### Document Release and Change Form

**Prepared For:** The U.S. Department of Energy, Assistant Secretary for Environmental Management  
**By:** Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352  
**Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08R14800**

**TRADEMARK DISCLAIMER:** Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America.

**2. Document Title**

Waste Acceptance Criteria for the Low Activity Waste Pretreatment System

**3. Design Verification Required**

- ☐ Yes
- ☒ No

**4. USQ Number**

- ☒ N/A

**5. PrHA Number**

- ☒ N/A

**6. USQ Screening:**

- **a.** Does the change introduce any new failure modes to the equipment?  
  - ☐ Yes
  - ☒ No
  
  Basis is required for Yes:

- **b.** Does the change increase the probability of existing failure modes?  
  - ☐ Yes
  - ☒ No
  
  Basis is required for Yes:

- **c.** For Safety Significant equipment, does the change require a modification to Chapter 4 of the DSA and/or FRED?  
  - ☐ Yes
  - ☒ No
  - ☒ N/A

**Basis is required for Yes:**

**7. Description of Change and Justification** *(Use Continuation pages as needed)*

Removal of Official Use Only designation from Rev. 0.

---

**8. Approvals**

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance Review</td>
<td>WASHINGTON, MARGUERITE</td>
<td>WASHINGTON, MARGUERITE</td>
<td>03/02/2016</td>
</tr>
<tr>
<td>Document Control Approval</td>
<td>WASHINGTON, MARGUERITE</td>
<td>WASHINGTON, MARGUERITE</td>
<td>03/02/2016</td>
</tr>
<tr>
<td>Originator</td>
<td>TARDIFF, BENJAMIN M</td>
<td>TARDIFF, BENJAMIN M</td>
<td>02/23/2016</td>
</tr>
<tr>
<td>Other Approver</td>
<td>REYNOLDS, JACOB G</td>
<td>REYNOLDS, JACOB G</td>
<td>02/23/2016</td>
</tr>
<tr>
<td>Responsible Manager</td>
<td>HOUGHTON, DAVID J</td>
<td>HOUGHTON, DAVID J</td>
<td>02/29/2016</td>
</tr>
</tbody>
</table>

**9. Clearance Review:**

**Restriction Type:**

- ☒ Public
- ☐ Official Use Only Exemption 3-Statutory Exemption (OUO-3)
- ☐ Official Use Only Exemption 4-Commercial/Proprietary (OUO-4)
- ☐ Official Use Only Exemption 5-Privileged Information (OUO-5)
- ☐ Official Use Only Exemption 6-Personal Privacy (OUO-6)
- ☐ Official Use Only Exemption 7-Law Enforcement (OUO-7)
## DISTRIBUTION:

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAVIS, NEIL R</td>
<td>ENGINEERING</td>
</tr>
<tr>
<td>FILIP, JEFF</td>
<td>LAWPS PROJECT</td>
</tr>
<tr>
<td>HOUGHTON, DAVID J</td>
<td>PROD OPERATIONS ENGINEERING</td>
</tr>
<tr>
<td>REYNOLDS, JACOB G</td>
<td>TNK WST INVENTORY &amp; CHARACTZTN</td>
</tr>
</tbody>
</table>

## TBDs or Holds

☒ N/A

## IMPACTED DOCUMENTS – ENGINEERING

☒ N/A

<table>
<thead>
<tr>
<th>Document Number</th>
<th>Rev.</th>
<th>Title</th>
</tr>
</thead>
</table>

## OTHER RELATED DOCUMENTS

☒ N/A

<table>
<thead>
<tr>
<th>Document Number</th>
<th>Rev.</th>
<th>Title</th>
</tr>
</thead>
</table>

## RELATED SYSTEMS, STRUCTURES, AND COMPONENTS:

<table>
<thead>
<tr>
<th>Related Building/Facilities</th>
<th>Related Systems</th>
<th>Related Equipment ID Nos. (EIN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>☒ N/A</td>
<td>☒ N/A</td>
<td>☒ N/A</td>
</tr>
<tr>
<td>DOCUMENT RELEASE AND CHANGE FORM CONTINUATION SHEET</td>
<td>Document No: RPP-RPT-58649  Rev. 01</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>-------------------------------------</td>
<td></td>
</tr>
</tbody>
</table>

[Start Continuation Here]
Waste Acceptance Criteria for the Low Activity Waste Pretreatment System

J. G. Reynolds  
Washington River Protection Solutions, LLC  
Richland, WA 99352  
U.S. Department of Energy Contract DE-AC27-08RV14800

EDT/ECN: DRCF  
UC: N/A  
Cost Center: Charge 202154  
B&R Code: N/A  
Total Pages: 17

Key Words: LAWPS, Waste Acceptance Criteria,

Abstract: This report defines the waste acceptance criteria for LAWPS

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Approved For Public Release
### Crossflow Filtration Flux Studies Comparison with Predicted Fluxes from the Waste Treatment and Immobilization Plant Equation

#### Change Control Record

<table>
<thead>
<tr>
<th>Revision</th>
<th>Description of Change – Replace, Add, and Delete Pages</th>
<th>Authorized for Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS 1</td>
<td>Removal of Official Use Only designation as LAWPS technical documents are no longer considered OUO</td>
<td>Jacob Reynolds 02/23/2015</td>
</tr>
</tbody>
</table>
Waste Acceptance Criteria for the Low Activity Waste Pretreatment System

J. G. Reynolds
Washington River Protection Solutions LLC

Date Published
February 2016

Prepared for the U.S. Department of Energy
Office of River Protection

P.O. Box 850
Richland, Washington
TABLE OF CONTENTS

1.0 INTRODUCTION AND PHILOSOPHY USED TO DEVELOP THE LOW ACTIVITY WASTE PRETREATMENT SYSTEM (LAWPS) WASTE ACCEPTANCE CRITERIA (WAC) .................................................................1
  1.1 Sodium Molarity .......................................................................................1
  1.2 Viscosity ..................................................................................................1
  1.3 Solids Concentration ..............................................................................2
  1.4 Cesium and Radioactive Cesium Concentration ...................................2
  1.5 Potassium Concentration ........................................................................2
  1.6 Susceptibility to Solids Precipitation ....................................................2
  1.7 Other Feed Parameters ..........................................................................2

2.0 LAWPS WASTE ACCEPTANCE CRITERIA ..............................................3

3.0 REFERENCES ............................................................................................9

LIST OF TABLES

Table 1. Low Activity Waste Pretreatment System Waste Acceptance Criteria. .................. 4
Table 2. Target Concentrations ......................................................................... 7
## LIST OF TERMS

### Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs</td>
<td>Cesium</td>
</tr>
<tr>
<td>CFF</td>
<td>Cross Flow Filter (or Cross Flow Filtration)</td>
</tr>
<tr>
<td>DF LAW</td>
<td>Direct Feed Low Activity Waste</td>
</tr>
<tr>
<td>LAWPS</td>
<td>Low Activity Waste Pretreatment System</td>
</tr>
<tr>
<td>ULD</td>
<td>Unit-Liter Dose</td>
</tr>
<tr>
<td>WAC</td>
<td>Waste Acceptance Criteria</td>
</tr>
<tr>
<td>WTP</td>
<td>Hanford Tank Waste Treatment and Immobilization Plant</td>
</tr>
</tbody>
</table>

### Units

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>degrees Celsius</td>
</tr>
<tr>
<td>Ci/L</td>
<td>curies per liter</td>
</tr>
<tr>
<td>Sv/L</td>
<td>Sieverts per liter</td>
</tr>
</tbody>
</table>
1.0 INTRODUCTION AND PHILOSOPHY USED TO DEVELOP THE LOW ACTIVITY WASTE PRETREATMENT SYSTEM (LAWPS) WASTE ACCEPTANCE CRITERIA (WAC)

The Low Activity Waste Pretreatment System (LAWPS) Project is part of the direct feed low activity waste (DF LAW) process for treating sodium-bearing waste in the Hanford Tank Farm. The LAWPS Facility has the main objective to remove undissolved solids and radioactive cesium (Cs) from the liquid LAW waste stream. Cesium is removed so that the waste can be treated as LAW as well as to minimize the shielding required at the vitrification facility. Cesium is removed in LAWPS by ion exchange. Solids are removed from the waste upstream of the ion-exchange column so that the ion-exchange column is not plugged. Solids are removed from the waste stream by cross flow filtration.

Due to the fact that there are only three main unit operations in LAWPS (filtration, ion exchange, and ion exchange regeneration), the waste properties that limit the performance are:

- Sodium molarity
- Viscosity
- Density
- Solids concentration
- Cesium and radioactive Cs concentration
- Potassium concentration
- Susceptibility to precipitation.

These factors are discussed individually here while other properties affecting LAWPS performance are discussed later.

1.1 SODIUM MOLARITY

Sodium molarity directly affects the ion-exchange performance because sodium competes with Cs for ion exchange sites on the resin and decreases Cs removal efficiency. Sodium molarity indirectly affects the filter throughput rate because it affects the waste viscosity. Sodium molarity is used in throughput accounting because the sodium concentration in glass is used as a measure of waste loading in the glass, allowing for the calculation of the amount of waste treated by the Na₂O content of glass and the total glass throughput rate.

1.2 VISCOSITY

Liquid viscosity affects plant throughput because the filter throughput is proportional to viscosity, where throughput decreases with increased viscosity. Liquid viscosity is somewhat correlated to the sodium molarity of the feed. Feed that meets the sodium molarity target will also likely meet the viscosity requirement.
1.3 SOLIDS CONCENTRATION

The solids concentration affects the throughput of the cross flow filter (CFF) because the filter flux is smaller with increased solids content. It may also impact mixing requirements in the filter feed tank, though this is not currently determined. The feed to the LAWPS is expected to have no solids or very low solids because the liquid feed will be staged for considerable period of time prior to being fed to LAWPS. A solids concentration limit is imposed to assure the feed is handled in the tank farm in a manner that minimizes solids to the LAWPS and maximizes CFF throughput while minimizing filter cleaning operations.

1.4 CESIUM AND RADIOACTIVE CESIUM CONCENTRATION

Cesium is the prime target of the ion exchange column. The amount of Cs in the feed is the most important factor in determining the frequency that the ion exchange column has to be eluted to recover the Cs. The more frequently the column is eluted, the slower the overall throughput of the facility. The amount of radioactive Cs is important because Cs-137 is expected to limit the design of the shielding of the facility. The target for the removal of Cs in the waste is also defined in terms of the Cs-137 concentration of the treated feed, and the higher the Cs-137 concentration of the feed, the more that must be removed for feed compliance.

1.5 POTASSIUM CONCENTRATION

Potassium has an affinity for the ion-exchange resin employed in LAWPS because of its chemical similarity to Cs. Consequently, the higher the potassium concentration, the more frequently the resin must be eluted and the lower the overall throughput of the facility.

1.6 SUSCEPTIBILITY TO SOLIDS PRECIPITATION

The LAWPS will be designed to handle small amounts of solute precipitation, but extensive precipitation should be avoided. Many different types of solids could precipitate depending on the concentration of sodium and anions in the waste. The concentration of one constituent may be okay in one feed batch but not okay in another due to the interactions between feed constituents. Putting a limit on the concentration of individual constituents that could precipitate would create a burdensome long list of constituents in the WAC, and would require a model to interpret the impact of the concentrations on precipitation in LAWPS. It is unknown if any solubility model is sufficiently accurate to perform that evaluation. Consequently, the limit will be based on the propensity of a given feed to precipitate solids under LAWPS conditions rather than the absolute concentration of any feed constituents. It is anticipated that this requirement would be met with either process knowledge or direct experiments on feed samples.

1.7 OTHER FEED PARAMETERS

The waste treated in the LAWPS is delivered to the Hanford Tank Waste Treatment and Immobilization Plant (WTP) LAW Vitrification Facility. The WTP Vitrification Facility has its own WAC to be documented in Interface Control Document #30, (also known as ICD-30). Given that the only waste treatment inside LAWPS is solids and Cs removal, the LAWPS cannot alter any
waste properties other than solids content and Cs content to meet the ICD-30 requirements (other than by dilution with water). Consequently, the LAWPS feed must also meet the ICD-30 requirements for everything but Cs concentration and the properties of solids. The draft ICD-30 is currently available, but the final ICD-30 is not expected to be issued until after this WAC is issued. The LAWPS feed will have to meet the ICD-30 requirements when they are defined officially.

The LAWPS WAC also has some safety driven requirements, such as the toxicological and radiological properties. Only the properties themselves are included in the WAC rather than the concentration of radionuclides or waste constituents that drive them. This is because more than one constituent contributes to the radiological and chemical source terms, so it will be possible to receive a higher concentration of one constituent if there is a lower concentration of another in the feed.

There are other miscellaneous requirements to protect design assumptions, and the basis for these parameters is discussed in the notes in the WAC table (Table 1). Some of the requirements are defined in terms of a “Macro Batch.” A macro batch is defined here as a batch of waste in a double-shell tank to be fed to the LAWPS rather than a batch within the LAWPS.

2.0 LAWPS WASTE ACCEPTANCE CRITERIA

The LAWPS WAC are reported in Table 1, developed according to the philosophy described in Section 1. Table 2 contains target waste properties that must be met in order to meet the LAWPS design throughput rate. In addition to these values, a limit of < 106,000 Ci of Cs-137 must be placed on the waste fed to the LAWPS in-between regeneration cycles for the ion-exchange column. This limit is not included in the tables below because it is a limit that must be controlled as part of the process control plan rather than as part of qualifying a large individual batch of feed.

For each of the properties in Table 1 and Table 2, a proposed method of determining if the feed meets the requirement is made in the notes column. These preliminary methods should be acknowledged as preliminary, and be will superseded with a Data Quality Objective or Process Control Plan that defines them, even if the present report is not revised. In some cases, it is expected that the property can be met from process knowledge because that type of information is typically available about tank waste at the present and it is assumed that will continue to be true in the future. However, some sort of measurement will have to be made if it turns out that the information is not actually available by process knowledge at the time of feed delivery.
Table 1. Low Activity Waste Pretreatment System Waste Acceptance Criteria.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Feed Temperature</td>
<td>&lt; 45 °C</td>
<td>Derived from PNNL-21109, “Ion Exchange Kinetics Testing with SRF Resin,” which showed poor ion exchange performance and that the resin rapidly degrades and gels above 45 °C. This property will likely be measured using a thermocouple in tank 241-AP-107.</td>
</tr>
<tr>
<td>Precipitation Control</td>
<td>A temperature target must be identified for each macro batch that minimizes solids precipitation.</td>
<td>This requirement is derived from knowledge that the liquid may be at saturation with salts. Therefore, the temperature that will minimize the precipitation of these salts must be identified to control solids within LAWPS. Note that there is no strict limit on this value, it just must be reported. There is no upper limit to this value, other than the maximum feed temperature listed above. This property will likely be determined experimentally on samples from the feed qualification tank.</td>
</tr>
<tr>
<td>All ICD-30 Requirements</td>
<td>The feed must meet all ICD-30 requirements except solids content, cesium-137 concentration, and properties of solids in the waste.</td>
<td>From ICD 30. LAWPS does not alter the waste properties other than removing solids and Cs. Therefore, the waste must meet all other requirements prior to acceptance to LAWPS.</td>
</tr>
<tr>
<td>Slurry Density</td>
<td>&lt; 1.35 g/mL</td>
<td>From RPP-SPEC-56967, “Project T5L01 Low Activity Waste Pretreatment System Specification.” This property will likely be determinable from process knowledge.</td>
</tr>
</tbody>
</table>
Table 1. Low Activity Waste Pretreatment System Waste Acceptance Criteria.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear Strength and other non-Newtonian rheological properties.</td>
<td>No non-Newtonian feeds shall be accepted, regardless of their solids content.</td>
<td>This was a management decision, so that the LAWPS does not need to design for liquid feed properties that will be rare or non-existent. Non-Newtonian properties are not expected for feeds that would be candidates for the treatment at the LAWPS Facility because non-Newtonian feeds are associated with high solids concentrations. This requirement is include to exclude any rare feed that is not currently anticipated.</td>
</tr>
<tr>
<td>Cesium-137 Concentration</td>
<td>&lt; 0.5 Ci/L</td>
<td>From RPP-RPT-58445, “Basis for Sodium, Potassium, and Cesium Values Used in the Design of LAWPS Ion Exchange System.” This property could be determined by process knowledge if the value is far from the limit, or sample analysis if close to the limit.</td>
</tr>
<tr>
<td>Cesium-137: Total Cs Ratio</td>
<td>&lt; 0.24</td>
<td>From RPP-RPT-58445. Note that ratios exceeding this value could be allowed in cases where the cesium-137 concentration is much less than 0.5 Ci/L. This exception would have to be evaluated on a case-by-case basis. This property could be determined by process knowledge if the value is far from the limit, or sample analysis if close to the limit.</td>
</tr>
<tr>
<td>Toxicological Unit Sum of Fractions (PAC-2)</td>
<td>Solids: 3.5 x 10^8 Liquids: 3.5 x 10^8</td>
<td>This is the upper-bounding PAC-2 USOF for double-shell tanks reported in Appendix B of RPP-58039, “Low Activity Waste Pretreatment System”</td>
</tr>
</tbody>
</table>
Table 1. Low Activity Waste Pretreatment System Waste Acceptance Criteria.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxicological Unit Sum of Fractions (PAC-3)</td>
<td>Solids: $2.3 \times 10^7$</td>
<td>This is the upper-bounding PAC-3 USOF for double-shell tanks reported in Appendix B of RPP-58039. Note that these values are unit less. This property will likely be determinable from process knowledge.</td>
</tr>
<tr>
<td></td>
<td>Liquids: $1.2 \times 10^7$</td>
<td></td>
</tr>
<tr>
<td>Radiological Source Term (in Sv/L)</td>
<td>Onsite Unit-Liter Dose (ULD)</td>
<td>These values are the highest values for the current double-shell tanks, excluding tanks 241-AZ-101, 241-AZ-102, 241-SY-102, 241-AN-107, and 241-AN-102. These five tanks were excluded because they were not deemed as credible feed for LAWPS. Note that these ULDs are higher than the values currently in RPP-58039. It is anticipated that RPP-58039 will be revised with the higher values in this table in the future so that the feed sent to the LAWPS Facility is not unnecessarily constrained. Note the highest solid ULDs came from tank 241-AY-101 and the highest liquid ULDs came from tank 241-AN-103, from the Best-Basis Inventory as of January 1, 2015, downloaded from the Tank Waste Inventory Network System Database. This property will likely be</td>
</tr>
<tr>
<td></td>
<td>Solids: $5.7 \times 10^4$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquids: 150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Offsite ULD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solids: $8.5 \times 10^4$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquids: 109</td>
<td></td>
</tr>
</tbody>
</table>
Table 1. Low Activity Waste Pretreatment System Waste Acceptance Criteria.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>determinable from process knowledge.</td>
</tr>
</tbody>
</table>

Table 2. Target Concentrations.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Molarity Range</td>
<td>5-6 M for maximum facility throughput.</td>
<td>Note that low end (5 M) is driven by the draft WTP waste acceptance criteria (see ICD-30). The LAWPS Facility may still be able to treat waste above 6 M sodium, but 6 M sodium is the limit for ensuring that the target throughput rate can be met. The highest sodium concentration where decontamination factor for Cs-137 can still be met is currently unavailable, but it is likely much higher than 6 M sodium. Planned technology tests may extend this range in the future. This property will likely be determined by sample analysis.</td>
</tr>
<tr>
<td>K⁺ Concentration</td>
<td>Any concentration can be accepted safely, but &lt; 0.35 M for meeting nameplate throughput.</td>
<td>From RPP-RPT-58445. This property will likely be determined by sample analysis.</td>
</tr>
<tr>
<td>Suspended Solids Concentration</td>
<td>&lt; 0.8 weight % at the start of processing an AP-107 Macro-batch; &lt; 3.3 weight % at the end of a macro-batch.</td>
<td>From RPP-RPT-58509. Suspended solids represent the solids suspended in the liquid in the feed tank and does not include solids settled to the bottom of the feed tank that will not be transferred with the feed. This property will likely be determinable from process knowledge and temperature control.</td>
</tr>
</tbody>
</table>
**Table 2. Target Concentrations.**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slurry Viscosity</td>
<td>&lt;15 cP</td>
<td>From RPP-SPEC-56967. This property will likely be determined by sample analysis, or by process knowledge if free from solids.</td>
</tr>
</tbody>
</table>
3.0 REFERENCES


