RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN
MARTIN LAKE STEAM ELECTRIC STATION
A-1 AREA LANDFILL
BECKVILLE, TEXAS

October 2016

Prepared for:

LUMINANT GENERATION COMPANY, LLC
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Prepared by:

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PBW Project No. 5196B

PROFESSIONAL CERTIFICATION

This document and all attachments were prepared by Pastor, Behling & Wheeler, LLC under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I hereby certify that the Run-on and Run-off Control System Plan has been prepared in accordance with the requirements of Section 257.81 of the CCR Rule.

STATE OF TEXAS
BRIAN D. THOMAS
91192
LICENSED
PROFESSIONAL ENGINEER
10/5/16

10/5/16
Brian D. Thomas, P.E.
Principal Engineer
PASTOR, BEHLING & WHEELER, LLC

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1.0 INTRODUCTION

Luminant Generation Company, LLC (Luminant) operates the Martin Lake Steam Electric Station (MLSES) located approximately five miles southwest of Tatum in Rusk County, Texas. The power plant and related support areas occupy approximately 700 acres on a peninsula on the southwest side of Martin Lake (Figure 1). The MLSES consists of three coal/lignite-fired units with a combined operating capacity of approximately 2,250 megawatts. Coal Combustion Residuals (CCR) including fly ash, bottom ash, gypsum are generated as part of MLSES unit operation. The CCRs are transported off-site for beneficial use by third-parties, are managed by Luminant on-site at Permanent Disposal Pond No. 5 (PDP-5) or are disposed at Luminant's A-1 Area Landfill. The A-1 Area Landfill is located approximately 2.5 miles southeast of the MLSES power plant within a reclaimed section of the Luminant Beckville Mine in Panola County (Figure 2).

The CCR Rule (40 CFR 257 Subpart D - *Standards for the Receipt of Coal Combustion Residuals in Landfills and Surface Impoundments*) has been promulgated by EPA to regulate the management and disposal of CCRs as solid waste under Resource Conservation and Recovery Act (RCRA) Subtitle D. The final CCR Rule was published in the Federal Register on April 17, 2015. The effective date of the CCR Rule was October 19, 2015.

The CCR Rule establishes national operating criteria for existing CCR surface impoundments and landfills, including development of a run-on and run-off control system plan (RRCSP) for all CCR landfills. Pastor, Behling & Wheeler, LLC (PBW) was retained by Luminant to develop this run-on and run-off control system plan for the A-1 Area Landfill.

1.1 CCR Landfill Run-on and Run-off Control System Plan Requirements

Section 257.81(c) of the CCR Rule specifies that a written run-on and run-off control system plan be prepared for each existing CCR landfill that describes the systems that have been designed and constructed to control run-on to and run-off from the landfill consistent with the requirements of the CCR Rule and recognized and generally accepted good engineering practices. The RRCSP must include, at a minimum, design, construction, operation, and maintenance information for the following:

- A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and
- A run-off control system from the active portion of the CCR unit to collect and control at least the

water volume resulting from a 24-hour, 25-year storm. Run-off from the active portion of the CCR unit must be managed in accordance with the requirements of 40 CFR 257.3–3 (prohibition against pollution of waters of the United States).

The RRCSP must be must be supported by appropriate engineering calculations and must be certified by a qualified professional engineer. The RRCSP must document how the run-on and run-off control system has been designed and constructed to comply with the requirements of section 257.81 of the CCR Rule.

In accordance with 40 CFR 257.81(c)(3) of the CCR Rule, the initial RRCSP for an existing CCR landfill must be completed and placed in the facility operating record no later than October 17, 2016. Periodic RRCSPs must be completed every five years from the completion date of the initial plan. In addition, the RRCSP must be amended whenever there is a change in conditions that would substantially affect the plan.

1.2 MLSES Units Subject to Run-on and Run-off Control System Plan Requirements

The CCR Rule defines coal combustion residuals such as fly ash, bottom ash, boiler slag, flue gas desulfurization (FGD) materials (gypsum), and related solids generated from burning coal for the purpose of generating electricity by electric utilities and independent power producers. The RRCSP requirements of the CCR Rule apply to existing and new CCR landfills that dispose or otherwise engage in solid waste management of CCR.

The only CCR Unit at MLSES that meets the definition of a CCR Landfill is the A-1 Area Landfill, which is located within a reclaimed section of the Luminant Beckville Mine. The registered boundary of the landfill covers an area of approximately 986 acres, and the A-1 Area Landfill is surrounded by and underlain by spoil material that was previously excavated during lignite mining operations. The A-1 Area Landfill is registered under the Texas Commission on Environmental Quality under SWR31277 (WMU002) and began receiving CCR in 1980.

This RRCSP was prepared for A-1 Area Landfill, and in accordance with 40CFR 257.81(c)(3) of the CCR Rule, the RRCSP must be amended when future lateral expansion of the landfill occurs.

1.3 Description of A-1 Area Landfill

The A-1 Area Landfill is located approximately 2.5 miles southeast of the MLSES (Figure 2). An existing a site plan is shown on Figure 3. The registered boundary of the A-1 Area Landfill covers an area of approximately 986 acres and is located entirely within the reclaimed section of the Luminant Beckville Mine. The A-1 Area Landfill is registered with the Texas Commission on Environmental Quality under SWR31277 (WMU 002) and began receiving CCR in 1980. Dewatered CCR is transported from MLSES to the A-1 Area Landfill by railcar for disposal. The landfill is surrounded by earthen embankments constructed of mine spoil, and prior to placement of CCRs, a 1-foot thick compacted clay bottom liner is constructed using suitable mine spoil. Construction of the bottom liner consists of scarifying and re-compacting suitable clay mine spoil to achieve the design specification of 95 percent of maximum density and an in-place permeability of $1x10^{-7}$ cm/sec or less. The compacted clay liner is underlain by mine spoil (predominantly clay soils) that vary in thickness from 70-100 feet. Specifications for the construction of the perimeter embankments include placement of a 3-foot thick compacted clay liner on the interior slope of the embankment. The interior embankment slopes are specified not to exceed a 3:1 (horizontal:vertical) sideslope, and the exterior sideslopes are specified not to exceed a 5:1 slope. Approximately 450-acres of the A-1 Area landfill has been capped by placement of a 3-foot thick compacted clay cap with a minimum 2-foot thick vegetative cover layer. Progressive capping/closure of the A-1 Area Landfill is performed as placement of CCR reaches the target cap subgrade elevations.

2.0 RUN-ON AND RUN-OFF CONTROL SYSTEM PLAN

The RRCSP for A-1 Area Landfill is described in this section. In accordance with 257.81(c) of the CCR Rule, the RRCSP addresses run-on and run-off control for the active portion of the landfill. Run-on and run-off control systems for the capped portion of A-1 Area Landfill are described in the Closure and Post-Closure Plans for the landfill.

2.1 Design Storm Conditions

In accordance with Sections 257.81(a)(1) and 257.81(a)(2) of the CCR Rule, the run-on and run-off control systems for the landfill must be designed to prevent run-on into the landfill and run-off from active portions of the landfill during the peak discharge from a 24-hour, 25-year storm. US Department of Commerce has created Technical Paper No. 40: Rainfall Frequency Atlas of the United States (Hershfield, 1961). Technical Paper No. 40: Rainfall Frequency Atlas (TP-40) can be used to estimate design storm precipitation totals, including the 25-year, 24-hour storm. Based on the TP-40, the 25-year, 24-hour storm for Panola County is 8.6 inches of rainfall. A copy of the TP-40 spreadsheet is shown in Appendix A.

2.2 Run-on Control System

The CCR Rule defines <u>run-on</u> as "any rainwater, leachate, or other liquid that drains overland <u>onto</u> any part of a CCR landfill or lateral expansion of a CCR landfill." The run-on control system for active portion A-1 Area Landfill (i.e. A-1 Expansion Area) is described below.

<u>2.2.1 Design and Construction</u>

The A-1 Area Landfill has been constructed to limit contact between storm water run-off from areas outside the landfill and CCR placed in the landfill. A significant portion of the landfill is surrounded by exterior earthen dikes that extend 10 to 15 feet or more above the surrounding grade. As shown on Figure 4, storm water run-off generated from areas outside the landfill is diverted away from the landfill by the dikes and associated drainage ditches, swales and other surface features. Given the size of the registered landfill boundary portions of the active disposal area utilize other interim run-on controls as placement of CCR progresses. As shown on Figure 4, these interim run-on controls include raised perimeter roadbeds and associated safety berms, an existing stockpile of suitable clay cap material (Estimated 1.75 million cubic yards) and drainage diversions. In accordance with Section 257.81(a)(1) of the CCR Rule, the height of the exterior landfill dikes as well as other interim controls relative to the surrounding topography indicate that run-off from a 25-year 24-hour storm will be diverted around the landfill and not flow onto any part of the landfill actively receiving CCR.

The landfill dikes and storm water drainage features are also designed and constructed to minimize soil erosion. The exterior of the existing dikes, post-reclamation drainage features and other permanent earthen structures are permanently vegetated to control erosion. Consistent with on-going mine reclamation, additional erosion protection (channel linings, rip rap, etc.) are used for maintenance of interim controls as well as at locations with higher storm water flow velocities and increased erosion potential.

2.2.2 Operation and Maintenance

Storm water drainage features along the exterior of A-1 Area Landfill will be operated and maintained to ensure that proper storm water run-on control is maintained throughout the life of the landfill. Storm water run-on operation and maintenance activities implemented at the landfill include:

- The landfill is visually inspected on a weekly basis by a qualified person in accordance 40 CFR 257.83(a) and annual by a professional engineer in accordance with 40 CFR 257.83 (b). The weekly and annual inspections address the exterior dikes around the landfill and storm water run-on control features along the dikes and include:
  - Verification that storm water generated from areas outside the CCR placement areas is diverted around the landfill by the dikes/associated drainage ditches, swales and other drainage features.
  - Verification that the drainage ditches, swales and other drainage features do not contain significant accumulated sediments or other flow obstructions;
  - Identification of areas of dike or drainage feature erosion/scouring that require repair.
- Accumulated sediment/debris are removed, as required, from the drainage features to maintain adequate storm water drainage. Areas of erosion/scour are repaired through backfilling, grading/reshaping, seeding and related activities. Drainage features may be redesigned/reconfigured if erosion/scouring are observed repeatedly in certain areas.
- Each inspection and maintenance activity is documented in a written inspection and maintenance record. Documentation includes the date, time, name of the individual performing the inspection/maintenance, a description of the problems observed (if any), maintenance/repairs performed (if any), and related information. The inspection and maintenance records are maintained in the facility operating record to provide an inspection and maintenance history for the landfill.

2.3 Run-off Control System

The CCR Rule defines run-off as "any rainwater, leachate, or other liquid that drains overland from any part of a CCR landfill or lateral expansion of a CCR landfill." For the purposes of this RRCSP, this run-off is also referred to as being generated from either active, capped areas, or previously reclaimed areas. The run-off control system for A-1 Area Landfill is described below.

2.3.1 Design and Construction

A-1 Area Landfill has been constructed to contain precipitation that falls directly on the active portions of the landfill. The majority of the landfill is surrounded by earthen dikes that extend 10 to 15 feet or more above the surrounding grade, so precipitation that falls within the active areas of the landfill is contained and managed within run-off collection areas. Similar to the run-on controls, interim controls are in-place within the active disposal area to divert run-off to collection areas present at the downgradient edge of the active disposal areas (Figure 4). Accumulated run-off is either applied to the CCR to control dust, allowed to evaporate (seasonally dependent), or pumped to two treatment ponds (located within the registered boundary) prior to discharge to the Beckville Mine drainage control system, which is ultimately monitored in accordance with an existing TCEQ permit authorization.

Luminant has developed a preliminary plan for sequential placement of CCR within the A-1 Area Landfill. Within the next five years Luminant currently anticipates that the North Run-Off Collection Area (NROCA) will be capped or reclaimed as placement of the final cover system progresses. The South Run-off Collection Area (SROCA), the Former South Run-off Collection Area (FSROCA), the South Treatment Pond (STP), and the North Treatment Pond (NTP) will remain in-service while active placement of CCR is occurring within the landfill. With exception of the NROCA and NTP, Luminant currently anticipates that these areas will be reclaimed. The NTP and NROCA will be dewatered and accumulated sediment will be stabilized prior to placement of the final cover system in this area.

Consistent with the on-going progressive closure activities, Luminant anticipates that construction of the final CCR cover system will continue in phases over several years. While a portion of the landfill is active, all precipitation that comes into contact with exposed CCR will be contained and managed within run-off collection areas. Once a portion of the landfill has been capped (either with a permanent cap or with a temporary soil cover), precipitation that falls on the capped area will be diverted away from the active areas of the landfill and/or the run-off collection areas. This storm water run-off will flow off of the capped portions of the landfill and be diverted away from the landfill by the drainage ditches, swales and other surface features along the perimeter of the landfill.

Run-off Volume Calculation Procedures

In accordance with Section 257.81(a)(2) of the CCR Rule, the A-1 Area Landfill has been constructed to contain the estimated volume of run-off generated from a 25-year, 24-hour storm. Run-off volume estimates were generated for the following landfill operating scenarios:

- Scenario 1: Phase I Progressive Closure Plan (Existing Conditions). Under this scenario, the current configuration of the landfill is evaluated. In this scenario the NROCA, FSROCA, and SROCA each provide run-off storage for the active disposal area. A significant portion of the drainage area managed by the NROCA consists of recently capped areas where establishment of vegetative cover is underway. As uniform vegetative cover is established run-off from these areas will be diverted off the cap to the perimeter drainage system, thereby progressively reducing the volume of run-off to the NROCA. Surface cover within the drainage areas of the SROCA and the FSROCA consist of exposed CCR or partially reclaimed mine spoil (i.e. future active disposal areas).

- Scenario 2: Phase II Progressive Closure Plan (NROCA Closure/Reclaim). Under this scenario, the NROCA will be reclaimed/capped. Hence, this scenario assumes the SROCA and FSROCA provide drainage control for the active areas of the landfill. The total volume of water stored also takes into consideration precipitation on the surface area of each pond.

Run-off volumes were estimated using the Curve Number (CN) method as described in the USDA publication *TR-55 - Urban Hydrology for Small Water Sheds* (USDA-NRCS, 1986). A key component of the TR-55 procedure is identifying the appropriate CN used in the evaluations. As a point of reference, a CN of 100 means 100 percent of the rainfall on an area runs off and none of the precipitation is retained by the exposed material through absorption, evaporation, localized ponding, infiltration and similar processes. Published CNs vary depending on material type, degree of saturation and other variables, ranging from 98 for impervious surfaces (concrete/asphalt pavement, etc.) to 50 or less for vegetated, well drained soils (USDA-NRCS, 1986).

The fly ash/bottom ash and gypsum placed within the A-1 Area Landfill is absorptive and is placed as a dry material. As a result, the exposed fly ash/bottom ash and gypsum will absorb/retain a measurable volume of the precipitation that falls on the active landfill cells. The Hydrologic Evaluation of Landfill Performance (HELP) model was used to estimate a CN for the exposed CCR in the cells (Schroeder, et. al, 1994). HELP model results for the exposed CCR are shown in Appendix B. Based on the HELP model results, a CN of 94 was assumed for estimating run-off volumes generated from active areas (i.e. exposed fly ash/bottom ash). The HELP model was also used to estimate a CN of 66 for the final cover system (Appendix B). A curve number of 72 was assumed for portions of the landfill that are in a partially reclaimed condition, which generally consists of mine spoil that is graded to drain and partially revegetated.

For each run-off scenario, the surface area of watersheds contributing to each of the collection areas were used to calculate run-off volumes. The watershed delineation for each scenario, which illustrates the surface area contributing to each run-off collection area, are reproduced in Appendices C and D. The calculated surface areas of the landfill cells were as follows:

- Scenario – 1
  - NROCA: 5,140,080 square feet (sf) or approximately 118 acres
  - SROCA: 8,799,120 sf or approximately 202 acres
  - FSROCA: 44,431,220 sf or approximately 102 acres
- Scenario – 2
  - SROCA: 8,799,120 sf or approximately 202 acres
  - FSROCA: 44,431,220 sf or approximately 102 acres

<u>Run-off Containment Capacities</u>

Run-off containment capacities for each of the collection areas were calculated using the terrain modelling capabilities of AutoCad Civil 3D. Outputs from the Civil 3D models showing the containment capacities of each run-off collection area are reproduced in Appendix E. The estimated containment capacities of each run-off collection area are based on the following assumptions:

- Luminant will continue to minimize storage of run-off in each area between precipitation events to ensure normal static pool elevations provided by Luminant are maintained;
- Existing topography surrounding each run-off collection area will not be modified in a manner that would reduce the currently available storage volume and the ponds; and
- Periodic removal of accumulated sediment/CCR will be performed.

Run-off Evaluation

Run-off volume estimates for each of the landfill operating scenarios described above are shown in Appendix F. The estimated volumes of run-off were compared to the containment capacities for the run-off collection areas shown in Appendix E to confirm that adequate run-off containment is provided for each scenario for the 25-year, 24-hour storm.

The results of the run-off evaluation can be summarized as follows:

- Scenario 1: Phase I Progressive Closure Plan (Existing Conditions).
  Under this scenario, three currently active run-off collection areas (NROCA, FSROCA and SROCA) provide containment for active CCR disposal areas. The following estimated run off volumes would be generated and conveyed to the respective collection areas under this scenario:

Collection Area	**Run off Volume**	**Containment Volume**	**Percent Containment**
NROCA	3,092,000 cubic feet (cf)	3,218,000 cf	105%
SROCA	6,399,000 cf	14,151,000 cf	221%
FSROCA	2,497,000 cf	3,256,000 cf	130%

  Adequate storage for run-off for the 25-year, 24-hour storm is provided by each collection area under this scenario.

  Although the NROCA provides adequate containment of the design storm event, Luminant also maintains a dedicated pumping system with the capacity to transfer approximately 577,000 cubic feet per day of run-off from this area to other storage areas (i.e. STP). As previously noted, the progressive establishment of uniform vegetative cover is on-going for capped portion of the NROCA watershed, and run-off will continue to be diverted off the capped areas to the perimeter drainage system of the landfill, as surface conditions of the capped areas permit. This progressive capping process will result in increasing amounts of run-off being diverted off the landfill prior to reaching the NROCA.

- Scenario 2: Phase II Progressive Closure Plan (NROCA Closure/Reclaim).

  Under this scenario, the NROCA will have been reclaimed or capped and will no longer receive run-off. Based on the assumed five year projections for installation of the final cover system on currently active portions of the landfill, the containment capacity for run-off generated from active portions of the landfill will be provided by the FSROCA and the SROCA. The following estimated run off volumes would be generated and conveyed to the respective collection areas under this scenario:

Collection Area	**Run off Volume**	**Containment Volume**	**Percent Containment**
SROCA	6,354,000 cf	14,151,000 cf	223%
FSROCA	2,497,000 cf	3,256,000 cf	130%

Future progressive installation of the final cover system of the landfill will result in smaller run-off volumes being conveyed to the SROCA over time; hence, Scenario 2 provides a conservative evaluation of drainage control requirements for the FSROCA and the SROCA.

Adequate storage for run-off from the 25-year, 24-hour storm is provided by each collection area under this scenario.

2.3.2 Operation and Maintenance

The run-off containment features of A-1 Area Landfill will be operated and maintained to ensure that proper run-off control for active areas are maintained throughout the life of the landfill. Run-off operation and maintenance activities implemented at the landfill include:

- Run off generated from active areas of the landfill is stored in collection areas for the shortest time practicable. Stored run-off is applied to the CCR to control dust and/or is allowed to evaporate. Run-off discharged from collection areas within the landfill will continue to be monitored in accordance with the existing TCEQ TPDES permit for the Beckville Mine or similar authorization.
- The landfill will continue to be visually inspected on a weekly basis by a qualified person in accordance 40 CFR 257.83(a) and annually by a professional engineer in accordance with 40 CFR 257.83 (b). The weekly and annual inspections address the interior and exterior dikes at the landfill and include:
  - Verification that run-off is being contained in the landfill and a minimum of 2 feet of freeboard is maintained along the exterior dikes in areas where run-off is temporarily stored.
- Each inspection and maintenance activity is documented in a written inspection and maintenance record. Documentation includes the date, time, name of the individual performing the inspection/maintenance, a description of the problems observed (if any), maintenance/repairs performed (if any), and related information. The inspection and maintenance records are maintained in the facility operating record to provide an inspection and maintenance history for the landfill.

2.4 Updates to Run-on and Run-off Control System Plan

In accordance with 257.81(c)(3) of the CCR Rule, this initial RRCSP must be placed in the A-1 Area Landfill facility operating record no later than October 17, 2016. Subsequent periodic RRCSPs must be completed every five years from the completion date of this initial plan. In addition, the RRCSP must be amended whenever there is a change in conditions that would substantially affect the plan.

3.0 REFERENCES

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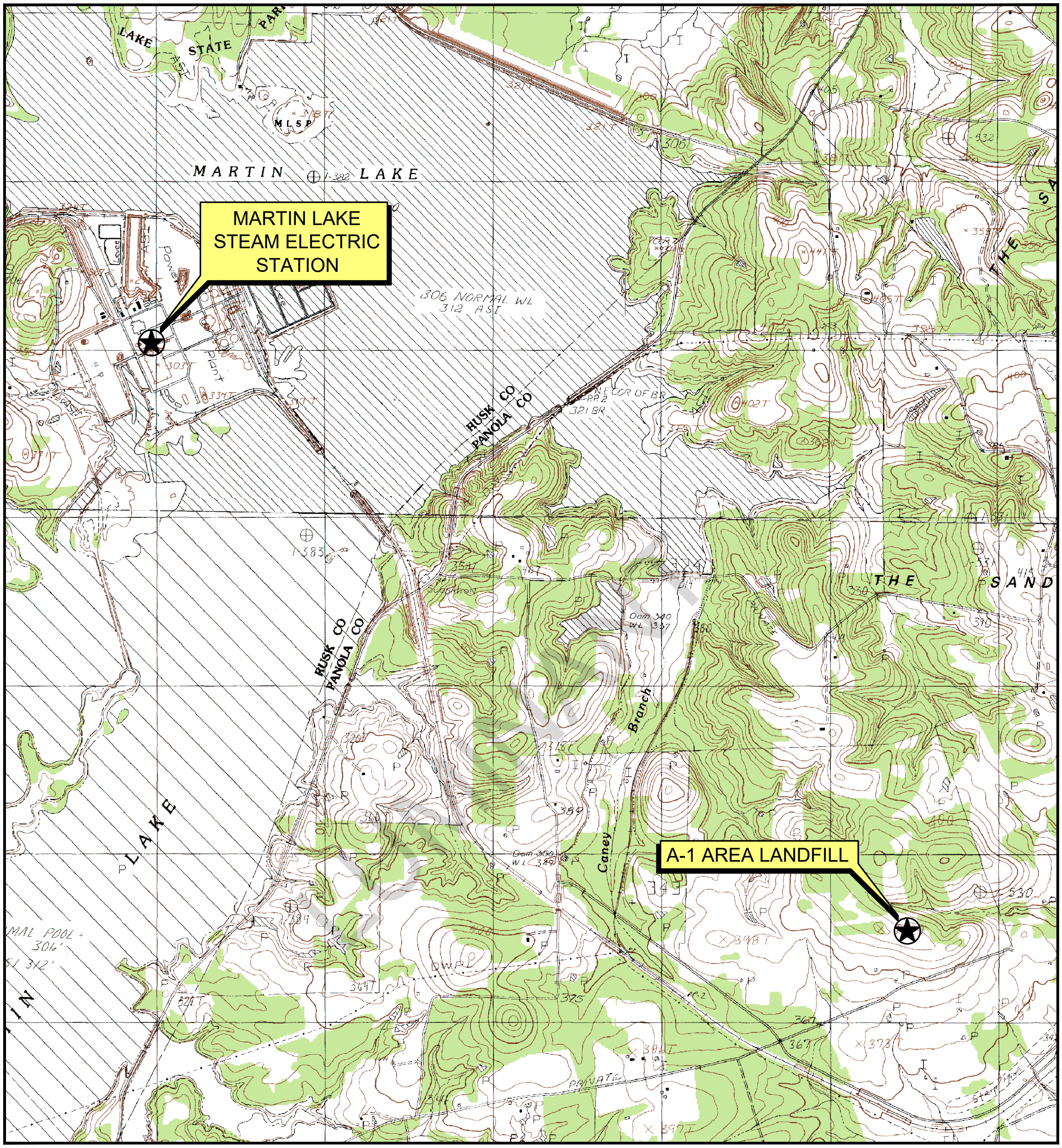
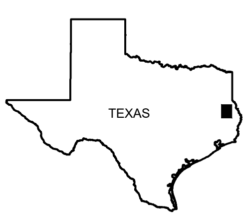
Figures





□UADRANGLE LOCATION

N

Scale in Feet

0 1500 3000

SOURCE:
Base map from www.tnris.gov, Tatum, TX 7.5 min. USGS □uadrangle dated 1983.

LUMINANT GENERATION COMPANY, LLC

MARTIN LAKE STEAM ELECTRIC STATION

Figure 1

SITE LOCATION MAP

PROJECT: 5196B	BY: AJD	REVISIONS
DATE: SEPT., 2016	CHECKED: BDT	

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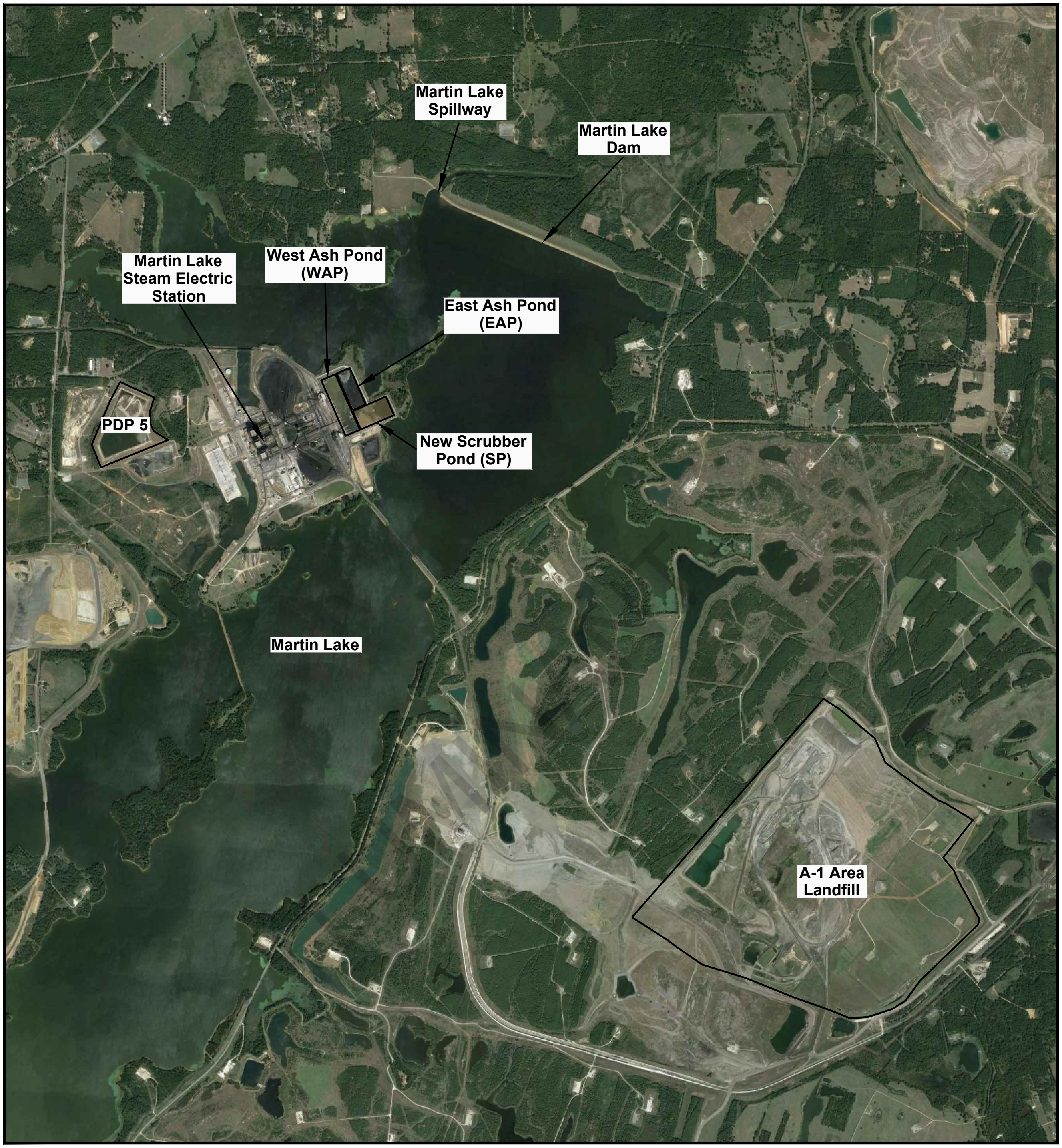
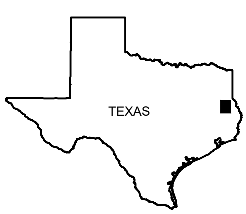
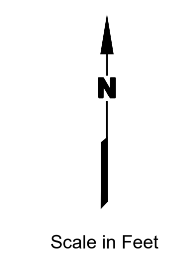
CONSULTING ENGINEERS AND SCIENTISTS







SOURCE:
Imagery from Google Earth, photography dated October 1, 2015.

LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Figure 2

SITE VICINITY MAP

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DATE: SEPT., 2016	CHECKED: BDT	

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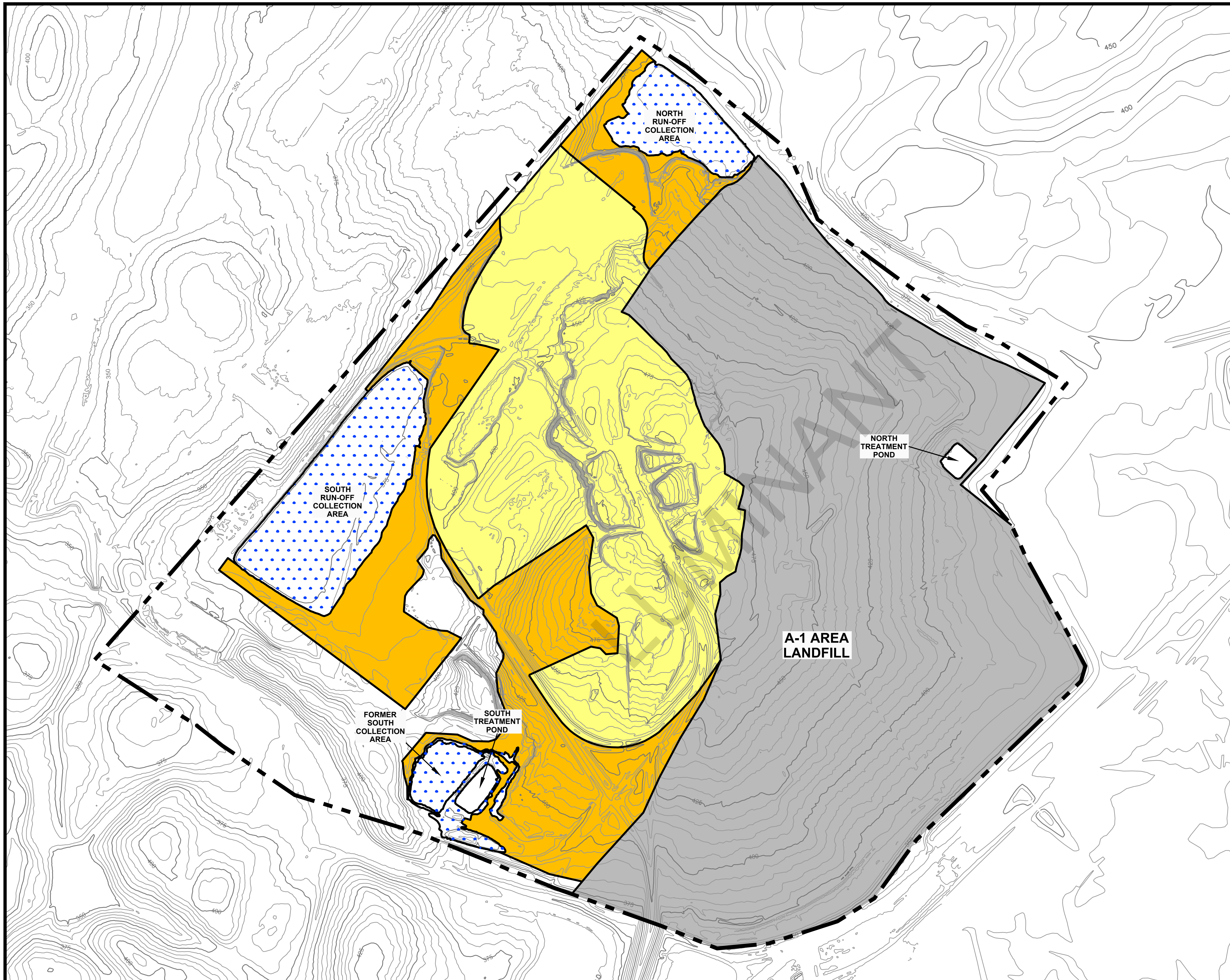

EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Capped Area (Existing)
- Active CCR Disposal/ Disturbed Area
- Existing Compacted Clay Liner
- Run-off Collection Area

Notes:
1. Extent of Capped Areas based on October 2016 site conditions.
2. Run-Off Collection Areas and Treatment Ponds are lined with compacted clay.

N

Scale in Feet
0 450 900

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MARTIN LAKE STEAM ELECTRIC STATION

Figure 3

EXISTING SITE PLAN

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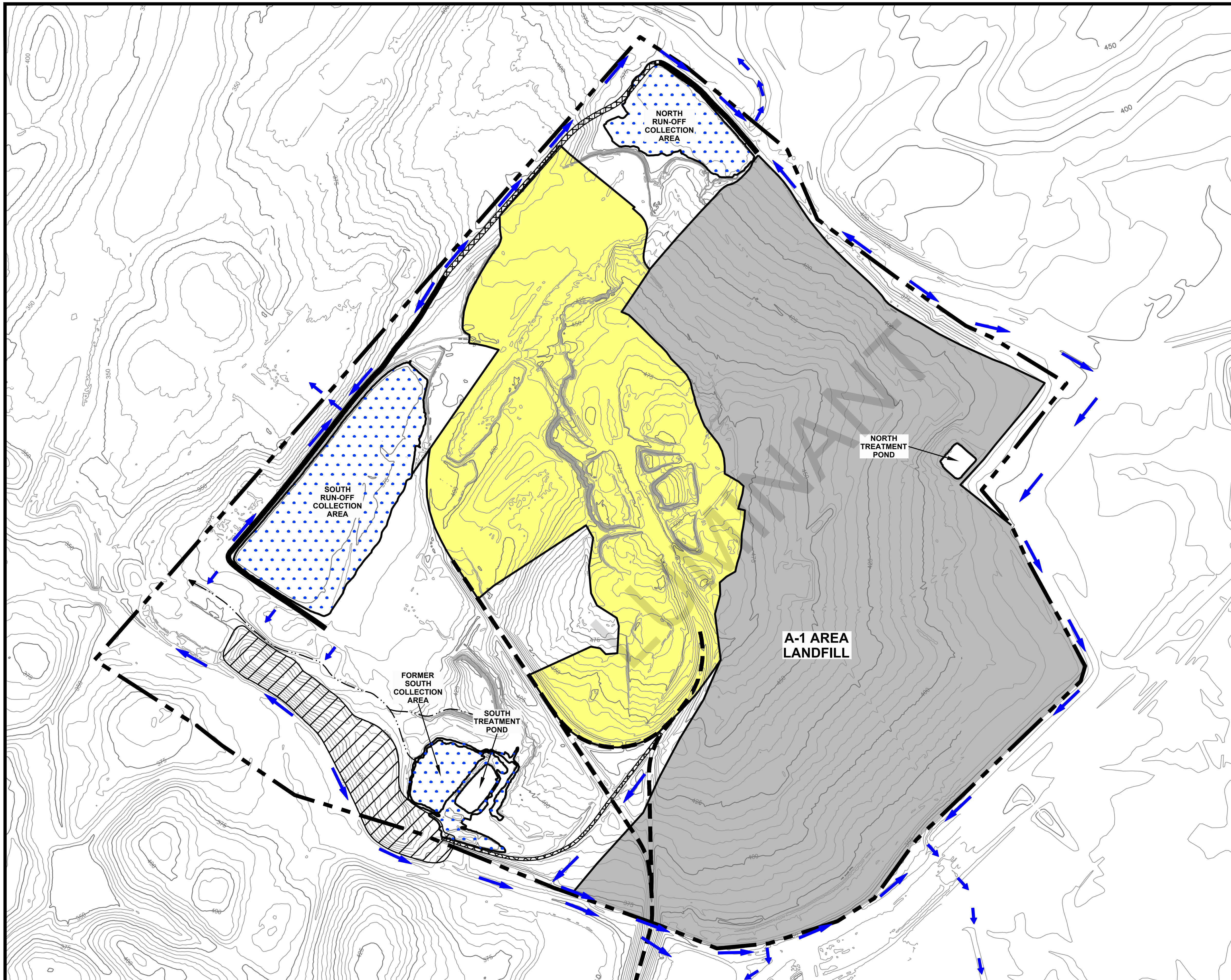

EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Approx. Limits of Existing Cap/Cover System
- Active CCR Disposal/ Disturbed Area
- Perimeter Run-On Control (Elevated Roadbed/Berms)
- Existing Emban□ment
- Clay Cap Material Stoc□pile
- Raised Rail Spur Emban□ment
- Stormwater Runoff Flow Direction
- Run-off Collection Area

N

Scale in Feet

0 450 900

LUMINANT GENERATION COMPANY, LLC

MARTIN LAKE STEAM ELECTRIC STATION

Figure 4

RUN-ON DIVERSION PLAN

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DATE: SEPT., 2016	CHECKED: BDT	

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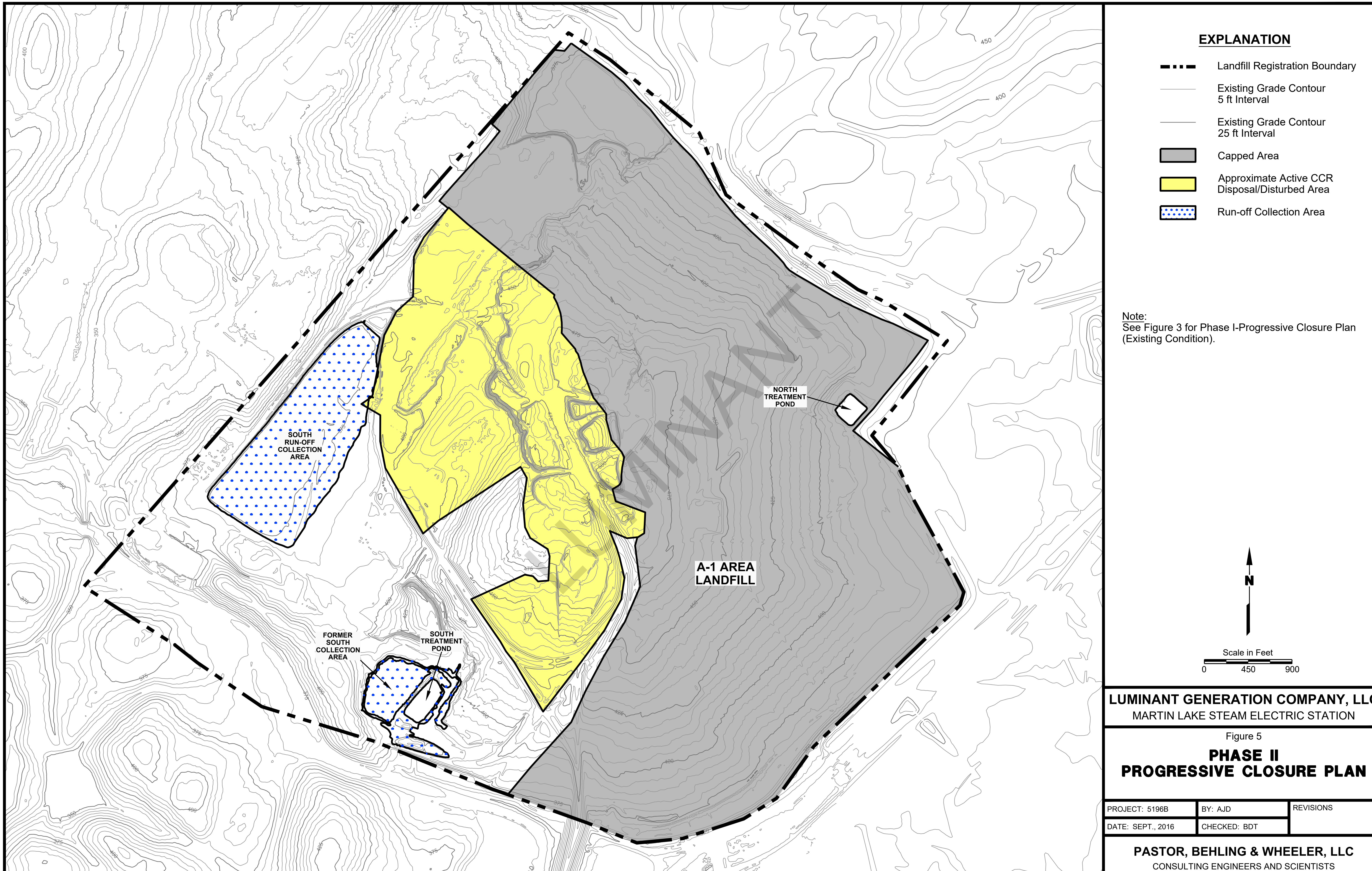

Note:
See Figure 3 for Phase I-Progressive Closure Plan (Existing Condition).

LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Figure 5

PHASE II PROGRESSIVE CLOSURE PLAN

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Appendix A

TP-40: Rainfall Frequency Atlas
25-Year 24-Hour Rainfall

U.S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary

WEATHER BUREAU
F. W. REICHELDERFER, Chief

TECHNICAL PAPER NO. 40

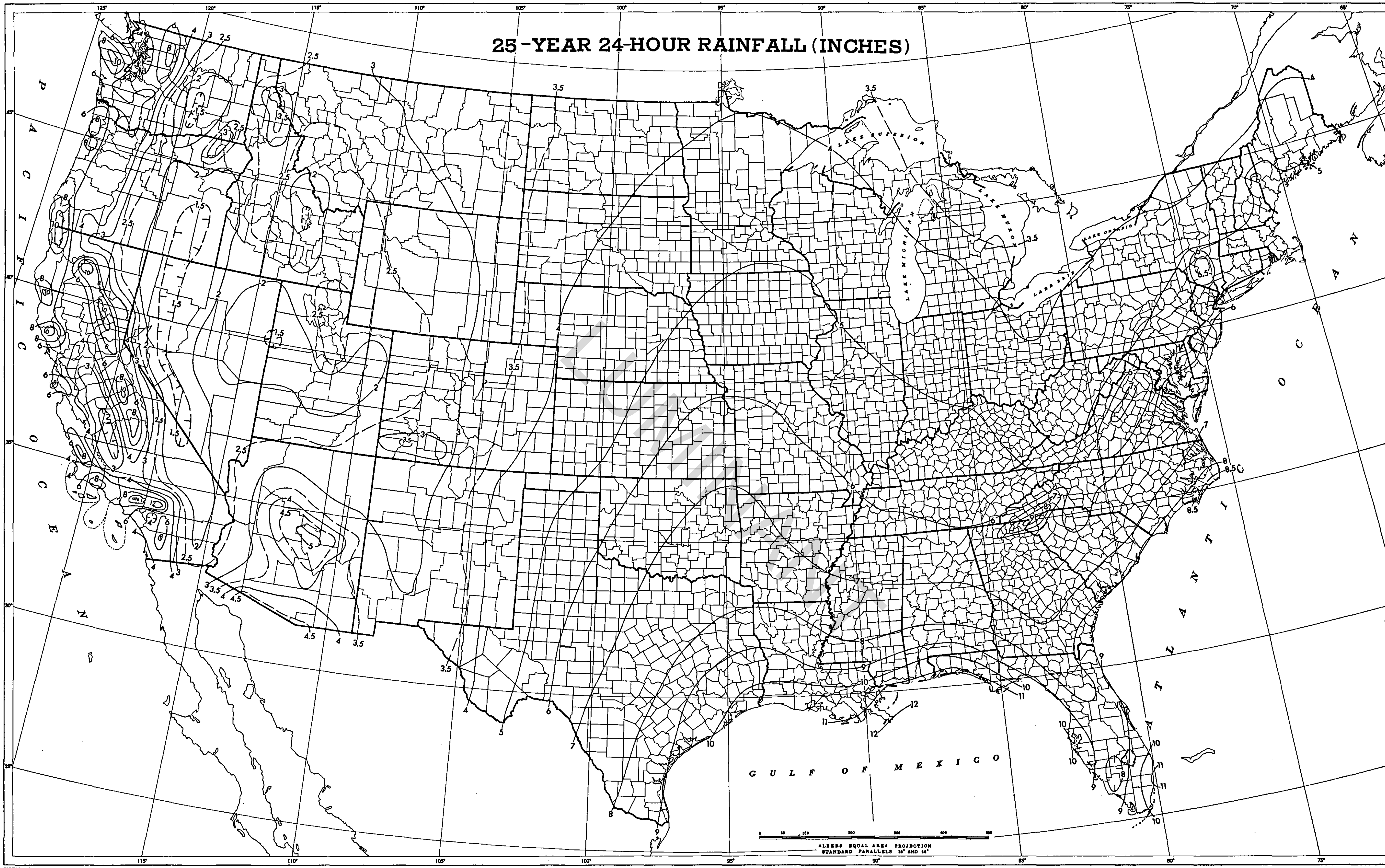
RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division
for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

WASHINGTON, D.C.
May 1961
Repaginated and Reprinted January 1963

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.25


25-YEAR 24-HOUR RAINFALL (INCHES)
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°

Appendix B

HELP Model Results

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**  HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE  **
**        HELP MODEL VERSION 3.07 (1 November 1997)          **
**       DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**         USAE WATERWAYS EXPERIMENT STATION              **
**FOR USEPA RISK REDUCTION ENGINEERING LABORATORY**
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PRECIPITATION DATA FILE: C:\WHI\VHELP22\data\P8054.VHP_weather1.dat
TEMPERATURE DATA FILE: C:\WHI\VHELP22\data\P8054.VHP_weather2.dat
SOLAR RADIATION DATA FILE: C:\WHI\VHELP22\data\P8054.VHP_weather3.dat
EVAPOTRANSPIRATION DATA: C:\WHI\VHELP22\data\P8054.VHP_weather4.dat
SOIL AND DESIGN DATA FILE: C:\WHI\VHELP22\data\P8054.VHP\I_395493.inp
OUTPUT DATA FILE: C:\WHI\VHELP22\data\P8054.VHP\O_395493.prt

TIME: 10:44   DATE: 9/21/2016

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TITLE: A1 Landfill Exposed CCR

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER   1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER   30

THICKNESS = 304.80 CM
POROSITY = 0.5410 VOL/VOL
FIELD CAPACITY = 0.1870 VOL/VOL
WILTING POINT = 0.0470 VOL/VOL
INITIAL SOIL WATER CONTENT = 0.2080 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 0.500001120000E-04 CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   5.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #30 WITH BARE
GROUND CONDITIONS, A SURFACE SLOPE OF   4.% AND
A SLOPE LENGTH OF   431. METERS.

SCS RUNOFF CURVE NUMBER = 94.44
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 20.2343 HECTARES
EVAPORATIVE ZONE DEPTH = 25.4 CM
INITIAL WATER IN EVAPORATIVE ZONE = 6.851 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 13.741 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 1.194 CM
INITIAL SNOW WATER = 0.000 CM
INITIAL WATER IN LAYER MATERIALS = 63.397 CM
TOTAL INITIAL WATER = 63.397 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Martin Lake (Shreveport)LA

STATION LATITUDE = 32.47 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 58
END OF GROWING SEASON (JULIAN DATE) = 331
EVAPORATIVE ZONE DEPTH = 10.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	57.00	65.70	73.00	79.80
82.90	82.40	77.10	66.70	55.70	48.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA
AND STATION LATITUDE = 30.56 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.60	2.99	3.85	4.96	4.51	3.71
	3.53	2.17	3.08	2.64	3.69	3.58
STD. DEVIATIONS	2.46	1.49	1.64	2.11	2.06	2.37
	1.79	1.84	1.72	1.45	1.20	2.26
RUNOFF						
TOTALS	0.945	0.692	0.816	1.358	1.250	1.176
	1.006	0.439	0.764	0.702	0.938	1.007
STD. DEVIATIONS	1.191	0.705	0.625	0.942	1.071	1.101
	0.857	0.664	0.798	0.771	0.451	1.344
EVAPOTRANSPIRATION						
TOTALS	1.682	2.086	2.974	3.744	3.446	2.617
	2.594	1.732	2.058	1.541	1.116	1.315
STD. DEVIATIONS	0.167	0.339	0.675	0.916	1.189	1.364
	1.245	1.208	0.949	0.825	0.260	0.219

PERCOLATION/LEAKAGE THROUGH LAYER 1

TOTALS	0.2556	0.1482	0.1696	0.2712	0.3712	0.4510
	0.4822	0.4559	0.4061	0.3832	0.3407	0.3610
STD. DEVIATIONS	0.1017	0.0819	0.2083	0.3244	0.3429	0.2601
	0.2085	0.1654	0.1299	0.1117	0.0947	0.0878

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.31 (7.468)	7679702.6	100.00
RUNOFF	11.091 (3.6596)	2013056.36	26.213
EVAPOTRANSPIRATION	26.907 (3.3466)	4883429.35	63.589
PERCOLATION/LEAKAGE THROUGH LAYER 1	4.09593 (1.58753)	743394.377	9.67999
CHANGE IN WATER STORAGE	0.219 (1.9488)	39822.64	0.519

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	4.10	744133.78060	1980021
RUNOFF	2.906	527373.97888	130016
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.061176	11103.25615	680020
SNOW WATER	2.84	515544.0726	130002
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3792		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0470		

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	31.5418	0.2628

SNOW WATER 0.000

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**  HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE  **
**          HELP MODEL VERSION 3.07  (1 November 1997)          **
**        DEVELOPED BY ENVIRONMENTAL LABORATORY        **
**            USAE WATERWAYS EXPERIMENT STATION            **
**FOR USEPA RISK REDUCTION ENGINEERING LABORATORY**
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE: C:\WHI\VHELP22\data\P8054.VHP_weather1.dat
TEMPERATURE DATA FILE: C:\WHI\VHELP22\data\P8054.VHP_weather2.dat
SOLAR RADIATION DATA FILE: C:\WHI\VHELP22\data\P8054.VHP_weather3.dat
EVAPOTRANSPIRATION DATA: C:\WHI\VHELP22\data\P8054.VHP_weather4.dat
SOIL AND DESIGN DATA FILE: C:\WHI\VHELP22\data\P8054.VHP\I_394356.inp
OUTPUT DATA FILE: C:\WHI\VHELP22\data\P8054.VHP\O_394356.prt

TIME: 10:43   DATE: 9/21/2016

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TITLE: A1 Landfill Compacted Clay Cap

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


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                     LAYER  1
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            TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   6
  THICKNESS                  =     60.96    CM
  POROSITY                   =     0.4530 VOL/VOL
  FIELD CAPACITY             =     0.1900 VOL/VOL
  WILTING POINT              =     0.0850 VOL/VOL
  INITIAL SOIL WATER CONTENT =     0.4275 VOL/VOL
  EFFECTIVE SAT. HYD. COND.  =  0.720001612800E-03 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   5.00
       FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                     LAYER  2
                     --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  29
  THICKNESS                  =     91.44    CM
  POROSITY                   =     0.4510 VOL/VOL
  FIELD CAPACITY             =     0.4190 VOL/VOL
  WILTING POINT              =     0.3320 VOL/VOL
  INITIAL SOIL WATER CONTENT =     0.4510 VOL/VOL
  EFFECTIVE SAT. HYD. COND.  =  0.100000000000E-06 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
       SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
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FAIR STAND OF GRASS, A SURFACE SLOPE OF 4.%
AND A SLOPE LENGTH OF 536. METERS.

SCS RUNOFF CURVE NUMBER = 66.18
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 27.5186 HECTARES
EVAPORATIVE ZONE DEPTH = 25.4 CM
INITIAL WATER IN EVAPORATIVE ZONE = 9.953 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 11.506 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 2.159 CM
INITIAL SNOW WATER = 0.000 CM
INITIAL WATER IN LAYER MATERIALS = 67.301 CM
TOTAL INITIAL WATER = 67.301 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Martin Lake (Shreveport)LA

STATION LATITUDE = 32.47 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 58
END OF GROWING SEASON (JULIAN DATE) = 331
EVAPORATIVE ZONE DEPTH = 10.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	57.00	65.70	73.00	79.80
82.90	82.40	77.10	66.70	55.70	48.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA
AND STATION LATITUDE = 30.56 DEGREES

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MONTHLY TOTALS (IN INCHES) FOR YEAR 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.84	2.07	1.98	2.47	8.45	2.54
	3.24	1.72	3.02	3.65	3.89	3.18
RUNOFF	0.000	0.000	0.000	0.000	3.584	0.000
	0.000	0.000	0.000	0.000	0.780	1.785
EVAPOTRANSPIRATION	1.614	1.745	3.186	3.700	4.537	1.580

	3.644	2.284	1.923	2.535	1.086	1.486
PERCOLATION/LEAKAGE THROUGH	0.1684	0.1456	0.1629	0.1438	0.1537	0.1410
LAYER 2	0.1487	0.1447	0.1385	0.1537	0.1601	0.1733

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	21.488	19.050	19.619	14.723	16.477	13.740
TOP OF LAYER 2	14.762	13.387	12.875	16.458	20.477	23.163
STD. DEVIATION OF DAILY	0.980	0.379	1.017	1.270	3.494	0.160
HEAD ON TOP OF LAYER 2	1.668	0.156	0.155	1.401	2.754	0.639

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.05	9145222.668	100.00
RUNOFF	6.149	1517733.345	16.60
EVAPOTRANSPIRATION	29.319	7236958.372	79.13
PERC./LEAKAGE THROUGH LAYER 2	1.834348	452780.602	4.95
AVG. HEAD ON TOP OF LAYER 2	17.1849		
CHANGE IN WATER STORAGE	-0.252	-62249.515	-0.68
SOIL WATER AT START OF YEAR	26.972	6657733.258	
SOIL WATER AT END OF YEAR	26.720	6595483.743	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.137	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.60	2.99	3.85	4.96	4.51	3.71
	3.53	2.17	3.08	2.64	3.69	3.58
STD. DEVIATIONS	2.46	1.49	1.64	2.11	2.06	2.37
	1.79	1.84	1.72	1.45	1.20	2.26
RUNOFF						
TOTALS	1.957	1.027	0.821	0.812	0.350	0.201
	0.082	0.000	0.090	0.120	0.669	1.862
STD. DEVIATIONS	2.245	1.144	1.148	1.010	0.848	0.791
	0.411	0.000	0.295	0.444	1.033	2.055
EVAPOTRANSPIRATION						
TOTALS	1.679	2.116	3.151	4.846	4.872	3.792
	3.455	2.086	2.474	1.663	1.068	1.260
STD. DEVIATIONS	0.174	0.297	0.584	0.659	1.420	2.180
	1.629	1.532	1.238	0.830	0.206	0.203

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.1708	0.1537	0.1662	0.1571	0.1526	0.1444
	0.1473	0.1458	0.1414	0.1495	0.1557	0.1707
STD. DEVIATIONS	0.0037	0.0047	0.0038	0.0050	0.0056	0.0043
	0.0038	0.0027	0.0046	0.0070	0.0112	0.0061

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	22.3261	21.6228	20.7545	19.4343	16.0974	14.9359
	14.2927	13.7858	13.8841	15.0423	18.9221	22.2857
STD. DEVIATIONS	1.2528	1.4403	1.2917	1.7502	1.9106	1.5274
	1.3042	0.9131	1.6268	2.4005	3.9594	2.0719

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.31	(7.468)	10444395.6	100.00
RUNOFF	7.990	(4.7750)	1972313.97	18.884
EVAPOTRANSPIRATION	32.460	(4.3675)	8012269.82	76.714
PERCOLATION/LEAKAGE THROUGH LAYER 2	1.85537	(0.02814)	457970.335	4.38484
AVERAGE HEAD ON TOP OF LAYER 2	17.782	(0.810)		
CHANGE IN WATER STORAGE	0.007	(0.6000)	1841.58	0.018

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	4.10	1012021.94161	1980021
RUNOFF	3.750	925585.11065	130016
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.005669	1399.35021	110002
AVERAGE HEAD ON TOP OF LAYER 2	24.000		
SNOW WATER	2.84	701139.9388	130002
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4530		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850		

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	10.4843	0.4368
2	16.2360	0.4510
SNOW WATER	0.000	

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**  HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                          **
**           HELP MODEL VERSION 3.07  (1 November 1997)                     **
**           DEVELOPED BY ENVIRONMENTAL LABORATORY                          **
**             USAE WATERWAYS EXPERIMENT STATION                            **
**FOR USEPA RISK REDUCTION ENGINEERING LABORATORY**
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\WHI\VHELP22\data\P8054.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\VHELP22\data\P8054.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:    C:\WHI\VHELP22\data\P8054.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\VHELP22\data\P8054.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:    C:\WHI\VHELP22\data\P8054.VHP\I_395512.inp
OUTPUT DATA FILE:             C:\WHI\VHELP22\data\P8054.VHP\O_395512.prt


TIME:   10:46       DATE:    9/21/2016


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      TITLE:   A1 Landfill Partial Reclaim

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      NOTE:   INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER   1
                              --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER    6
          THICKNESS                  =      60.96    CM
          POROSITY                   =       0.4530 VOL/VOL
          FIELD CAPACITY             =       0.1900 VOL/VOL
          WILTING POINT              =       0.0850 VOL/VOL
          INITIAL SOIL WATER CONTENT  =       0.2380 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.720000000000E-03 CM/SEC
        NOTE:   SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY   5.00
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                 GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                 ----------------------------------------

        NOTE:   SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                SOIL DATA BASE USING SOIL TEXTURE # 6 WITH A
                FAIR STAND OF GRASS, A SURFACE SLOPE OF   3.%
                AND A SLOPE LENGTH OF     30. METERS.

        SCS RUNOFF CURVE NUMBER                =      71.56
        FRACTION OF AREA ALLOWING RUNOFF       =     100.0     PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE     =      25.4952 HECTARES
        EVAPORATIVE ZONE DEPTH                 =      25.4     CM
        INITIAL WATER IN EVAPORATIVE ZONE      =       5.097   CM
        UPPER LIMIT OF EVAPORATIVE STORAGE     =      11.506   CM
        LOWER LIMIT OF EVAPORATIVE STORAGE     =       2.159   CM
        INITIAL SNOW WATER                     =       0.000   CM
        INITIAL WATER IN LAYER MATERIALS       =      14.509   CM
        TOTAL INITIAL WATER                    =      14.509   CM
        TOTAL SUBSURFACE INFLOW                =       0.00    MM/YR
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EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Martin Lake (Shreveport)LA

STATION LATITUDE = 32.47 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 58
END OF GROWING SEASON (JULIAN DATE) = 331
EVAPORATIVE ZONE DEPTH = 10.0 INCHES
AVERAGE ANNUAL WIND SPEED = 8.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 72.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.02	3.46	3.77	4.71	4.70	3.54
3.56	2.52	3.29	2.63	3.77	3.87

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.00	49.80	57.00	65.70	73.00	79.80
82.90	82.40	77.10	66.70	55.70	48.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Martin Lake (Shreveport)LA
AND STATION LATITUDE = 30.56 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.60	2.99	3.85	4.96	4.51	3.71
	3.53	2.17	3.08	2.64	3.69	3.58
STD. DEVIATIONS	2.46	1.49	1.64	2.11	2.06	2.37
	1.79	1.84	1.72	1.45	1.20	2.26
RUNOFF						
TOTALS	0.018	0.012	0.003	0.009	0.031	0.033
	0.025	0.002	0.014	0.017	0.000	0.037
STD. DEVIATIONS	0.095	0.035	0.011	0.021	0.093	0.062
	0.085	0.007	0.045	0.075	0.002	0.095
EVAPOTRANSPIRATION						
TOTALS	1.665	1.972	2.757	3.461	3.409	2.756
	2.800	1.898	2.244	1.583	1.182	1.406
STD. DEVIATIONS	0.220	0.440	0.707	0.892	1.069	1.422
	1.201	1.289	1.039	0.858	0.280	0.186

PERCOLATION/LEAKAGE THROUGH LAYER 1

TOTALS	2.2384	1.3574	1.1591	1.4709	1.3544	1.1056
	0.7647	0.4598	0.5149	0.7422	1.6241	2.2214
STD. DEVIATIONS	1.9744	1.0291	1.1342	1.0339	1.2552	1.2307
	0.9017	0.5297	0.7504	0.7779	1.0406	1.9950

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	42.31	(7.468)	9676425.3	100.00
RUNOFF	0.201	(0.2308)	45928.63	0.475
EVAPOTRANSPIRATION	27.132	(3.3649)	6204738.70	64.122
PERCOLATION/LEAKAGE THROUGH LAYER 1	15.01282	(5.14854)	3433207.432	35.48012
CHANGE IN WATER STORAGE	-0.033	(0.8865)	-7449.33	-0.077

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	4.10	937608.56355	1980021
RUNOFF	0.496	113429.05610	130016
PERCOLATION/LEAKAGE THROUGH LAYER 1	2.604084	595515.01639	1380030
SNOW WATER	2.84	649585.5315	130002
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3751		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850		

****
****

FINAL WATER STORAGE AT END OF YEAR 30

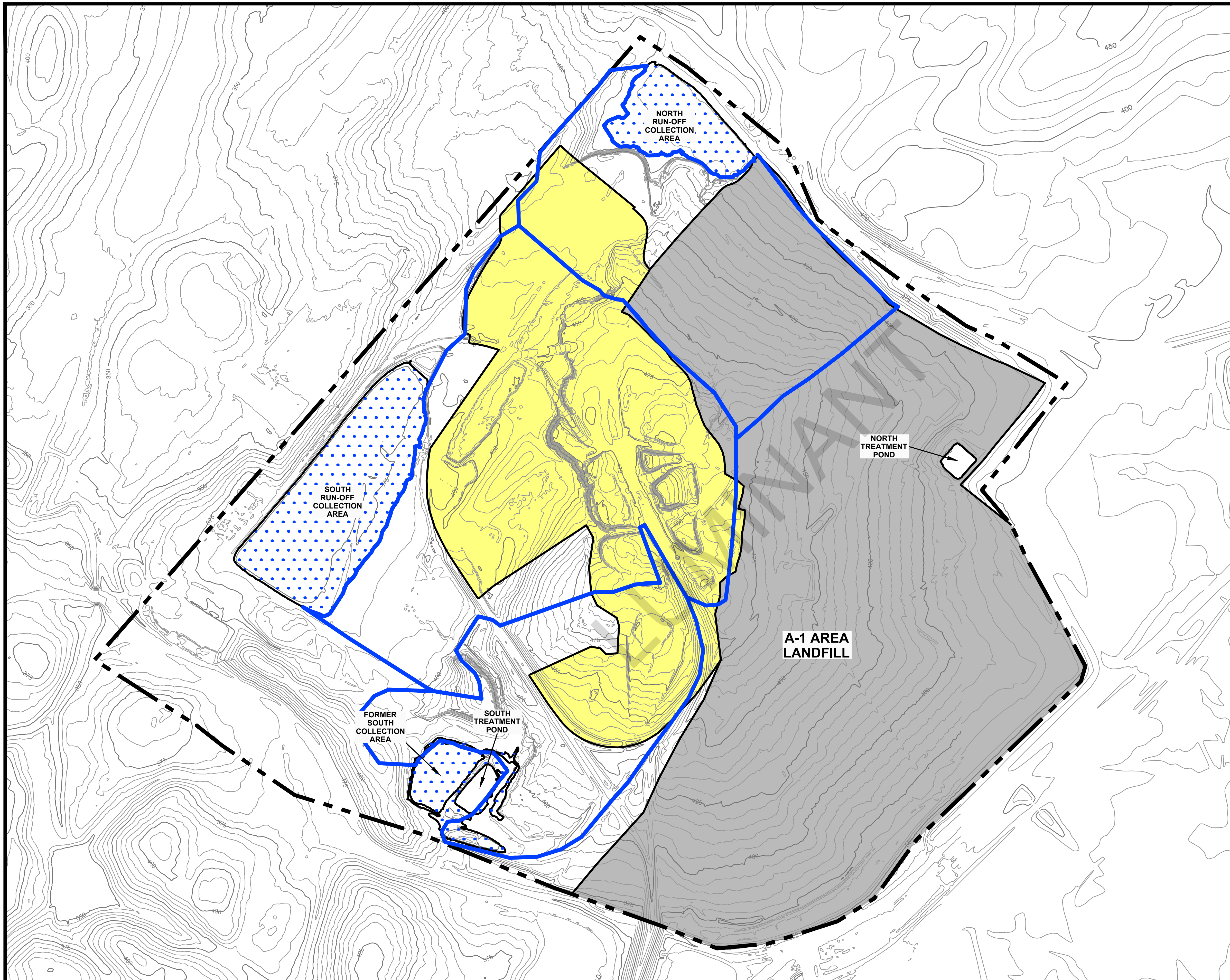
LAYER	(INCHES)	(VOL/VOL)
1	4.7350	0.1973

SNOW WATER 0.000

****
****

Appendix C

Watershed Boundaries – Phase I Landfill Operating Scenario (Existing Condition)



EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Capped Area
- Active CCR Disposal/ Disturbed Area
- Run-off Collection Area
- Watershed Boundary

PHASE I WATERSHED SUMMARY

NORTH RUN-OFF POND	
Active CCR Disposal	= 50 acres
Capped/Closed Area	= 68 acres
Total Area	**= 118 acres**
FORMER SOUTH RUN-OFF POND	
Active CCR Disposal	= 39 acres
Partial Reclaim	= 63 acres
Total Area	**= 102 acres**
SOUTH RUN-OFF POND	
Active CCR Disposal	= 123 acres
Partial Reclaim	= 79 acres
Total Area	**= 202 acres**

N

Scale in Feet
0 450 900

LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Appendix C

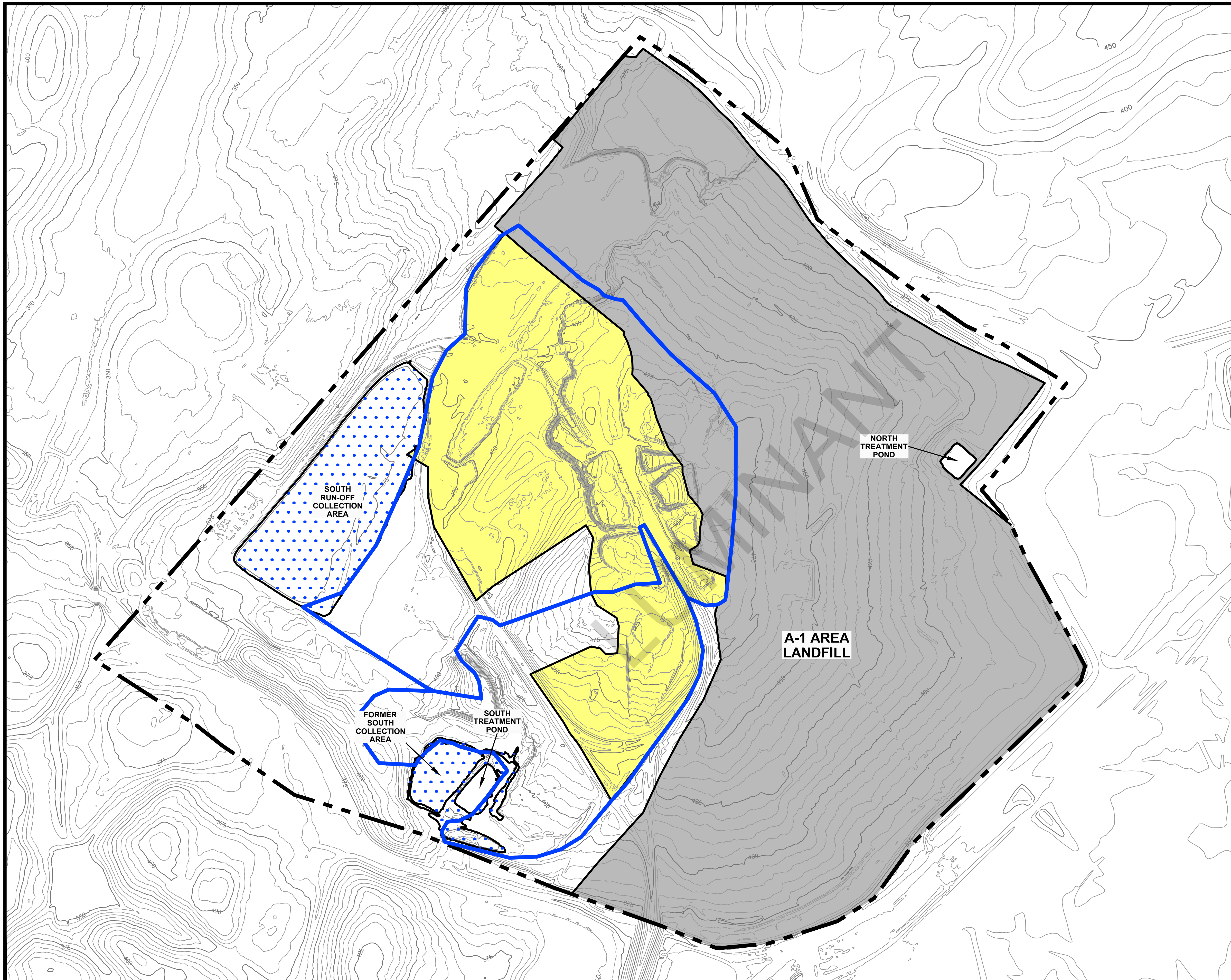
WATERSHED BOUNDARIES PHASE I - EXISTING CONDITIONS

PROJECT: 5196B	BY: AJD	REVISIONS
DATE: SEPT., 2016	CHECKED: BDT	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS

Appendix D

Watershed Boundaries – Phase II Landfill Operating Scenario (Future Cover System)



EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Capped Area
- Approximate Active CCR Disposal/Disturbed Area (Phase II)
- Run-off Collection Area
- Watershed Boundary

PHASE II WATERSHED SUMMARY	
Active CCR Disposal/Disturbed	= 126 acres
Capped/Closed Area	= 28 acres
Partial Reclaim*	= 48 acres
Total Area	**= 202 acres**

FORMER SOUTH RUN-OFF POND	
Active CCR Disposal	= 39 acres
Partial Reclaim	= 63 acres
Total Area	**= 102 acres**

Note:
* Denotes areas of partially reclaimed mine spoil and/or areas where bottom liner has been prepared. Composite SCS Curve Number of 72 used to characterize these areas.

N

Scale in Feet
0 450 900

LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Appendix D

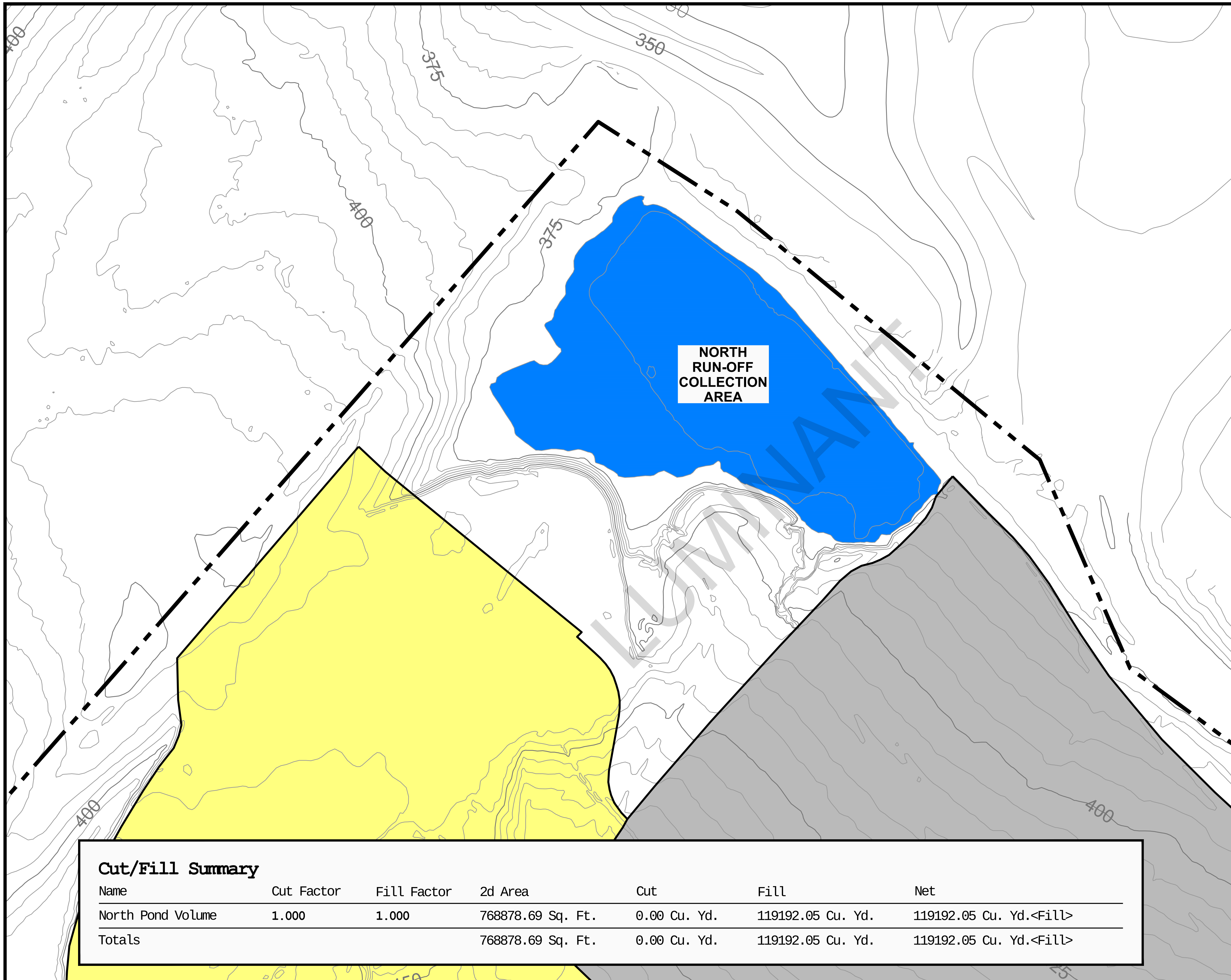
WATERSHED BOUNDARIES PHASE II - LANDFILL OPERATING SCENARIO

PROJECT: 5196B	BY: AJD	REVISIONS
DATE: SEPT., 2016	CHECKED: BDT	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS

Appendix E

Run-off Containment Capacities



Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
North Pond Volume	1.000	1.000	768878.69 Sq. Ft.	0.00 Cu. Yd.	119192.05 Cu. Yd.	119192.05 Cu. Yd.<Fill>
Totals			768878.69 Sq. Ft.	0.00 Cu. Yd.	119192.05 Cu. Yd.	119192.05 Cu. Yd.<Fill>

EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Capped Area
- Active CCR Disposal/ Disturbed Area
- Run-off Collection Area

Note:
1. North run-off pond capacity estimated based on top of emban□ment elevation of 370 ft-msl and assumed minimum water elevation of 364.2 ft-msl (Based on January 2016 survey).

N

Scale in Feet
0 150 300

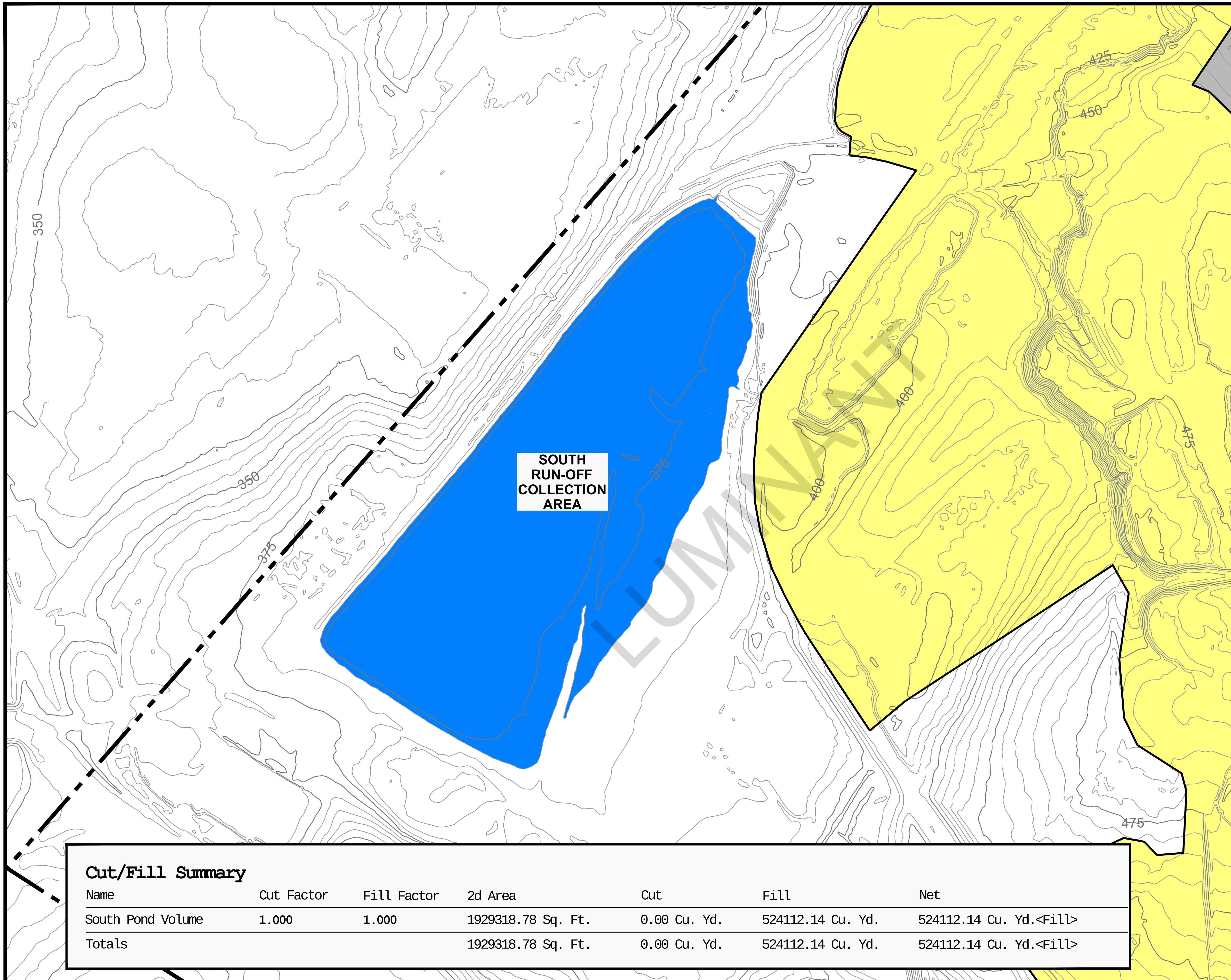
LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Appendix E-1

NORTH RUN-OFF COLLECTION AREA CONTAINMENT CAPACITY

PROJECT: 5196B	BY: AJD	REVISIONS
DATE: SEPT., 2016	CHECKED: BDT	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS



Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
South Pond Volume	1.000	1.000	1929318.78 Sq. Ft.	0.00 Cu. Yd.	524112.14 Cu. Yd.	524112.14 Cu. Yd.<Fill>
Totals			1929318.78 Sq. Ft.	0.00 Cu. Yd.	524112.14 Cu. Yd.	524112.14 Cu. Yd.<Fill>

EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Capped Area
- Active CCR Disposal/ Disturbed Area
- Run-off Collection Area

Note:
1. South run-off pond capacity estimated based on top of emban□ment elevation of 380 ft-msl and assumed minimum water elevation of 370.6 ft-msl (Based on January 2016 survey).

N

Scale in Feet
0 200 400

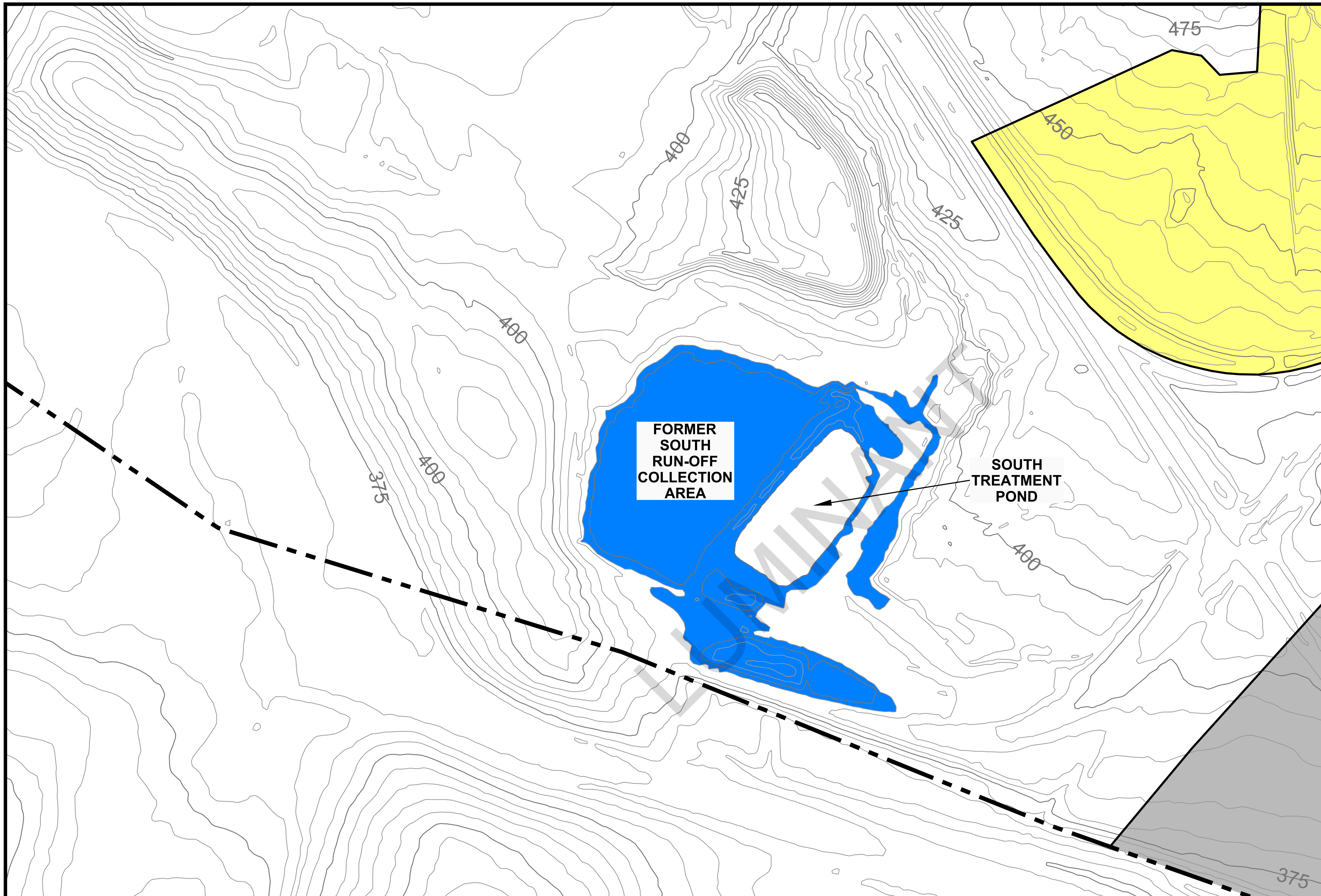
LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Appendix E-2

SOUTH RUN-OFF COLLECTION AREA CONTAINMENT CAPACITY

PROJECT: 5196B	BY: AJD	REVISIONS
DATE: SEPT., 2016	CHECKED: BDT	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS



Cut/Fill Summary

Name	Cut Factor	Fill Factor	2d Area	Cut	Fill	Net
Former South Run-off Pond	1.000	1.000	645677.37 Sq. Ft.	0.00 Cu. Yd.	120611.04 Cu. Yd.	120611.04 Cu. Yd.<Fill>
Totals			645677.37 Sq. Ft.	0.00 Cu. Yd.	120611.04 Cu. Yd.	120611.04 Cu. Yd.<Fill>

EXPLANATION

- Landfill Registration Boundary
- Existing Grade Contour 5 ft Interval
- Existing Grade Contour 25 ft Interval
- Capped Area
- Active CCR Disposal/ Disturbed Area
- Run-off Collection Area

Note:
1. Former South Run-off Collection Area capacity estimate is based on run-off accumulation up to elevation of 380 ft-msl and initial assumed water elevation of 371.4 ft-msl (Based on January 2016 survey).
2. Effective capacity of the former south run-off collection area (3,256,000 ft^3) does not include accumulation of run-off in the South Treatment Pond.

N

Scale in Feet
0 150 300

LUMINANT GENERATION COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION

Appendix E-3

FORMER SOUTH RUN-OFF COLLECTION AREA CONTAINMENT CAPACITY

PROJECT: 5196B	BY: AJD	REVISIONS
DATE: SEPT., 2016	CHECKED: BDT	

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS

Appendix F

Run-off Volume Calculations

APPENDIX F-1
PHASE I – PROGRESSIVE CLOSURE PLAN – EXISTING CONDITION

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

Definitions

Active Area Runoff -	storm water that comes into contact with waste
Storm Water Runoff from Inactive Areas-	storm water that falls outside of an active waste management area and does not come into contact with waste (i.e. capped or previously reclaimed areas)

Assumptions

1) North Run-off Collection Area (NROCA) is partially capped (i.e. protective soil areas)
2) Active Area Run-off water is generated on a limited portion of NROCA
3) Active Area Run-off volume based on a 25-year, 24-hr storm
4) Assumed exposed fly and bottom ash, and exposed protective soil exist in NROCA
5) Storm water runoff volumes are estimated using the Curve Number method as described in USDA's Urban Hydrology for Small Water Sheds (TR-55)

Area that Generates Run-off

NROCA – Exposed Ash Area:	2,178,000	sf
NROCA – Exposed Ash Area:	50	acres
NROCA – Protective Soil Area:	2,962,080	sf
NROCA – Protective Soil Area:	68	acres

Design Rainfall

From Technical Paper No. 40: Rainfall Frequency Atlas
Panola County 25-Yr, 24-hr: 8.6 in/day

Curve Numbers

From TR-55, Table 2-2a:
- For exposed fly and bed ash, use CN = 94 (See HELP Model Results)
- For protective soil (capped areas), use CN = 72 (See HELP Model Results)

Calculate Weighted Curve Number for Site

Description	Area (acres)	CN	Area X CN
Exposed Fly and Bottom Ash	50	94	4,700
Protective Soil (capped areas)	68	66	4,488
	118		9,188

Weighted Curve Number = (Sum of CN X A) /(Total Area)
Weighted Curve Number = 78

APPENDIX F-1
PHASE I – PROGRESSIVE CLOSURE PLAN – EXISTING CONDITION

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

<u>Calculate Run-off Volume Using TR-55 Procedures</u>

1) Calculate Potential Retention of Water (S). Assume this represents water adsorbed by ash and protective cover (non free water)

S = (1000/CNW)-10

where: S = Potential Retention of Water, inches
CN = Curve Number for Site

S = 2.84 inches

2) Calculate Depth of Run-off (Q)

Q = [(P-0.2S)^2]/[P-0.8S)]

where: Q = Depth of run-off generated, inches S =
Potential Retention of Water, inches
P = Design rainfall, inches

Q = 5.93 inches

3) Calculate Volume of Run-Off

V = Q X A

where: Q = depth of run-off generated, ft A = Total Area, sf

Q = 5.93 inches
Q = 0.49 feet
Area = 118 acres Area =
5,140,080 sf

V = 5,140,080 sf X 0.49 feet = 2,540,823 cf

4) Calculate Volume of Precipitation on NROCA

V= surface area (sf) X design storm precipitation (ft)
V= 768,879 sf X (8.6/12) ft
V= 551,000 cf

Total Run-off Volume (NROCA): 3,092,000 cf

APPENDIX F-1
PHASE I – PROGRESSIVE CLOSURE PLAN – EXISTING CONDITION

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

Definitions

Active Area Runoff -	storm water that comes into contact with waste
Storm Water Runoff from Inactive Areas-	storm water that falls outside of an active waste management area and does not come into contact with waste (i.e. capped or previously reclaimed areas)

Assumptions

1) Former South Runoff Collection Area (FSROCA) is partially reclaimed
2) Active Area Run-off water is generated on a limited portion of FSROCA
3) Active Area Run-off volume based on a 25-year, 24-hr storm
4) Assumed exposed fly and bed ash, as well as partially reclaimed soil exist in FSROCA
5) Storm water runoff volumes are estimated using the Curve Number method as described in USDA's Urban Hydrology for Small Water Sheds (TR-55)

Area that Generates Run-off

FSROCA – Exposed Ash Area:	1,698,840	sf
FSROCA – Exposed Ash Area:	39	acres
FSROCA – Partially reclaimed area:	2,744,280	sf
FSROCA – Partially reclaimed area:	63	acres

Design Rainfall

From Technical Paper No. 40: Rainfall Frequency Atlas
Panola County 25-Yr, 24-hr: 8.6 in/day

Curve Numbers

From TR-55, Table 2-2a:

- For exposed fly and bed ash, use CN =	94	(See HELP Model Results)
- For partially reclaimed area, use CN =	72	(See HELP Model Results)

Calculate Weighted Curve Number for Site

Description	Area (acres)	CN	Area X CN
Exposed Fly and Bed Ash	39	94	3,666
Partially Reclaimed Area	63	72	4,536
	102		8,202

Weighted Curve Number = (Sum of CN X A) /(Total Area)
Weighted Curve Number = 80.4

APPENDIX F-1
PHASE I – PROGRESSIVE CLOSURE PLAN – EXISTING CONDITION

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

<u>Calculate Run-off Volume Using TR-55 Procedures</u>

1) Calculate Potential Retention of Water (S). Assume this represents water adsorbed by ash and protective cover (non free water)

S = (1000/CNW)-10

where: S = Potential Retention of Water, inches
CN = Curve Number for Site

S = 2.44 inches

2) Calculate Depth of Run-off (Q)

Q = [(P-0.2S)^2]/[P-0.8S)]

where: Q = Depth of run-off generated, inches S =
Potential Retention of Water, inches
P = Design rainfall, inches

Q = 6.24 inches

3) Calculate Volume of Run-off

V = Q X A

where: Q = depth of run-off generated, ft A = Total Area, sf

Q = 6.24 inches
Q = 0.52 feet
Area = 102 acres Area =
4,443,120 sf

V = 4,443,120 sf X 0.52 feet = 2,310,000 cf

4) Calculate Volume of Precipitation on FSROCA

V= surface area (sf) X design storm precipitation (ft)
V= 260,880 sf X (8.6/12) ft
V= 187,000 cf

Total Run-off Volume (FSROCA): 2,497,000 cf

APPENDIX F-1
PHASE I – PROGRESSIVE CLOSURE PLAN – EXISTING CONDITION

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

Definitions

Active Area Runoff - storm water that comes into contact with waste
Storm Water Runoff from Inactive Areas- storm water that falls outside of an active waste management area and does not come into contact with waste (i.e. capped or previously reclaimed areas)

Assumptions

1) South Run-off Collection Area (SROCA) is partially capped (i.e. protective soil areas)
2) Active Area Run-off water is generated on a limited portion of SROCA
3) Active Area Run-off volume based on a 25-year, 24-hr storm
4) Assumed exposed fly and bed ash, as well as partially reclaimed area exist in SROCA
5) Storm water runoff volumes are estimated using the Curve Number method as described in USDA's Urban Hydrology for Small Water Sheds (TR-55)

Area that Generates Run-off

SROCA – Exposed ash area: 5,357,880 sf
SROCA – Exposed ash area: 123 acres
SROCA – Partially reclaimed area: 3,441,240 sf
SROCA – Partially reclaimed area: 79 acres

Design Rainfall

From Technical Paper No. 40: Rainfall Frequency Atlas
Panola County 25-Yr, 24-hr: 8.6 in/day

Curve Numbers

From TR-55, Table 2-2a:
- For exposed fly and bed ash, use CN = 94 (See HELP Model Results)
- For partially reclaimed area, use CN = 72 (See HELP Model Results)

Calculate Weighted Curve Number for Site

Description	Area (acres)	CN	Area X CN
Exposed Fly and Bed Ash	123	94	11,562
Partially Reclaimed Area	79	72	5,688
	202		17,250

Weighted Curve Number = (Sum of CN X A) /(Total Area)
Weighted Curve Number = 85.4

APPENDIX F-1
PHASE I – PROGRESSIVE CLOSURE PLAN – EXISTING CONDITION

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

Calculate Run-off Volume Using TR-55 Procedures

1) Calculate Potential Retention of Water (S). Assume this represents water adsorbed by ash and protective cover (non free water)

S = (1000/CNW)-10

where: S = Potential Retention of Water, inches
CN = Curve Number for Site

S = 1.71 inches

2) Calculate Depth of Run-off (Q)

Q = [(P-0.2S)^2]/[P-0.8S)]

where: Q = Depth of run-off generated, inches S =
Potential Retention of Water, inches
P = Design rainfall, inches

Q = 6.84 inches

3) Calculate Volume of Run-off

V = Q X A

where: Q = depth of run-off generated, ft A = Total Area, sf

Q = 6.84 inches
Q = 0.57 feet
Area = 202 acres Area =
8,799,120 sf

V = 8,799,120 sf X 0.57 feet = 5,016,000 cf

4) Calculate Volume of Precipitation on SROCA

V= surface area (sf) X design storm precipitation (ft)
V= 1,929,319 sf X (8.6/12) ft
V= 1,383,000 cf

Total Run-off Volume (SROCA): 6,399,000 cf

APPENDIX F-2
PHASE II – PROGRESSIVE CLOSURE PLAN – COVER SYSTEM

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

Definitions

Active Area Runoff -	storm water that comes into contact with waste
Storm Water Runoff from Inactive Areas-	storm water that falls outside of an active waste management area and does not come into contact with waste (i.e. capped or previously reclaimed areas)

Assumptions

1) NROCA is completely capped
2) Active Area Run-off water is generated on a limited portion of SROCA
3) Active Area Run-off volume based on a 25-year, 24-hr storm
4) Assumed exposed fly and bed ash, and partially reclaimed area exist in SROCA
5) Storm water runoff volumes are estimated using the Curve Number method as described in USDA's Urban Hydrology for Small Water Sheds (TR-55)

Area that Generates Run-off

SROCA – Exposed Ash Area:	5,488,560 sf
SROCA – Exposed Ash Area:	126 acres
SROCA – Capped Area:	1,219,680 sf
SROCA – Capped Area:	28 acres
SROCA – Partially Reclaimed Area:	2,090,880 sf
SROCA – Partially Reclaimed Area:	48 acres

Design Rainfall

From Technical Paper No. 40: Rainfall Frequency Atlas
Panola County 25-Yr, 24-hr: 8.6 in/day

Curve Numbers

From TR-55, Table 2-2a:

- For exposed fly and bed ash, use CN =	94	(See HELP Model Results)
- For capped area, use CN =	66	(See HELP Model Results)
- For partially reclaimed area, use CN =	72	(See HELP Model Results)

Calculate Weighted Curve Number for Site

Description	Area (acres)	CN	Area X CN
Exposed Fly and Bed Ash	126	94	11,844
Capped Area	28	66	1,848
Partially Reclaimed Area	48	72	3,456
	202		17,148

Weighted Curve Number = (Sum of CN X A) /(Total Area)
Weighted Curve Number = 84.9

APPENDIX F-2
PHASE II – PROGRESSIVE CLOSURE PLAN – COVER SYSTEM

LUMINANT GENERATING COMPANY, LLC
MARTIN LAKE STEAM ELECTRIC STATION – A-1 AREA LANDFILL
RUN-OFF VOLUME CALCULATIONS

<u>Calculate Run-off Volume Using TR-55 Procedures</u>

1) Calculate Potential Retention of Water (S). Assume this represents water adsorbed by ash and protective cover (non free water)

S = (1000/CNW)-10

where: S = Potential Retention of Water, inches
CN = Curve Number for Site

S = 1.78 inches

2) Calculate Depth of Run-off (Q)

Q = [(P-0.2S)^2]/[P-0.8S)]

where: Q = Depth of run-off generated, inches S =
Potential Retention of Water, inches
P = Design rainfall, inches

Q = 6.78 inches

3) Calculate Volume of Run-off

V = Q X A

where: Q = depth of run-off generated, ft A = Total Area, sf

Q = 6.78 inches
Q = 0.57 feet
Area = 202 acres Area =
8,799,120 sf

V = 8,799,120 sf X 0.57 feet = 4,972,000 cf

4) Calculate Volume of Precipitation on SROCA

V= surface area (sf) X design storm precipitation (ft)
V= 1,929,319 sf X (8.6/12) ft
V= 1,383,000 cf

Total Run-off Volume (SROCA): 6,354,000 cf

NOTE – FSROCA Watershed conditions and runoff remain unchanged from Phase 1 – Progressive Closure Plan (See Phase I Pages 3-4).