Savannah River Remediation
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SDU 6 Lessons Learned for SDU 7

SRR-SDU-2014-00020

Revision 4

6/21/17	
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Abbreviations & Acronyms

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BOP	Balance of Plant
CARB	Corrective Action Review Board
CDE	Construction Discipline Engineer
CHAP	Consolidated Hazards Analysis Process
CSI	Construction Specifications Institute
DAHJ	Delegated Authority Having Jurisdiction
DOE	Department of Energy
DOP	Dioctylpthalate
EDR	Engineering Document Requirements
EFCO	Company name (SDU6 Wall forms)
EPR	External Project Review
FE	Field Engineer
HDPE	High Density Polyethylene
HEPA	High Efficiency Particulate Air (filter)
IR	Inspection Report
LL	Lessons Learned
M&TE	Measuring and Test Equipment
MIEES	Modular Instrumentation Electrical Equipment Skid
MRT	Management Review Team
NCR	Non-Conformance Report
NEMA	National Electrical Manufacturers Association
NQA	Nuclear Quality Assurance
NTP	Notice to Proceed
PA	Performance Assessment
PA	Public Address
PFHA	Project Fire Hazards Analysis
pH	Measure of the hydrogen ion concentration in an aqueous solution
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCIP	Quality Control Inspection Plan
QIP	Quality Improvement Plan
QVDR	Quality Verification Document Requirements
REA	Request for Engineering Assistance
RFI	Request for Information
ROWS	Remote Operating Work Stations
SDDR	Supplier Deviation Disposition Request

SDU	Saltstone Disposal Unit
SLA	Service Level Agreement
SME	Subject Matter Expert
SOW	Statement of Work
SRR	Savannah River Remediation
SRS	Savannah River Site
SSCs	Structure, System and Components
TAIC	Technical Agency Identification Checklist
TSP	Task Specific Plan
UWMQ	Unreviewed Waste Management Questions
UWMQRD	Unreviewed Waste Management Question Requirements Document

1.0 PURPOSE

The purpose of this document is to identify and summarize the actions taken by the Saltstone Disposal Unit 6 (SDU 6) project team to address the lessons learned from the construction of the SDU 6. This document is intended to provide applicable lessons to SDU 7. SDU 7 will evaluate these lessons and the recommendations to accept, reject, or modify as appropriate.

2.0 BACKGROUND

The mission of the Saltstone Facility in Z-Area is to process and dispose of radioactive waste salt solution from the tank farm facilities to meet the objectives identified in the Liquid Waste System Plan. Built in the 1980s, the Z Area Saltstone Facility immobilizes the low level radioactivity waste salt solution by mixing it with a dry material mixture of fly ash, slag, and cement to produce a flowable grout mixture. This grout is poured into large concrete disposal units, where it cures to become saltstone, a leach-resistant solid monolith, for permanent disposal.

The scope of the SDU 6 project includes the design, procurement, fabrication, installation, construction, testing, and turnover of a minimum 30 million gallon disposal unit. This is the first of the 32 million gallon tanks, so lessons learned from construction and operation will provide beneficial improvements to future tanks.

Numerous reference documents were used in developing this document. References and sources include:

- SDU 6 Management Review Team meeting minutes.
- Various meetings with project and field personnel to solicit lessons learned.
- SRR-SDU-2014-00024, "SDU6 Post CD-3 Lessons Learned".
- SRR-SDU-2014-00002, "Lessons Learned Application to SDU6 from Previous SDUs".
- SRR-SDU-2013-00018, "SDU 3A/B and 5A/B Lessons Learned".
- SRR-SDU-2012-00062, "Saltstone Disposal Unit (SDU6) Lessons Learned and Recommended Improvements from SDU 2 Construction Compliance Matrix".
- SRR-TR-2010- 00197, Engineering Team Lessons Learned Assessment

3.0 CONCLUSION

The final revision of this document is being issued after DOE Critical Decision 4. Therefore, Revision 4 of this document is the Final Lessons Learned version for SDU 6.

The lessons learned with recommendations are shown in the following attachment.

Attachment: Lessons Learned for SDU7

Attachment: Lessons Learned for SDU 7 SRR-SDU-2014-00020

NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
1	Performance Assurance (PA) Model	Events and conditions occur that may push or exceed the PA modeling boundaries. Modeling computations take weeks to complete. This can impact schedule and work performance if work must stop until calculations are completed.	The PA model should be generic enough to accommodate the day-to-day issues the project encounters (ex. Cracks on the roof).	Re-run Porflow and Goldsim models to identify margin.
2	SDU Geotechnical Analysis (#2)	Geotechnical analysis would be more cost effective and result in reduced project schedule durations if the analysis were done for multiple SDUs at a time (e.g., one analysis for the north area and one for the south area).	Lessons Learned (LL) for Previous SDUs, SRR-SDU-2014-00002, R1	Geotechnical work for SDUs 7, 8 and 9 should be accomplished as part of the SDU7 scope.
3	General Design Improvements	The External Project Review (EPR) #20 discusses less than adequate work control by the subcontractor and lack of early recognition and resolution of the subcontractor's shortcomings by SRR. In addition, the report discusses a number of acceptable construction processes allowed by the Code, but were not included in the specification that could have allowed alternative methods and reduced the number of nonconformances. Discussed in 7/16/14 Management Review Team Source: April 2014 External Project Review (EPR) #20	A consideration for future projects is to reduce the programmatic requirements and focus on a strong design with adequate design margins for constructability, strong construction work control processes, and appropriate and targeted quality control to ensure the final product will meet the performance requirements required for the structure.	During the detailed design of SDU 7, the specification and drawings should be reviewed against the constructability issues during SDU 6. A review of programmatic requirements with consideration for reducing non value added ones should be done.
4		The tank was designed for American Concrete Institute (ACI) 350 Code which does not in any way guarantee a completely leak tight tank.	With this applicable Code, commitment should have been to provide an "essentially leak-tight" tank to allow for some leakage per ACI 350.1. Source: Javeed Munshi, Bechtel Structural SME. Report documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	Functional requirement is to achieve a "leak-tight" tank which would require going above and beyond the requirements of the ACI 350 Code by providing either a post-tensioned base or by using appropriate liners or coatings to prevent leakage. SDU 6 recommends SDU 7 consider adding language and requirements from ACI 350.2R to the specification to minimize cracking and use a liner/coating system to assist in achieving leak tightness.
5		One of the contributing factors to concrete cracking probably was caused by restraints provided by thicker perimeter pours and outward slope of the base	Construction sequence should be carefully engineered and planned to minimize restraints and time needed to complete the placement. Source: Javeed Munshi, Bechtel Structural Subject Matter Expert (SME). Report documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	Engineer construction sequence of the roof and floor to minimize restraints and time needed to complete the placement.
6		VOID		
7		VOID		
8	Foundation Design	There is not enough space to accommodate a typical footing form bracket. The short anchoring is unstable and allows the form to move during placement and does not allow for any adjustment.	The overlap distance of the tank slab onto the upper mud mat is 1'-0". Due to the short distance from the edge of the footing to the outside edge of the upper mud mat, the concrete anchor has to be reduced from a 3/4" concrete anchor to a 1/2" anchor.	Recommend pouring the upper mud mat minimum of 6" wider to allow for solid anchoring of footing form brackets (18" form brackets).
9		Limited access on the mud mats during construction of the footing wall and foundation slab created inefficiencies due to the large area and the delayed time to hand transfer materials and equipment back and forth across the floor area.	Additionally limited access of the concrete transit mix vehicles required additional pumping distances. The pumping distances proved challenging with this particular concrete mix design with regard to air entrainment.	Allow driving on mud mats (forklift, crane, concrete trucks). Recommend that calculations be performed to allow the use of material handling vehicles and concrete transit delivery vehicular access on the mud mats during placement of the foundation wall and footing and structural slab. Perform necessary calculations and incorporate into specifications to allow the vehicular access during placement of other components. SDU6 recommends adding a General Note on the applicable drawing(s).

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
10		Outer most mud mat (lower mud mat) elevation was designed to sit into the excavation foot print thereby creating a constant collection point for all sheet drain from the center of the excavation outward. After every rain event the area had to be hand excavated to remove all loose material in order to place the mud mat on in situ condition soil surfaces. This caused the over excavation of several inches in places of soil, which in turn required more concrete to be placed in order to maintain the top of slab design elevation. In addition eight intermediate french drains had to be placed around the perimeter to allow the drainage of water from the High Density Polyethylene (HDPE) Liner during the hydro testing period.	Perimeter liner should be above grade for water runoff. To assist in drainage, place gravel around the entire perimeter of the tank.	Recommend that the bottom of lower mud slab elevation be placed above the working surface around the perimeter of the excavation allowing drainage away from the mud mat and the placement of the HDPE Liner between mud mats. It is also recommend design inclusion of intermediate French Drain system around the perimeter of the out most mud mat to allow for drainage away from the mud mats and HDPE Liner. Incorporate design changes to allow for proper excavation and draining of the area. SDU7 Project Management and Construction should place gravel around the entire perimeter of the tank.
11		Placement of two separate mud mats appeared to be more than necessary to provide a stable base to work from as well as cost.	Lower 4" mud mat consumed 2300 yds. of concrete while the upper 6" mud mat consumed 2800 yards.	Future SDUs should review the mud mat design to minimize materials needed to meet function.
12		VOID		
13		The SDU 6 Construction Specifications Institute (CSI) specification provided performance parameters for the mud mat concrete, which led to confusion by the vendor.	The SDU 6 CSI specification does not provide for a specific Type II concrete mix design but states only that , "This mix design shall be developed by the Subcontractor and shall meet the following minimum requirements: I. Concrete compressive strength at 7 days: 1,400 psi minimum. ii. Concrete compressive strength (f'c) at 28 days: 2,000 psi." This caused additional work by the subcontractor.	The CSI specification should include performance parameters and an option of using an existing mud mat mix design, where performance parameters are known.
14	Concrete Slab Design	The Polyvinyl Chloride (PVC) waterstop with a center bulb incorporated into the SDU 6 concrete horizontal and vertical construction joints, proved difficult to hold in place during form installation as well as concrete placement.	No tolerance was specified for any "misalignment" of the waterstop, which resulted in numerous Nonconformance Reports (NCRs) and Supplier Deviation Disposition Requests (SDDRs).	Eliminate waterstop center bulb at floor-to-floor joints and wall-to-wall joints. Allows waterstop to be more secure during placement. Recommend using a flat PVC waterstop that can be installed more securely during placement. Specify tolerance for misalignment of waterstop, based on manufacturer's recommendation of reduced liquid head pressure due to misalignment (reference SDDRs). SDU6 recommends changing the waterstop design and allow for greater tolerances in placement of the waterstop.
15	Concrete Slab Design (cont.)	High pressure abrasive blasting to 1/4" amplitude at the face of adjoining horizontal slabs introduces potential for damage to the PVC waterstop, and interferes with the continuous curing of the face of the slab. Applying curing compound to the face introduces the potential that residual curing compound may be present at the PVC waterstop, thereby reducing the bond between the fresh concrete and the PVC waterstop, and introducing the potential for leakage.	Eliminate roughening at joints and avoid curing compound at the face of construction joints – potential to decrease bond of the waterstop. Omit requirement to scarify the structural slab surface to place the column pedestals providing there is no curing compound present and the proper presoak is completed	SDU6 recommends an analysis be performed regarding the deletion of the 1/4" amplitude to the surfaces of adjoin horizontal faces. Consider using formwork that has a rough face of the correct amplitude. Consider water curing the face of construction joints in lieu of curing compounds at this location. SDU6 recommends incorporating this lesson into the design and specifications.
16		Show termination and tolerance for wall joint waterstop.	Waterstop in walls not detailed for termination points at the upper most point of walls.	SDU6 recommends this be incorporated into the design. Include termination details on drawing and add tolerances for waterstop.
17		Soaking and maintaining continuous wetting of adjoining surfaces prior to place of concrete for a minimum period of 24 hours is difficult achieve on small areas such as interior of column form cans, pedestal bases etc. This is particularly difficult in seasons of higher temps as it requires personnel to come onsite after hours which in turn requires additional support personnel etc.	Eliminate pre-soak of construction joints between 18 – 24 hours. Recommend soak within 2 hours and immediately prior.	SDU6 recommends one of two approaches; 1. Revise the requirement to soak continuous for 24 hours prior to placing concrete against adjoining concrete surface and reduce to 2 hours prior and again immediately prior. Or 2. Consider using bonding agent as an alternative.SDU6 recommends incorporating the selected approach into design.

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18		SDU 6 had extensive cracking in the floor slab. Some of the cracks went through the entire slab causing the tank to leak during the first hydro test when there was not a liner installed.	The ACI 350 code for the water tank industry, does not ensure a leak tight design (i.e., zero leakage) as discussed in Lessoned Learned #4. There are a number of contributing factors that can be managed to ensure less cracking in future SDUs. These include the mix design, the concrete placement including both number of individual slabs and their order of placement, the curing techniques, the amount of rebar, and the slab thickness.	SDU6 recommends that SDU 7 consider all of these contributing factors in a study to determine the appropriate path forward to minimize shrinkage and cracking with the understanding that SDU 6 passed the leak tightness test with a liner installed. Leak Tightness Testing of SDU 7 should be done after the coating/liner is installed
19		The majority of the tank leakage prior to the liner being installed was through the floor as discussed above in LL # 18. The walls of SDU 6 did not leak. Joints in the walls were handled differently than construction joints in the floors.	The wall joints included injectable hose along with the waterstop and fared well during the hydrostatic test. The floor construction joints did not contain injectable hoses.	Consider adding injectable hoses, or similar technology, to the floor and roof construction joints with the waterstop, similar to wall joint construction.
20		VOID		
21		VOID		
22		VOID		
23	Wall Design	To ensure compliance with the floor flatness requirement, a concrete grinder was used on the top of floor surface underneath the wall bearing pad locations, leading to increased safety concerns and project delays.	In addition, using a concrete grinder near the PVC waterstop creates the potential for damage to the PVC waterstop.	Design wall footing to allow increased floor flatness tolerance (greater than 1/8" in 10 ft.) at base of wall. Recommend an analysis be performed on the bearing pad to allow increased floor flatness tolerance minimizing the need for a concrete grinder.
24		The 10" wall thickness at the upper most portion of the wall forced tight tolerances for reinforcing rod placement on the upper beam in relation to concrete clearance between stirrups and between stirrups and the bearing plates of prestressing units. This increased installation and inspection time and introduced the possibility for inadequate concrete consolidation.	In addition, because of the 8" minimum dimension for Type V concrete, at the upper portion of the wall, the rubber form tie plugs were required to be installed very close to the outside face of the wall. This created the potential for damage to the rubber plugs during the surface preparation of the outside face of wall.	Consider thickening the upper wall section to 12" at the upper most point and re-designing the reinforcing, allowing for more coverage of the form tie plugs and more concrete clearance around the reinforcing. Increased concrete thickness of wall may allow reduction in quantity of stirrups. This is a monetary and ease of construction issue. The top of the existing wall design is difficult but not impossible to work. If accepted by SDU7. Revise the design to allow for thicker upper most point of wall to 12" in lieu of 10".
25	Bearing Pad Configuration Design	The 40 durometer bearing pad beneath the wall created an unnecessarily tight tolerance for the radial location of the floor to wall waterstop and the lateral cable sleeves.	The performance of the waterstop and lateral cable sleeves does not require such a tight tolerance. Numerous NCRs and SDDRs were processed due to this one issue.	Consider a different configuration and/or location of the 40 durometer bearing pad, floor to wall waterstop, and lateral cable sleeves to allow increased tolerance. SDU6 recommends increasing the tolerance for pad placement and incorporate into the design.
26		The specified 8' x 6' equipment hatch opening is difficult size for loading lifting equipment and personnel lifts through without breaking down parts of the equipment.	If the hatch was dimensionally larger it would present a much safer means of access into the tank cell as well as reduce the possibility of equipment being left in an unsafe condition due to job site dismantling .	Recommend that the equipment hatch be enlarged to 6' x 9' or 7' x 9' in lieu of the Steel Door cast the hatch from concrete. Incorporate into design.
		VOID		
27		Margin case for column diameter in PA	Table 2.4-4 of the Unreviewed Waste Management Questions (UWMQ) Requirements Document lists only the column diameter (24 inches) with ACI allotted construction tolerance with no discussion on concrete imperfections (i.e. bug holes) that may locally impact the diameter. Discussion on the repair methodology delayed work.	SDU 6 recommends further clarification for these types of concrete imperfections within the Unreviewed Waste Management Question Requirements Document (UWMQRD).
28		Concrete repairs to the SDU 6 tank took up weeks of critical path schedule at the end of construction.	During construction, columns that appeared to have blemishes that required repair were not made immediately following discovery. Several times this led to schedule and resource allocation issues later, delaying other work.	SDU6 recommends that a discussion of concrete repairs and critical path impact be included in the procurement documents and this discussion be held during the subcontract award process. The successful subcontractors schedule should be reviewed prior to acceptance to ensure it reflects a firm expectation relative to schedule and repairs. It is noted that some repairs cannot be made immediately. Examples are inside wall cracks prior to horizontal prestressing. The work supervisor has to have the ability to prioritize the work activities.

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
29		Nonstructural repairs on columns and pedestals contributed to time in the schedule and maybe removed with surface prep for linings and/or coating systems	The experience with column placement revealed that there was some minor separation of aggregate and cement paste at the bottoms of the column form cans where the bleed water would exit under the can forms and thereby exposing small areas of aggregate face not meeting the classification of structural repair conditions. Under the current specification that exposure of aggregate would warrant a repair.	Recommend nonstructural concrete surface blemishes be coordinated with other subcontractors for acceptability.
30	General Concrete Specification Change	Tight tolerances on air entrainment in concrete were sometimes difficult to maintain and resulted in rejecting numerous concrete trucks.	Air entrainment at this climate is not a necessary admixture as the freeze thaw cycles are of short duration and not substantive or severe in nature. The concrete roof slab will be covered by a minimum of a cool seal type coating and will never receive a deicer product there by eliminating the need for air entrainment. The experience with testing and the concrete producer providing consistent air entrained concrete proved to be a difficult in sever task. There are several points of concern with this admixture in this particular application as there were a minimum of 2 trucks rejected on a significant number of placements due to air entrainment not meeting the specified tolerance requirements. There were also a couple of placements completely canceled due to inconsistent air entrainment requirements. Additionally the air entrainment admixture often appeared to be faulty as it would not pump through the concrete boom pump. The mix would be tested at the point of discharge and be at minimal acceptance levels but then when tested at point of placement it would fail.	Recommend that since the effects and conditions that require the use of air entrainment to produce a solid surface without spalling in severe weather climates will not be realized on SDU construction that SDU 7 review the use of this additive in the concrete mix design.
31		Type V concrete is expensive, has limited suppliers and requires extensive time to reach required strength creating both cost and schedule risk to the project.	The concrete mix requires an extended cure time and a continuous wet cure method due to the density and the other additives such as fly ash, silica fume and slag. This has promoted inconsistent curing, excessive cracking, and air entrainment. This has also caused difficult placements and tougher finishing. In addition, the local supplier of Type V cement is no longer supplying it adding cost to ship from more distant suppliers.	Suggest evaluating the gradation of the additives and aggregate to develop a more consistent concrete that performs more evenly when developing compressive and tensile strength. In addition, SDU 6 recommend SDU 7 develop additional Type 2 mix designs as opportunities and risk reduction to using Type V.
32		VOID		
33		VOID		
34		VOID		
35		VOID		
36	SDU 6 Site Excavation Plan	During site plan development enlarge the footprint of the initial excavation to support crane service and work area outside of the Cell foot print. Provide wider area for access to allow greater protection of the French Drain System.	The 375' foot diameter of the SDU Mega Cell requires 208 internal column pedestals and columns. During the construction phase of concrete placement there is often cranes and concrete pumping activity. The pumping activity requires that there be full access around the Cell for the Transit Mixed trucks to enter the area, discharge their load and then exit the excavation at the same time while there is crane working on the outside of the Cell foot print.	Increase the footprint of the actual excavation floor by 10' on all sides. This will create a footprint that is 20' overall larger. This larger foot print will increase the safety for vehicles and employees passing in the same areas. It will also increase the efficiency of the concrete placement activities by allowing dual trucks to pass around the tank structure. SDU6 recommends the revised site plans reflect a 48' work zone around the tank.
37		VOID		

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
38		Add engineering controls to ensure short length drill bits are used for any small diameter drilled nail holes to ensure maximum allowed depth per the performance assessment is not exceeded. Allow repair of small diameter drilled holes using 2 part flowable epoxy.	Numerous nail holes were created to support formwork and/or for reinforcing templates. These holes proved difficult to locate due to the small diameter and repairing the holes using the specified method of Type V dry pack requires increasing the diameter of the holes.	Recommend short length drill bits be designated for this purpose to ensure maximum depth is not exceeded. Also recommend an analysis be performed to determine if flowable epoxy may be used for the repair of small diameter holes in the floor and roof and incorporate into specifications. SDU6 recommends providing a general repair method for these holes for the craft to repair quickly. SDU 6 recommends consideration be evaluated by PA requirements and review oversight. In addition SDU7 recommends a repair method.
39		Embed plate thickness and weight caused constructability issues.	During construction the large and heavy embed plates proved to be difficult to keep in place during placements.	Suggest that the thickness of the plates be re-evaluated for reduction in size to allow better and safer handling during installation and incorporate into design.
40		Rebar tolerances too tight - Re-evaluate	Numerous SDDRs were written during construction regarding placement and tying of rebar due to the tolerances either too tight to fit adjoining work or to allow for development of adjacent bars.	Ensure rebar tolerances are not more stringent than code requirements.
41		Temporary Safety Railings were nailed into the tank roof resulting in unknown penetration depths and PA issues	During roof top construction activities a temporary site wood railing system was employed for the safety railing. This application required countless numbers of nail holes to be drilled into the tank top slab. Based on the PA model for the roof slab the immense number of holes added to an overabundance of structural void; additionally as a result the nail holes qualified as required repairs.	SDU6 recommends the following: 1. A prefabricated, self-supporting temporary railing system be specified to eliminate the need to drill the tank roof slab to place nails. 2. Wherever the roof and floor slabs do have to be drilled to place nails to secure temporary formwork and other temporary protection apparatus that the nail holes be repaired as soon as the nail is removed with flowable epoxy filler thereby eliminating the opportunity to miss holes during a delayed repair process. 3. Provide a general repair method for nail holes. 4. Install permanent guardrail as soon as possible.
42		Excessive SDDRs were generated to allow material substitutions in the specification.	It is permissible to have pre-approved materials, but an "or equal" in the specs should not require an SDDR. The "or equal" can be evaluated through the submittal process.	SDU6 recommends including "or approved equal" whenever listing specific approved products in the spec. "Or approved equals" can be accepted via submittal review and approval.
43		Over Specificity in the Specification. Be careful what we ask for and be sure we need it. (Engineering Document Requirements (EDRs, Quality Verification Document Requirements (QVDRs).	There may exist a tendency to over-specify materials, documents, items, services, equipment, etc.	SDU6 recommends that SDU7 always question is the correct level of quality and technical specificity.
44	General Specification Change Recommend-ations	The tracking of the repair process was difficult.	During the construction process there were numerous classifications of repairs identified as well as what repair was required and whose responsibility it was to repair. The segregation of each of the repair processes needs to be tracked by mapping as well as photographic documentation. That process needs to be consistent with each class of repair and type of mapping.	SDU6 recommends that mapping and repair documentation be developed and listed in the specification. Consider establishing criteria for each level of repair.
45		VOID		
46		QC Requirements for Tank Subcontractor (#11) QA/QC subcontract personnel on SDU 6 did not have the numbers or experience to implement a Nuclear Quality Assurance (NQA)-1 project of this scope.	Qualification of subcontract personnel that are hired to perform the QC supervision/inspection functions need to be included in the procurement documents regarding their work experience as it relates to application of national codes and standards relative to the nuclear industry. Subcontractor QA/QC Manager should have sufficient experience in construction using NQA-1 QA Program	Increase QA/QC Manager experience in NQA-1 construction to 10 years. SDU6 recommends identifying and approving key subcontract personnel for QA/QC positions (QC Manager and QC Inspectors) and a minimum amount of time they must stay on the project. The contract should specify penalties for the contractor if these personnel leave the project early. SDU6 recommends incorporating these requirements into specifications or Statements Of Work (SOW) for all large scale nuclear work.

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
47		Subcontractor Safety (#6) This lessons learned communicates the importance of placing a "Safety Incentive" in contracts prior to award to ensure the subcontractor places a priority on having a good safety program. SOURCE: LL from Previous SDUs, SRR-SDU-2014-00002, R1.	The contract for SDU 3/5 contained a "Safety Incentive" which is an agreed upon percentage of the total awarded contract, which helped to instill the need for a good safety program while working at Savannah River Site (SRS). The prime subcontractor worked over 200,000 man-hours without a recordable injury on the SDU 3/5 cells, thus earning the incentive and a safety award per contract terms.	It is good practice to consider placing a "Safety Incentive" for large contracts, to ensure the subcontractor maintains emphasis on having a good safety program throughout the duration of their contract at SRS. This was adopted for SDU6 and is recommended for SDU7.
48		Throughout the implementation of this subcontract there have been continuous conflicts based upon the subcontractor not understanding the process within the DOE complex. Often times it has been procedural and many times it has been with reference to working offsite in a commercial environment.	If there was an indoctrination training program as part of the required Pre Construction meeting and award of Notice To Proceed (NTP) the subcontractor would be much better prepared to meet the daily requirements of fulfilling their obligations. The process should include the submittal process and applicable distributions, application for payment process, Worker Protection Plan, Task Specific Plan (TSP) development, and Quality Assurance /Quality Control, Site expectation (construction, office, facility etc.).	Require introductory training of subcontractors prior to mobilization to indoctrinate them to the expectations for quality, inspections, badging, document completion, invoice procedures, accrual procedures, and submittals process etc. SDU6 recommends the following be considered; 1) Develop a training program given by each of the various functional leads as to what the expectations will be for the administration of the subcontract. Make it part of the subcontract training requirements. 2) Incorporate into the Subcontract Field Conditions Continuation Sheets for contract inclusion. 3) Close and direct observation in the field to enforce the training.
49	Vendor Selection	The lack of a full time Subcontractor's Field Engineer caused delays to the construction effort .	Field Engineers should be employed by the subcontractor to perform in-process inspections, prepare as-built drawings, SDDRs and Requests for Engineering Assistance (REAs), Require this engineering support to be on the project when physical work starts.	SDU7 should consider specifying the presence of the subcontractor's Field Engineer onsite when work is in progress in the Subcontract Field Conditions Continuation Sheets.
50		Early in the SDU6 contract, the numbers, status and revision to EDR submittals overwhelmed the existing subcontractor staff.	A dedicated Document Control Specialist was hired and eventually brought the situation under control.	Document Control person should be employed by the subcontractor before start of work for EDR submittals. - Add resource. SDU6 recommends that the Document Control resource be hired early in the Engineering Documents Requirements (EDR) process. Also, EDR status and look ahead should be part of the weekly meetings with contractors.
51		VOID		
52		VOID		
53		Confusion existed for Notice to Proceed (NTP) for field work, procurement actions, or fabrication actions	There are contract and technical/quality requirements to achieve NTP.	SDU6 recommends indoctrinating the subcontractor to the requirements for achieving NTP for both contract and technical/quality requirements. Ensure key NTP milestones are incorporated into the project schedule.
54		Personnel movement on the tank top during shotcrete or Prestressing work is restricted which caused schedule delays	Access to the rooftop during this time is prohibited limiting subcontractor efficiency.	If the subcontractor chooses to work inside tank while prestressing, require development of a plan to safely execute the work. SDU6 recommends this lesson for consideration.
55	Housekeeping	The jobsites lost housekeeping control several times creating unsafe working conditions.	DAILY housekeeping must include - Tie Wire - Nails, screws - Trash cans, water / drink bottles, and general trash - Scrap material - Proper storage of tools, fall protection, retractable rigging.	Enforce requirement of DAILY housekeeping. Recommend maintaining adequate laborers to do so, as necessary, and/or requiring each craft to clean up. SDU6 recommends this lesson for consideration.
56	Equipment	Equipment Handling	Eliminate improper handling of equipment (e.g., wrapping chain around tongue of equipment and pulling via forklift; relocating via forks of forklift when use of lifting eye is recommended by manufacturer, etc.).	Recommend having lift assists / handling devices for frequent relocation of Air Compressors and Generators. Additional lift eye forklift attachment (properly rated for the type of forklift used) may also be beneficial. SDU6 recommends this lesson for consideration.

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
57		Spares for Critical Construction Equipment	Example – vibrators used for columns placements at SDU6 had problems such that generator had to be loaded on lift in order for it to function.	Spare equipment for critical tasks should be on site and available whenever possible. SDU6 recommends this lesson for consideration.
58		VOID		
59		VOID		
60		For installation of outdoor National Electrical Manufacturers Association (NEMA) rated electrical connection boxes upside down beneath supports or trays, select a box with flush mounted top.	Flush mounted NEMA box covers will minimize the potential of corrosion. Source: DOE assessment 2016-SA-003490 and STAR item 2016-CTS-006552.	For outdoor NEMA rated electrical connection boxes that are mounted upside down beneath supports or trays, select a box with flush mounted top versus hinged tops with lips that will collect water.
61	Ventilation	More air ventilation / circulation needed in tank during summer months.	For forced air ventilation into the tank, SDU6 utilized 4 Coppus Double-Duty 24K10DW fans with 9500 cfm each, and 2 Coppus Hornet 6-HP blowers with ~3860 cfm each (with 30' flex duct). For circulating air within the tank, only two or three 36" fans were operable at any one time inside the tank. This was not sufficient during the summer months given the size of the tank. During roof shoring installation and demolition in the summer months, the air temperature at the top of the tank was excessive.	Evaluate use of an outdoor rated fan (preferably the Double-Duty 24K10DW Coppus blower or equivalent) for the following; 1. Bring in fresh air at ***each*** of the eight 36" ports. If an alternate blower or fan is considered, be cognizant of sound levels so as to avoid requirement for use of hearing protection. Verify sound levels. 2. Arrange interior circulation provided by 36" fans blowing in same direction along inside perimeter without kicking up dust. 3. Secure flex duct via columns at ceiling level to direct air movement along ceiling for shoring operations.
62	Concrete Placement	SDU 6 noticed a sharp rise in the number of subcontractor NCRs and SDDRs associated with 'first of a kind' work activity.	Prior to the start of new major work activities, discuss and reach consensus with the subcontractor on what the spec requires. Questions, comments and improvements can be addressed and/or worked into revised requirements well ahead of the new activity.	SDU6 recommends the following be accepted; 1. In advance of major new work activities, Engineering and Quality should closely review specification instructions with the Subcontractor to ensure they understand the requirements. 2. Identify acceptable alternatives, if any, and incorporate into specification and inspection criteria. 3. Adequately staff the project with technical and quality personnel early.
63		Concrete batch tickets from the concrete plant come in triplicate, self-copying paper. These are usual dark blue ink on light blue paper. Scanning for Records Management usually yields poor legibility	SRR receives a copy that usually does not meet record quality requirements. Making a copy of this poor copy loses information.	1. The subcontractor will keep the original concrete batch tickets in hardcopy form and turn over to SRR once concrete form removal is complete. 2. Contact the concrete batch plant and arrange for them to use improved legibility batch tickets. SDU6 recommends Quality Assurance keep working the issue.
64		Construction aids and minimal support allowed during Rebar installation causing excessive rework of drawings.	Minimal added rebar for construction aid or additional support should not require change to plans. Rebar fabrication drawings are for the rebar fabricator, not the inspector. We should not have to re-submit when rebar changes happen in the field to rebar that is already installed.	SDU6 recommends this lesson. The allowance for construction aids should not be made in the specification. The subcontractor should contact the DAHJ, in accordance with the Communications Plan, to consider some types of aids on a case by case basis. Situation dependent.
65		Communication issue in field on differing interpretation of specification.	A Request for Information (RFI) is not the answer when we don't have a question (i.e., if we are solid in our interpretation but the inspector disagrees). Rebar tolerances in terms of locations; ACI requirements in location. With different parties (e.g., Subcontractor, General Subcontractor, and SRR) inspections challenging. Should be different for SDU7. Clarity on chain of command/authority in decision making. Sit down with Technical Team (page by page) early in the process. Key: correct decision makers present from all groups. Clear direction will come from SRR. Communication Plan is key. The decision makers include QA, STR, Procurement, Professional Engineer, Special Inspectors.	The DAHJ should be established as the mediator for technical issues in the Communications Plan . SDU6 recommends this be included in SDU7's communications plan.
66		Drawing revisions for errors and omissions required SDDRs. SRR owns the specs and drawings, so they should be able to change drawings/specs on their own without any request from a subcontractor.	Sometimes SRR Project personnel requested the subcontractor submit an SDDR for SRR errors or omissions. This was seen as an extra burden on part of the subcontractor. SDDRs or REAs?	SDU6 concurs. This should be addressed as part of the streamlining process to be applied to SDU7. Role play exercise would be beneficial (Lean Event)

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67		Sometimes aerial lifts were used improperly when aligning and holding the wall rebar curtain in place.	JLG aerial lifts are designed to be used as man-lifts, not for pushing, pulling material. The JLGs were sometimes used to push the rebar wall curtains to help position them into place and secure against the EFCO wall forms. Depending on how the JLG was positioned, this resulted in either side-loading or front loading of the JLG.	SDU7 should consider an alternate means of positioning the rebar wall curtains into place. Aerial work platforms should not be side or front loaded, nor used as a means to position / push the curtain in place until secured. Another means of securing the wall curtains should be evaluated e.g., possibly use come-alongs through the EFCO windows to pull curtain into place, or some other acceptable / feasible means.
68		Cracking of foundation and roof slabs.	Minimize concrete shrinkage. Sources: Steve Young, Bechtel Concrete/Materials SME and Allen Hulshizer AECOM Structural Engineer. Reports documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	SDU6 recommends SDU7 consider the following. Concrete shrinkage cannot be eliminated but can be minimized by: 1. Maximize the size of the aggregate used in the mix based on rebar spacing and thickness of pour. 2. Utilize a well graded aggregate with absolutely no gaps in sizing from course through fine sand. 3. Minimize the fines from sand; follow American Society for Testing & Materials (ASTM) C33 gradation for natural sand with no manufactured sand used. 4. Reduce the paste requirement and cement/cementitious materials requirement of the mix. 5. Minimize the water content to wet the aggregate surface and hydrate the cementitious materials. 6. Utilize a shrinkage reducing admixture. 7. Utilize self-consolidating concrete to speed placement and eliminate finishing issues. 8. A larger sizing up to 2 inch with an even gradation down through the fine natural sand will act to decrease the shrinkage. 9. The addition of a shrinkage reducing admixture to the water reducer and superplastizer being used would also reduce shrinkage.
69	Concrete Placement	Cracking of foundation and roof slabs.	Prevention of cracking due to the surface moisture loss. Sources: Steve Young, Bechtel Concrete/Materials SME and Allen Hulshizer AECOM Structural Engineer. Reports documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	SDU6 recommends SDU7 consider the following. Prevention of cracking due to the surface moisture loss can be achieved by the following means: 1. Fogging during placement to maximize the humidity at the surface and prevent air drying. 2. Tenting or providing shading to prevent direct sun exposure and radiant energy surface drying. 3. Wind breaks at the perimeter of the pour to prevent wind exposure and drying. 4. Utilize an evaporation retarder to aide in reducing surface moisture losses. 5. Utilizing wet curing to maintain the surface moisture and replace any losses to the atmosphere during placement. 6. Do not use curing compounds as they are not 100% effective in preventing moisture loss and will allow a percentage of the surface water to evaporate through the "barrier".
70		Cracking of foundation and roof slabs.	The time-temperature and strength gain with time of concrete mix should be determined. This will help determine the need for any extended curing and protection of concrete and help decide appropriate time for form removal. If forms are to be removed early for the roof, early age effect should be included in calculation of deflection, creep and cracking. Source: Javeed Munshi, Bechtel Structural SME. Report documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	The time-temperature and strength gain with time of concrete mix should be determined. SDU7 should consider this study to aid in construction and form removal schedule.

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71		Cracking of foundation and roof slabs.	Extended curing may be required for certain concrete mixes because of presence of supplemental cementitious materials. Simple broom finish after floating and minimal troweling will help prevent craze cracking. Sources: Steve Young, Bechtel Concrete/Materials SME and Javeed Munshi, Bechtel Structural SME. Reports documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	Concrete should be wet cured for at least 7 days before applying the curing compound. SDU6 recommends this lesson for consideration
72		Numerous NCRs relative to cold/hot concrete placements	Precautions shall be taken during hot and cold placements Source: Javeed Munshi, Bechtel Structural SME. Report documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	Concrete shall be adequately protected from the environment by strictly following the specifications and industry standards for hot and cold weather concrete. SDU6 concurs with this recommendation.
73		Many SDU 6 cracks are less than 100 μm in size and have a potential for self- healing if high pH water can be supplied to those cracks. However, many of these larger cracks were sealed off by epoxy which reduced the potential for self- healing of SDU 6 cracks.	Self- healing would likely result from reaction of unhydrated Portland cement and residual latent hydraulic slag particles. It would take significantly high solution pH levels (greater than 1 N to more than 10 N hydroxide solutions) to activate unreacted fly ash particles via geopolymerization reactions. Source: United States Army Corp of Engineers Petrographic Analysis of Concrete Core Samples from Saltstone Disposal Unit #6 at the Savannah River Site, Aiken, SC, Robert D. Moser, E. Rae Gore, and Kyle L. Klaus, March 2016	Use of high pH water prior to epoxy repair of cracks should be investigated to determine if high pH levels would activate fly ash and unreacted cement to heal thin cracks. SDU7 should consider this recommendation that will allow autogenous healing.
74	Concrete Curing	SDU 6 roof cracking has a unique pattern which would indicate a structural issue.	SDU 6 roof cracking has a unique pattern which would indicate a structural issue probably due to early formwork removal. Concrete developing acceptable compressive strength would require much greater time to achieve sufficient tensile strength to prevent the top surface cracking located at pillar tops and running between pillar locations. Source: Steve Young, Bechtel Concrete/Materials SME. Report documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	Recommend leaving formwork on roof panels longer to increase tensile strength and reduce cracking. SDU6 recommends this lesson for consideration.
75		Cracking of foundation and roof slabs.	Use of an accelerator to decrease concrete set time. Source: Allen Hulshizer AECOM Structural Engineer. Reports documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	Consider use of a non-chloride accelerator to decrease the concrete set time to achieve an earlier bond development of the concrete to rebar. SDU6 recommends this lesson for consideration.
76		Cold Weather Monitoring During Curing	Temperature gages were mounted on the forms during cold weather curing. This does not indicate the actual temperature of the concrete.	Recommend that concrete thermocouples be placed inside the forms to measure actual concrete temperatures to reduce NCRs and confusion over actual temperature of the concrete, SDU6 recommends this lesson for consideration.
77	Area Communications	Temporary cell phone towers and local wireless networks were established for SDU6. PA announcements from Saltstone could not be heard. Alternate methods of accountability and communication were established.	Ensure cell phone, wireless computer network, and remote worker communications are established in the construction area.	1. SRR is pursuing installation of a cellular communication tower to improve cell phone coverage in the vicinity of SDU 6 and future SDUs. 2. SRR should tie into the existing PA trunk line on the bridges to bring PA announcements to the job site. SDU6 recommends this lesson for consideration.

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78		At times the distance with key principals being located out of the area proved to be challenging and time restrictive.	Project team located at the site.	All key personnel should be located at the construction site. SDU6 recommends this lesson for consideration.
79		During construction there were numerous points where required observation points or inspection were skipped and new work proceeded with in adequate closure	Use of work release card added to specification.	SDU6 developed a work release card for QA/QC to be utilized on all work that requires inspection prior to new work being started. Evaluate and incorporate into the specification for SDU7.
80		Continuous break down of communication in the field between all parties. QC, Subcontractor, STR. Engineering and Management must communicate through the proper channels to allow swift action and documentation flow in the field.	Communication plan for SRR/Subcontractor. Communication Plan DOE / SRR	Develop a communication plan based on the subcontract requirements and incorporate into the specifications SDU6 recommends this idea. Establish flow for communications with the contractor early, especially concerning QC Inspectors and Special Inspectors to the contractor.
81		Lack of Public Address (PA) system	This will create the need for SDU7 activities to be performed as remote worker	SDU6 recommends adding installation of a PA system to SDU7 scope.
82		QA/QC Meetings	Improve communications within the quality organizations by setting aside time for face-to-face discussion.	SDU7 should conduct regular QA/QC meetings. Frequency would be dependent upon the current and upcoming work activities.
83	Coatings	Holiday testing for coatings	In order to apply an interior coating that is free of voids there needs to be Holiday Testing	Require Holiday Testing. SDU6 warns this may not be applicable for some products. SDU7 should consider the recommendation if holiday testing is found to be applicable.
84	Coatings	The design life chosen for the liner was much longer than the necessary operational service life. Inspection and maintenance of the liner/coating cannot be performed after operations begins.	Once filling the tank begins the lining will be inaccessible for maintenance so the first thing that must be established is the minimum maintenance free service life required of any candidate lining material. The lining maintains a complete seal of the concrete. A lining material's service life will depend on the temperature and chemicals it is subjected to so service conditions must be defined and the linings ability to resist those conditions for the required length of time firmly established. Source: Patrick Nau, Bechtel Protective Coatings SME. Report documented in SRR-SDU-2016-00006 Rev. 0, Bechtel Subject Matter Expert Summary Reports, *SDU 6 Tank Cracking SME Reports*, March 2016	SDU6 recommends establishing the minimum maintenance free service life required of any candidate lining material where the lining maintains a complete seal of the concrete during grout pouring operations into the SDU. At the end of its operational life, the free liquid is removed, and it is expected that any pore solution remaining in the saltstone will have minimal impact to the lining because there is no driving force to replenish the corrosive species.
85		Achieving the required leak tightness without a coating/liner, while conceptually feasible, is a low probability.	All concrete exhibits some level of cracking influenced by; concrete mix, shrinkage, curing, placement size, restrained boundaries, and weather. SDU6 explored an opportunity to pass a leak tightness test without a coating/liner, but was not successful.	SDU6 adopted the liner concept for leak tightness and conducted the required testing. SDU6 recommends liners be used for leak tightness in SDU7.
86	Start-Up and Testing	Use of a Test Station to Minimize Facility Impacts (#24) Installation of a Remote Operating Work Station (ROWS) reduced the outage time and allowed continued operation of the facility concurrent with startup testing of SDU 3&5. The ROWS can be used by future Saltstone projects to reduce outage time and allow continued operation concurrent with startup testing.	J-DCP-Z-12006 provides for the additional fiber optic cables required for tie-in to the ROWS which will provide the required interface necessary for the independent "off line" testing of the SDU 6 software modifications without impacting facility operations	Future salt projects should utilize the remote operating work station (located in ECR room) simultaneously while the facility continues operation. SDU6 is currently performing this recommendation. SDU6 recommends it continues with SDU7.
87		Dye test and adding dye. There was some confusion around the roles and responsibilities and scope of performing the leak tightness test including the use of dye.	Testing and scoping of leak tightness test were unclear including, who adds the dye, when and how to add the dye, The testing decision making process for completing vs. aborting an in process test were also unclear.	Have clear roles and responsibilities for leak tightness testing. Ensure scope boundaries between SRR and subcontractors are well understood and clear in the specifications. SDU6 recommends SRR executes the leak tightness test procedure
88		VOID		
89		VOID		

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
90	System Engineering	This lessons learned communicates results of DOE's assessment and finding regarding use of the Systems Engineering Process defined in the System Engineering Management Plan to conduct the requirements analysis and to perform the necessary technical integration.	From 2014-SA-002456, Evaluation of the Need for SDU6 Internal Coating for Protection Against Sulfate Degradation	Evaluate changes to SDU6 functions, requirements or design of Systems, Structures and Components (SSCs) that are considered for application to SDU7 and future SDUs (e.g., future considerations to pursue removal of the internal coating (Reference: 2014-SA-002456)) against Y-SEMP-Z-00001; Saltstone Disposal Unit 6 System Engineering Management Plan. Utilize a system engineering approach to evaluate such changes, applying a graded approach as appropriate. SDU6 recommends incorporating the liner into the design of SDU7.
91	System Engineering	SDDRs are time consuming for the contractor and SRR. SDDR process - streamline in specification.	SRR described the SDDR process in the specification as it is required by Engineering procedures.	SDU6 recommends an effort be made to streamline project processes (i.e., Engineering, Procurement and SDDRs) while maintaining compliance with SRR procedures. Need to challenge current SRR procedure interpretations.
92		The layers of design team inputs in order to make minor to average changes over loaded the SDDR process and those task with administering the process.	Changes should be allowed in the field with approval of SRR, STR and an Engineering representative, and documentation of the changes should be allowed to work concurrently with the construction activity. This presents a perfect opportunity to utilize the "Red Line" engineering process with this class of changes.	SDU6 recommend that the specification allow for "Red Line" Engineering process to reduce the time delays and over utilization of resources for insignificant changes.
93		Active Ventilation. SDU 6 was originally designed for active and passive ventilation to control the flammability of the internal volume gases. Later, calculations showed that for the intended feed products, an active ventilation system was not needed.	SDU 6 procurement of active ventilation was kept "on hold" until calculations were completed.	SDU7 should reach concurrence on the types and capacities of various ventilation techniques early in the project's design phase.
94	Reuse of Existing SDU components	Procurement of all new components for SDU6 does not support efforts to reduce, reuse, and recycle. Inherent to SDU6s design should be the opportunity to reuse components from previous SDUs. This Lesson can apply to stair towers, Modular Instrumentation Electrical Equipment Skid (MIEES), passive ventilation and more.	During the preparations for procurement of the passive ventilation units for SDU6, extensive discussions and reviews were conducted to evaluate the options of procuring new units versus relocating existing units from another SDU. The resultant path forward for SDU6 was to procure a single new unit and reuse three existing units.	SDU6 recommends the following: 1. During initial planning and design phases for future SDUs, evaluate the opportunity to relocate existing components in lieu of procuring new as an opportunity to reduce lifecycle costs (i.e., passive vent housings and semi-permanent handrails) 2. Consider attachment of components (bolting vs. welding) to make future reuse on another project easier.
95	Quality	Nonconformance Reporting The project has two different nonconformance reporting methods; internal NCRs governed by the QAPP and Project Procedures, and external construction NCRs governed by 1E6, 10-01.03.	Both processes rely on hardcopy records making tracking more difficult. Having two processes makes for confusion among the reviewers as the processes and forms are different.	SDU6 recommends developing a site-acceptable procedure for nonconformance reporting for the project. Describe the process in the QA Project Plan.
96		Subcontractor QC Weekly Reports. Weekly reports, as developed for the SDU6 Project, are complex and bulky. Some ranging over 300 pages.	1) If SRR subcontracts a managing company to direct and schedule the tank fabricator then there needs to be a streamlined system to report completed inspections and turn over records to SRR in a timely manner. 2) At first, the subcontractor did not have a QC Technician dedicated to these reports.	SDU6 recommends the following; 1. Early in the SDU7 work scope, details of the Weekly Report need to be agreed upon. All the cross referencing of NCRs, Repairs and General Inspection Reports need to be agreed upon. 2. Consider adopting the Task identification system used with the Special Inspector numbering system. 3. A dedicated subcontractor QC Technician in charge of weekly reports is highly recommended.
97		Tracking Inspections. Subcontractor and Independent Inspection Reports, and Professional Observations are created based upon a single or small group of components. Tracking all these acceptance and re-inspection documents through the entirety of construction is extremely difficult.	A tracking mechanism for hundreds of subcontractor and independent inspection reports need to be developed early and maintained throughout the construction phase.	SDU6 recommends the following: 1. Create a map of all concrete components (mud mat, floor, walls, etc.). In this map are references to inspections and nonconformance reports. 2. Use SRR task number for Inspection Report (IR) report numbers.

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98		The concrete repair process was difficult to follow and caused delays.	Define Major and Minor Defects in all the concrete components. Define repair techniques available for use for each type of defect.	This is similar to Lesson # 29. Recommend SDU7 place definitions and acceptable repair methods in the specification for Major and Minor Defects. Individual Inspection Reports are written for repair of Major Defects. Minor Defects are tracked in the repair log.
99		Inconsistencies in the repair log numbering system partly due to the assignment of the subcontract have caused irregularities in the traceability of documents.	Develop and specify repair log number process.	SDU6 recommends developing a numbering system and applying it in the specification to the inspection and repair processes.
100	Quality	The role of the Special Inspector was often included in the QA/QC process instead of the oversight role. It continued to cause confusion and miscommunication with the subcontractor	Update Special Inspector procedure	The subcontractor is responsible for the quality of his work. Recommend to define roles and responsibilities, streamline and remove redundant roles. SDU6 recommends detailed communication to the project team and concerning the role of the Special Inspector and the extent they engage in the QA/QC process. Incorporate to specifications and drawing notes.
101		Complete post-placement inspections as soon as possible after stripping formwork so repairs can commence. Several times this was pushed off and led to schedule and resource allocation issues later, delaying other work.	Define process; provide clarity on post-placement inspection and repairs; what comes first, repair or inspections; who has what responsibility.	SDU6 recommends revision to the specification as follows: A. Review structural vs. cosmetic repairs. B. Establish repair methods. C. Allow subcontractor to investigate repairs. D. EDR submittal for a Repair Manual.
102		QC phase meetings cause delays if any pending paperwork was in process. Subcontractor could not move forward until an RFI response was received. A couple of occasions, the Subcontractor waited to submit the RFI until after the phase meeting to avoid delays.	Evaluate where phase meeting are required and the details to be addressed including who is to attend (craft personnel performing the work).	SDU6 recommends streamlining the Phase Meeting schedule and revise the specification.
103		Qualification issue. No need for two company inspectors looking at same attribute.	Need decision on QA/QC approach for SDU7 then DAHJ approval. Look at this lesson for streamlining/cross training.	Ensure contract responsibilities are clearly defined. Consider contract revision to have QC supplied by SRR and revise Inspection Reports accordingly. Combine Special and QC inspectors. Combine special inspector and QC inspection reports.
104		Service Level Agreements (SLAs) are managed programmatically on a Fiscal Year basis and are difficult to track costs against estimates for scope spanning multiple years	Without tracking systems in place and regular review of SLA performance, it is difficult to determine accurate estimates-at-complete.	Develop tracking system to monitor costs against total commitments for SLAs.
105		Crack criteria was specified in the specification but inspections were not useful as most repair techniques rely on gravity to penetrate.	Define underside of roof Inspection Criteria	Depending upon the PA and use of top coating, consider deleting underside roof inspections.
106		DOE Finding Proceduralize the records management and identification.	Records tracking database.	SDU6 created the Tank Tracking Database that recorded each QC Inspection Report with each work task. SDU6 recommends that the SDU7 QA Group utilize something like the Tank Tracking Database and add its description to the QA Project Plan.
107		Process for validating inspection and testing were completed is difficult due to the nature of the report used by the High Density Polyethylene(HDPE) Subcontractor	HDPE Documents - Develop clear inspection Report.	SRR Engineering develops the criteria. SDU7 should issue standard Inspection Report Forms to sub-contractors.
108		VOID		
109		Immature NQA-1 Program, initially Subcontractor did not possess a quality assurance program that would meet the projects requirements.	Subcontractor failed to efficiently develop a Quality Assurance Project Plan (QAPP).	Recommend SDU7 consider SRR performing QA/QC, then develop procedures and tie to the Project Specific QAPP
110		Communication problem existed as subcontractor QC did not have a method to communicate issues with in process work.	QC needs a tool at their disposal to document and relay to the subcontractor of work, items, or processes that are in-process and do not meet the design requirements. This tool or document shall be addressed and verified by the Field Engineer (FE) prior to final buy off. Initial Event Report? Problem Report? Process is being discussed, needs to be added to the specification so it is effective	A Communications Plan will be developed to define how in-process and final inspections will be managed as well as how issues are communicated that are identified during in-process or final inspections.

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111		QCIP lacked Performance Assessment (PA) section-specific criteria	Multiple revisions to QCIP (inspection reports) to document PA specific criteria.	Include PA specific criteria in Quality Control Inspection Plan (QCIP).
112		A 2014 DOE assessment documented a finding in the processing and timeliness of SDDRs and not proceeding with conditions that are indeterminate until proper resolution and documentation has been completed.	Source: DOE assessment 2014-SA-006927 and STAR item 2015-CTS-004150.	SDU6 recommends the following 1. Update QA briefing for SDU7 to address details on procedure compliance, the time out process, verbatim compliance and review Best Practices Guide for additional items. 2. Add slide to QA briefing for notification indeterminate conditions in a timely manner and processing of the SDDR prior to continuing work.
113	Balance of Plant (BOP)	Engineered Equipment. The change in the BOP execution strategy from subcontract to direct hire resulted in the need for added Design Services and Procurement resources. NOTE: Manpower costs were the same.	Additional resource hours were needed to initiate and manage material requisitions that were planned to be procured by the fixed price BOP subcontractor.	1. Consider change in execution strategy as a risk in project planning. Ensure that Engineered Equipment is properly identified in project estimate (vs. bulk material). 2. Plan for at least two submittal review cycles per engineered equipment item. 3. Assign a dedicated materials engineer/procurement representative to track and expedite engineered equipment for direct hire Construction execution.
114		Flanges on Drain Water Return. Drain water return piping was originally designed to be all welded construction. Having a welded pipe increases time to tie in to plant piping and can impede future maintenance	SDU6 tie in points to Saltstone need to be fast and flexible. Equipment on the SDU must be maintenance-friendly. Connections for replacement equipment should have flanges.	1. Add flanges to the last section of drain water return piping. 2. Include the Operations representative in all design/ planning discussions. Must have committed resource early in the project. 3. Consider early tie-ins (i.e. Piping supports, valving and electrical) to align with facility outages, based on the location of the next SDU).
115		There was confusion on the QC inspection roles and responsibilities related to BOP scope.	QC inspections were performed by Construction Discipline Engineers (CDEs) per "normal" site processes on the Balance of Plant work, including the bridge, which had limited required special inspections.	Recommend SDU7 QCIP address BOP work .
116	Stand-alone Drawings	Drawings should have adequate information to stand-alone and be usable by the subcontractor and field forces.	In many cases, specifics are contained in the specification as well as the drawings. In some cases the specification may have more detail.	Maintain the emphasis to keep details in the drawings. In some cases, remove specifics from the specification and rely heavily on the drawings to provide the needed detail. Changes to detail (if needed) can be effected by revising the drawing(s) as opposed to the specification AND drawings.
117	Schedule Engineering Deliverables, Reviews, External Processes	The tank project is one of many priorities assigned to shared site resources like Fire Protection or Facility Safety. Sometimes the capabilities of the shared resources have a detrimental impact on the SDU tank schedule.	Incorporate the use of shared resources in the tank schedule. Firm commitments of resources and due date is needed from the functional resource Lead.	1. Schedule and plan all reviews such as Project Fire Hazards Analysis (PFHA), and Consolidated Hazards Analysis Process (CHAP). Get concurrence early from Engineering functional resources to complete documents and reviews in a timely manner that supports the project schedule. Hold functional resources accountable for deadlines and impact to project schedule. 2. Make sure functional organizations understand impact of emergent issues on the project (e.g.. Mercury issue).
118	Epoxy from Manlift	Prestressing cable ends are embedded in pockets to maintain profile. Workers should complete the embedment and epoxy the pocket from a manlift in lieu of the Prestressing platform.	The worker is better protected by use of handrail and fall protection from manlift than by use of fall protection only from prestress work platform.	Epoxy pockets using a manlift while the prestressing machine has moved off and laid the cable in the immediate area. SDU6 recommend this be placed as a requirement in the subcontractor TSP.
119	Management Review Team (MRT)/Corrective Action Review Board (CARB)	MRT meetings do not include subcontractor	The SRR Project Team held Management Review Team meetings without the primary subcontractors in attendance.	Consider input from major subcontractors for participation in MRTs.
120		VOID		

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NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
121	Re-space Wall Stirrups	Re-space wall stirrups to eliminate congestion.	Wider wall can rely on concrete strength instead of rebar confinements (this held up Wall #1).	Engineering will either increase the width at the top of the wall, or reduce the width of the upper bearing plate.
		VOID		
123		VOID		
124		VOID		
125		VOID		
126		VOID		
127	Eliminate hooked bars	Eliminate hooked bars at edge of roof through columns.	Not required per ACI.	Accept SDU6 recommends detailing roof-column interface with drop panels.
128	Re-design edge of roof detailing	Construction interference with rebar and roof cans.	Design a beam instead of the floating circumferential bars in order to avoid interference with roof cans.	Recommend SDU 7 consider this during design phase.
129	Steel joints	Extension bars extended beyond the roof forms requiring adjacent shoring for support.	Requires a lot more shoring (rebar detail).	Recommend stopping steel 2" short of roof joints/floor joints and add galvanized/epoxy coated dowels through joints instead of 12 foot extensions. SDU6 recommends the use of epoxy coated dowels through roof and floor construction joints.
130		VOID		
131		VOID		
132		VOID		
133		VOID		
134		VOID		
135	Amount of survey	Reduce the amount of survey. It is not necessary to survey all the formwork and use this as a basis for cancelling concrete placements. Survey should be for completed as-built work, or in-process surveys should be for information only. (Example: if the survey shows the formwork needs to come up ¼", just go do it and pour the floor, do not require a follow up survey to confirm that the ¼" was achieved). There is too much reliance on survey data	Survey should be completed for as-built work, or in-process surveys and should be for information only. (Example: if the survey shows the formwork needs to come up ¼", just go do it and pour the floor, don't require a follow up survey to confirm that the ¼" was achieved). There is too much reliance on survey data.	Matrix being put together to determine what needs to be surveyed.
136		VOID		
137		VOID		
138		VOID		
139		VOID		
140	Determination of repairs	Allow investigative work at contractor's risk to determine appropriate repair. You can't determine appropriate repair method until you do investigative work to determine cause/extent of damage, but you can't do investigative work without approved repair method; circular logic.	Need documentation/evaluation right away.	Recommend CSI specification identify appropriate sequence for rework.
141		VOID		
142		VOID		
143	Pour Cards	Subcontractor often lacked knowledge of pre-requisites required to begin work.	We cannot move forward until an RFI response is received? A couple times we just waiting to submit the RFI until after the phase meeting to avoid delays. One pre-job briefing before each phase.	Evaluate submittal process to ensure pre-requisites are clearly identified. One phase meeting to communicate expectations.
144	Submittals	Challenging to get submittals back in a timely manner.	Could have been a Subcontractor issue. NOTE: When mark-ups changed, required another round of approval cycle.	Role play exercise would be beneficial (Lean Event).
145		VOID		
146		VOID		
147	Training	Unfamiliarity with work processes (e.g. SDDR, RFIs) led to work delays		SDU 6 recommends SDU7 consider QA and Engineering to develop training class and follow-up meetings as required.

Attachment: Lessons Learned for SDU 7 SRR-SDU-2014-00020

NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
148	Information Sharing	Communication issues existed between SRR, General Contractor and lower tier subcontractors (i.e. tank fabricator)		SDU 6 recommends partnering sessions be held in the initial phase of the job and as required throughout construction to maintain good communication.
149		VOID		
150	Alternate materials	CHAP Process drove preventive maintenance items for SDU 6 drainwell compressors.		Recommend replacing drainwell compressor hoses with tubing reducing future work to facility (elimination of Preventive Maintenance item)
151	Convenience Power receptacles	Operations has identified the need for additional power receptacles	Operations has identified the need for additional power receptacles on the roof of SDU 6 to operate permanently installed monitoring equipment. This equipment was not identified in the design review of SDU 6. The Technical Agency Identification Checklist (TAIC) form was used and operations signed off as no comments on the design.	Future SDUs will include additional convenience outlets, as required by the Facility, to eliminate the use of long extension cords which are being used today on the roof of SDU 6.
152	High Efficiency Particulate Air (HEPA) Filter design and installation	HEPA filter Dioctylpthalate (DOP) testing was not successful with the current installation set up	The distance between the HEPA filter and the challenge aerosolinjection port must be at least 10 duct diameters (10 feet) to allow proper injection and mixing of the mist used to establish a baseline condition before measuring efficiency of the HEPA filter. A modified test set up was necessary on SDU 6 by using a 10 foot long piece of 12 in duct and modifying the HEPA Pre Filter inlet door and blocking off the inlet to the tank.	Future SDUs must place the actual HEPA filter 10 duct diameters away from the inlet mist test port to allow proper mixing of the mist before it enters the HEPA filter to measure efficiency.
153	Guardrails	During a drill, the firetruck with extension ladder could not safely land the bucket of the ladder for manlift because the SDU 6 railings were in the way.	The guardrails for SDU6 are too close to the edge of the tank	Consider moving the railings in significantly from the edge of the tank. Also consider having designated areas where the guardrail is further in so the ladder bucket can safety land on the roof to access emergency personnel pick up.
154	Slippery roof top conditions	The roof coating is slippery when wet	Operators making round may be exposed to conditions that are slippery when surfaces are wet	Future SDUs should add non-slip material to the coating mixture at designated walkways. Paint whole roof non-skid.
155		VOID		
156	Water in Sumps	Water was identified in the sumps after the HDPE was buttoned up	Three recommendations from 3&5: (1) sloping mud mat (2) eliminating (3) not trap rainwater. Calc was performed at rain event. Moisture trapped at button up. SDU 3A pumping continues. There is a large surface area (feet wide, circumference of tank) that is exposed to rain prior to the final HDPE welding.	SDU 7 should consider construction sequencing to minimize exposing the stone fabric and matting from rainwater intrusion. The order of finishing and closing sections in a work shift should be considered.
157	Calibration	Subcontractor completed work on HDPE, demobilized and did not provide post-calibration data.	This will ensure Measuring & Test Equipment (M&TE) wasn't out of calibration when it was used.	Add include requirement for subcontractor to provide post calibration documentation for any M & TE used during the project in the specification and EDR.
158		VOID		
159		Transmittal of large submittal files between Contractor and subcontractor was an issue.	Large files must often be transferred between entities and must be done so quickly and efficiently.	SDU7 should review options for large file transfers and add to the specification.
160		VOID		
161	Inspection Criteria	Referencing of the QCP and not including details caused significant confusion during the inspection process	This will reduce confusion when the subcontractor is bidding the job	Include detailed inspection reports with the specification.
162	Inspection Criteria	Include subcontractor in development, or share with subcontractor, the Quality Improvement Plan (QIP), so that the subcontractor and SRR concur with the inspection attributes. At times the subcontractor was unsure of what criteria they were being inspected against or what the specific hold points were	STR would not give copy of the QIP to subcontractor since it was not in their contract to be given that document. Put examples together to be used during pre-bid.	
163	Tank Roof Loading	The subcontracts was required to submit a roof loading plan but was not given guidance on what the roof loading could not exceed	Give guidance in the specification on what the max loads are on the roof so the subcontractor has an idea before submitting what their loading can be.	General guidelines to be provided. Include maximum loading requirements.

Attachment: Lessons Learned for SDU 7 SRR-SDU-2014-00020

NO	TITLE	SITUATION	DISCUSSION	RECOMMENDATION
164	Subcontractor QC	Subcontractor would call for inspections and not be ready, or confusion on who was the QC lead for subcontractor	Require Subcontractor to have QC oversight or QC manager as the interface between SRR and subcontractor. This person would be responsible for insuring subcontractor is complying with the quality requirements and meeting the hold points.	Quality Coordinator needed. Suggest adding as a requirement that the subcontractor be required to bring its key personnel to SRS for a day to undergo a training session on all aspects of the subcontract at SRS process. This should include all phase of involvement from Post award documentation requirements, NTP document requirements, submittal process and time requirements, change documentation and procedure change proposal requirements for procurement, quality expectations and conformances, etc. etc. Each work group could provide a one hour session and slides on their specific requirements. This would ease the burden of the transition and the expectations and requirements.