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Summary of Saltstone Disposal Unit Cell 2A Core Drill Activities

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EXECUTIVE SUMMARY

Core drilling of Saltstone Disposal Unit (SDU) Cell 2A was conducted to extract samples of emplaced saltstone. The primary objective is to enable measurement of field-emplaced samples with respect to properties that influence long-term performance, such as saturated hydraulic conductivity, for comparison to measured properties of simulated samples prepared in the laboratory.

Based on mock-up activities conducted from Fiscal Years (FY) 2013 through 2015 and physical constraints associated with the SDU 2A structure, standard wet core-drilling techniques were selected for this activity. An essential requirement for the core-drilling technique was that it minimize physical or chemical changes to the samples that would artificially alter key properties. The mock-ups were conducted in an attempt to establish the viability of the wet coring technique, and assess or develop tools, procedures, and techniques necessary to implement core drilling and retrieval activities in field conditions.

Tools, techniques, and procedures developed during mock-up activities were used to conduct the SDU 2A core drilling, sample extraction, transportation, and storage at the Savannah River National Laboratory (SRNL). The most significant developments were a new procedure for core drill operation, extraction in a radiation and contamination environment, and design and fabrication of drill equipment mounting devices and sample retrieval tools. In addition, some of the planned chemical analyses required that the samples be isolated from exposure to atmospheric oxygen. Special inerting tubes for sample transport, and an anaerobic chamber for SRNL, were specially fabricated to accommodate this requirement.

Core drilling activities were conducted between April 16, 2015 and May 6, 2015. Three 11-inch diameter camera ports in the roof of SDU 2A were used to access the saltstone waste form. Two core drill attempts per camera port were conducted to ensure that adequate samples were collected for analysis. Drilled cores were extracted from the waste form one at a time using specially designed extraction tubes. Each extraction tube containing the core material intended for analysis was then placed in an inerting tube inside the contamination area adjacent the drilling operation. Each inerting tube was surveyed by radiological protection personnel to verify that transferable contamination was not present outside the tube and then relocated to a low dose area off of the SDU roof. Each tube underwent a 5-minute inerting procedure, using nitrogen gas. Each tube was again surveyed by radiological protection personnel to verify that transferable contamination was not present outside the tube, and the tube was placed in a transport container. Two samples per day were generated and packaged side by side in a single transport container, then transported to SRNL. The cumulative dose acquired during the core drilling activities was approximately 2.7 man-rem.

In total nine individual tubes of sample material were generated and transported to SRNL. In addition, one approximately 18-inch sample became stuck in the drill bit and was transported to SRNL but may be discarded since the material within may or may have been altered by the core drilling process and adequate material is available to meet the analytical objectives. The total length of core material removed for analysis was approximately 191 inches. Approximately 99 inches were collected and transported from approximately 24 to 48 inches below the grout surface. Approximately 92 inches were collected and transported from approximately 48 to 72

inches below the grout surface. The quality of the samples varied substantially, but enough high quality material was collected to perform all required analyses.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
FOSC	Facility Operating Safety Committee
FY	Fiscal Year
HEPA	High-Efficiency Particulate Air
IH	Industrial Hygiene
JPM	Job Performance Measure
LEL	Lower Explosive Limit
ND	Non-Detect
OJT	On the Job Training
PVC	Polyvinyl Chloride
RCO	Radiological Control Operations
RWP	Radiological Work Permit
SDU	Saltstone Disposal Unit
SHC	Saturated Hydraulic Conductivity
SPF	Saltstone Production Facility
SRNL	Savannah River National Laboratory
SRR	Savannah River Remediation LLC
SRS	Savannah River Site
TCLP	Toxicity Characteristic Leaching Procedure
WDA	Waste Disposal Authority

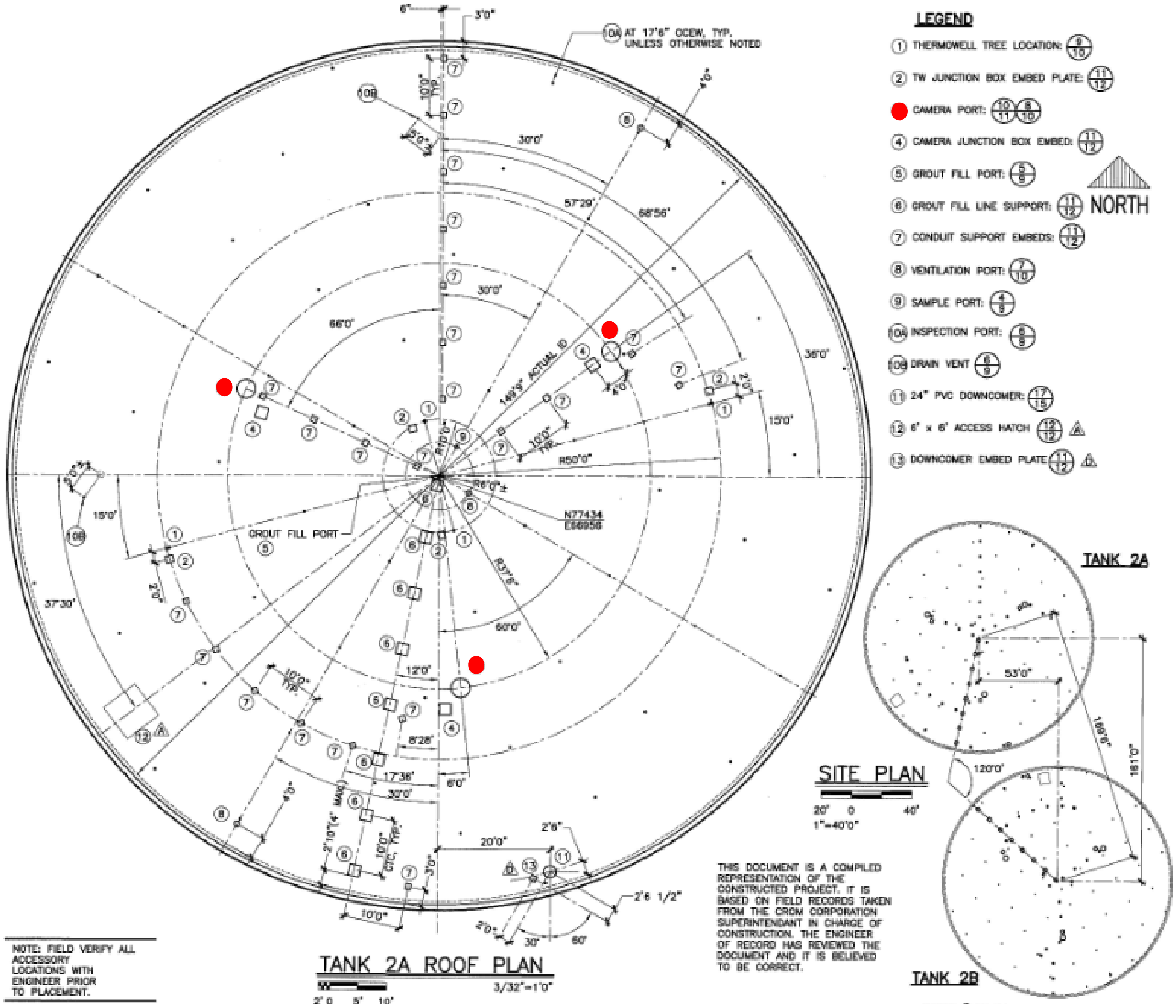
1.0 BACKGROUND AND OBJECTIVES

This report documents the Saltstone Disposal Unit (SDU) 2A core drilling, sample retrieval, packaging, and transportation conducted between April 16, 2015 and May 6, 2015. The primary objectives of sampling SDU Cell 2A are:

1. To enable measurement of field-emplaced saltstone samples with respect to several properties of interest. Most notable among those properties are saturated hydraulic conductivity (SHC) and contaminant (e.g., technetium [Tc-99]) leaching behavior, both of which serve as key inputs to the time-dependent contaminant transport models utilized in the *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site* (SRR-CWDA-2009-00017). Since saltstone contains redox sensitive components, special care is required to inert the sample environment from removal time until the testing is completed.
2. To compare the aforementioned properties for field-emplaced samples and laboratory-prepared simulant samples, that would validate the past and future use of data derived using saltstone simulant processed and cured in the laboratory.

The configuration of the SDU 2A roof contains penetrations of various sizes to accommodate equipment required to support grout fill operations and is not specifically designed to accommodate sample collection. For the core drilling operations, three camera ports 120 degrees apart and approximately 37.5 feet from the cell center point were used. The red circles on Figure 1.0-1 indicate the camera port locations on SDU 2A.

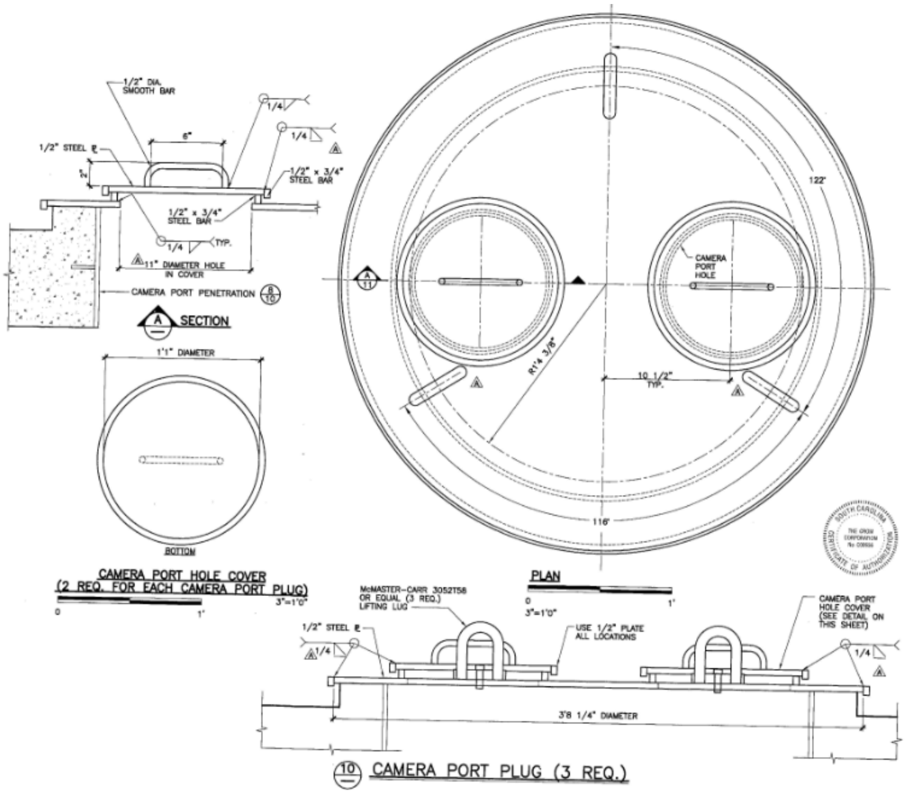
Figure 1.0-1: SDU 2A Camera Port Locations



[WB00001K-004-G, Sheet 4]

Each location consisted of dual camera ports. For core drill operations, one port served as the drill location while the sister port was used to install a micro camera to observe coring operations within the cell. Figure 1.0-2 depicts the designed camera port configuration while Figure 1.0-3 shows the camera port configuration with the drill stand installed adjacent to the port.

Figure 1.0-2: Camera Port Configuration (Typical)



[WB00001K-004-G, Sheet 11]

Figure 1.0-3: Drill Equipment Installation at SDU 2A Camera Port (Typical)

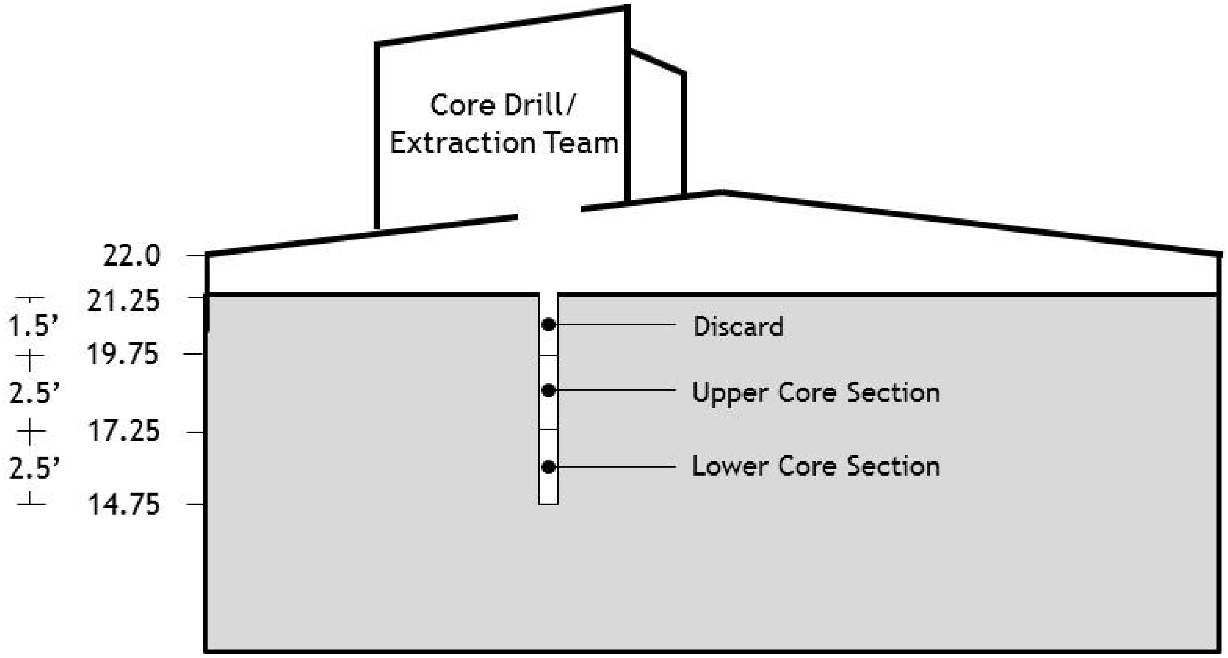
The objective of the core drill task was to obtain samples from each camera port so that the sample analyses in Table 1.0-1 could be performed.

Table 1.0-1: Planned Sample Analyses and Material Requirements

Sample Analysis	Sample Configuration	Required Sample Mass or Dimensions
Saturated Hydraulic Conductivity	Cylindrical sample with little or no observable surface damage	2 inch x 2 inch (Diameter x Height)
Density, Porosity, Moisture Content	Fractured samples – exposure to oxygen will not affect data	≈10 grams
Total Activity (Tc-99, Sr-90, Se-79, I-129, Ra-226)	Fractured samples – exposure to oxygen will not affect data	≈10 grams for each isotope
Distribution Coefficient (K_d) (Tc, Sr, Se, I, Ra)	Sub-sample removed from intact sample interior to ensure minimal oxygen exposure – sub-sample ground for measurement	≈10 grams for all elements – leachate separated for individual element measurements
Tc(VII) / Tc(Total) Ratio	Sub-sample removed from intact sample interior to ensure minimal oxygen exposure – sub-sample ground for measurement	≈10 grams
pH / Eh	Fractured samples ground for measurement	≈10 grams
Toxicity Characteristic Leaching Procedure (TCLP) (reduced sample)	Sub-sample removed from intact sample interior to ensure minimal oxygen exposure – sub-sample crushed for measurement but must be maintained in an anoxic environment for transfer and measurement	≈50 grams
TCLP (oxidized sample)	Fractured samples – sample should be proximately located to reduced TCLP sample – sample should be crushed and exposed to air during transfer and measurement	≈50 grams

Ideal samples were located from a depth of 48 to 72 inches from the top of the emplaced saltstone. This depth corresponded to samples obtained from the Saltstone Processing Facility (SPF) during August 2013, as well as laboratory simulant prepared from analysis of Tank 50 feed material at that time. Samples from a depth of 24 to 48 inches were also obtained to provide additional material for analysis should that be desired. Figure 1.0-4 demonstrates the approximate configuration of the grout and sample elevations in SDU 2A.

Figure 1.0-4: Schematic Illustrating Sample Elevations in SDU 2A



Since single input values are used in the performance assessment, sample material from anywhere in the unit should provide data to support many of the planned analyses. In order to accommodate some of the planned analyses, the samples were required to be maintained in an inert environment to the extent practical.

To validate the core drill, extraction, and inerting tasks required to obtain samples, a series of mock-up tests and training were conducted at the TNX area at Savannah River Site (SRS). Mock-up activities involved conducting core drill, extraction, and inerting tasks on monoliths of simulated, non-radioactive saltstone. The mock-up activities demonstrated the viability of the core drill, extraction, and inerting techniques that were employed on SDU 2A. [SRR-SPT-2013-00044, SRR-CWDA-2014-00059, SRR-CWDA-2015-00002] In addition, the mock-up provided an opportunity to develop and test the core drill procedure (SW24.6-SDU2, Section 5.6) and tools and equipment developed and fabricated specifically for this evolution such as the extraction tubes, inerting tubes, shield plates, etc.

2.0 RISK MITIGATION

Various technical risks and possible mitigation strategies were developed and reviewed with the project team. Risks generally centered around protection of personnel from hazards associated with the activities, risks associated with the drill equipment, and risks associated with unanticipated conditions encountered from drilling. The Risk Identification and Mitigation Matrix not only identified postulated risks requiring mitigation, but also enabled timely identification of baseline data requirements such as vapor space chemical concentrations and facilitated evaluation of the need for mitigative actions. Table 2.0-1 below summarizes risks identified for the project and mitigative actions.

Table 2.0-1: Risk Identification and Mitigation Matrix

Event	Mitigation
Inclement weather - High winds, Rain	None
Heat	Conduct mock-up to expedite work
	Utilize ventilation
	Utilize cool vests
Simulant vs. Emplaced Saltstone Properties	Contract commercial coring consultant
	Purchase a range of drill motors
	Purchase a variety of drill bits
Higher than expected dose rates	Fabricate steel split plates for port openings
	Locate non-drill activities to low dose areas
Chemical vapor concentrations	Conduct preliminary air sampling
	Ventilate cell vapor space using blowers (emergency ventilation configuration designed for SDUs 3 and 5)
	Utilize supplied air
Excessive contamination (grout spray from rotating core barrel) from core drill operations	Fabricate steel split plates for port openings
	Employ Teflon tape on threaded connections
	Employ electrical tape on external joints
Mounting plate anchor bolt failure	Conduct a mock-up evolution without one anchor bolt locked in place to verify operability
	Stage construction materials and personnel to respond to anchor bolt shear if needed
Inadvertent pressurization of inerting device	Develop critical steps in the procedure
	Conduct training of container handling and inerting
	Incorporate pressure relief valve into inerting device
Inerting device failure during inerting process	Establish temporary contamination area for inerting operation
Savannah River National Laboratory (SRNL) readiness to receive samples	Conduct weekly status meetings with SRNL after mock up is complete
Core sample material binds in the core barrel and cannot be removed	Design/fabricate field deployable push rod
Core sample material binds in the core barrel and cannot be removed	Use 2-foot drill string for lower sections of core so that the drill string can be disassembled and core material shipped in the drill string

Since this activity was non-routine facility work, a mission status checklist was also developed. The mission status checklist identified both direct and support organizations supporting the activities, status (either go or hold), open items that would preclude initiating the mission, specific actions required to close open items, and individuals responsible for conducting those actions. The mission status checklist proved valuable in ensuring accountability and quickly identifying issues preventing initiation of work activities, as well as resolutions to those issues. Figure 2.0-1 contains an example of the mission status checklist.

Figure 2.0-1: Mission Status Checklist Example

T - XX Hours		Status				
Functional Area	**Responsible Individual**	**Go**	**Hold**	**Open Items**	**Action**	**Responsibility**
Training		☑	☐			
Procedures		☑	☐			
Transportation		☑	☐			
SRNL		☑	☐			
Camera Crew		☑	☐			
Facility Engineering		☑	☐			
Project Engineering		☑	☐			
Operations		☑	☐			
Rad Con		☑	☐			
IH		☑	☐			
Safety		☑	☐			
FOSC		☑	☐			

Weather		☑	☐

Industrial Hygiene (IH)
Facility Operating Safety Committee (FOSC)

3.0 FACILITY MODIFICATIONS, MATERIALS, AND EQUIPMENT

3.1 SDU 2A Field Modifications

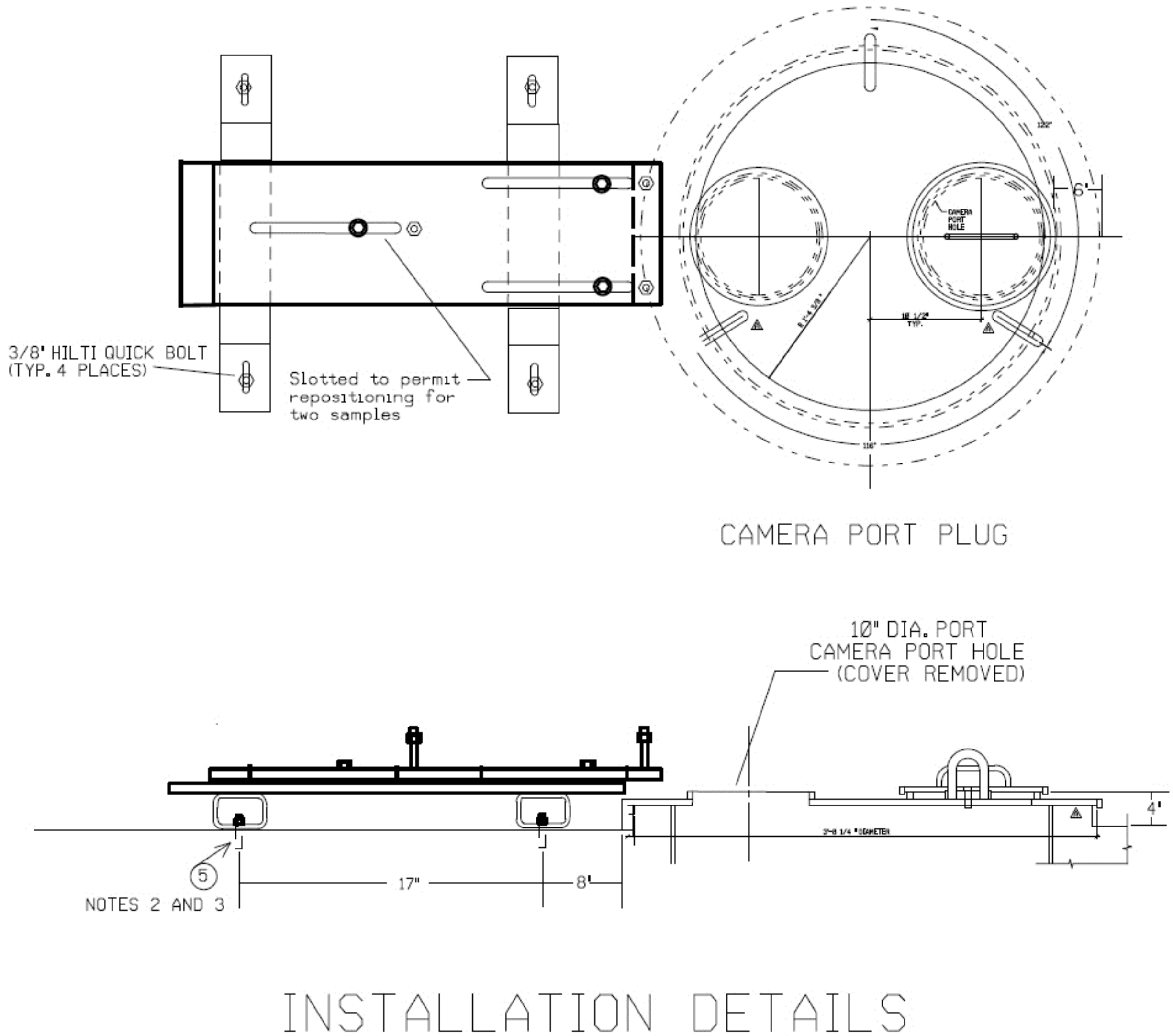
To conduct core drill activities in a contaminated environment, containment huts were shop fabricated and installed over each camera port. Each hut, shown in Figure 3.1-1, was approximately 15 feet by 15 feet by 12 feet high with an adjacent air lock. [WO 1387479-02] Temporary ventilation was added to each hut while in use as a precaution in case airborne concentrations exceeded radiological work permit (RWP) and IH levels.

Figure 3.1-1: Fabricated Containment Huts

SDU 2A normally has only passive ventilation. Supplemental active ventilation was installed to ventilate the cell vapor space, induce negative pressure in the containment huts, and reduce or eliminate both airborne radiological contamination as well as chemical contaminates of concern.

In addition, to anchor the drill equipment to the concrete cell roof, anchor bolts were installed in the roof at the three camera ports. A shop-fabricated drill mounting platform (Figure 3.1-2) was installed over the anchor bolts, securing the drill rig to a stable foundation. [U-FS-Z-00001] Shims were also used to enhance the ability to lock the movable drill mounting plate in place during drilling operation.

Figure 3.1-2: Fabricated Drill Mounting Platform Inside a Containment Hut



[U-FS-Z-00001]

3.2 Drill Equipment

The Hilti® commercially available core drilling equipment was used to drill samples from the saltstone monolith. Specific equipment used was:

- Hilti® Model No. DD 200 and DD 350 coring systems
- 2-inch internal diameter threaded Diamond® core and KOR-IT® bits modified to cut a wider 2.5-inch kerf to enable insertion of core retrieval tools (Figure 3.2-1)
- 2.25-inch internal diameter threaded core extension barrels (drill string).

The initial attempt to core drill used the KOR-IT® bit, which became plugged with core material. Subsequent attempts successfully used the Diamond® drill bit.

Figure 3.2-1: 2-Inch Internal Diameter Core-Drill Diamond® Drill Bit with Double Kerf to Produce a 2.5-Inch Diameter Core Hole

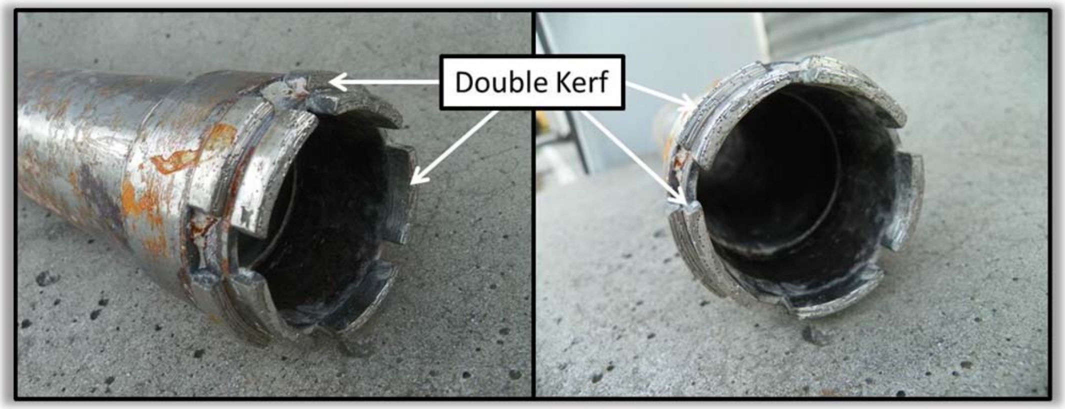


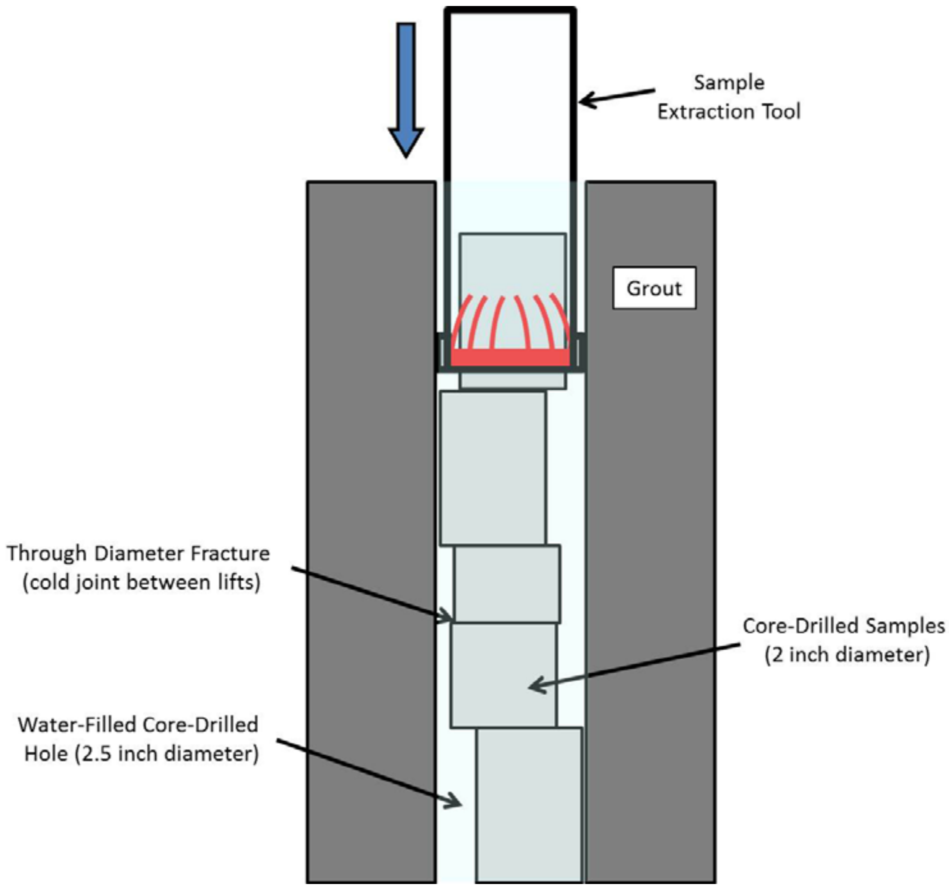
Figure 3.2-2 depicts the final drill equipment arrangement as installed within the containment hut just prior to initiating drill operations.

Figure 3.2-2: Final Equipment Arrangement

3.3 Core Extraction Tools

Special core extraction tools were fabricated to extract core material remaining in the holes after drilling. Core extraction tools were developed and refined through mock-up activities conducted prior to field execution. Each tube was made of clear polyvinyl chloride (PVC). A glued coupling was fitted on the top of the tube so that threaded extension rods could be installed to insert and remove the tube from the hole. Another thinned-glued coupling and a "toothed" basket was installed on the bottom end of the tube to capture sample material. During mock-up the misalignment of drilled core material in the drill hole was encountered. Figure 3.3-1 shows an example of a potential misalignment of 2-inch diameter samples in a 2.5-inch diameter core hole and illustrates how misalignment of the cores could adversely impact retrievability.

Figure 3.3-1: Potential Misalignment of 2-Inch Diameter Samples in a 2.5-Inch Diameter Core Hole



To increase the probability of successfully retrieving core material, a glued coupling with a hand crafted "scoop" was fitted at the bottom end of the tube. The "scoop" was used to assist in centering cores relative to the extraction tube. Each extraction tube contained drilled drain holes so water from the drilling did not remain in the tube after extraction. Rotating the extraction tube with the "scoop" design (Figure 3.3-2) would enhance the ability to align core material and provide a greater probability of successful core extraction. Figure 3.3-3 depicts the fabricated core extraction tube.

Figure 3.3-2: Operation of "Scoop" Design to Assist in Core Alignment

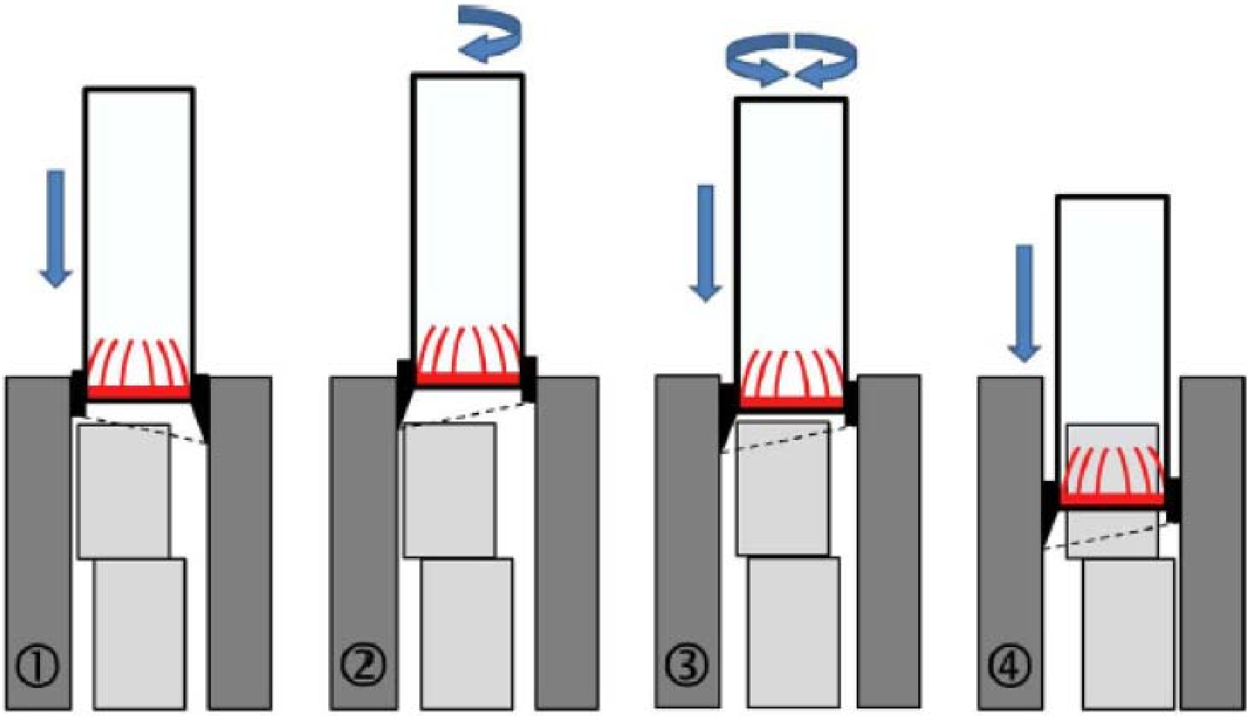
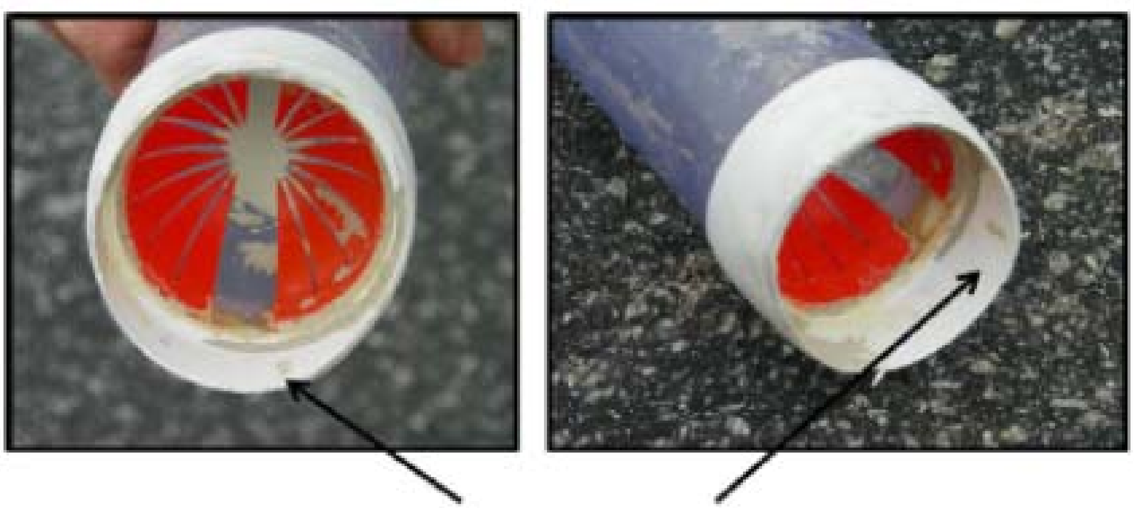


Figure 3.3-3: Fabricated Core Extraction Tool Illustration



3.4 Sample Inerting Tubes

Special inerting tubes were fabricated to ensure that the samples were maintained in an oxygen-free environment after extraction and throughout transportation to SRNL for eventual storage in an anaerobic chamber. [WO 1424366-01] Inerting tubes were approximately 38 inches in length with the main tube body being 3-inch diameter PVC. A quick disconnect was added to

one tube end to connect the nitrogen gas supply. A purge valve fitted with a high-efficiency particulate air (HEPA) filter was added at the opposite end of the tube. Each inerting tube underwent leak testing by maintaining pressure of 3 inches of water for two minutes at the fabrication shop before being released for use in the field. The inerting process consisted of a 5-minute purge with nitrogen gas at 1 cfm. Figure 3.4-1 shows one of the fabricated inerting tubes during the inerting process.

Figure 3.4-1: Fabricated Inerting Tube During Inerting Process

3.5 Transportation Packaging

The configuration of the samples and inerting tubes did not fit into standard sample shipping containers used by Savannah River Remediation LLC (SRR). In order to ship the core sample material, a 150-quart Igloo® cooler was qualified as SRS-1 packaging, in accordance with the requirements in the *Transportation Safety Manual*, 19Q Manual. The transportation packages were qualified to ship samples quantities of 20 linear feet or less. The packaging was qualified, shipping procedures modified to incorporate the new shipping containers, and the Radioactive Package Approval Log was updated to reflect the change. This approach eliminated the need to use more sophisticated and cumbersome transportation casks as well as minimizing the rigging and labor required to manipulate and move those transportation packages. Figure 3.5-1 shows one of the transportation coolers prepared for shipment with inerting tubes and foam packing.

Figure 3.5-1: Transportation Packaging (Typical)

3.6 Laboratory Anaerobic Chamber

A special anaerobic chamber was fabricated to receive, store, and prepare the samples for analysis in an inert environment at SRNL. The chamber contained a transfer chamber to introduce samples to the main anaerobic chamber, a main anaerobic chamber equipped with gloves, and an integrated oxygen monitoring/nitrogen purge system. Damage to the main chamber was discovered upon receipt. SRR formed a Damage Assessment and Recovery Team to assess the extent of the damage, options to repair or replace the unit, and contingency plans, consisting of a temporary, fabricated glove bag with anaerobic capabilities, if the unit could not be repaired in time to receive core samples as scheduled. Repairs to the chamber were performed by SRS personnel and the box tested prior to use to ensure that an inert atmosphere could be maintained. Figure 3.6-1 shows the anaerobic chamber fabricated to receive and store cores extracted from SDU 2A.

Figure 3.6-1: Anaerobic Chamber with Prototype Inerting Tube in Transfer Chamber

3.7 Miscellaneous Tools and Equipment

Miscellaneous tools and equipment were also fabricated or utilized during core drill activities including:

- Commercially available collapsible dryer vent used as a drip shield around the drill string. This was critical in preventing water from saturating personnel protective clothing that would compromise its protective ability (Figure 3.2-2).
- Commercially available “grabber” tools in the event core material fell from the bottom of the inerting tube onto the surface of saltstone
- Slotted mounting plate to adjust drill equipment within camera port
- Micro cameras (Figure 3.7-1) mounted inside the cell to assist in monitoring core drill operations inside the cell on a closed-circuit television monitor.
- Shield plates (Figure 3.7-1) fabricated to install micro cameras in one side of the dual camera port
- Shield plates (Figure 3.7-2) fabricated to accommodate the drill string in the sister side of the dual camera port
- Operator aid (Figure 3.7-3) to assist in estimating drill position relative to saltstone layers as drill penetrated the saltstone monolith. Attachment 2 includes completed operator aides and incorporates core length data obtained from laboratory evaluation of each core section.

Figure 3.7-1: Micro Camera Shield Plate

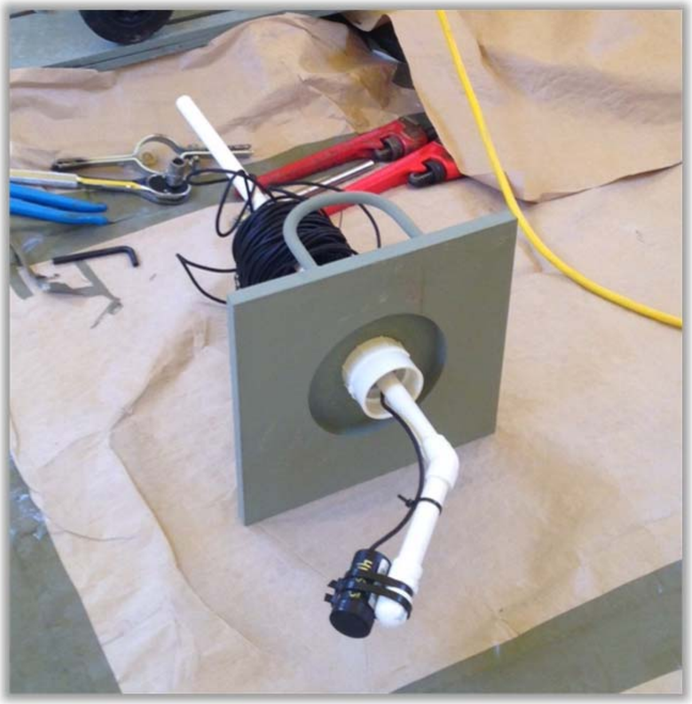
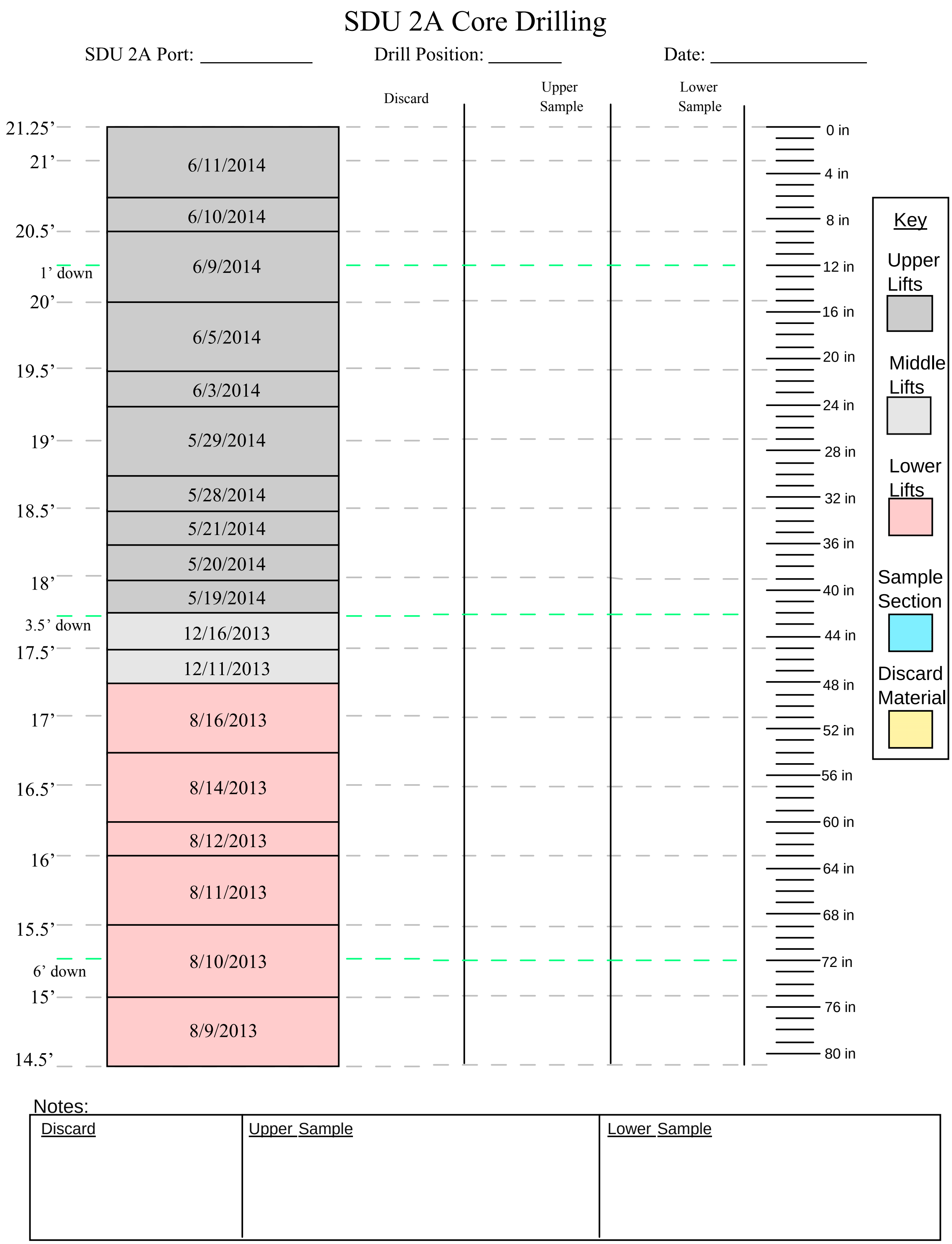


Figure 3.7-2: Drill String Shield Plate (Dry Fit Prior to Operations)

Figure 3.7-3: Saltstone Layer Operator Aide (Typical)



4.0 PROCEDURES AND TRAINING

4.1 Procedures

A new procedure, SW24.6-SDU2, Section 5.6, was developed to perform core drilling tasks. The scope of the procedure addressed the following significant steps:

- Drill motor operation
- Drill string addition and removal
- Extraction tube operation
- Inerting tube operations
- Shipping requirements

The main elements of the procedure were drafted as part of the mock-up activities. The procedure was intended to minimize time needed to conduct drilling operations in a radiation area while preserving the integrity of the samples. A team review of the draft procedure was conducted after the mock-up, ensuring that elements of Radiological Control Operations (RCO), IH, and Conduct of Operations were appropriately addressed in the final procedure. In addition, during the team review, critical steps were identified in the inerting process. Critical steps were clarified as such in the procedure and incorporated into training. A special Chain of Custody Form (OSR 46-307) was developed and tailored to the data needs of saltstone core sampling. The procedure documents estimates of drill depths, core lengths extracted, and provides documentation of samples via the chain of custody, as shown in Attachment 1.

A post job review of the initial core drill attempt resulted in minor procedure revisions focused on providing flexibility in the drill-extraction sequencing. This flexibility resulted in the ability to drill and remove sample material as needed throughout the evolution to increase the probability of obtaining high quality core material.

4.2 Training

Training for both core drill and inerting operations was conducted during the mock-up activities. Training was developed in accordance with the *Training and Qualification Program* (4B Manual). The *Operate Inerting Container – Task Analysis* (WZI00066TANL000100) was performed to establish the need and basis for training. Based on the task analysis, training was developed and conducted specifically for the core drill and inerting activities. Because critical steps were included in the inerting steps of the procedure the *Operate Inerting Container - On the Job Training Guide* (WZI00066OJTG000100) and *Operate Inerting Container - Job Performance Measure* (WZI00066JPMZ000100), respectively, were developed and conducted to qualify personnel on the inerting process.

5.0 CORE DRILL/EXTRACTION/INERTING

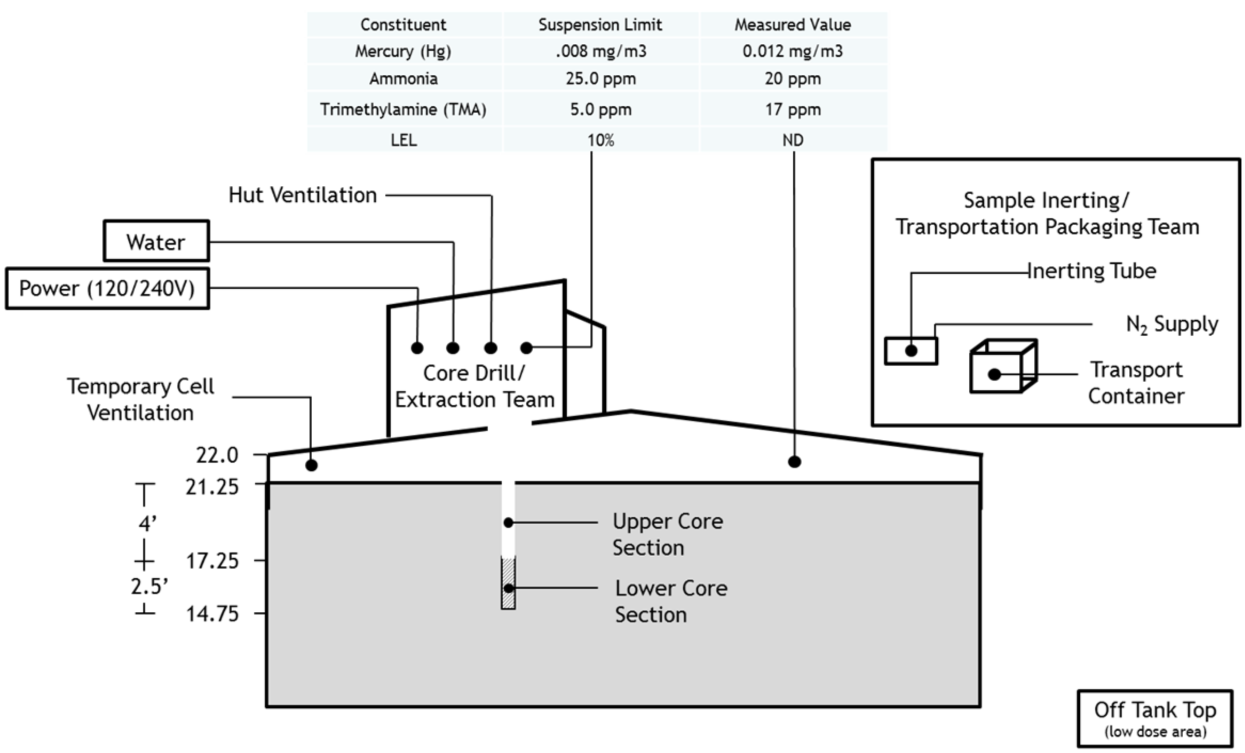
In the sections that follow, summaries of core drilling activities and descriptions of samples retrieved are provided. In addition, worker dose summaries for the core drill activities associated with each camera port are provided based on electronic personal dosimetry readings. However, additional dose from initial hut construction, equipment installation and checkout, demobilization, etc., is not included at this time.

Waste Disposal Authority (WDA) and SRNL have evaluated the condition of each core section to ensure that there is adequate quantity and quality of material available to perform the required testing on each sample set. Key activities and observations from planning activities and each camera port, along with pictures of each core shipped to SRNL, are summarized in the following sections.

5.1 Planning

Figure 5.1-1 depicts a schematic diagram of the equipment arrangement on, and surrounding, SDU 2A, including baseline chemical concentrations of mercury, ammonia, and trimethylamine.

Figure 5.1-1: SDU 2A Equipment Arrangement Schematic Diagram



The Risk Identification and Mitigation Matrix identified the need to establish baseline vapor space concentrations of constituents of concern. IH data was obtained from the cell vapor space prior to initiating cell modifications. Table 5.1-1 summarizes the suspension limits by constituent along with the baseline IH data obtained for SDU 2A.

Table 5.1-1: Baseline IH Data Summary

Constituent	Suspension Limit	Measured Value
Mercury (Hg)	0.008 mg/m^3	0.012 mg/m^3
Ammonia	25.0 ppm	20 ppm
Trimethylamine (TMA)	5.0 ppm	17 ppm
LEL	10%	ND

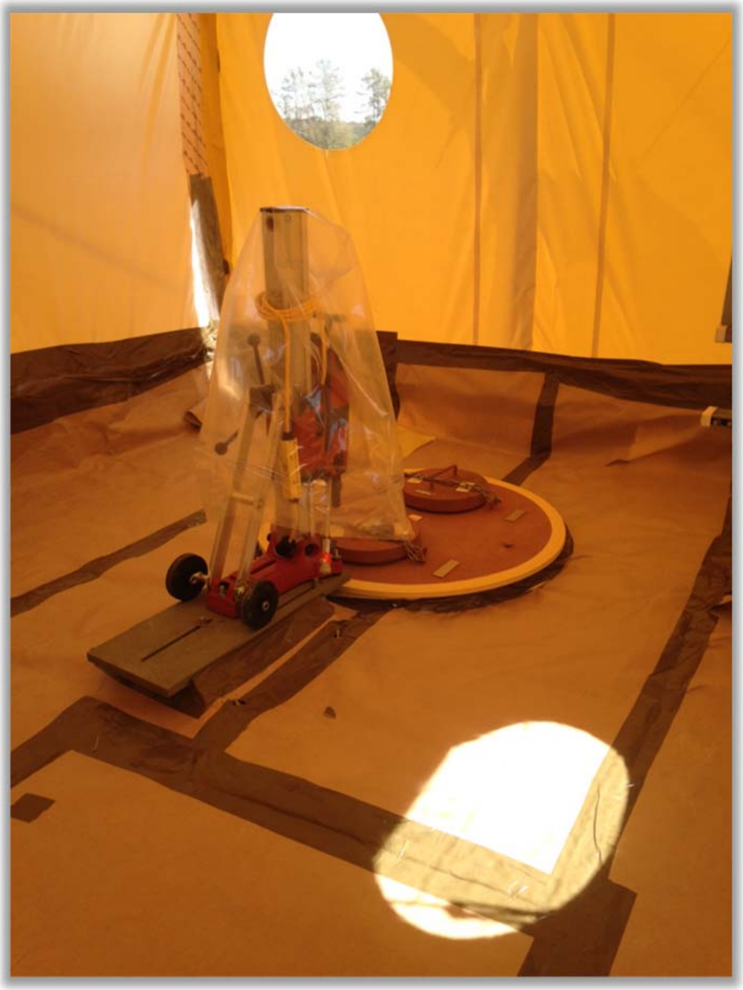
Non-Detect (ND)
Lower Explosive Limit (LEL)

Baseline IH data indicated that vapor space concentrations would require cell ventilation to ensure that concentrations within the containment hut did not exceed suspension limits.

Activities and services not associated directly with core drill operations, such as power, water, sample inerting station, and transportation packaging were established off the SDU 2A roof in low dose areas. General area dose rates on the cell roof were generally a minimum of 10 mrem/hr. To the extent practical, support personnel not required to be on the roof were asked to muster in low dose areas until needed.

The initial plan for each camera port was to obtain material from two separate holes in a single camera port. To achieve this objective, the drill was mounted on a slotted plate that was anchored to the concrete roof, as shown in Figure 5.1-2. The slotted plate could be adjusted as necessary to accommodate two drill attempts per camera port.

Figure 5.1-2: SDU 2A Core Drill Mounting Plate



5.2 Daily Entry Activities

Core drilling, sample extraction, inerting, and sample transportation activities were initiated on April 16, 2015. Since baseline vapor space data previously indicated elevated levels of some chemicals, each daily entry into SDU 2A began by initiating cell ventilation to reduce vapor space concentrations and minimize the potential for elevated levels within the containment hut. IH surveyed the cell ventilation exhaust each daily entry and ensured that ventilation exhaust was vented away from support personnel. Following cell ventilation activities, entry into the hut was made, camera port covers removed, and IH and radiological surveys performed to ensure that conditions were within limits for work activities to begin. Routine surveys were conducted throughout the core drill/extraction activities to ensure that conditions remained within specified limits to ensure worker health and safety. Mercury levels as high as 0.007 mg/m^3 were observed in the breathing zone within the containment hut shortly after entering a containment hut, but these levels dropped as the cell ventilation actively removed trapped vapors from the cell vapor space.

5.3 Camera Port B Operations

Camera port B was used for the initial drilling activities, beginning on April 16, 2015, since it was the closest port to the inerting station established off SDU 2A in a low dose area. Drilling began in the extended drill position using the DD 200 drill motor and a KOR-IT® drill bit. The initial 2 foot of drilling behavior was as expected from mock-up and training experience. However, at the 2-foot level water flow dropped significantly and the drill motor traverse speed slowed significantly. At approximately 4 feet the drill motor penetration speed slowed even further and dramatically increased drill resistance was encountered. This behavior continued until the targeted depth of approximately 6.5 feet below the grout surface was attained.

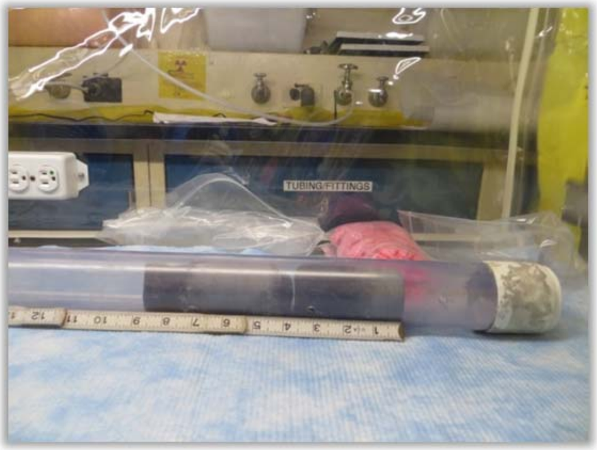
Per the initial procedure, the drill string was removed and any material remaining in the drill string was to be pushed out of the drill string back into the hole. However, material was bound in the drill string so tightly that it could not be removed safely with the tools available inside the contamination area. The drill string and bit containing the bound material was removed, sleeved to prevent spread of contamination, and staged inside the hut away from the drill activities. Per procedure, the drill mounting plate was moved to the retracted position to begin drilling the second hole in the camera port.

Since the initial bit remained plugged with material, a Diamond® drill bit was used for the second hole in camera port B. Drilling behavior in the second hole in camera port B was as expected for the initial 4 feet. At the 4-foot level both the water flow and the drill penetration speed dropped significantly. A dramatic increased drill resistance was again encountered. Since this behavior was experienced once again, the team decided to suspend drill operations and workers were removed from the hut.

Over the next several days, the core drill team preformed a post-job evaluation of the activities, including the conditions encountered on April 16, 2015. The evaluation prompted development of a new approach for restart of the core drill operations. Key changes to the restart plan included using the more powerful DD 350 drill motor to allow a greater range of operating speeds and minimize vibration, frequent removal of overlying drilled material, and flushing of the hole prior to drill motor restart.

On April 22, 2015, the team re-entered the hut to resume core drilling activities. The restart approach proved effective at reducing drill resistance, though drill penetration speed remained slower than expected until a depth of approximately 6.5 feet was attained. Drill string was removed and core retrieval was initiated. The core retrieval process was able to retrieve, package, inert, and ship approximately 9 inches of core from the hole (SDU2A-0931-B-2-L). At that depth, the retrieval tool encountered blockage and could not be inserted further into the hole. The likely cause of the blockage was small fragments of saltstone, fractured during the core drilling operation, filling the kerf. The operators described the material as “feeling like gravel”. This condition was encountered during mock-up and training activities and was an anticipated but undesired condition. Figure 5.3-1 are core sample photos taken at SRNL. The core samples in the “as received” condition is pictured left and in the “post-inspection” condition pictured right.

Figure 5.3-1: Core Sample SDU2A-0931-B-2-L



A post-job evaluation was conducted to assess the day's activities and further improve the operational plan. The improvements stemming from the extensive post-job evaluation included planned drill stoppage at specified depths, followed by material removal, followed by flushes of the hole bottom. A minor revision to the procedure was required to implement the new sequencing. In addition, since the second hole in camera port B rendered good quality sample material from the upper section of the monolith a decision was made to collect this core material as well, place it in an inerting tube, and transfer it to SRNL along with the lower cores. Based on the experience gained from the April 16, 2015 and April 22, 2015 activities, implementation of the new plan and accompanying procedure revisions, it became apparent that the time required to perform the core drill scope would increase as a result. RCO recognized the additional dose implications of this and implemented additional measures to reduce worker dose such as requiring workers in the airlock to remain in low dose areas until their airlock function was required and rotating support personnel to minimize individual dose. These improvements were implemented in camera port C. Total worker dose for camera port B operations is summarized in Table 5.3-1.

Table 5.3-1: Camera Port B Cumulative Worker Dose

Date	Activity	Dose (mrem)
16-Apr	Core Drill	357
22-Apr	Core Drill	183
23-Apr	Hut Cleanup / Next Hut Prep	47
	TOTAL→	**587**

5.4 Camera Port C Operations

Camera port C, Hole #1 drilling activities began on April 28, 2015 and used refinements developed from lessons learned from camera port B. Drilling began in the retracted drill position

using the DD 350 drill motor and the same Diamond® drill bit used in camera port B. The initial 12 inches of material was drilled, removed, and the hole flushed thoroughly. Drilling recommenced and the next 30 inches was drilled, removed, and inerted as the upper core sample (SDU2A-0931-C-1-U). The hole was once again thoroughly flushed and the drill reset at the bottom of the hole. The final 30 inches was then drilled, approximately 21 inches removed, and inerted (SDU2A-0931-C-1-L). Both core sections were shipped to SRNL.

Camera port C, Hole #2 drilling activities began on April 30, 2015. Using the operator aide, along with a desire to maximize sample material from the lower depth, the upper discard portion was targeted at 18 inches from the grout surface. Drilling began in the extended drill position using the DD 350 drill motor and the same Diamond® drill bit used since camera port B. The first 18 inches of material was drilled and 17 inches was measured as removed and contained in the extraction tool. However, the hole depth was measured at 15 inches. Had this material remained in the hole the upper core sample would have been from a region higher than anticipated. This would have also resulted in the lower sample being from a higher region than anticipated. To ensure that the samples would be from the appropriate region the next 30 inches was drilled, the top section (approximately 6 inches) was removed and discarded, then approximately 24 inches removed, and inerted as the upper core sample (SDU2A-0931-C-2-U). The hole was once again thoroughly flushed and the drill reset at the bottom of the hole. The final 30 inches was then drilled, approximately 29 inches removed, and inerted (SDU2A-0931-C-2-L). Both core sections were shipped to SRNL. Figures 5.4-1 through 5.4-4 are core sample photos taken at SRNL. Each figure shows the core samples in the "as received" condition (left picture) and in the "post-inspection" condition (right picture).

Figure 5.4-1: Core Sample SDU2A-0931-C-1-U

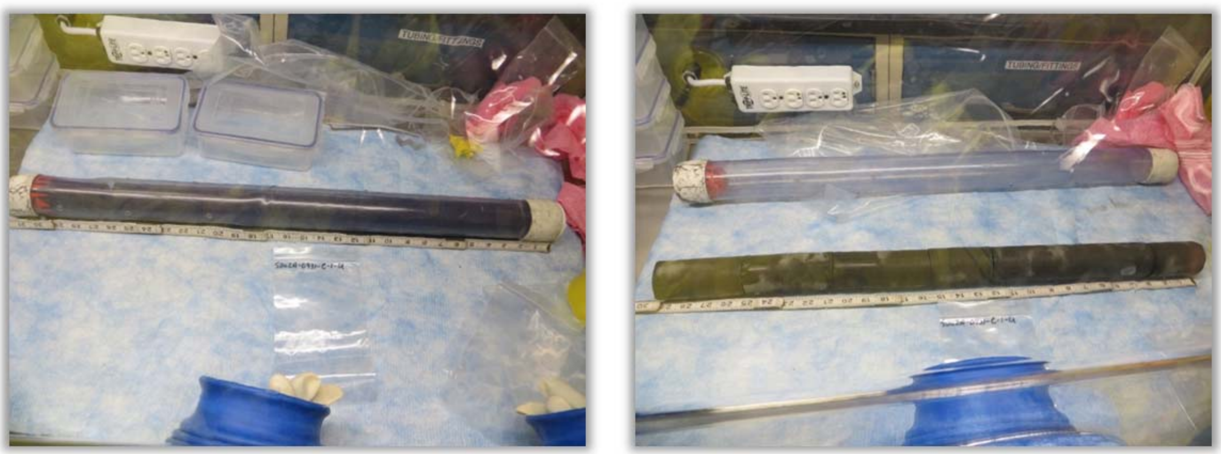


Figure 5.4-2: Core Sample SDU2A-0931-C-1-L

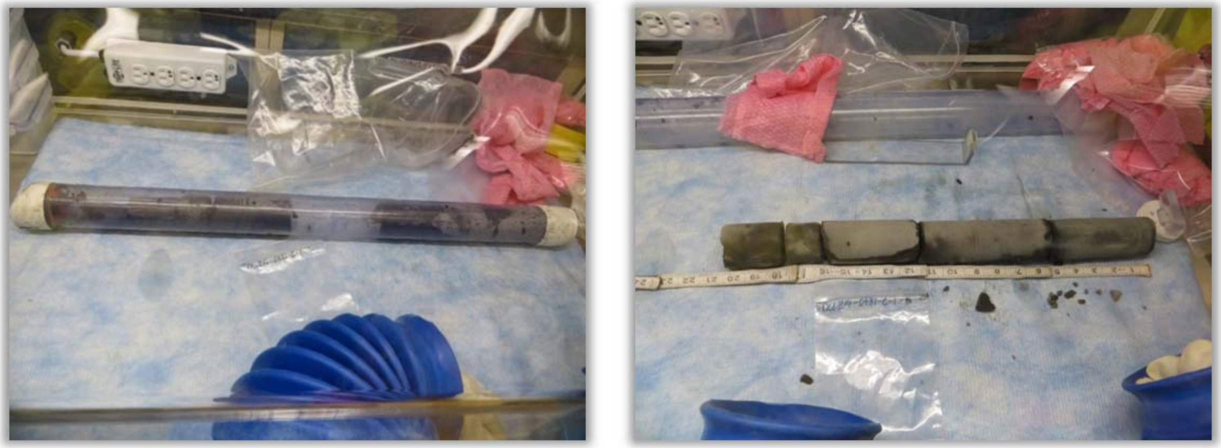


Figure 5.4-3: Core Sample SDU2A-0931-C-2-U

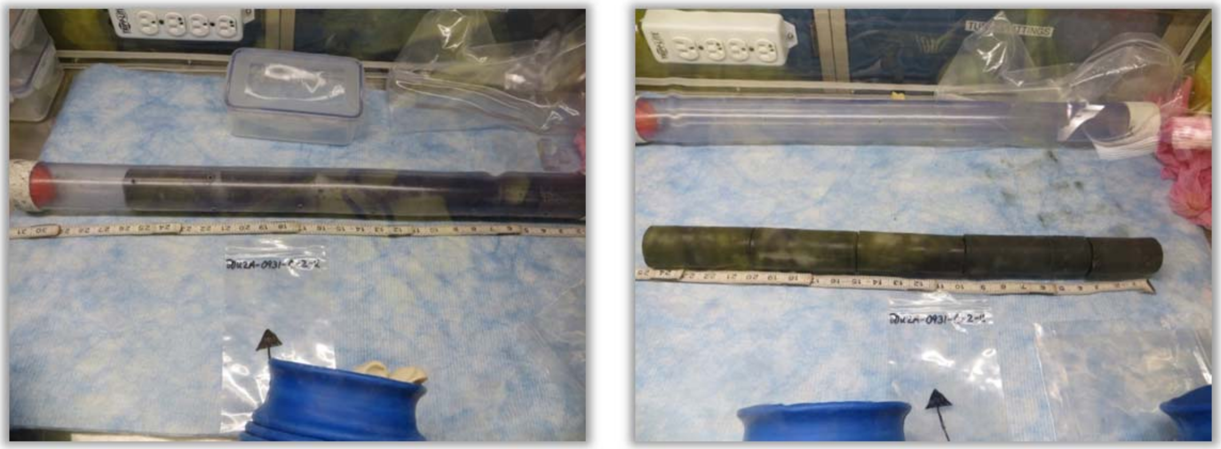


Figure 5.4-4: Core Sample SDU2A-0931-C-2-L

The new drilling and retrieval approach resulted in higher quality samples but, as expected, increased the time required to perform the work. RCO measures instituted to control worker dose maintained total dose essentially constant even though the total time to perform the work increased from the initial approach. Total worker dose for camera port C operations is summarized in Table 5.4-1.

Table 5.4-1: Camera Port C Cumulative Worker Dose

Date	Activity	Dose (mrem)
27-Apr	Hut Prep	42
28-Apr	Core Drill	271
30-Apr	Core Drill	276
	TOTAL→	**589**

5.5 Camera Port A Operations

Camera port A, Hole #1 drilling activities began on May 5, 2015 and used refinements developed from lessons learned from camera ports B and C. Drilling began in the retracted drill position using the DD 350 drill motor and the same Diamond® drill bit used in camera ports B and C. The first 24 inches of material was drilled, removed, and the hole flushed thoroughly. The next 24 inches was drilled, 22 inches was extracted, and inerted as the upper core sample (SDU2A-0931-A-2-U). The hole was once again thoroughly flushed and the drill reset at the bottom of the hole. The final 24 inches was then drilled, approximately 17 inches removed, and inerted (SDU2A-0931-A-2-L). Both core sections were shipped to SRNL.

Camera port A, Hole #2 drilling activities began on May 6, 2015. Drilling began in the extended drill position using the DD 350 drill motor and a new Diamond® drill bit. The first 15 inches of material was drilled. During removal of the drill string to extract the top 12 inches of material, it became apparent that the initial angle of the hole was not perpendicular. TNX mock-up experience demonstrated that this condition could yield poor samples. The initial drill string and bit were discarded and the bit used in Hole #1 was attached to new drill string. This was repositioned between Hole #1 and the initial attempt to drill Hole #2. The new hole will be referred to as Hole #2A. The position of Hole #2A required a small overlap of Hole #2. Since Hole # 2 did not penetrate the upper core region (i.e., 24 to 48 inches from the surface), the overlap did not impact the upper core sample region of Hole # 2A. The slowest drill speed was used to carefully establish a kerf in Hole #2A in a perpendicular direction. This approach proved successful and Hole #2A was drilled from this position.

The first 24 inches of material from Hole #2A was drilled, removed, and the hole flushed thoroughly. The next 24 inches was drilled, 24 inches was extracted, and inerted as the upper core sample (SDU2A-0931-A-1-U). The hole was once again thoroughly flushed and the drill reset at the bottom of the hole. The final 24 inches was then drilled, approximately 17 inches removed, and inerted (SDU2A-0931-A-1-L). Both core sections were shipped to SRNL.

Figures 5.5-1 through 5.5-4 are core sample photos taken at SRNL. Each figure shows the core samples in the “as received” condition (left picture) and in the “post-inspection” condition (right picture).

Figure 5.5-1: Core Sample SDU2A-0931-A-2-U

Figure 5.5-2: Core Sample SDU2A-0931-A-2-L

Figure 5.5-3: Core Sample SDU2A-0931-A-1-U

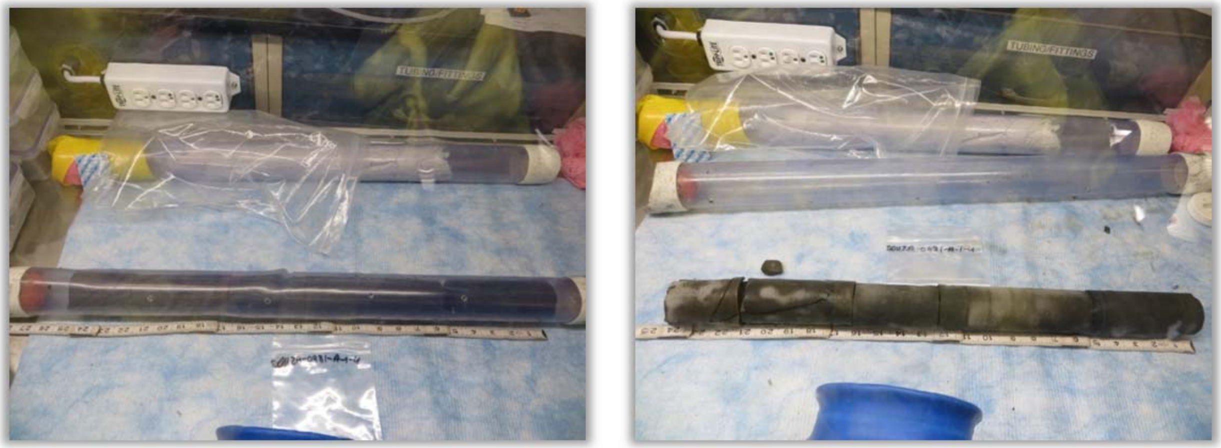


Figure 5.5-4: Core Sample SDU2A-0931-A-1-L

Total worker dose for camera port A operations is summarized in Table 5.5-1. A significant increase in dose during drilling operations in camera port A, Hole #2A was due to abandoning the initial hole placement and re-starting drill operations between Hole # 1 and the initial hole placement.

Table 5.5-1: Camera Port A Cumulative Worker Dose

Date	Activity	Dose (mrem)
4-May	Hut Prep	97
5-May	Core Drill	266
6-May	Core Drill	353
	TOTAL→	**716**

Table 5.5-2 summarizes the sequence and dates of sample activities conducted in each camera port on SDU 2A.

Table 5.5-2: SDU 2A Core Sample Summary

Date	Port	Hole #	Drill Position	Approximate Sample Length (in)	Sample Region	Sample Condition	Notes
16-Apr	B	1	1	N/A	N/A	Undefined	Material found bound in drill bit. Drill activities suspended prior to core extraction
22-Apr	B	2	2	9	Lower	Degraded	Drilled to approximately 78 inches. Extraction tube could only be inserted into top 9 inches of the target region. Hole possibly obstructed with grout fragments
28-Apr	C	1	2	29	Upper	Excellent	
28-Apr	C	1	2	20	Lower	Good	
30-Apr	C	2	1	24	Upper	Excellent	
30-Apr	C	2	1	29	Lower	Excellent	
5-May	A	1	2	22	Upper	Average	
5-May	A	1	2	17	Lower	Marginal	
6-May	A	2	1	24	Upper	Excellent	
6-May	A	2	1	17	Lower	Average	

5.6 Laboratory Receipt and Storage

All samples were shipped to SRNL the same day they were retrieved. Inerting tubes containing the samples were received into the SRNL anaerobic chamber, unpackaged, evaluated, catalogued, and the sample material repackaged into rectangular sealable plastic containers within 24 hours of receipt. Figure 5.6-1 depicts the anaerobic chamber with all samples repackaged in re-sealable containers at the completion of the core drill activities.

Figure 5.6-1: Final Sample Storage Configuration in SRNL Anaerobic Chamber

6.0 SUMMARY

Samples of emplaced saltstone were drilled, extracted, inerted, and shipped to SRNL from SDU 2A between April 16, 2015 and May 6, 2015. A total of approximately 192 inches of saltstone was transported to SRNL. Table 6.0-1 summarizes the saltstone core material retrieved from each camera port on SDU 2A.

Table 6.0-1: Saltstone Core Material Retrieved

Camera Port	Hole #1		Hole #2	
	Upper	Lower	Upper	Lower
A	22	17	24	17
B	N/A	N/A	N/A	9
C	29	20	24	29

Sample quantity and quality were evaluated by SRR and SRNL and deemed sufficient for the planned analysis using only the lower samples. Thus, core drilling activities were declared complete.

The mock-up and training activities proved valuable to develop tools, techniques, and procedural steps to maximize the probability of obtaining the quantity and quality of samples to perform the proposed analyses, while attempting to minimize worker exposure and the spread of contamination.

The time to perform the tasks increased beyond that originally planned due to the nature of the material being drilled. Changes in the drilling and retrieval approach not only increased the probability of obtaining quality samples, but also increased the time required to perform the work. As a result worker doses were higher than originally planned. Additional RCO measures were implemented to maintain worker dose as low as reasonably achievable (ALARA). Table 6.0-2 summarizes worker doses incurred from the start of core drill activities through shipment of the last samples. Final clean-up activities are not included in the doses presented.

Table 6.0-2: Saltstone Core Drill Cumulative Dose Received

Camera Port	Dose (mrem)
Preparation and Support	822
A	716
B	587
C	589
TOTAL→	**2,714**

Administrative tools developed to support project planning were effective in management of risks and ensured all aspects of the activity were prepared and fully supported when needed.

Early development of the Risk Identification and Mitigation Matrix was essential in identifying potential risks to personnel and the objectives of the project and identifying potential strategies to mitigate consequences. The Mission Status Checklist developed to implement this unique evolution in the facility ensured that all direct and support organizations were prepared with personnel, procedures, and training needed to support core drill activities.

The successful retrieval of core samples enables future analyses required to support Performance Assessment assumptions of material properties, most notably saturated hydraulic conductivity and contaminant leachate behavior. These analyses are planned to begin during FY2015.

7.0 REFERENCES

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WZI00066TANL000100, Anderson, S.H., *Operate Inerting Container - Task Analysis*, Savannah River Site, Aiken, SC, March 17, 2015.

8.0 ATTACHMENTS

ATTACHMENT 1: Saltstone Disposal Facility Core Sample Chain of Custody Records

ATTACHMENT 2: Completed Operator Aides

ATTACHMENT 1:

Saltstone Disposal Facility Core Sample Chain of Custody Records

OSR 46-307
Rev. 0
3/12/2015

SALTSTONE FORM

Savannah River Site (SRS)

SALTSTONE DISPOSAL FACILITY CORE SAMPLE CHAIN OF CUSTODY RECORD

Page 1 of 1

Disposal Cell: SDU-2A

Access Port ID: 0931B

Sample Number	Drill Position	Sample Collection Data: Sample Date	Drill Complete Time	Sample Removal Start Time	Inerting Complete Time	Approximate Sample Length (Nominal 2" Diameter): Length (ft.)	Initial	Observations and Explanation
0931B-1	2	4/22/15	1230	1105	1115	2.5	[illegible]	~~NONE~~ extraction tube w/core
0931B-2	1	4/22/15	1005	~~0930~~ 1035	1049	.75	[illegible]	~~NONE~~ Drill bit w/cores

1. Relinquished By (print)	Date	Received By (print)	3. Relinquished By (print)	Date	Received By (print)
Roy Richardson	4/22/15	B. Canham	B. Canham	4-22-15	Kim Roberts
(sign) [signature]	Time 1118	(sign) [signature]	(sign) [signature]	Time 1245	(sign) [signature]
2. Relinquished By (print)	**Date**	**Received By** (print)	**4. Relinquished By** (print)	**Date**	**Received By** (print)
(sign)	Time	(sign)	(sign)	Time	(sign)

Remarks: Suspended drilling on Thursday 4/16/15. Completed sample retrieval on Wednesday 4/22/15.
Closed per "Closure Instructions for the 150 Qt. Marine cooler", see attachment.

OSR 46-307
Rev. 0
3/12/2015

SALTSTONE FORM

Savannah River Site (SRS)

SALTSTONE DISPOSAL FACILITY CORE SAMPLE CHAIN OF CUSTODY RECORD

Page ___ of ____

Disposal Cell: SDU 2A

Access Port ID: 0931-C

Sample Number	Drill Position	Sample Collection Data: Sample Date	Drill Complete Time	Sample Removal Start Time	Inerting Complete Time	Approximate Sample Length (Nominal 2" Diameter): Length (ft.)	Initial	Observations and Explanation
SDU 2A 0931-C-1-U	2	4/28/15	10:05	10:11	10:25	2.5	RM	
SDU 2A 0931-C-1-L	2	4/28/15	11:25	11:38	11:55	2	RM	

1. Relinquished By (print)	Date	Received By (print)	3. Relinquished By (print)	Date	Received By (print)
Ricky Moxley	4/28/15	Sherry James	S. James	4/28/15	Kim Roberts
(sign) [signature]	Time 12:10	(sign) [signature]	(sign) [signature]	Time 4/28/15	(sign) [signature]
2. Relinquished By (print)	**Date**	**Received By** (print)	**4. Relinquished By** (print)	**Date**	**Received By** (print)
(sign)	**Time**	(sign)	(sign)	**Time**	(sign)

Remarks:

Section	Core Length (in)	Hole Depth (in)
1	12	12
2	29	41.5
3	23	70

Closed per Attached closure Instructions for the 150 Qt. Marine Cooler

OSR 46-307
Rev. 0
3/12/2015

SALTSTONE FORM

Savannah River Site (SRS)

Page 1 of 1

SALTSTONE DISPOSAL FACILITY CORE SAMPLE CHAIN OF CUSTODY RECORD

Disposal Cell: SDU 2A   Access Port ID: 0931-C

Sample Number	Drill Position	Sample Collection Data: Sample Date	Drill Complete Time	Sample Removal Start Time	Inerting Complete Time	Approximate Sample Length (Nominal 2" Diameter): Length (ft.)	Initial	Observations and Explanation
SDU 2A 0931-C-2-U	1	4/30/15	10:39	1044	10:59	2	RM	TOP 21" DISCARDED TOP OF CORE ELEVATION ~19.5 ft
SDU 2A 0931-C-2-L	1	4/30/15	12:00	12:10	12:30	2.5	RM	

1. Relinquished By (print)	Date	Received By (print)	3. Relinquished By (print)	Date	Received By (print)
R. Moxley	4/30/15	S. James	S. James	4/30/15	Kim Roberts
(sign) R. Moxley	Time 1242	(sign) S. James	(sign) S. James	Time 1330	(sign) Kim Roberts
2. Relinquished By (print)	**Date**	**Received By** (print)	**4. Relinquished By** (print)	**Date**	**Received By** (print)
(sign)	**Time**	(sign)	(sign)	**Time**	(sign)

Remarks:

SECTION	CORE LENGTH (in)	HOLE DEPTH (in)
1	~21	~21
2	~24.5	~48
3	28.5	N/A

Closed per Attached Closure Instructions for the 150 QT Marine Cooler.

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Rev. 0
3/12/2015

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River Site (SRS)

SALTSTONE DISPOSAL FACILITY CORE SAMPLE CHAIN OF CUSTODY RECORD

Page 1 of 1

Disposal Cell: SDU 2A **Access Port ID:** 0931-A

Sample Number	Drill Position	Sample Collection Data: Sample Date	Drill Complete Time	Sample Removal Start Time	Inerting Complete Time	Approximate Sample Length (Nominal 2" Diameter): Length (ft.)	Initial	Observations and Explanation
SDU 2A 0931-A-2-U	2	5/5/15	10:19	10:30	10:46	2	RM	
SDU 2A 0931-A-2-L	2	5/5/15	11:47	11:55	12:11	1.5	RM	

1. Relinquished By (print)	Date	Received By (print)	3. Relinquished By (print)	Date	Received By (print)
R. Moxley	5/5/15	S. James	S. James	5/5/15	Kim Roberts
(sign) R. Moxley	Time 12:30	(sign) S. James	(sign) S. James	Time 5/5/15	(sign) Kim Roberts
2. Relinquished By (print)	**Date**	**Received By** (print)	**4. Relinquished By** (print)	**Date**	**Received By** (print)
(sign)	**Time**	(sign)	(sign)	**Time**	(sign)

Remarks:
CLOSED PER ATTACHED CLOSURE INSTRUCTIONS FOR THE 150 QT. MARINE COOLER

TOP OF UPPER CORE = 24 in FROM SURFACE

TOP OF LOWER CORE: APPROXIMATELY = 47 in FROM SURFACE

OSR 46-3..
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3/12/2015

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SALTSTONE DISPOSAL FACILITY CORE SAMPLE CHAIN OF CUSTODY RECORD

Sa...nah River Site (SRS)
Page 1 of 1

Disposal Cell: SDU 2A **Access Port ID:** 0931-A

Sample Number	Drill Position	Sample Collection Data						Observations and Explanation
		Sample Date	Drill Complete Time	Sample Removal Start Time	Inerting Complete Time	Approximate Sample Length (Nominal 2" Diameter)		
						Length (ft.)	Initial	
SDU 2A 0931-A-1-U	1	5/6/15	11:53	11:57	12:10	2	KR	
SDU 2A 0931-A-1-L	1	5/6/15	1330	1342	13:53	1.5	KR	

1. Relinquished By (print)	Date	Received By (print)	3. Relinquished By (print)	Date	Received By (print)
R. Moxley	5/6/15	J. David Hewett			
(sign) [signature]	Time 1354	(sign) [signature]	(sign)	Time	(sign)
2. Relinquished By (print)	**Date**	**Received By** (print)	**4. Relinquished By** (print)	**Date**	**Received By** (print)
J. David Hewett	5/6/15	Kim Roberts			
(sign) [signature]	Time 1452	(sign) [signature]	(sign)	Time	(sign)

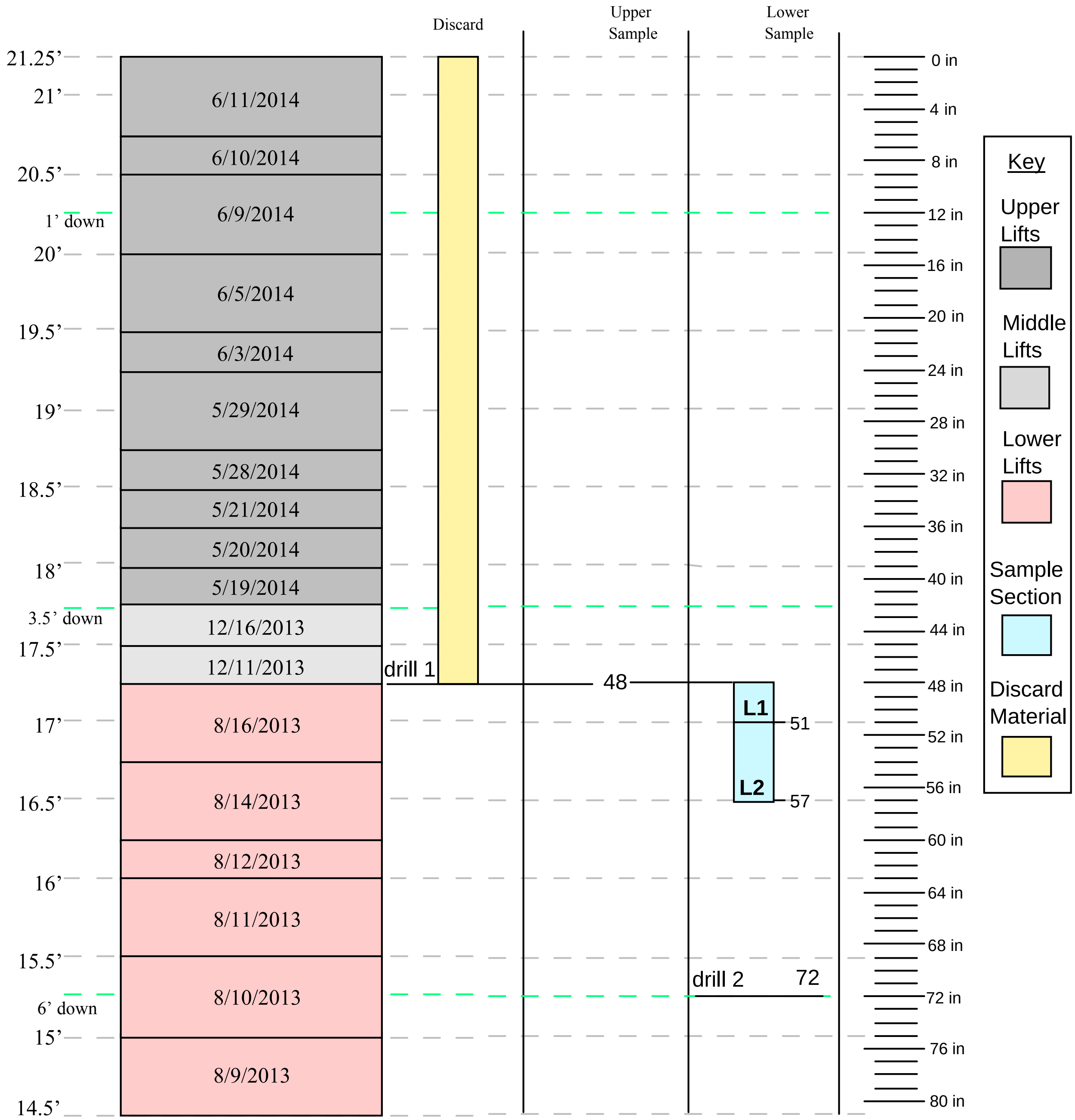
Remarks:
CLOSED PER ATTACHED CLOSURE INSTRUCTIONS FOR THE 150 QT. MARINE COOLER
TOP OF UPPER CORE @ 24 in FROM SURFACE
TOP OF LOWER CORE @ ~48 in FROM SURFACE

ATTACHMENT 2:

Completed Operator Aides

SDU 2A Core Drilling

SDU 2A Port: B   Drill Position: 2   Date: April 22, 2015

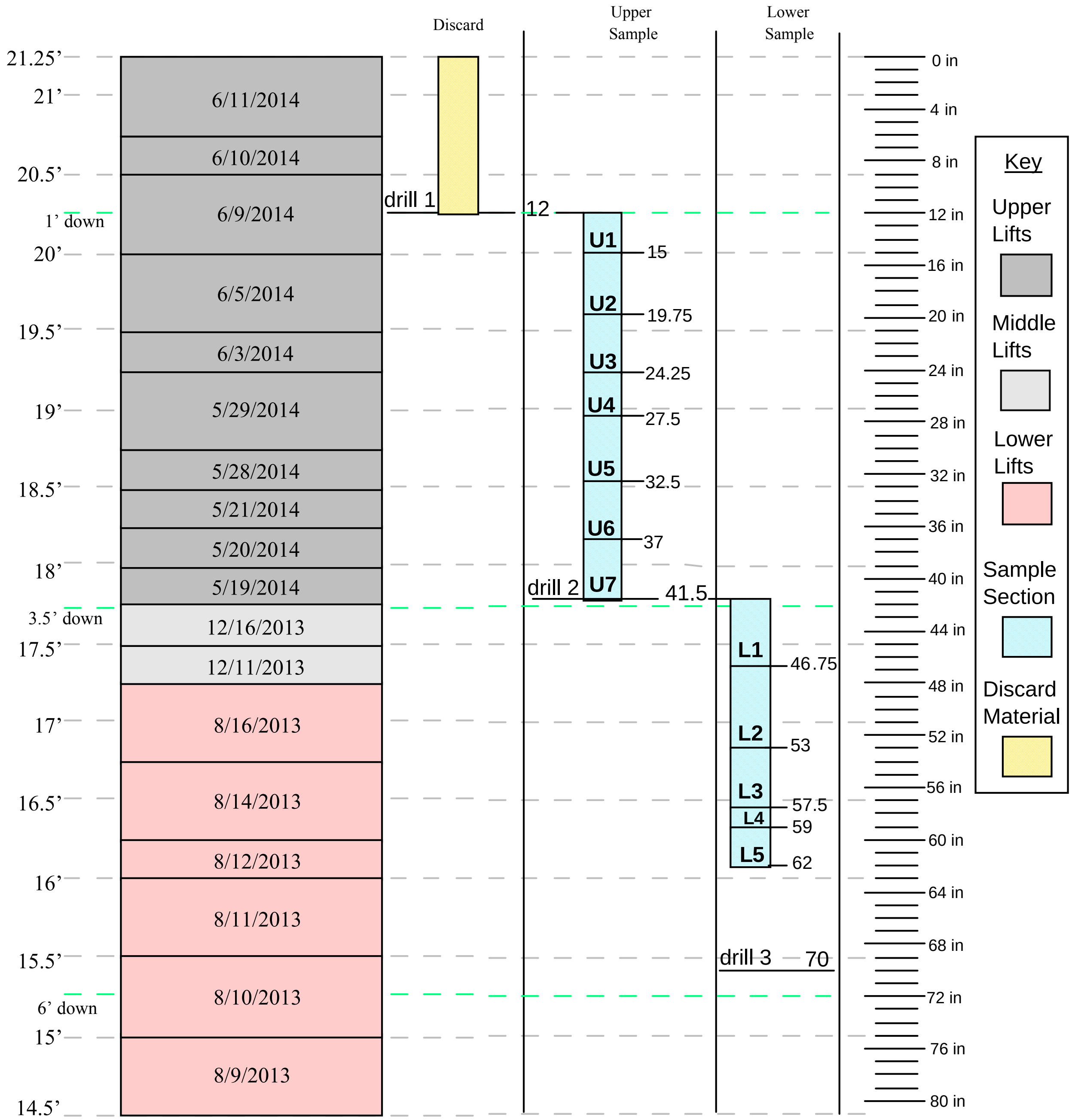


Notes:

Discard	Upper Sample	Lower Sample

SDU 2A Core Drilling

SDU 2A Port: C Drill Position: 2 Date: April 28, 2015



Notes:

Discard	Upper Sample	Lower Sample
No notes.	Sample quality is excellent. Drill behavior and speed similar to TNX mock-up. Extraction of the core went smoothly and quickly. Core material appeared solid and completely in tact, comparable to TNX experience.	Top 12 inches excellent quality; Lower 9 inches - variable quality. Drill behavior began to exhibit reaction to the "hardness" of the saltstone at depth. (continued on next page)

SDU 2A Core Drilling

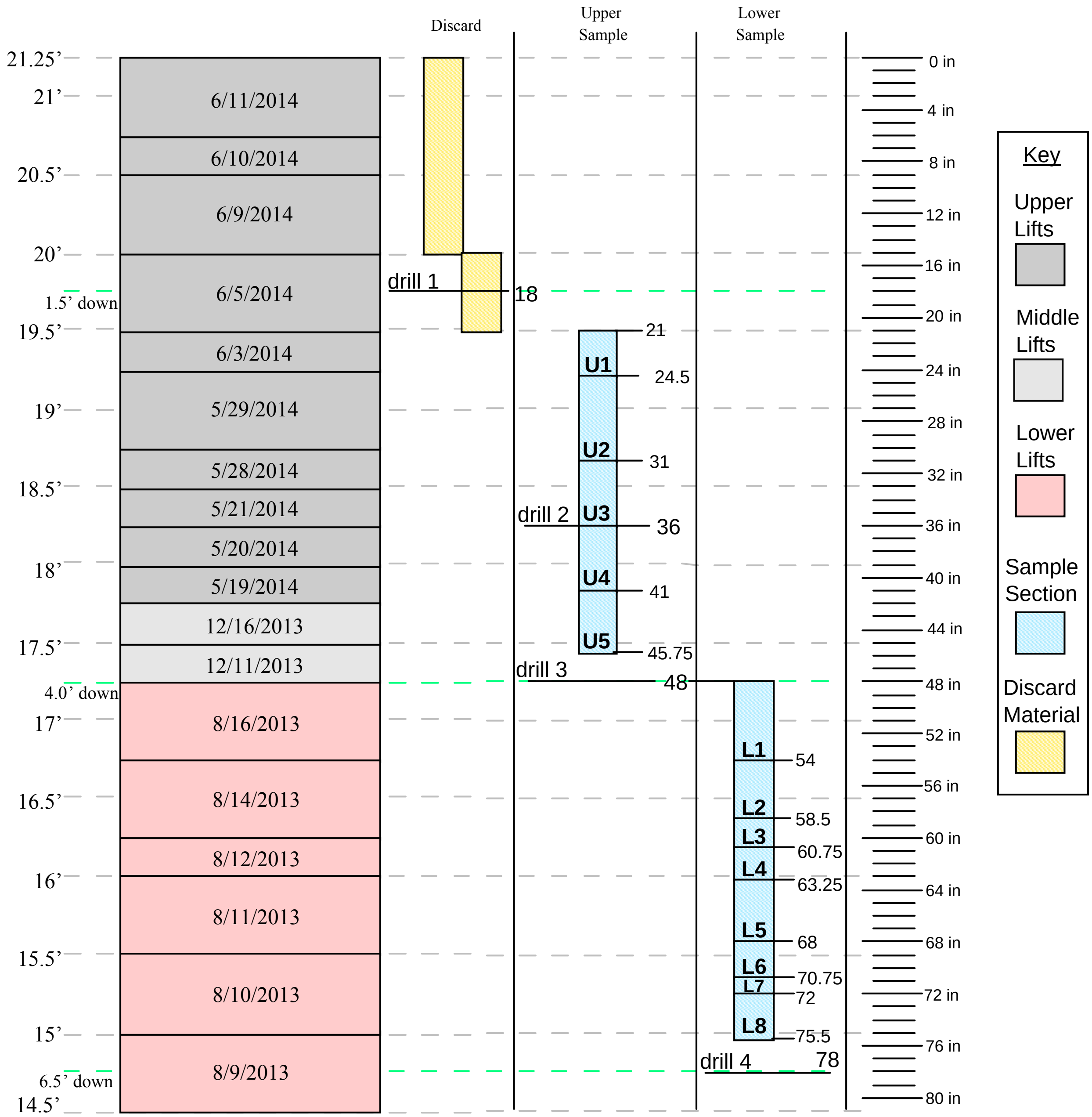
SDU 2A Port: C   Drill Position: 2   Date: April 28, 2015

Notes Continued:

Discard	Upper Sample	Lower Sample
		Drill was geared down, slowing the rotational speed to adjust for drill behavior. Extraction of the core went somewhat smoothly, but required several attempts to reach the depth finally retrieved. The upper 16 inches of core material appeared solid and completely in-tact, comparable to TNX experience. The lower 7 inches of core material was variable in quality. Some sections appeared in tact while others appeared to be either deteriorated somewhat or skewed inside the extraction tube.

SDU 2A Core Drilling

SDU 2A Port: C   Drill Position: 1   Date: April 30, 2015

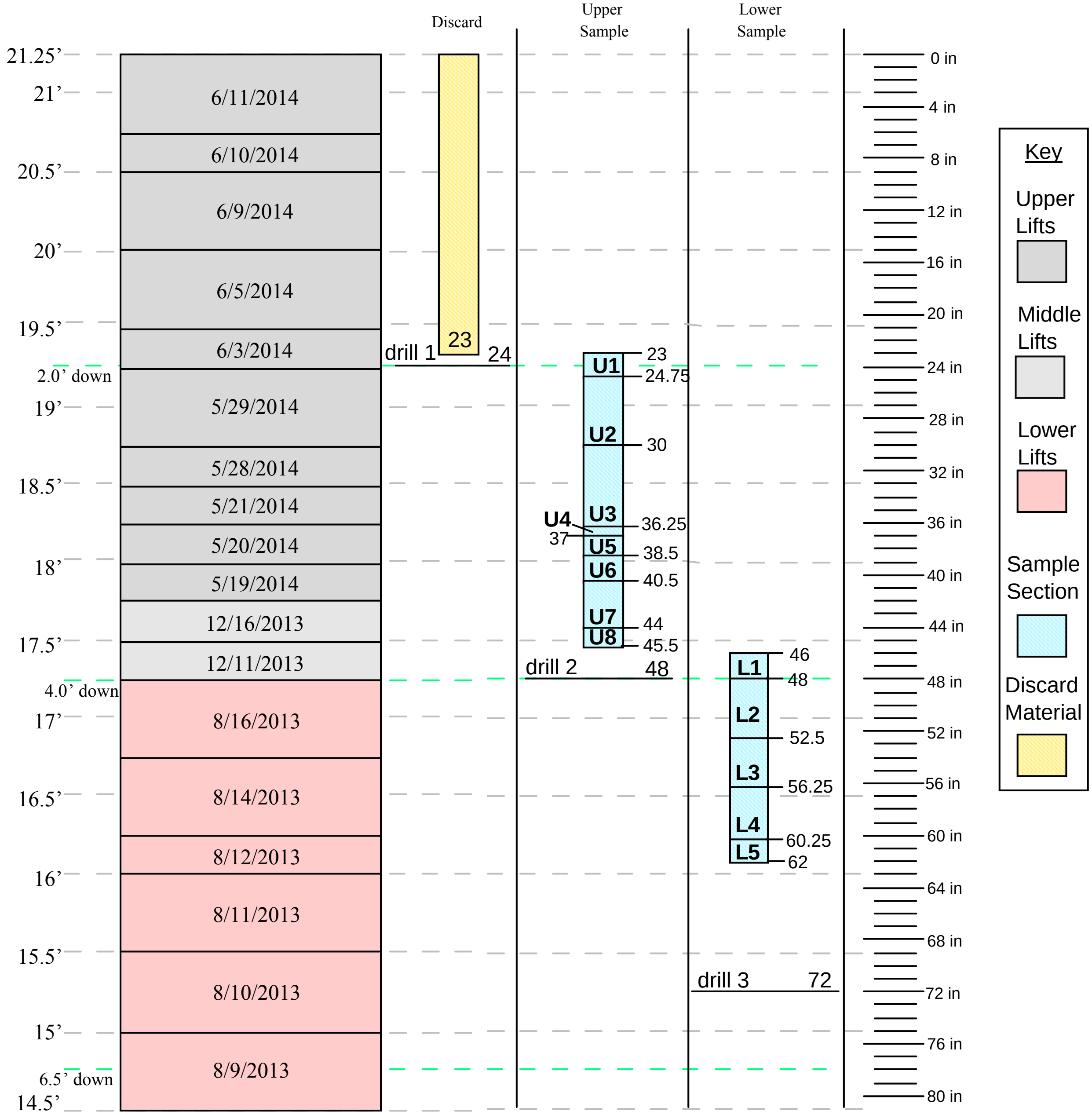


Notes:

Discard	Upper Sample	Lower Sample
First sample section length is 17 inches, hole depth 15 inches. Material has chips (some chips are suspected to have turned in the extraction tube).	Retrieved and discarded additional 6 inches off the top. Upper sample section 24 inches, hole depth 48 inches.	Lower core section length 28.5 inches. Excellent quality. Much like the upper section and clearly better than drill position 1.

SDU 2A Core Drilling

SDU 2A Port: A   Drill Position: 2   Date: May 5, 2015

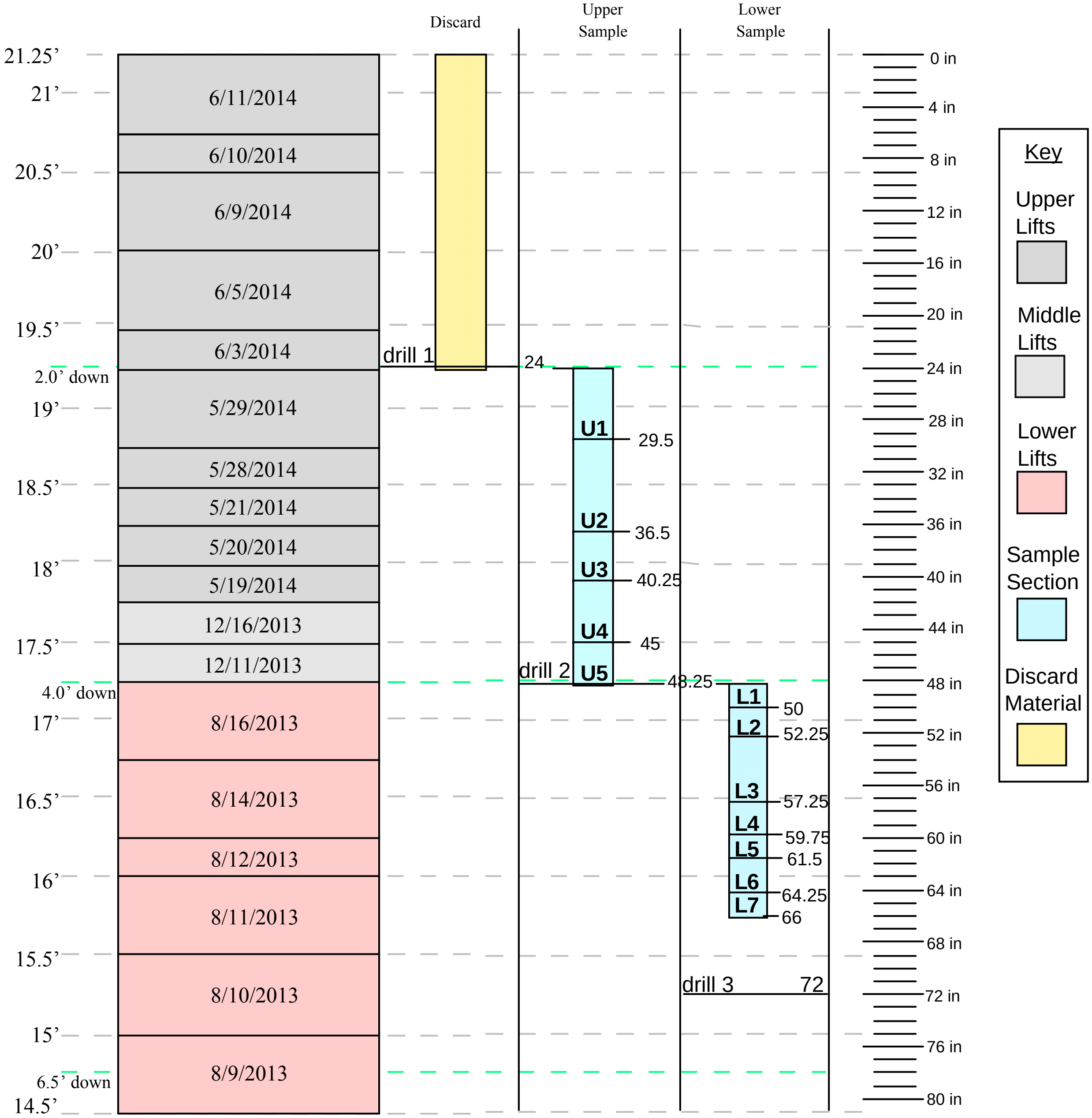


Notes:

Discard	Upper Sample	Lower Sample
	Approximately 1/2 inch below U8 was not usable.	

SDU 2A Core Drilling

SDU 2A Port: A Drill Position: 1 Date: May 6, 2015



Notes:

Discard	Upper Sample	Lower Sample