after, exposure to ionizing radiation or other carcinogens.

As applied to populations, the postulated number of fatal cancers in a given population due to the calculated or measured collective dose to that population as a result of a given action or activity.

As applied to individuals, the probability of a fatal cancer in a given individual due to the calculated or measured dose received by that individual as a result of a given action or activity.

leachate – As applied to mixed low-level waste trenches, any liquid, including any suspended components in the liquid, that has percolated through or drained from hazardous waste.

lost workday cases (LWCs) – Represent the number of cases recorded resulting in days away from work or days of restricted work activity, or both, for affected employees.

lost workdays (LWDs) – The total number of workdays (consecutive or not), after the day of injury or onset of illness, during which employees were away from work or limited to restricted work activity because of an occupational injury or illness.

low-activity waste – The waste that remains after separating from high-level waste as much of the radioactivity as practicable, and that when solidified may be disposed of as low-level waste in a near-surface facility.

low-income person – A person living in a household that reports an annual income less than the United States official poverty level, as reported by the U.S. Census Bureau.

low-level (radioactive) waste (LLW) – Radioactive waste that is not high-level waste, spent nuclear fuel, transuranic waste, byproduct material (as defined in section 11e[2] of the Atomic Energy Act of 1954, as amended), or naturally occurring radioactive material.

macroencapsulation – Treatment method applicable to debris wastes as defined by RCRA. Refers to application of surface coating materials, such as polymeric organics (for example, resins and plastics) or of a jacket of inert material to reduce surface exposure to potential leaching media.

maximally exposed individual (MEI) – The maximally exposed individual is a hypothetical person who has a lifestyle, and is in a location, such that that any other individual would be unlikely to receive a higher exposure to radiation or hazardous materials. The MEI may be an individual who resides or works near the Hanford Site, or who is temporarily at a publicly accessible location where the maximum dose from a short-term event would occur.

microbiotic (cryptogamic) crusts – generally occur in the top 1 to 4 mm of soil and are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials.

microencapsulation – The encapsulation of waste components in the atomic structure of compounds or materials such as glass, cement, or polymer waste forms.

minority – Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

mixed low-level waste (MLLW) – Low-level waste determined to contain both source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954, as amended, and a hazardous component subject to the Resource Conservation and Recovery Act (RCRA), as amended, or Washington State Dangerous Waste Regulations. See also hazardous waste, dangerous waste.

modular facility – As used in this HSW EIS, a modular disposal facility would consist of a number of expandable segments or areas within an overall master facility. Each module would be designed to handle certain waste types or forms. For example remote handled wastes might be in a different area or “module” than standard packages of contact handled low-level waste or mixed low-level waste.

neutralization – Changing the pH of a solution to near 7 by adding an acidic or basic material.

no action alternative – In this EIS, the no action alternative consists of continuing ongoing activities, but does not include development of new capabilities to manage wastes that cannot currently be disposed of.

noise – Sound that is unwanted and perceived as unpleasant or a nuisance.

non-standard (packaging) – Non-standard waste packages refer to specially designed waste containers or packages used for large, or odd shaped low-level waste, mixed low-level waste or transuranic waste items or items with high dose rates or other unique conditions. See also standard (packaging).

normal operations – As used in this HSW EIS, normal operations refers to routine waste management activities, for example, waste treatment activities (including processing), packaging and repackaging, storage, and final disposal of waste, and is exclusive of accident conditions, save for minor process upsets.

order of magnitude – As used in this EIS, an order of magnitude is taken as a power (or factor) of 10.

operational waste – Solid wastes that are generated in support of cleanup activities, including such items as contaminated personnel protective clothing, disposable laboratory supplies, and failed tools and equipment.

physical extraction – Separation or removal of materials or components based on size or material characteristic.

PM₁₀ – Particulates with an aerodynamic diameter less than or equal to a nominal diameter of 10 micrometers.

PM_{2.5} – Particulates with an aerodynamic diameter less than or equal to a nominal diameter of 2.5 micrometers.

pore water – The amount of water effectively trapped or retained by a volume of soil.

processing – As used in this HSW EIS, refers to any activity necessary to prepare waste for disposal. Processing waste may consist of repackaging, removal, or stabilization of non-conforming waste, or treatment of physically or chemically hazardous constituents in compliance with state or federal regulations.

radioactive waste – In general, waste that is managed for its radioactive content. Waste material that contains source, special nuclear, or by-product material is subject to regulation as radioactive waste under the Atomic Energy Act. Also, waste material that contains accelerator-produced radioactive material or a high concentration of naturally occurring radioactive material may be considered radioactive waste.

release – Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing of a material into the environment. Statutory or regulatory definitions of release may differ.

remedial action – Activities conducted to reduce potential risks to people and/or harm to the environment from radioactive and/or hazardous substance contamination. See also cleanup.

remote-handled (RH) waste – Packaged radioactive waste for which the external dose rate exceeds that defined for contact-handled waste (generally 200 mrem/hr at the container surface). These wastes require handling using remotely controlled equipment, or placement in shielded containers, to reduce the human exposures during routine waste management activities. See also contact-handled waste.

retrievably stored waste – Waste stored in a manner that is intended to permit retrieval at a future time.

review 1 species – A plant taxon of potential concern that is in need of additional field work before a status can be assigned. See also species of concern.

shrub-steppe – Plant community consisting of short-statured, widely spaced, small-leaved shrubs, sometimes aromatic, with brittle stems and an understory dominated by perennial bunchgrasses.

sensitive species – A taxon that is vulnerable or declining and could become endangered or threatened in Washington state without active management or removal of threats. The federal listings classify species as listed (endangered/threatened), candidate, or proposed.

seep – To flow slowly, or ooze; on the Columbia River, seepage occurs below the river surface and exposed riverbank, particularly noticeable at low-river stage. The seeps flow intermittently, apparently influenced primarily by changes in the river level.

site – A geographic entity comprising leased or owned land, buildings, and other structures required to perform program activities.

species of concern – Plants identified by the Washington Natural Heritage Program as sensitive (vulnerable or declining and could become endangered or threatened), Review 1 (more field work needed), or Review 2 (unresolved taxonomic problems). See also endangered species and threatened species. The federal listings classify species as listed (endangered/threatened), candidate, or proposed.

stabilization – Mixing an agent such as Portland cement with the waste to increase the mechanical strength of the resulting waste form and decrease its leachability.

standard (packaging) – Standard waste packages refer to the common forms of waste packages (such as drums and boxes) used for low-level waste and mixed low-level waste. See also non-standard (packaging).

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 value was reported.

stochastic variability – Natural variation of a measured quantity; for example, in a room full of people, there is an average height with some being taller and some shorter; the stochastic variability of that group is described by the differences between the individuals' heights and the average.

storage – The holding of waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere.

taxa – Plural of taxon.

taxon – A group of organisms sharing common characteristics in varying degrees of distinction that constitute one of the categories of taxonomic classification, such as a phylum, class, order, family, genus, or species.

TEEL-1 – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.

TEEL-2 – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action.

TEEL-3 – The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

threatened species – Any plants or animals that are likely to become endangered species within the foreseeable future throughout all or a significant portion of their ranges, and which have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures set out in the Endangered Species Act and its implementing regulations (50 CFR 424).^(a) Washington State defines threatened species as any wildlife species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state (WAC 232-12-297).^(b) See also candidate species and endangered species.

teleost fish – Of or belonging to the Teleostei or Teleostomi, a large group of fishes with bony skeletons, including most common fishes. The teleosts are distinct from the cartilaginous fishes such as sharks, rays, and skates.

total recordable cases (TRCs) – Work-related deaths, illnesses, or injuries resulting in loss of consciousness, restriction of work or motion, transfer to another job, or required medical treatment beyond first aid.

Toxic Substances Control Act (TSCA) waste – Any waste, including polychlorinated biphenyl commingled waste, regulated under the TSCA requirements codified in 40 CFR 761.^(c)

toxicological impact – Impact on human health, due to exposure to, or intake of, chemical materials. These impacts are typically described in terms of damage to affected organs.

transportation index (TI) of the package or packages – is defined as the highest package dose rate (mrem per hour) that would be received by an individual located at a distance of 1 m (3.3 ft) from the external surface of the package.

(a) 50 CFR 424. “Listing Endangered and Threatened Species and Designating Critical Habitat.” Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/50cfr424_01.html

(b) WAC 232-12-297. “Endangered, threatened, and sensitive wildlife species classification.” Washington Administrative Code, Olympia, Washington. Online at: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=Section&Section=232-12-297>

(c) 40 CFR 761. “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution In Commerce, and Use Prohibitions.” Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_01/40cfr761_01.html

transuranic isotope – Isotopes of any element having an atomic number greater than 92 (the atomic number of uranium).

transuranic (TRU) waste – Transuranic waste is radioactive waste containing more than 100 nanocuries (3700 becquerels) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for the following:

- high-level radioactive waste
- waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations
- waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.^(a)

For the purposes of this document TRU waste may also include hazardous constituents, and may be referred to in the document as mixed TRU waste.

treatment – The physical, chemical, or biological processing of dangerous waste to make such waste non-dangerous or less dangerous, safer for transport, amenable for energy or material resource recovery, amenable for storage, or reduced in volume, with the exception of compacting, repackaging, and sorting as allowed under WAC 173-303-400^(b) and 173-303-600.^(b)

Tri-Party Agreement (TPA) – Informal title for the “Hanford Federal Facility Agreement and Consent Order,” an agreement between the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology. The agreement establishes milestones to bring operating DOE facilities into compliance with the RCRA, and to coordinate cleanup of Hanford’s inactive disposal sites under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

vadose zone – The soil layer between the ground surface and the top of the saturated zone.

waste characterization – The identification of waste composition and properties, whether by review of process knowledge, or by non-destructive examination, non-destructive assay, or sampling and analysis, to determine appropriate storage, treatment, handling, transportation, and disposal requirements.

waste certification – A process by which a waste generator certifies that a given waste or waste stream meets the waste acceptance criteria of the facility to which the generator intends to transfer waste for treatment, storage, or disposal.

(a) 10 CFR 61. “Licensing Requirements for Land Disposal of Radioactive Waste.” Code of Federal Regulations. Online at: http://www.access.gpo.gov/nara/cfr/waisidx_02/10cfr61_02.html

(b) WAC 173-303. “Dangerous Waste Regulations.” Washington Administrative Code, Olympia, Washington. Online at: <http://www.leg.wa.gov/wac/index.cfm?fuseaction=chapterdigest&chapter=173-303>

waste container – Any portable device in which a material is stored, transported, treated, disposed, or otherwise handled (WAC 173-303-400^(b)). A waste container may include any liner or shielding material that is intended to accompany the waste in disposal. At Hanford, waste containers typically consist of 55-gal (208-L) or 85-gal (320-L) drums and standard waste boxes. Other sizes and styles of containers may also be employed depending on the physical, radiological, and chemical characteristics of the waste.

waste disposal – See disposal.

waste life cycle – The life of a waste from generation through storage, treatment, transportation, and disposal.

waste stream – A waste or group of wastes from a process or a facility with similar physical, chemical, or radiological properties. In the context of this document, a waste stream is defined as a collection of wastes with physical and chemical characteristics that will generally require the same management approach (that is, use of the same storage, treatment, and disposal capabilities).

waste type – In the context of this document, four waste types managed by the solid waste program are defined: low-level waste, mixed low-level waste, transuranic waste, and waste treatment plant waste (ILAW and melters).

Watch List species – A category of plant species of concern as identified by the Washington Natural Heritage Program. Watch List species consist of those plant taxa of concern that are more abundant and/or less threatened than previously assumed.

Glossary of Terms Related to Radioactivity, Radiation Dose, and Exposure

absorbed dose – The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray = 100 ergs/gram of material).

activity – A measure of the quantity of a radioactive material, the special unit of which is the curie and the SI unit is the becquerel.

becquerel (Bq) – A unit of activity equal to 1 disintegration per second.

collective dose – The sum of the total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person-rem (or person-sievert).

committed dose equivalent – The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert).

committed effective dose equivalent – The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

curie (Ci) – A unit of activity equal to 37 billion disintegrations per second, or 37 billion becquerels.

dose (radiological) – A generic term meaning absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, or total effective dose equivalent, as defined elsewhere in this glossary.

dose equivalent – The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert).

effective dose equivalent – The summation of the products of the dose equivalent received by specified tissues of the body and the appropriate weighting factor. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rem (or sievert).

external dose or exposure – The portion of the dose equivalent received from radiation sources outside the body (i.e., “external sources”).

half-life (radiological) – The time in which one-half of the atoms of a specific radionuclide decay into another nuclear form or energy state. Half-lives for different radionuclides range from fractions of a second to billions of years.

gray – The SI (International System of Units) unit of absorbed dose. One gray (Gy) is equal to an absorbed dose of 1 joule/kg (1 Gy = 100 rads). (The joule in the SI unit of energy, abbreviated as J, and is equivalent to 10 million ergs.)

internal dose – That portion of the dose equivalent received from radioactive material taken into the body (i.e., “internal sources”).

millirem (mrem) – A subunit of a rem. One mrem equals 1/1000th (0.001) of a rem.

person-rem – Unit of collective total effective dose equivalent.

quality factor – The principal modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor. The quality factors to be used for determining dose equivalent in rem are shown in the following table:

Quality Factors ^(a)

Radiation type	Quality factor
X-rays, gamma rays, positrons, electrons (including tritium beta particles).....	1
Neutrons, < 10 keV.....	3
Neutrons, > 10 keV.....	10
Protons and singly-charged particles of unknown energy with rest mass greater than one atomic mass unit.....	10
Alpha particles and multiple-charged particles (and particles of unknown charge) of unknown energy.....	20

When spectral data are insufficient to identify the energy of the neutrons, a quality factor of 10 shall be used.

(ii) When spectral data are sufficient to identify the energy of the neutrons, the following mean quality factor values may be used:

Quality Factors for Neutrons

[Mean quality factors, Q (maximum value in a 30-cm dosimetry phantom), and values of neutron flux density that deliver in 40 hours, a maximum dose equivalent of 100 mrem (0.001 sievert).]

Neutron energy (MeV)	Mean quality factor	Neutron flux density (cm ² s ⁻¹)
2.5 x 10 ⁻⁸ thermal.....	2	680
1 x 10 ⁻⁷	2	680
1 x 10 ⁻⁶	2	560
1 x 10 ⁻⁵	2	560
1 x 10 ⁻⁴	2	580
1 x 10 ⁻³	2	680
1 x 10 ⁻²	2.5	700
1 x 10 ⁻¹	7.5	115
5 x 10 ⁻¹	11	27
1.....	11	19
2.5.....	9	20
5.....	8	16
7.....	7	17
10.....	6.5	17
14.....	7.5	12
20.....	8	11
40.....	7	10
60.....	5.5	11
1 x 10 ²	4	14
2 x 10 ²	3.5	13
3 x 10 ²	3.5	11
4 x 10 ²	3.5	10

(a) Source: 10 CFR 835.

rad – A unit of radiation absorbed dose (such as, in body tissue). One rad is equal to an absorbed dose of 0.01 joule/kg (1 rad = 0.01 gray).

radiation – In the context of this EIS a simplified term for ionizing radiation such as alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions.

radioactive decay – The decrease in the amount of any radioactive material with the passage of time, due to spontaneous nuclear disintegration (e.g., emission from atomic nuclei of charged particles, photons, or both).

radioactivity – The property or characteristic of radioactive material to spontaneously “disintegrate” or “decay” with the emission of energy in the form of radiation.

rem – The special unit of radiation effective dose equivalent (1 rem = 0.01 Sievert).

roentgen (R) – The special unit of X- or gamma- radiation exposure. One roentgen equals 2.58 x 10⁻⁴ coulombs per kilogram of air.

sievert (Sv) – The SI (International System of Units) unit of radiation effective dose equivalent (1 Sv = 100 rem).

total effective dose equivalent (TEDE) – The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). Total effective dose equivalent is expressed in units of rem (or sievert).

weighting factor – The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to a specific tissue. The dose equivalent to each tissue is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue. The weighting factors are as follows:

Weighting Factors For Various Tissues^(a)

Organs or tissues	Weighting factor
Gonads.....	0.25
Breasts.....	0.15
Red bone marrow.....	0.12
Lungs.....	0.12
Thyroid.....	0.03
Bone surfaces.....	0.03
Remainder ^(b)	0.30
Whole body ^(c)	1.00

(a) Source: 10 CFR 835.

(b) "Remainder" means the five other organs or tissues with the highest dose (for example, liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor for each remaining organ or tissue is 0.06.

(c) For the case of uniform external irradiation of the whole body, a weighting factor equal to 1 may be used in determination of the effective dose equivalent.

Units of Measure

The principal units of measurement used in the HSW EIS are SI units, an abbreviation for the International System of Units, a metric system accepted by the International Organization of Standardization as the legal standard at a meeting in Elsinore, Denmark, in 1966. In this system, most units are made up of combinations of six basic units, of which length in meters, mass in kilograms, and time in seconds are of most importance in the EIS. An exception is radiological units that use the common system (e.g., rem, millirem).

Numerical (Scientific or Exponential) Notation

Numbers that are very small or very large are often expressed in scientific or exponential notation as a matter of convenience. For example, the number 0.000034 may be expressed as 3.4×10^{-5} or 3.4E-05 and 65,000 may be expressed as 6.5×10^4 or 6.5E+04. In the EIS, numerical values less than 0.001 or greater than 9999 are generally expressed in exponential notation, or 1.0E-03 and 9.9E+03, respectively.

Multiples or sub-multiples of the basic units are also used. A partial list of prefixes that denote multiples and sub-multiples follows, with the equivalent multiplier values expressed in scientific and exponential notation:

Name	Symbol	Value Multiplied by:		
atto	a	0.000000000000000001	or 1×10^{-18}	or 1E-18
femto	f	0.000000000000001	or 1×10^{-15}	or 1E-15
pico	p	0.000000000001	or 1×10^{-12}	or 1E-12
nano	n	0.000000001	or 1×10^{-9}	or 1E-09
micro	μ	0.000001	or 1×10^{-6}	or 1E-06
milli	m	0.001	or 1×10^{-3}	or 1E-03
centi	c	0.01	or 1×10^{-2}	or 1E-02
kilo	k	1,000	or 1×10^3	or 1E+03
mega	M	1,000,000	or 1×10^6	or 1E+06
giga	G	1,000,000,000	or 1×10^9	or 1E+09
tera	T	1,000,000,000,000	or 1×10^{12}	or 1E+12

The following symbols are occasionally used in conjunction with numerical expressions: < less than; \leq less than or equal to; > greater than; \geq greater than or equal to.

In some cases, numerical values in this document have been rounded to an appropriate number of significant figures to reflect the accuracy of data being presented. For example, the numbers 0.021, 21, 2100, and 2,100,000 all contain 2 significant figures. In some cases, where several values are summed to obtain a total, the rounded total may not exactly equal the sum of its rounded component values.

Basic Units and Conversion Table

Unit of Measure	English Unit	Symbol	Metric Unit	Symbol
Length	inches	in	centimeters	cm
	feet	ft	meters	m
	yards	yd	kilometers	km
	miles	mi		
Area	square feet	ft ²	square meters	m ²
	acres	ac	hectares	ha
	square miles	mi ²	square kilometers	km ²
Volume (dry)	cubic feet	ft ³	cubic meters	m ³
	cubic yards	yd ³		
Volume (liquid)	gallons	gal	liters	L
Mass	ounces	oz	grams	g
	pounds	lb	kilograms	kg
Concentration	parts per million	ppm	grams per liter	g/L
Radioactivity	curies	Ci	becquerels	Bq
Radiation Absorbed Dose	rad	rad	Gray	Gy
Radiation Effective Dose Equivalent	rem	rem	Sievert	Sv
Temperature	degrees Fahrenheit	°F	degrees Centigrade	°C

Base Unit	Multiply By	To Obtain	Base Unit	Multiply By	To Obtain
in	2.54	cm	cm	0.394	in
ft	0.305	m	m	3.28	ft
yd	0.914	m	m	1.09	yd
mi	1.61	km	km	0.621	mi
ft ²	0.093	m ²	m ²	10.76	ft ²
ac	0.405	ha	ha	2.47	ac
mi ²	2.59	km ²	km ²	0.386	mi ²
ft ³	0.028	m ³	m ³	35.3	ft ³
yd ³	0.765	m ³	m ³	1.31	yd ³
gal	3.77	L	L	0.265	gal
oz	28.349	g	g	0.035	oz
lb	0.454	kg	kg	2.205	lb
ppm	0.001	g/L	g/L	1000	ppm
Ci	3.7 x 10 ¹⁰	Bq	Bq	2.7 x 10 ⁻¹¹	Ci
rad	0.01	Gy	Gy	100	rad
rem	0.01	Sv	Sv	100	rem
°F	(°F - 32) x 5/9	°C	°C	(°C x 9/5) + 32	°F

Radionuclide Nomenclature^(a,b)

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
Ac-227*	actinium-227	22 yr	Pu-240	plutonium-240	6537 yr
Ag-110m	silver-110m	250 d	Pu-241	plutonium-241	14 yr
Am-241	americium-241	432 yr	Pu-242	plutonium-242	3.7 x 10 ⁵ yr
Ba-137m	barium-137m	2.6 min	Pu-244	plutonium-244	8.1 x 10 ⁷ yr
Be-7*	beryllium-7	53 d	Ra-224*	radium-224	3.7 d
Bi-212*	bismuth-212	61 min	Ra-226*	radium-226	1600 yr
Bi-214*	bismuth-214	20 min	Ra-228*	radium-228	5.8 yr
C-14*	carbon-14	5730 yr	Rb-87*	rubidium-87	4.8 x 10 ¹⁰ yr
Cd-113m*	cadmium-113m	15 yr	Rh-106	rhodium-106	30 sec
Ce-144	cerium-144	285 d	Ru-106	ruthenium-106	374 d
Cl-36	chlorine-36	3.0 x 10 ⁵ yr	Sb-125	antimony-125	2.8 yr
Cm-244	curium-244	18 yr	Sb-126m	antimony-126m	11 sec
Co-60	cobalt-60	5.3 yr	Se-75	selenium-75	120 d
Cs-137	cesium-137	30 yr	Se-79	selenium-79	6.5 x 10 ⁵ yr
Eu-152	europium-152	14 yr	Sm-147*	samarium-147	1.1 x 10 ¹¹ yr
Eu-154	europium-154	8.6 yr	Sm-151	samarium-151	90 yr
Eu-155	europium-155	4.8 yr	Sn-126	tin-126	1.0 x 10 ⁵ yr
Fe-55	iron-55	2.7 yr	Sr-90	strontium-90	29 yr
H-3*	tritium	12 yr	Tc-99	technetium-99	2.1 x 10 ⁵ yr
I-125	iodine-125	59 d	Th-228*	thorium-228	1.9 yr
I-129	iodine-129	1.6 x 10 ⁷ yr	Th-229	thorium-229	7880 yr
K-40*	potassium-40	1.3 x 10 ⁹ yr	Th-230*	thorium-230	7.5 x 10 ⁴ yr
Mn-54	manganese-54	312 d	Th-232*	thorium-232	1.4 x 10 ¹⁰ yr
Mo-93	molybdenum-93	4000 yr	Th-234*	thorium-234	24 d
Nb-94	niobium-94	2.0 x 10 ⁴ yr	U-232	uranium-232	69 yr
Ni-59	nickel-59	7.6 x 10 ⁴ yr	U-233	uranium-233	1.6 x 10 ⁵ yr
Ni-63	nickel-63	100 yr	U-234*	uranium-234	2.5 x 10 ⁵ yr
Np-237	neptunium-237	2.1 x 10 ⁶ yr	U-235*	uranium-235	7.0 x 10 ⁸ yr
Pa-231*	protactinium-231	3.3 x 10 ⁴ yr	U-236	uranium-236	2.3 x 10 ⁷ yr
Pb-210*	lead-210	22 yr	U-238*	uranium-238	4.5 x 10 ⁹ yr
Pb-212*	lead-212	11 hr	W-185	tungsten-185	75 d
Pd-107	palladium-107	6.5 x 10 ⁶ yr	Y-90	yttrium-90	2.7 d
Pr-144	praseodymium-144	17 m	Zn-65	zinc-65	244 d
Pu-238	plutonium-238	88 yr	Zr-93	zirconium-93	1.5 x 10 ⁶ yr
Pu-239	plutonium-239	2.4 x 10 ⁴ yr	Zr-95	zirconium-95	64 d

(a) From *CRC Handbook of Chemistry and Physics*. 74th edition. ed. David R. Lide, CRC Press, Boca Raton, Florida 1993.

(b) Listing includes radionuclides evaluated in this document. Metastable isomers are indicated by the addition of an *m*. Short-lived decay products are not shown.

* Indicates naturally occurring radionuclides.

Reference Citations

Throughout the text of the HSW EIS, in-text reference citations are presented where information from the referenced document was used. These in-text reference citations are contained within parentheses and provide a brief identification of the referenced document. This brief identification corresponds to the complete reference citation located in the reference lists, which are located at the end of each section and appendix in the HSW EIS. The references are listed in alphabetical or numeric order and do not necessarily reflect the order of their appearance in the text.

An example of an in-text reference citation is (DOE 1997a), which corresponds to the complete reference citation provided in section or appendix reference lists. In the reference list, DOE 1997a, DOE 1997b, and DOE 1997c are listed in the following manner (based on the alphabetical order of the document title, not the order in which they might appear in the text):

DOE. 1997a. *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*. DOE/EIS-0200-F, U.S. Department of Energy, Washington, D.C.

DOE. 1997b. *Integrated Data Base Report – 1996: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics*. DOE/RW-0006, Rev. 13, U.S. Department of Energy, Office of Environmental Management, Washington, D.C.

DOE. 1997c. *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*. DOE/EIS-0026-S-2, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, New Mexico.