APPENDIX H.2

KW BASIN SLUDGE (RC-OP-1, RIVER CORRIDOR) EVALUATION UNIT SUMMARY TEMPLATE

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PART I. EXECUTIVE SUMMARY

EU LOCATION

100K Area

The KW Basin and the Sludge Treatment Project (STP) Facility are located in the 100 area at the KW Reactor Facility in the K area near the Columbia River.

T Plant, which will serve as a storage area for the sludge is located in 200 West are several miles inland from the Columbia River.

RELATED EUS

KE/KW Reactors, T Plant

PRIMARY CONTAMINANTS, CONTAMINATED MEDIA AND WASTES:

The waste that is the focus of the STP is the sludge stored in the KW Basin which will be packaged and transferred to T Plant for interim storage. The sludge in KW Basin is classified as remote handled TRU. This waste consists primarily of sludge retrieved from the KE Basin and contains aluminum cladding shards, oxidized fuel, and metal fuel particles as well as windblown sand and environmental debris, spalled concrete from the basin walls, iron and aluminum corrosion products, and ion exchange resin beads. Sludge retrieved from the KW Basin floor and pit sludge stream prior to the retrieval and packaging of SNF for its removal and receipt of sludge transferred from the KE Basin consisted primarily of windblown sand and environmental debris, spalled concrete from the basin walls, iron and aluminum corrosion products, flexible graphite [GrafoilTM1], plus limited amounts of uranium oxides, and uranium fuel particles. The KE Basin sludge generally contains a higher percentage of uranium fuel particles, while the KW Basin sludge stream contains a higher percentage of windblown sand and environmental debris because the SNF elements in the KW West Basin were stored in closed canisters so less fuel particles mixed with the floor sludge.[1]

BRIEF NARRATIVE DESCRIPTION

The Sludge Treatment Project consists of two phases that are described in this document. These phases are: (1) Storage and transfer of sludge from KW Basin to T Plant and (2) Treatment of sludge and shipment for disposal. Each of these phases has several stages. Phase 1 stages include: (a) storage of sludge in KW Basin; (b) the Engineered Container Removal and Transfer System (ECRTS); and (c) storage of sludge in T Plant. Phase 2 stages include (a) Sludge Treatment. A third phase, processing of Knock out pot (KOP) material, has been completed and is not discussed in this review.

Stage a, mostly takes place in the KW Basin. Typical operations in the basin include the operation of the water treatment system; management of fuel fragments, retrieval, storage, movement and containerization of sludge; sorting and removal of debris (e.g. dust and sand), removal and disposition of equipment no longer in use; and handling and interim storage of waste, and the construction of the KW Basin Annex, which will house ECRTS, is also part of Stage a.[2]

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[1] HNF-40475- 2013. Page 5.
[2] HNF-SD-WM-SAR-062, 2014. Page 2-13.

Stage b, is ECRTS which will take place in the KW basin and an annex of the KW Basin currently under construction. The sludge will be transferred from the KW Basin using the Xago Hydrolance™ tool[3] to the annex for packaging in sludge transport and storage containers (STSCs). The duration of operations in this phase is planned to be one year. The STSCs, which are made of stainless steel, are designed to store sludge for 30 years. Operations in ECRTS include STSC preparation, sludge retrieval and transfer into the STSC, flushing the transfer lines to the STSC, adding flocculant to the supernate in the STSC to increase sludge settling velocity, decanting supernate from the STSC, backwashing sludge from the sand filter to the STSC, removing any excess sludge from the STSC, disconnecting the piping and purging the STSC, and inerting the STS with nitrogen and pressurizing it.[4]

Stage c involves transporting the STSCs to T Plant and then storage in cells at T Plant. Transportation will meet the requirements of the Hanford Sitewide Transportation Safety Document[5] and will involve the transport of the STSC on non-public site roads via tractor trailer.[6] This tractor trailer will back up into the T Plant rail loading bay, where the cask will be unloaded and stored in cells covered by concrete shield blocks in the T Plant canyon for interim storage[7].

Phase 2: At a point in the future that is not defined because of funding uncertainties this stored sludge will be retrieved from the STSCs, processed into a form that is certifiable for transportation and disposal at the Waste Isolation Pilot Plant (WIPP) (or alternate future disposal facility)[8], and packaged. Although several technology options have been identified, this phase is still in the design and decision-making process.

Summary Tables of Risks and Potential Impacts to Receptors

Table H.2-1 provides a summary of nuclear and industrial safety related risks to humans and impacts to important physical Hanford site resources.

Human Health: A Facility Worker is deemed to be an individual located anywhere within the physical boundaries of the KW Reactor Building (where the sludge is currently housed) or immediate areas around the outside of the building; a Co-located Person (CP) is an individual located 100 meters from the KW Reactor Building; and Public is an individual located at the closest point on the Hanford Site boundary not subject to DOE access control, which in this instance is the bank of the Columbia River. The nuclear related risks to humans are based on unmitigated (unprotected or controlled conditions) dose exposures expressed in a range of from Not Discernible (ND) to High. The estimated mitigated exposure that takes engineered and administrative controls and protections into consideration, is shown in parentheses.

Groundwater and Columbia River: Direct impacts to groundwater resources and the Columbia River, have been rated based on available information for the current status and estimates for future time periods. These impacts are also expressed in a range of from Not Discernible (ND) to Very High.

Ecological Resources: The risk ratings are based on the degree of physical disruption (and potential additional exposure to contaminants) in the current status and as a potential result of remediation options.

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[3] The Xago Hydrolance is a combined sludge fluidizer and eductor for creating and removing a sludge slurry for further processing.
[4] PRC-STP-00718, 2014. Pages x-xii.
[5] DOE-RL-2001-36, 2002.
[6] SNF-10823, Rev. 1E, 2008.
[7] PRC-STP-00109, Rev. 0.
[8] PRC-STP-00615, Rev. 0, 2012. Page ES-1.

Cultural Resources: No risk ratings are provided for Cultural Resources. Table H.2-1 identifies the three overlapping Cultural Resource landscapes that have been evaluated: Native American (approximately 10,000 years ago to the present); Pre-Hanford Era (1805 to 1943) and Manhattan/Cold War Era (1943 to 1990); and provides initial information on whether an impact (both direct and indirect) is KNOWN (presence of cultural resources established), UNKNOWN (uncertainty about presence of cultural resources), or NONE (no cultural resources present) based on written or oral documentation gathered on the entire EU and buffer area. Direct impacts include but are not limited to physical destruction (all or part) or alteration such as diminished integrity. Indirect impacts include but are not limited to the introduction of visual, atmospheric, or audible elements that diminish the cultural resource's significant historic features. Impacts to Cultural Resources as a result of proposed future cleanup activities will be evaluated in depth under Section 106 of the National Historic Preservation Act (16 USC 470, et. seq.) during the planning for remedial action.

Table H.2-1. Risk Rating Summary (for Human Health, unmitigated nuclear safety basis indicated, mitigated basis indicated in parentheses (e.g., "Very High" (Low)).

		Evaluation Time Period	
		Active Cleanup (to 2064)	
Population or Resource		**Current Condition:** Safe Storage at KW Basin	**From Cleanup Actions:** ECRTS
Human Health	Facility Worker	Medium (Not Discernible (ND))	High (Low)
	Co-located Person	Medium (Low)	High (Low)
	Public	Low (Low)	Low (Low)
Environmental	Groundwater	ND	ND
	Columbia River	ND	ND
	Ecological Resources[a]	ND	ND
Social	Cultural Resources[a]	**Native American:** Direct: Known Indirect: Known **Historic Pre-Hanford:** Direct: Known Indirect: Known **Manhattan/Cold War:** Direct: Known Indirect: Known	**Native American:** Direct: Known Indirect: Known **Historic Pre-Hanford:** Direct: Known Indirect: Known **Manhattan/Cold War:** Direct: Known Indirect: Known

a. For both Ecological and Cultural Resources see Appendices J and K, respectively, for a complete description of Ecological Field Assessments and literature review for Cultural Resources. Ecological ratings are described in Table 4-11 of the Final Report.

SUPPORT FOR RISK AND IMPACT RATINGS FOR EACH POPULATION OR RESOURCE

Human Health

Current

The current condition is Stage a: sludge storage at K Basin along with continued cleanup of the pool contents such as sludge, debris, and equipment. There are 117 total accidents analyzed in the Streamline (sic) Hazards Analysis for KW Basin. Of the 117, 43 are no longer applicable because the activities that could lead to the initiating events have ended. Of the 74 accidents remaining, all had low consequences to the maximally exposed offsite individual (MOI) and the collocated worker (CW). All 74 accidents also had no consequences to the facility worker. Several accidents did have potential consequences to the environment; 3 of these had a frequency of anticipated.[9]

Building and Facility: The safe storage of sludge at KW Basin can impacted by the following accident and natural phenomenon hazards:

Hydrogen Explosion: Integrated Water Treatment System Annular Filter Hydrogen Explosion. Deflagration of accumulated hydrogen has been identified through one major accident scenario: hydrogen is generated through radiolysis and fuel corrosion accumulating in the headspace of the annular filter vessel while the IWTS is out of service for an extended period of time (a leak allows air to enter, and a deflagration results). The likelihood of this event is unlikely.

Unmitigated Risk: Collocated Person – Medium; Public – Low

Mitigation: No safety SSCs or TSRs are credited for prevention or mitigation of hydrogen deflagrations in the annular filter vessel or IXMs. Design features of the annular filter vessel and the particulate vessel may mitigate the consequences. There is also a defense in depth control in the periodic operation of the Integrated Water Treatment System to flush the filter vessel headspace.

Mitigated Risk: Collocated Person: Low; Public: Low

Fire: Diesel fuel spills that could result in a fire can occur from (1) forklift (maximum diesel fuel capacity of 30 gal); and (2) IXM transport tractor (maximum controlled fuel capacity of 100 gal). The likelihood of this event is extremely unlikely.

Unmitigated Risk: Collocated Person – Medium; Public – Low

Mitigation: Controls in place: Active: KW transfer bay bridge cranes; Passive: KW Basin Superstructure, KW Basin Structure; Administrative: TSR controls include vehicle controls, KW heavy load controls, KW basin water controls, Fire Protection Program.

Mitigated Risk: Collocated Person: Low; Public: Low

Seismic Event: Beyond Design Basis Earthquake: A BDBE occurs causing drain down and dryout of the basin. Leakage rates could be higher than that for the seismic event (i.e., >50 gal/min). Consequences are based on pre-cleanout inventories. This analysis is retained for historical reference.

Unmitigated Risk: Collocated Person – Medium; Public – Low

Mitigation: This event is retained for historical purposes. The design basis event has consequences that are not discernible. There are controls in place to mitigate the design basis earthquake. These

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[9] DD-53838, Rev. 0, 2014. Appendix C.

include: Passive: KW Basin Superstructure, KW Basin Structure; Administrative: TSR controls include KW basin water controls.

Mitigated Risk: Collocated Person: Low; Public: Low

Industrial Safety: Potential industrial safety accidents at the KW Basin include crane incidents, fires, slips, trips and falls, and others. Industrial accidents would not have impact outside the KW Basin (hence no risk to CW or Public).

Unmitigated Risk: Facility Worker – Medium

Mitigation: The DOE and contractor Safety Management programs that include work control, fire protection, training, occupational safety and industrial hygiene, emergency preparedness, and management and organization have proven to be effective in reducing industrial accidents at the Hanford site to well below that in private industry.

Mitigated Risk: Facility Worker – Low

Risks and Potential Impacts from Selected or Potential Cleanup Approaches

For ECRTS (Stage b), it is important to note that the hazards and operability (HAZOP) study[10] only provides unmitigated consequences. Therefore the risk ratings below may seem higher than they would be in the hazards analysis that considers mitigation measures which will be prepared further along in the design and operations of the facility. The HAZOP Study for ECRTS analyzes 260 events. Of these events, 143 have high unmitigated consequences to the facility worker, and the majority of these high consequence events are anticipated[11]. For the co-located worker, there are 13 events that are anticipated and have high consequences including uncontrolled releases from a number of initiating events. There are also 22 events that are anticipated and will have a moderate effect on co-located workers. All analyzed events have either low or no unmitigated consequences to the public. The environment was not included in this study.[12]

Based on available information, we estimated the following ratings:

Unmitigated Risk Operation of ECRTS: Facility Worker – High; CP – High; Public – Low

Mitigation: In ECRTS, the following safety systems and controls will be used: above water slurry transfer lines, slurry transfer line rupture disk, double valve isolation, slurry transfer line secondary containment, slurry transfer line secondary confinement, slurry transfer line leak detection systems, safety control panels, the physical structure of the annex, auxiliary ventilation system, oxygen analyzer, pressure indicators, STSC design features such as the sloped fin, STSC liquid level instrumentation, truck scale instrumentation, nitrogen purge panel, safety control panel, and the STSC vent assembly.[13]

Mitigated Risk: Collocated Person – Low; Public – Low

Ecological Resources

Current

Currently no ecological resources on EU, and only 1 acre of level 3 on buffer area.

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[10] PRC-STP-00687, Rev.1, 2013. Appendix D.

[11] Note: The HAZOP study which considers unmitigated consequences is the most current documentation of hazards at ECRTS. As a consequence, the risk ratings will be higher than mitigated consequences. When the project ultimately considers mitigative measures the risks will be lower to an extent unknown.

[12] PRC-STP-00687, Rev.1, 2013. Appendix D.

[13] PRC-STP-00718, Rev 0 (2014). Pages xviii to xx.

Risks and Potential Impacts from Selected or Potential Cleanup Approaches
Any risk depends upon the quality and quantity of re-vegetation following remediation. Could be a risk from invasion of exotic species.

Cultural Resources

Current
Manhattan Project/Cold War significant resources have already been mitigated.

Area within the EU is heavily disturbed, but the entire area is extremely culturally sensitive based on prehistoric, ethno-historic, and historic land use in the area. Traditional cultural places are known to be located in the vicinity as well as National Register eligible archaeological sites associated with all 3 landscapes.

Risks and Potential Impacts from Selected or Potential Cleanup Approaches
Due to highly sensitive cultural resources in vicinity of the EU, consultation is needed.

Archaeological investigations or monitoring may also need to occur. Direct and indirect effects are likely to archaeological sites and traditional cultural places in vicinity of EU.

Permanent direct and indirect effects are possible due to high sensitivity of area.

Considerations for timing of the cleanup actions

If the ECRTS project is delayed, the waste will remain in K Basin and proportionately delay D&D activities of the KW reactor site.

Near-Term, Post-Cleanup Risks and Potential Impacts

The Phase 2 Sludge Treatment Process is in the technology selection phase and, thus, there is insufficient information to provide risk ratings at this time.

PART II. ADMINISTRATIVE INFORMATION

OU AND/OR TSDF DESIGNATION(S)

RC-OP-1 K Basins Sludge

COMMON NAME(S) FOR EU

KW Basin Sludge, ECRTS, Sludge Treatment Project

KEY WORDS

KW Basin, KE Basin, Sludge, TRU, ECRTS, STP, T Plant

REGULATORY STATUS

Regulatory basis: The regulatory basis for managing the K Basin sludge is CERCLA combined with TSCA. The removal action from the K Basin will be a CERCLA action, and the sludge contains enough PCBs that it will be managed under TSCA authority at T Plant.

Applicable regulatory documentation

Removal of Sludge from the K Basins and transport to T Plant: The CERCLA documentation associated with the removal of sludge from the KW Basin is either in place or identified in the project's Field Execution Schedule as "to be completed/approved" and consists of the following[14]:

- Remedial Design and Action Work Plan (DOE/RL-2010-63, Remedial Design/Remedial
- Action Work Plan for the K Basins Interim Remedial Action: Removal of K Basins Sludge from the River Corridor to the Central Plateau; and Removal of Knock Out Pot Contents from the K Basin),
- Waste Management Plan (SNF-9430, Waste Management Plan for K Basins Interim Remedial Action),
- Air Monitoring Plan (In development),
- Data Quality Objectives (HNF-36985, Data Quality Objectives for Sampling and Analysis of K Basin Sludge)
- End Point Criteria (HNF-20632, Endpoint Criteria for the K-Basins Interim Remedial Action),
- Qualified Process and Plan to Meet End Point Criteria (DOE/RL-2010-107, 105-K West Basin Qualified Process and Plan to Satisfy End-Point Criteria -Fuel, Sludge, and Below-Water Debris)
- Quality Assurance Project Plans/Sampling and Analysis Plans (e.g., KBC-33786, Quality Assurance Project Plan/Sampling and Analysis Plan for Sludge in the KW Engineered Containers and DOE/RL-2010-63-ADD2, Appendix A, Quality Assurance Project Plan/Sampling and Analysis Plan (QAPP/SAP) for the Hanford KW Basin Knockout Pot Product Material for 105-K West Basin Field Measurements and HNF-6479, Sampling and Analysis Plan For Sludge from the 105 K Basins to Support Transport to and Storage in T Plant).

Storage of Sludge at T Plant: The sludge management activities at T Plant involving the receipt and interim storage of packages sludge in casks pending treatment have been previously determined by the U.S. Environmental Protection Agency (EPA) to be "off-site". Therefore modifications to that facility and the storage of sludge are subject to all applicable administrative permitting and licensing requirements. Permitting actions will involve screening the following facility environmental documentation for sufficiency and updating and obtaining approvals as necessary: National Environmental Policy Act (NEPA) documentation including past Environmental Impact Statements (EISs) and Environmental Assessments; cultural resource review documentation; air permitting documentation; Toxic Substance Control Act documentation; and RCRA documentation.[15]

In accordance with TPA milestone M-016-140, DOE/RL-2011-15, Remedial Design/Remedial Action Work Plan for the K Basins Interim Remedial Action: Treatment and Packaging of K Basins Sludge, was prepared and approved by DOE-RL and EPA. Phase 2 Treatment and Packaging has not been defined in sufficient detail at this time to provide information that can be used in identifying those associated permits, licenses, or other environmental documentation that may be required to support construction and operational activities of this phase of the project.[16]

Applicable Consent Decree or TPA milestones

TPA milestone M-016-140

[14] KBC-30811, Rev. 5. 2012. Pages 1-16-1-17.
[15] KBC-30811, Rev. 5. 2012. Pages 1-16-1-17.
[16] KBC-30811, Rev. 5. 2012. Page 1-17.

Risk Review Evaluation Information

Completed: Revised February 4, 2015

Evaluated by: B. Burkhardt, A. Croff, L. Fyffe, S. Krahn

Ratings/Impacts Reviewed by: D. Kosson, J. Burger, H. Mayer, J. Salisbury, A. Bunn

PART III. SUMMARY DESCRIPTION

Current land use

DOE Hanford Site

Designated future land use:

The Columbia River would continue to be managed to allow limited public access and use as a Low-Intensity Recreation area. Access to the Columbia River's islands would remain restricted to protect cultural and biological resources. Public access to the Reactors on the River area (i.e., the 100 Areas) would remain restricted.[17]

Primary EU Source Components

High-Level Waste Tanks and Ancillary Equipment

Not Applicable

Legacy Source Sites

There are several soil contamination sites in the 100K area surrounding the reactors as well as waste sites. See Section V for a full description.

Groundwater Plumes

There is a chromium plume that extends to the KW reactor facility from the south, a Sr-90 plume to the northeast of the KW Basin Annex, an nitrate plume that directly underlies the KW basin and Annex, a chromium plume that extends under the KW basin and annex facility, and a C-14 plume that also extends under the KW basin and annex facility. See section V for a full description.

Operating Facilities

The operating facilities of concern for the STP include the KW Basin, the KW Basin Annex, and T Plant.

D&D of Inactive Facilities

The KW basin will begin D&D after the removal of the sludge, and the KE Basin has undergone D&D and been removed. D&D continues on the surrounding KE facility. The activities on the KW Basin are expected to continue into the future.

[17] EIS-0222, 1990. Page 19.

Location and Layout Maps

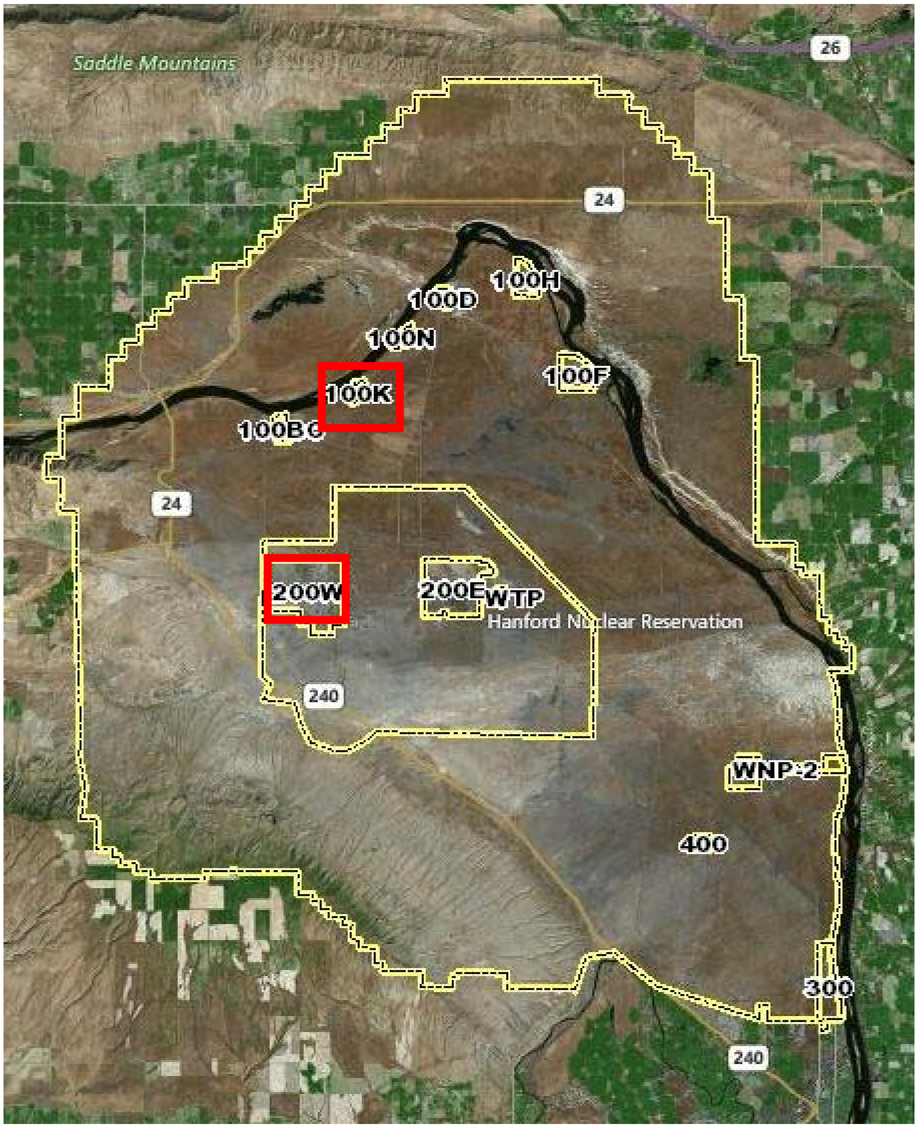

Figure H.2-1. Location of STP Facilities on the Hanford Site.

Figure H.2-1 illustrates the Hanford site. The 100K area where the KW Basin and KW Basin Annex are located is highlighted in a red rectangle, as is the 200W area where the STSCs will be stored until sludge treatment.

Figure H.2-2. Location of the KW Basin and Annex within the 100K Area.

Within the 100K area, the K West Basin and Annex location are highlighted by the red rectangle. The KE basin has been removed, and the KE Reactor facility is in the D&D process. Some sludge in the KW Basin came from this area which is highlighted by the green rectangle.

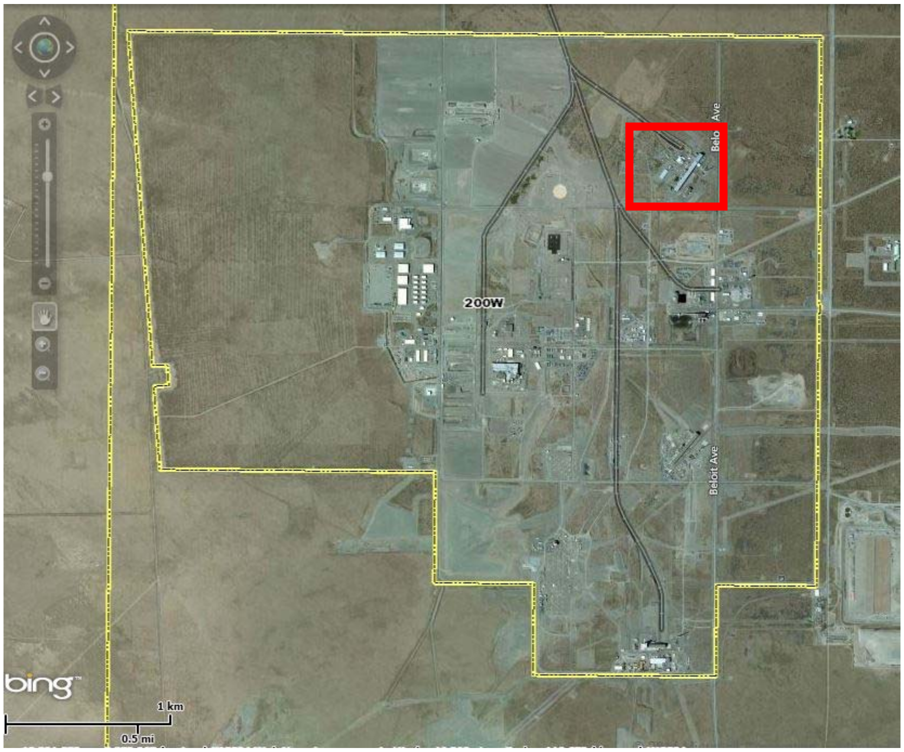

Figure H.2-3. Location of T Plant within the 200W Area.

T Plant where the STSCs will be stored is highlighted by the red rectangle.

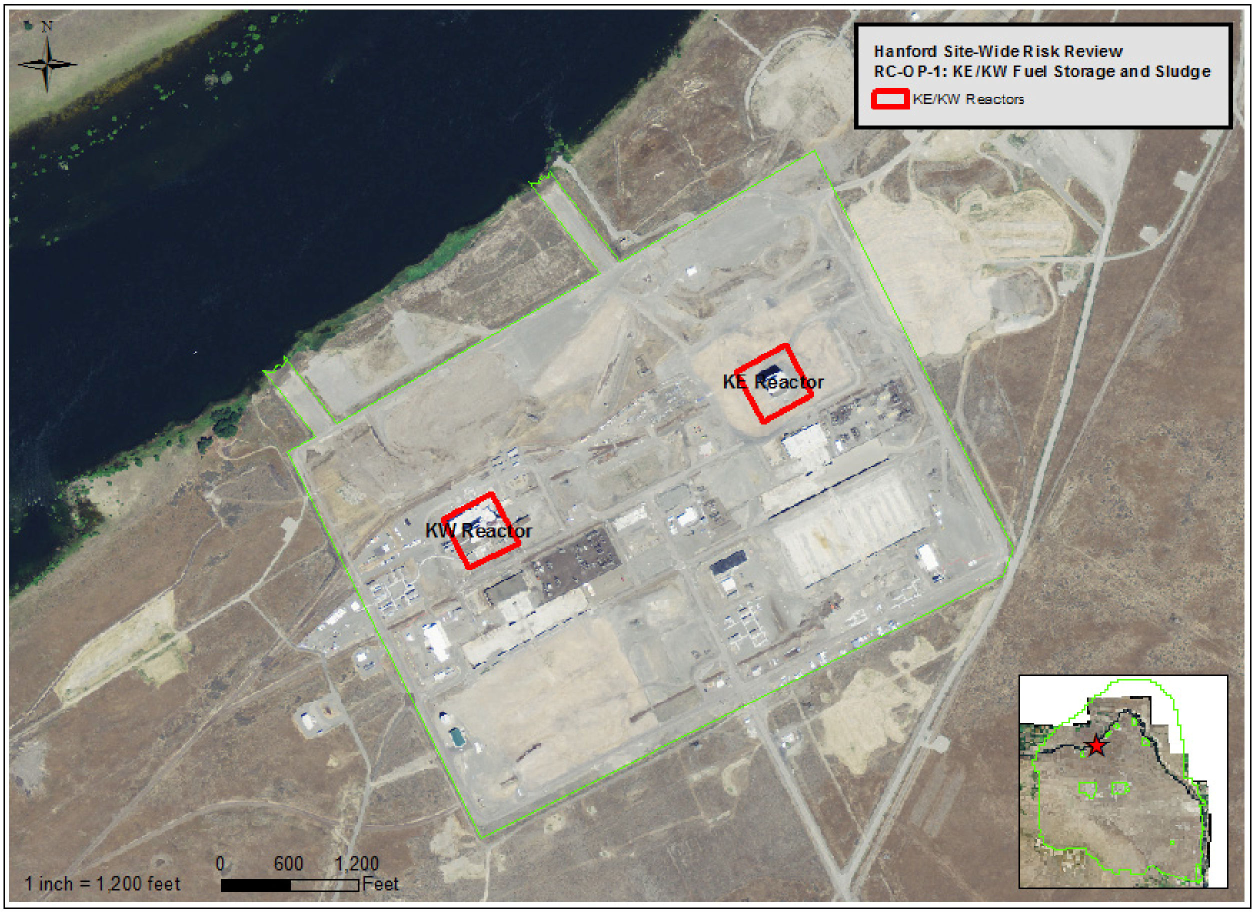

Figure H.2-4. EU Boundary Map.

PART IV. UNIT DESCRIPTION AND HISTORY

EU Former/Current Use(s)

The evaluation units of interest here are the KW Basin, the KW Basin Annex, and T Plant all of which are or will be operating facilities.

Legacy Source Sites

Not Applicable

High-Level Waste Tanks

Not Applicable

Groundwater Plumes

Not Applicable

D&D of Inactive Facilities

To be completed in a separate evaluation.

OPERATING FACILITIES

What processes produced the radioactive material and waste contained in the facility?

The sludge stored at the K Basins was created when irradiated fuel rods from the N Reactor that had been stored in these basins began to deteriorate. The sludge is a mixture of fuel corrosion particles, fuel rod and metal fragments, and wind-blown soil and sand.

What are the primary radioactive and non-radioactive constituents that are considered risk drivers?

The sludge is ultimately to be classified as TRU. As of the most recent analysis, the following radionuclides are present in the sludge at a concentration exceeding 100 Ci/m^3: Pu-241, Cs-137, Ba-137m, Sr-90, Y-90 and Am-241.[18]

What types of containers or storage measures are used for radioactive materials at the facility?

In Phase 1 stage a, the present stage, the waste is stored in KW Basin in sludge containerization system (SCS) containers which are rigid, self-supporting, free-standing structures of bolted stainless steel construction with Lexan covers. Each SCS container is able to store 11.6 m^3 of sludge, with more than 6 ft of water above the sludge for shielding purposes.[19] Also included in the basins are settler tanks, and ion exchange modules (IXM), as well as sand filters with a sand-garnet filtration material.

Once the sludge is processed through stage b, ECRTS, it will be packaged in STSCs. These containers will meet American Society of Mechanical Engineers Section VIII pressure vessels requirements and are approximately 5 ft in diameter and 9.5 ft tall, with elliptical top and bottom heads. [20]

Phase 2, transferring the waste from the STSCs stored at T Plant and treating it for final disposal at WIPP will involve placing the waste in transportation and WIPP (or alternate disposition) certified containers. These containers have yet to be designed.[21]

How is the radioactive material and waste contained or stored within the facility classified?

The sludge is classified as RH TRU.

What are the average and maximum occupational radiation doses incurred at the facility?

Average and maximum radiation doses incurred in the current (Phase 1 stage a) remain to be acquired. The 2013 year-to-date collective doses for KW Basin are included given in Table H.2-2[22]:

[18] HNF 41051. 2010.
[19] HNF-SD-WM-SAR-062, Rev. 20, 2014. Page 2-32.
[20] PRC-STP-00718, Rev. 0- 2014, Page x.
[21] PRC-STP-00615, Rev.0, 2012.
[22] Hastings, 2014.

Table H.2-2. 2013 Year to Date Person-Rem for K Basins Activities.

Low, Medium, and High Hazards Tasks for 2013

Description	Goal (1.525 P-Rem)	YTD P-Rem	% Comp
K Basins (Ops & Maint.) Craft Routines:	0.3	0.142	100%
Sludge Depth Measurements	0.125	0.139	100%
Settler Tank Surveys	0.2	0.0	0%
Sand Filter Operations Activities	0.1	0.030	100%
Facility Modifications & Support Activities	0.4	0.30	100%

CH2MHILL
Plateau Remediation Company

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ECRTS is not yet operational, however, the ALARA dose estimates for workers in ECRTS have been determined and are listed in Table H.2-3 and Table H.2-4[23].

[23] PRC-STP-00702, Rev.3 2013. Pages 27-28.

Table H.2-3. Mitigated Dose Rate for ECRTS Process Workers.

Worker Type	Dose per normal STSC filling operation (person-mRem)		Dose per STSC filling operation including overfill recovery operation (person-mRem)		Dose for 26 normal STSC filling operations (person-mRem)	
					No Overfill Recovery	
	Extremity	ED	Extremity	ED	Extremity	ED
Nuclear Chemical Operators (NCO)	380	59	772	121	9,880	1,534
Radiological Control Technicians (RCT)	346	49	886	127	8,996	1,274
Truck Driver	0.6	0.4	0.6	0.4	16	10
Millwright	254	31	271	33	6,604	806
Quality Assurance/Engineering	4.6	1	4.6	1	120	26
Pipefitter	0.1	0.1	0.1	0.1	2.6	2.6
Total Dose (person-mRem)	**985**	**140**	**1,934**	**282**	**25,618**	**3,653**

Table H.2-4. Mitigated Dose Rates and Doses in Continuously Occupies Areas of the Annex during Sludge Transfer Operations.

Mitigated Dose Rates and Total Dose for Normal Sludge Transfers						
Room	Maximum Dose Rate (mrem/hr)	Maximum Dose in One Hour (mrem)	Maximum Total Dose for 26 STSCs (mrem)	Average Dose Rate (mrem/hr)	Average Dose in One Hour (mrem)	Average Total Dose for 26 STSCs (mrem)
Mechanical Equipment	0.25	<0.06	1.6	0.09	<0.02	0.6
HEPA Filter	1.14	<0.29	7.5	0.3	<0.08	2.0
Change	0.91	<0.23	6.0	0.57	<0.14	3.7

Stage c and Phase 2 associated with the STP (storage in T Plant and eventual treatment and shipment to WIPP) do not have dose calculations associated with them at this time.

What processes and operations are conducted within the facility?

In Phase 1 , stage a, storage in KW Basin, the following operations are conducted: operation of the water treatment system, management of fuel fragments, retrieval, storage, movement and containerization of sludge, sorting and removal of debris, removal and disposal of equipment no longer in use, and packaging, handling and interim storage of waste.[24] In addition to storage at KW Basin, construction on the K-Basin annex is ongoing. The construction approach uses conventional practices to prepare the site and construct the Modified Annex. Construction involves the following activities: KW Basin Fuel Transfer System Annex Modifications, installation of buyer-furnished equipment, and interface with existing facilities and programs. The equipment expected to be used during these processes includes: excavator, bulldozer, backhoe, front end loader, haul truck, dump truck, semi delivery trucks, water truck, concrete truck, concrete pump truck, grader, asphalt paving equipment, light trucks, support vehicles, Environmental Restoration Disposal Facility Containers, forklifts, extended forklifts, powered and non-powered hand tools, cutting/welding torch, concrete saw, cranes and boom trucks, man lifts, aerial lifts, scissor lifts, and scaffolding.[25]

In ECRTS (Phase 1, stage b), the following processes will be conducted: a batch of sludge is retrieved from an Engineered Container now stored in KW Basin and transferred directly into a sludge transport and storage container (STSC) located inside a Sludge Transport System (STS) cask. The STSC and STS cask are located on a trailer inside the modified annex building adjacent to the K West (KW) Basin. For settler sludge, an STSC with a water filled annulus is used to enhance the heat transfer rate, thereby increasing the amount of sludge that can be contained in the STSC. The sludge is allowed to settle within the STSC to concentrate the solids and clarify the supernate. A flocculant is being evaluated to coalescence small sludge particles and increase sludge settling rates to reduce the loading time. After sludge settling, the supernate is decanted and filtered through a sand filter to remove suspended sludge particles. The filtered supernate is returned to the basin. Subsequent batches of sludge are added to the STSC, settled, and excess supernate removed in the same manner until the prescribed quantity of sludge is collected into a STSC. The solids collected on the sand filter unit are then removed by backwashing and transferred back into the STSC. The STS cask is purged with an inert gas (nitrogen), the seal is leak tested and the cask transported to T Plant, the interim storage facility.[26]

While in storage at T Plant, the STSCs would be monitored annually for water loss due to evaporation and replenished with make-up water as necessary. This is necessary to ensure the sludge remains in a fully wetted environment to prevent drying out and potential uranium metal oxidation. During storage, the headspace in the STSC is vented via natural circulation through two vents at different heights. The concentration of hydrogen is maintained at less than 4 volume percent in the T Plant cells and in the headspace of the STSC through operation of the T Plant exhaust ventilation system. In the event the T Plant exhaust ventilation system is inoperable, the chimney effect of the STSC vents and the natural circulation of air through the T Plant cells as a result of temperature differential will ensure the concentration of hydrogen is maintained at less than 4 volume percent in the T Plant cells and in the headspace of the STSC.[27]

What is the process flow of material into and out of the facility?

The following process flow diagram illustrates the collection of the sludge from the existing containers currently in safe storage in KW Basin, through the ECRTS process described above in the KW Basin Annex, and out for interim storage at T Plant.[28]

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[24] HNF-SD-WM-SAR-062, Rev. 20, 2014. Page 2-13.
[25] DD-50769, Rev. 1, 2014. Pages 3-5 and 3-6.
[26] HNF-41051, Rev. 6 Page X
[27] HNF 41051, Rev. 6, 2014. Page 41.
[28] Process flow diagram taken from: HNF 41051, Rev. 6, 2014. Page 11.

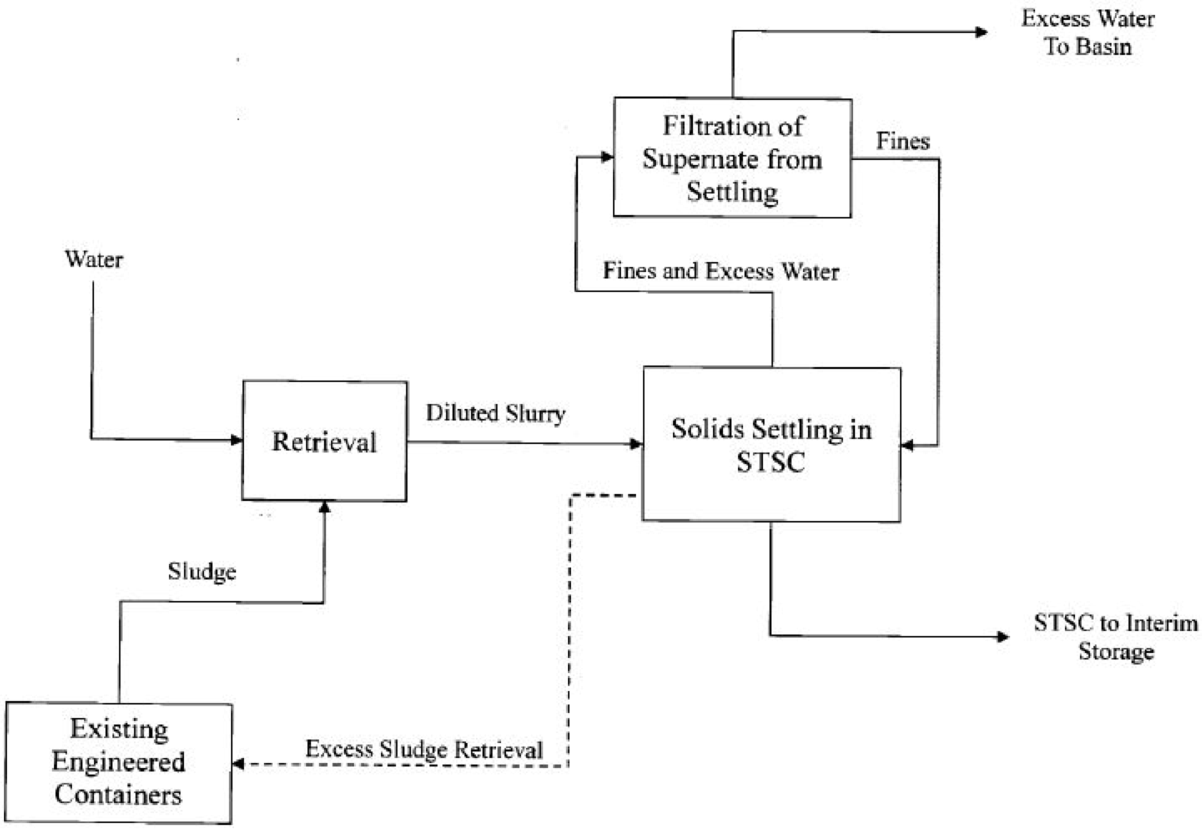

Figure H.2-5. Process Flow Diagram for Sludge through Storage at T Plant.

Once in T Plant, the material will be stored until it is removed for final processing and packaging for disposition at WIPP. This is the Phase 2 processing flow, and is illustrated in the following diagram.[29]

[29] Process flow diagram taken from: PRC-STP-00615, Rev. 0, 2012. Page 1-3.

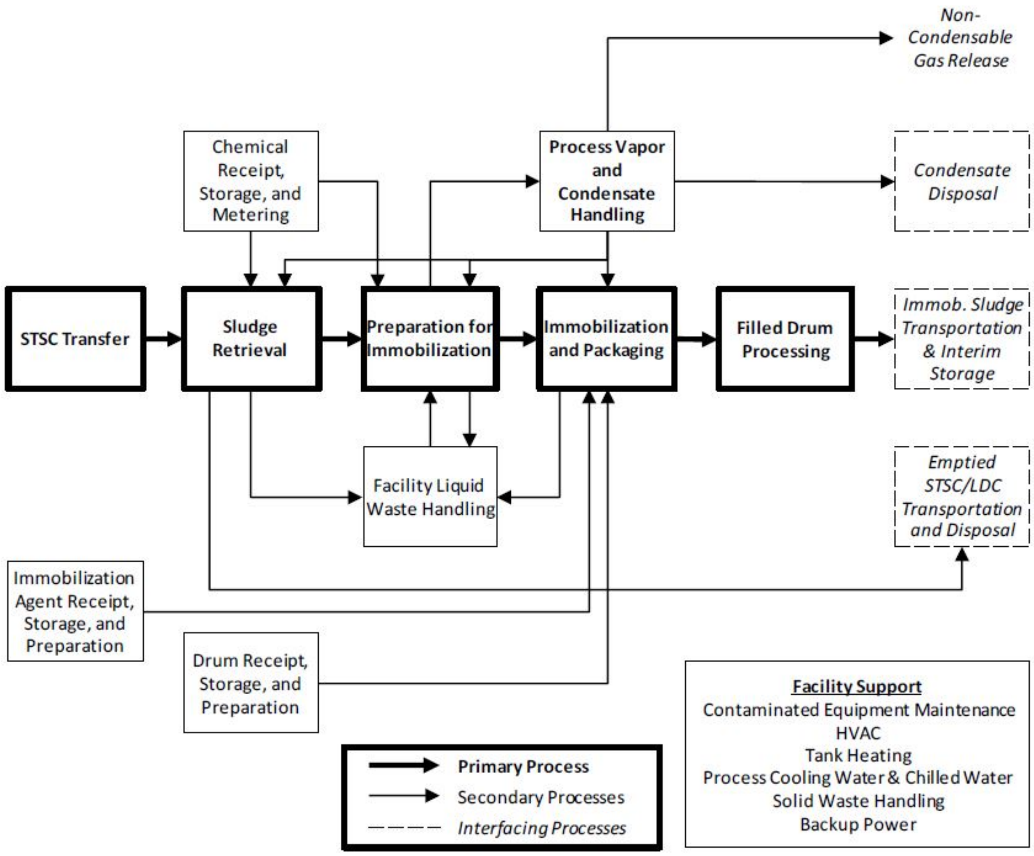

Figure H.2-6. Process Flow Diagram for Phase 2 Sludge Treatment.

What effect do potential delays have on the processes, operations, and radioactive materials in the facility?

This is a multi-phase project and delay would have different impacts, depending on when it occurred. These will be addressed in chronological order.

1. Delay in Removing the Sludge from the KW-Basin – the sludge stored in Engineered Containers at KW-Basin is the last significant quantity of nuclear material in the K Area (and for that matter on the River Corridor). Transportation of this material out of the K Area to T Plant is on the critical path to being able to complete environmental restoration activities on the K Area.
2. Delay in Design, Construction and Construction of the Phase 2 Sludge Treatment System – T Plant is intended to be only an interim stop for the sludge material from K Basins. CHPRC has completed alternatives analysis[30] and recommended a warm water oxidation system to stabilize the remaining uranium in the sludge (along with some limited development of backup/enhancement technologies). DOE-RL has approved[31] this path forward and CHPRC has developed a preliminary technology development plan[32] to mature the technologies to support design of the Phase 2 treatment system. Delays in design and construction of the Phase 2 treatment system, or the technology development program to support it, would result in the sludge being stored for a

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[30] PRC-STP-00465, "K-Basins Sludge Treatment Project – Phase 2 Technology Evaluation and Alternatives Analysis," 2011
[31] DOE-RL letter 12-AMRC-0051, December 23, 2011
[32] PRC-STP-00615, "Preliminary Technology Maturation Plan for the K-Basins Sludge Treatment and Packaging Facility," March 2012

longer time period in T-Plant. Such a delay could make retrieval of the sludge for processing problematic (note: the aging properties of the sludge materials while in storage at T Plant is a line of inquiry in the technology development planning) or challenge the design life of the STS casks or STSCs.

What other facilities or processes are involved in the flow of radioactive material into and out of the facility?

There are no other Hanford facilities beyond the Modified KW Basin Annex and ECRTS, T Plant, and the eventual Phase 2 Sludge Treatment system. These steps are all described elsewhere in the document.

In addition, contaminated materials may be removed to the Environmental Restoration Disposal Facility (ERDF) for disposal. ERDF is discussed in H.5, a further appendix in this report.

Is shipping of material involved and if so, how often and by what means?

Shipment of material is involved in two distinct phases.

The first phase of shipment is the transfer of the inerted STSCs in STS casks from the KW Basin Annex and ECRTS process to T Plant for interim storage. The STS cask is loaded on a trailer that is a four-axle single drop flat bed with an overall length of 10.7m and a width of 3m. The trailer is fabricated of welded carbon steel shapes, plates and tubular sections in accordance with industry-accepted standards. The cask tiedown system consists of deck-mounted lugs, which engage four slots at the base of the STS cask and a framework that envelops the top of the STS cask. The authorized payload consists of the 60/40 settled sludge mix, and can contain one cask that may be loaded with no more than 2 m^3 of sludge covered with water to a minimum depth of 25.4 cm. The payload is a fissile, Type B highway route controlled quantity with a total maximum activity of 1.23×10^{15} Bq and maximum heat load of 107.6W.[33]

The STSC is placed into the transport system, assumed to be the same as the Sludge Transport System (STS) used for the ECRTS to bring the STSCs to T Plant from the 100 K Area. Prior to shipment of the loaded STSC, inert gas (nitrogen) will be introduced into the STSC headspace until the measured oxygen concentration of the purge outlet stream is below 1% by volume. The shipping cask lid will then be installed and the airspace in the sealed cask will be purged to less than 1% by volume oxygen. This will provide a shipping window of at least 72 hours before venting and/or purging is required again.[34]

The second shipment phase will transport sludge that has been treated and packaged at T Plant to the WIPP. This transportation system has not yet been designed, but will be consistent with shipping standards for TRU to WIPP already used on site.

What infrastructure is considered a part of the facility?

There are several facilities currently involved in the planning and mission of STP.

In KW Basin, the infrastructure associated with STP includes the KW Basin, the Modified KW Basin Annex, and the transfer line.

At T Plant, the infrastructure involved includes the rail loading dock as well as the storage bins reserved for STSCs.

There will also be infrastructure required for the sludge treatment and packaging process that has not yet been designed.

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[33] SNF-10823, Rev. 1-E. Page viii.

Ecological Resources Setting

Landscape Evaluation and Resource Classification

The ecological resources in the vicinity of the K Basins are based on the evaluation for the KE and KW Reactors. The amount and proximity of biological resources in the EU was examined within two adjacent landscape buffer areas; each landscape buffer area is defined by a circle radiating approximately 146 m from the geometric center of each reactor (equivalent to 27.8 acres for the two buffer zones combined). Most of the EU the adjacent landscape buffer areas consist of level 0 biological resources—94.2% of the combined total area. The adjacent landscape buffer area includes a small area designated as resource level 4. The level 4 area is a species resource and is considered a level 4 resource because it intersects a designated buffer zone for a bald eagle (*Haliaeetus leucocephalus*) roosting area at the river's edge close to the northwest corner of the 100-K Area.

Field Survey

The K Basin Sludge EU, along with the KE and KW Reactors EU, and the adjacent habitat were evaluated by vehicle and pedestrian surveys in October 2014. The EU consists entirely of built structures and graveled and concrete surfaces and no field measurements of vegetation were made. Some sparse Russian thistle (*Salsola tragus*) was noted around the periphery of parking areas and graveled slopes. No wildlife was observed at the K basins during the October survey. Data collected during an ECAP survey of 100-K Area buildings notes various bird species using the reactors buildings at that time. Much of the infrastructure around the reactors has been removed since that survey was completed, and the available nesting/perching areas that were used by birds likely no longer exist.

Cultural Resources Setting

Cultural resources documented within the K Basin Sludge EU include two Manhattan Project/Cold War Era Landscape resources. In accordance with the 1998 *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan (*DOE/RL-97-56), all documentation requirements have been completed for properties contributing to the Manhattan Project and Cold War era historic district. No other archaeological resources or TCPs are known to be recorded within the EU.

A small portion of the K Basin Sludge EU has been inventoried for archaeological resources. Remediation of waste sites within the K Area Waste Sites Evaluation Unit has been addressed by a NHPA Section 106 review. There are 10 archaeological sites within 500 meters of the EU: 4 archaeological sites (3 eligible and 1 unevaluated) represent the Native American Pre-contact and Ethnographic landscape; 1 archaeological site (eligible) represents the Pre-Hanford Early Settlers/Farming landscape, 3 archaeological sites (1 eligible, 1 not eligible, and 1 unevaluated); and 2 isolates (2 not eligible) represent the Manhattan Project/Cold War era landscape.

The geomorphologic composition of the EU, historic map, and modern aerial imagery all suggest low potential for subsurface intact archaeological resources in EU. Consultation with Hanford Tribes (Confederated Bands of the Yakama Nation, Wanapum, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce) and other groups who may have an interest in the areas (e.g. East Benton Historical Society, Prosser Cemetery Association, Franklin County Historical Society, the Reach, and the B-Reactor Museum Association) may need to occur. Consultation with Hanford Tribes may also be necessary to provide input on indirect effects to both recorded and potential unrecorded TCPs in the area and other cultural resource issues of concern.

PART V. WASTE AND CONTAMINATION INVENTORY

Brief description of contaminated media and materials

The KE and KW Basins were constructed in the early 1950's to support K-reactor operations. After irradiation, fuel was pushed from the horizontal fuel channels in the reactors into the discharge chutes and then sorted, canned, and queued underwater in the basins. This allowed for decay of radionuclides with short half-lives prior to reprocessing the fuel at either the 202-S Reduction-Oxidation (REDOX) or the 202-A Plutonium Uranium Extraction (PUREX) facilities for plutonium and uranium recovery. The basins originally had a 20-year design life and were deactivated when the KW and KE reactors were shut down. They were placed in long-term standby in February 1970 and January 1971, respectively.

In 1967, the REDOX reprocessing facility was shutdown. In the early 1970s, the PUREX reprocessing facility was placed on standby while the N Reactor continued to operate with a dual-purpose mission to produce fuels-grade plutonium and electricity. Spent fuel storage at N Reactor filled up so the KE Basin was reactivated in 1975. The KW Basin was reactivated in 1981 as supplemental storage for irradiated N Reactor fuel. The fuel stored in the KE Basin was contained in open-topped canisters, many of which had screened or perforated bottoms. The fuel stored in the K West Basin was contained in closed and sealed canisters that contained Grafoil [Grafoil is a registered trademark of Graffech International] gaskets.

The PUREX reprocessing facility was operated again from 1983 through 1990 and processed much of the N Reactor fuel (Zircaloy clad metallic uranium) that contained weapons-grade plutonium. When a U.S. government policy decision was made in the early 1990s to stop recovery of plutonium, some 2,100 metric tons (MT) of irradiated fuel remained in storage in the KE and KW basins. This inventory was irradiated uranium metal fuel, some of which was aluminum clad and the majority of which was Zircaloy clad. Some of the fuel suffered cladding damage or breaches during reactor operation, primarily during discharge and handling. This provided a pathway for water contact of the fuel and, eventually, corrosion of the metallic uranium fuel. Over time, well beyond the design basis of the fuel (approximately 20 years for KE Basin and 15 years for KW Basin), significant fuel element corrosion occurred and the resulting corrosion products escaped from the canisters to the basins floors and pits.

The basin superstructures are not sealed from the environment, which allowed sand, dirt, and organic material (weeds, bugs, etc.) to be deposited in the basins. Normal and off-normal basin operations contributed spent ion exchange resins and other detritus like spalled concrete, paint chips, Grafoil gasket material, and sand filter material; polychlorinated biphenyls (PCB) bearing materials; and hydroxides of iron, aluminum, and uranium to the sludge accumulation, mostly in the KE Basin. Sludge accumulations in the KW Basin were considerably less due to the sealed fuel storage canisters, better condition of the fuel placed into the basin, better control of the basin water quality, and a prior basin c1eanout campaign along with sealing the surfaces of the basin walls.

During the years of fuel storage, basin operation periodically required sludge relocation. This often resulted in portions of the sludge being pumped from the floor of the fuel storage area and settled in the various pits adjacent to the main basins. Over time, the sludge became identified by its deposition location: floor sludge, pit sludge, and canister sludge. The floor and pit sludge in the basins became a non-homogenous accumulation. By DOE-RL definition, sludge was defined to be anything in the basins that would pass through a 0.64-cm (0.25-in) screen. Material larger than that has been separated and managed as spent fuel, scrap or debris.

In the mid-1990s, the decision was made to disposition the fuel stored in the KE and KW Basins by packaging it, drying it, and moving it to dry storage on the 200 Area Central Plateau at the Hanford site.

After the fuel was transferred from November 2002 to July 2004, four Engineered Containers were installed in the KE Basin to collect and consolidate most of the KE Basin sludge, which was completed in 2006. In June 2004, approximately 3.5 m^3 of sludge from the KE North Load-out Pit was determined to be contact-handled transuranic (CH-TRU) waste. This sludge was transported to T Plant, then grouted and packaged into approximately 300 drums for disposal. The sludge collected in the Engineered Containers within the KE Basin was hydraulically transferred to three out of six Engineered Containers (numbers SCS-CON-240, 250, and 260) located in the fuel storage bays of the KW Basin beginning in October 2006. Removal of all sludge from the KE Basin was completed in June 2007, which allowed basin decommissioning.

Sludge retrieved from the KW Basin floor and pits was transferred into two Engineered Containers (number SCS-CON-210 and 220) in the KW Basin, which was completed in July 2007. The source of the sludge contained in Engineered Container numbers SCS-CON-210 and 220 is primarily sludge from the west bay in KW Basin (consisting of small fuel pieces), KE and KW canister sludge, and KW floor sludge. The fuel pieces contain higher concentration of uranium metal than other sludge types. The distribution of the KW Basin west bay sludge between Engineered Container number SCS-CON-210 and 220 is uncertain. A sixth Engineered Container (number SCS-CON-230) has received the Settler Tank sludge. The contaminant inventory for the K Basins sludge is provided in Table H.2-6 through Table H.2-8.

Table H.2-5. Contaminant Inventory- K Basins Sludge[35,36]

WIDS	Description and Reference	Radionuclide Inventory (Ci)								Chemical Inventory (kg)				
		Cs-137	Sr-90	Tc-99	I-129	H-3	Pu (total)	Am-241	U (total)	CCl_4	Cr (total)	Cr (VI)	TCE	NO_3
100-K-42	Closed- Inventory has been moved to KW Basin and is included in KW Basin Listing- WID 100-K-43.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
100-K-43	Sludge inventory for KW basin obtained from HNF41051 pages 20-21. The design concentration for each source of sludge is used and multiplied by the volumes from PRC-STP00718.	12739	16807	9	None known.	None known.	14867	2097	17.2	Not known.	Not known.	Not known.	Not known.	Not known.

[35] HNF41051, 2010. Pages 20-22.
[36] PCR-STP-00718, 2014.

CONTAMINATION WITHIN PRIMARY EU SOURCE COMPONENTS

Legacy Source Sites and Vadose Zone Contamination

There are several soil contamination sites in the 100K area surrounding the reactors as well as waste sites. Figure H.2-7 illustrates the waste sites in blue and the soil sites by white or yellow dots. [37]

Figure H.2-7. Soil Contamination and Waste Sites around KW Basin and ECRTS.

Groundwater Plumes

There is a chromium plume that extends to the KW reactor facility from the south, a Sr-90 plume to the northeast of the KW Basin Annex, a nitrate plume that directly underlies the KW Basin and Annex, a second chromium plume that extends under the KW Basin and annex facility, and a C-14 plume that also extends under the facility. Figure H.2-8 illustrates the groundwater plumes that could affect the KW basin and ECRTS. [38]

[37] Data obtained using the Phoenix Mapping Tool. Accessed 10/23/14.
[38] Data obtained using the Phoenix mapping tool, accessed 10/23/14.

Figure H.2-8. Groundwater Plumes around KW Basin and ECRTS.

Facilities for D&D

The KE/KW reactors are currently undergoing D&D. The KW Basin resides within the KW Reactor complex, and can be affected by D&D activities.

Operating Facilities

The operating facilities involved at the present time include KW Basin, Modified KW Basin Annex, T Plant.

Detailed inventories are provided in Table H.2-6, Table H.2-7, and Table H.2-8. All values are to 2 significant figures. The source document should be consulted for greater precision data. The sum for each primary contaminant is shown in the first row. Table H.2-9 provides a summary of the evaluation of threats to groundwater as a protected resource from saturated zone and remaining vadose zone contamination associated with the evaluation unit.

Table H.2-6. Inventory of Primary Contaminants[a]

WIDS	Description	Decay Date	Ref[b]	Am-241 (Ci)	C-14 (Ci)	Cl-36 (Ci)	Co-60 (Ci)	Cs-137 (Ci)	Eu-152 (Ci)	Eu-154 (Ci)	H-3 (Ci)	I-129 (Ci)
All	Sum			2100	NR	NR	NR	13000	NR	NR	NR	NR
100-K-43	UPR	2013	See note b	2100	NR	NR	NR	13000	NR	NR	NR	NR

a. NR = Not reported for indicated EU
b. Ref = HNF 41051, 2010 and PCR-STP-00718, 2014

Table H.2-7. Inventory of Primary Contaminants (cont)[a]

WIDS	Description	Decay Date	Ref[b]	Ni-59 (Ci)	Ni-63 (Ci)	Pu (total) (Ci)	Sr-90 (Ci)	Tc-99 (Ci)	U (total) (Ci)
All	Sum			NR	NR	15000	17000	9	17
100-K-43	UPR	2013	See note b	NR	NR	15000	17000	9	17

a. NR = Not reported for indicated EU
b. Ref = HNF 41051, 2010 and PCR-STP-00718, 2014

Table H.2-8. Inventory of Primary Contaminants (cont)[a]

WIDS	Description	Ref[b]	CCl4 (kg)	CN (kg)	Cr (kg)	Cr-VI (kg)	Hg (kg)	NO3 (kg)	Pb (kg)	TBP (kg)	TCE (kg)	U (total) (kg)
All	Sum		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
100-K-43	UPR	See note b	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

a. NR = Not reported for indicated EU
b. Ref = HNF 41051, 2010 and PCR-STP-00718, 2014

Table H.2-9. Summary of the Evaluation of Threats to Groundwater as a Protected Resource from Saturated Zone (SZ) and Remaining Vadose Zone (VZ) Contamination associated with the Evaluation Unit

PC	Group	WQS	Porosity[a]	K_d (mL/g)[a]	ρ (kg/L)[a]	VZ Source M^{Source}	SZ Total M^{SZ}	Treated[b] M^{Treat}	VZ Remaining M^{Tot}	VZ GTM (Mm^3)	VZ Rating[c]
C-14	A	2000 pCi/L	0.18	0	1.84	---	---	---	---	---	ND
I-129	A	1 pCi/L	0.18	0.2	1.84	---	---	---	---	---	ND
Sr-90	B	8 pCi/L	0.18	22	1.84	---	---	---	---	---	ND
Tc-99	A	900 pCi/L	0.18	0	1.84	---	---	---	---	---	ND
CCl4	A	5 µg/L	0.18	0	1.84	---	---	---	---	---	ND
Cr	B	100 µg/L	0.18	0	1.84	---	---	---	---	---	ND
Cr-VI	A	10 µg/L	0.18	0	1.84	---	---	---	---	---	ND
TCE	B	5 µg/L	0.18	2	1.84	---	---	---	---	---	ND
U(tot)	B	30 µg/L	0.18	0.8	1.84	---	---	---	---	---	ND

a. Parameters obtained from the analysis provided in Attachment 6-1 to Methodology Report (CRESP 2015).

b. Treatment amounts from the 2015 Hanford Annual Groundwater Report (DOE/RL-2016-09, Rev. 0).

c. Groundwater Threat Metric rating based on Table 6-3, Methodology Report (CRESP 2015).

PART VI. POTENTIAL RISK/IMPACT PATHWAYS AND EVENTS

CURRENT CONCEPTUAL MODEL

Narrative description of pathways and barriers to receptors and conditions/events that can lead to completed pathways

Pathways and Barriers: (1. description of institutional, natural and engineered barriers (including material characteristics) that currently mitigate or prevent risk or impacts, 2. Time scale from loss of each barrier to realization of risk or impacts)

Briefly describe the current institutional, engineered and natural barriers that prevent release or dispersion of contamination, risk to human health and impacts to resources:

1. *What nuclear and non-nuclear safety accident scenarios dominate risk at the facility? What are the response times associated with each postulated scenario?*

In the present condition, sludge storage in KW Basin and Construction of the Modified KW Basin Annex, there are several accident scenarios that dominate risk. For storage in KW Basin, these include: Heavy load drops, cask-multi canister overpack (MCO) drops, damage to drain valves, damage to outside weirs or north wall, SNF overlift, hydrogen explosion in the integrated water treatment system annular filter, spray releases from IWTS, overflow or pumpout of radioactive water from the KW Basin, design basis earthquake, uncontrolled vehicles, fires and CERCLA fires.[39]

For construction at the Modified KW Basin Annex, the following accident scenarios dominate risk: uncontrolled vehicles, loss of confinement from vehicle impact (collision or damage occurs in specific locations) results in release from KW Basin, Load dropped into the KW Basin, vehicle fuel spill and fire/explosion impacts KW Basin superstructure, and construction material fire spreads to KW basin superstructure.[40] (Note: construction of the Annex is essentially complete.)

For ECRTS operation, there are three accident scenarios that dominate the risk at the facility and also the development of controls. These include: a spray release of sludge slurry from a ruptured hose, hydrogen explosion, and STSC and STS Cask over-pressurization release.[41]

2. *What are the safety class and safety significant systems and controls?*

For storage at the KW Basin, the following systems and controls are in place: KW Basin superstructure, KW transfer bay bridge cranes, KW Basin floor and pit sludge retrieval strainer, KW Basin structure, FRS manipulator rail support structure tether, particulate settler vessel and annular filter vessels. [42]

For the KW Basin Modified Annex construction, controls include the KW Basin structure, as well as several TSR controls including: vehicle controls, KW heavy load controls, KW Basin water level and KW Basin Water Makeup Controls.[43]

In ECRTS, the following safety systems and controls will be used: above water slurry transfer lines, slurry transfer line rupture disk, double valve isolation, slurry transfer line secondary containment, slurry transfer line secondary confinement, slurry transfer line leak detection systems, safety control panels,

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[39] HNF-SD-WM-SAR-062, Rev. 20, 2014. Page 3-23 to 3-36.
[40] DD-50769, Rev. 1, 2014. Page 5-2.
[41] PRC-STP-00718, Rev 0 (2014). Pages xiv to xv.
[42] HNF-SD-WM-SAR-062, Rev. 20, 2014. Page 4-7 to 4-10.
[43] DD-50769, Rev. 1, 2014. Page 6-2.

instrument bypass panels, the physical structure of the annex (including the truck stop and trailer entrance, the mezzanine), auxiliary ventilation system, oxygen analyzer, pressure indicators, STSC design features such as the sloped fin, STSC liquid level instrumentation, truck scale instrumentation, nitrogen purge panel, safety control panel, the STSC vent assembly, the cask vent tool, seismic shut-down switches, the shielded hose chases, the bridge crane and associated supports, the annex exhaust stack, the fire protection sprinkler system supports, HVAC duct supports, cable tray supports, and nuclear safety interlock.[44]

Present planning for removal of K-Basins Sludge from the KW Basins involves interim storage of the sludge in Sludge Transportation and Storage Containers (STSCs) in several unused cells at T-Plant. This storage mission will involve a limited amount of system modifications to T-Plant, which had been previously designed and evaluated for a mission that was not accomplished (storage of Large Diameter Canisters, LDCs, containing high-activity KE Basin sludge). The changes to T-Plant systems and operations were evaluated to determine whether they amounted to a major modification under DOE-STD-1189, and thus would require the development of a Safety Design Strategy (SDS) and associated safety planning documentation (i.e., Conceptual Safety Design Report, etc.). The review[45] determined that although some changes were anticipated to T-Plant safety documentation[46] to address variation in sludge loading from prior analyses, along with the activation of a safety-related system (Inert Gas System), these minor modifications could be adequately addressed through the normal safety basis revision process.

3. *What are the current barriers to release or dispersion of contamination from the primary facility? What is the integrity of each of these barriers? Are there completed pathways to receptors or are such pathways likely to be completed during the evaluation period? Credited controls, administrative controls*

There are three major types of barriers to release of contamination from the primary facility: (1) Engineered systems including the sludge containers and building features described in Question 2 above (2) Operating Procedures; and (3) Safety Management Systems such as transportation safety. These systems are graded according to their importance in preventing or mitigating accidents and include safety significant and safety class systems.

There is a completed pathway anticipated for the workers to receive a dose of radiation from operations at ECRTS. This anticipated dose has been calculated and measures have been put into place to keep it ALARA. Documentation for this anticipated pathway is described above in the previous section.

4. *What forms of initiating events may lead to degradation or failure of each of the barriers? E.G., seismic event resulting in loss of water in pools*

Initiating events considered for KW Basin include: floods, seismic events, extreme winds, rain and snow loads, ashfall loads, lightning, range fires, aircraft activity, and transportation accidents.[47]

5. *What are the primary pathways and populations or resources at risk from this source?*

The primary pathway of concern is airborne dispersion of material from sludge. The primary populations at risk from this source include workers and the co-located person.

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[44] PRC-STP-00718, Rev 0 (2014). Pages xviii to xx.
[45] PRC-STP-00109 (Rev. 0), "Sludge Treatment Project Major Modification Determination for T Plant," February 2010
[46] HNF-14741 (Rev. 6A), "Master Documented Safety Analysis (MDSA) for the Solid Waste Operations Complex"
[47] HNF-SD-WM-SAR-062, Rev. 20, 2014. Page 1-9 to 1-19.

6. *What is the time frame from each of the initiating events to human exposure or impacts to resources?*

For all initiating events, because the primary pathway to the receptors is airborne, the duration of human exposure or impacts will be very short ranging from hours to weeks.

7. *Are there current on-going releases to the environment or receptors?*

There is an anticipated competed pathway through the occupational dose to workers described above from ECRTS.

There are no known releases ongoing from the KW Basins sludge project. However, there is soil and groundwater contamination in the area surrounding the KW Basin and Modified KW Basin Annex that is known and being monitored, but is not coming from the sludge in the KW basin. Maps of these releases are provided above in this report.

8. *Provide a table of initiating events and potential effects on the various receptors*

Table H.2-8 illustrates the potential impacts for the receptors from various initiating events that could occur during the present Phase 1, stage a, storage at the KW Basin.

The potential high impact to the environment from a worker accident involved human error with an equipment failure. This scenario was unlikely but the resulting release had high environmental consequences (in this case groundwater, surface water and ecological resources were included as environment). The high impact on the groundwater and surface water from the structural decay or failure involves a structural decay of the foundation of the KW Basins structure and is unlikely but has high consequences.

Populations and Resources Currently at Risk or Potentially Impacted

Facility Worker

Workers are the resource impacted by the only current completed pathway of occupational radiation exposure. In the instance of the initiating events described above, any exposure would likely be airborne dispersion of waste and exposure via inhalation or external radiation due to proximity to contamination.

Co-Located Person (CP)

See above. Co-located workers also could receive occupational radiation exposure as predicted for ECRTS and described previously.

Public

Risk to the public is low level but could be realized if airborne dispersion were to occur, or potential leakage into the groundwater which might then be transported to the river.

Groundwater

Threats to groundwater could emerge if the transfer lines leaked sludge, although there are several safety systems in place to prevent such a leak. However, KW Basin contamination is confined to the basin and there are no vadose zone sources or current groundwater contamination associated with this EU. This leads to a ND rating.

Columbia River

Due to the proximity to the river, an event at the KW Basins Modified Annex resulting in release of sludge could potentially affect the river. However, KW Basin contamination is confined to the basin and there are no vadose zone sources or current groundwater contamination associated with this EU. This leads to a ND rating.

Ecological Resources

- Deconstruction and decommissioning of the KE/KW reactors (with basins) would not be expected to result in loss of any additional habitat at the EU. All habitat resources are level 0.
- Previous surveys noted nesting birds associated with the KE and KW Reactor buildings; however it is not evident that the infrastructure and building features that supported nesting are still in existence.
- Remediation actions taken for this EU are not expected to impact habitat connectivity within the adjacent landscape.
- A portion of the adjacent landscape buffer area for the KW reactor is relatively near (within 400 meters) an active bald eagle roost site. Noise and construction activities associated with deconstruction and decommissioning could potentially influence eagle use of the roost.

Cultural Resources

- There are no known TCPs within the EU.
- No archaeological resources have been documented in the EU.
- Two Manhattan Project/Cold War Era Historic District resources are located within the Evaluation Unit. Mitigation for contributing buildings/structures have been completed as per the *Hanford Site Manhattan Project and Cold War Era Historic District Treatment Plan* (DOE/RL-97-56) and building demolition is ongoing.

Name	Description
105KE	Reactor Building
105KW	Reactor Building and Process Water Tunnels

Archaeological sites and TCPs located within 500 meters of the EU

- There are no known TCPs within 500 meters of the EU.
- Ten additional cultural resources have been documented within 500-meters of the EU. These resources include archaeological sites and isolates representing the pre-contact, ethnographic, historic era, and Manhattan Project/Cold War era cultural landscapes.

Closest Recorded TCP

- Known TCPs exist in the vicinity of the EU.

CLEANUP APPROACHES AND END-STATE CONCEPTUAL MODEL

Selected or Potential Cleanup Approaches

What are the selected cleanup actions or the range of potential remedial actions?

Cleanup of this project involves the closure of several facilities: KW Basin, K Basin Modified Annex, T Plant, and the future sludge treatment system facility.

In terms, of KW Basin, the removal sludge is an integral part of the D&D process. When the sludge has been removed from KW Basin, the KW basins will undergo D&D procedures including the K Basin Modified Annex.

Contaminant Inventory Remaining at the Conclusion of Planned Active Cleanup Period

At the conclusion of the ECRTS activities, the sludge will be stored in T Plant in the STSCs. These will eventually be removed from T Plant for Phase 2 of sludge processing from which point the treated and packaged sludge will be stored and eventually shipped to WIPP. The emptied remaining STSCs will be disposed of at a location TBD.

Once the sludge has been removed, some inventory will remain in the basin, consisting of the contaminated equipment and basin, as well as the ECRTS process equipment. The D&D of the KW Basin will be addressed as part of the K Area D&D.

Risks and Potential Impacts Associated with Cleanup

The project is taking place in several phases, each of which has a set of potential impacts. Some of the impacts and hazards associated with ECRTS and the Phase 2 sludge treatment project are described below.

The hazardous conditions identified by the HAZOP study for ECRTS are:

- Spray release
- Splash and splatter/pool release
- Hydrogen explosion
- STSC overpressurization
- Radiological Control
  - Airborne radioactive material
  - Contamination
  - High external dose rate.
- Industrial Safety
  - Hose whip
  - Oxygen deficient atmosphere.

The hose whip hazardous condition is considered to be a standard industrial hazard that is addressed by the Occupational Safety and Health Safety Management Program.[48]

POPULATIONS AND RESOURCES AT RISK OR POTENTIALLY IMPACTED DURING OR AS A CONSEQUENCE OF CLEANUP ACTIONS:

Workers (directly involved)

The ECRTS phase of the project has several identified anticipated events with high consequence to the facility worker. There is also an anticipated completed pathway in occupational radiation exposure.

Co-located (CW)

The ECRTS phase of the project has several anticipated events with medium consequences to the co-located worker. There is also an anticipated completed pathway in occupational radiation exposure.

Public

The public risk from ECRTS would likely be due to public river access. The Preliminary Documented Safety Analysis evaluates a Slurry Spray Release accident that produces consequences to the MOI.

[48] PRC-STP-00687, Rev.1, 2013. Page 4-1.

Mitigation of this accident includes safety significant systems discussed in Section VI as a part of the current conceptual model.

Groundwater

Threats to groundwater could emerge if the transfer lines leaked sludge, although there are several safety systems in place to prevent such a leak. However, KW Basin contamination is confined to the basin and there are no vadose zone sources or current groundwater contamination associated with this EU and none are expected over the next 50 years. This leads to a ND rating.

Columbia River

Due to the proximity to the river, an event at the KW Basins Modified Annex resulting in release of sludge could potentially affect the river. However, KW Basin contamination is confined to the basin and there are no vadose zone sources or current groundwater contamination associated with this EU and none are expected over the next 50 years. This leads to a ND rating.

Ecological Resources

No ecological resources are in this EU, and thus there are no effects

Cultural Resources

Personnel, car, and truck traffic on paved roads as well as use of heavy equipment will not have any direct impact on archaeological resources because there is no disturbance to soil/ground or alteration to the landscape. Assuming heavy equipment locations and staging areas have been cleared for cultural resources, then it is assumed adverse effects would have been resolved and/or mitigated. If heavy equipment locations and staging areas have not been cleared, this could result in artifact breakage and scattering, compaction and disturbance to the soil surface and immediate subsurface, thereby compromising stratigraphic integrity of an archaeological site. TCPs may be directly affected if personnel are on roads located on TCP and if personnel are unaware of cultural resource sensitivity, appropriate behaviors and protocols. For traffic on paved roads located on TCP, direct effects include visual, auditory and vibrational alterations to landscape/setting. Heavy equipment may cause direct effects to TCPs including destruction of culturally important plants, physical attributes of the TCP and introduction of noise and vibrations also altering the setting. These actions may interfere with traditional uses of TCP. Revegetation activities may cause direct effects to TCPs include physical alteration to or restoration of TCP depending on how the area is recontoured and what plants are selected for revegetation. Contamination remaining in situ may have direct effects including permanent physical alteration of TCP, and lead to permanent intrusion in long-term use and access to TCP.

Indirect effects from personnel, car, and truck traffic on paved roads as well as use of heavy equipment may lead to the introduction of invasive plant species or removal of culturally important plants that alters the landscape/setting for roads located within the viewshed and noise-scape of TCP. Existing road causes no alteration to viewshed or noise-scape. Presence of vehicles may result in visual, auditory and vibrational alterations to landscape/setting. Remediation actions may lead to visual alteration of landscape/setting. Introduction of noise alters landscape/setting. Introduction of equipment and buildings may interfere with traditional uses of TCP. Revegetation could lead to indirect effects from visual alterations to setting depending on how the area is recontoured and what plants are selected for revegetation. Remaining contamination could lead to indirect effects from permanent intrusion, which could limit the use and access to TCP.

ADDITIONAL RISKS AND POTENTIAL IMPACTS IF CLEANUP IS DELAYED

This is a multi-phase project and delay would have different impacts, depending on when it occurred. These will be addressed in chronological order.

Delay in Removing the Sludge from the KW-Basin – the sludge stored in Engineered Containers at KW-Basin is the last significant quantity of nuclear material in the K Area (and for that matter on the River Corridor). Transportation of this material out of the K Area to T Plant is on the critical path to being able to complete environmental restoration activities on the K Area.

Delay in Design, Construction and Construction of the Phase 2 Sludge Treatment System – T Plant is intended to be only an interim stop for the sludge material from K Basins. CHPRC has completed alternatives analysis[49] and recommended a warm water oxidation system to stabilize the remaining uranium in the sludge (along with some limited development of backup/enhancement technologies). DOE-RL has approved[50] this path forward and CHPRC has developed a preliminary technology development plan[51] to mature the technologies to support design of the Phase 2 treatment system. Delays in design and construction of the Phase 2 treatment system, or the technology development program to support it, would result in the sludge being stored for a longer time period in T-Plant. Such a delay could make retrieval of the sludge for processing problematic (note: the aging properties of the sludge materials while in storage at T Plant is line of inquiry in the technology development planning).

NEAR-TERM, POST-CLEANUP STATUS, RISKS AND POTENTIAL IMPACTS

The Phase 2 Sludge Treatment Process is in the technology selection phase and, thus, there is insufficient information to provide risk ratings at this time.

Groundwater

It is assumed that the waste will have been removed from the basin by the end of the 150 year evaluation period. This leads to a ND rating.

Columbia River

It is assumed that the waste will have been removed from the basin by the end of the 150 year evaluation period. This leads to a ND rating.

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[49] PRC-STP-00465, "K-Basins Sludge Treatment Project – Phase 2 Technology Evaluation and Alternatives Analysis," 2011
[50] DOE-RL letter 12-AMRC-0051, December 23, 2011
[51] PRC-STP-00615, "Preliminary Technology Maturation Plan for the K-Basins Sludge Treatment and Packaging Facility," March 2012

POPULATIONS AND RESOURCES AT RISK OR POTENTIALLY IMPACTED AFTER CLEANUP ACTIONS (from residual contaminant inventory or long-term activities)

Table H.2-10. Population or Resource Risk/ Impact Rating.

Population or Resource		Risk/Impact Rating	Comments
Human	Facility Worker	N/A	To be covered by D&D of KW Reactor
	Co-located Person	N/A	To be covered by D&D of KW Reactor
	Public	N/A	To be covered by D&D of KW Reactor
Environmental	Groundwater	ND	It is assumed that the waste will have been removed from the basin by the end of the 150-year evaluation period.
	Columbia River	ND	It is assumed that the waste will have been removed from the basin by the end of the 150-year evaluation period.
	Ecological Resources[(a)]	ND-Low	Any risk depends upon the quality and quantity of re-vegetation following remediation. Could be a risk from invasion of exotic species.
Social	Cultural Resources[(a)]	**Native American:** Direct: Known Indirect: Known **Historic Pre-Hanford:** Direct: Known Indirect: Known **Manhattan/Cold War**: Direct: None Indirect: None	Permanent direct and indirect effects are possible due to high sensitivity of area.

a. For both Ecological and Cultural Resources see Appendices J and K, respectively, for a complete description of Ecological Field Assessments and literature review for Cultural Resources. Ecological ratings are described in Table 4-11 of the Final Report.

LONG-TERM, POST-CLEANUP STATUS – INVENTORIES AND RISKS AND POTENTIAL IMPACT PATHWAYS

Dependent on D&D methodologies discussed in detail in the KE/KW Reactors D&D EU.

PART VII. SUPPLEMENTAL INFORMATION AND CONSIDERATIONS

DETAILED RISK RATINGS FOR SLUDGE STORAGE AT KW BASIN, ECRTS AND PHASE 2 SLUDGE TREATMENT

Sludge Storage in KW Basin- Ratings Details

The identified hazardous conditions fit into the following categories for the current condition of safe storage at K Basin.

- Criticality
- Loss of KW Basin Water
- IWTS Annular Filter Hydrogen Deflagration
- IWTS Spray Release
- Overflow of Radioactive Water from KW Basin
- Fires
- CERCLA Waste Staging Area Fire
- Facility Worker Hazards
- Spent Nuclear Fuel Overlift
- Pumpout or Siphoning of Radioactive Water from KW Basin
- Design Basis Earthquake
- Containerized Sludge Hydrogen Release and Deflagration

None of the postulated hazardous conditions result in "high" or "moderate" offsite or onsite radiological consequences. The postulated events were low risk for the CWs and the offsite public. No significant consequences were identified for the facility worker. Several hazardous conditions were selected for additional analysis to ensure a complete spectrum of accidents was evaluated.[52]

There are 117 total accidents analyzed in the Streamline Hazards Analysis for KW Basin. Of these, 43 are no longer applicable to ongoing activities. Of the 74 accidents remaining, all had low consequences to the maximally exposed offsite individual (MOI) and the collocated worker (CW). All 74 accidents also had no consequences to the facility worker. Several accidents did have potential consequences to the environment including 6 loss of confinement accidents of the basin due to various initiating events, 5 beyond design basis earthquake events, a loss of confinement with damage to the outside weirs and north wall, and 4 loss of confinement events due to overflow of the basin.

Among these events, there are three anticipated events which will have an environmental impact. There are also several direct dose events which are anticipated. [53]

ECRTS Ratings Details

This phase of the project will cover the ECRTS project and transfer to T Plant.

There are 260 events analyzed in the Hazards and Operability Study for ECRTS. Of these events, 143 have high unmitigated consequences to the facility worker, and the majority of these high consequence

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[52] DD-53838, Rev. 0, 2014. Page 5-1.
[53] DD-53838, Rev. 0, 2014. Appendix C.

events are anticipated[54]. These include hydrogen explosions and uncontrolled releases from a number of initiating events. For the co-located worker, there are 13 events that are anticipated and have high consequences including uncontrolled releases from a number of initiating events. There are also 22 events that are anticipated and will have a moderate effect on co-located workers. All analyzed events have either low or no unmitigated consequences to the public. The environment was not included in this study.[55]

Phase 2 Sludge Treatment Ratings Details

This section will cover the Phase 2 Sludge Treatment System after the sludge has been retrieved from interim storage in T Plant. The preferred alternative, warm water oxidation has the following safety benefits: Warm Water Oxidation (WWO)

- Advantages
  - No significant safety hazards have been identified beyond those typical of all processes that handle (move, mix, pump, and package) bulk quantities of the highly radioactive K Basin sludge slurries.
  - No chemical additives required.
- Disadvantages
  - Relatively long processing time results in longer risk period.[56]

This project is still in the design and decision making stage. Insufficient data exists to complete a risk rating based on the current status of the project.

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[54] Note: As the HAZOP study is the most current documentation of hazards at ECRTS, the risk ratings will tend to be high. This is due to the consideration of consequences without mitigation. When the project moves forward to a higher level of Hazards Analysis, mitigative measures will be considered and the risks may be lower.
[55] PRC-STP-00687, Rev.1, 2013. Appendix D.
[56] PRC-STP-00465, Rev 0, 2012. Page 4-3.

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