ROCKY MOUNTAIN ARSENAL

Annual Covers Report for Integrated Cover System 2015

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U.S. Department of the Army
Shell Oil Company

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APPENDICES (ALL ON CD)

ACRONYMS

ACR	Annual Covers Report
AMA	Army Maintained Areas
BBM	Biota Barrier Material
BGS	Below Ground Surface
CAT	Complex (Army) Trenches
CPSM	Cover Perimeter Survey Monuments
DCN	Design Change Notice
FY14	Fiscal Year 2014
FY15	Fiscal Year 2015
ICS	Integrated Cover System
LTCP	Long-Term Care Plan
NRAP	Non-Routine Action Plan
O&M	Operations and Maintenance
OMC	Operations and Maintenance Contractor
PMC	Program Management Contractor
QA/QC	Quality Assurance/Quality Control
RAP	Recycled Asphalt Pavement
RCRA	Resource Conservation and Recovery Act
RMITS	Records Management Information Technology System
SCMMS	Soil Cover Moisture Monitoring System
SDT	Shell Disposal Trenches
SOP	Standard Operating Procedure
USFWS	United States Fish and Wildlife Service
VWC	Volumetric Water Content

EXECUTIVE SUMMARY

This 2015 Annual Covers Report (ACR) for the Integrated Cover System (ICS) at the Rocky Mountain Arsenal Federal Facility Site was prepared in accordance with the *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan,* Revision 2 (LTCP) (TtEC 2011). The purpose of this ICS ACR is to document cover inspection results and maintenance activities performed on the ICS during the reporting period, and to describe future plans to improve or sustain cover condition. This ICS ACR documents cover maintenance-related activities performed on the ICS Army Maintained Area (AMA) during the 2015 fiscal year (FY15), that is, between October 1, 2014 and September 30, 2015.

Revegetation and irrigation of the ICS AMA were completed in 2009 and the site is currently in the Interim Operations and Maintenance (O&M) Period defined in Section 1.0 of the LTCP. This report addresses the sixth year of Interim O&M for the ICS since construction was completed in early 2010.

The Army's records/data management contractor, Records Management Information Technology System (RMITS), maintained a Soil Cover Moisture Monitoring System (SCMMS) database that manages data produced by various types of instrumentation installed in the Shell Disposal Trenches (SDT) Resource Conservation and Recovery Act (RCRA)-Equivalent Cover. The database contains precipitation data collected from a rain gauge located near Lysimeter 002, percolation data collected from tipping buckets located in each of the four SDT lysimeter manholes, and soil moisture and temperature data; all of which are routinely reported in separate quarterly reports. The combined total precipitation measured between October 1, 2014 and September 30, 2015 was 18.62 inches. Precipitation data are provided in Appendix A, SDT percolation data are provided in Appendix B, and soil moisture and temperature data are provided in Appendix C.

In general, the cover on ICS was in good condition throughout FY15. Cover deficiencies observed during the reporting period included occasional erosion rills, differential settlement, noxious or undesirable weeds, areas of poor vegetation, and silt in the concrete lined channels. Cover inspection documentation is located in Appendix E of this report, and maintenance and repair documentation is located in Appendix F. Soil cover thickness loss for FY15 was within the compliance standard and the non-routine action trigger level.

Table 7.0-2 presents rolling nine-month percolation totals for comparison to the non-routine action trigger level of 1.0 mm, and Table 7.0-3 presents twelve-month rolling totals for comparison to the compliance standard of 1.3 mm/year.

As shown in Tables 7.0-2 and 7.0-3 all ICS lysimeters, except Lysimeters 001, 002, 003, and 003A were well below the non-routine action trigger level and the compliance standard for the entire year. The excessive percolation collected by the Shell Disposal Trenches (SDT) Lysimeters is a part of an ongoing investigation focusing on the cover soil and root density of the vegetation.

The first objective of the SCMMS, or moisture probe system, is to demonstrate the development of a capillary barrier between the cover soil and the underlying material. During FY15 four SCMMS Data Evaluation Summaries were prepared by Army contractors (Navarro 2014a, 2015a, 2015b, and 2015c) that provide evidence of a functional capillary barrier at the SDT RCRA-Equivalent Cover. The formation of a capillary barrier can be seen in the SCMMS data by analyzing the behavior of soil moisture in the lower portions of the cover, and also by comparing soil moisture and percolation data from Lysimeter 003A with those of the other SDT lysimeters.

The 2015 Vegetation Performance Assessment was conducted in accordance with Standard Operating Procedure (SOP) 002 of the LTCP, Revision 2. Results of the assessment are summarized on Table 6.0-1. Appendix D includes additional tables that provide cover and frequency by species, expanded vegetation performance assessments, sample adequacy checks, and raw transect data. Separate assessments were performed on the ICS RCRA-Equivalent Cover and on the ICS 2-Foot and 3-Foot Soil Cover. In all, data from 45 vegetation transects were collected. Figures 1 and 2 in Appendix D illustrate transects sampled on the ICS. The dates on which the assessments were conducted were inside the range specified in LTCP SOP 002 (between August 1 and September 15). Total live vegetation values were well above the compliance standard of 25 percent for all areas. The two-year average of total ground cover was also comfortably above the compliance standard of 50 percent for all cover areas, and the three-year running average of total ground cover was also well above the compliance standard of 67 percent.

Cost incurred performing Interim O&M of the ICS AMA during FY15, including inspections, repairs, and maintenance was $134,588. A complete budget for FY16 has not been approved as of the issuance of this report. However, the FY16 budget is estimated to be approximately $243,390.

In summary and based on the information presented in this report, corrective action is required regarding percolation performance of the SDT RCRA-Equivalent Cover. The Army/Shell, in cooperation with the Regulatory Agencies, is developing an investigation and evaluation process that will lead to corrective action. Corrective actions for excess percolation have not been required prior to April 21, 2015. However, now that the percolation compliance standard has been exceeded at Lysimeters 001, 002, and 003, the SCMMS data are being used in the evaluation process. Data from the SCMMS will be combined with other information to determine the cause of the excessive percolation, to assist in selection of the corrective action, and to assess the effectiveness of the corrective action.

Recommendations for Fiscal Year 2016 (FY16) include continued diligence in weed control efforts; overseeding of areas with poor vegetative vigor; the areas already identified with differential settlement will continue to be monitored and the larger diameter holes will be repaired and seeded; continued examination and repair of erosion rills or gullies, ponding areas, and localized settlement; and the percolation exceedance at the SDT lysimeters will continue to be monitored and investigated. These recommendations are planned for FY16 and will be discussed in the 2016 ICS ACR.

1.0 INTRODUCTION

This 2015 Annual Covers Report (ACR) for the Integrated Cover System (ICS) at the Rocky Mountain Arsenal Federal Facility Site was prepared in accordance with the *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan,* Revision 2 (LTCP) (TtEC 2011). The purpose of this ICS ACR is to document cover inspection results and maintenance activities performed on the ICS during the reporting period, and to describe future plans to improve or sustain cover condition. This ICS ACR documents cover maintenance-related activities performed on the ICS Army Maintained Area (AMA) during the 2015 fiscal year (FY15), that is, between October 1, 2014 and September 30, 2015.

The ICS is currently in the Interim Operations and Maintenance (O&M) Period defined in Section 1.0 of the LTCP. This report addresses the sixth year of Interim O&M for the ICS since construction was completed in early 2010.

2.0 METHODOLOGY

The Resource Conservation and Recovery Act (RCRA)-Equivalent, 2-Foot, and 3-Foot Covers and associated non-cover areas within the outside shoulder of the perimeter access road, collectively referred to as the ICS AMA, were inspected, monitored, repaired, and maintained in accordance with the LTCP, Revision 2 and related Standard Operating Procedures (SOPs), and the Soil Cover Moisture Monitoring System (SCMMS) O&M Plan (TtEC 2006). The results of inspections and monitoring of vegetation, percolation, and cover soil thickness were used to verify cover performance and to trigger cover maintenance and repair work.

2.1 Type I and Type II Cover Inspections

The procedure for inspecting soil cover conditions and infrastructure features is detailed in LTCP SOP 001, *Cover Conditions Inspections.* This SOP includes procedures for Type I and Type II cover inspections, as well as a procedure for collecting cover soil thickness data, which were used to evaluate the actual cover thickness against the cover thickness compliance standard. Where feasible, multiple inspections were conducted concurrently for efficiency and to minimize traffic on the cover. For example, Type I inspections were implemented concurrently with the Type II inspections. Copies of the cover inspection forms are provided in Appendix E.

2.2 Vegetation Performance Assessment

LTCP SOP 002, *Cover Vegetation Performance Assessment*, provides the procedure to collect and document vegetation conditions for assessment and future management. This SOP includes a procedure for conducting the annual quantitative vegetation survey. Data collected using LTCP SOP 002 was used to evaluate the vegetation against the vegetation performance standard. The results of the evaluation are presented in Section 7.1.1. Refer to Appendix D for photos and other information collected during the 2015 Vegetation Performance Assessment.

2.3 Percolation Monitoring

The procedure for collecting percolation data and operating the lysimeters is provided in LTCP SOP 003, *Percolation Monitoring System Data Collection and Operation*. Data collected under LTCP SOP 003 were used to evaluate the measured percolation against the percolation compliance standard. The results of the evaluation are presented in Section 6.2. Monthly percolation measurements from all ICS lysimeters are provided in Table 7.0-1. Percolation data collected by automated tipping buckets in the Shell Disposal Trenches (SDT) RCRA-Equivalent Cover lysimeters are also provided in Appendix B.

2.4 Soil Cover Moisture Monitoring System

The SCMMS was operated and maintained in accordance with the SCMMS O&M Plan and associated SOPs. The SCMMS database, which manages data produced by various types of instrumentation installed in the SDT RCRA-Equivalent Cover, was maintained by the Army's Records Management Information Technology System Contractor. The database contains precipitation data collected from a rain gauge located near Lysimeter 002, percolation data collected from tipping buckets located in each of the SDT cover lysimeter manholes, and soil moisture and temperature data; all of which are routinely reported in separate reports. Information regarding the SCMMS is presented in Section 8.0, and moisture sensor data are located in Appendix C. The precipitation and percolation data are described in Sections 3.0 and 6.0, respectively.

2.5 Maintenance and Repair Activities

Routine maintenance and repair activities are listed in Table 3.2-1 of the LTCP, while conditions requiring non-routine actions are listed in Table 3.2-2 of the LTCP. Routine and non-routine maintenance and repair activities performed in FY15 are discussed in Section 4.0 of this report.

3.0 PRECIPITATION AND WEATHER CONDITIONS

Precipitation is recorded at the SDT RCRA-Equivalent Cover by a rain gauge located near Lysimeter 002. The combined total precipitation measured between October 1, 2014 and September 30, 2015 was 18.62 inches. Precipitation data are provided in Appendix A.

The climate backdrop for the Rocky Mountain Region for the fall months can be variable and 2014 was no different. October was warmer and drier than average, November was colder and slightly wetter than normal, and December wrapped up to be somewhat wetter and warmer than normal. An Arctic air mass entrenched the region with high temperatures failing to make it into the teens from November 11th through the 13th. This is the first time since records have been taken in Denver beginning in 1872 that there were three consecutive days with max temperatures below 20 degrees F in the month of November.

The winter months of 2015 proved to be warmer than the historical norm. January was warmer and drier than normal, February was wetter and slightly warmer than normal, and March wrapped up to be warmer and drier than normal. February recorded 22.4 inches of snowfall which is 16.7 inches above normal. This made February 2015 the snowiest February on record and broke the old record of 22.1 inches set back in 1912.

The spring months typically bring unpredictable weather conditions and 2015 was no different. April was warmer and wetter than normal, May was wetter and colder than normal, and June wrapped up to be warmer and wetter than normal. The total precipitation for the month of April was 2.51 inches which was 0.80 inches above the historical norm of 1.71 inches. May recorded 4.83 inches of precipitation which was 2.71 inches above normal and June recorded 4.89 inches of precipitation which was 2.91 inches above normal

The summer months also brought variable weather conditions to the Rocky Mountain Region in 2015. July was slightly cooler with near normal precipitation, August was much warmer and drier, and September set a new record for temperature and was also drier than average. The average temperature at Denver International Airport for the month of September was 69.4 degrees which was 6.0 degrees above normal. This makes September 2015 the warmest September on record.

4.0 SOIL COVER ASSESSMENT, MAINTENANCE AND REPAIR ACTIONS

During FY15, the condition of the ICS AMA was inspected during the Type I and Type II inspections in accordance with the LTCP. Type I inspections were conducted on December 3, 2014, March 11, 2015, May 13, 2015, June 3, 2015, July 1, 2015, and August 5, 2015. The spring Type II inspection was conducted on April 1, 2015 and the fall Type II inspection was conducted on November 4, 2015. The fall Type II inspection was delayed because the USFWS was going to conduct a controlled burn on the ICS AMA in October 2015, which would facilitate visual inspection of the cover surface. However, the controlled burn was cancelled due to unfavorable weather conditions, smoke permit restriction, and other Region VIII control measures. Please refer to NRAP-2015-007 for detailed information regarding the fall 2015 Type II inspection.

One significant storm event occurred in FY15 where the RMA received more than one inch of precipitation in a 24-hour period. The date of this event recorded by the Lysimeter 002 rain gauge was June 4, 2015. However, post-storm inspections are triggered by a second rain gauge located near the Lime Basins Metering Building, which reports 24-hour precipitation totals in real time. The Lime Basins rain gauge recorded three significant storm events in FY15. The significant storm events recorded by the Lime Basins rain gauge occurred on April 17, 2015, June 4, 2015, and July 9, 2015. The Operations and Maintenance Contractor (OMC) staff drove the perimeter road and access roads following each significant storm, as recorded by the Lime Basins rain gauge, and documented all observations in the project logbook. Post-storm inspections were performed when field conditions improved, minimizing the potential for damaging the cover. The post-storm inspections were performed on May 13, 2015, July 1, 2015, and August 5, 2015.

The soil covers were inspected for the following:

- Surface Conditions
- Vegetative Cover
- Engineering and Access Controls
- Monthly Percolation Monitoring - Lysimeters
- Surface Drainage Controls
- Erosion/Settlement Monuments
- Other deleterious conditions

In general, the cover on ICS was in good condition throughout FY15. Observations made during the reporting period are described below and cover inspection documentation is located in

Appendix E. The repair actions associated with these observations are shown on Figure 4.0-1 and are also described below.

Ponding Areas or Other Conditions that Could Interrupt Cover Drainage: In October 2014, there were numerous repairs made to holes or other conditions that could interrupt cover drainage. The following points were repaired by filling the identified area with cover soil and then hand seeding the repaired area:

The areas repaired from the ICS fall 2013 Type II inspection include "waypoint 5 sinkhole" near point 540O on the east transects, "waypoint 3 sinkhole" near point 744N on the east transects, and "waypoint 1 localized settlement" near point 555K on the east transects.

The areas repaired from the ICS spring 2014 Type II inspection include "1-hole" near point 556J on the east transects, "6-washout/seed" near point 554K on the east transects, "16-hole to fill" near point 547O on the east transects, and "020-hole to fill" near point 539O on the east transects.

The areas repaired from the ICS fall 2014 Type II inspection include "001-hole" near point 702N on the west transects and "sinkhole" near point 743N on the east transects.

The area repaired from the ICS June 2014 Type I inspection includes the depression that was identified just northwest of Channel 16.

The holes that were observed at the outlet end of Channel 6 during the March 2015 Type I inspection were repaired in October 2015.

Differential Settlement: In October 2014, some of the larger diameter holes located in the northern CAT area of ICS were backfilled using cover soil and then hand seeded. This was in response to these larger diameter holes posing a health and safety concern for employees and wildlife.

An area of differential settlement was identified near point 524M on the west transects during the ICS spring 2015 Type II inspection. In October 2015, this hole was backfilled using cover soil and then hand seeded.

Erosion/Settlement Monuments: In the fall ICS 2013 Type II inspection, erosion monuments ER51, ER74, and ER83 were documented to be in need of additional fill so that they match the surrounding grade around the monuments. In October 2014, these monuments had cover soil hand graded around the monument and then were hand seeded to complete the repair.

It was noted in the 2015 spring Type II inspection that the cap for ER29 was loose and needed to be glued back on. This repair was not made in FY15 and will therefore be discussed in the 2016 ICS ACR.

Cover Perimeter Survey Monuments: The Cover Perimeter Survey Monuments (CPSM) were inspected and surveyed in November 2014 as a part of the Five Year Review. During this inspection, two CPSM tags were noted to need repair. The tag for CPSM 21 was noted to be bent and the tag for CPSM 62 was missing. These repairs did not happen in FY15 and will therefore be discussed in the 2016 ICS ACR.

Bare Areas of Vegetation: A poor area of growth was observed around Lysimeter 003. This area was overseeded using a drill seeder in November 2014.

The following points from the spring 2014 Type II inspection were mowed prior to seeding in March 2015: 551P, 750S, and 748S. In April 2015, these areas were overseeded using a drill seeder.

The point near 516Q from the spring 2014 Type II inspection was evaluated by the OMC Vegetation Expert in March 2015 and deemed to have enough seeded grass species and was therefore removed from the maintenance list.

An area south of Channel 17 and on and around the Long Term Cover Soil Stockpile were mowed in March 2015 to knock down the weedy species. In April 2015, the bare area on the Long Term Cover Soil Stockpile was seeded using a drill seeder. This area was bare due to soil being excavated to use for miscellaneous repair areas.

Noxious or Undesirable Weeds: Canada and Musk thistles and bindweed were identified on many areas of ICS. Weed control efforts were performed as needed during FY15.

A combination of herbicides were applied as a ground clear in March 2015 along the shoulders of the ICS roadways, the cattle guards, the well pads on the Lime Basins access road, around the Lime Basins Metering Building, and gate entrances. The herbicide combination included Diuron, Perspective, and Roundup.

The herbicides 2-4D and Banvel were applied to target broad leaf weedy species on the Long Term Cover Soil Stockpile and adjacent areas and also along the south side of Channel 17 in June 2015.

In August 2015, the herbicide Esplanade, that targets cheatgrass, was applied south of Channel 17 and on and around the Long Term Cover Soil Stockpile.

Lysimeters: In October 2014, standing water was pumped from the following lysimeter manholes: 006, 012, 013, and 014. In September 2015, Lysimeters 004, 005, and 012 had the standing water inside of the lysimeter manhole pumped. The collection procedure was made difficult for these lysimeters due to the amount of water in the bottom of the manholes.

In January 2015, the batteries were replaced in the four SDT lysimeter panel boxes.

In March 2015, the steel pipe nipples on nine of the ICS lysimeters were replaced with Schedule 80 PVC units to prevent galvanic corrosion. The SDT lysimeters did not receive this upgrade due to a different configuration with the tipping buckets. Lysimeters 005, 010, and 013 received the Schedule 80 PVC upgrade in April 2015 and also received motorized ball valves as a test demonstration with the lysimeter collection procedure.

NRAP-2015-003 documents the tipping bucket failure at Lysimeters 001, 002, 003, and 0003A. These tipping buckets were not repaired in FY15 and will therefore be discussed in the 2016 ICS ACR. As a result of the tipping bucket failure, these lysimeters were pumped by hand and the volumes of removed water replaced the tipping bucket data for May 2015 through October 2015.

As a result of the excessive percolation that was experienced in the summer and spring of 2015, an investigation was started in FY15 for the SDT cover. In August and September of 2015, vegetation transects were conducted over Lysimeters 001, 002, 003, 004, 007, and 015. These lysimeters were chosen to be included in the investigation due to the orientation of the lysimeters.

Perimeter Fence: The fence cleaner was used on the entire ICS perimeter fence in January 2015 to remove the accumulated tumble weeds.

In January 2015, a section of the ICS perimeter fence north of Gate N was noted to have split open and was repaired. This split in the fence was presumed to be made by a large animal passing under the fence.

Erosion Rills: After a rain event in May 2014, Drainage Crossing 8 was noted to have erosion present. Rock-Amended Vegetative Layer was used to repair the side slope erosion at Drainage Crossing 8 and then hand seeded. This repair was performed in October 2014. In October 2015, 4 inch minus rock was added to repair the perimeter road erosion along Drainage Crossing 8.

Perimeter Road: In October 2014, all of the ICS drainage crossings had the silt and sediment removed. Also, more gravel was added in between the Articulated Concrete Blocks using a walk behind broom.

In December 2014, the ICS perimeter road was graded with a motor grader to remove the washboard in the Recycled Asphalt Pavement (RAP) and to regrade the gravel that had built up in the corners of the road.

In January 2015, pot holes on D Street were repaired with RAP.

Excessive Siltation in the Channel: Silt was observed to be present at the outlet end of Channel 11A. In October 2014, all of the ICS concrete lined channels had the silt and debris removed from the channel outlets.

Cracked or Degraded Concrete: It was observed that the caulk was missing or separating from the substrate at concrete joints in Channel 11. In January 2015, the OMC inspected this channel again and found no deficiencies in the caulk so therefore no repair was necessary.

Groundwater Wells: Groundwater well 36535 had a broken Carsonite marker. This marker was replaced in April 2015.

Well 01681 was repaired in October 2015. This well required the interior PVC riser pipe to be shortened so that the exterior well cap could be secured to the protective casing.

The maintenance items listed below were identified as improvements that were necessary to facilitate effective operation and maintenance of ICS and were not the result of inspection observations.

Bison Expansion Project: The Hazardous Waste Caution signs and metal posts that were along the ICS perimeter road were removed and the Caution signs were hung on the wooden posts of the perimeter fence. This was to preserve these signs so that they did not get damaged by bison activity. Also, the delineator posts that were installed along the ICS perimeter road were removed to prevent damage from bison activity. The wings from the cattle guards at the entrance to the Lime Basins and CAT access roads were removed in October 2014. In December 2014, the removed wings were replaced by corral panels. Corral panels were also installed along D Street just north of the road to the Lime Basins Metering building and along the north perimeter road to the west of Drainage Crossing 9. These two locations are where the USFWS bison pasture fence ties into the ICS perimeter fence.

5.0 SOIL COVER THICKNESS LOSS

The ICS cover includes a network of 92 erosion/settlement monuments embedded within the cover soil. The monuments are generally positioned on a 500-foot grid, except for on the SDT RCRA-Equivalent Cover, where monuments are positioned at specific locations. Cover soil thickness loss was measured at each of the monuments during the Type II inspections in April and November of 2015 in accordance with SOP 001, *Cover Conditions Inspections*. The measurements for each monument are provided on Table 5.0-1. All cover soil thickness loss measurements were below the non-routine action trigger level of 0.25 foot and the compliance standard of 0.5 foot.

6.0 VEGETATION PERFORMANCE ASSESSMENT

The 2015 Vegetation Performance Assessment was conducted in accordance with SOP 002 of the LTCP, Revision 2. Results of the assessment are summarized on Table 6.0-1. Appendix D includes additional tables that provide cover and frequency by species, expanded vegetation performance assessments providing two and three year running average comparisons, sample adequacy checks, and raw transect data. Separate assessments were performed on the following areas:

ICS RCRA-Equivalent Cover (30 transects sampled between August 20 and August 28, 2014);

ICS 2-Foot and 3-Foot Soil Cover (15 transects sampled between August 14 and August 20, 2014).

In all, data from 45 vegetation transects were collected in August 2015 for the ICS Cover areas. Figures 1 and 2 in Appendix D illustrate transects sampled on the ICS. The dates on which the assessments were conducted were inside the range specified in LTCP SOP 002 (between August 1 and September 15). Prior to performing the assessments, transect locations and compass bearings were randomly selected using Geographical Information System software. Photos, provided in Appendix D, were taken along the compass bearing at the start of each 50-meter transect. A total of 100 observations were made along each transect. All plant species present, but not encountered during transect observations within one meter on either side of the 50-meter transect were recorded and used to calculate a species density value (species per 100 square meters). Appendix D includes cover and frequency summary tables as well as vegetation performance assessment tables for each of the sample areas. These tables meet the reporting requirements set forth by the *Revegetation of the Basin A Soil Cover*, developed during the Basin A dispute resolution process in 1999.

There did not appear to be any excessive soil moisture stress or other biological stressors on the grassland community at the time of the assessment. Insects and other wildlife, such as small rodents, grassland birds and deer were observed on all of the areas. Several plant species not previously observed on the ICS Covers were recorded. The increase in species diversity may be an indication of both continued development of plant community complexity, as well as improved performance by individual established plants due to increased precipitation.

6.1 ICS RCRA-Equivalent Cover

After the 2015 growing season, the areas of the ICS RCRA-Equivalent Cover continued to be dominated by cool season species. Based on 30 transects sampled, cool season grasses, primarily western wheatgrass (*Pascopyrum smithii*), provided an average cover of 62 percent. Seeded warm season species were represented by only about 7 percent cover on average. Weedy species, primarily kochia (*Bassia sieversiana*), contributed an average cover of about 1 percent continuing the trend of very low cover by weedy species on the ICS in general. Average cover by litter was about 37 percent, a large increase from the previous year reflecting the large amount of production by vegetation that resulted after the prescribed burn conducted during the spring of FY14.

6.1.1 Comparison to the Performance Standard

Total live vegetation was estimated to be 62 percent, well above the performance standard of 25 percent. Total ground cover was very high at 99 percent, and corresponding bare ground was low at 1 percent. The two-year running average for absolute total ground cover was 96 percent, well above the standard. The three-year running average for absolute total ground cover was 95 percent, also well above the standard.

6.1.2 Comparison to the Non-Routine Action Trigger Level

The results of the quantitative vegetation assessment performed on the ICS RCRA-Equivalent Cover determined that only 2 percent of the total live vegetation (relative cover) was comprised of undesirable annual or biennial species. Therefore, the results of comparison to the non-routine action trigger level evaluation are identical to those of the vegetative performance standard described in Section 6.1.1 because cover by undesirable annual and biennial species did not exceed 10 percent of the total live vegetation. The absolute live cover vegetation for this site is well above the non-routine trigger level established in the LTCP.

6.2 ICS 2-Foot and 3-Foot Soil Covers

During the 2015 season, cover by a variety of weedy species composed only a small part of the total vegetation cover. Based on data from 15 samples, relative cover by weedy species was only about 1.4 percent. Average absolute live cover was about 58 percent. Average total cover remained high at 99 percent, with litter contributing about 42 percent cover. Cool season grasses, primarily western wheatgrass, provided an average cover of approximately 52 percent.

Average cover by warm season grasses was about 5 percent. Cover by live vegetation was similar in both the ICS RCRA-equivalent and 2-foot and 3-foot Covers.

6.2.1 Comparison to the Non-Routine Action Trigger Level

Total allowable live vegetation was estimated to be 58 percent, well above the non-routine action trigger level of 25 percent. The estimate for total ground cover was 99 percent, and corresponding bare ground was relatively low at 1 percent. The two-year running average for absolute total ground cover was 97 percent, well above the standard. The three-year running average for absolute total ground cover was 98 percent also well above the standard.

6.3 Sample Adequacy

Sample adequacy calculations were performed for each of the cover areas. The intent of the sample adequacy calculation is to determine whether sufficient samples have been gathered to be able to detect a 10 percent reduction in the mean with 90 percent confidence. Sample adequacy was calculated using the formula provided in SOP 002:

$$N_{\min} = t_{\alpha}^{2} s^{2} / (d\bar{x})^{2}$$

To ensure that the sample size is adequate, N_{min} must be less than, or equal to the number of transects sampled in the respective area. If N_{min} is greater than the number of transects sampled, additional vegetation transects need to be sampled until N_{min} becomes less than, or equal to the number of transects sampled, or all transect blocks within the respective area have been sampled, whichever comes first. Sample adequacy was calculated for total live vegetation only. The results of the sample adequacy calculations are provided in Table 6.4-1. Sample adequacy calculations indicated that variability was very low and that an acceptable number of samples were collected for all cover areas.

7.0 PERCOLATION MONITORING

The RCRA-Equivalent covers use a network of lysimeters to monitor deep percolation. The ICS cover has 15 lysimeters, including three located on the SDT RCRA-Equivalent Cover, with an additional lysimeter located outside the southeast boundary of the SDT RCRA-Equivalent Cover. The SDT RCRA-Equivalent Cover lysimeters are equipped with tipping buckets that measure the volume of percolation that drains from the lysimeter pans. The tipping bucket data are stored in the SCMMS database with data from the moisture sensors described in Section 8.0. For the lysimeters located elsewhere on the ICS, the volume of percolation is directly measured by opening a valve, collecting the accumulated percolation water, and measuring the volume in the field.

7.1 Lysimeter 003A

The SDT RCRA-Equivalent Cover was originally designed with three lysimeters. However, during cover construction, Lysimeter 003A was added to the cover design via Design Change Notice (DCN)-SDTC-004. The lysimeter is located in the 50-foot Biota Barrier Material (BBM) runout in the southeast corner of the site. The lysimeters aspect, mid-slope location, and orientation were chosen to mimic Lysimeter 003 as closely as possible without encroaching on the cover. All components of Lysimeter 003A, including instrumentation, were constructed, inspected, and tested in the same manner as the corresponding components of the other SDT lysimeters. However, the cover components over Lysimeter 003A did not include chokestone or geotextile (capillary barrier components), only BBM and cover soil.

The lack of capillary barrier components over the lysimeter was objectionable to the Regulatory Agencies because the materials did not meet the approved RCRA-equivalent cover design requirements. The Regulatory Agencies expressed concern that the Army/Shell could use the differing cover components as a basis for the ICS RCRA-Equivalent Cover design without a true field demonstration program. The Army/Shell acknowledged the Regulatory Agencies' concerns and proceeded with construction of the lysimeter with an understanding that Lysimeter 003A would not be used as a basis for changes to the RCRA-equivalent cover designs. DCN-SDTC-004 was conditionally released by the Army/Shell and was not approved by the Regulatory Agencies.

Since Lysimeter 003A is located off of the RCRA-equivalent cover and was not approved by the Regulatory Agencies, the lysimeter is not subject to the non-routine trigger level or the compliance standard for percolation. However, the data collected from Lysimeter 003A is useful for comparison with data collected from the other SDT lysimeters. Therefore, data from Lysimeter 003A are included in this report for that purpose.

7.2 Percolation Compliance

Percolation is reported in millimeters, which is calculated by dividing the measured percolation volume by the area of the lysimeter pan, or 1,500 square feet (139.35 square meters). The volume of percolation measured monthly from each lysimeter is presented in Table 7.0-1. Table 7.0-2 presents rolling nine-month percolation totals for comparison to the non-routine action trigger level of 1.0 mm, and Table 7.0-3 presents twelve-month rolling totals for comparison to the compliance standard of 1.3 mm/year. The compliance standard for percolation is the quantity of percolation that, if exceeded, would subject the Army to potential enforcement actions by the Regulatory Agencies. The compliance standard became enforceable by the Regulatory Agencies on April 21, 2015.

As shown in Tables 7.0-2 and 7.0-3 all ICS lysimeters, except Lysimeters 001, 002, 003, and 003A which are discussed in Section 7.3, were well below the non-routine action trigger level and the compliance standard for the entire year.

7.3 Percolation Exceedances

On May 21, 2015 the Army notified the Regulatory Agencies via email (Army 2015a) that the amount of water collected by Lysimeters 001 and 002 on the SDT RCRA-equivalent cover exceeded the percolation compliance standard. The Army notified the Regulatory Agencies again via email (Army 2015b) on June 10, 2015 that Lysimeter 003 also exceeded the percolation compliance standard. Lysimeter 003 is also located on the SDT RCRA-equivalent cover.

The lysimeters on the other ICS RCRA-equivalent covers did not exceed the percolation standard over the same timeframe. In fact, most of the monthly measurements collected at the other ICS lysimeters showed no measurable volume of percolation water for the last year or more. This implies that the SDT RCRA-equivalent cover is more susceptible to percolation than the other ICS RCRA-equivalent covers. There were several differences in design and construction methods between the SDT cover and the other ICS RCRA-equivalent covers. It is not clear which of these differences, or combination of differences, may have led to the out-of-compliance condition. Likewise, the appropriate response to prevent further percolation standard exceedances has not been determined. However, the Army is planning to perform cover soil sampling and testing to determine the most likely cause of the excessive percolation on the SDT cover.

7.3.1 Fiscal Year 2015 Exceedances

A routine monthly inspection of the Integrated Cover System (ICS) lysimeters, including those on the SDT RCRA-equivalent cover, was performed on May 13, 2015. The inspectors noted a slight increase in the water levels at the bottom of the manholes of Lysimeters 001 and 002. There was also a significant increase in the water level at Lysimeter 003A, which is not used for compliance purposes. Operational history with the lysimeters has shown that sudden increases in percolation at Lysimeter 003A can be an indication that percolation breakthrough is imminent at the other three SDT lysimeters.

As a result of the inspection findings, the Caps and Covers O&M staff began downloading lysimeter moisture sensor and tipping bucket data daily, rather than weekly, and began making daily inspections of the SDT lysimeters. The Army was notified of the situation and the potential for exceeding the percolation compliance standard.

NRAP-2015-003 documents the tipping bucket failure in the SDT lysimeters. The maximum allowable water depth before damaging the tipping bucket electronics is nine inches. The standing water depths that measured greater than nine inches inside of the lysimeter manholes were recorded on the following dates:

- Lysimeter 001: 9.5 inches on May 29, 2015
- Lysimeter 002: 10.5 inches on May 21, 2015
- Lysimeter 003: 15.0 inches on June 10, 2015
- Lysimeter 003A: 25.0 inches on May 13, 2015

The water that accumulated in each of the SDT lysimeter manholes was of sufficient depth as to render the tipping buckets useless and therefore the data invalid. As an alternative, the depths of water standing in the bottoms of the manholes were measured, and the volumes were recorded as the water was pumped out of each manhole. The change in data collection method occurred on the following dates:

- Lysimeter 001 beginning on May 11, 2015 at 0600
- Lysimeter 002 beginning on May 14, 2015 at 0600
- Lysimeter 003 beginning on June 6, 2015 at 1200
- Lysimeter 003A beginning on May 10, 2015 at 2400

Please refer to Table 7.3-1 for the volumes of water removed from each lysimeter.

During FY15, there were also three Consultative Meetings conducted between the Army and the Regulatory Agencies that were on the topic of the SDT percolation exceedance. The meetings were held on June 25, 2015 where the SDT Percolation Exceedance was discussed, August 11, 2015 where the Corrective Measures Plan of Action Revisions were discussed, and September 10, 2015 where the Cover Soil Sampling and Analysis Plan was discussed. The investigation of the SDT cover soil and root density of the vegetation is ongoing and will therefore be discussed further in the 2016 ICS ACR.

8.0 SCMMS O&M

The SCMMS was operated and maintained in accordance with the *SDT Soil Remediation Project SCMMS O&M Plan*, Revision 2. The *SCMMS O&M Plan* includes the SOPs for data collection and system maintenance activities, and guidelines for data reporting.

Reporting the SCMMS data supports the objectives of the *Resolution Agreement: Use of Moisture Sensors on Full-Scale RCRA-Equivalent Covers at the Rocky Mountain Arsenal,* April 8, 2004 (RVO 2004) (Moisture Probe Resolution Agreement). In accordance with this agreement, data collected from moisture sensors (probes), in conjunction with other monitoring data, will be used as follows:

- To demonstrate that a capillary break develops at the interface between the moisture storage layer and the underlying material;
- To assist in selection of an appropriate corrective action in the event that percolation in excess of the 1.3 mm/year percolation compliance criterion is measured in a lysimeter and to assess the effectiveness of corrective actions performed; and
- To provide diagnostic information that may assist in selection and assessment of operation and maintenance activities.

The *Moisture Probe Resolution Agreement* requires the system to operate continuously for a period of time that includes seven full spring seasons following cover construction. This report includes data from the eighth full spring season. However, both equipment failure and unprecedented amounts of percolation were experienced during FY15. The Army believes that continuing the operation of the SCMMS may provide insight regarding the large percolation quantities and the behavior of the soil cover during the annual peak evapotranspiration period. Therefore the Army will continue to operate and report on a quarter-by-quarter basis until the Army is satisfied with the data summary results.

8.1 Data Collection and System Checks

The data presented in Appendix C were taken from a database created specifically to manage the SCMMS data. This database is administered by the Army's data management contractor, Records Management Information Technology System (RMITS). The OMC staff collected data by downloading data from the SCMMS, following the procedures in SOP-002-SDT. Data downloading was generally performed on a weekly basis. In addition to downloading data, the OMC staff also routinely checked the status of the datalogger and program by checking the program signature, battery voltage, date/time stamp, and other system parameters.

8.2 Data Review

After each download was completed, the Project Quality Assurance/Quality Control (QA/QC) Representative performed a QA/QC check on the data. Suspect readings, such as out of range readings, error messages, and data impacted by hardware malfunctions were flagged and reviewed. All flagged data were evaluated to determine whether the issue was a short-term "blip" or indication of a system error. System component failures are described in Section 8.3.

8.3 System Issues and Refinements

The following issues and refinements were encountered prior to, and during, this reporting period.

Lysimeter 003A, Moisture Probe Nest 1: Probes 3 and 6 did not operate properly for the duration of the reporting period.

Lysimeter 003A, Moisture Probe Nest 4: Probes 1, 2, and 6 did not operate properly for the duration of the reporting period. Probes 4 and 7 have not operated properly since August 8, 2009, but beginning on September 1, 2015 these probes began recording data. The data that was recorded from these probes was flagged in the database due to unreliability of the data being received.

8.4 Data Analysis and Interpretation

The following SCMMS data evaluation summaries were issued between October 1, 2014 and September 30, 2015.

- *Soil Cover Moisture Monitoring System Data Evaluation Summary, July 2014 to September 2014* (Navarro 2014a)
- *Soil Cover Moisture Monitoring System Data Evaluation Summary, October 2014 to December 2014* (Navarro 2015a)
- *Soil Cover Moisture Monitoring System Data Evaluation Summary, January 2015 to March 2015* (Navarro 2015b)
- *Soil Cover Moisture Monitoring System Data Evaluation Summary, April 2015 to June 2015* (Navarro 2015c)

These reports include raw data generated by the system as well as graphical representations of the soil moisture data. Data received from the moisture probes seem to be similar to those recorded during the RCRA-Equivalent Cover Demonstration Project. As with the demonstration project data, interpretation of the soil moisture data requires caution. While a simple comparison of moisture content at different probes may be misleading, assessing the moisture content change over time at a particular probe is more meaningful.

8.5 Capillary Barrier Development

The first objective of the SCMMS is to demonstrate the development of a capillary barrier between the cover soil and the underlying material. During FY15 four SCMMS Data Evaluation Summaries were prepared by the Army contractor (Navarro 2014a, 2015a, 2015b, and 2015c) that provide evidence of a functional capillary barrier at the SDT RCRA-Equivalent Cover. The formation of a capillary barrier can be seen in the SCMMS data by analyzing the behavior of soil moisture in the lower portions of the cover, and also by comparing soil moisture and percolation data from Lysimeter 003A with those of the other SDT lysimeters.

8.5.1 Behavior of Deep Cover Moisture

Data presented in the SCMMS reports for FY15 demonstrate the development of a capillary barrier between the cover soil and the underlying material. The Volumetric Water Content (VWC) of the middle and lower soil horizons are of particular interest. The lower portions of the soil column consistently indicate the highest VWC levels and show the least amount of variability. Both evaporation and transpiration contributed to the reduction of soil moisture throughout the cover thickness.

8.5.1.1 October 2014 through December 2014

Data collected during the first quarter of FY15 showed a drying trend. Lysimeters 001, 002, and 003A recorded percolation during this time frame. Lysimeter 003 did not experience percolation which may have been due to the native vegetative cover over much of Lysimeter 003 is lacking when compared to the surrounding area and other lysimeters. The shortage of established vegetation may have resulted in a quicker drying of the cover soil due to a deficiency of tension between the roots of the plant community and the cover soil moisture.

However, there does seem to be a difference when comparing the percolation trend between the other SDT lysimeters and Lysimeter 003A for this quarter. The lowest soil moisture probes at Lysimeters 001, 002, and 003 for this quarter recorded higher VWC values when compared to Lysimeter 003A. The difference in storage capacity may be a result of Lysimeter 003A not containing capillary barrier components.

8.5.1.2 January through March 2015

Data collected between January through March 2015 continued to show that the VWC of the middle and lower soil horizons recorded high VWC values. These data suggest that the cover retained moisture in the lower portions of the cover soil and the capillary barrier layer is functioning as intended, and that the vegetation for most of this reporting period remained dormant and did not transpire much moisture from the deepest part of the cover.

8.5.1.3 April through June 2015

This reporting quarter was unique due to significant percolation quantities collected by all of the SDT lysimeters. The percolation event of May 2015 provides an opportunity to observe soil moisture behavior leading up to, during, and after a significant capillary breakthrough event.

For this quarter, most of the probes at 38 inches BGS recorded higher VWC values than the deeper probes beginning around early May for Lysimeters 001 and 002. This trend appears to be a precursor to capillary breakthrough. Lysimeter 003 also experienced this phenomena, but not until early June. However, as anticipated, when the probes placed at 38 inches BGS began to record higher VWC readings than the probes placed at 46 inches BGS in early June, capillary breakthrough occurred for Lysimeter 003. The percolation collected from Lysimeter 003 during this reporting period is less substantial than Lysimeters 001 and 002, but still exceeds the compliance standard. Lysimeter 003A experienced significant capillary breakthrough for this quarter comparable to the other SDT lysimeters, but due to the lack of capillary barrier components it is not subject to the compliance standard.

8.5.1.4 July through September 2015

For Lysimeters 001 and 002, the probes at 38 inches BGS continued to record similar VWC values to those of the deepest probes. When the VWC values at 38 inches BGS are equal to, or greater than, the VWC values at 46 inches BGS, capillary breakthrough tends to occur. The VWC values remained similar for the probes placed at 38 BGS and 46 BGS for July. However, during August 2015, all of the probes began a drying trend and the separation of VWC from the probes placed 38 BGS and 46 BGS became more pronounced as the reporting period progressed. Lysimeter 002 Nest 3 is particularly interesting for this time frame because by the end of September 2015, all of the depths of moisture probes have converged to approximately the same VWC. This depicts that the cover soil most likely has returned back to a dry and steady state.

The deeper soil moisture probes behaved slightly differently at Lysimeter 003 when compared to Lysimeters 001 and 002. All of the moisture probes depict a drying trend, but the reporting period for Lysimeter 003 begins with a substantial separation between the probes placed at 38 BGS and 46 BGS for most of the nests. Lysimeter 003 also had the least amount of percolation collected when compared to the other SDT lysimeters when breakthrough was experienced during the 2015 spring and summer seasons.

8.5.2 Impact of Capillary Barrier Components

The Army presented arguments for a functional capillary barrier in the SCMMS data evaluation summaries published in FY15. The conclusions were based partially on the relationship between moisture content and percolation in Lysimeters 003 and 003A.

The soil moisture at Lysimeter 003A behaved similarly to the other SDT lysimeters for FY15. For instance, the VWC values at the base of the soil cover remained higher than the other cover strata for most of the lysimeter nests. This behavior is not typical of Lysimeter 003A; in fact, the lowest sensors typically record the lowest VWC values for this lysimeter. However, after reviewing the data for FY15, VWC data recorded from probes placed 46 inches BGS are not as stable for Lysimeter 003A when compared to the lower soil moisture monitoring probes at the other SDT lysimeters. This observation may be due to the fact that Lysimeter 003A does not have the capillary barrier components between the cover soil and the BBM and therefore is not as capable of storing the water in the bottom layers of the cover soil.

The only substantive difference between the cover at Lysimeter 003A and the other SDT lysimeters is the lack of capillary barrier components between the cover soil and BBM. This component was intentionally removed from the cover at Lysimeter 003A to investigate how this alternative configuration would perform. After reviewing the data collected over the past eight years on the SDT cover, it is clear that Lysimeters 001, 002, and 003 have a mechanism for water storage in the deeper layers of the soil cover much more so than at Lysimeter 003A. Thus, after eight years of data comparison, it is reasonable to conclude that a capillary barrier has developed between the cover soil and the underlying material at Lysimeter 003.

8.6 Selection and Assessment of Corrective Actions

Corrective actions for excess percolation have not been required prior to April 21, 2015. However, now that the percolation compliance standard has been exceeded at Lysimeters 001, 002, and 003, the data are being used in the evaluation process. Data from the SCMMS will be combined with other information to determine the cause of the excessive percolation, to assist in selection of the corrective action, and to assess the effectiveness of the corrective action.

8.7 O&M Diagnostic Information

The SCMMS data does not indicate that any O&M activities are required. Routine O&M actions are performed as needed in accordance with the LTCP.

9.0 ROUTINE AND NON-ROUTINE ACTIONS

9.1 Routine Actions

Routine maintenance and repairs were performed on ICS and were intended to ensure that the cover continues to function as designed. Routine maintenance and repair actions were identified during inspections and are discussed in Section 4.0 of this report. Figure 4.0-1 illustrates the locations of routine maintenance and repair activities performed on ICS during FY15. Appendix F includes Contractor Daily Quality Control Reports that describe the work performed.

9.2 Non-Routine Actions

The implementation of non-routine actions is described in the LTCP. The LTCP provides criteria for non-routine actions, and a mechanism for consultation between the parties and documentation of the consultative outcome. Each time a non-routine action was identified a NRAP was prepared to document the substandard condition, the actions that will be carried out to remedy the condition, consultation between the parties, and concurrence on the proposed action. All NRAPs applicable to ICS for this reporting period are referenced in Section 4.0 of this report and the complete NRAP Log is provided in Appendix G. Figure 4.0-1 illustrates the locations of non-routine maintenance and repair activities performed on ICS during FY15. Appendix F includes Contractor Daily Quality Control Reports that describe the work performed.

10.0 RECOMMENDATIONS AND CORRECTIVE MEASURES

Inspections and assessments performed during FY15 produced the following recommendations for FY16:

- The percolation exceedance at the SDT lysimeters will continue to be monitored and investigated.
- The site should be examined for weeds throughout FY16. Occurrences of cheatgrass, Canada thistle and other noxious weeds should be spot sprayed. In particular, repaired areas that have been re-seeded will require continued weed control as established plants fill in sparse areas.
- The site should continue to be examined for erosion rills or gullies, ponding areas, excessive tire tracks and ruts, burrowing animal holes, and localized settlement.
- The areas already identified with differential settlement will continue to be monitored and investigated.

The Army currently has plans to perform a prescribed burn on the ICS AMA during FY16. Therefore, a burn plan will be prepared and provided to the Regulatory Agencies in an NRAP in accordance with the LTCP prior to performing the prescribed burn.

Corrective action is required regarding percolation performance of the SDT RCRA-Equivalent Cover. The Army/Shell, in cooperation with the Regulatory Agencies, is developing an investigation and evaluation process that will lead to corrective action. Corrective actions for excess percolation have not been required prior to April 21, 2015. However, now that the percolation compliance standard has been exceeded at Lysimeters 001, 002, and 003, the SCMMS data are being used in the evaluation process. Data from the SCMMS will be combined with other information to determine the cause of the excessive percolation, to assist in selection of the corrective action, and to assess the effectiveness of the corrective action.

11.0 FY15 COSTS AND FY16 BUDGETS

Cost incurred performing Interim O&M of the ICS AMA during FY15, including inspections, repairs, and maintenance was $134,588. A complete budget for FY16 has not been approved as of the issuance of this report. However, the FY16 budget is estimated to be approximately $243,390.

12.0 REFERENCES

Army (U.S. Army)

2015a (May 21) *Email sent by James L. Green, Subject: Exceedance of Percolation Compliance Standard (UNCLASSIFIED)*

2015b (Jun 10) *Email sent by James L. Green, Subject: FW: Exceedance of Percolation Compliance Standard (UNCLASSIFIED)*

Navarro (Navarro Research and Engineering, Inc.)

2014a (Oct 27) *Soil Cover Moisture Monitoring System Data Evaluation Summary, July 2014 to September 2014.* Revision 0.

2015a (Feb 4) *Soil Cover Moisture Monitoring System Data Evaluation Summary, October 2014 to December 2014.* Revision 0.

2015b (May 6) *Soil Cover Moisture Monitoring System Data Evaluation Summary, January 2015 to March 2015.* Revision 0.

2015c (Aug 5) *Soil Cover Moisture Monitoring System Data Evaluation Summary, April 2015 to June 2015.* Revision 0.

RVO (Remediation Venture Office for Rocky Mountain Arsenal)

2004 (Apr 8) *Resolution Agreement Use of Moisture Sensors on Full-Scale RCRA-Equivalent Covers at the Rocky Mountain Arsenal.*

TtEC (Tetra Tech EC Inc.)

2006 (Jun 15) *SDT Soil Remediation Project SCMMS O&M Plan.* Revision 2.

2011 (Sep 29) *RCRA-Equivalent, 2-, and 3-Foot Covers Long-Term Care Plan.* Revision 2.

TABLES

Table 5.0-1: ICS Soil Cover Thickness Loss

ICS Monument No.	Loss (in.) April 1, 2015	Loss (in.) November 4, 2015
ER01	0.00	0.00
ER02	0.50	0.50
ER03	0.00	0.00
ER04	1.75	2.00
ER05	1.50	1.75
ER06	1.25	2.00
ER07	0.00	0.00
ER08	1.50	1.50
ER09	1.25	1.25
ER10	1.00	0.75
ER11	1.00	1.00
ER12	0.50	0.50
ER13	1.00	1.50
ER14	0.00	0.75
ER15	0.00	0.00
ER16	1.00	1.50
ER17	0.00	0.00
ER18	0.00	0.00
ER19	0.00	0.00
ER20	1.00	1.50
ER21	1.00	1.25
ER22	1.50	1.75
ER23	0.00	0.00
ER24	0.00	0.00
ER25	1.00	1.50
ER26	0.00	0.00
ER27	1.50	1.50
ER28	1.25	1.00
ER29	2.00	2.00
ER30	2.50	2.50
ER31	1.75	2.00
ER32	0.75	1.00
ER33	1.25	1.50
ER34	1.00	1.50
ER35	1.50	1.50
ER36	2.00	2.75
ER37	1.75	2.25
ER38	1.50	1.50
ER39	0.25	1.00
ER40	1.00	1.50
ER41	1.50	2.50
ER42	0.00	0.75
ER43	2.00	2.00

Table 5.0-1: ICS Soil Cover Thickness Loss

ICS Monument No.	Loss (in.) April 1, 2015	Loss (in.) November 4, 2015
ER44	1.75	1.75
ER45	1.50	1.75
ER46	2.00	2.50
ER47	2.00	2.00
ER48	1.00	1.00
ER49	0.50	0.50
ER50	1.00	0.50
ER51	0.00	0.00
ER52	0.25	0.50
ER53	1.00	1.50
ER54	0.00	0.00
ER55	0.50	0.75
ER56	0.25	0.75
ER57	0.00	1.00
ER58	0.00	0.00
ER59	1.25	1.25
ER60	1.75	2.00
ER61	0.25	0.00
ER62	0.00	0.25
ER63	1.00	1.25
ER64	1.25	1.25
ER65	2.25	3.00
ER66	1.50	1.25
ER67	0.00	0.00
ER68	1.00	1.50
ER69	0.75	0.75
ER70	0.00	0.00
ER71	0.75	1.00
ER72	1.50	1.50
ER73	1.25	1.25
ER74	0.00	0.00
ER75	1.00	1.25
ER76	1.25	1.25
ER77	1.00	1.00
ER78	2.25	1.25
ER79	0.00	0.00
ER80	0.75	0.50
ER81	0.25	0.75
ER82	0.25	1.00
ER83	0.00	0.00
ER84	1.25	1.50
ER85	0.25	0.50
ER86	0.00	0.00

Table 5.0-1: ICS Soil Cover Thickness Loss

ICS Monument No.	Loss (in.) April 1, 2015	Loss (in.) November 4, 2015
ER87	0.00	0.00
ER88	1.50	1.25
ER89	0.75	1.25
ER90	2.00	2.50
ER91	0.50	1.00
ER92	0.00	0.75

Table 6.0-1: 2015 Vegetation Performance Assessment Summary

Performance Criterion and Evaluation	2-Foot and 3-Foot Covers (Note 1)	ICS RCRA-Equivalent Cover
Total Absolute Ground Cover	99.30%	98.60%
Allowable Total Absolute Live Vegetation Cover 2013	57.70%	61.80%
Vegetation Performance Standard for Total Live Vegetation	≥ 25%	≥ 25%
Is Vegetation Performance Standard met?	Yes	Yes
Two Year Running Average for Total Absolute Ground Cover	97.20%	96.00%
Vegetation Performance Standard for Two Year Running Average	≥ 50%	≥ 50%
Is Vegetation Performance Standard met?	Yes	Yes
Three Year Running Average for Total Absolute Ground Cover	97.70%	94.50%
Vegetation Performance Standard for Three Year Running Average	≥ 67%	≥ 67%
Is Vegetation Performance Standard met?	N/A	N/A
Relative Weed Cover	1.40%	1.70%
Relative Allowable Weed Cover	N/A (Note 3)	≤ 10%
Calculate Total Live Vegetation without the weed fraction? (Note 2)	N/A (Note 3)	No

Note 1: For 2-Foot and 3-Foot soil covers, vegetation performance criteria function as Non-Routine Action Trigger Levels, not compliance standards.

Note 2: The relative weed cover is less than 10 percent, therefore, subtracting all but 10 percent of the total live vegetation cover fraction that is comprised of weeds does not affect the Total Live Vegetation calculation. The Total Live Vegetation values are within the Non-Routine Action Trigger Levels.

Note 3: The relative weed fraction does not affect vegetation compliance or non-routine actions on the 2-Foot and 3-Foot soil covers.

Table 6.4-1: Sample Adequacy Results[1]

Cover Area	Sample Size (n)	Minimum Sample Size total live cover (N_{min})
ICS RCRA-Equivalent Covers	30	2.12
ICS 2-Ft and 3-Ft Soil Covers	15	2.45

Note 1: Based on absolute total live vegetation cover

Table 7.0-1: Monthly Percolation Measurements

Lysimeter No.	Monthly Percolation Measurement (ml)											
	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15
Lysimeter 001	14,579	88	0	0	0	0	0	963,000[(1)]	3,884,000[(2)]	1,419,000[(3)]	415,000[(4)]	44,000[(5)]
Lysimeter 002	247	128	24	16	40	40	64	1,834,032[(1)]	3,458,000[(2)]	1,335,000[(3)]	93,000[(4)]	76,000[(5)]
Lysimeter 003	0	0	0	0	0	0	0	0	1,252,000[(2)]	62,000[(3)]	53,000[(4)]	16,000[(5)]
Lysimeter 003A	5801	8	8	0	8	0	0	1,254,000[(1)]	3,477,000[(2)]	710,000[(3)]	301,000[(4)]	59,000[(5)]
Lysimeter 004	Trace	Trace	Trace	0	0	0	0	0	0	0	0	Trace
Lysimeter 005	1,000	Trace	Trace	Trace	0	0	0	0	0	0	11,000	15,500
Lysimeter 006	0	0	0	0	0	0	0	0	0	0	0	0
Lysimeter 007	0	0	0	0	0	0	0	0	0	67,500	5,500	4,500
Lysimeter 008	0	0	0	0	0	0	0	0	0	0	0	0
Lysimeter 009	0	0	0	0	0	0	0	0	0	0	0	0
Lysimeter 010	0	0	0	0	0	0	0	Trace	0	22,500	1,000	1,000
Lysimeter 011	Trace	0	0	0	0	0	0	0	0	0	0	0
Lysimeter 012	0	0	0	0	0	0	0	0	0	0	0	0
Lysimeter 013	1,000	Trace	0	0	0	0	0	0	0	0	Trace	2,000
Lysimeter 014	500	Trace	Trace	0	0	0	0	0	0	0	0	0
Lysimeter 015	0	Trace	0	0	0	0	0	0	0	0	0	0

Note 1: Approximately 963 liters of water was pumped from the Lysimeter 001 manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 6.91 mm. Approximately 1,834 liters of water was pumped from the Lysimeter 002 manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 13.16mm. Approximately 1,254 liters of water was pumped from the Lysimeter 003A manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 9.00 mm.

Note 2: Approximately 3,884 liters of water was pumped from the Lysimeter 001 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 27.87 mm. Approximately 3,458 liters of water was pumped from the Lysimeter 002 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 24.81 mm. Approximately 1,252 liters of water was pumped from the Lysimeter 003 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 8.98 mm. Approximately 3,477 liters of water was pumped from the Lysimeter 003A manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 24.95 mm.

Note 3: Approximately 1,419 liters of water was pumped from the Lysimeter 001 manhole on in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 10.18 mm. Approximately 1,335 liters of water was pumped from the Lysimeter 002 manhole in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 9.58 mm. Approximately 62 liters of water was pumped from the Lysimeter 003 manhole in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.44 mm. Approximately 710 liters of water was pumped from the Lysimeter 003A manhole in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 5.09 mm.

Note 4: Approximately 415 liters of water was pumped from the Lysimeter 001 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 2.98 mm. Approximately 93 liters of water was pumped from the Lysimeter 002 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.67 mm. Approximately 53 liters of water was pumped from the Lysimeter 003 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.38 mm. Approximately 301 liters of water was pumped from the Lysimeter 003A manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 2.16 mm.

Note 5: Approximately 44 liters of water was pumped from the Lysimeter 001 manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.32 mm. Approximately 76 liters of water was pumped from the Lysimeter 002 manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.55 mm. Approximately 16 liters of water was pumped from the Lysimeter 003 manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.11 mm. Approximately 59 liters of water was pumped from the Lysimeter 003A manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.42 mm.

Table 7.0-2: Rolling Nine-Month Percolation Totals

Lysimeter No.	Rolling Nine-Month Percolation Total (mm)											
	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15
Lysimeter 001	35.35	35.35	35.35	35.35	35.35	1.27	0.96	7.23[(1)]	34.89[(2)]	44.97[(3)]	47.94[(4)]	48.26[(5)]
Lysimeter 002	5.77	5.77	5.77	5.77	5.77	0.27	0.27	13.17[(1)]	37.98[(2)]	47.56[(3)]	48.22[(4)]	48.77[(5)]
Lysimeter 003	30.02	30.02	30.02	30.02	30.02	16.46	1.06	0.07	8.98[(2)]	9.43[(3)]	9.81[(4)]	9.92[(5)]
Lysimeter 003A	15.63	15.63	15.63	15.63	15.63	2.28	1.37	9.25[(1)]	33.99[(2)]	39.04[(3)]	41.20[(4)]	41.63[(5)]
Lysimeter 004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.08	0.11
Lysimeter 006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.47	0.52
Lysimeter 008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 010	0.29	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.16	0.17	0.17
Lysimeter 011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 013	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.01	0.00	0.00	0.01
Lysimeter 014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 015	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00

Note 1: Approximately 963 liters of water was pumped from the Lysimeter 001 manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 6.91 mm. Approximately 1,834 liters of water was pumped from the Lysimeter 002 manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 13.16mm. Approximately 1,254 liters of water was pumped from the Lysimeter 003A manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 9.00 mm.

Note 2: Approximately 3,884 liters of water was pumped from the Lysimeter 001 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 27.87 mm. Approximately 3,458 liters of water was pumped from the Lysimeter 002 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 24.81 mm. Approximately 1,252 liters of water was pumped from the Lysimeter 003 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 8.98 mm. Approximately 3,477 liters of water was pumped from the Lysimeter 003A manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 24.95 mm.

Note 3: Approximately 1,419 liters of water was pumped from the Lysimeter 001 manhole on in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 10.18 mm. Approximately 1,335 liters of water was pumped from the Lysimeter 002 manhole in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 9.58 mm. Approximately 62 liters of water was pumped from the Lysimeter 003 manhole in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.44 mm. Approximately 710 liters of water was pumped from the Lysimeter 003A manhole in July 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 5.09 mm.

Note 4: Approximately 415 liters of water was pumped from the Lysimeter 001 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 2.98 mm. Approximately 93 liters of water was pumped from the Lysimeter 002 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.67 mm. Approximately 53 liters of water was pumped from the Lysimeter 003 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.38 mm. Approximately 301 liters of water was pumped from the Lysimeter 003A manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 2.16 mm.

Note 5: Approximately 44 liters of water was pumped from the Lysimeter 001 manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.32 mm. Approximately 76 liters of water was pumped from the Lysimeter 002 manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.55 mm. Approximately 16 liters of water was pumped from the Lysimeter 003 manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.11 mm. Approximately 59 liters of water was pumped from the Lysimeter 003A manhole in September 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.42 mm.

Table 7.0-3: Rolling Twelve-Month Percolation Totals

Lysimeter No.	Rolling Twelve-Month Percolation Total (mm)											
	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15
Lysimeter 001	35.35	35.35	35.35	35.35	35.35	35.35	35.35	42.26(1)	36.05(2)	45.93(3)	48.26(4)	48.36(5)
Lysimeter 002	5.77	5.77	5.77	5.77	5.77	5.77	5.77	18.93(1)	38.25(2)	47.83(3)	48.23(4)	48.77(5)
Lysimeter 003	30.34	30.05	30.02	30.02	30.02	30.02	30.02	30.02	25.44(2)	10.49(3)	9.88(4)	9.92(5)
Lysimeter 003A	15.70	15.63	15.63	15.63	15.63	15.63	15.63	24.63(1)	36.23(2)	40.41(3)	41.45(4)	41.67(5)
Lysimeter 004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.09	0.20
Lysimeter 006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.52	0.56
Lysimeter 008	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 010	0.33	0.33	0.32	0.29	0.02	0.02	0.02	0.02	0.01	0.17	0.18	0.18
Lysimeter 011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 013	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.02
Lysimeter 014	0.13	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lysimeter 015	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00

Note 1: Approximately 963 liters of water was pumped from the Lysimeter 001 manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 6.91 mm. Approximately 1,834 liters of water was pumped from the Lysimeter 002 manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 13.16mm. Approximately 1,254 liters of water was pumped from the Lysimeter 003A manhole in May 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 9.00 mm.

Note 2: Approximately 3,884 liters of water was pumped from the Lysimeter 001 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 27.87 mm. Approximately 3,458 liters of water was pumped from the Lysimeter 002 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 24.81 mm. Approximately 1,252 liters of water was pumped from the Lysimeter 003 manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 8.98 mm. Approximately 3,477 liters of water was pumped from the Lysimeter 003A manhole in June 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 24.95 mm.

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Note 4: Approximately 415 liters of water was pumped from the Lysimeter 001 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 2.98 mm. Approximately 93 liters of water was pumped from the Lysimeter 002 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.67 mm. Approximately 53 liters of water was pumped from the Lysimeter 003 manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 0.38 mm. Approximately 301 liters of water was pumped from the Lysimeter 003A manhole in August 2015. This estimated quantity was not recorded by the tipping bucket and equates to approximately 2.16 mm.

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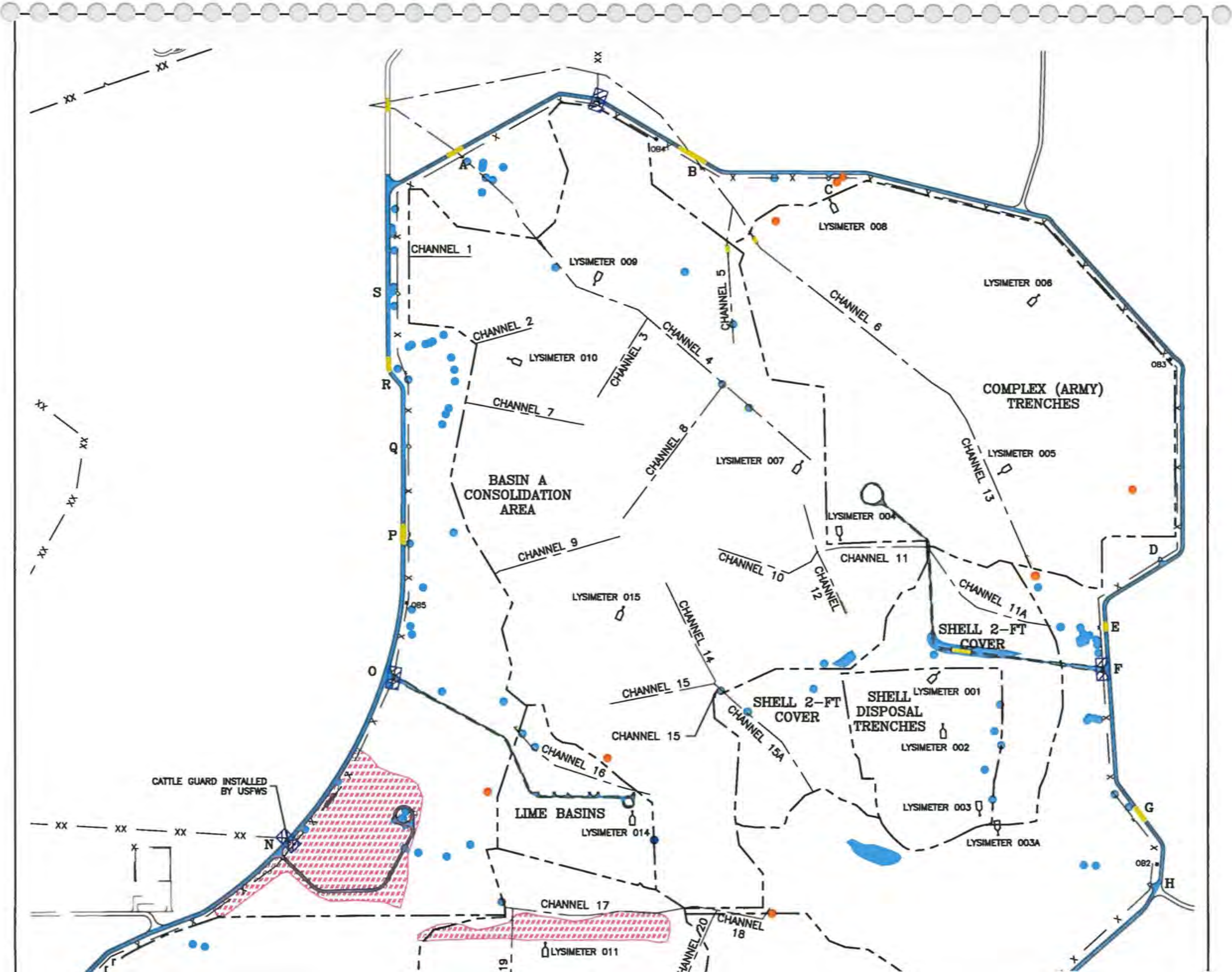
Table 7.3-1: SDT Lysimeter Pumping Events

DATE	Lysimeter 001			Lysimeter 002			Lysimeter 003			Lysimeter 003A		
	Volume Removed (liters)	Volume Removed to Date (liters)	Percolation to Date (mm)	Volume Removed (liters)	Volume Removed to Date (liters)	Percolation to Date (mm)	Volume Removed (liters)	Volume Removed to Date (liters)	Percolation to Date (mm)	Volume Removed (liters)	Volume Removed to Date (liters)	Percolation to Date (mm)
05/14/15	107	107	0.77	84	84	0.60				643	643	4.61
05/15/15										294	937	6.72
05/18/15	37	144	1.03	51	135	0.97				197	1,134	8.14
05/21/15	51	195	1.40	240	375	2.69						
05/26/15				735	1,110	7.97				120	1,254	9.00
05/27/15	556	751	5.39									
05/28/15				624	1,734	12.44						
05/29/15	212	963	6.91	100	1,834	13.16						
06/02/15	157	1,120	8.04	163	1,997	14.33				806	2,060	14.78
06/09/15	857	1,977	14.19	794	2,791	20.03						
06/10/15							340	340	2.44			
06/11/15	726	2,703	19.40	737	3,528	25.32				887	2,947	21.15
06/15/15	184	2,887	20.72				551	891	6.39			
06/16/15	984	3,871	27.78	920	4,448	31.92	177	1,068	7.66			
06/17/15										931	3,878	27.83
06/29/15	976	4,847	34.78				184	1,252	8.98			
06/30/15				844	5,292	37.98				853	4,731	33.95
07/14/15	766	5,613	40.28				62	1,314	9.43			
07/15/15				779	6,071	43.57				710	5,441	39.04
07/20/15	653	6,266	44.96	556	6,627	47.55						
08/06/15	415	6,681	47.94	93	6,720	48.22	53	1,367	9.81	301	5,742	41.20
09/02/15	44	6,725	48.26	76	6,796	48.77	16	1,383	9.92	59	5,801	41.63

FIGURE



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BASIN A CONSOLIDATION AREA
COMPLEX (ARMY) TRENCHES
SHELL 2-FT COVER
SHELL 2-FT COVER
SHELL DISPOSAL TRENCHES
LIME BASINS
CATTLE GUARD INSTALLED BY USFWS

APPENDICES (All on CD)

Appendix A	Precipitation Data (October 1, 2014 through September 30, 2015)
Appendix B	Percolation Data (October 1, 2014 through September 30, 2015)
Appendix C	SCMMS Data (October 1, 2014 through September 30, 2015)
Appendix D	2015 Vegetation Performance Assessment Documentation
Appendix E	Cover Inspection Documentation (October 1, 2014 through September 30, 2015)
Appendix F	Maintenance and Repair Documentation (October 1, 2014 through September 30, 2015)
Appendix G	NRAP Log