Lamb Island Dairy
Final Detailed Design
SFWMD Contract No. C-13410
HSA Project No. 8005-7106-00
February 2004

Professional Engineer Certification

Remediation system design for: **Lamb Island Dairy Remediation**
Okeechobee, Florida

In accordance with Chapter 471, Florida Statues, I hereby certify that to the best of my knowledge that all engineering plans, specifications and calculations included herein are in accordance with standard and appropriate engineering practices.

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1.0 INTRODUCTION AND BACKGROUND

As captioned in the attached detailed design drawings and specifications package, the following remedial measures have been designed for and are planned to be implemented at the former Lamb Island Dairy:

- Construct a surface water containment berm around the HIAs and high P soils, gravity flow of storm water runoff to the existing eco-reactor and swale for biological (wetland) treatment;
- Construct a containment berm at the edge of farm to collect and store a pre determined amount of outer pasture runoff;
- Construct terrace berms in the pasture runoff containment area;
- Construct a wetland/marsh at the southern end of the pasture runoff containment area for biological (wetland) treatment;
- Alum amendment of the dairy wastes (residual manure solids) material contained in ponds 1 and 2 leaving inactivated material in-place;
- Fill/grade pond 1;
- Fill/grade pond 2 or suitable to maintain a crop;
- Alum amendment of the impounded waters contained in the settling pond (Pond 3) and cooling pond to inactivate and precipitate water column phosphorus content;
- Dewatering and backfilling the onsite perimeter ditch; and,
- Hay cropping of all available land areas.

Design drawings showing planned construction activities are attached to this report (**Appendix A**). A brief narrative review of the planned construction activities and the supporting documentation used to develop the remedial design components is provided below.

2.0 STORM WATER RUNOFF COLLECTION SYSTEM

The remedial design includes collecting storm water runoff in two areas, (1) the high intensity area (HIA); and (2) the outer pasture (**Figure 1**).

2.1 <u>HIA Runoff Collection</u>

An approximate 40-acre surface water containment area will be created by constructing an earthen berm around the original HIA and other high-P soils. The HIA collection system design includes using the existing berms on the north side of the eco-reactor. Ditches on the upstream side of the berm will convey the runoff by gravity to the eco-reactor cell 1. **Figure 2** shows the flow pattern for the containment area.

The top of berm (TOB) elevation will be 44 feet NGVD (± 0.3 feet) with the design maximum water elevation set at 43 feet. This containment area will store up to up to 8.0 inches of storm water runoff or a resulting volume of 26.7 acre-feet (32,950 m^3). **Figure 3** shows the maximum retention capacity of the HIA containment area. The net contributing drainage area (excluding Pond 3) is 40 acres. This area encompasses the HIA and other high-P soils identified in the AgNMA (SWET, 2002).

Project team member, Engineering and Applied Sciences (EAS), estimated the storm water runoff from the land area located east of Lamb Island Dairy Road. The adICPR Model utilizing the U.S. Soil Conservation Service (SCS) Method was used to calculate runoff volume and peak discharges (EAS, 2002). For these runoff calculations, the input data included hydrologic soil group, land use, Curve Number (CN), rainfall amount and SFWMD rainfall distribution, and time of concentration. SFWMD rainfall distribution data were used. A monthly rainfall forecast was developed using the SCS Method and historical rainfall data included in the CREAMS-WT model for the Site. **Appendix B** contains the estimated monthly runoff average and maximum volumes for a 10 year period of record.

The SCS Method was used to calculate the storm event associated with 8.0 inches of runoff using the equation:

$$Q= (P-0.2*S)^2 / (P+0.8S) \text{ and, } S = (1000/CN-10).$$

A CN of 89 was used and the storm event (P) associated with 8.0 inches of runoff (allowable containment area depth) was calculated to be 9.3 inches of rainfall. Rainfall curves included in the "Surface Water Design Aids" section of Volume IV of the SFWMD *Environmental Resources Permit Manual* (2000) were used to estimate the equivalent design storm event. The equivalent design storm is the 25-year return period/72-hour event duration. *The site specific factors (i.e., matching new berm heights to existing eco-reactor berms) results in an atypical design frequency (design storm event).*

Aside from the 40 acre collection system, the HIA containment area includes an additional estimated 21.5 acres of storage contained in the eco-reactor (~6.5 acres) and the existing swale (~15 acres) located downstream of the eco-reactor. Berms will be constructed on the South and East sides of the swale routing runoff to a discharge location at the Southern end of the swale (KREA 44). The swale berms were also designed to accommodate 9.3 inches of rainfall in the eco-reactor and the swale.

The SCS Method was used to determine the amount of runoff from the eco-reactor and the swale. Using a storm event of 9.3 inches of rainfall and a CN of 98, resulted in 9.1 inches of runoff or approximately 4.9 acre-feet (6,050 m^3) of storm water runoff from the eco-reactor. The runoff from the swale was calculated using the SCS Method with a CN of 89 and a storm event of 9.3 inches resulting in 8.0 inches of runoff or approximately 10 AF (12,340 m^3) of storm water runoff from the swale. The berms around the swale will be constructed with a TOB elevation of 40 feet NGVD. The maximum water elevation will be set at 39 feet providing for storage of runoff from the eco-reactor and swale from a 9.3 inch storm event and allow for one foot of freeboard in the containment area.

The containment berm heights will vary depending on the existing original ground elevation and the berm dimensions will be approximately two feet wide at the top with 4:1 side slopes. These side slopes are specified to allow for maintenance of the berms using standard equipment. The internal eco-reactor berms will be improved as necessary to provide a TOB elevation of at least 43 feet NGVD (see attached plans). These berms are already constructed with 2.5:1 side slopes and maintenance of the internal berms is not anticipated.

Ditches will be constructed on the upstream side of the berms to convey the runoff by gravity to the eco-reactor or other discharge location. Positive flow conditions are required for all ditches and the minimum physical slope will be maintained at 0.0005 ft/ft. The ditch configuration will be a minimum of 10 feet wide with side slopes of 3:1 or flatter.

2.2 Outer Pasture Runoff Collection

An approximate 109-acre surface water containment area will be created by constructing earthen berms along the Eastern and Southern sides of the property. Ditches on the upstream side of the berm will convey the runoff by gravity to a new discharge location on the South side of property (**Figure 1**). **Figure 2** shows the flow pattern for the containment area.

The containment area size is based on maintaining an optimum water height of 18 inches (WSI, 2002) in the wetland/marsh at the southern end of the containment area (see **Section 3.0 Storm Water Runoff Treatment**). The berms surrounding the wetland will be constructed without ditches and therefore material will have to be borrowed. Based on the existing site topography, the most cost effective method to construct the wetland is a combination of creating a depression in the wetland area and constructing berms and ditches around the pasture containment area to store and convey runoff to the wetland. Soils will be scraped/excavated from approximately 14 acres in the wetland area creating an average grade elevation of approximately 36.25 feet NGVD. The bottom of the existing lounging pond (approximately 2-acres) will remain at between 35-36 feet NGVD. The maximum water height in the wetland/containment area will be maintained at 37.75 feet NGVD with a TOB elevation of 38.75 feet NGVD. The resulting capacity of the containment area is approximately 27.2 acre-feet (33,565 m^3) of storm water runoff. **Figure 3** shows the maximum retention capacity of the containment area. The contributing area includes the former pasture area outside the HIA. This area includes the low to moderate-P soils identified in the AgNMA (SWET, 2002).

Based on the storage capacity of 27.2 AF, the containment area will store an average of 3.0 inches of runoff [(27.2 AF ÷ 109 acres)*(12inches/foot)]. The SCS Method was used to determine the storm event associated with the containment area volume. A CN of 89 was used and the storm event (P) associated with 3.0 inches of runoff (allowable containment area depth) was calculated to be 4.2 inches of rainfall. Using the SFWMD rainfall curves (see **Appendix B**), the equivalent design storm is approximately the 5-year return period/24-hour event duration.

The containment berm heights will vary depending on the existing original ground elevation and the berm dimensions will be approximately two feet wide at the top with 4:1 side slopes. These side slopes are specified to allow for maintenance of the berms using standard equipment.

Ditches will be constructed on the upstream side of the containment berms to convey the runoff by gravity to the wetland/marsh at the southern end of the containment area. Positive flow conditions are required for all ditches and the minimum physical slope will be maintained at 0.0005 ft/ft. The ditch configuration will be a minimum of 10 feet wide with side slopes of 3:1 or flatter.

Three terrace berms (6-12 inch berm height) will be constructed across the pasture area as shown on the Plans. The terrace berms are designed to increase runoff retention, ET, and phosphorus uptake in the pasture area.

2.3 Flow control structures

The cumulative runoff from the HIA will flow by gravity through the former eco-reactor and swale system via a series of metal culverts with riser inlets. Runoff from the HIA containment area will ultimately flow by gravity through a culvert at an existing discharge location (KREA 44) and the outer pasture area runoff will ultimately flow by gravity through a culvert at a new discharge location (**Figure 1**). At the recommendation of the District staff, a culvert (instead of an overflow weir) will be employed to maintain one foot of freeboard and to set the maximum water level within the HIA containment area at 43 feet NGVD before storm waters are allowed to discharge from the containment area. The culvert will be installed to drain runoff into the existing ditch located on the East side of the eco-reactor. Boards will be installed in the culvert risers spanning from the culvert invert elevation to the control elevation.

Manning's equation was used to determine the minimum culvert diameter required to drain the accumulated runoff from the containment areas within 72 hours. Hydraulic calculations are included in **Appendix C**. Using Manning's equation, it was calculated that a 24-inch diameter culvert with a slope of 0.005 (0.05 feet of fall per 10-feet of run) would be adequate to provide for drainage of the containment area within 72 hours. At the recommendation of the District staff, a 36-inch culvert will be used for the emergency overflow structure and at the two discharge locations to provide additional flow capacity. See the plans (**Appendix A**) for the proposed culvert locations and dimensions.

3.0 STORM WATER RUNOFF TREATMENT

3.1 Storm Water Quality

Samples of standing and flowing surface waters at various internal sites within the former Lamb Island Dairy property were collected on two separate occasions during the month of September 2003. Field sampling activities were planned to coincide with substantial regional rainfall events. Using the topographical survey map previously supplied by the SFWMD, sampling locations were established in depressions and low elevation runoff channels in order to assess the relative amount of P contained in the surface runoff at various internal sites. Soluble Reactive, total dissolved and total phosphorus samples were collected at all sites. The results from the supplemental sampling program are presented in **Appendix D**.

3.2 Storm Water Treatment System

The overall goal of the treatment system is to reduce P discharging from the Site. The previous design included treatment by only overland flow in the pasture area. Additional treatment efficiency will be achieved by adding terraces and creating a wetland in the pasture area. Therefore, the storm water treatment system design proposed includes:

- Collection and retention of storm water runoff within the HIA containment area and wetland treatment in the existing eco-reactor ponds and swales;
- Collection and retention of storm water runoff within the pasture;
- Construction of terraces in the pasture; and,
- Construction of a wetland/marsh in the southern end of the pasture.

From the 40 acre runoff containment area, water will flow by gravity to the existing 6.5 acre eco-reactor. Within the eco-reactor, a total of four discrete cells will be maintained and the water will sequentially flow by gravity from one cell to the other. From the eco-reactor retention area, water will then flow by gravity into an existing swale prior to discharge off the property. The wetland treatment system area is comprised of approximately 21.5 acres including:

- Eco-reactor Cell 1 (1.38 acres);
- Eco-reactor Cell 2 (1.12 acres);
- Eco-reactor Cell 3 (0.98 acres);
- Eco-reactor Cell 4 (3.01 acres); and,
- Existing swale (15 acres).

Water levels in the eco-reactor cells and swale will be maintained at depths of 12 to 18 inches using new riser culverts as internal water control structures. It is anticipated that emergent vegetation such as cattails and potentially some SAV will be established (volunteer growth) within the eco-reactor cells and within the boundary of the existing swale system.

The pasture area will include three terrace areas:

- Terrace 1 (40 acres);
- Terrace 2 (31 acres); and,
- Terrace 3 (22 acres).

Terrace berms (6-12 inch berm height) will be constructed by disking and then grading the areas shown on the Plans. The terraces will receive direct rainfall, runoff from upstream terraces, and may also receive overflow from the HIA during extreme wet conditions. The TOB elevation of Terrace 1 will be 40.75 feet NGVD and the TOB for Terrace 2 will be 39.25 feet. Terrace 3 will be constructed by grading and improving the existing swale and the TOB elevation will be 37.75 feet NGVD.

An approximate 16 acre wetland/marsh will be created on the southern end of the pasture area. This area includes a 2-acre former lounging pond. The other 14 acres in this area will cleared and graded to a bottom elevation of 36.25 feet NGVD. Water levels in the wetland will be maintained at 37.75 feet NGVD.

3.2.1 <u>Performance Estimate</u>

Project team member Wetlands Solutions, Inc. (WSI) previously provided an estimate of the expected performance of the eco-reactor and swale in terms of P reduction (WSI, November 10, 2003; and WSI, December 3, 2003). Subsequently, WSI estimated the treatment system performance as a sensitivity analysis with changes in influent P concentrations (3.5 mg/L and 7.9 mg/L) and varying effective terrace areas (treatment in 5%, 10%, 50%, and 100% of the total terrace area). This analysis (WSI, January 26, 2003) estimated edge-of-field concentrations ranging from 0.24 to 1.20 mg/L. Copies of the WSI performance memos are included in **Appendix E**.

These performance estimates used annual average runoff volumes calculated using the SCS Method, which result in runoff volumes significantly exceeding the actual runoff volumes typically observed in the watershed. After further discussions with the SFWMD, WSI estimated the system performance based on storm events. The SCS Method was used to determine the storm water runoff from the 1-year, 5-year and 10-year storm events for 24-hour event durations. The treatment system performance was estimated using these runoff volumes and varying runoff P concentration (3.5 mg/L and 7.9 mg/L). The performance estimates used the acreage immersed when six inches of standing water is at the downstream edge of the terrace (e.g., immediately upstream of the terrace berm) as the effective terrace areas. **Table 1** provides a summary of the performance estimate criteria. WSI estimated edge-of-field P concentrations ranging from 3.0 to 7.2 mg/L (see **Appendix E**). This is a very conservative approach since it does not consider antecedent moisture conditions or runoff containment area capacity. **Table 2** summarizes the treatment system performance.

Three different scenarios were used to estimate the annual average edge-of-field P load from equivalent storm events resulting in approximately 11 inches of runoff.

1. The first scenario predicted the edge-of-field load resulting from six 1-yr/24-hr storm events. The equivalent annual runoff is approximately 11.4 inches

   (6 * 1.9 inches of runoff/storm event = 11.4 inches of runoff)

2. The second scenario predicted the edge-of-field load resulting from four 5-yr/24-hr storm events. The equivalent annual runoff is approximately 11.2 inches

   (4 * 2.8 inches of runoff/storm event = 11.2 inches of runoff)

3. The third scenario predicted the edge-of-field load resulting from three 10-yr/24-hr storm events. The equivalent annual runoff is approximately 11.4 inches

   (3 * 3.8 inches of runoff/storm event = 11.4 inches of runoff)

These three scenarios estimate a range of P_{in} from 2,080 to 3,695 lb (945 to 1,680 kg); P_{out} from 1,822 to 3,383 lb (828 to 1,538 kg); $P_{removed}$ from 174 to 589 lb (79 to 268 kg); and, predicted that the treatment system will provide from 8 to 15% P load reduction. In lieu of actually modeling the daily runoff values and removal rates, this simplified approach is suitable for conservatively estimating the treatment system performance.

4.0 TREATMENT OF RESIDUAL MANURE WASTE

Treatability studies were conducted to determine the effectiveness of alum treatment on P concentration in pond waste. The process included weighing a 50 g sample of the manure collected from Pond 1 and Pond 2, adding 200 ml of deionized water, mixing with different doses of alum, and settling for 45 minutes. The samples were analyzed in the field using a colorimetric analytical method and a Hach spectrophotometer to measure absorbance and to determine the SRP concentration of the raw and treated manure (see **Appendix F** for details of the manure treatability study).

Based on the results of the manure treatability study, the residual manure will be amended with alum using 2.5 ml of alum per pound of manure as the maximum dose. Periodic measurements will be made in the field to confirm that SRP concentrations in the manure are being reduced to a level of 150 parts per billion or less of leachable SRP in the amended wastes. The following procedure will be followed to amend the residual manure with alum and cover the treated waste in-place.

a. Excavate a sump in the Northwest corner of Pond 2 and install at least one dewatering pump with the pump intake in the sump.
b. Pump all standing water from Pond 2 into Pond 3.
c. Use heavy equipment and/or chopper pump to consolidate solids at the pond bottom at the North side of Pond 2. Engineer to verify in the field differentiation between the residuals solids (dark layer) and the pond bottom (sand layer).

d. Excavate a sump in the Southwest corner of Pond 1 and install one dewatering pump with the pump intake in the sump.
e. Pump all standing water from Pond 1 into Pond 3.
f. Use heavy equipment and/or chopper pump to transfer the residual solids from Pond 2 into Pond 1.
g. At a minimum, collect representative solids samples at the beginning and end of each day and analyze on-site for SRP using a spectrophotometer and Standard Method 4500-P E. (Ascorbic Acid Method) or equivalent.
h. Add approximately 1,700 gallons of liquid alum to each section of pond to be treated (pond will be treated in 4 or 5 sections) and completely mixed (using chopper type pumps with internal pond recirculation) with the manure. In total approximately 8,700 gallons of alum will be added.
i. Continue to remove standing water into Pond 3.
j. Allow the mixed residuals to consolidate and continue dewatering for a maximum of 10-14 days.
k. At the direction of the field engineer, after the surface of the amended material develops a crust, install Orenco (or equivalent) filter fabric across the surface of Pond 1. Place the exiting berm soil material surrounding the pond on top of the filter fabric and level to slightly above grade

5.0 TREATMENT OF POND WATER

The pond remediation measures include amending the water columns in pond 3 overlaying any residual solids with alum. In addition, the old borrow pit/ cooling pond at the Southwest area of the property will be treated with alum. Treatability studies were conducted to determine the effectiveness of alum treatment on P concentration in the pond water. The process included adding alum doses ranging from 5 to approximately 30 mg/L (as aluminum) to pond water samples, allowing the floc to settle, and analyzing a sample of the water column in the field for SRP. The results (**Appendix F**) indicated that as the alum dose increased the SRP concentration measured in the treated mixture decreased. A doses of 10 mg/l as Al resulted in a non detectable concentration of SRP. The pond water will be titrated with alum up to an anticipated maximum of 15 mg/l to achieve a treated SRP value of less than or equal to 0.15 mg/l as P. Samples of the treated water will be collected and analyzed in the field using Standard Method 4500-P E., or equivalent, to confirm the effective dosage. The following procedure will be followed to amend the pond water with alum.

a. Supply a raft equipped with temporary storage tanks, transfer pump(s), piping, and motor;
b. Construct alum dispersion piping to run a minimum of eight feet perpendicular to the flow of the boat with holes spaced equally along the length of pipe; and,
c. Traverse the pond at a speed and spacing interval calculated to add the equivalent of 3 milliliters of alum per gallon of pond water. An estimated total of approximately 6,900 gallons of alum will be added to the estimated total pond volume of 32 million gallons.

Use a spectrophotometer and Standard Method 4500-P E. (Ascorbic Acid Method) or equivalent to make sure the water is amended adequately. Confirmatory analyses will be conducted by an off site analytical laboratory.

Alum will be carefully metered on a pre-established grid to evenly apply the alum to the water surface. The raft will start in one corner of the pond and transverse the pond length wise (East-West) in a diagonal direction to the opposite bank and returning to the same bank. This process will continue until the length of the pond is treated. Then the boat will transverse the pond width wise (North-South) in a diagonal direction to the opposite bank and returning to the same bank. This process will continue until the entire width of the pond is treated.

6.0 SCHEDULE

A copy of the Project Completion Schedule and the Construction Schedule are included in **Appendix G**. Phase I construction activities will be completed by June 2004 and monitoring will continue through May 2005.

7.0 MONITORING

HSA will prepare and submit a Draft Performance Monitoring Plan for review and approval concurrently with completion of the construction activities. The Monitoring Plan will describe frequency of sampling and flow estimating to determine the surface water total P load reduction from the entire project site. The Plan will also include site plans showing the sampling locations and describe the sampling methodology and laboratory analytical techniques. The Plan will propose collecting and analyzing samples prior to implementation of remedial activities to establish baseline and background concentration before treatment.

The following monitoring measures are proposed for the former Lamb Island Dairy:

<u>Residual manure solids</u> samples will be collected and analyzed prior to and during alum treatment. Samples will be analyzed on-site for SRP using a spectrophotometer and Standard Method 4500-P E. (Ascorbic Acid Method) or equivalent. Confirmatory samples will be collected and analyzed by an off site lab. These data will be reviewed to confirm the overall effectiveness of alum treatment of the residual manure solids.

<u>Pond water</u> samples will be collected and analyzed prior to and during alum treatment. Samples will be analyzed on-site for SRP using a spectrophotometer and Standard Method 4500-P E. (Ascorbic Acid Method) or equivalent. Confirmatory samples will be collected and submitted to an off site lab. Review of these data will confirm the effectiveness of alum treatment of the pond water.

<u>Groundwater</u> samples will be collected from the existing monitoring well (**Figure 4)** before alum treatment and at least quarterly after alum treatment. The groundwater samples will be submitted to an off site lab for total P, SRP, and total aluminum.

After construction, 15 site visits will be conducted during the next twelve months to monitor the performance of the wetland treatment system. These site visits will be conducted to collect grab surface water samples at the two discharge locations (KREA 44 and the newly constructed site) and throughout the eco-reactor during periods of run off from the site (**Figure 4**). The samples will be analyzed on-site for water quality parameters (DO, temperature, conductivity, pH, turbidity) and submitted to JEL for analysis of total P, SRP, and total aluminum.

Runoff flows from the farm will be estimated by recording the stage upstream of the discharge locations and measuring the height of water flowing over the control elevation. Staff gauges will be installed upstream of the three 36-inch diameter culvert (S-1 the HIA overflow location; and S-6 and S-8, the two discharge locations). Standard equations for flow over a weir will be used to calculate the discharge from the site. The flow data and laboratory total P data will be used to calculate the P load discharging from the site.

Quarterly Reports will be submitted to the SFWMD which will describe the treatment system performance monitoring activities and summarize all relevant field and analytical data generated.

8.0 TREATMENT SYSTEM OPERATION AND MAINTENACE (O&M)

HSA will prepare and submit a Draft O&M Manual for review and approval before the completion of the one year of post construction monitoring (see Project Schedule in **Appendix E**). The O&M Manual will address, at a minimum, a summary of the design assumptions, O&M of water control structures and wetland treatment system future monitoring requirements, cropping systems for residual P management, and any O&M related information gained from the project performance evaluation.

The following O&M activities will be completed during the 15 post construction site visit.

- The containment berms will be inspected and corrective actions, if necessary, will be recommended to the SFWMD; and,
- Boards will be either added or removed in the culverts to optimize on-site surface water retention.

The O&M activities completed at the site will be summarized in the Quarterly Reports and submitted to the SFWMD.

9.0 CONSTRUCTION COSTS

The cost estimate to implement the remedial activities is approximately $285,618, as summarized in **Appendix H.** HSA is willing to complete the project within the budget of $282,493. A proposed Construction Payment Schedule is also included in **Appendix H.**

10.0 REFERENCES

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Table 1
Treatment System Criteria for Performance Estimate
Lamb Island Dairy

Outer Pasture/wetland area

Storm events			Terrace 1				Terrace 2				Terrace 3				Marsh/wetland		
duration (hour)	return period (year)	rainfall (inches)	area (acres)	runoff (inches)	runoff Q (gpm)	trtmnt area (acres)	area (acres)	runoff (inches)	runoff Q (gpm)	trtmnt area (acres)	area (acres)	runoff (inches)	runoff Q (gpm)	trtmnt area (acres)	area (acres)	runoff (inches)	runoff Q (gpm)
24 hr	1 yr	3.0	40	1.9	1433	9.5	31	1.9	1111	10.7	22	1.9	788	2.2	16	2.8	845
24 hr	5 yr	4.0	40	2.8	2112	9.5	31	2.8	1637	10.7	22	2.8	1162	2.2	16	3.8	1146
24 hr	10 yr	5.0	40	3.8	2866	9.5	31	3.8	2221	10.7	22	3.8	1576	2.2	16	4.8	1448

HIA area

Storm events			HIA				Eco-reactor				Swale			
duration (hour)	return period (year)	rainfall (inches)	area (acres)	runoff (inches)	runoff Q (gpm)	trtmnt area (acres)	area (acres)	runoff (inches)	runoff Q (gpm)	trtmnt area (acres)	area (acres)	runoff (inches)	runoff Q (gpm)	trtmnt area (acres)
24 hr	1 yr	3.0	40	1.9	1433	40	6.5	2.8	343	6.5	15	1.9	537	5.0
24 hr	5 yr	4.0	40	2.8	2112	40	6.5	3.8	466	6.5	15	2.8	792	5.0
24 hr	10 yr	5.0	40	3.8	2866	40	6.5	4.8	588	6.5	15	3.8	1075	5.0

Table 2
Treatment System Performance Summary
Lamb Island Dairy

Outer Pasture/Wetland Area:

Storm events		Runoff Volume	P_{in}	P_{out}	Edge-of-field Load			
duration	return period	(Mgal)	(mg/L)	(mg/L)	P_{in}	P_{out}	$P_{removed}$	
(hour)	(year)				(lb)	(lb)	(lb)	(%)
24 hr	1 yr	7.62	3.5	3.0	222	188	33.9	15%
24 hr	5 yr	11.0	3.5	3.1	320	284	35.3	11%
24 hr	10 yr	14.6	3.5	3.2	425	389	36.0	8%

Storm events		Runoff Volume	P_{in}	P_{out}	Edge-of-field Load			
duration	return period	(Mgal)	(mg/L)	(mg/L)	P_{in}	P_{out}	$P_{removed}$	
(hour)	(year)				(lb)	(lb)	(lb)	(%)
24 hr	1 yr	7.62	7.9	6.7	502	424	77.7	15%
24 hr	5 yr	11.0	7.9	7.0	722	641	80.3	11%
24 hr	10 yr	14.6	7.9	7.2	960	878	81.9	9%

HIA Area:

Storm events		Runoff Volume	P_{in}	P_{out}	Edge-of-field Load			
duration	return period	(Mgal)	(mg/L)	(mg/L)	P_{in}	P_{out}	$P_{removed}$	
(hour)	(year)				(lb)	(lb)	(lb)	(%)
24 hr	1 yr	3.33	7.9	4.2	136	115	20.6	15%
24 hr	5 yr	4.85	7.9	4.4	200	179	21.4	11%
24 hr	10 yr	6.52	7.9	4.6	272	250	22.0	8%

Annual edge-of-field load calculations:

1. Using the load caluclated from (6) 1-yr/24-hr storm events.

(i) Using P_{in} for outer pasture = 3.5 mg/L and Pin for HIA = 7.9 mg/L

P_{in}	2149	lb
P_{out}	1822	lb
$P_{removed}$	327	lb

(ii) Using P_{in} for outer pasture = 7.9 mg/L and Pin for HIA = 7.9 mg/L

P_{in}	3828	lb
P_{out}	3238	lb
$P_{removed}$	589	lb

2. Using the load caluclated from (4) 5-yr/24-hr storm events.

(i) Using P_{in} for outer pasture = 3.5 mg/L and Pin for HIA = 7.9 mg/L

P_{in}	2080	lb
P_{out}	1853	lb
$P_{removed}$	227	lb

(ii) Using P_{in} for outer pasture = 7.9 mg/L and Pin for HIA = 7.9 mg/L

P_{in}	3688	lb
P_{out}	3281	lb
$P_{removed}$	407	lb

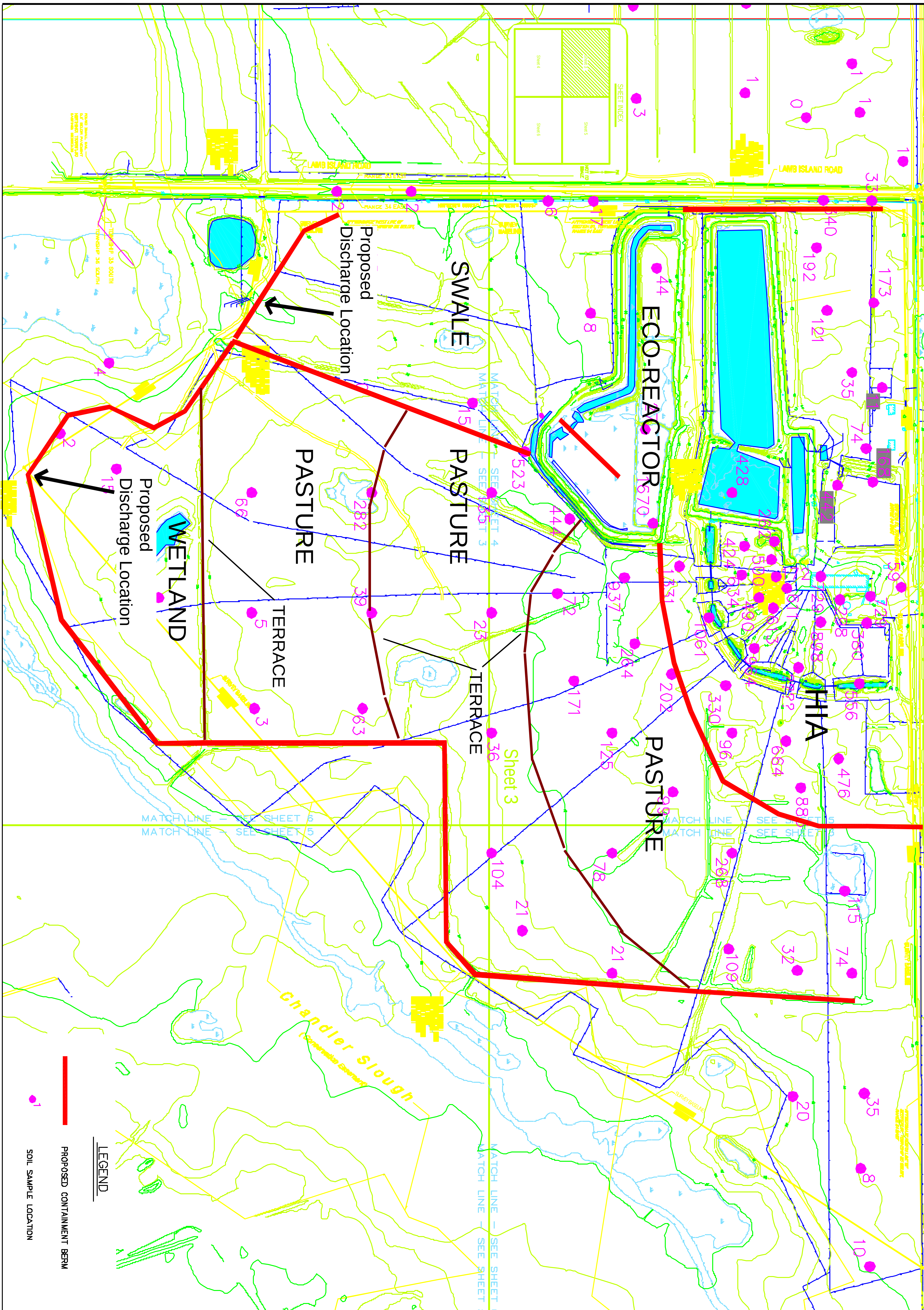
3. Using the load caluclated from (3) 10-yr/24-hr storm events.

(i) Using P_{in} for outer pasture = 3.5 mg/L and Pin for HIA = 7.9 mg/L

P_{in}	2091	lb
P_{out}	1917	lb
$P_{removed}$	174	lb

(ii) Using P_{in} for outer pasture = 7.9 mg/L and Pin for HIA = 7.9 mg/L

P_{in}	3695	lb
P_{out}	3383	lb
$P_{removed}$	312	lb



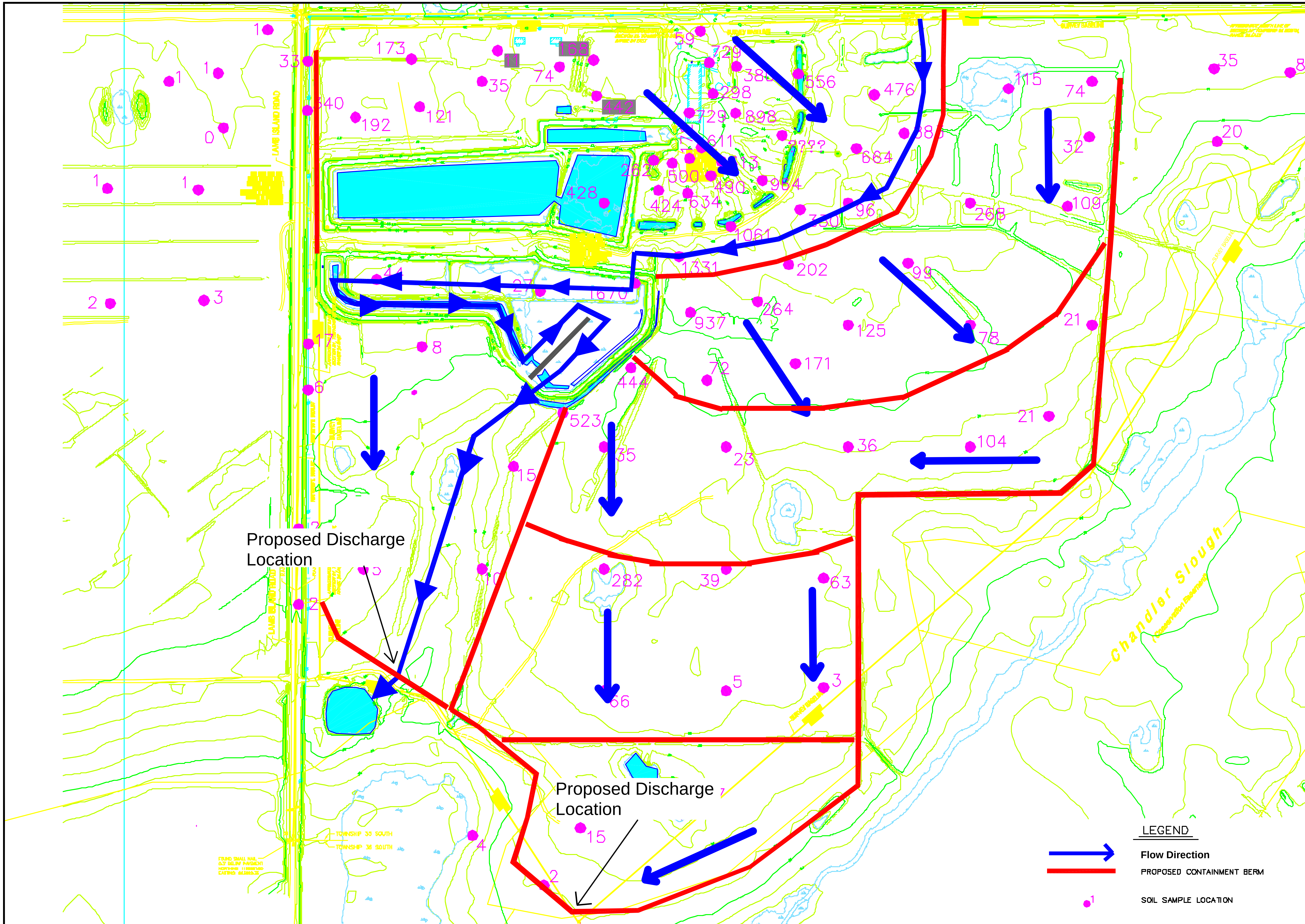
LAMB ISLAND DAIRY REMEDIATION
PROPOSED TREATMENT SYSTEM
OKEECHOBEE COUNTY, FLORIDA
SECTION 31
TOWNSHIP 36 SOUTH
RANGE 34 EAST

CADD FILE NO.
DRAWING NO. 1
SHEET 1 OF 4

DRAWN: | CHECKED: | DWG. DATE: 10/18/02 | SCALE: 1"=300'
FIELD PERSON(S):
FIELD DATE(S):
FIELD BOOK(S):
PAGE(S):
DATA COLLECTOR FILE(S):

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & PROJECT MANAGEMENT DEPARTMENT
P.O. BOX 24680
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33416-4680

DRAWN	CHECKED	DATE	REVISIONS



SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & PROJECT MANAGEMENT DEPARTMENT
P.O. BOX 24680
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33416-4680

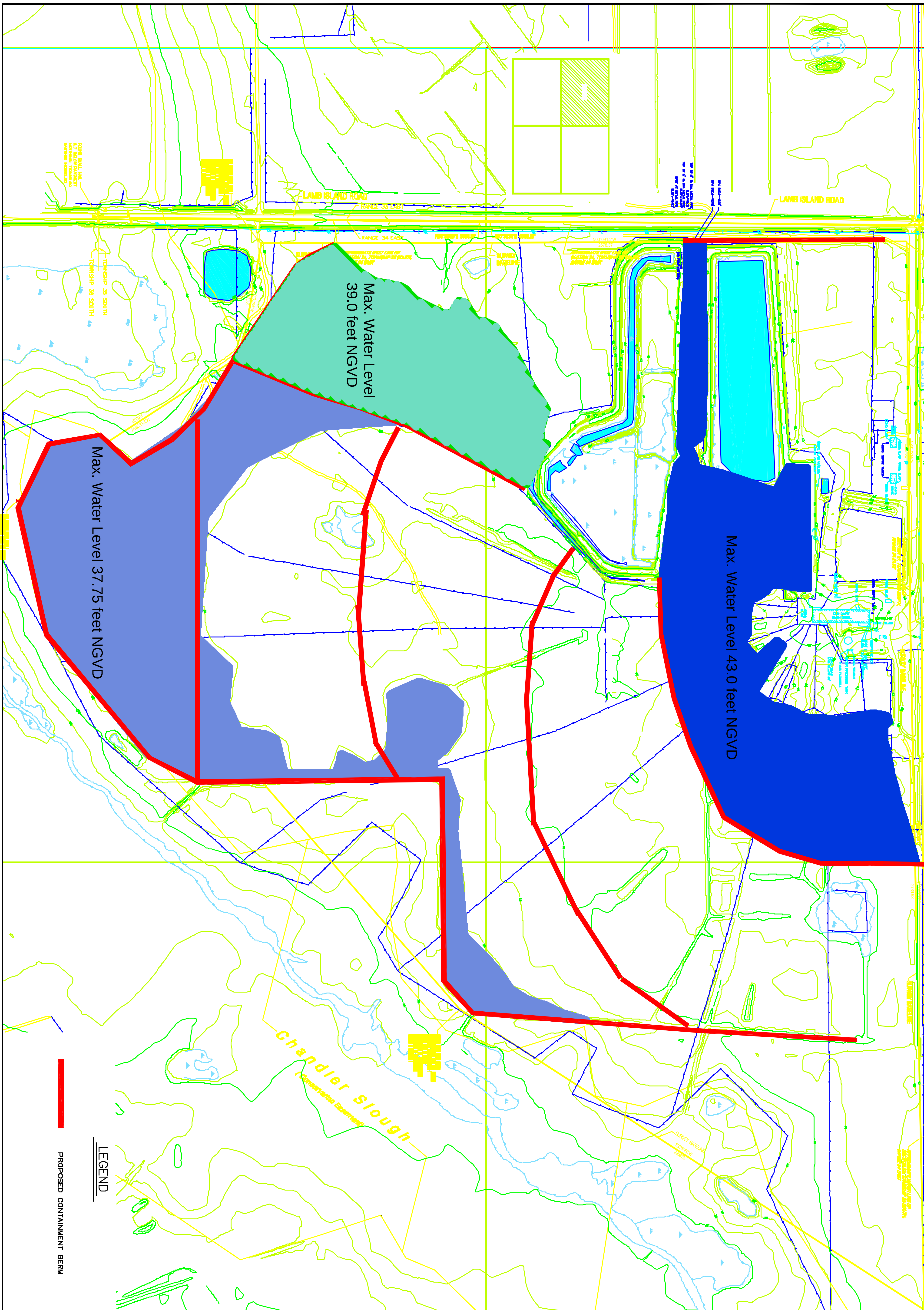
DRAWN	CHECKED	DATE	REVISIONS

DRAWN: ML | CHECKED: | INFO. DATE: 10/18/01 | SCALE: 1"=300'

FIELD PERSONS:
FIELD DATE(S):
FIELD BOOK(S):
PAGE(S):
DATA COLLECTOR FILE(S):

LAMB ISLAND DAIRY REMEDIATION
CONTAINMENT AREA FLOW PATTERN
OKEECHOBEE COUNTY, FLORIDA
SECTION 31
TOWNSHIP 36 SOUTH
RANGE 34 EAST

CADD FILE NO.
DRAWING NO.
SHEET 2 OF 3



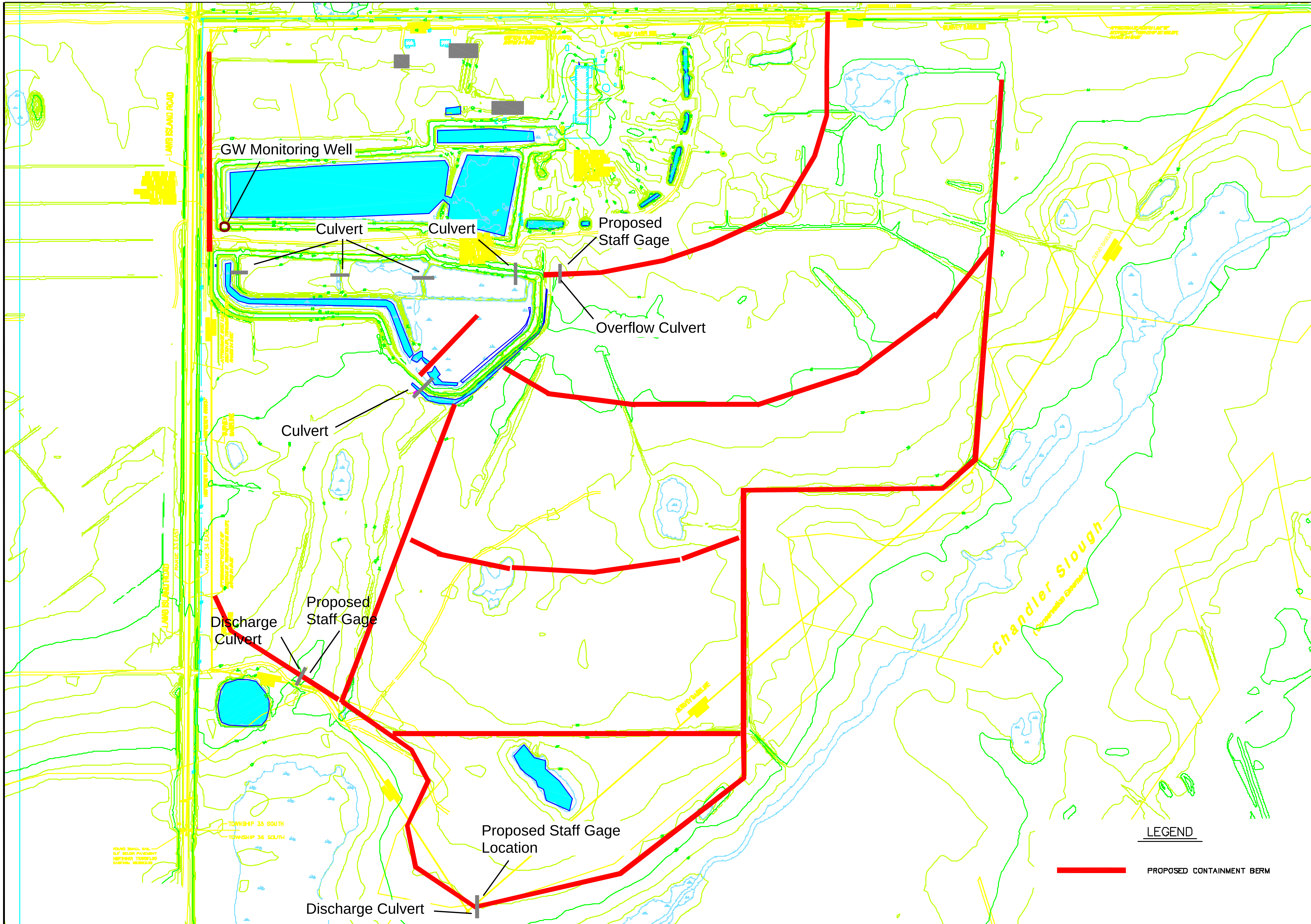
LAMB ISLAND DAIRY REMEDIATION
Containment Area Retention Capacity
OKEECHOBEE COUNTY, FLORIDA
SECTION 31
TOWNSHIP 36 SOUTH
RANGE 34 EAST

CADD FILE NO.
DRAWING NO. 1
SHEET 3 OF 4

DRAWN NO. | CHECKED: | DWG. DATE 08/28/03 | SCALE: 1"=300'
FIELD PERSON(S):
FIELD DATE(S):
FIELD BOOK(S):
PAGE(S):
DATA COLLECTOR FILE(S):

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & PROJECT MANAGEMENT DEPARTMENT
P.O. BOX 24680
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33416-4680

DRAWN	CHECKED	DATE	REVISIONS



SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & PROJECT MANAGEMENT DEPARTMENT
P.O. BOX 24680
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33416-4680

LAMB ISLAND DAIRY REMEDIATION
Sampling Plan
OKEECHOBEE COUNTY, FLORIDA
SECTION 31
TOWNSHIP 36 SOUTH
RANGE 34 EAST

CADD FILE NO.
DRAWING NO. 1
SHEET 4 OF 4

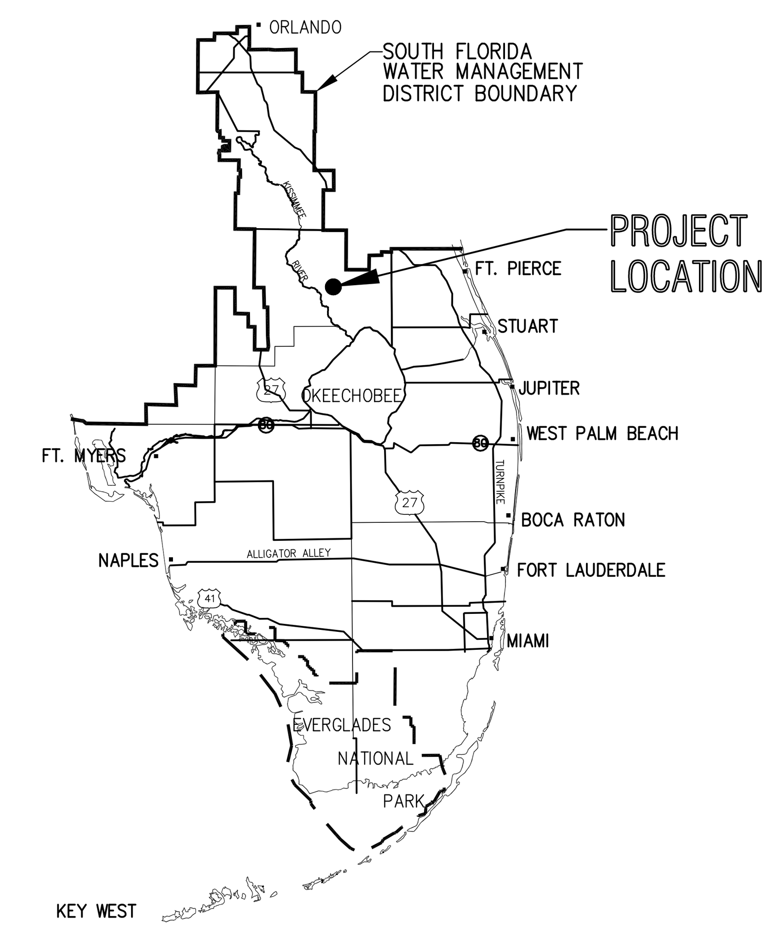
APPENDIX A

DESIGN DRAWINGS

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

LAMB ISLAND DAIRY REMEDIATION

OKEECHOBEE COUNTY, FLORIDA



GOVERNING BOARD

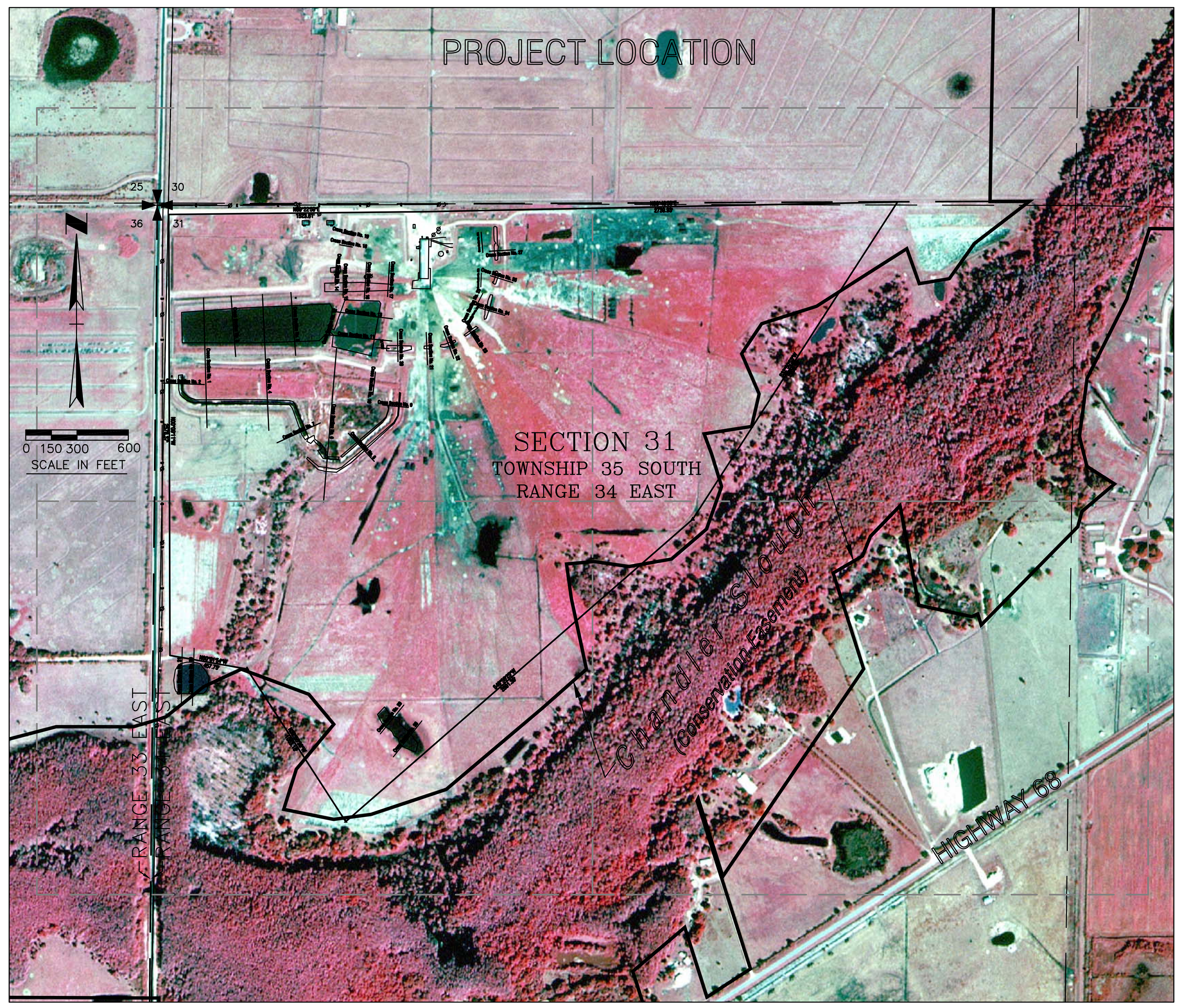
NICOLAS GUTIERREZ
CHAIRMAN

PAMELA BROOKS–THOMAS
VICE–CHAIRMN

LENNART LINDAHL
IRELA BAGUE
HUGH ENGLISH
KEVIN McCARTY
MICHAEL COLLINS
HARKLEY R. THORNTON
TRUDI K. WILLIAMS
BOARD MEMBERS

EXECUTIVE OFFICE

HENRY DEAN
EXECUTIVE DIRECTOR



LOCATION MAP

INDEX OF SHEETS

1. COVER SHEET AND LOCATION MAP
2. SITE PLAN
3. DETAILS
4. CROSS SECTIONS
5. CROSS SECTIONS
6. CROSS SECTIONS
7. CROSS SECTIONS
8. CROSS SECTIONS
9. CROSS SECTIONS

DIRECTIONS

DIRECTIONS TO SITE FROM OKEECHOBEE TRAVEL WEST ON SR 70 TO US 98. GO NORTH ON US 98 TO CR 68 (NW 160th STREET) GO EAST ON CR 68 TO LAMB ISLAND DAIRY ROAD (NW 144th AVENUE) GO NORTH ON LAMB ISLAND DAIRY ROAD FOR APPROXIMATELY 1 MILE. SITE IS LOCATED EAST SIDE OF LAMB ISLAND DAIRY ROAD.

CONTRACT NO. C-13410

DESIGNED BY:
HSA ENGINEERS & SCIENTISTS

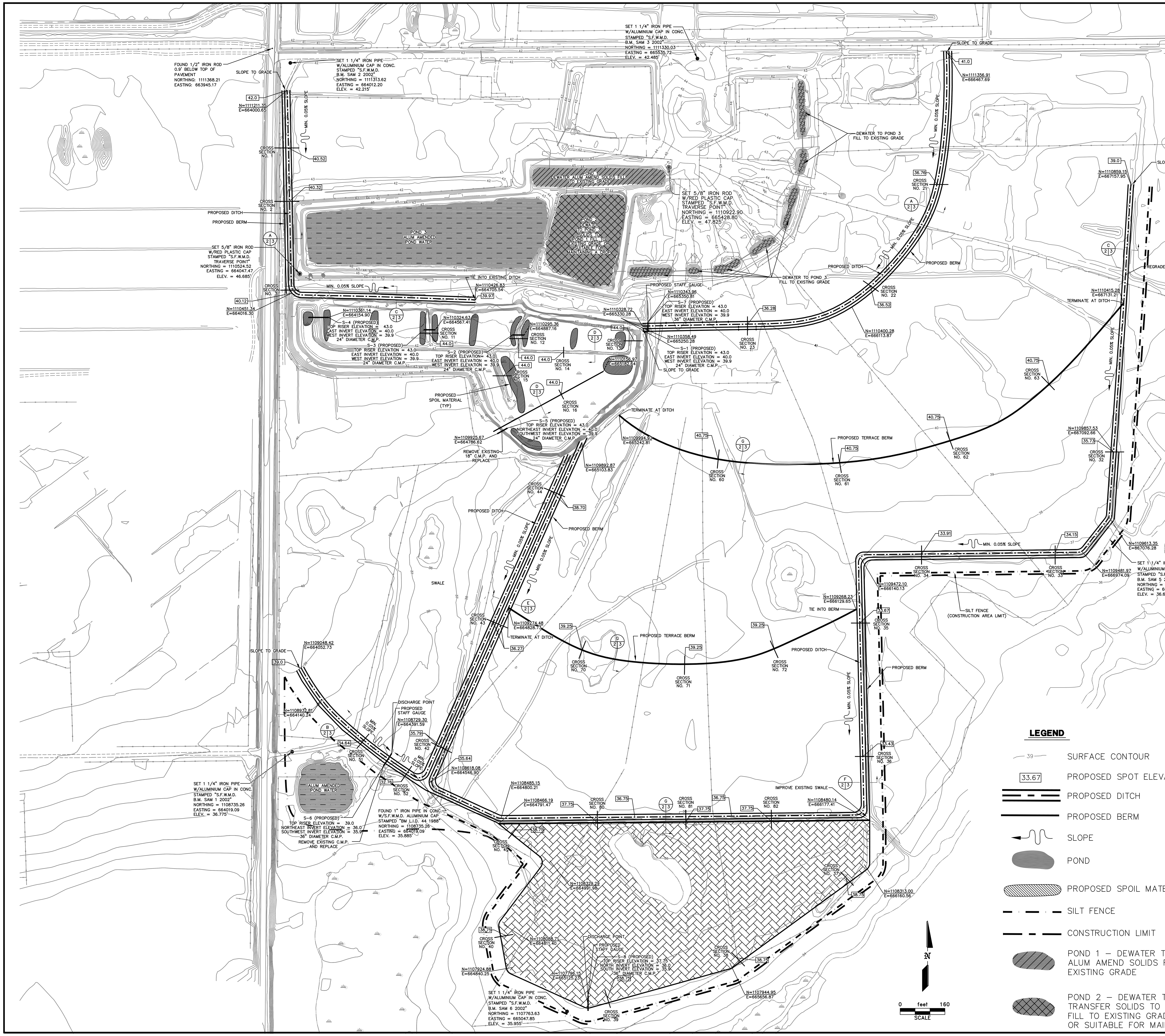
DATE | DRAWN | REV.# | REVISION DESCRIPTION

ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
CHECKED:
DATE: 01/08/04
SCALE: AS SHOWN

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
PHONE: 561-686-8800
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

LAMB ISLAND DAIRY
OKEECHOBEE COUNTY, FLORIDA
COVER SHEET AND PROJECT LOCATION MAP

CONTRACT NO. C-13410
DRAWING NO. 8005716000[001]
SHEET 1 OF 9



SUGGESTED CONSTRUCTION SEQUENCE

1.) SILT FENCING

2.) CLEARING AND GRUBBING

3.) BERM CONSTRUCTION/CULVERT INSTALLATION
   - A.) OUTER PASTURE/SWALE
   - B.) HIA
   - C.) ECO-REACTOR
   - D.) SEED BERMS

4.) DEWATER AND FILL HIA DITCHES

5.) AMEND MANURE SOLIDS
   - A.) DEWATER POND 2
   - B.) PUMP SOLIDS FROM POND 2 TO POND 1
   - C.) AMEND SOLIDS WITH ALUM
   - D.) INSTALL FILTER FABRIC IN POND 1
   - E.) KNOCK DOWN EXISTING BERMS AND BACKFILL PONDS 1 AND 2

6.) POND WATER ALUM AMENDMENT

LEGEND

- 39 — SURFACE CONTOUR
- 33.67 — PROPOSED SPOT ELEVATION
- PROPOSED DITCH
- PROPOSED BERM
- SLOPE
- POND
- PROPOSED SPOIL MATERIAL
- SILT FENCE
- CONSTRUCTION LIMIT
- POND 1 – DEWATER TO POND 3 ALUM AMEND SOLIDS FILL TO EXISTING GRADE
- POND 2 – DEWATER TO POND 3 TRANSFER SOLIDS TO POND 1 FILL TO EXISTING GRADE OR SUITABLE FOR MAINTAINING A CROP
- DEWATER FILL TO EXISTING GRADE
- POND 3/COOLING POND – ALUM AMEND POND WATER
- PROPOSED SPOIL MATERIAL FOR BERM CONSTRUCTION AND FILL FOR POND 1 EXCAVATE TO 36' NGVD

NOTES:

1.) SEED ALL BERMS.

2.) SLOPE AT THE END OF BERM TO MATCH THE EXISTING GRADE.

3.) DITCH WIDTH VARIES, SEE CROSS SECTIONS.

0 feet 160 SCALE

DESIGNED BY:

HSA ENGINEERS & SCIENTISTS

DATE	DRAWN	REV.#	REVISION DESCRIPTION

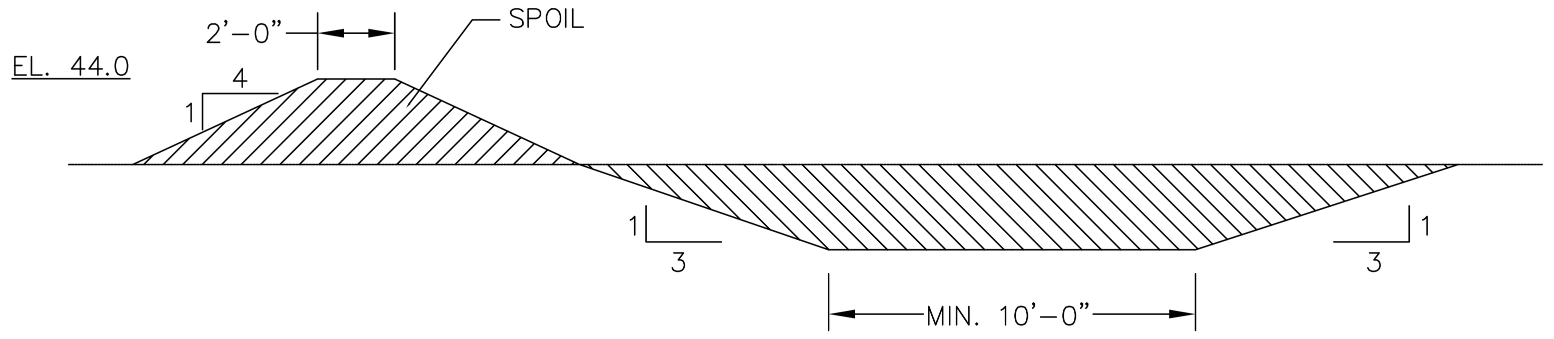
ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
CHECKED:
DATE: 01/27/04
SCALE: 1"=160'

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
PHONE: 561-686-8800
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

LAMB ISLAND DAIRY
OKEECHOBEE COUNTY, FLORIDA

SITE PLAN

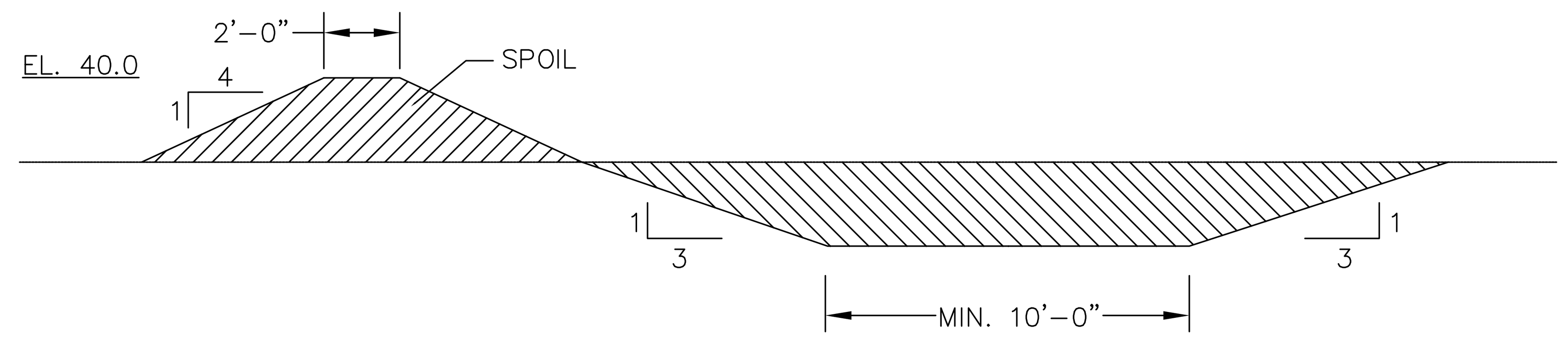
CONTRACT NO. C-13410
DRAWING NO. 8005716000[002]



SEE PLAN AND CROSS
SECTION FOR ELEVATION

TYP. SWALE SEC A

NOT TO SCALE



SEE PLAN AND CROSS
SECTION FOR ELEVATION

TYP. SWALE SEC B

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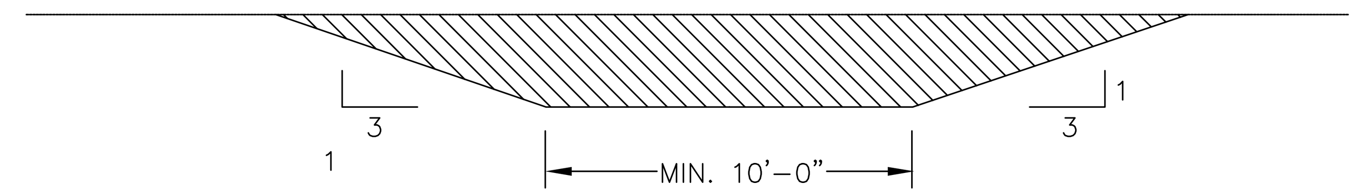

TYP. SWALE SEC C

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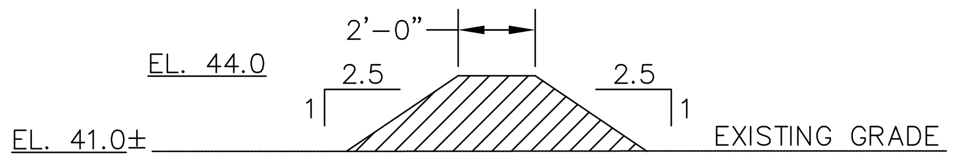

TYP. BERM SEC D

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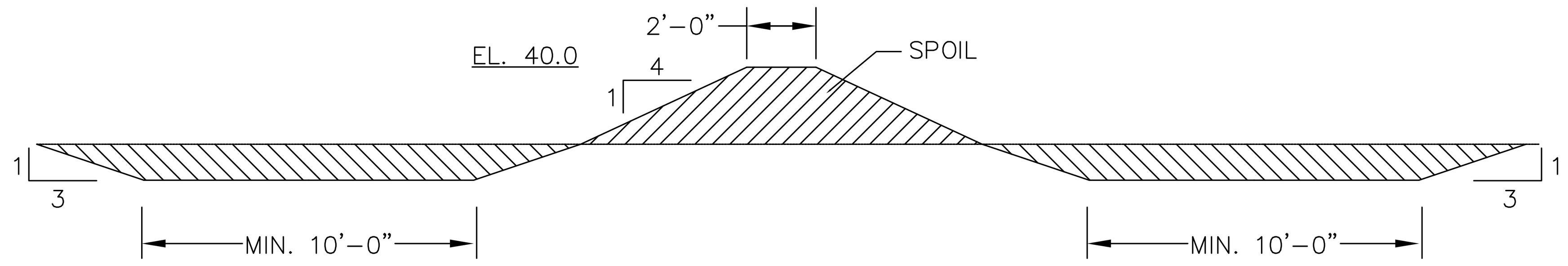

TYP. SWALE SEC E

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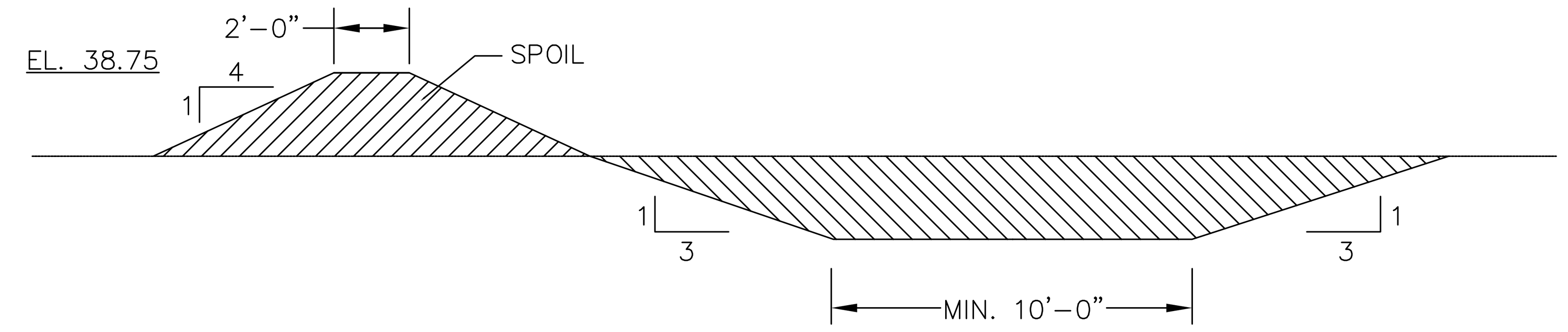

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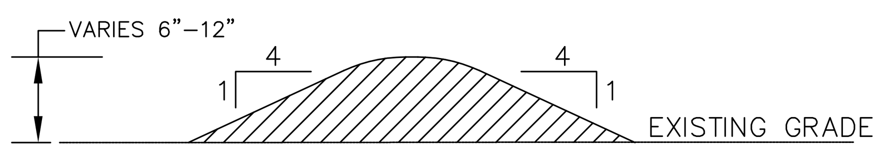

TYP. SWALE SEC G

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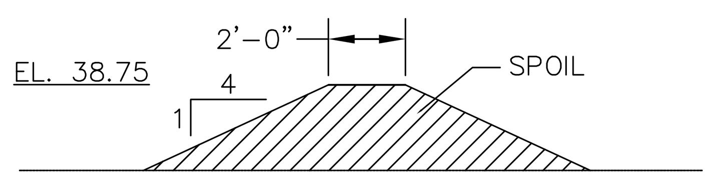

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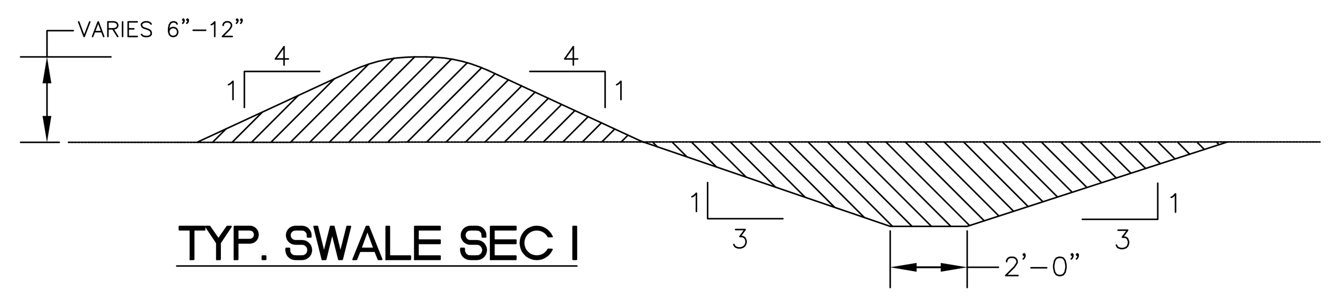
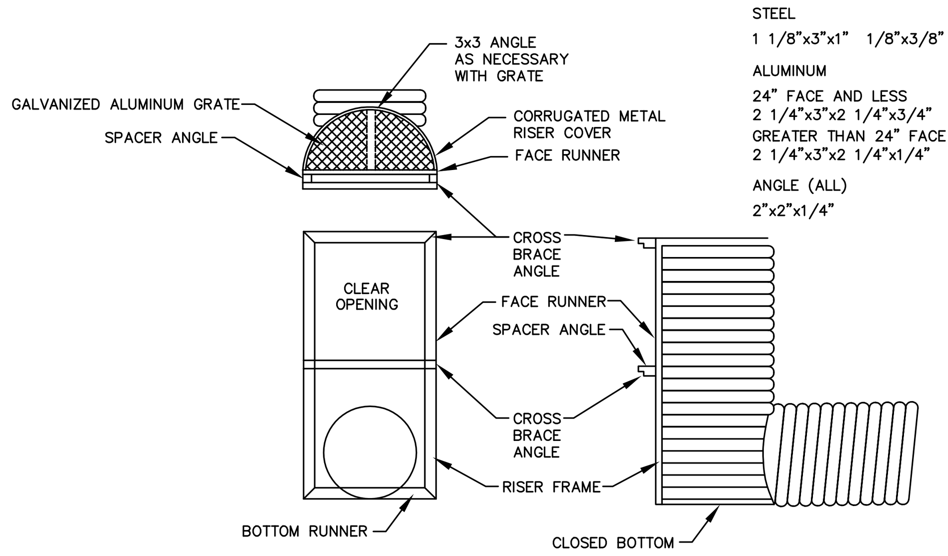


TYP. SWALE SEC I

NOT TO SCALE



CHANNEL

STEEL
1 1/8"x3"x1" 1/8"x3/8"

ALUMINUM
24" FACE AND LESS
2 1/4"x3"x2 1/4"x3/4"
GREATER THAN 24" FACE
2 1/4"x3"x2 1/4"x1/4"

ANGLE (ALL)
2"x2"x1/4"

NOTES:
1. RISER GREATER THAN 5' HIGH HAVE CROSS BRACE ANGLE IN CENTER OF RISER FACE.
2. RISERS LESS THAN 1' CLEAR OPENING HAVE ONLY ONE BRACE AT TOP OF RISER.
3. DIMENSIONS & SPECIFICATIONS PER SOUTHERN CULVERT OR APPROVED EQUAL.

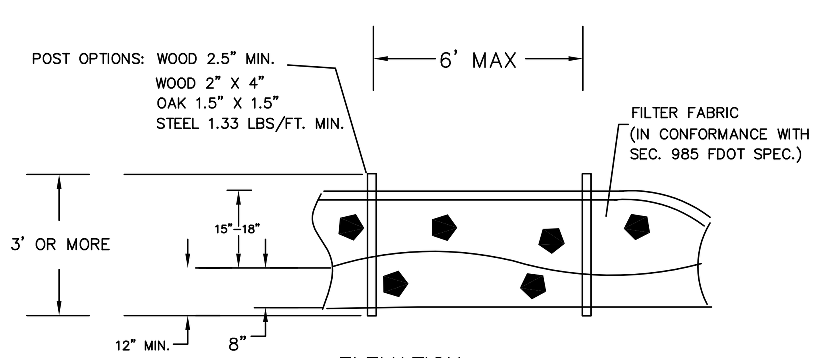
SINGLE FACE RISER
NOT TO SCALE

ALUMINUM RISER DETAIL (A/–)

CULVERT SCHEDULE

STUB. DIA.	STUB. DIA.	RISER COVER FACE WIDTH	RISER COVER GA.	RISER COVER SHEET LENGTH	FRAME WIDTH
12"	16	21	16	35	23
15"	16	24	16	40	26
18"	16	27	16	45	29
21"	16	30	16	50	32
24"	16	36	16	57.5	38
30"	14	42	14	68	44
36"	14	48	14	78	50
17"x33"	16	24	16	40	26
21"x15"	16	27	16	40	29
24"x18"	16	30	16	53	32
28"x20"	16	36	16	57.5	38
36"x24"	14	42	14	68	44
42"x29"	14	48	14	78	50

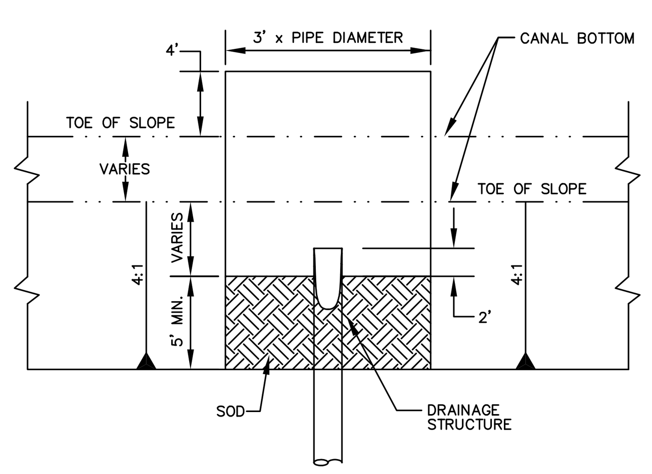
STRUCTURE	PIPE DIA.	TOP RISER ELEVATION	INVERT ELEVATION	LENGTH (FEET)
S-1	24"	43.0	40.0	20
S-2	24"	43.0	40.0	20
S-3	24"	43.0	40.0	20
S-4	24"	43.0	40.0	40
S-5	24"	43.0	40.0	20
S-6	36"	39.0	36.0	20
S-7	36"	43.0	40.0	20
S-8	36"	37.75	36.0	20



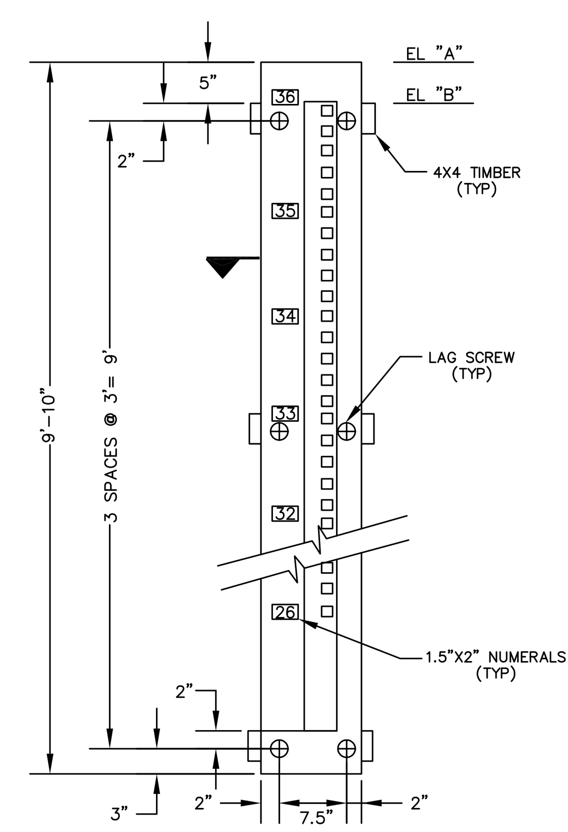
ELEVATION

TYPE III SILT FENCE
(F.D.O.T. INDEX NO. 102)

SILT FENCE DETAIL (C/–)
NOT TO SCALE

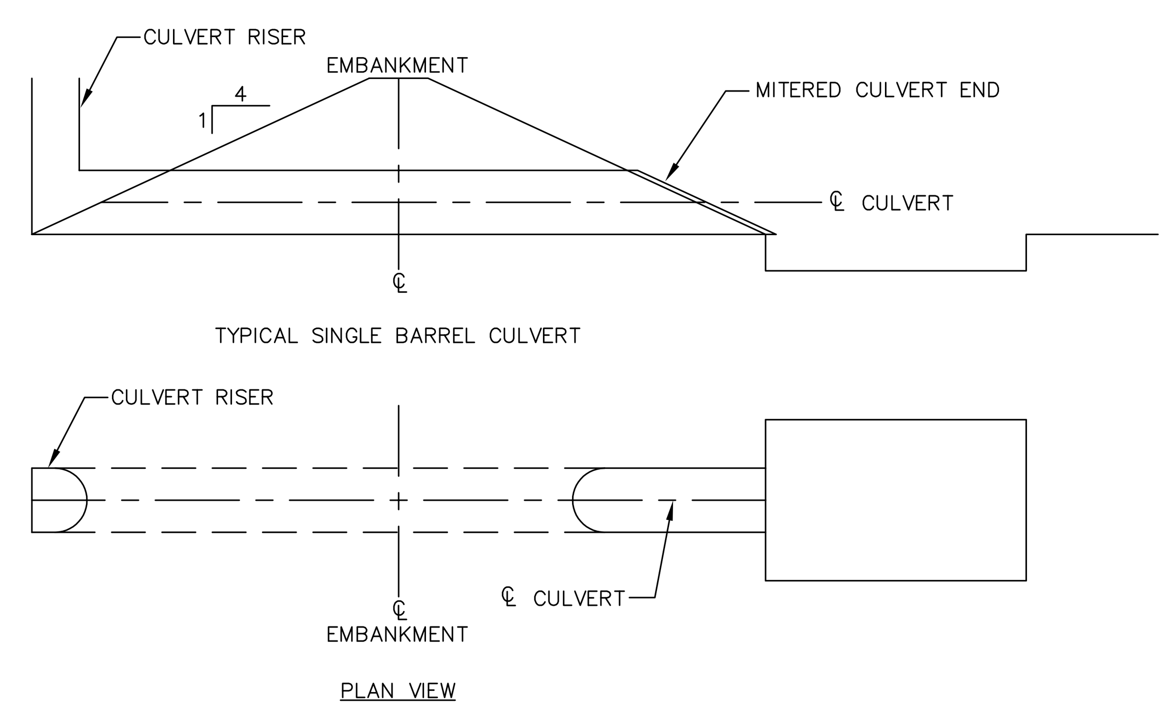


CULVERT OUTLET DETAIL (B/–)
NOT TO SCALE



NOTE:
1.) NUMBERS MAY VARY FROM THOSE SHOWN HERE.

STAFF GAUGE (C/–)
NOT TO SCALE



CULVERT DETAIL

NOT TO SCALE

DESIGNED BY:

HSA
ENGINEERS & SCIENTISTS

DATE	DRAWN	REV.#	REVISION DESCRIPTION

ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
CHECKED:
DATE: 01/08/04
SCALE: AS SHOWN

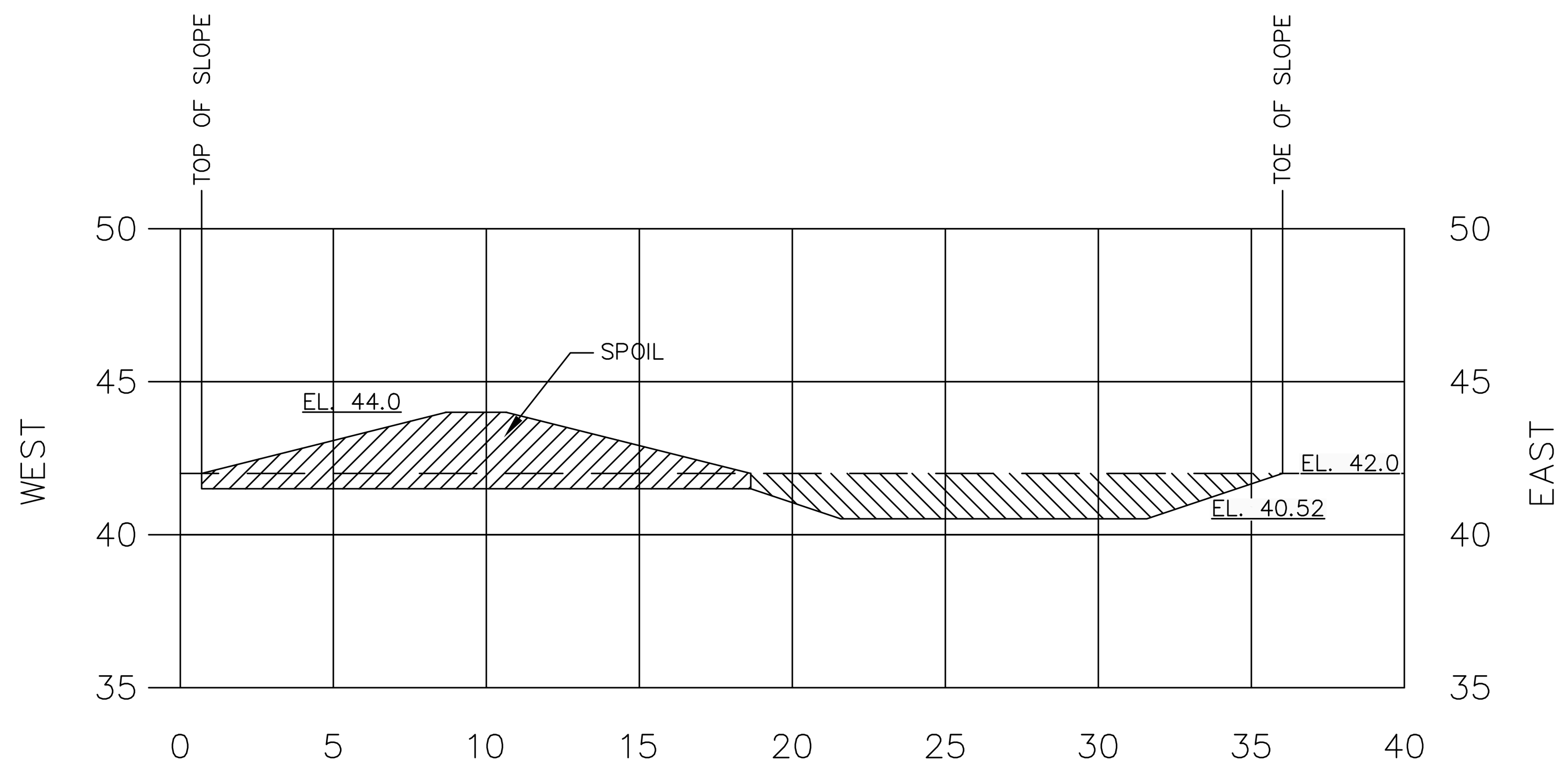
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
PHONE: 561-686-8800
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

LAMB ISLAND DAIRY
OKEECHOBEE COUNTY, FLORIDA

DETAILS

CONTRACT NO.
C-13410
DRAWING NO.
8005716000[003]

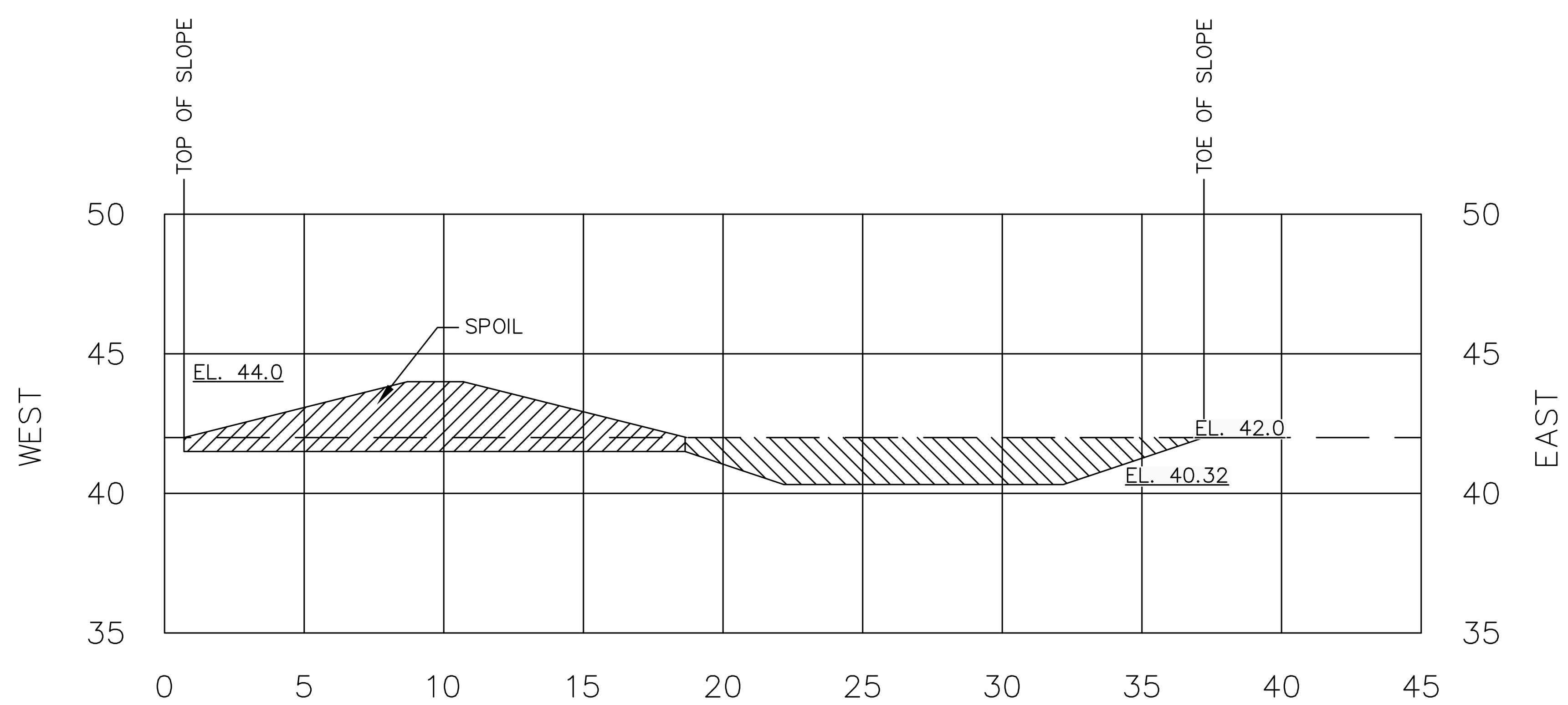
SHEET
3 OF 9



CROSS SECTION NO. 1 (TYP. SEC A)

NORTH SOUTH DRAINAGE DITCH

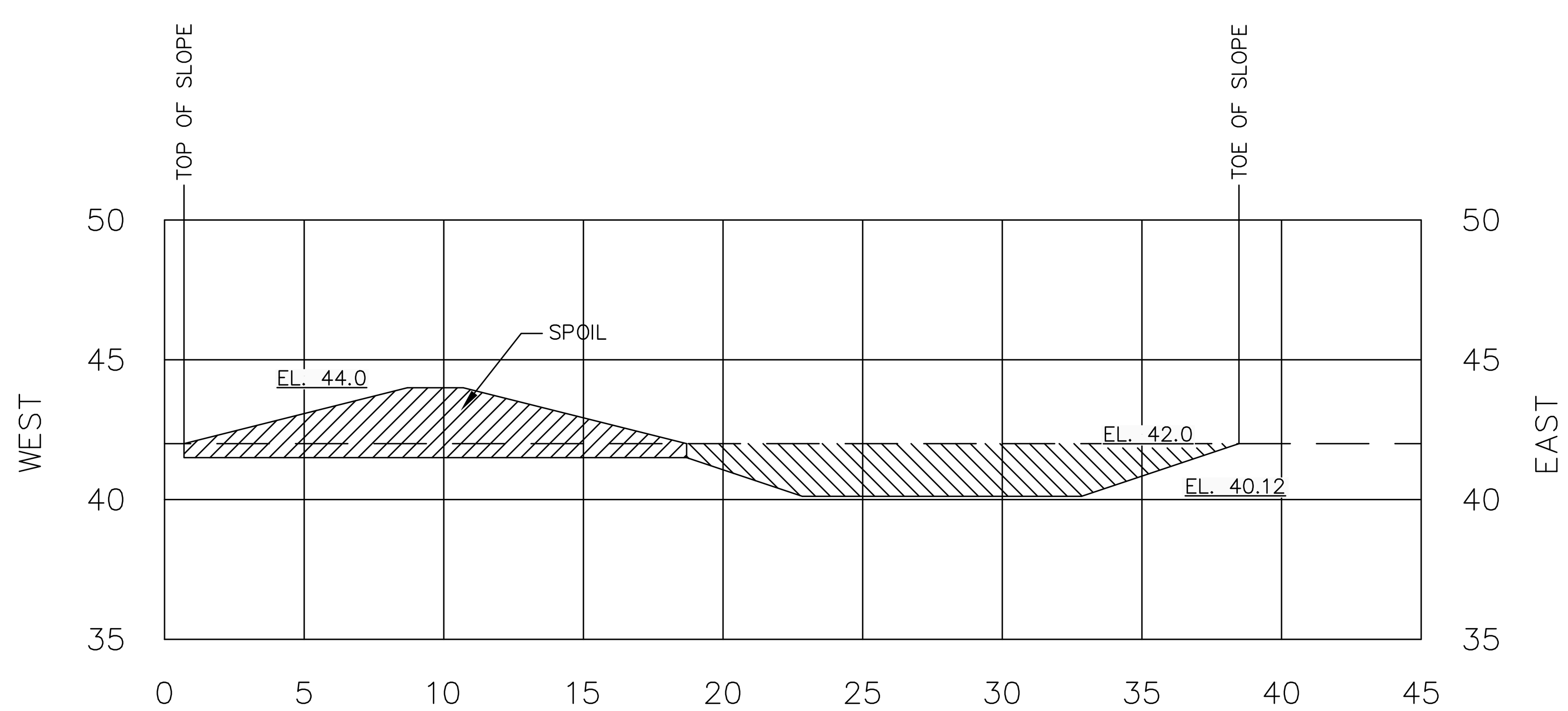
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 2 (TYP. SEC A)

NORTH SOUTH CONTAINMENT AREA

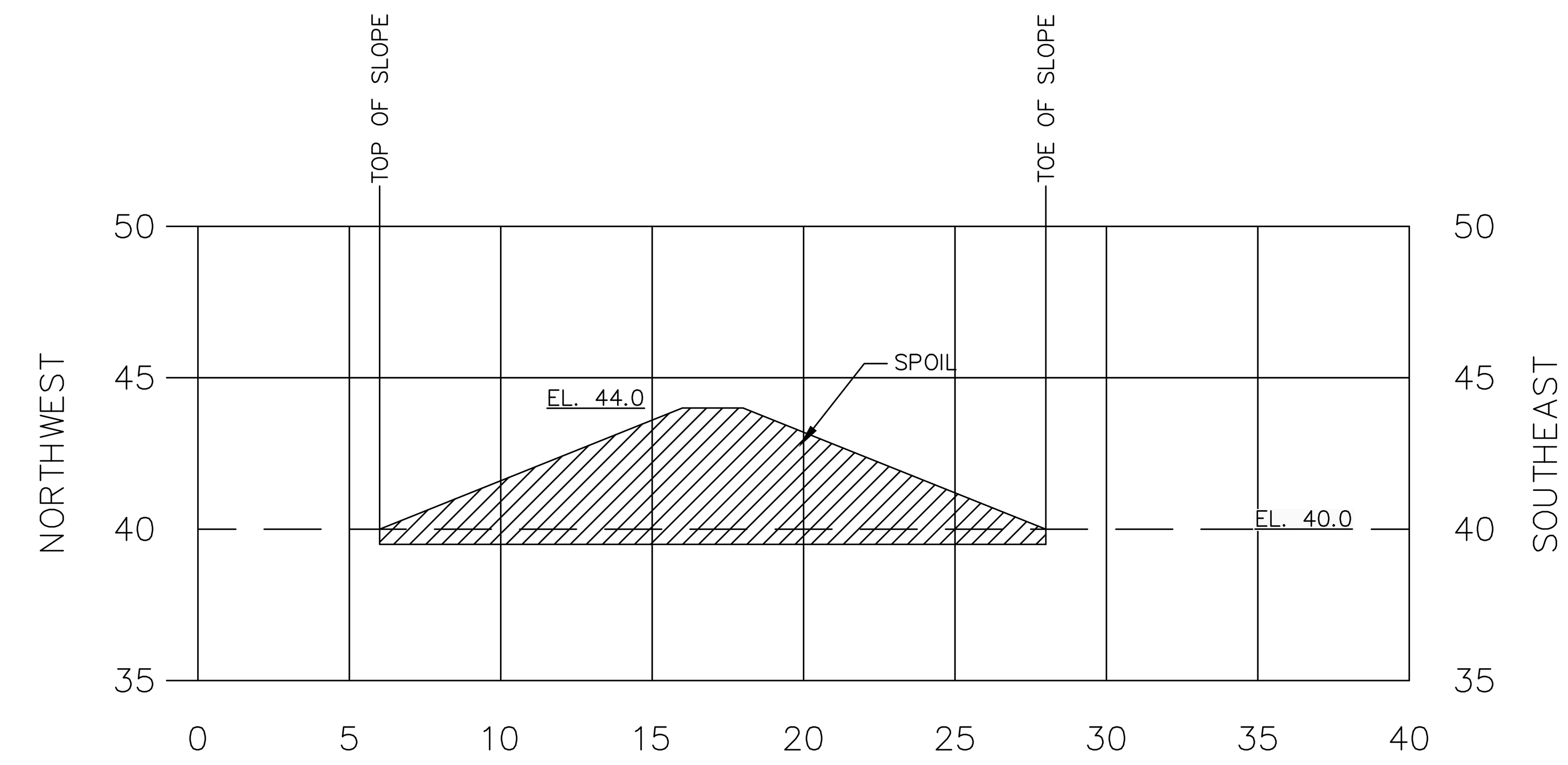
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 3 (TYP. SEC A)

NORTH SOUTH DRAINAGE DITCH

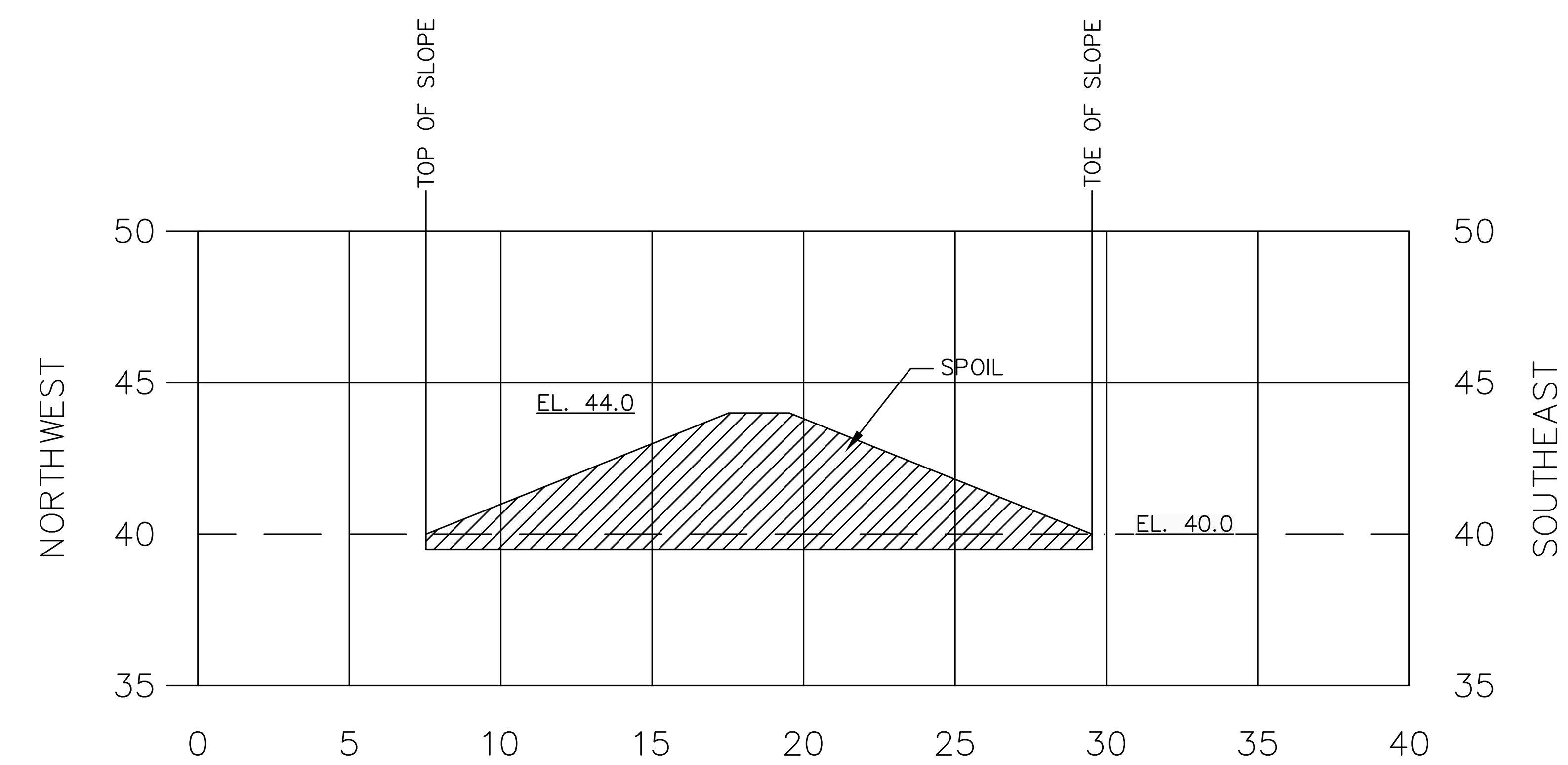
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 11 (TYP. SEC D)

TREATMENT SYSTEM BERM

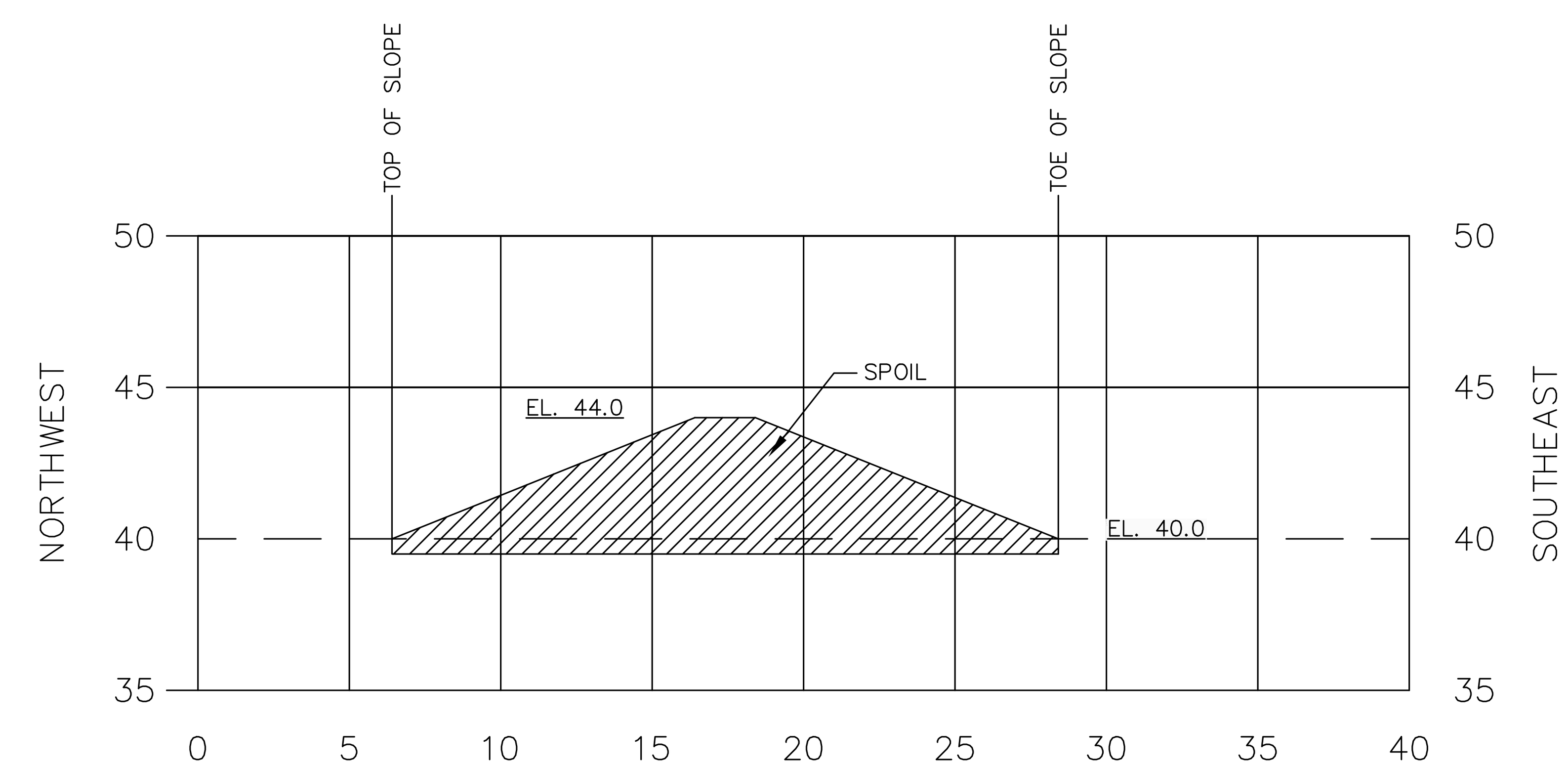
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 12 (TYP. SEC D)

TREATMENT SYSTEM BERM

SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 13 (TYP. SEC D)

TREATMENT SYSTEM BERM

SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

DESIGNED BY:

HSA ENGINEERS & SCIENTISTS

REVISION DESCRIPTION | DATE | DRAWN | REV.#

ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
CHECKED:
DATE: 01/08/04
SCALE: AS SHOWN

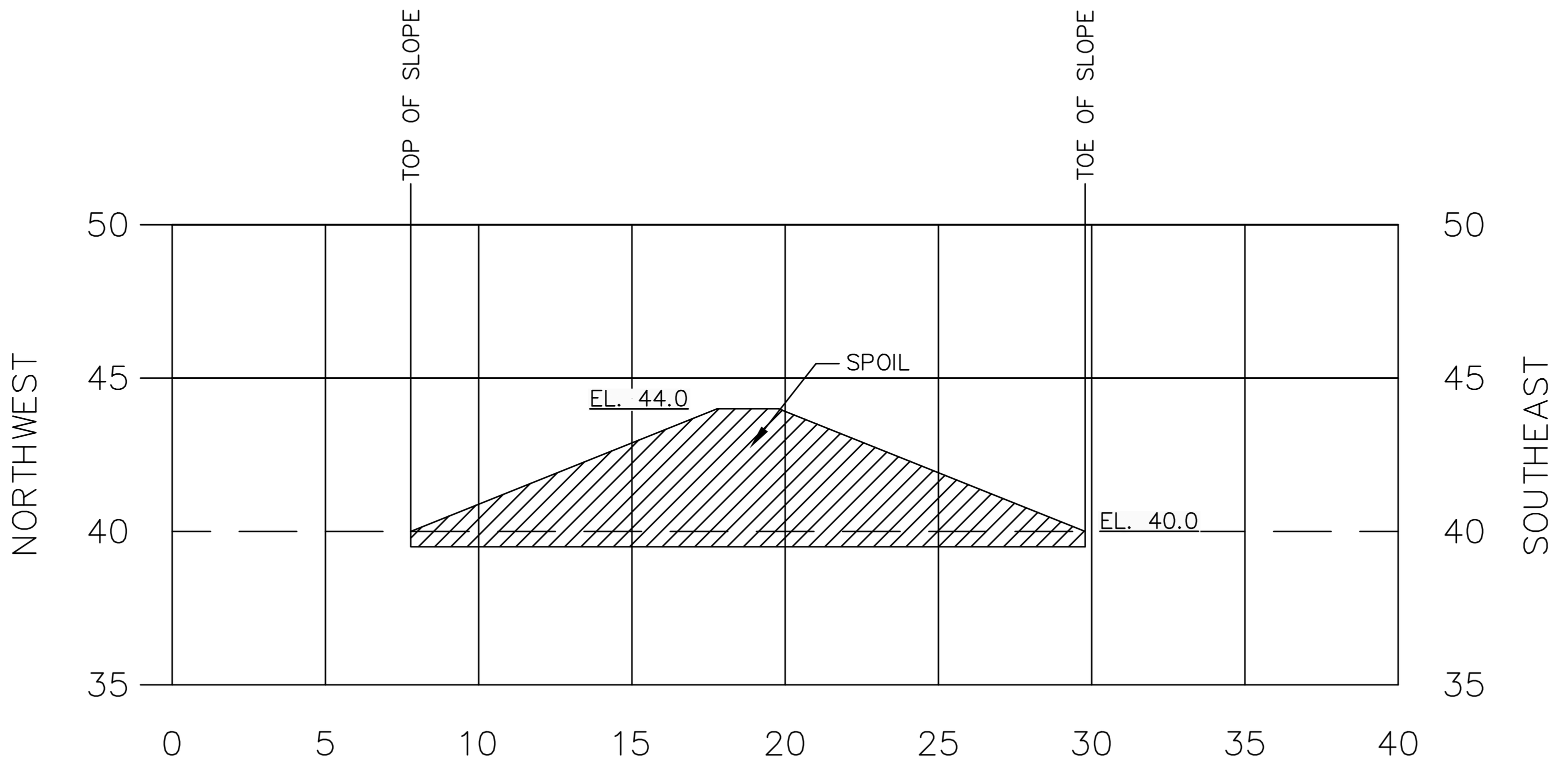
SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
PHONE: 561-686-8800
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

LAMB ISLAND DAIRY
OKEECHOBEE COUNTY, FLORIDA

CROSS SECTIONS

CONTRACT NO. C-13410
DRAWING NO. 8005716000[004]

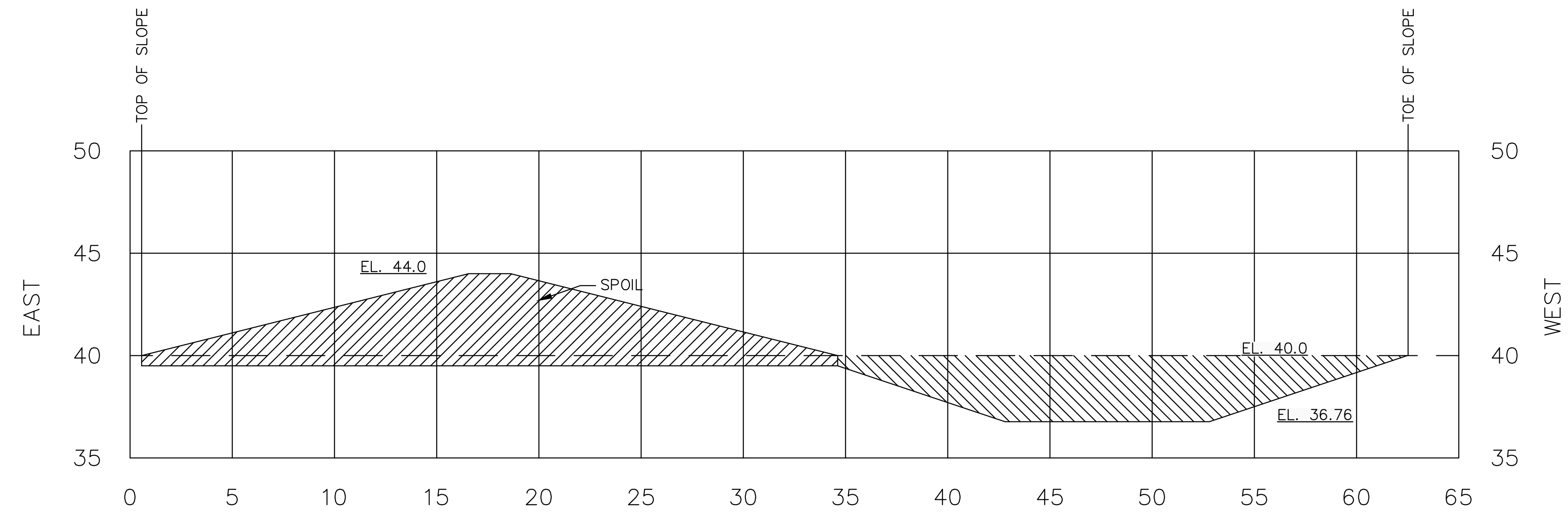
SHEET 4 OF 9



CROSS SECTION NO. 14 (TYP. SEC D)

TREATMENT SYSTEM BERM

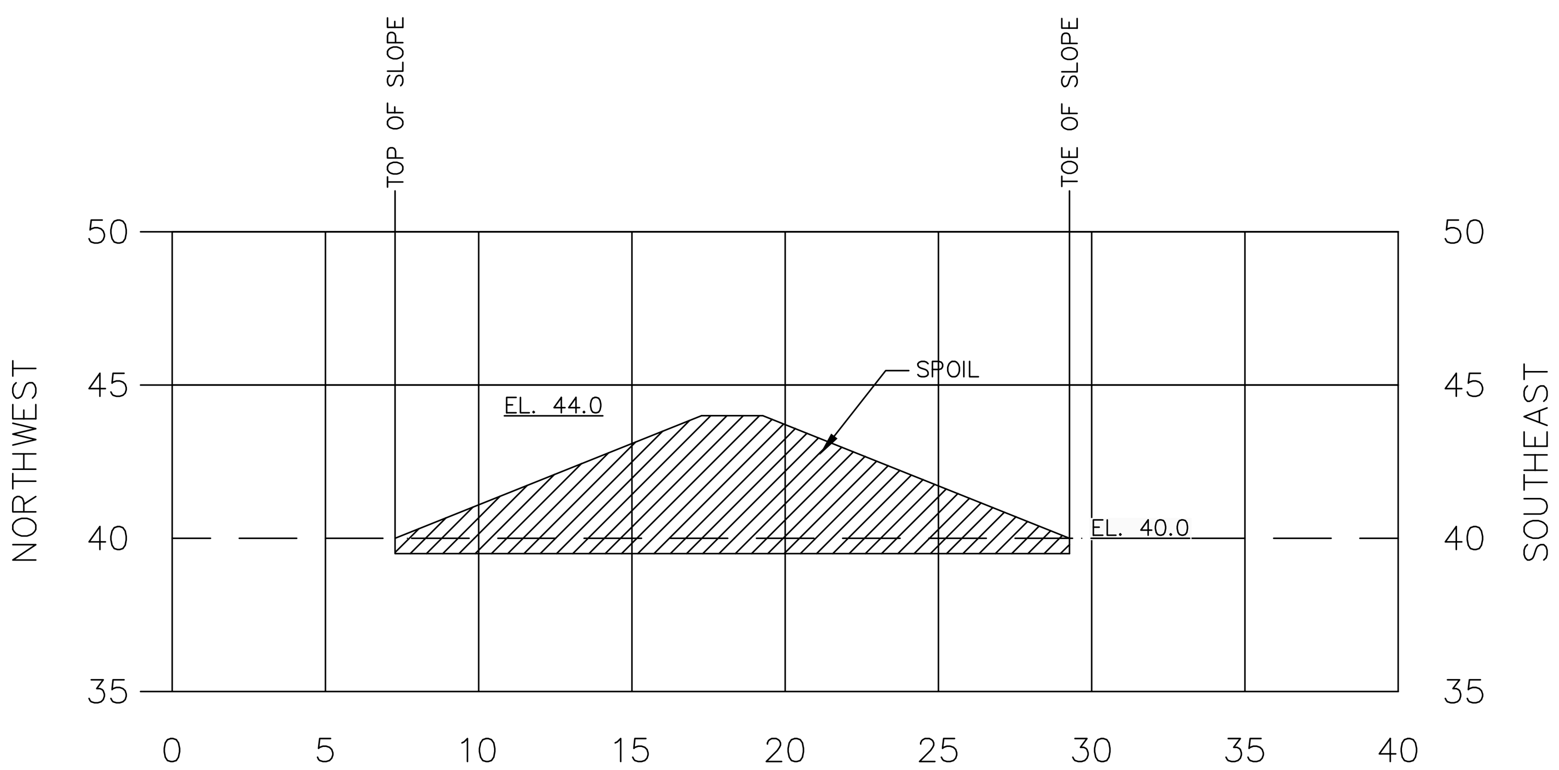
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 21 (TYP. SEC A)

NORTH SOUTH CONTAINMENT AREA

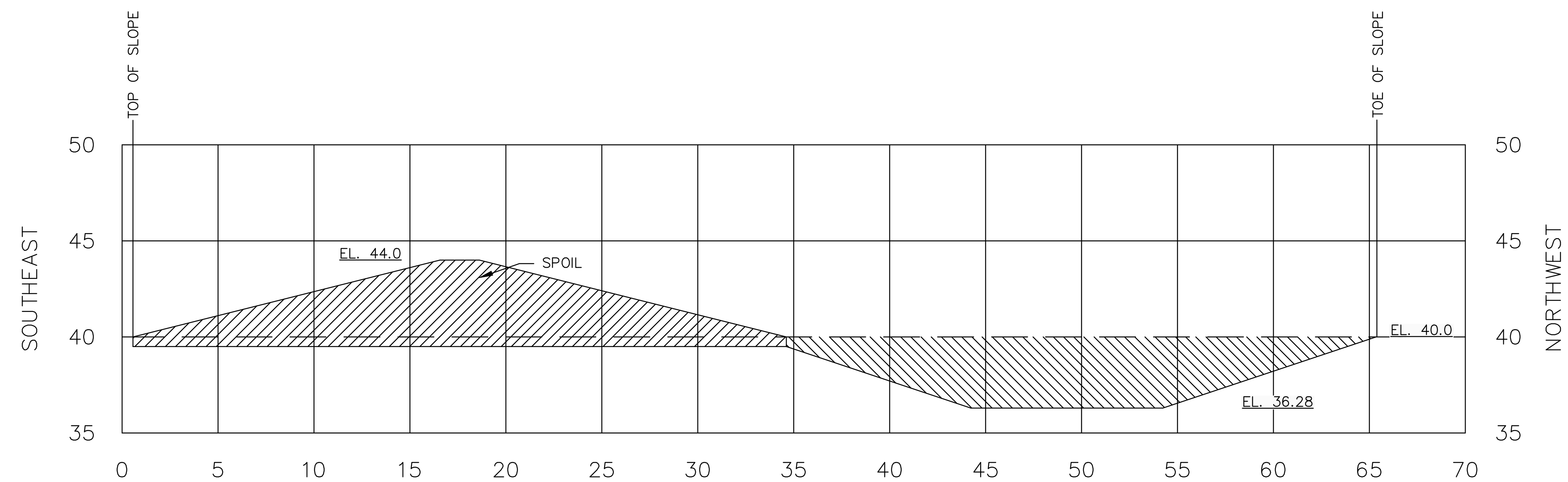
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 15 (TYP. SEC D)

TREATMENT SYSTEM BERM

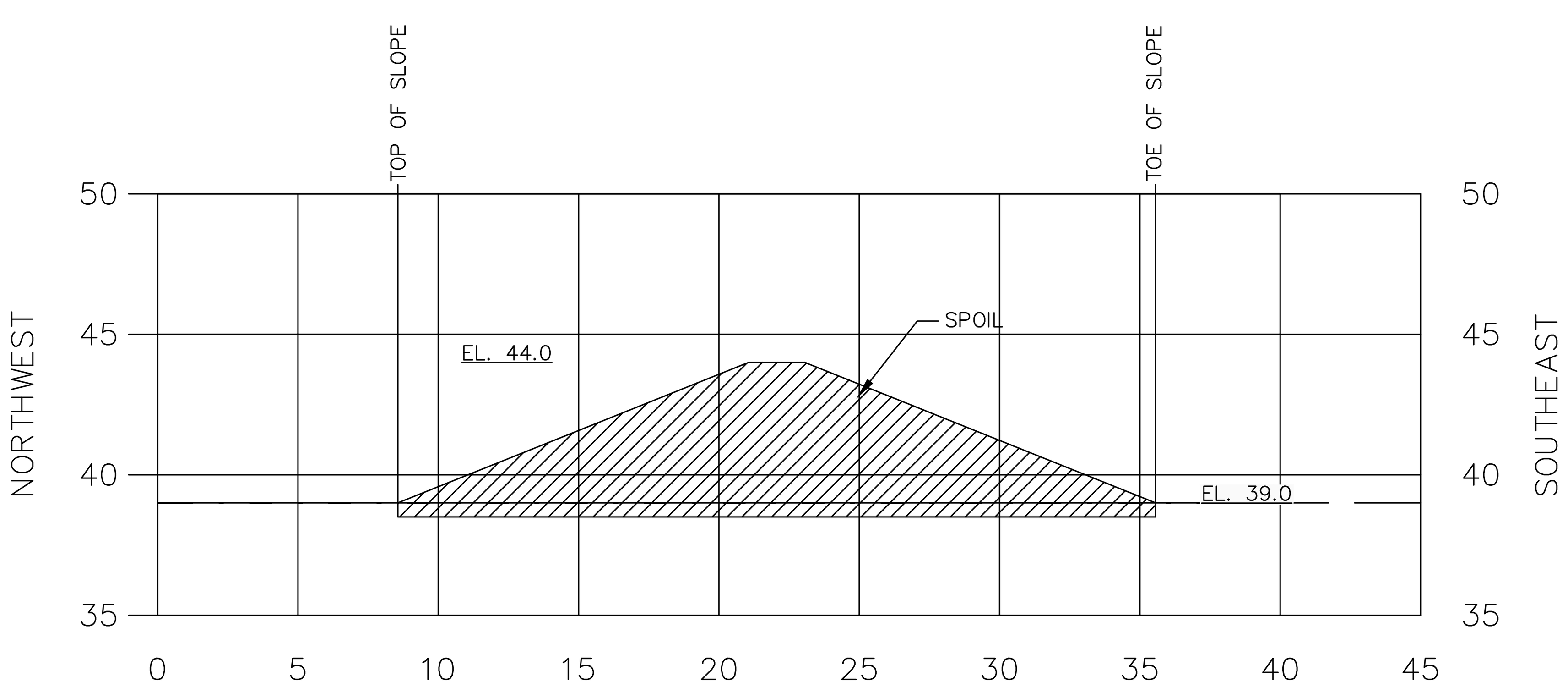
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 22 (TYP. SEC A)

EAST WEST CONTAINMENT AREA

SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



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TREATMENT SYSTEM BERM

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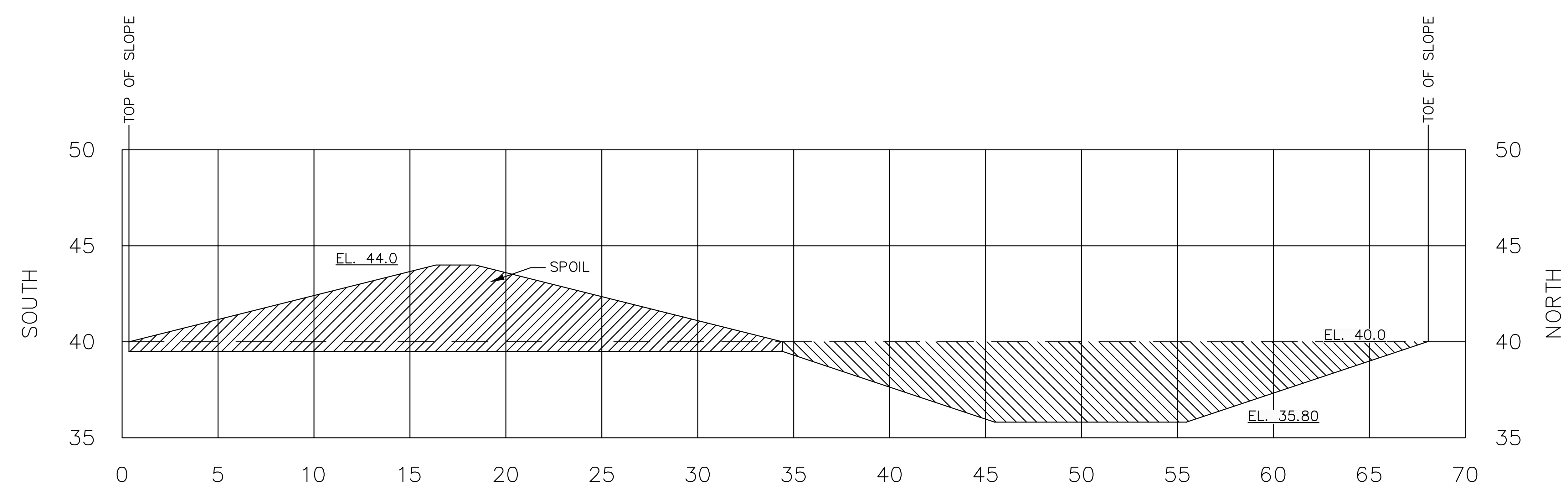

CROSS SECTION NO. 23 (TYP. SEC A)

EAST WEST CONTAINMENT AREA

SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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ENGINEER: TERRENCE HORAN
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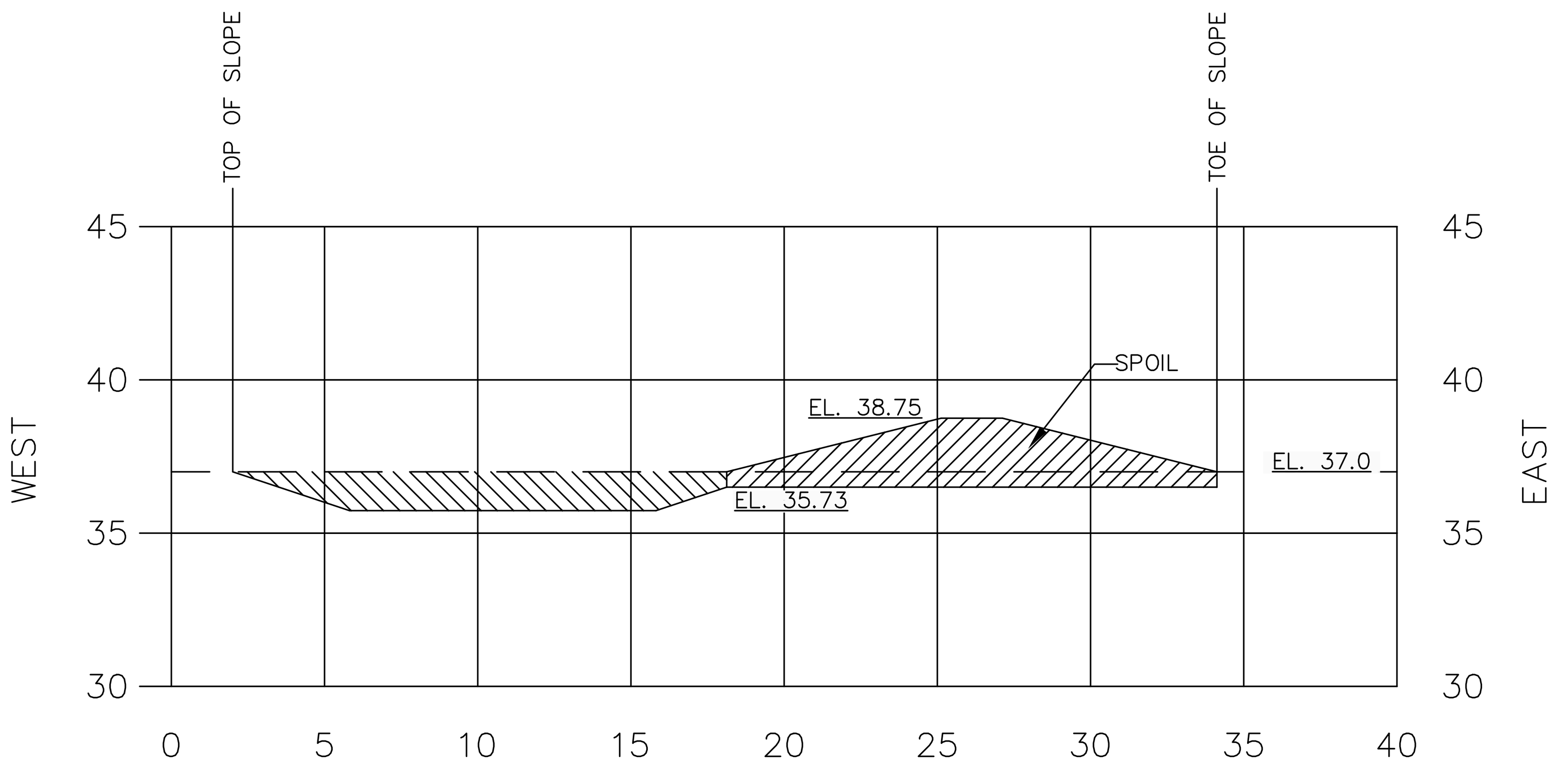
OKEECHOBEE COUNTY, FLORIDA

CROSS SECTIONS

CONTRACT NO. C-13410
DRAWING NO. 8005716000[005]

SHEET 5 OF 9



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NORTH SOUTH COLLECTION AREA

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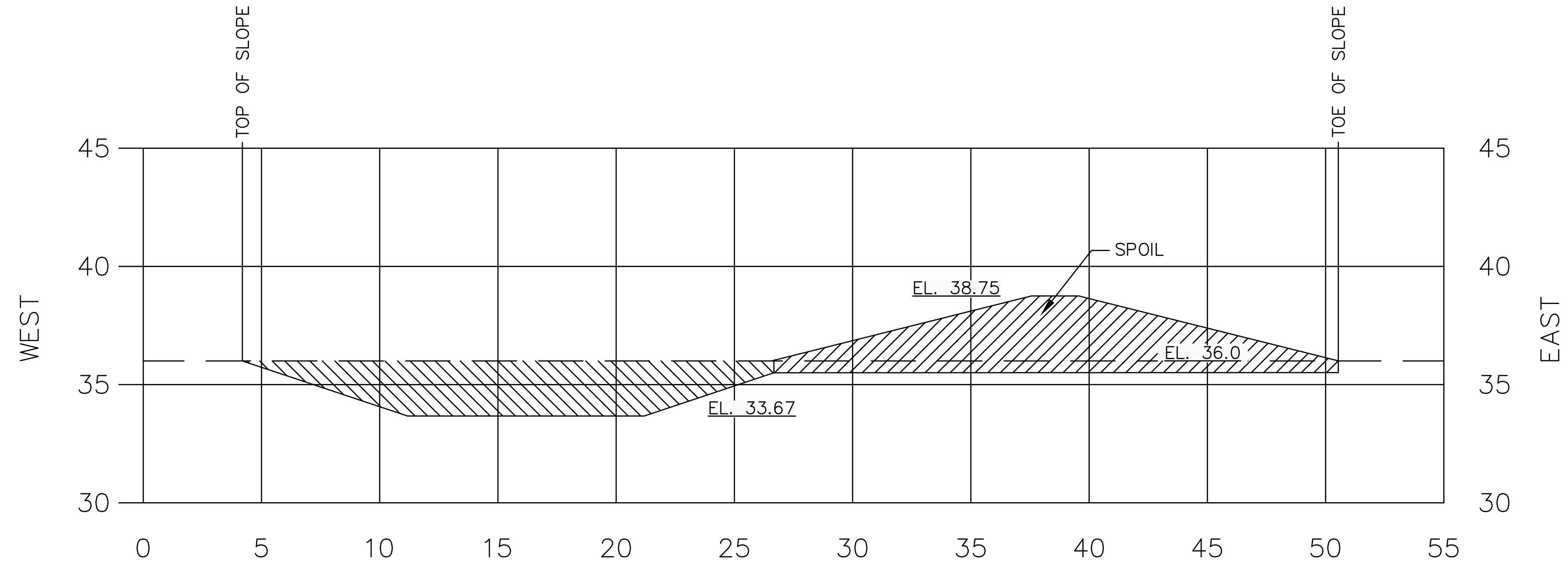
VERTICAL: 1"–5'



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NORTH SOUTH COLLECTION AREA

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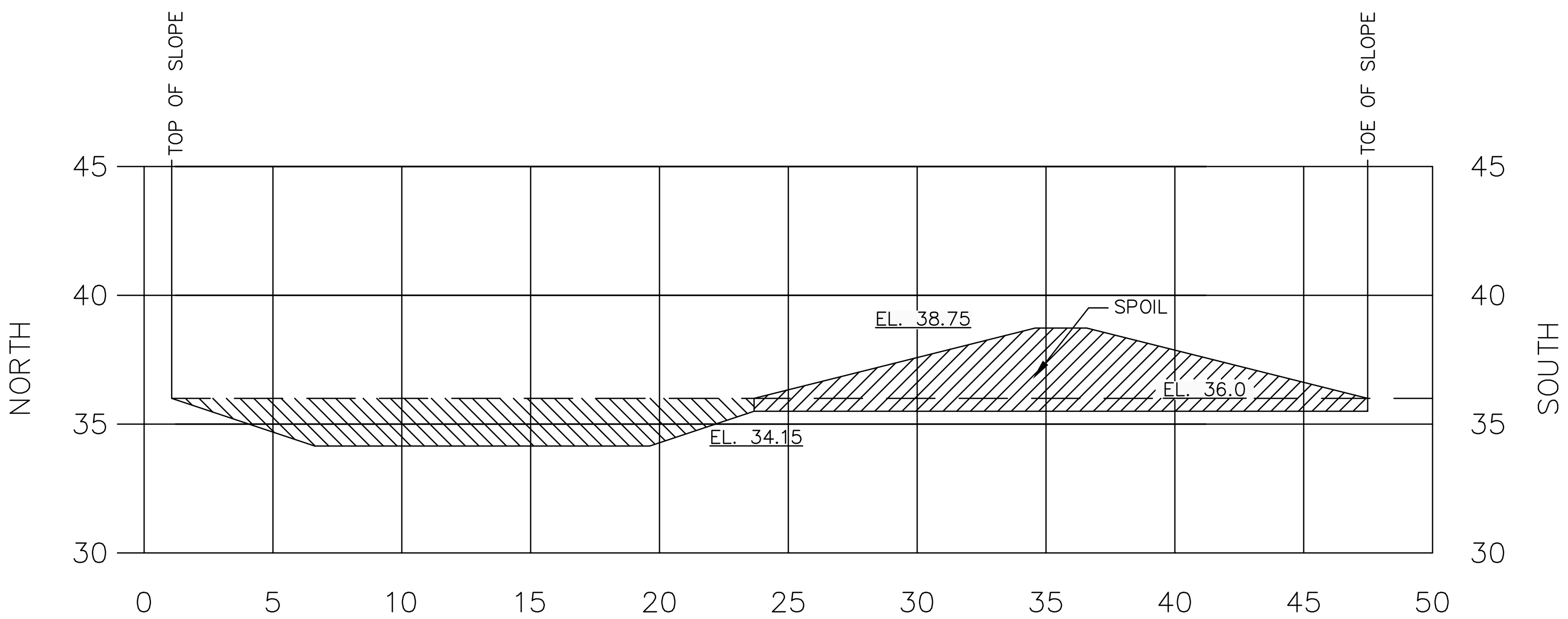

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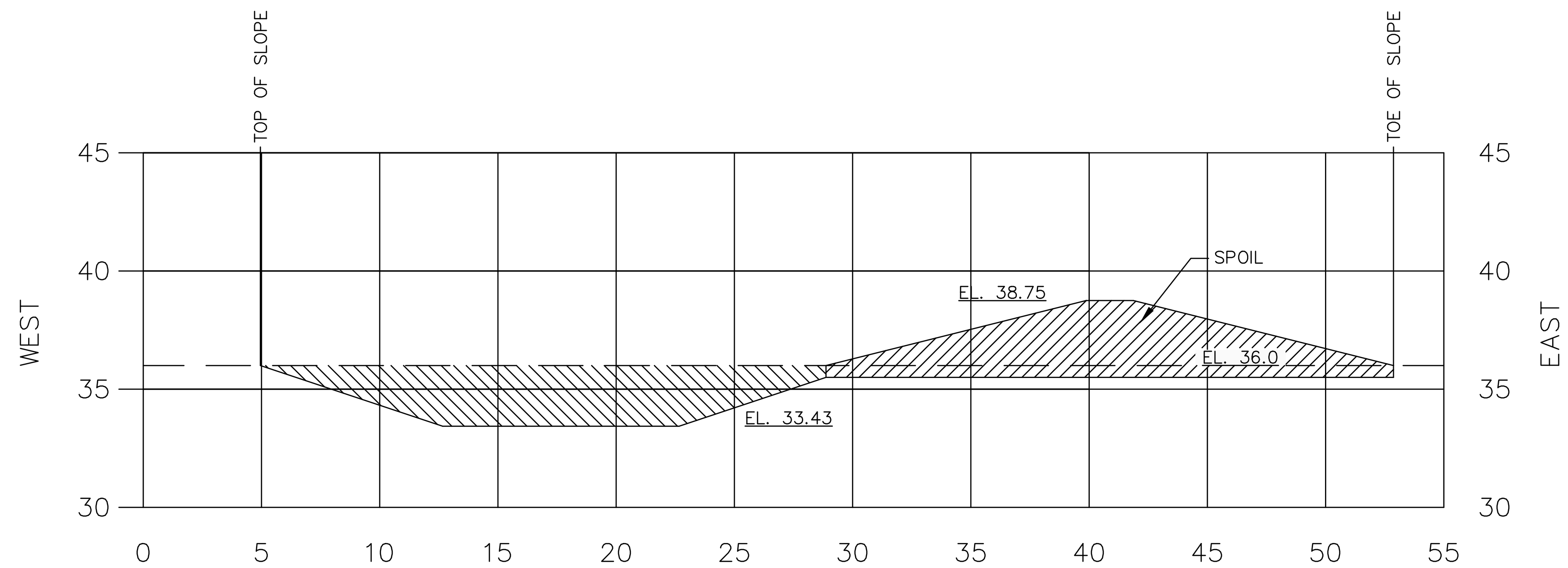

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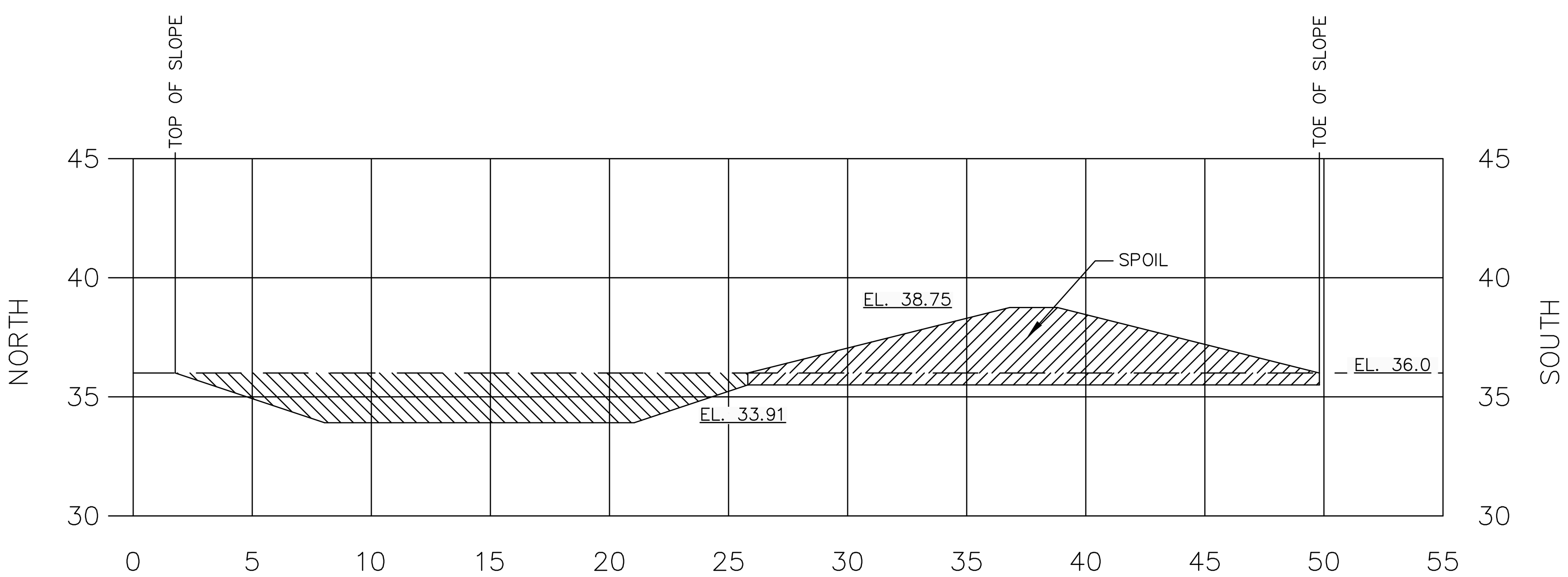

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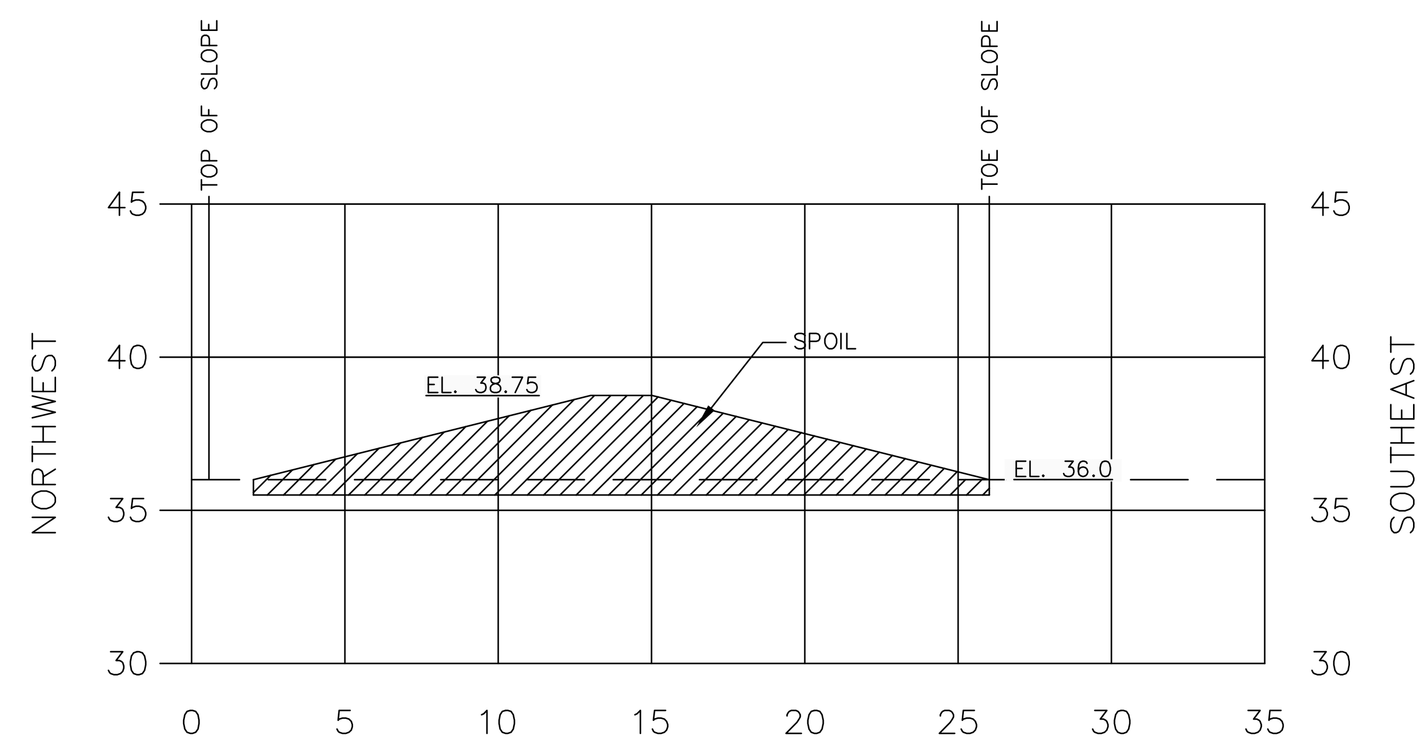
VERTICAL: 1"–5'



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NORTH SOUTH COLLECTION AREA

SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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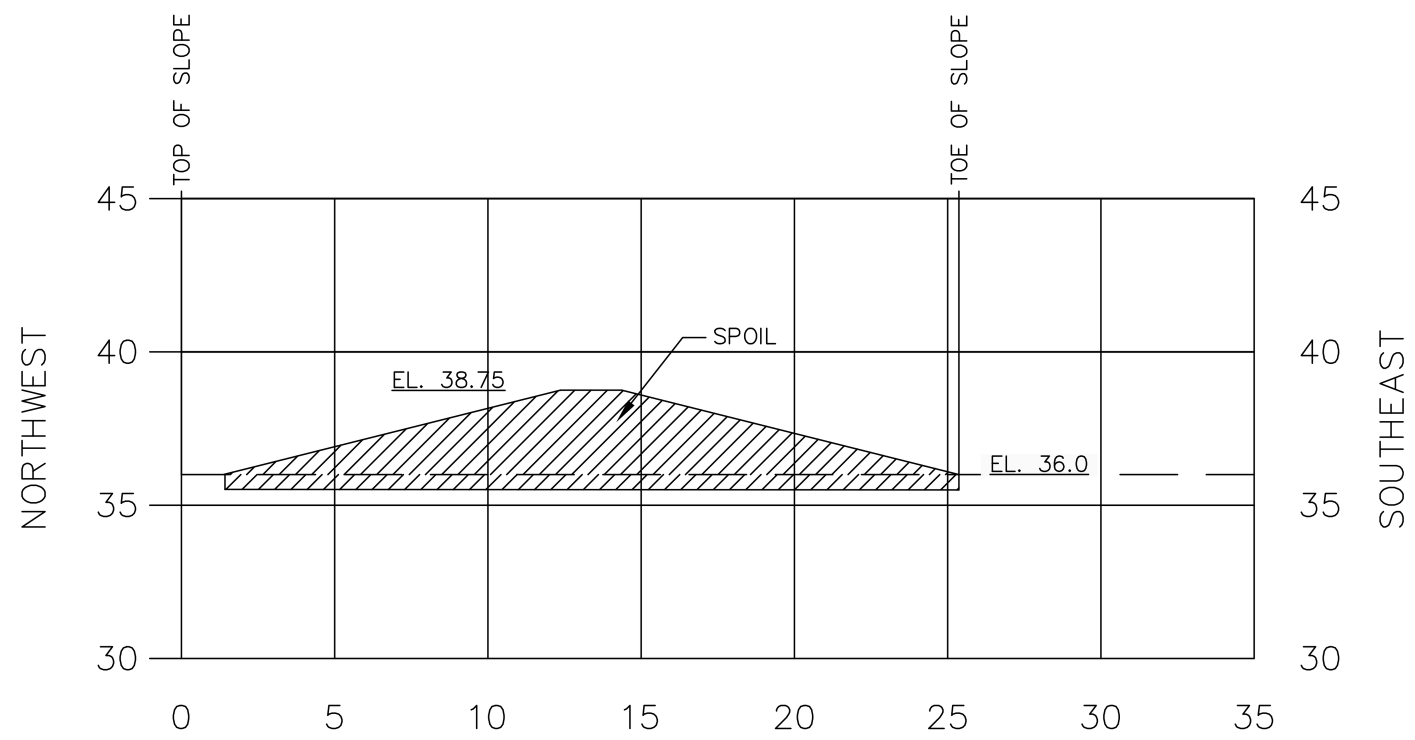
CONTRACT NO. C-13410
DRAWING NO. 8005716000[006]

SHEET 6 OF 9



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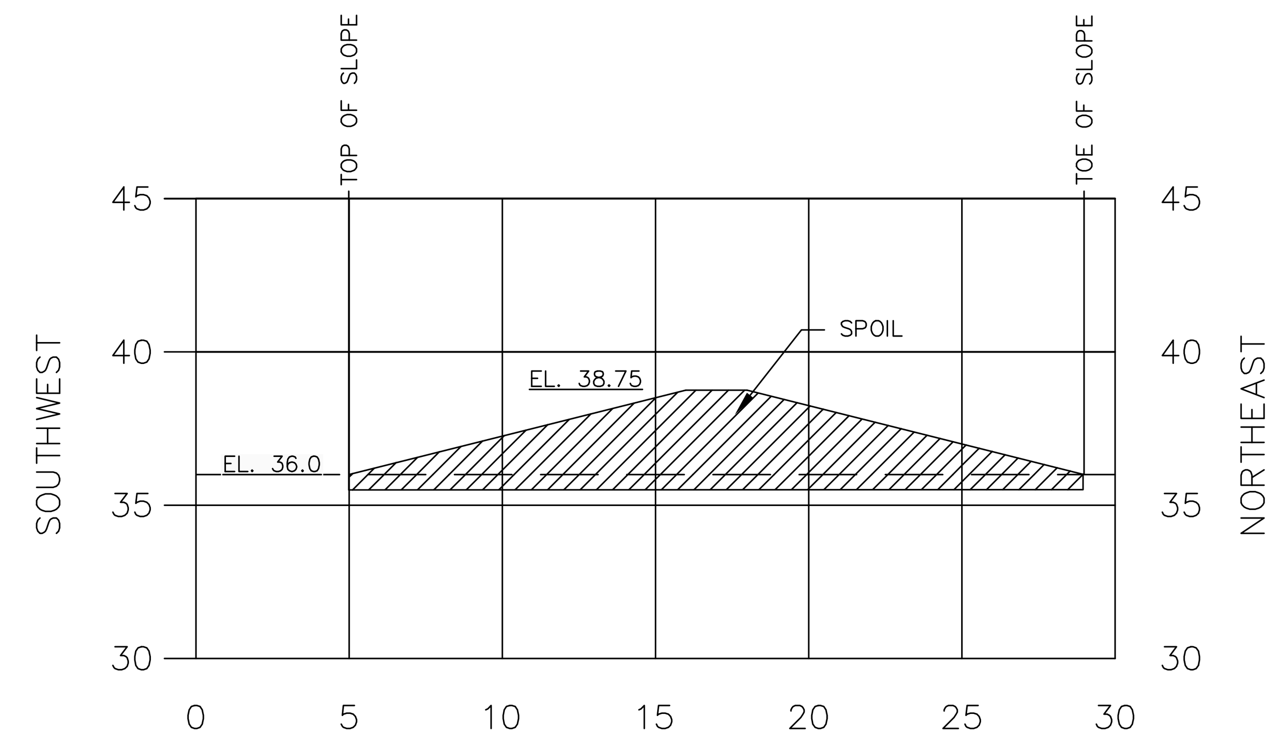

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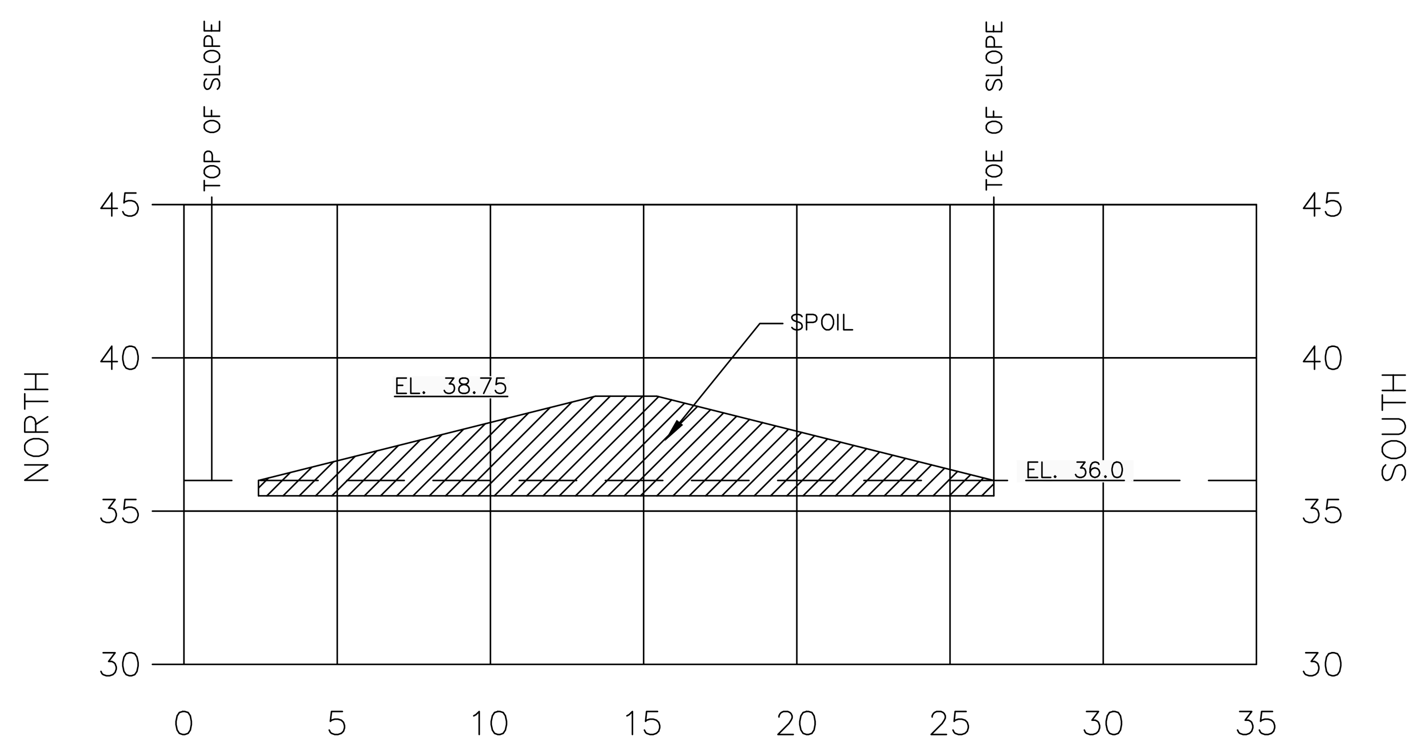

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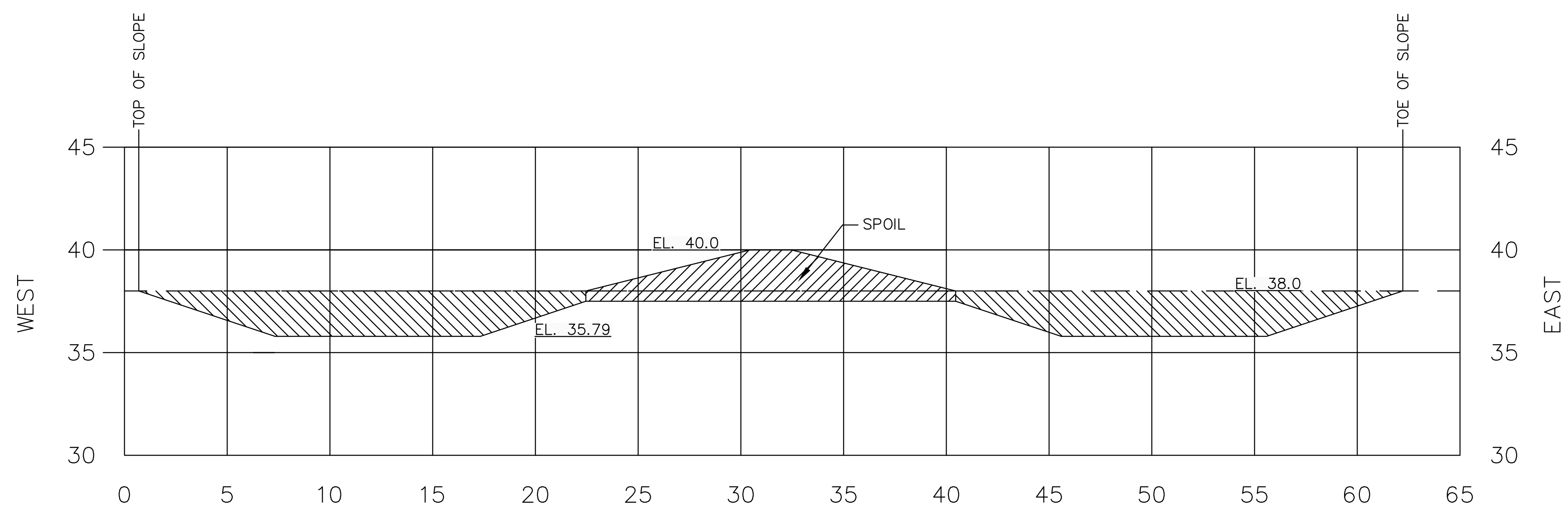

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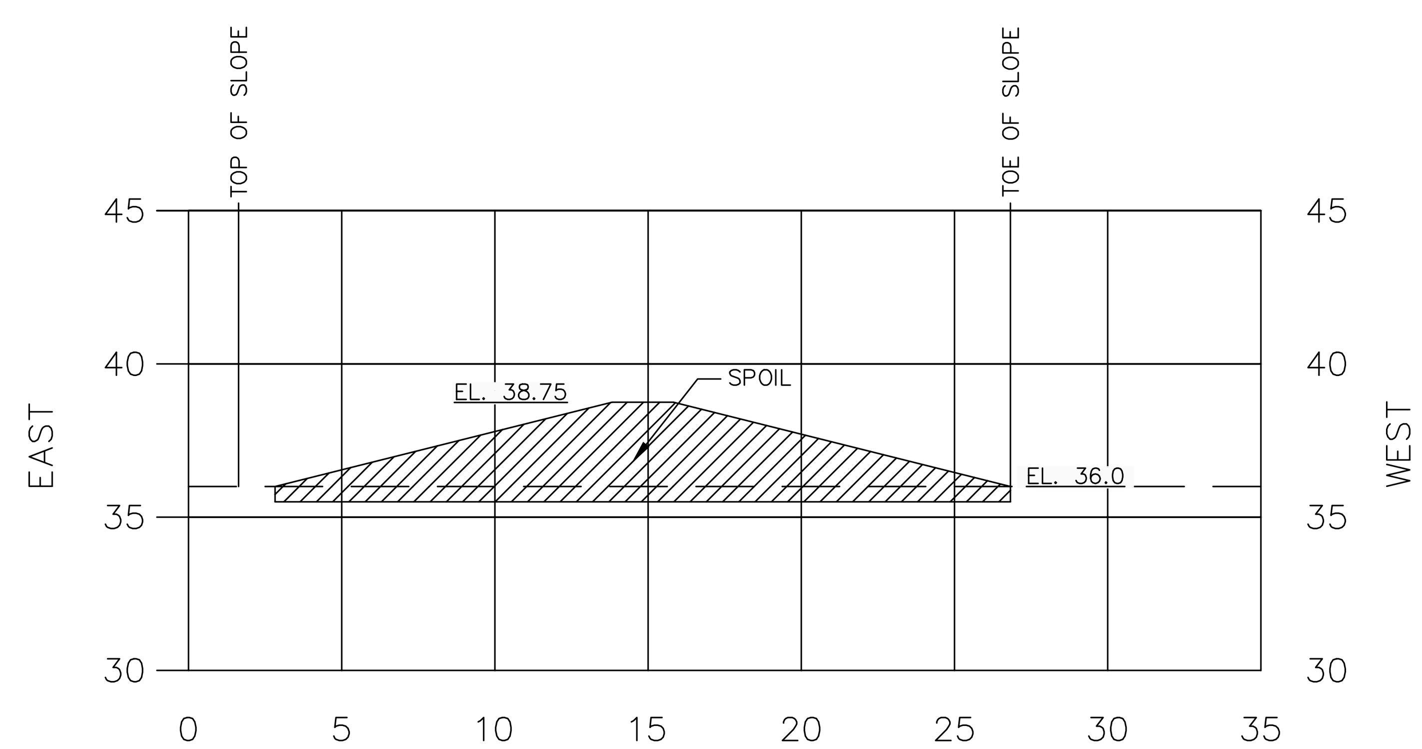

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NORTH SOUTH COLLECTION AREA

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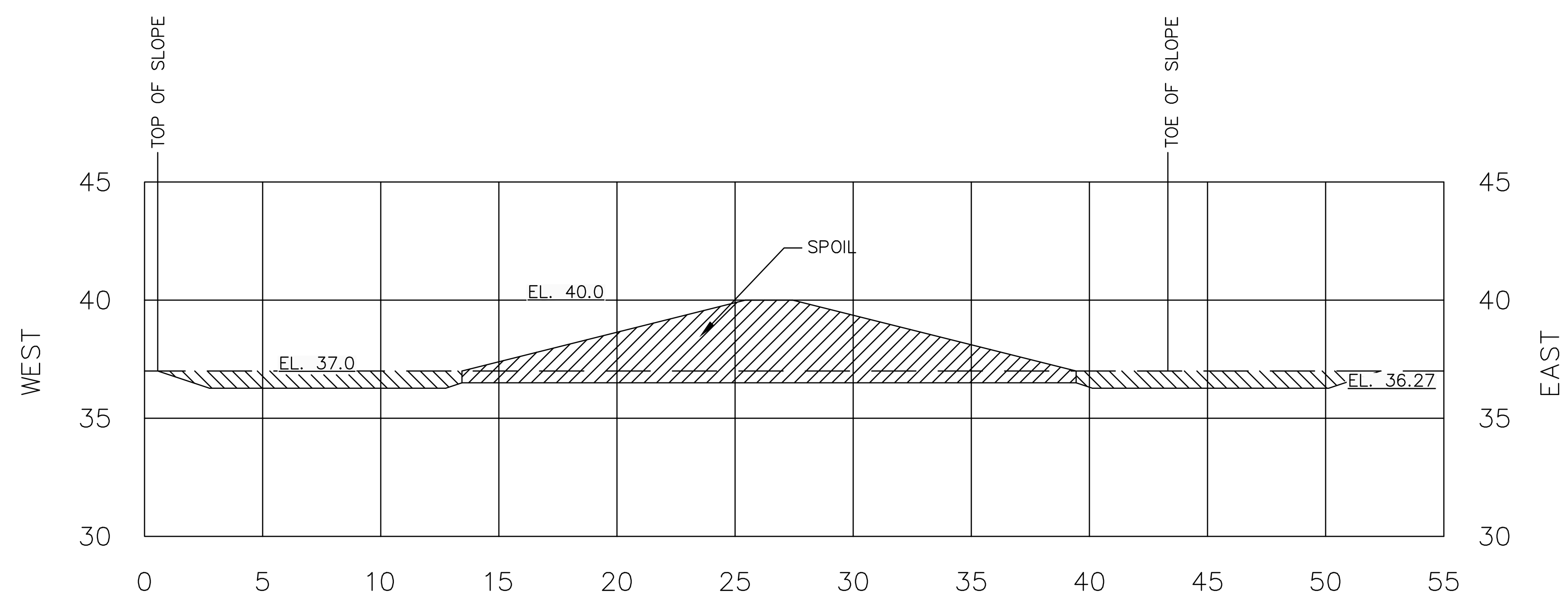

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SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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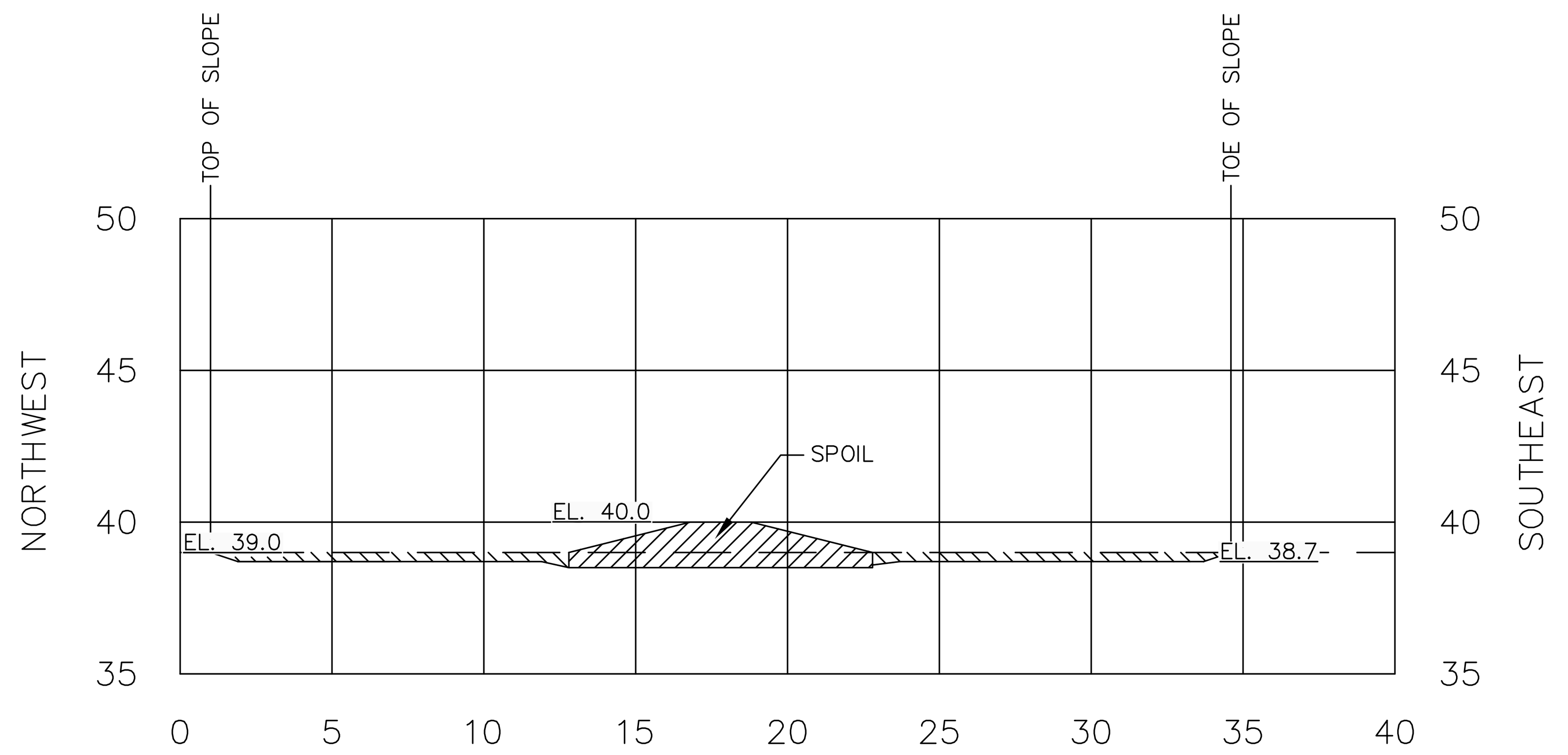
OKEECHOBEE COUNTY, FLORIDA

CROSS SECTIONS

CONTRACT NO. C-13410
DRAWING NO. 8005716000[007]

SHEET 7 OF 9



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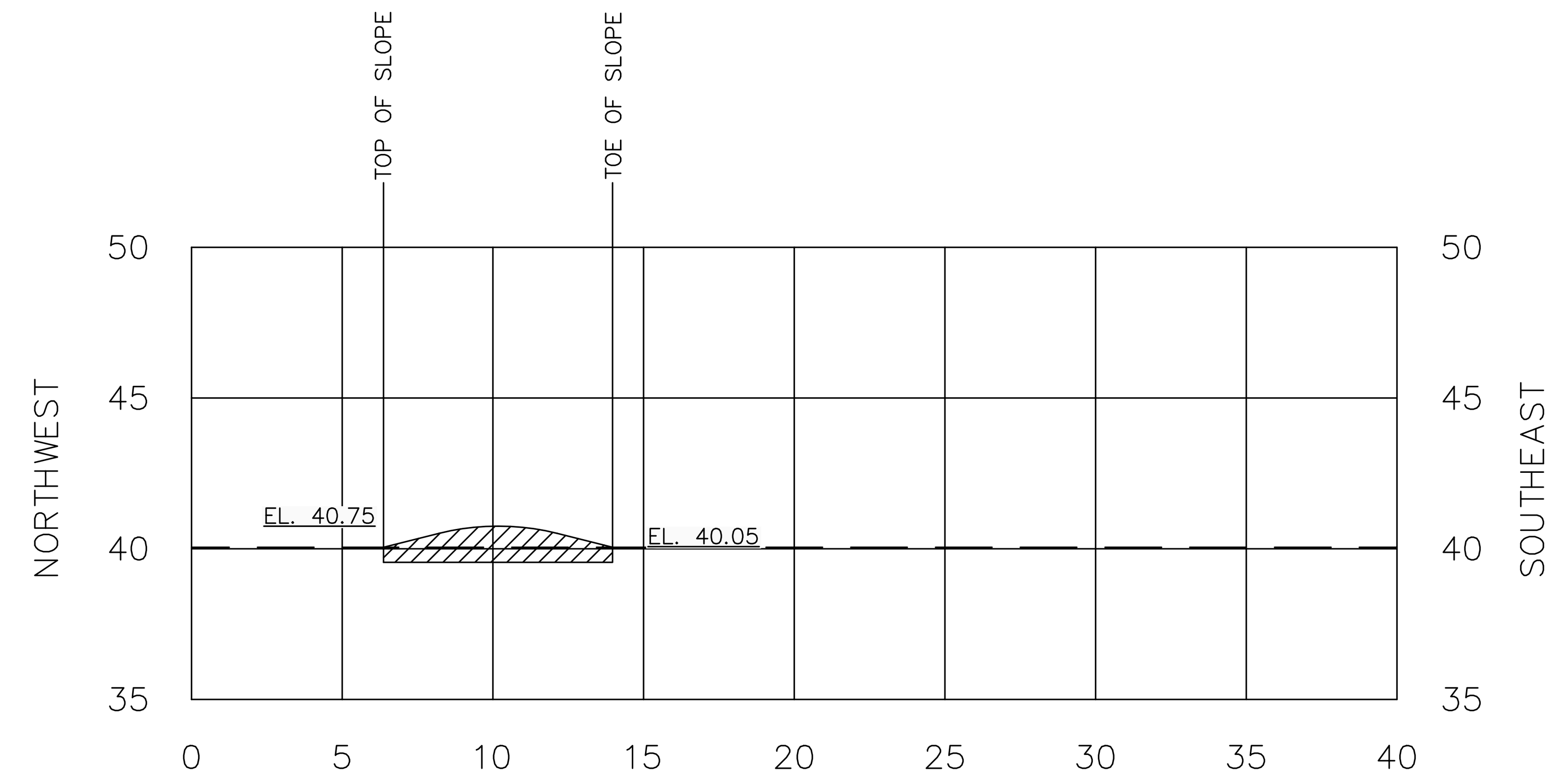

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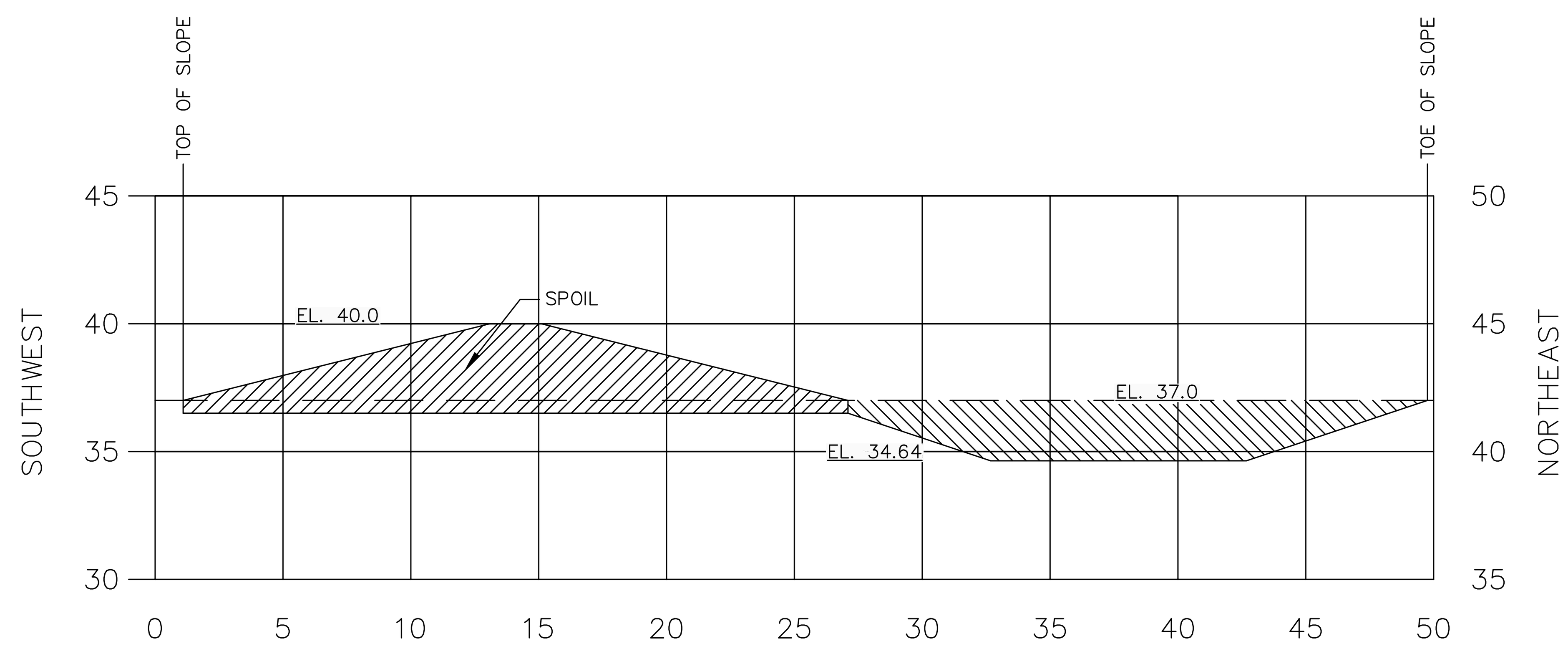

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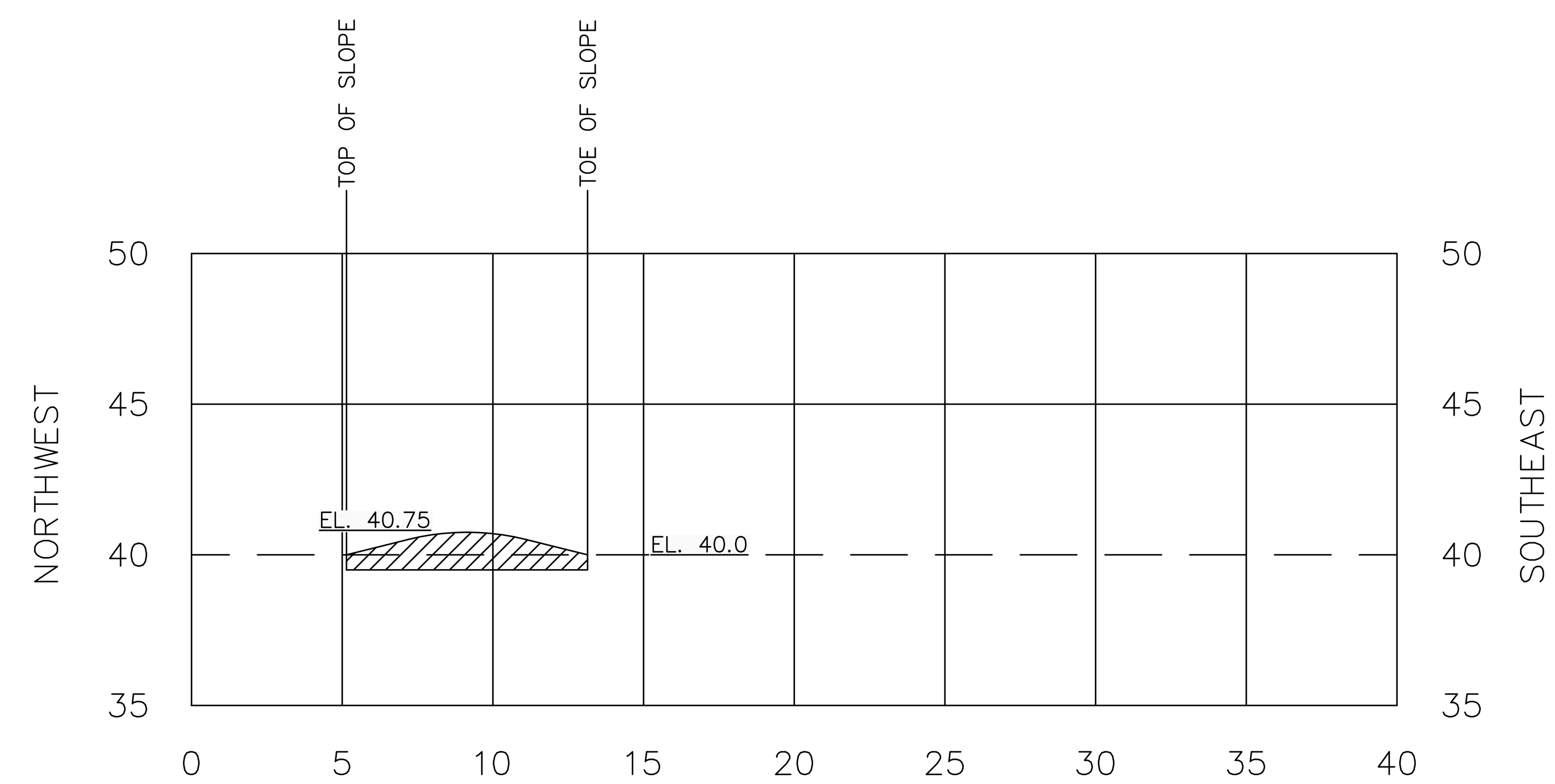

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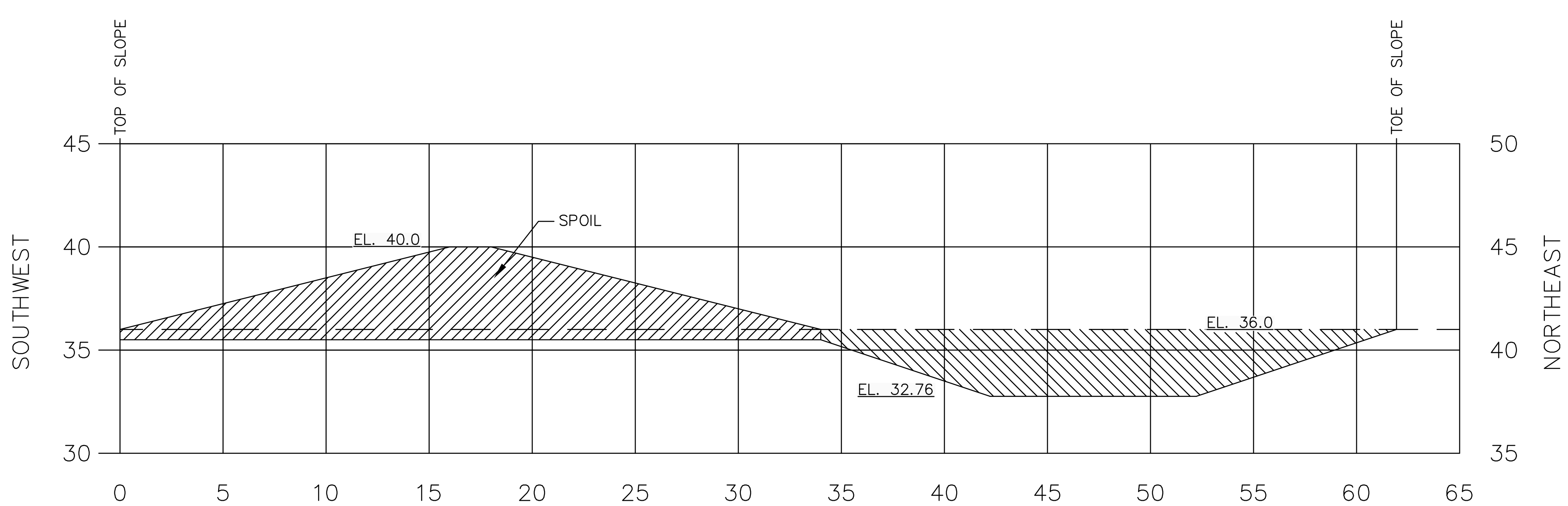

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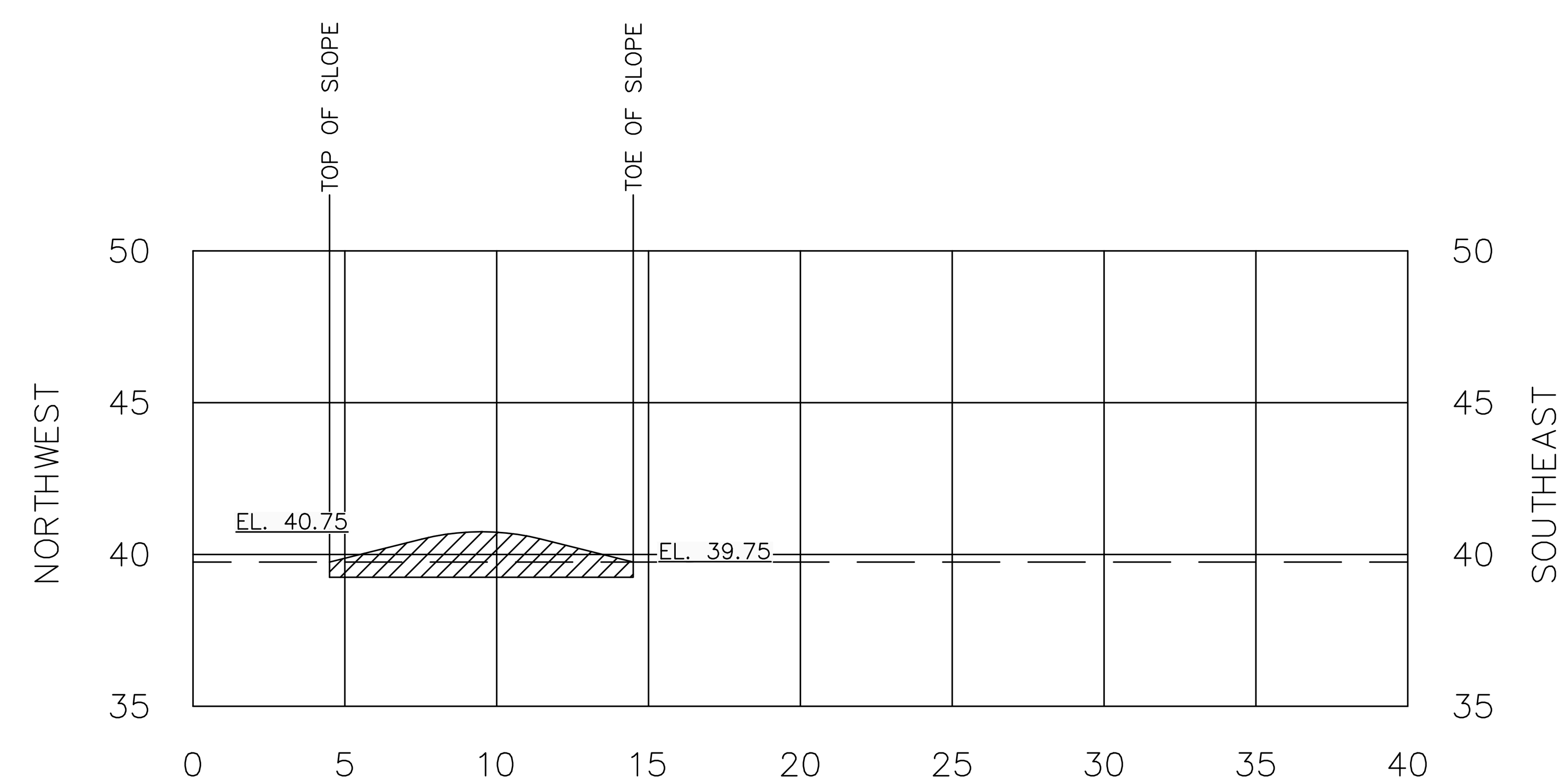

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SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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CONTRACT NO. C-13410
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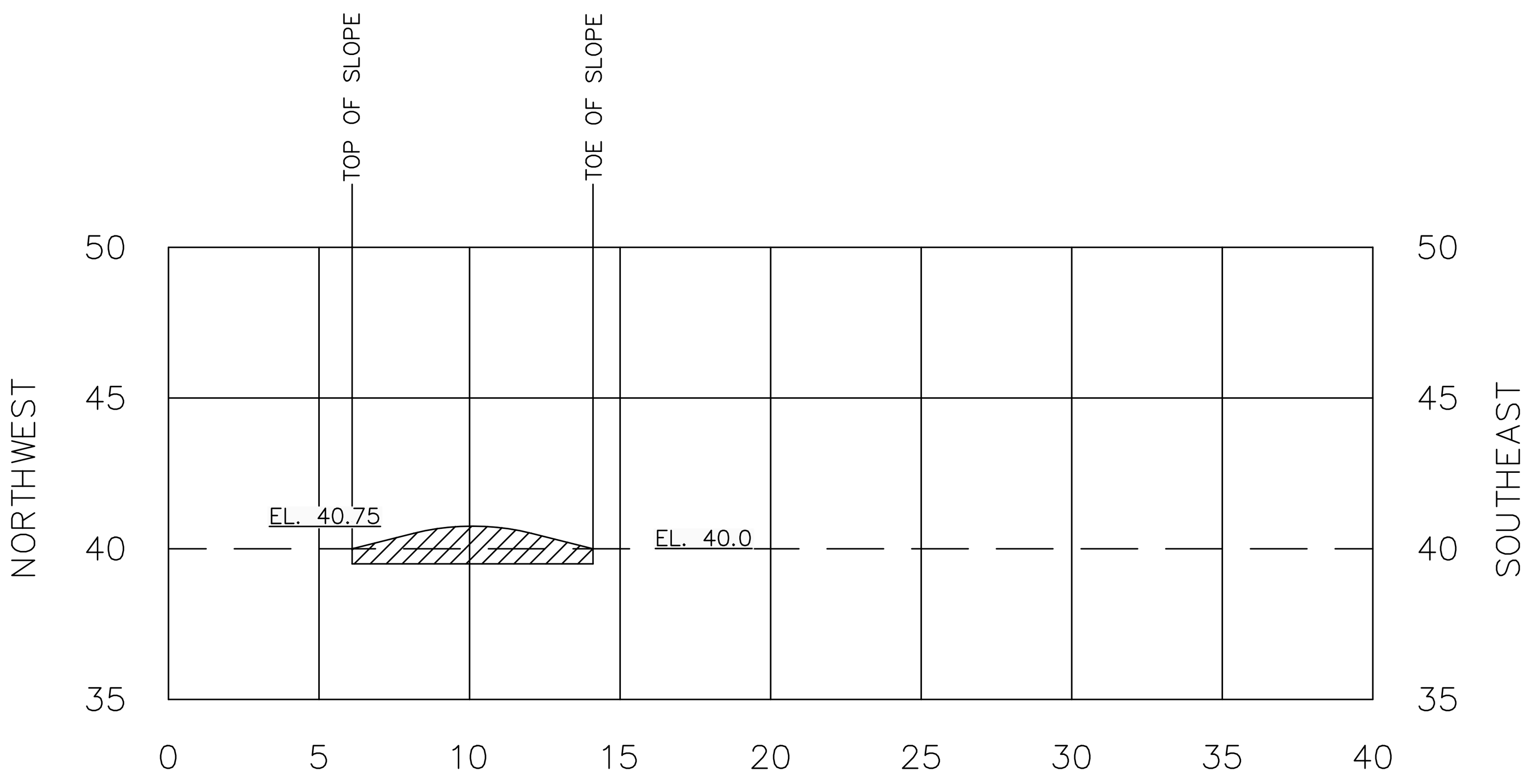
SHEET 8 OF 9



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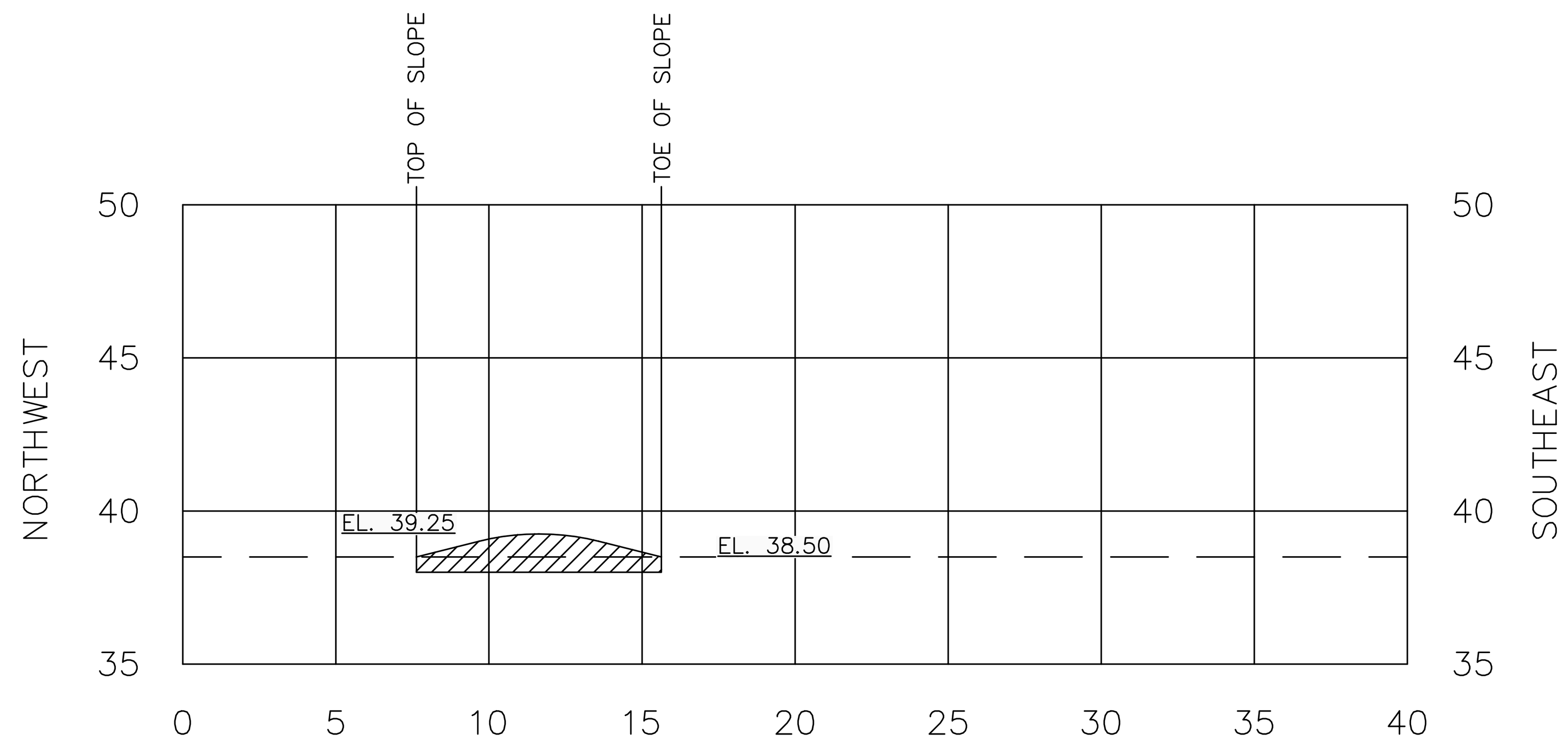
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



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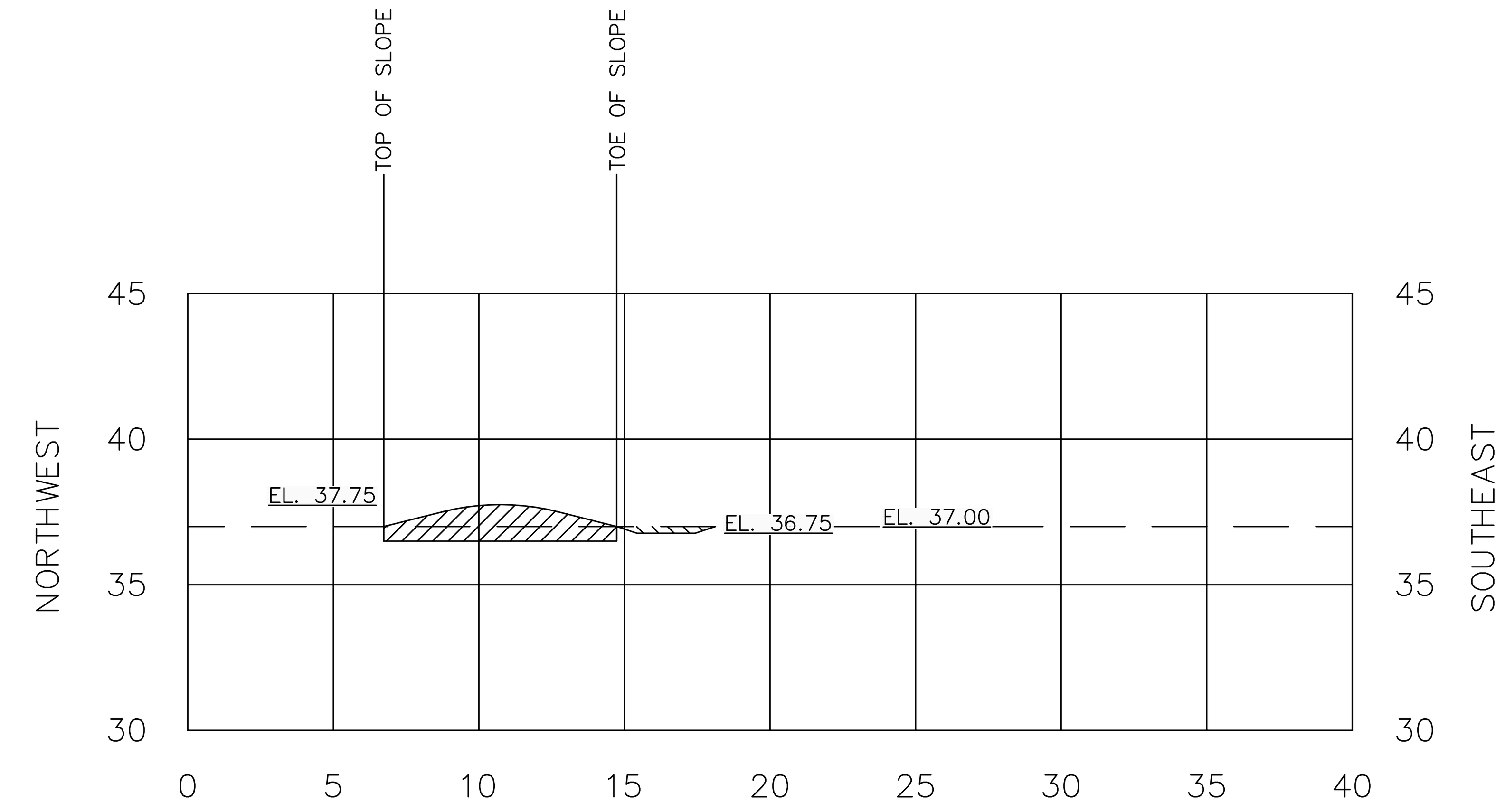

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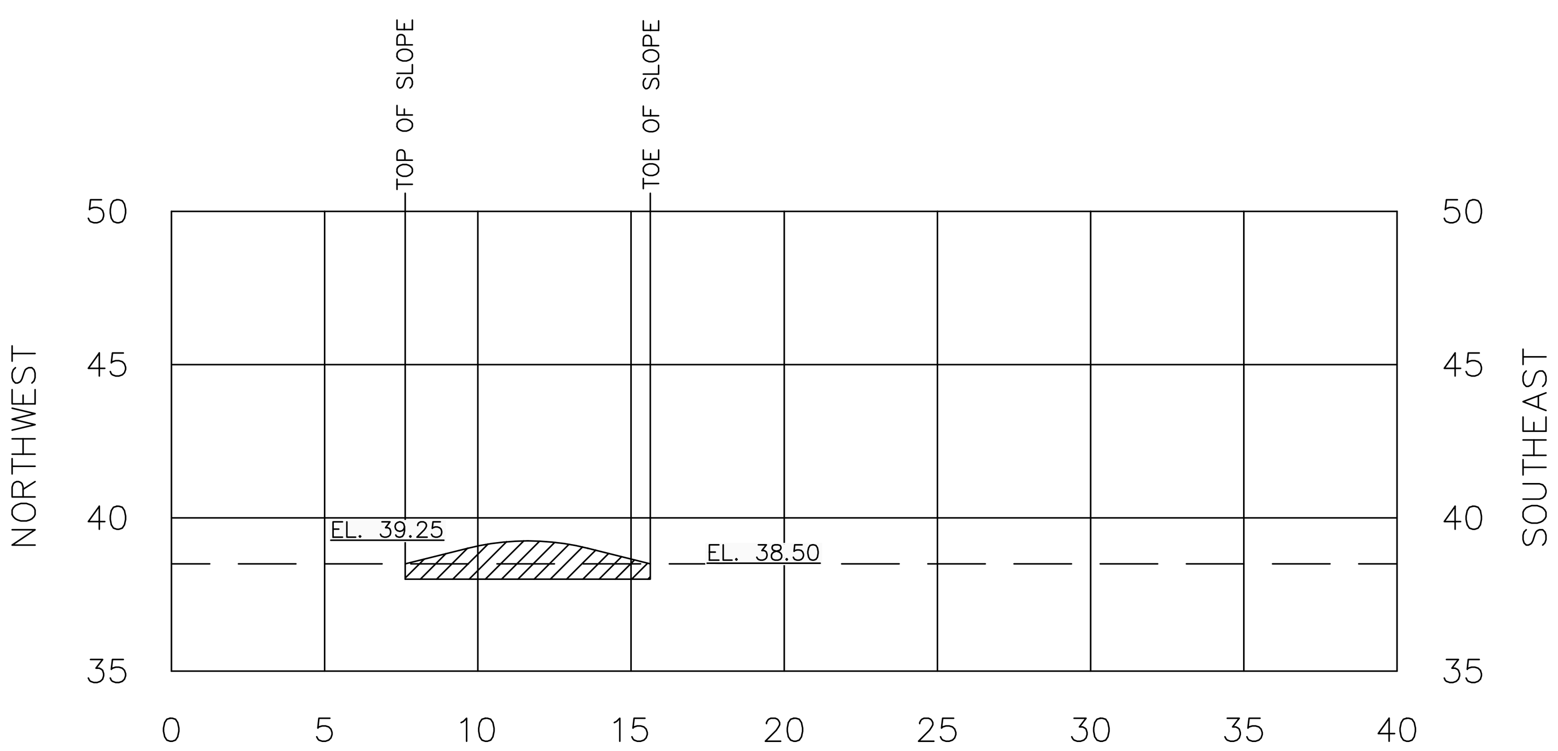

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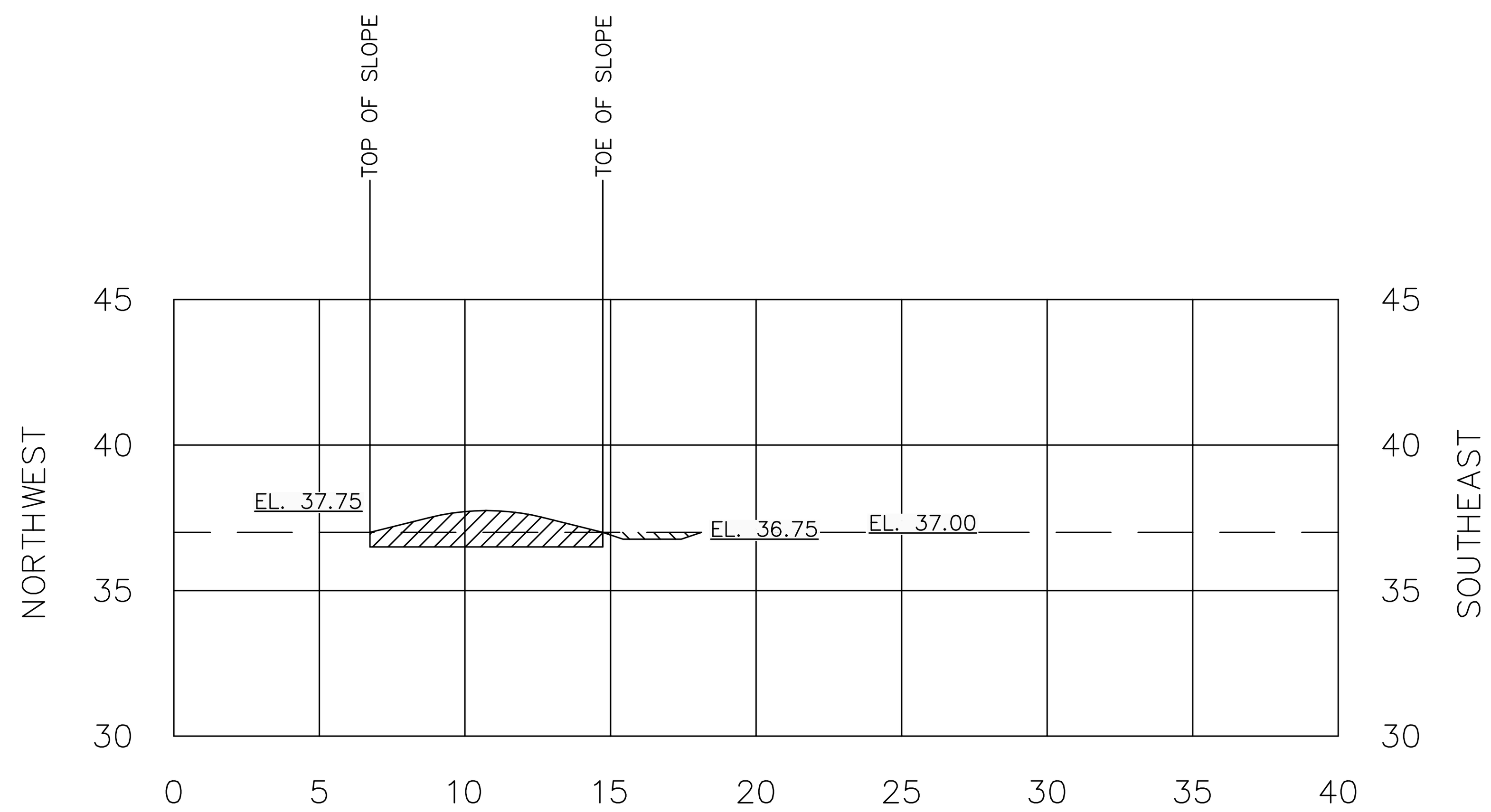

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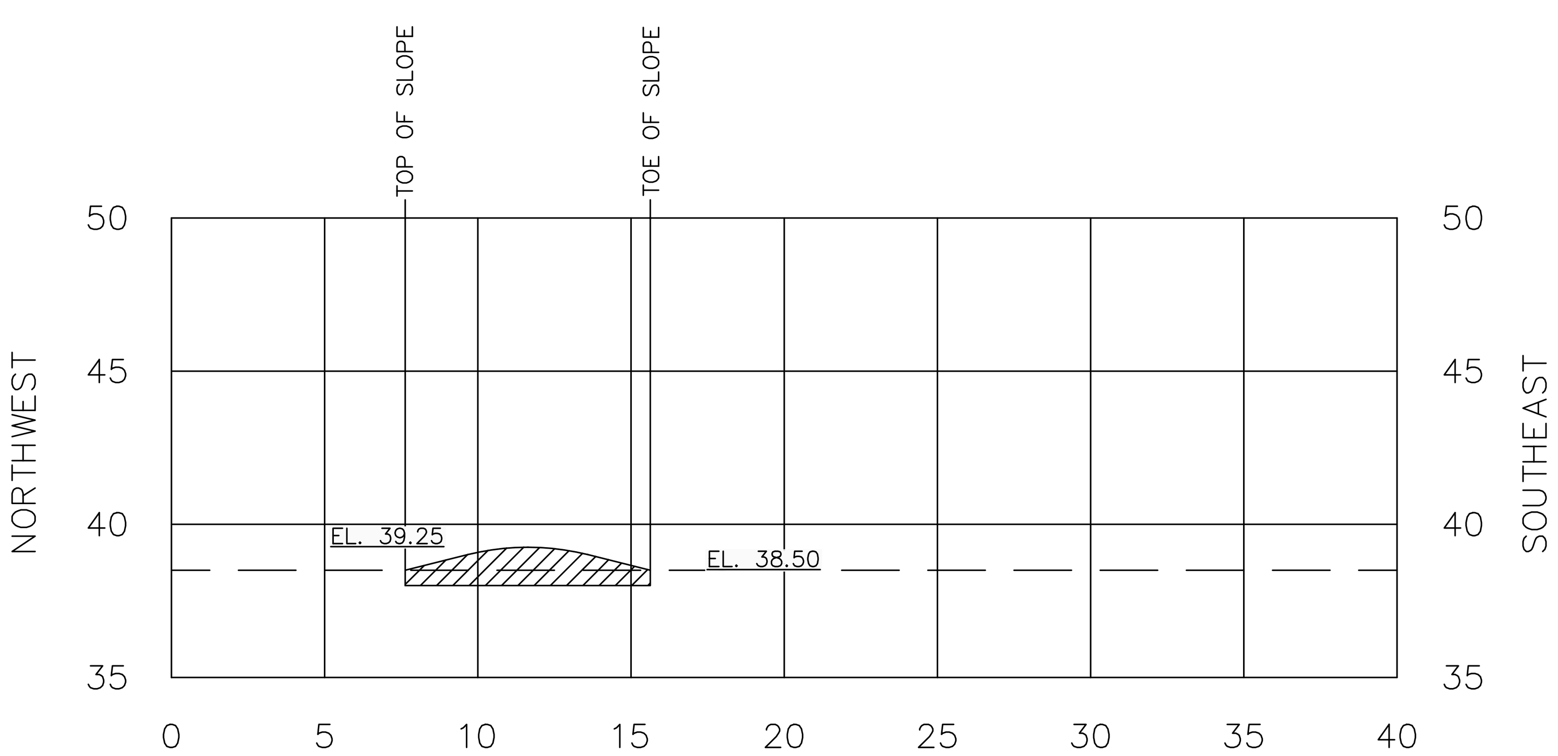

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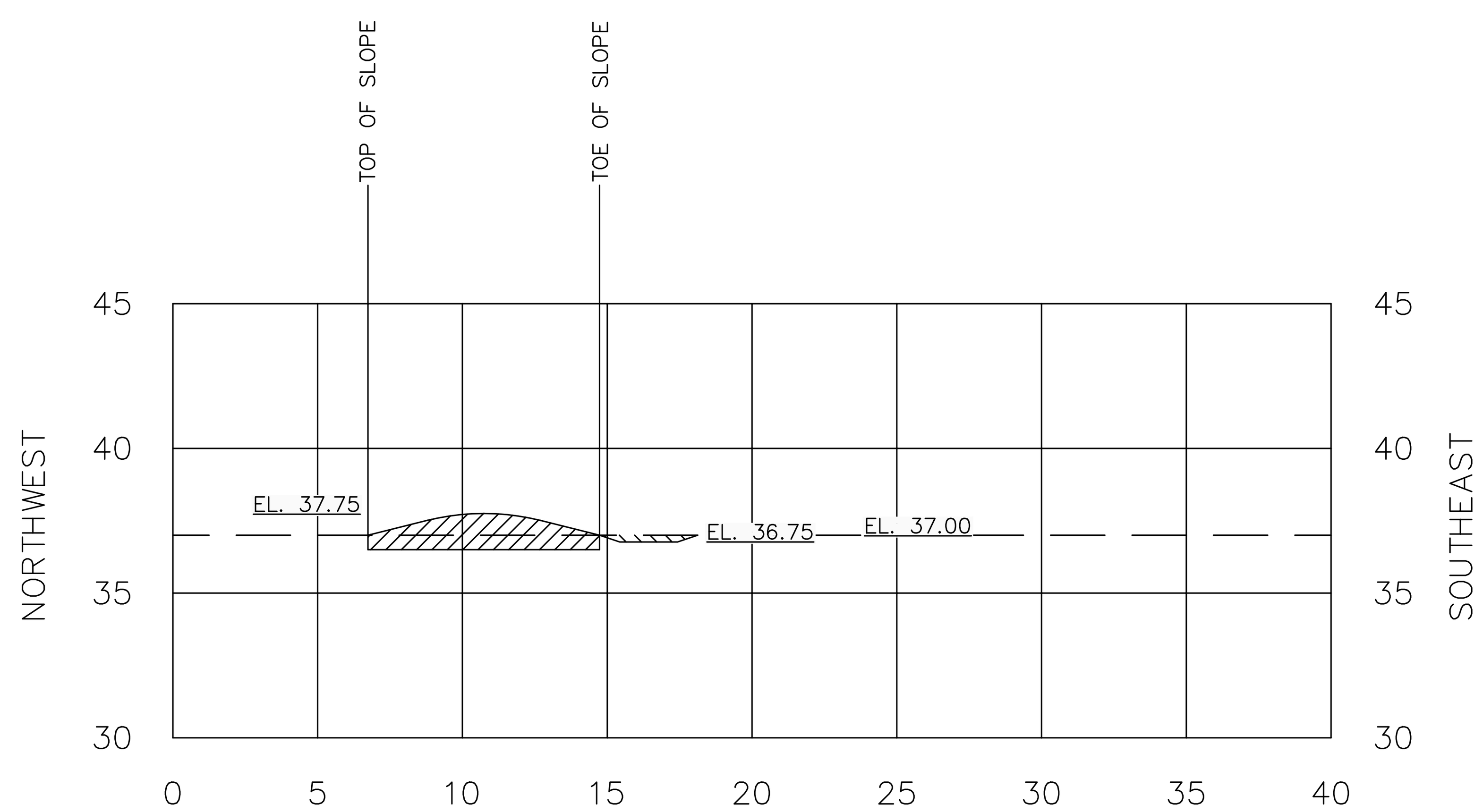
VERTICAL: 1"–5'



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SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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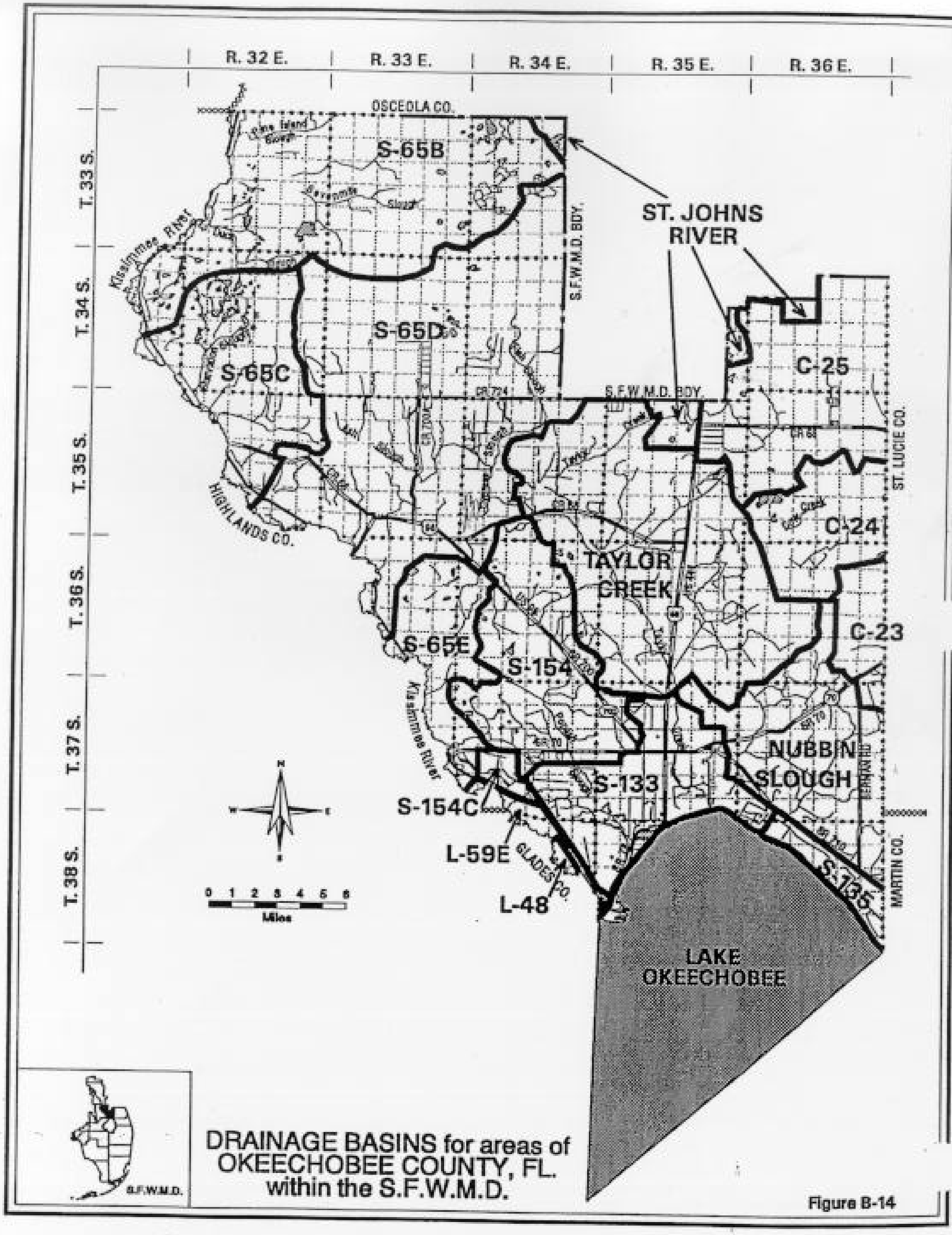
DRAWING NO. 8005716000[009]

APPENDIX B

RUNOFF MODELING CALCULATIONS

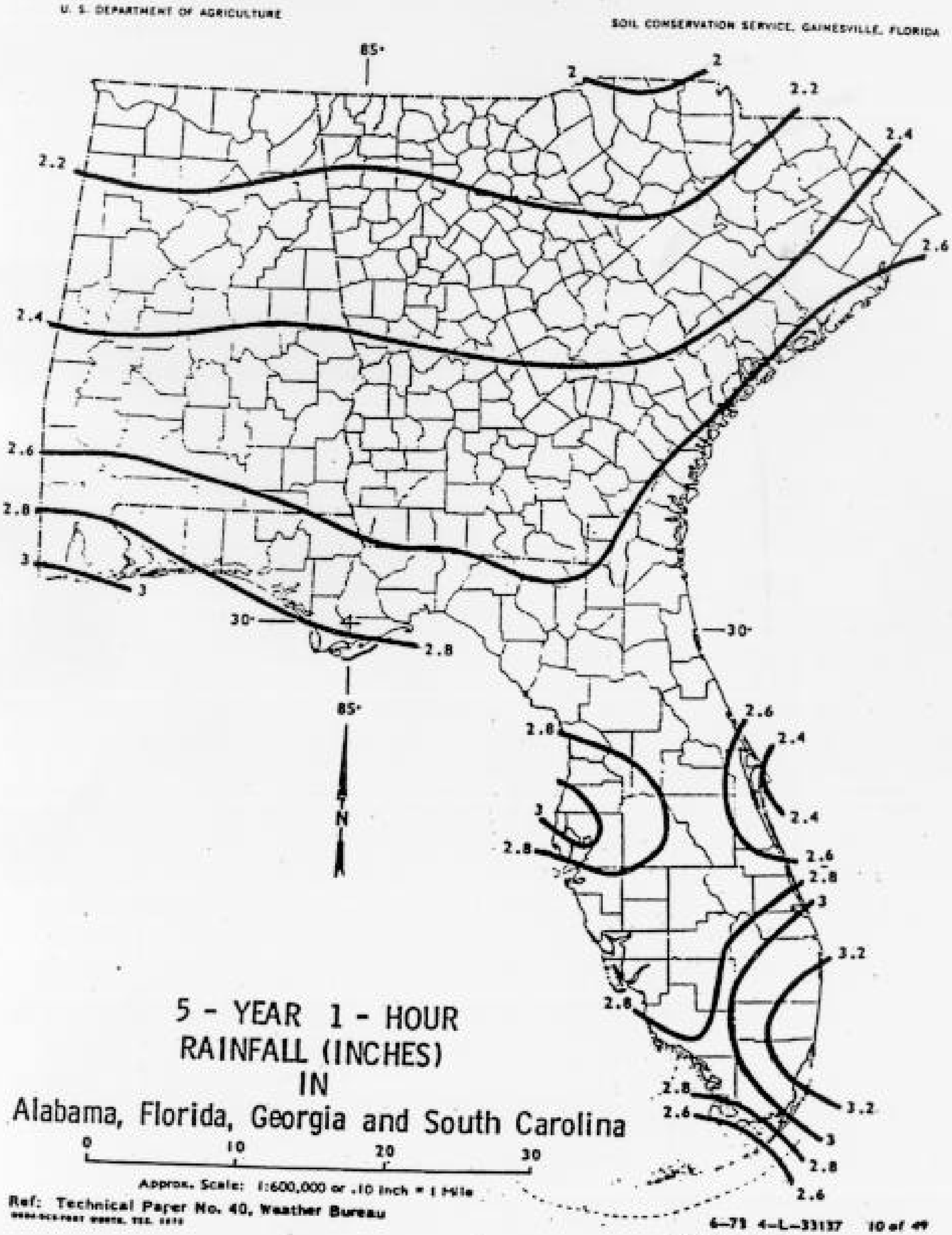
Rainfall Data
Lamb Island Dairy

Month	average monthly rainfall (inches)
January	2.7
February	2.5
March	4
April	3.2
May	3.8
June	7.1
July	5.8
August	7.9
September	6.3
October	4.2
November	1.7
December	1.7
Total	50.9
Period of record from 1988 to 1999.	



DRAINAGE BASINS for areas of OKEECHOBEE COUNTY, FL. within the S.F.W.M.D.

Figure B-14



5 - YEAR 1 - HOUR RAINFALL (INCHES) IN Alabama, Florida, Georgia and South Carolina

Figure C-1

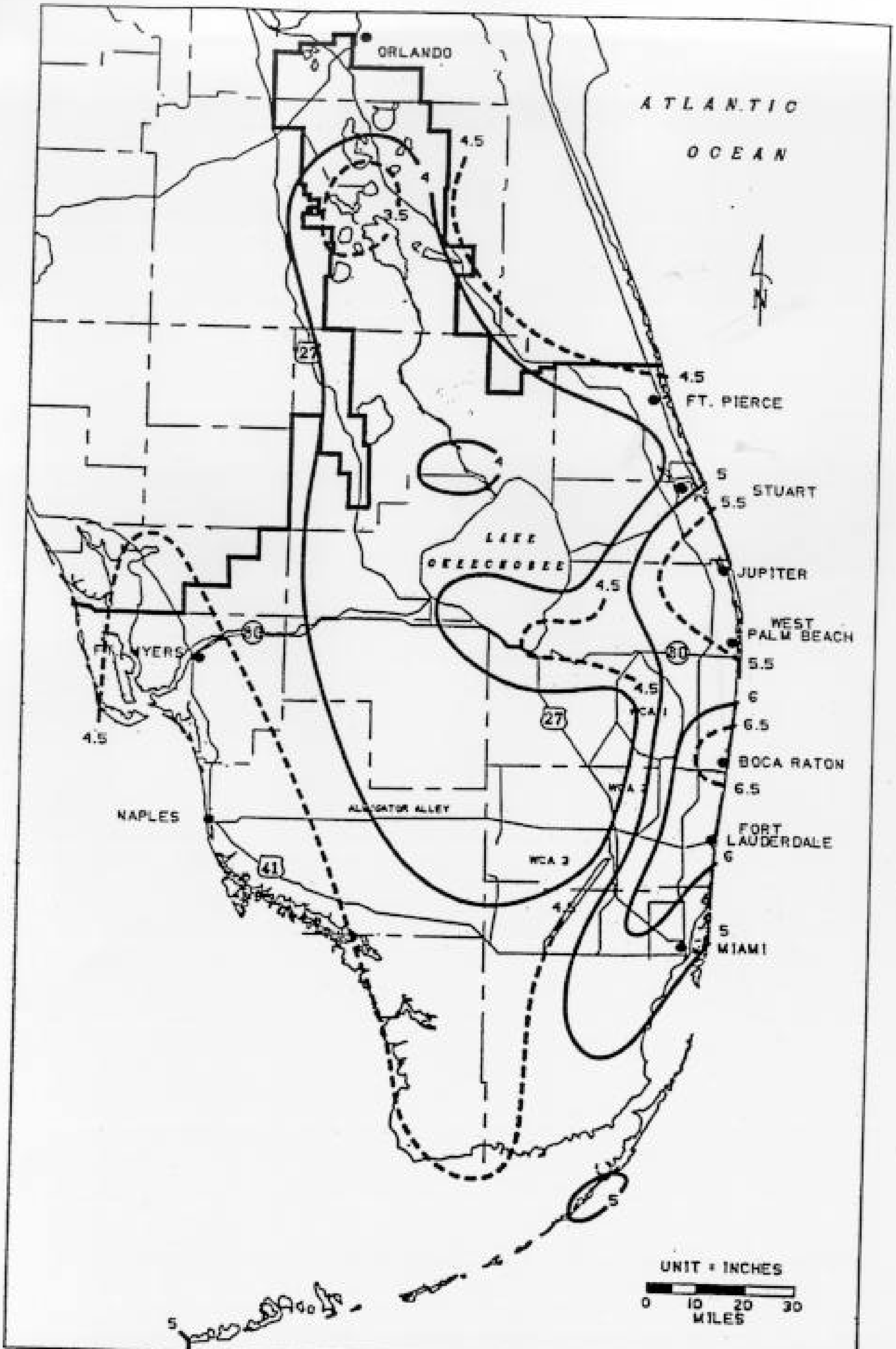


FIGURE C-2. 1-DAY RAINFALL: 3-YEAR RETURN PERIOD

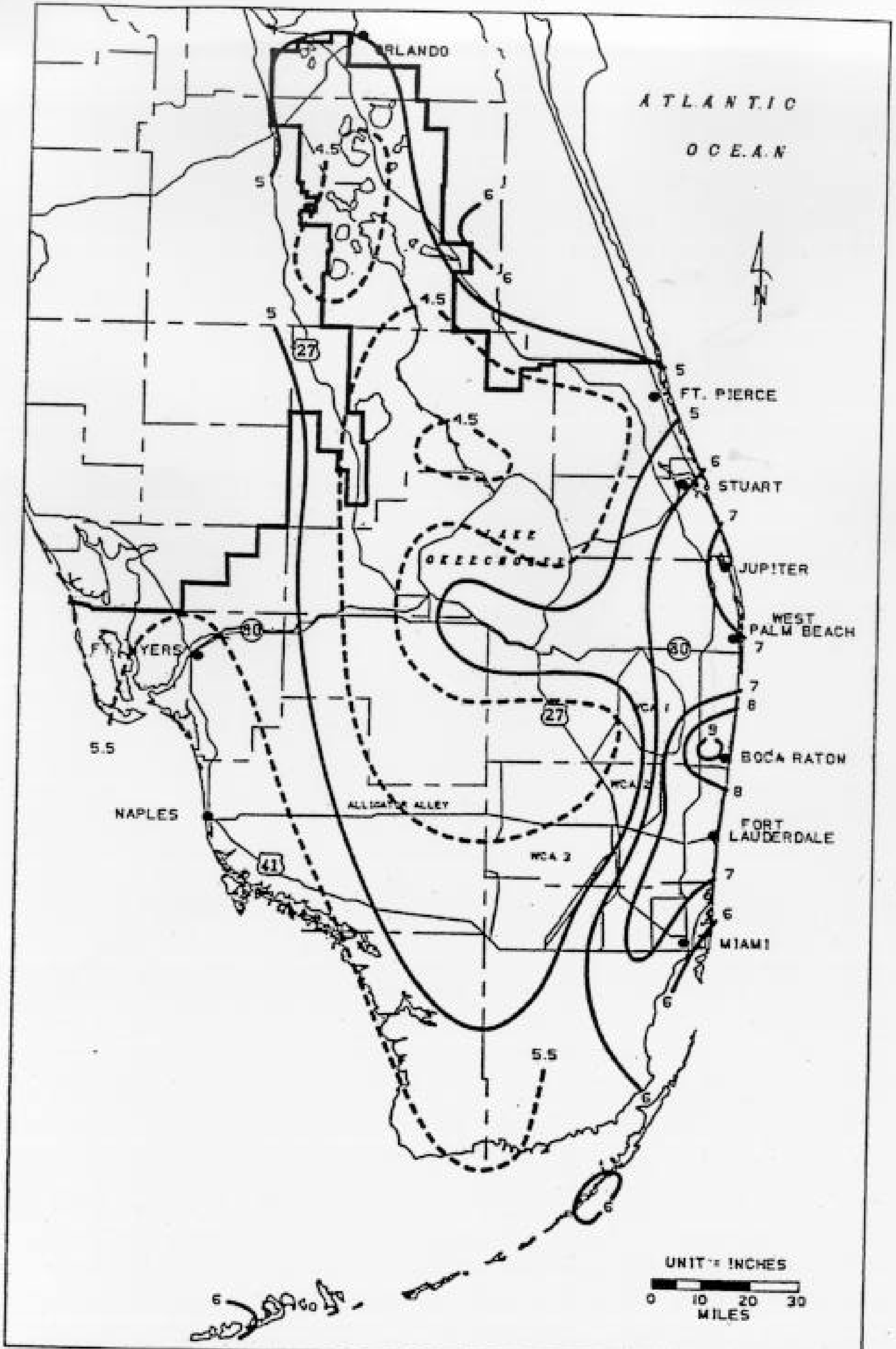


FIGURE C-3. 1-DAY RAINFALL: 5-YEAR RETURN PERIOD

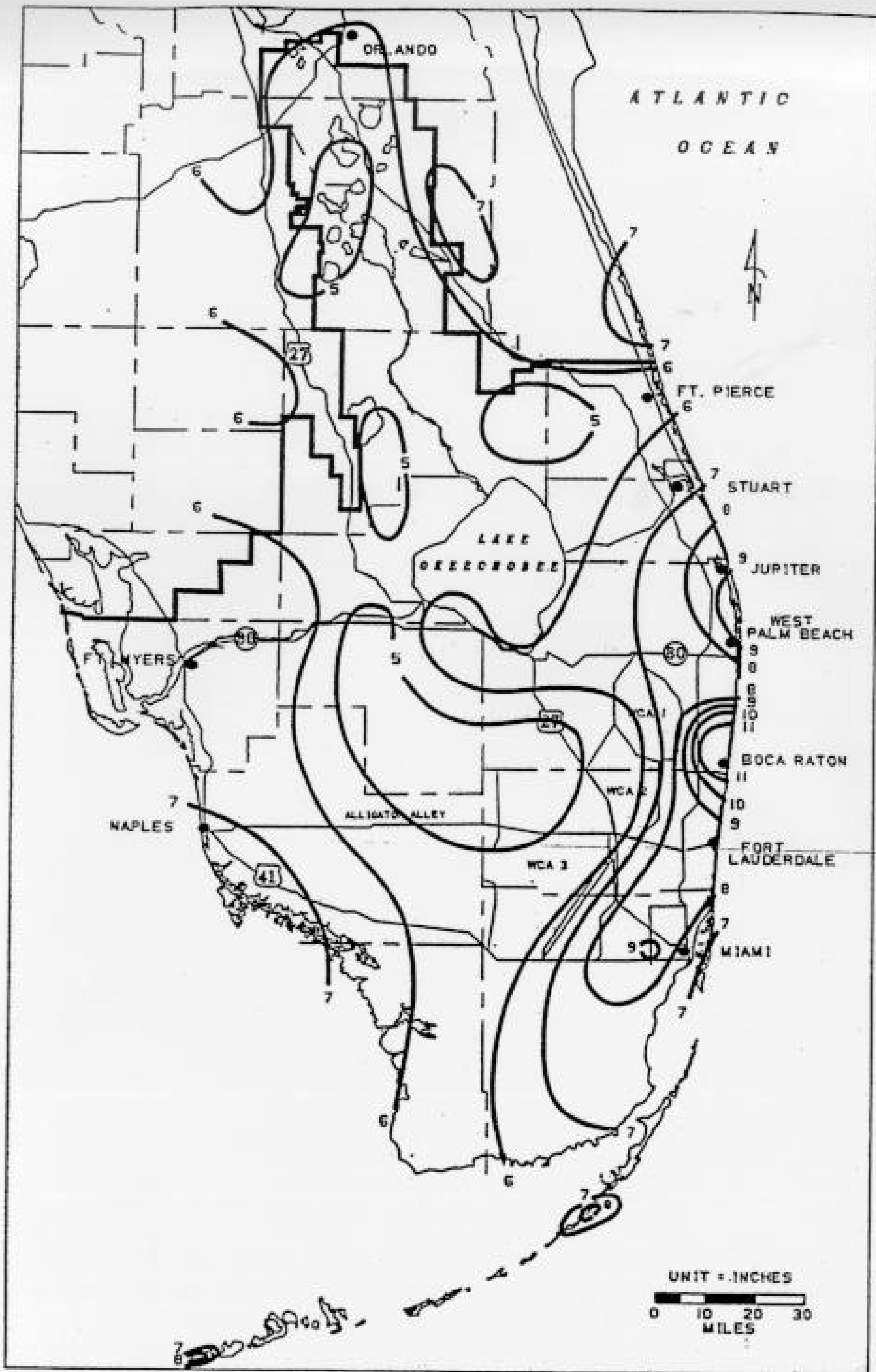


FIGURE C-4. 1-DAY RAINFALL: 10-YEAR RETURN PERIOD

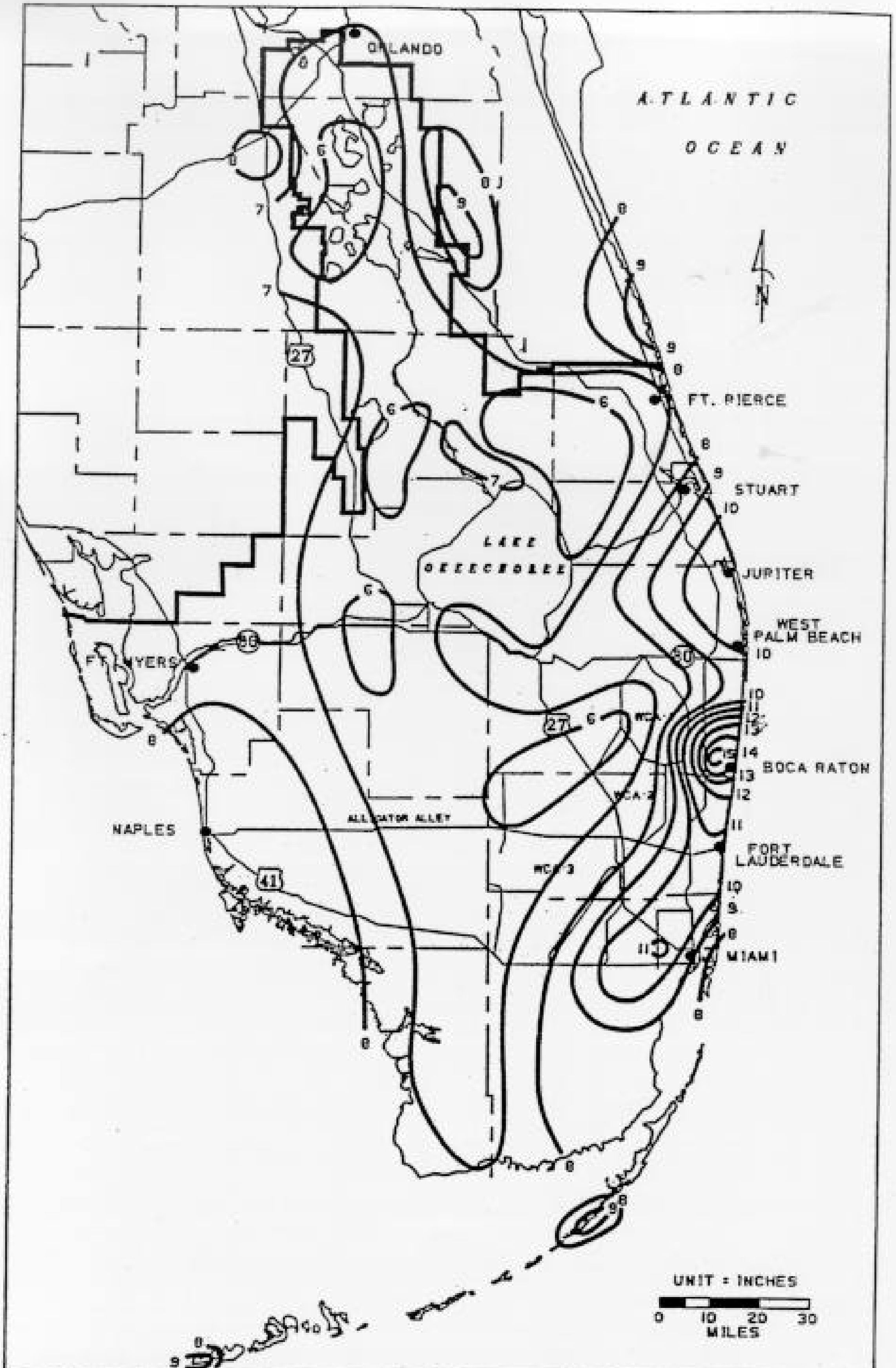


FIGURE C-5. 1-DAY RAINFALL: 25-YEAR RETURN PERIOD

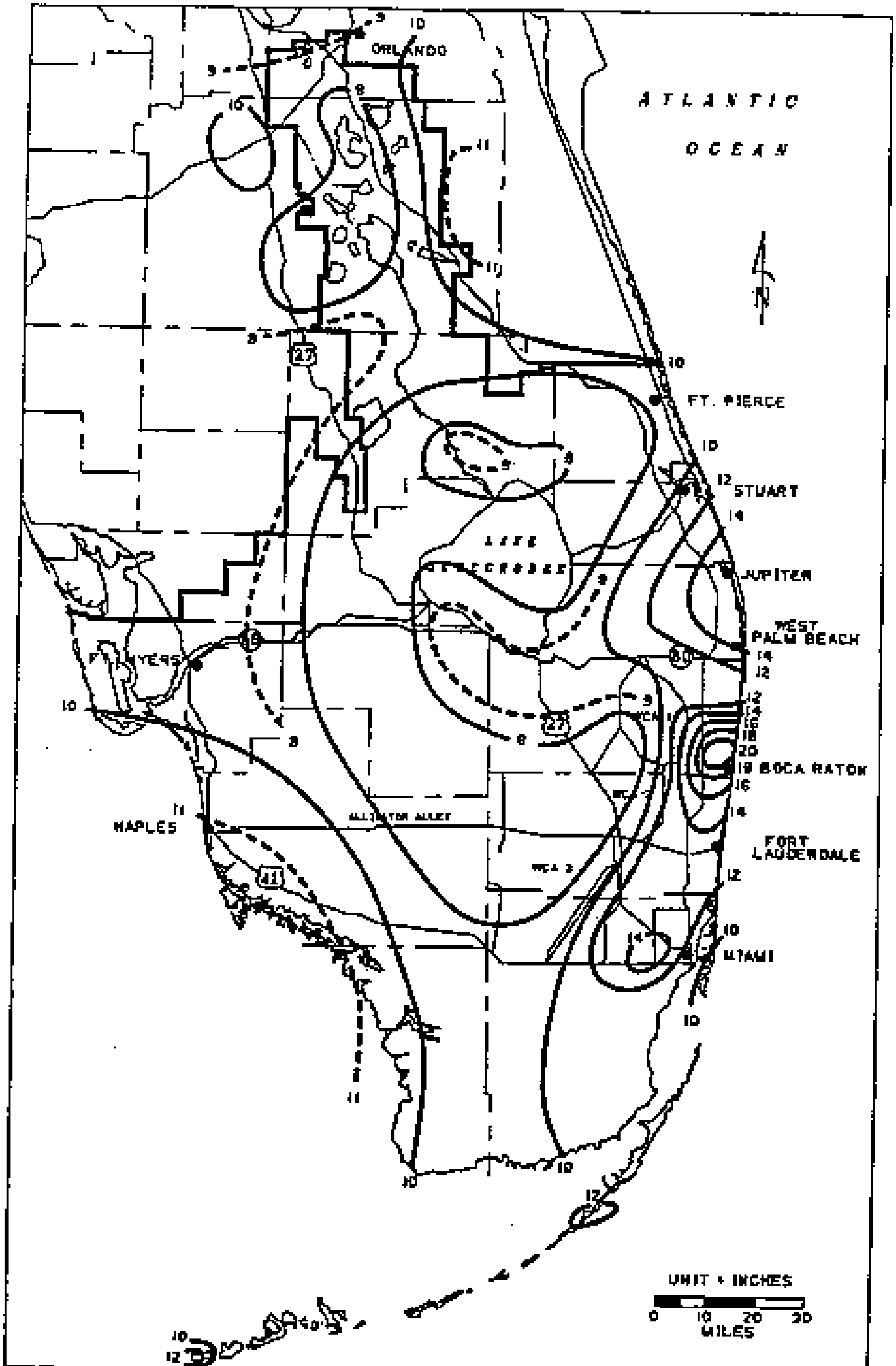


FIGURE C-6. 1-DAY RAINFALL: 100-YEAR RETURN PERIOD

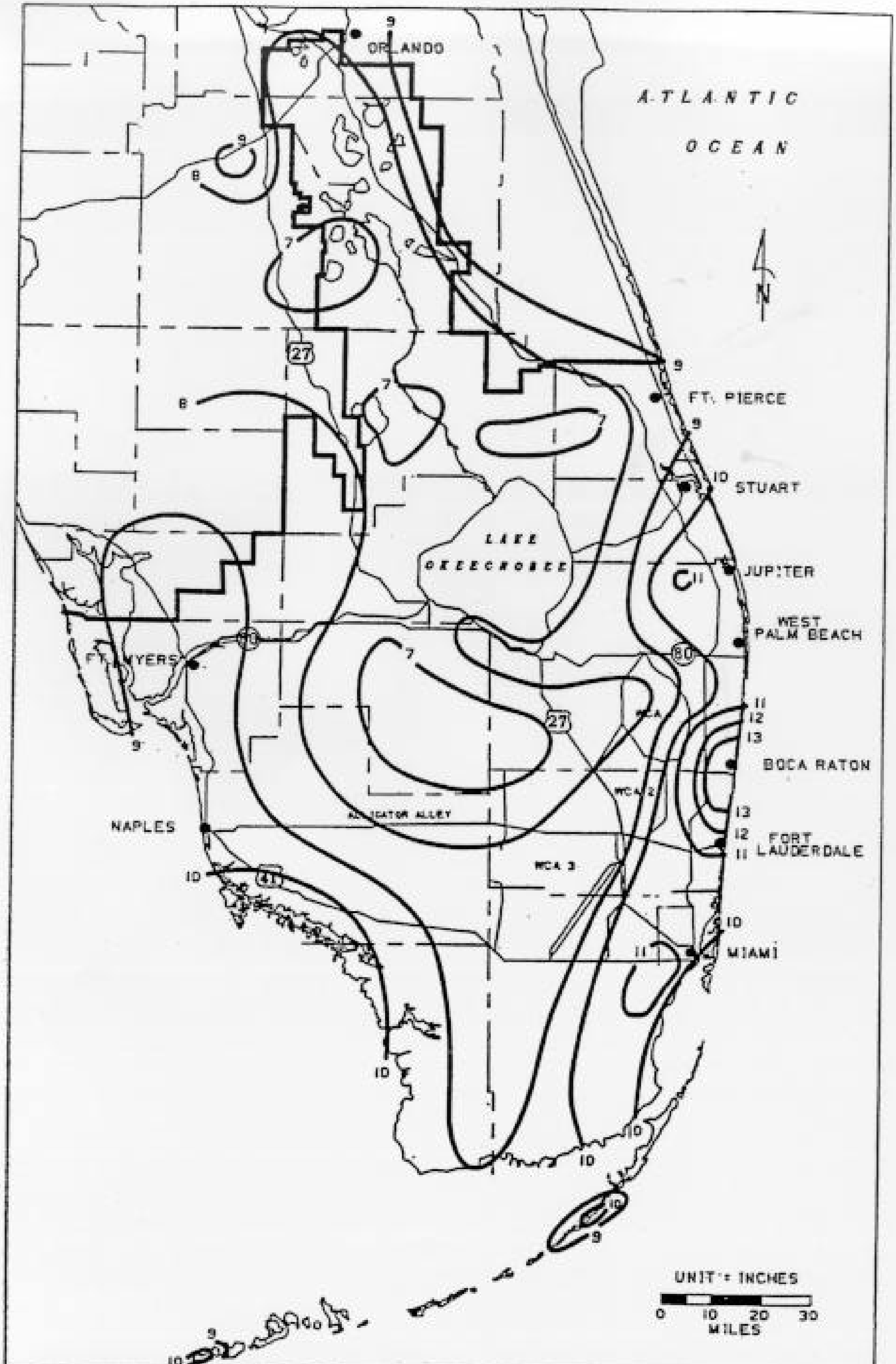


FIGURE C-7. 3-DAY RAINFALL: 10-YEAR RETURN PERIOD

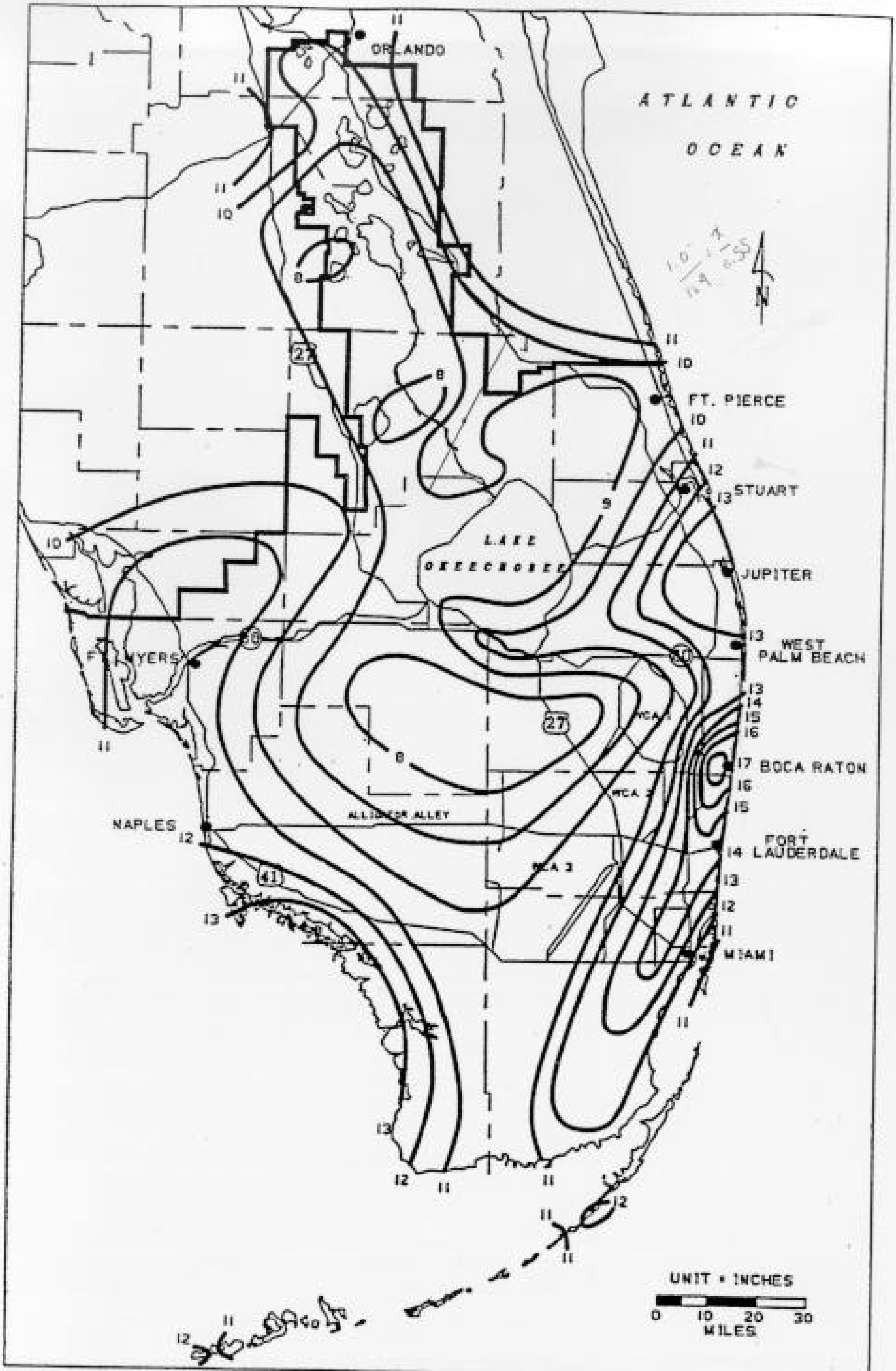


FIGURE C-8. 3-DAY RAINFALL: 25-YEAR RETURN PERIOD

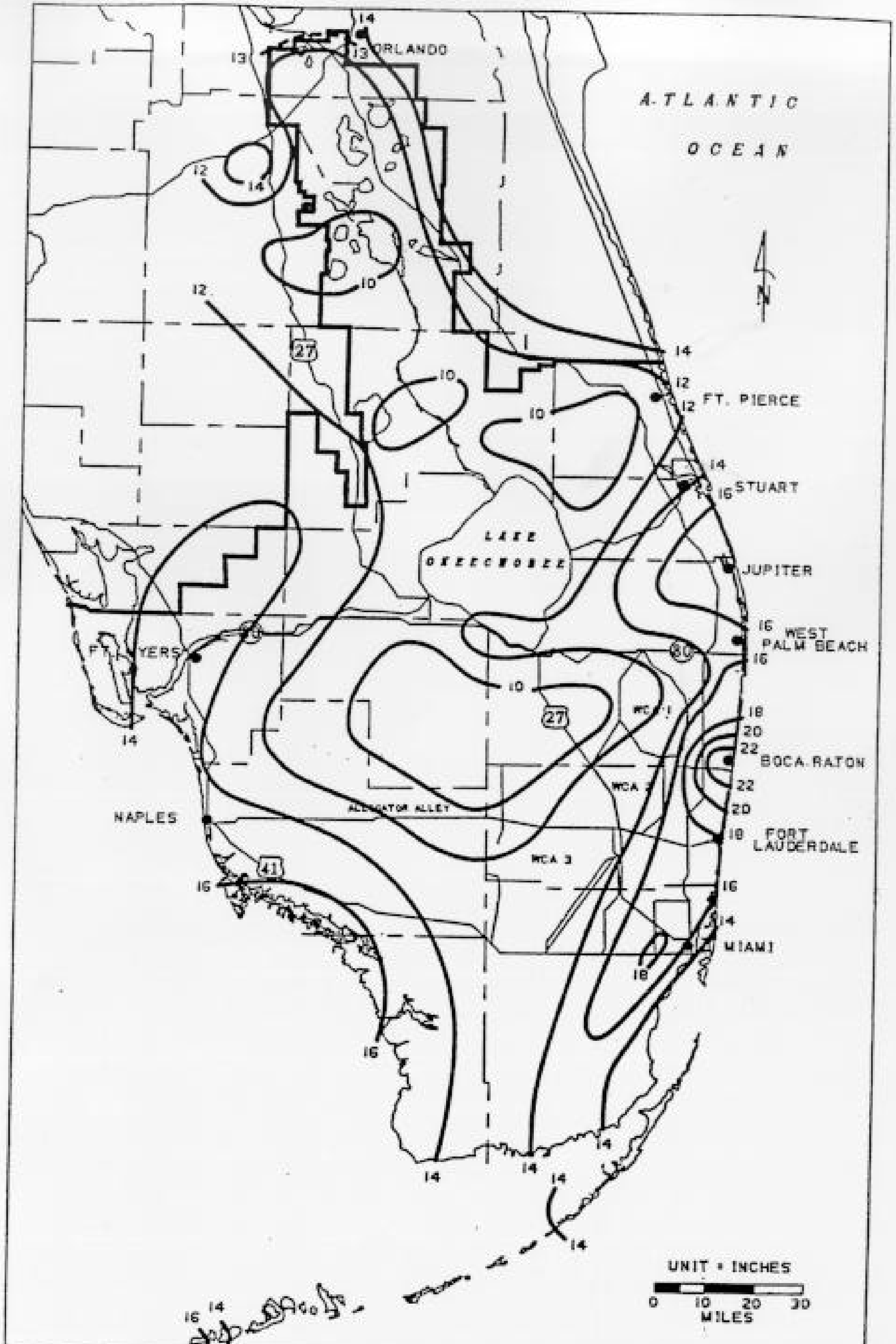


FIGURE C-9. 3-DAY RAINFALL: 100-YEAR RETURN PERIOD

APPENDIX C

HYDRAULIC CALCULATIONS

HSA
HSA Engineers & Scientists

PROJECT No.: 8005-7106
PROJECT NAME: Lamb Island Dairy Culvert Calcs
DATE: 10/27/08

DESIGNED BY:
CHECKED BY:
PAGE 1 OF

DETERMINE MINIMUM SIZE OF CULVERTS

i) To drain HIA containment area

Volume: 8" runoff on 40-acres = 26.7 AF or 8.69 Mgal

Q_{TOTAL} (to drain area in 72-hrs): $\dfrac{8.69 \times 10^6 \text{ gal}}{72 \text{ hr} \times 60 \text{ min/hr}} = 2012 \text{ gpm} = 4.5 \text{ cfs}$

Containment area has 2 outfalls

a.) 24" ϕ CMP draining into Eco-reactor cell 1

USE $n = 0.024$ (Hydraulic System Design notes, pg. 54)

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

$$= \frac{1.49}{0.024} \left(\pi \left(\frac{2}{2}\text{ft}\right)^2\right) \left(\frac{1}{4} * 2\text{ ft}\right)^{2/3} (0.005)^{1/2}$$

$= 8.7$ cfs

~ 3900 gpm

b.) 36" ϕ CMP overflow structure

$$Q = \frac{1.49}{0.024} \left(\pi \left(\frac{3}{2}\text{ft}\right)^2\right) \left(\frac{1}{4} * 3\text{ft}\right)^{2/3} (0.005)^{1/2}$$

$= 25.6$ cfs

$\sim 11,500$ gpm

* Size culvert to drain containment area through O/F structure to prevent disruption of eco-reactor (wash-out).

District staff recommend using culverts $\geq$ 36" for O/F

11,500 gpm $\geq$ 2012 gpm ✓

Preliminary Hyd. Grade Line – terrain $\frac{42.4\text{ FT} - 35.6\text{ FT}}{1600\text{ FT}} = 0.0043$ FT/FT $= 0.43\%$

Total Runoff: $Q = CIA$
$= (0.20)(0.13 \text{ in/hr})(40 \text{ Ac})$
$= 1.04$ cfs

Determine pipe size:

Using 24" pipe: Friction slope (0.4%) ≤ preliminary HGL slope (0.43%) ✓

Minimum physical slope: (produce a velocity of 2.5 ft/s flowing full); $n = 0.024$

$$S_{(min)} = \left[Vn / (1.49 R^{2/3})\right]^2$$

$$= \left[2.5 \text{ ft/s } (0.024) / (1.49 \cdot (\tfrac{1}{4} 2 \text{ ft})^{2/3})\right]^2$$

$= 0.004$
$= 0.4\%$

Minimum pipe fall = 20 FT × 0.4% = 0.08 FT
Pipe fall = 0.1 FT (minimum fall rounded up to nearest 0.1')
Physical slope = 0.1 FT / 20 FT = 0.50%
Upper end flow line = 42.0 FT
Lower end flow line = 42.0 − 0.1 = 41.9 FT

Top of berm ≤ 43.5 FT
Pipe cover: 43.5 − 41.9 = 1.6 FT ≥ 1.0 (manufacturer spec.) ✓

Calculate the flow velocity

Vel = $Q/A = 1.04$ cfs / $(\pi D^2/4)$
$= 1.04$ cfs / $(\pi (2 \text{ FT})^2/4)$
$= 0.33$ fps

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HSA Engineers & Scientists

PROJECT No. :
PROJECT NAME:
DATE:

DESIGNED BY:
CHECKED BY:
PAGE 3 OF

CALCULATE THE TIME OF FLOW IN PIPE SECTION:

TIME = LENGTH / VELOCITY
= 20 FT / 0.33 fps = 61 seconds = 1.0 MINUTES

CHECK FLOW OVER RISER (USE TOLERANCE +/- 0.15FT AND 24" Φ PIPE)

$Q = 3.13\, L\, H^{1.5}$
$= 3.13\,(2.0 - 0.15)\,(1\text{in}/12)^{1.5}$ = 0.14 CFS @ 1"
= 0.40 CFS @ 2"
= 0.72 CFS @ 3"
= 1.1 CFS @ 4"

$\bar{X}$ ANNUAL rainfall = 77 gpm = 0.17 CFS
$\bar{X}$ max. rainfall = 180 gpm = 0.40 CFS

@ 2" WATER HT OVER RISER ≥ max. rainfall Q (MAINTENANCE ✓)

APPENDIX D

SUPPLEMENTAL SAMPLING PROGRAM

Storm Water Quality Sampling

Samples of standing and flowing surface waters at various internal sites within the former Lamb Island Dairy property were collected on two separate occasions during the month of September 2003. Field sampling activities were planned to coincide with substantial regional rainfall events. **Figure 1** provides a bar graph summary of daily rainfall in the Lamb Island Dairy area and indicates that substantial rainfall occurred during or shortly before both the September 7 and September 30 sampling events. These rainfall data were obtained from SFWMD monitoring stations located near the property (station numbers S65C and S65D). As shown in **Figure 1**, approximately 1.9 inches of rain was recorded during the three day period prior to the 9/7 sampling event and roughly 1.3 inches of rain fell during the three day period ahead of the 9/30 sampling event.

A total of four stations were sampled on September 7 and nine sampling locations were sampled on September 30, 2003. A hand held GPS unit was used to identify the exact sampling locations. The GPS coordinates and summarized phosphorus analytical results for each sampling station are shown on **Figure 2**. Soluble Reactive, total dissolved and total phosphorus samples were collected at all sites and a tabular summary of the testing results are provided in **Table 1**.

Using the topographical survey map previously supplied by the District, sampling locations were established in depressions and low elevation runoff channels in order to assess the relative amount of P contained in the surface runoff at various internal sites. Use of the term "standing water" does not imply that low velocity sheet flow was not occurring at the sites during field activities. At some stations, visible flow was observed. At others, it was difficult to determine the extent of flow due to a combination of the tall grass contained throughout the property and due to the low velocities of the sheet flow. Standing water was sampled at each of the locations and extreme care was taken to carefully approach the sites and to collect samples in such a manner as to minimize disturbance of the immediate area. The tall grass obscured oblique observation of the standing water from a distance and it was necessary to be very near the respective sampling stations (e.g., within six to eight feet) to confirm the presence of water. A brief description of each sampling location is provided below:

<u>Lamb Island Site 1 (LI 1)</u>

Samples were collected on 9/7 and 9/30 at LI 1 which is located at the northeast corner of the former eco-reactor system. Samples were collected from a local depression and from apparent standing water that had a total depth of roughly six inches at the time of sampling. **Figure 3** provides a photograph taken at LI 1 during the 9/7 sampling event. No visible flow was observed at the station during sampling. Soluble reactive phosphorous (SRP) averaged 4.3 mg/L as P and total phosphorus (TP) equaled 5.1 mg/L.

Lamb Island Site 2 (LI 2)

Samples were collected on 9/7 and 9/30 at LI 2 and the station is located at the southwestern corner of the property. Samples were collected from the culvert located at this site. **Figure 4** provides a photograph taken at LI 2 during the 9/7 sampling event. Visible flow was observed through the culvert at the station during sampling. SRP averaged 2.1 mg/L as P and TP equaled 2.3 mg/L.

Lamb Island Site 3 (LI 3)

Samples were collected on 9/7 and 9/30 at LI 3 which is located at the southeastern corner of the property. **Figure 5** provides a photograph taken at LI 3 during the 9/7 sampling event. Visible flow was observed at the station during sampling. SRP averaged 7.6 mg/L as P and TP equaled 7.8 mg/L.

Lamb Island Site 4 (LI 4)

Samples were collected on 9/30 at LI 4 which is located at the southeastern edge of the property. Samples were collected from standing water at this site. No visible flow was observed at the station during sampling. The SRP value of the sample was 5.7 mg/L as P and TP equaled 5.8 mg/L.

Lamb Island Site 5 (LI 5)

Samples were collected on 9/7 and 9/30 at LI 5 which is located near the eastern edge of the property. Samples were collected from standing water at this site. No visible flow was observed at the station during sampling. The SRP value of the samples averaged 15 mg/L as P and TP equaled 15 mg/L.

Lamb Island Site 6 (LI 6)

Samples were collected on 9/30 at LI 6 which is located near the northeastern edge of the property. Samples were collected from standing water at this site. No visible flow was observed at the station during sampling. The SRP value of the samples averaged 8.0 mg/L as P and TP equaled 8.1 mg/L.

Lamb Island Site 7 (LI 7)

Samples were collected on 9/30 at LI 7 which is located in a site depression southeast of the former dairy high intensity area (HIA). Samples were collected from standing water at this site. No visible flow was observed at the station during sampling. The SRP value of the samples averaged 13 mg/L as P and TP equaled 13 mg/L.

Lamb Island Site 8 (LI 8)

Samples were collected on 9/30 at LI 8 which is located in a site depression south of the former dairy high intensity area. Samples were collected from standing water at this site. No visible flow was observed at the station during sampling. The SRP value of the samples averaged 7.2 mg/L as P and TP equaled 7.6 mg/L.

Lamb Island Site 9 (LI 9)

Samples were collected on 9/30 at LI 9 which is located in a site depression south of the HIA. Samples were collected from standing water at this site. No visible flow was observed at the station during sampling. The SRP value of the samples averaged 8.1 mg/L as P and this represented 100 percent of the TP value.

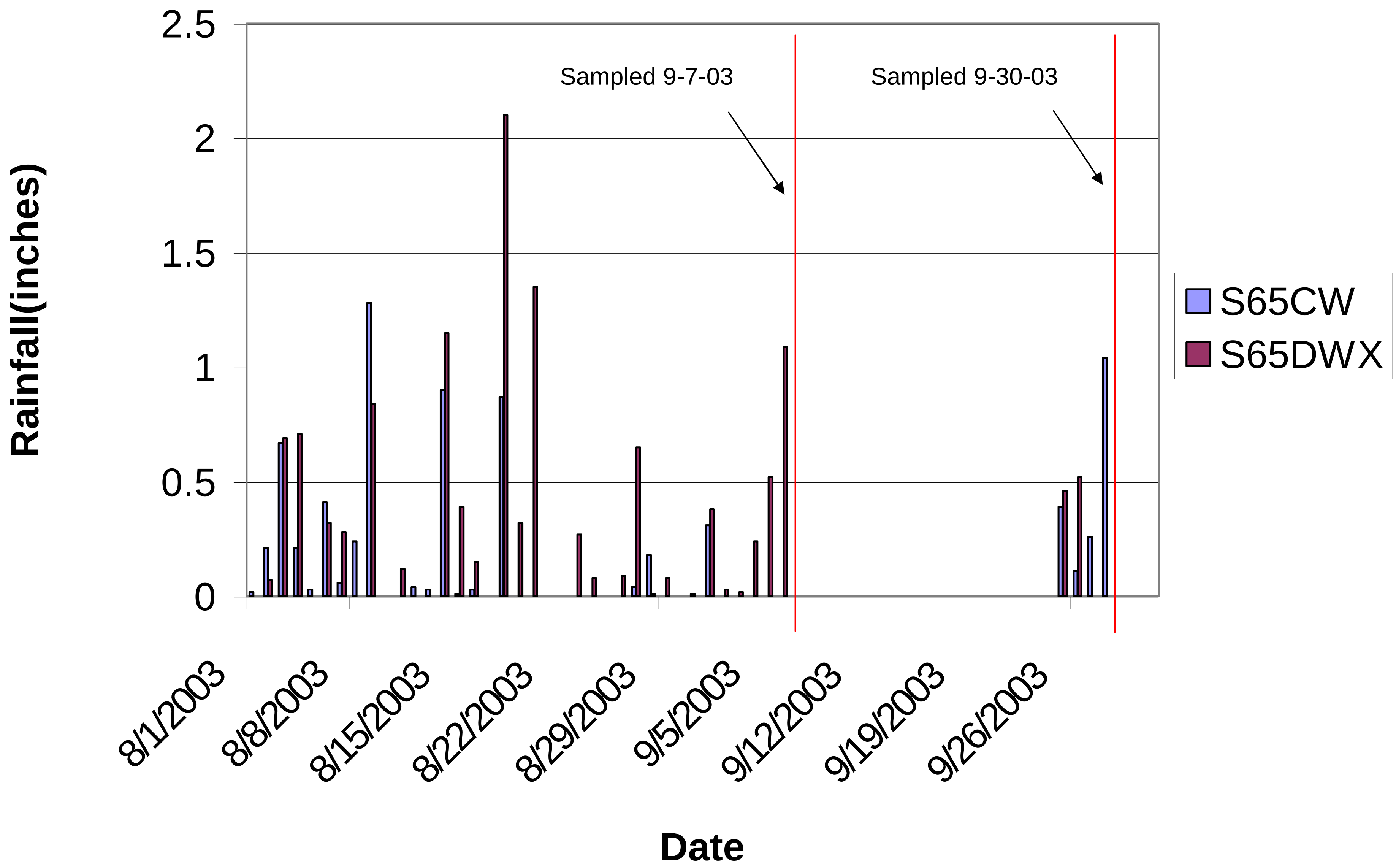
Lamb Island Dairy Stormwater Runoff Sampling Data

	Alkalinty	Calcium	Hardness	Magnesium	OPO4 (SRP)	TDPO4	TPO4
LI1							
9/7/2003	204	--	--	--	5.1	5.7	6.4
9/30/2003	196	36	200	23.6	3.4	3.3	3.8
Arithmatic Mean	200	36	200	23.6	4.3	4.5	5.1
LI2							
9/7/2003	146	--	--	--	2.6	2.6	2.9
9/30/2003	87	27.1	100	12.4	1.5	1.5	1.6
Arithmatic Mean	116.5	27.1	100	12.4	2.1	2.1	2.3
LI3							
9/7/2003	84	--	--	--	7.4	7.5	7.8
9/30/2003	67	20.5	100	12.5	7.7	7.6	7.7
Arithmatic Mean	75.5	20.5	100	12.5	7.6	7.6	7.8
LI4							
9/7/2003	--	--	--	--	--	--	--
9/30/2003	54	18.8	90	10.8	5.7	5.7	5.8
Results	54	18.8	90	10.8	5.7	5.7	5.8
LI5							
9/7/2003	363	--	--	--	21	22	22
9/30/2003	159	26.8	200	24.7	8.0	8.0	8.1
Arithmatic Mean	261	26.8	200	24.7	15	15	15
LI6							
9/7/2003	--	--	--	--	--	--	--
9/30/2003	119	24.5	100	17	8.0	8.0	8.1
Results	119	24.5	100	17	8.0	8.0	8.1
LI7							
9/7/2003	--	--	--	--	--	--	--
9/30/2003	351	58.5	400	55.4	13.0	13	13
Results	351	58.5	400	55.4	13.0	13	13
LI8							
9/7/2003	--	--	--	--	--	--	--
9/30/2003	129	19.8	100	16.6	7.2	7.2	7.6
Results	129	19.8	100	16.6	7.2	7.2	7.6
LI9							
9/7/2003	--	--	--	--	--	--	--
9/30/2003	41	15.1	70	8.9	8.1	8.0	7.9
Results	41	15.1	70	8.9	8.1	8.0	7.9

Note:

1. All values shown in mg/L
2. Calcium reported as mg/L as $CaCO_3$
3. All phosphorus forms reported as mg/L as P

Figure 1. Rainfall Data From SFWMD Monitoring Stations Near Lamb Island Dairy



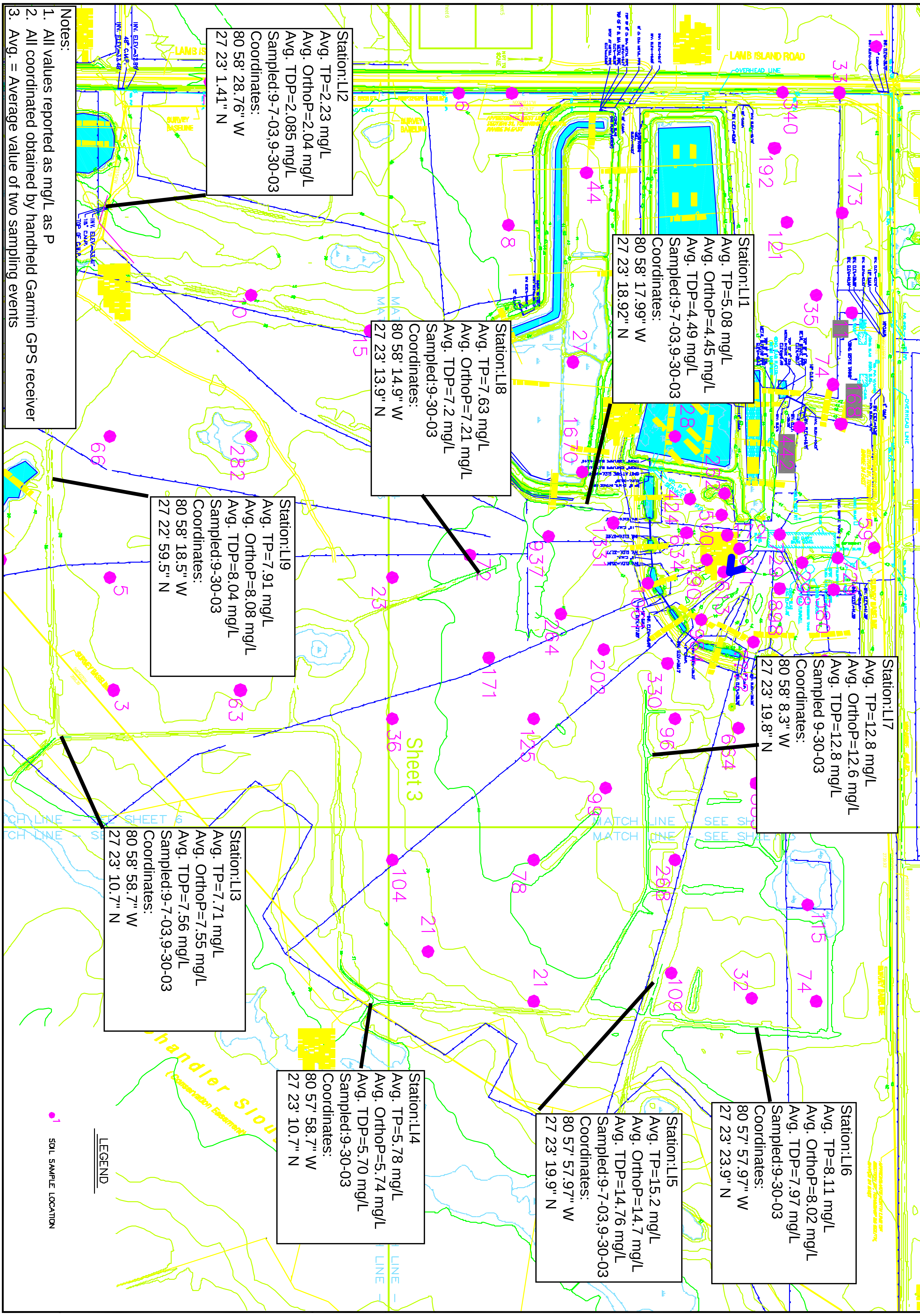


Figure 2. Water Quality Sampling Stations

Figure 4. Farm Run off through culvert at sample station 2 (LI 2)

Figure 5. Sampling Station 3 (LI 3)

Figure 3. Collecting samples from sample station 1 (LI 1) on 9/7/03 field event.

APPENDIX E

WETLAND SYSTEM PERFORMANCE MEMO

Wetland Solutions, Inc.

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MEMORANDUM

Lamb Island Dairy Remediation Project – Performance Estimates for Overland Flow Terraces and HIA-EcoReactor-Swale System

TO: Terry Horan/HSA

COPIES: Bob Knight/WSI

FROM: Chris Keller/WSI

DATE: February 12, 2004

The attached performance estimates were prepared at the request of HSA Engineers and Scientists (HSA) based upon direction provided by the South Florida Water Management District (District). These estimates provide a variation on previous phosphorus (P) removal modeling work completed by WSI (WSI, 2003a; WSI, 2003b) for the Lamb Island Dairy Remediation Project. These results represent expected P removal for individual 24-hour rainfall events (1-year, 5-year, and 10-year return periods). Exhibit 1 presents the estimated edge of field concentrations for each of the storm events identified above for varying runoff P concentrations (3.5 milligrams per liter [mg/L] and 7.9 mg/L).

EXHIBIT 1
Estimated Edge of Field Phosphorus Concentrations

Case	1-yr	5-yr	10-yr
Overland Flow Terraces			
P_{runoff} = 3.5 mg/L	3.0	3.1	3.2
P_{runoff} = 7.9 mg/L	6.7	7.0	7.2
HIA-Ecoreactor-Swale			
P_{runoff} = 7.9 mg/L	4.2	4.4	4.6

It should be noted that the k-C* model (Kadlec and Knight, 1996) used for this and previous project memoranda was not developed for single rainfall event modeling. Accordingly, the model output is representative of expected system performance if the hydraulic and P loading rates shown in the following output sheets were sustained over a long period of time. Actual performance may vary from the estimates summarized above.

References

Kadlec, R.H. and R.L. Knight. 1996. Treatment Wetlands. CRC/Lewis Publishers, Boca Raton, FL. 893 pp.

Wetland Solutions, Inc. 2003a. Draft Memorandum –Lamb Island Dairy Remediation Project – Estimated Performance of Overland Flow Terraces. Prepared for HSA Engineers and Scientists. December 3, 2003.

Wetland Solutions, Inc. 2003b. Draft Memorandum – Estimated Performance of the Proposed Lamb Island Dairy Remediation Project. Prepared for HSA Engineers and Scientists. November 10, 2003.

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 1-yr Event; Runoff P Concentration = 3.5 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	1.9	1.9	1.9	2.8	6.3	11.2	16.2	23.4
Annual Average Runoff Rate (gpm)					1433	2544	3654	5291

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	2.064	1433	8.0	2,920	7,812	20.3	74.2
Q_{out} =	2.064	1,433	8.0	2,920	7,812	20.3	74.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	60.24	6.34	27.32	7.11	C*	0.05
TP_{FWM} =	3.50	60.24	6.34	27.32	7.11	θ	1.00
TP_{out} =	3.06	52.61	5.54	23.86	6.21		
TP_{rem} =	0.44	7.63	0.80	3.46	0.90		
TP_{rem} (%) =	13	13	13	13	13		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	2.064	1,433	7.1	2,593	7,812	18.0	65.9
Q_{runoff} =	1.599	1111	5.5	2,009	6,054	14.0	51.0
Q_{out} =	3.663	2,544	12.6	4,602	13,865	32.0	116.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.06	52.61	4.92	23.86	5.51	k_{20}	10.2
TP_{runoff} =	3.50	46.68	4.36	21.17	4.89	C*	0.05
TP_{FWM} =	3.25	99.29	9.28	45.03	10.40	θ	1.00
TP_{out} =	2.98	91.12	8.52	41.32	9.54		
TP_{rem} =	0.27	8.17	0.76	3.71	0.86		
TP_{rem} (%) =	8	8	8	8	8		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	3.663	2,544	61.3	22,381	13,865	155.7	568.5
Q_{runoff} =	1.599	1111	26.8	9,772	6,054	68.0	248.2
Q_{out} =	5.262	3,654	88.1	32,153	19,919	223.8	816.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.98	91.12	41.42	41.32	46.41	k_{20}	10.2
TP_{runoff} =	3.50	46.68	21.22	21.17	23.78	C*	0.05
TP_{FWM} =	3.14	137.80	62.64	62.50	70.19	θ	1.00
TP_{out} =	3.10	136.12	61.87	61.73	69.34		
TP_{rem} =	0.04	1.68	0.77	0.76	0.86		
TP_{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	5.262	3,654	12.1	4,421	19,919	30.8	112.3
Q_{runoff} =	2.357	1637	5.4	1,980	8,922	13.8	50.3
Q_{out} =	7.619	5,291	17.5	6,401	28,841	44.5	162.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.10	136.12	8.51	61.73	9.53	k_{20}	14
TP_{runoff} =	3.50	68.80	4.30	31.20	4.82	C*	0.05
TP_{FWM} =	3.22	204.91	12.81	92.93	14.35	θ	1.00
TP_{out} =	2.963	188.27	11.77	85.38	13.19		
TP_{rem} =	0.26	16.64	1.04	7.55	1.17		
TP_{rem} (%) =	8	8	8	8	8		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 5-yr Event; Runoff P Concentration = 3.5 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	2.8	2.8	2.8	3.8	9.3	16.6	23.8	33.6
Annual Average Runoff Rate (gpm)					2112	3749	5385	7606

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	3.041	2112	11.8	4,303	11,512	29.9	109.3
Q_{out} =	3.041	2,112	11.8	4,303	11,512	29.9	109.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	88.77	9.34	40.26	10.47	C*	0.05
TP_{FWM} =	3.50	88.77	9.34	40.26	10.47	θ	1.00
TP_{out} =	3.19	80.97	8.52	36.72	9.55		
TP_{rem} =	0.31	7.80	0.82	3.54	0.92		
TP_{rem} (%) =	9	9	9	9	9		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	3.041	2,112	10.5	3,821	11,512	26.6	97.0
Q_{runoff} =	2.357	1637	8.1	2,961	8,922	20.6	75.2
Q_{out} =	5.398	3,749	18.6	6,781	20,433	47.2	172.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.19	80.97	7.57	36.72	8.48	k_{20}	10.2
TP_{runoff} =	3.50	68.80	6.43	31.20	7.21	C*	0.05
TP_{FWM} =	3.33	149.77	14.00	67.92	15.69	θ	1.00
TP_{out} =	3.14	141.29	13.20	64.08	14.80		
TP_{rem} =	0.19	8.48	0.79	3.85	0.89		
TP_{rem} (%) =	6	6	6	6	6		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	5.398	3,749	90.4	32,983	20,433	229.5	837.8
Q_{runoff} =	2.357	1637	39.5	14,401	8,922	100.2	365.8
Q_{out} =	7.755	5,385	129.8	47,384	29,355	329.7	1203.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.14	141.29	64.22	64.08	71.97	k_{20}	10.2
TP_{runoff} =	3.50	68.80	31.27	31.20	35.04	C*	0.05
TP_{FWM} =	3.25	210.08	95.49	95.28	107.01	θ	1.00
TP_{out} =	3.22	208.34	94.70	94.48	106.12		
TP_{rem} =	0.03	1.75	0.79	0.79	0.89		
TP_{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	7.755	5,385	17.9	6,515	29,355	45.3	165.5
Q_{runoff} =	3.199	2221	7.4	2,687	12,108	18.7	68.3
Q_{out} =	10.953	7,606	25.2	9,203	41,463	64.0	233.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.22	208.34	13.02	94.48	14.59	k_{20}	14
TP_{runoff} =	3.50	93.37	5.84	42.34	6.54	C*	0.05
TP_{FWM} =	3.30	301.70	18.86	136.83	21.13	θ	1.00
TP_{out} =	3.114	284.43	17.78	128.99	19.92		
TP_{rem} =	0.19	17.28	1.08	7.83	1.21		
TP_{rem} (%) =	6	6	6	6	6		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 10-yr Event; Runoff P Concentration = 3.5 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	3.8	3.8	3.8	4.8	12.7	22.5	32.3	44.7
Annual Average Runoff Rate (gpm)					2866	5087	7309	10114

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	4.127	2866	16.0	5,840	15,623	40.6	148.3
Q_{out} =	4.127	2,866	16.0	5,840	15,623	40.6	148.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	120.47	12.68	54.64	14.21	C*	0.05
TP_{FWM} =	3.50	120.47	12.68	54.64	14.21	θ	1.00
TP_{out} =	3.27	112.58	11.85	51.06	13.28		
TP_{rem} =	0.23	7.89	0.83	3.58	0.93		
TP_{rem} (%) =	7	7	7	7	7		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	4.127	2,866	14.2	5,185	15,623	36.1	131.7
Q_{runoff} =	3.199	2221	11.0	4,018	12,108	28.0	102.1
Q_{out} =	7.326	5,087	25.2	9,203	27,731	64.0	233.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.27	112.58	10.52	51.06	11.79	k_{20}	10.2
TP_{runoff} =	3.50	93.37	8.73	42.34	9.78	C*	0.05
TP_{FWM} =	3.37	205.95	19.25	93.40	21.57	θ	1.00
TP_{out} =	3.23	197.28	18.44	89.47	20.66		
TP_{rem} =	0.14	8.66	0.81	3.93	0.91		
TP_{rem} (%) =	4	4	4	4	4		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	7.326	5,087	122.6	44,762	27,731	311.5	1137.0
Q_{runoff} =	3.199	2221	53.5	19,544	12,108	136.0	496.4
Q_{out} =	10.524	7,309	176.2	64,306	39,839	447.5	1633.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.23	197.28	89.67	89.47	100.49	k_{20}	10.2
TP_{runoff} =	3.50	93.37	42.44	42.34	47.56	C*	0.05
TP_{FWM} =	3.31	290.65	132.11	131.81	148.05	θ	1.00
TP_{out} =	3.29	288.87	131.30	131.01	147.14		
TP_{rem} =	0.02	1.78	0.81	0.81	0.91		
TP_{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	10.524	7,309	24.2	8,842	39,839	61.5	224.6
Q_{runoff} =	4.040	2806	9.3	3,395	15,294	23.6	86.2
Q_{out} =	14.565	10,114	33.5	12,237	55,133	85.2	310.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.29	288.87	18.05	131.01	20.23	k_{20}	14
TP_{runoff} =	3.50	117.94	7.37	53.49	8.26	C*	0.05
TP_{FWM} =	3.35	406.80	25.43	184.49	28.49	θ	1.00
TP_{out} =	3.204	389.15	24.32	176.49	27.26		
TP_{rem} =	0.15	17.65	1.10	8.00	1.24		
TP_{rem} (%) =	4	4	4	4	4		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 1-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	1.9	1.9	1.9	2.8	6.3	11.2	16.2	23.4
Annual Average Runoff Rate (gpm)					1433	2544	3654	5291

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	2.064	1433	8.0	2,920	7,812	20.3	74.2
Q_{out} =	2.064	1,433	8.0	2,920	7,812	20.3	74.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	135.96	14.31	61.66	16.04	C*	0.05
TP_{FWM} =	7.90	135.96	14.31	61.66	16.04	θ	1.00
TP_{out} =	6.89	118.60	12.48	53.79	13.99		
TP_{rem} =	1.01	17.36	1.83	7.87	2.05		
TP_{rem} (%) =	13	13	13	13	13		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	2.064	1,433	7.1	2,593	7,812	18.0	65.9
Q_{runoff} =	1.599	1111	5.5	2,009	6,054	14.0	51.0
Q_{out} =	3.663	2,544	12.6	4,602	13,865	32.0	116.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	6.89	118.60	11.08	53.79	12.42	k_{20}	10.2
TP_{runoff} =	7.90	105.37	9.85	47.79	11.04	C*	0.05
TP_{FWM} =	7.33	223.97	20.93	101.57	23.46	θ	1.00
TP_{out} =	6.72	205.38	19.19	93.14	21.51		
TP_{rem} =	0.61	18.59	1.74	8.43	1.95		
TP_{rem} (%) =	8	8	8	8	8		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2.2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	3.663	2,544	61.3	22,381	13,865	155.7	568.5
Q_{runoff} =	1.599	1111	26.8	9,772	6,054	68.0	248.2
Q_{out} =	5.262	3,654	88.1	32,153	19,919	223.8	816.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	6.72	205.38	93.36	93.14	104.62	k_{20}	10.2
TP_{runoff} =	7.90	105.37	47.90	47.79	53.67	C*	0.05
TP_{FWM} =	7.08	310.75	141.25	140.93	158.29	θ	1.00
TP_{out} =	6.99	306.92	139.51	139.19	156.34		
TP_{rem} =	0.09	3.83	1.74	1.74	1.95		
TP_{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	5.262	3,654	12.1	4,421	19,919	30.8	112.3
Q_{runoff} =	2.357	1637	5.4	1,980	8,922	13.8	50.3
Q_{out} =	7.619	5,291	17.5	6,401	28,841	44.5	162.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	6.99	306.92	19.18	139.19	21.50	k_{20}	14
TP_{runoff} =	7.90	155.28	9.71	70.42	10.88	C*	0.05
TP_{FWM} =	7.27	462.20	28.89	209.62	32.37	θ	1.00
TP_{out} =	6.678	424.33	26.52	192.44	29.72		
TP_{rem} =	0.60	37.87	2.37	17.18	2.65		
TP_{rem} (%) =	8	8	8	8	8		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 5-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	2.8	2.8	2.8	3.8	9.3	16.6	23.8	33.6
Annual Average Runoff Rate (gpm)					2112	3749	5385	7606

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	3.041	2112	11.8	4,303	11,512	29.9	109.3
Q_{out} =	3.041	2,112	11.8	4,303	11,512	29.9	109.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	200.36	21.09	90.87	23.63	C*	0.05
TP_{FWM} =	7.90	200.36	21.09	90.87	23.63	θ	1.00
TP_{out} =	7.20	182.62	19.22	82.82	21.54		
TP_{rem} =	0.70	17.74	1.87	8.05	2.09		
TP_{rem} (%) =	9	9	9	9	9		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	3.041	2,112	10.5	3,821	11,512	26.6	97.0
Q_{runoff} =	2.357	1637	8.1	2,961	8,922	20.6	75.2
Q_{out} =	5.398	3,749	18.6	6,781	20,433	47.2	172.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.20	182.62	17.07	82.82	19.13	k_{20}	10.2
TP_{runoff} =	7.90	155.28	14.51	70.42	16.26	C*	0.05
TP_{FWM} =	7.51	337.91	31.58	153.25	35.39	θ	1.00
TP_{out} =	7.08	318.61	29.78	144.49	33.37		
TP_{rem} =	0.43	19.30	1.80	8.75	2.02		
TP_{rem} (%) =	6	6	6	6	6		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	5.398	3,749	90.4	32,983	20,433	229.5	837.8
Q_{runoff} =	2.357	1637	39.5	14,401	8,922	100.2	365.8
Q_{out} =	7.755	5,385	129.8	47,384	29,355	329.7	1203.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.08	318.61	144.82	144.49	162.29	k_{20}	10.2
TP_{runoff} =	7.90	155.28	70.58	70.42	79.10	C*	0.05
TP_{FWM} =	7.33	473.89	215.40	214.91	241.39	θ	1.00
TP_{out} =	7.27	469.92	213.60	213.11	239.36		
TP_{rem} =	0.06	3.97	1.81	1.80	2.02		
TP_{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	7.755	5,385	17.9	6,515	29,355	45.3	165.5
Q_{runoff} =	3.199	2221	7.4	2,687	12,108	18.7	68.3
Q_{out} =	10.953	7,606	25.2	9,203	41,463	64.0	233.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.27	469.92	29.37	213.11	32.91	k_{20}	14
TP_{runoff} =	7.90	210.74	13.17	95.57	14.76	C*	0.05
TP_{FWM} =	7.45	680.65	42.54	308.69	47.67	θ	1.00
TP_{out} =	7.021	641.35	40.08	290.86	44.92		
TP_{rem} =	0.43	39.31	2.46	17.83	2.75		
TP_{rem} (%) =	6	6	6	6	6		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

24-hr, 10-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	3.8	3.8	3.8	4.8	12.7	22.5	32.3	44.7
Annual Average Runoff Rate (gpm)					2866	5087	7309	10114

Terrace Compartment 1

Parameter	acres	ft²	hectares	m²
Area =	9.5	413,820	3.84	38,445

Parameter	mgd	gpm	in/d	in/yr	m³/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	4.127	2866	16.0	5,840	15,623	40.6	148.3
Q_{out} =	4.127	2,866	16.0	5,840	15,623	40.6	148.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	271.92	28.62	123.32	32.08	C*	0.05
TP_{FWM} =	7.90	271.92	28.62	123.32	32.08	θ	1.00
TP_{out} =	7.38	253.97	26.73	115.18	29.96		
TP_{rem} =	0.52	17.96	1.89	8.14	2.12		
TP_{rem} (%) =	7	7	7	7	7		

Terrace Compartment 2

Parameter	acres	ft²	hectares	m²
Area =	10.7	466,092	4.33	43,301

Parameter	mgd	gpm	in/d	in/yr	m³/d	cm/d	m/yr
Q_{in} =	4.127	2,866	14.2	5,185	15,623	36.1	131.7
Q_{runoff} =	3.199	2221	11.0	4,018	12,108	28.0	102.1
Q_{out} =	7.326	5,087	25.2	9,203	27,731	64.0	233.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.38	253.97	23.74	115.18	26.60	k_{20}	10.2
TP_{runoff} =	7.90	210.74	19.70	95.57	22.07	C*	0.05
TP_{FWM} =	7.61	464.71	43.43	210.75	48.67	θ	1.00
TP_{out} =	7.28	444.99	41.59	201.81	46.60		
TP_{rem} =	0.32	19.71	1.84	8.94	2.06		
TP_{rem} (%) =	4	4	4	4	4		

Terrace Compartment 3

Parameter	acres	ft²	hectares	m²
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m³/d	cm/d	m/yr
Q_{in} =	7.326	5,087	122.6	44,762	27,731	311.5	1137.0
Q_{runoff} =	3.199	2221	53.5	19,544	12,108	136.0	496.4
Q_{out} =	10.524	7,309	176.2	64,306	39,839	447.5	1633.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.28	444.99	202.27	201.81	226.67	k_{20}	10.2
TP_{runoff} =	7.90	210.74	95.79	95.57	107.35	C*	0.05
TP_{FWM} =	7.47	655.73	298.06	297.39	334.01	θ	1.00
TP_{out} =	7.42	651.68	296.22	295.55	331.95		
TP_{rem} =	0.05	4.06	1.84	1.84	2.07		
TP_{rem} (%) =	1	1	1	1	1		

Wetland Compartment

Parameter	acres	ft²	hectares	m²
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m³/d	cm/d	m/yr
Q_{in} =	10.524	7,309	24.2	8,842	39,839	61.5	224.6
Q_{runoff} =	4.040	2806	9.3	3,395	15,294	23.6	86.2
Q_{out} =	14.565	10,114	33.5	12,237	55,133	85.2	310.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.42	651.68	40.73	295.55	45.64	k_{20}	14
TP_{runoff} =	7.90	266.20	16.64	120.72	18.64	C*	0.05
TP_{FWM} =	7.56	917.88	57.37	416.27	64.29	θ	1.00
TP_{out} =	7.226	877.71	54.86	398.06	61.47		
TP_{rem} =	0.33	40.16	2.51	18.21	2.81		
TP_{rem} (%) =	4	4	4	4	4		

Lamb Island Dairy
Estimated Performance for HIA-EcoReactor-Swale System

24-hr, 1-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
HIA	40	89	1.24
EcoReactor	6.5	89	1.24
Swale	15	89	1.24
Total	61.5		

	Runoff (inches)			Cumulative Runoff (ac-ft)		
	HIA	EcoReactor	Swale	HIA	EcoReactor	Swale
Total	1.9	2.8	1.9	6.3	7.9	10.2
Annual Average Runoff Rate (gpm)				1433	1776	2314

HIA

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	2.064	1433	1.9	694	7,812	4.8	17.6
Q_{out} =	2.064	1,433	1.9	694	7,812	4.8	17.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	0
TP_{runoff} =	7.90	135.96	3.40	61.66	3.81	C*	0.05
TP_{FWM} =	7.90	135.96	3.40	61.66	3.81	θ	1.00
TP_{out} =	7.90	135.96	3.40	61.66	3.81		
TP_{rem} =	0.00	0.00	0.00	0.00	0.00		
TP_{rem} (%) =	0	0	0	0	0		

EcoReactor

Parameter	acres	ft^2	hectares	m^2
Area =	6.5	283,140	2.63	26,304

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	2.064	1,433	11.7	4,268	7,812	29.7	108.4
Q_{runoff} =	0.494	343	2.8	1,022	1,871	7.1	26.0
Q_{out} =	2.558	1,776	14.5	5,290	9,682	36.8	134.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.90	135.96	20.92	61.66	23.44	k_{20}	14
TP_{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP_{FWM} =	6.37	135.96	20.92	61.66	23.44	θ	1.00
TP_{out} =	5.75	122.61	18.86	55.61	21.14		
TP_{rem} =	0.63	13.35	2.05	6.05	2.30		
TP_{rem} (%) =	10	10	10	10	10		

Swale

Parameter	acres	ft^2	hectares	m^2
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	2.558	1,776	18.8	6,877	9,682	47.9	174.7
Q_{runoff} =	0.774	537	5.7	2,081	2,929	14.5	52.8
Q_{out} =	3.332	2,314	24.5	8,957	12,611	62.3	227.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	5.75	122.61	24.52	55.61	27.48	k_{20}	14
TP_{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP_{FWM} =	4.41	122.61	24.52	55.61	27.48	θ	1.00
TP_{out} =	4.15	115.38	23.08	52.33	25.86		
TP_{rem} =	0.26	7.24	1.45	3.28	1.62		
TP_{rem} (%) =	6	6	6	6	6		

Lamb Island Dairy
Estimated Performance for HIA-EcoReactor-Swale System

24-hr, 5-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
HIA	40	89	1.24
EcoReactor	6.5	89	1.24
Swale	15	89	1.24
Total	61.5		

	Runoff (inches)			Cumulative Runoff (ac-ft)		
	HIA	EcoReactor	Swale	HIA	EcoReactor	Swale
Total	2.8	3.8	2.8	9.3	11.4	14.9
Annual Average Runoff Rate (gpm)				2112	2578	3370

HIA

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	3.041	2112	2.8	1,022	11,512	7.1	26.0
Q_{out} =	3.041	2,112	2.8	1,022	11,512	7.1	26.0

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	0
TP_{runoff} =	7.90	200.36	5.01	90.87	5.61	C*	0.05
TP_{FWM} =	7.90	200.36	5.01	90.87	5.61	θ	1.00
TP_{out} =	7.90	200.36	5.01	90.87	5.61		
TP_{rem} =	0.00	0.00	0.00	0.00	0.00		
TP_{rem} (%) =	0	0	0	0	0		

EcoReactor

Parameter	acres	ft^2	hectares	m^2
Area =	6.5	283,140	2.63	26,304

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	3.041	2,112	17.2	6,289	11,512	43.8	159.7
Q_{runoff} =	0.671	466	3.8	1,387	2,539	9.7	35.2
Q_{out} =	3.712	2,578	21.0	7,676	14,050	53.4	195.0

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.90	200.36	30.83	90.87	34.54	k_{20}	14
TP_{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP_{FWM} =	6.47	200.36	30.83	90.87	34.54	θ	1.00
TP_{out} =	6.03	186.59	28.71	84.62	32.17		
TP_{rem} =	0.45	13.78	2.12	6.25	2.38		
TP_{rem} (%) =	7	7	7	7	7		

Swale

Parameter	acres	ft^2	hectares	m^2
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	3.712	2,578	27.3	9,979	14,050	69.4	253.5
Q_{runoff} =	1.140	792	8.4	3,066	4,317	21.3	77.9
Q_{out} =	4.852	3,370	35.7	13,045	18,367	90.8	331.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	6.03	186.59	37.32	84.62	41.82	k_{20}	14
TP_{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP_{FWM} =	4.61	186.59	37.32	84.62	41.82	θ	1.00
TP_{out} =	4.42	178.95	35.79	81.16	40.11		
TP_{rem} =	0.19	7.64	1.53	3.46	1.71		
TP_{rem} (%) =	4	4	4	4	4		

Lamb Island Dairy
Estimated Performance for HIA-EcoReactor-Swale System

24-hr, 10-yr Event; Runoff P Concentration = 7.9 mg/L

Location	Area (ac)	CN	S
HIA	40	89	1.24
EcoReactor	6.5	89	1.24
Swale	15	89	1.24
Total	61.5		

	Runoff (inches)			Cumulative Runoff (ac-ft)		
	HIA	EcoReactor	Swale	HIA	EcoReactor	Swale
Total	3.8	4.8	3.8	12.7	15.3	20.0
Annual Average Runoff Rate (gpm)				2866	3454	4529

HIA

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	4.127	2866	3.8	1,387	15,623	9.7	35.2
Q_{out} =	4.127	2,866	3.8	1,387	15,623	9.7	35.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	0
TP_{runoff} =	7.90	271.92	6.80	123.32	7.62	C*	0.05
TP_{FWM} =	7.90	271.92	6.80	123.32	7.62	θ	1.00
TP_{out} =	7.90	271.92	6.80	123.32	7.62		
TP_{rem} =	0.00	0.00	0.00	0.00	0.00		
TP_{rem} (%) =	0	0	0	0	0		

EcoReactor

Parameter	acres	ft^2	hectares	m^2
Area =	6.5	283,140	2.63	26,304

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	4.127	2,866	23.4	8,535	15,623	59.4	216.8
Q_{runoff} =	0.847	588	4.8	1,752	3,207	12.2	44.5
Q_{out} =	4.974	3,454	28.2	10,287	18,830	71.6	261.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	7.90	271.92	41.83	123.32	46.88	k_{20}	14
TP_{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP_{FWM} =	6.55	271.92	41.83	123.32	46.88	θ	1.00
TP_{out} =	6.22	257.84	39.67	116.94	44.45		
TP_{rem} =	0.34	14.08	2.17	6.38	2.43		
TP_{rem} (%) =	5	5	5	5	5		

Swale

Parameter	acres	ft^2	hectares	m^2
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	4.974	3,454	36.6	13,374	18,830	93.1	339.7
Q_{runoff} =	1.548	1075	11.4	4,161	5,859	29.0	105.7
Q_{out} =	6.522	4,529	48.0	17,535	24,688	122.0	445.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	6.22	257.84	51.57	116.94	57.79	k_{20}	14
TP_{runoff} =	0.00	0.00	0.00	0.00	0.00	C*	0.05
TP_{FWM} =	4.74	257.84	51.57	116.94	57.79	θ	1.00
TP_{out} =	4.60	249.95	49.99	113.36	56.02		
TP_{rem} =	0.15	7.90	1.58	3.58	1.77		
TP_{rem} (%) =	3	3	3	3	3		

Estimated Edge of Field P Concentrations

	Effective Terrace Area			
Case	5%	10%	50%	100%
Average Flow				
P_{runoff} = 3.5 mg/L	0.52	0.44	0.27	0.24
P_{runoff} = 7.9 mg/L	1.13	0.93	0.56	0.48
Maximum Flow				
P_{runoff} = 3.5 mg/L	1.20	1.03	0.52	0.38

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					77	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	0.1	37	419	0.3	0.9
Q_{out} =	0.111	77	0.1	37	419	0.3	0.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	3.23	0.08	1.47	0.09	C*	0.05
TP_{FWM} =	3.50	3.23	0.08	1.47	0.09	θ	1.00
TP_{out} =	0.05	0.05	0.00	0.02	0.00		
TP_{rem} =	3.45	3.18	0.08	1.44	0.09		
TP_{rem} (%) =	99	99	99	99	99		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	31	1,350,360	12.55	125,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	0.1	48	419	0.3	1.2
Q_{runoff} =	0.086	60	0.1	37	325	0.3	0.9
Q_{out} =	0.196	136	0.2	85	744	0.6	2.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.05	0.05	0.00	0.02	0.00	k_{20}	10.2
TP_{runoff} =	3.50	2.50	0.08	1.14	0.09	C*	0.05
TP_{FWM} =	1.56	2.55	0.08	1.16	0.09	θ	1.00
TP_{out} =	0.06	0.10	0.00	0.05	0.00		
TP_{rem} =	1.49	2.45	0.08	1.11	0.09		
TP_{rem} (%) =	96	96	96	96	96		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	22	958,320	8.90	89,030

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	0.3	120	744	0.8	3.0
Q_{runoff} =	0.086	60	0.1	52	325	0.4	1.3
Q_{out} =	0.282	196	0.5	172	1,068	1.2	4.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.06	0.10	0.00	0.05	0.01	k_{20}	10.2
TP_{runoff} =	3.50	2.50	0.11	1.14	0.13	C*	0.05
TP_{FWM} =	1.11	2.61	0.12	1.18	0.13	θ	1.00
TP_{out} =	0.15	0.36	0.02	0.16	0.02		
TP_{rem} =	0.95	2.25	0.10	1.02	0.11		
TP_{rem} (%) =	86	86	86	86	86		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.15	0.36	0.02	0.16	0.03	k_{20}	14
TP_{runoff} =	3.50	3.10	0.19	1.40	0.22	C*	0.05
TP_{FWM} =	1.07	3.46	0.22	1.57	0.24	θ	1.00
TP_{out} =	0.24	0.77	0.05	0.35	0.05		
TP_{rem} =	0.83	2.69	0.17	1.22	0.19		
TP_{rem} (%) =	78	78	78	78	78		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					77	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	0.1	37	419	0.3	0.9
Q_{out} =	0.111	77	0.1	37	419	0.3	0.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	7.29	0.18	3.31	0.20	C*	0.05
TP_{FWM} =	7.90	7.29	0.18	3.31	0.20	θ	1.00
TP_{out} =	0.05	0.05	0.00	0.02	0.00		
TP_{rem} =	7.85	7.25	0.18	3.29	0.20		
TP_{rem} (%) =	99	99	99	99	99		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	31	1,350,360	12.55	125,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	0.1	48	419	0.3	1.2
Q_{runoff} =	0.086	60	0.1	37	325	0.3	0.9
Q_{out} =	0.196	136	0.2	85	744	0.6	2.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.05	0.05	0.00	0.02	0.00	k_{20}	10.2
TP_{runoff} =	7.90	5.65	0.18	2.56	0.20	C*	0.05
TP_{FWM} =	3.48	5.70	0.18	2.58	0.21	θ	1.00
TP_{out} =	0.08	0.13	0.00	0.06	0.00		
TP_{rem} =	3.40	5.57	0.18	2.52	0.20		
TP_{rem} (%) =	98	98	98	98	98		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	22	958,320	8.90	89,030

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	0.3	120	744	0.8	3.0
Q_{runoff} =	0.086	60	0.1	52	325	0.4	1.3
Q_{out} =	0.282	196	0.5	172	1,068	1.2	4.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.08	0.13	0.01	0.06	0.01	k_{20}	10.2
TP_{runoff} =	7.90	5.65	0.26	2.56	0.29	C*	0.05
TP_{FWM} =	2.46	5.78	0.26	2.62	0.29	θ	1.00
TP_{out} =	0.28	0.67	0.03	0.30	0.03		
TP_{rem} =	2.17	5.11	0.23	2.32	0.26		
TP_{rem} (%) =	88	88	88	88	88		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.28	0.67	0.04	0.30	0.05	k_{20}	14
TP_{runoff} =	7.90	6.99	0.44	3.17	0.49	C*	0.05
TP_{FWM} =	2.36	7.66	0.48	3.47	0.54	θ	1.00
TP_{out} =	0.48	1.55	0.10	0.70	0.11		
TP_{rem} =	1.89	6.11	0.38	2.77	0.43		
TP_{rem} (%) =	80	80	80	80	80		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	5%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					77	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	2	87,120	0.81	8,094

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	2.0	744	419	5.2	18.9
Q_{out} =	0.111	77	2.0	744	419	5.2	18.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	3.23	1.62	1.47	1.81	C*	0.05
TP_{FWM} =	3.50	3.23	1.62	1.47	1.81	θ	1.00
TP_{out} =	2.06	1.90	0.95	0.86	1.07		
TP_{rem} =	1.44	1.33	0.66	0.60	0.74		
TP_{rem} (%) =	41	41	41	41	41		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	1.55	67,518	0.63	6,273

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	2.6	960	419	6.7	24.4
Q_{runoff} =	0.086	60	2.0	744	325	5.2	18.9
Q_{out} =	0.196	136	4.7	1,704	744	11.9	43.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.06	1.90	1.23	0.86	1.38	k_{20}	10.2
TP_{runoff} =	3.50	2.50	1.62	1.14	1.81	C*	0.05
TP_{FWM} =	2.69	4.41	2.84	2.00	3.19	θ	1.00
TP_{out} =	2.14	3.50	2.26	1.59	2.53		
TP_{rem} =	0.55	0.91	0.59	0.41	0.66		
TP_{rem} (%) =	21	21	21	21	21		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	1	47,916	0.45	4,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	6.6	2,401	744	16.7	61.0
Q_{runoff} =	0.086	60	2.9	1,048	325	7.3	26.6
Q_{out} =	0.282	196	9.5	3,449	1,068	24.0	87.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.14	3.50	3.18	1.59	3.56	k_{20}	10.2
TP_{runoff} =	3.50	2.50	2.28	1.14	2.55	C*	0.05
TP_{FWM} =	2.55	6.00	5.46	2.72	6.12	θ	1.00
TP_{out} =	2.28	5.36	4.87	2.43	5.46		
TP_{rem} =	0.27	0.65	0.59	0.29	0.66		
TP_{rem} (%) =	11	11	11	11	11		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.28	5.36	0.33	2.43	0.38	k_{20}	14
TP_{runoff} =	3.50	3.10	0.19	1.40	0.22	C*	0.05
TP_{FWM} =	2.61	8.45	0.53	3.83	0.59	θ	1.00
TP_{out} =	0.52	1.69	0.11	0.77	0.12		
TP_{rem} =	2.09	6.76	0.42	3.07	0.47		
TP_{rem} (%) =	80	80	80	80	80		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	10%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					76.9	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	4	174,240	1.62	16,187

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	1.0	372	419	2.6	9.4
Q_{out} =	0.111	77	1.0	372	419	2.6	9.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	3.23	0.81	1.47	0.91	C*	0.05
TP_{FWM} =	3.50	3.23	0.81	1.47	0.91	θ	1.00
TP_{out} =	1.22	1.13	0.28	0.51	0.32		
TP_{rem} =	2.28	2.10	0.53	0.95	0.59		
TP_{rem} (%) =	65	65	65	65	65		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	3.1	135,036	1.25	12,545

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	1.3	480	419	3.3	12.2
Q_{runoff} =	0.086	60	1.0	372	325	2.6	9.4
Q_{out} =	0.196	136	2.3	852	744	5.9	21.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	1.22	1.13	0.36	0.51	0.41	k_{20}	10.2
TP_{runoff} =	3.50	2.50	0.81	1.14	0.91	C*	0.05
TP_{FWM} =	2.22	3.63	1.17	1.65	1.31	θ	1.00
TP_{out} =	1.40	2.30	0.74	1.04	0.83		
TP_{rem} =	0.81	1.33	0.43	0.61	0.48		
TP_{rem} (%) =	37	37	37	37	37		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	3.3	1,201	744	8.4	30.5
Q_{runoff} =	0.086	60	1.4	524	325	3.6	13.3
Q_{out} =	0.282	196	4.7	1,725	1,068	12.0	43.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	1.40	2.30	1.04	1.04	1.17	k_{20}	10.2
TP_{runoff} =	3.50	2.50	1.14	1.14	1.28	C*	0.05
TP_{FWM} =	2.04	4.80	2.18	2.18	2.45	θ	1.00
TP_{out} =	1.63	3.83	1.74	1.74	1.95		
TP_{rem} =	0.41	0.97	0.44	0.44	0.50		
TP_{rem} (%) =	20	20	20	20	20		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	1.63	3.83	0.24	1.74	0.27	k_{20}	14
TP_{runoff} =	3.50	3.10	0.19	1.40	0.22	C*	0.05
TP_{FWM} =	2.14	6.93	0.43	3.14	0.49	θ	1.00
TP_{out} =	0.44	1.41	0.09	0.64	0.10		
TP_{rem} =	1.70	5.51	0.34	2.50	0.39		
TP_{rem} (%) =	80	80	80	80	80		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	50%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					77	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	20	871,200	8.09	80,937

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	0.2	74	419	0.5	1.9
Q_{out} =	0.111	77	0.2	74	419	0.5	1.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	3.23	0.16	1.47	0.18	C*	0.05
TP_{FWM} =	3.50	3.23	0.16	1.47	0.18	θ	1.00
TP_{out} =	0.07	0.06	0.00	0.03	0.00		
TP_{rem} =	3.43	3.17	0.16	1.44	0.18		
TP_{rem} (%) =	98	98	98	98	98		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	15.5	675,180	6.27	62,726

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	0.3	96	419	0.7	2.4
Q_{runoff} =	0.086	60	0.2	74	325	0.5	1.9
Q_{out} =	0.196	136	0.5	170	744	1.2	4.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.07	0.06	0.00	0.03	0.00	k_{20}	10.2
TP_{runoff} =	3.50	2.50	0.16	1.14	0.18	C*	0.05
TP_{FWM} =	1.57	2.56	0.17	1.16	0.19	θ	1.00
TP_{out} =	0.19	0.32	0.02	0.14	0.02		
TP_{rem} =	1.37	2.25	0.15	1.02	0.16		
TP_{rem} (%) =	88	88	88	88	88		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	11	479,160	4.45	44,515

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	0.7	240	744	1.7	6.1
Q_{runoff} =	0.086	60	0.3	105	325	0.7	2.7
Q_{out} =	0.282	196	0.9	345	1,068	2.4	8.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.19	0.32	0.03	0.14	0.03	k_{20}	10.2
TP_{runoff} =	3.50	2.50	0.23	1.14	0.26	C*	0.05
TP_{FWM} =	1.20	2.82	0.26	1.28	0.29	θ	1.00
TP_{out} =	0.41	0.96	0.09	0.44	0.10		
TP_{rem} =	0.79	1.86	0.17	0.84	0.19		
TP_{rem} (%) =	66	66	66	66	66		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.41	0.96	0.06	0.44	0.07	k_{20}	14
TP_{runoff} =	3.50	3.10	0.19	1.40	0.22	C*	0.05
TP_{FWM} =	1.25	4.06	0.25	1.84	0.28	θ	1.00
TP_{out} =	0.27	0.88	0.06	0.40	0.06		
TP_{rem} =	0.98	3.18	0.20	1.44	0.22		
TP_{rem} (%) =	78	78	78	78	78		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	5%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					77	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	2	87,120	0.81	8,094

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	2.0	744	419	5.2	18.9
Q_{out} =	0.111	77	2.0	744	419	5.2	18.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	7.29	3.65	3.31	4.09	C*	0.05
TP_{FWM} =	7.90	7.29	3.65	3.31	4.09	θ	1.00
TP_{out} =	4.63	4.27	2.14	1.94	2.39		
TP_{rem} =	3.27	3.02	1.51	1.37	1.69		
TP_{rem} (%) =	41	41	41	41	41		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	1.55	67,518	0.63	6,273

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	2.6	960	419	6.7	24.4
Q_{runoff} =	0.086	60	2.0	744	325	5.2	18.9
Q_{out} =	0.196	136	4.7	1,704	744	11.9	43.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	4.63	4.27	2.75	1.94	3.09	k_{20}	10.2
TP_{runoff} =	7.90	5.65	3.65	2.56	4.09	C*	0.05
TP_{FWM} =	6.06	9.92	6.40	4.50	7.17	θ	1.00
TP_{out} =	4.79	7.86	5.07	3.56	5.68		
TP_{rem} =	1.26	2.07	1.33	0.94	1.49		
TP_{rem} (%) =	21	21	21	21	21		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	1	47,916	0.45	4,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	6.6	2,401	744	16.7	61.0
Q_{runoff} =	0.086	60	2.9	1,048	325	7.3	26.6
Q_{out} =	0.282	196	9.5	3,449	1,068	24.0	87.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	4.79	7.86	7.14	3.56	8.00	k_{20}	10.2
TP_{runoff} =	7.90	5.65	5.14	2.56	5.76	C*	0.05
TP_{FWM} =	5.74	13.51	12.28	6.13	13.76	θ	1.00
TP_{out} =	5.11	12.04	10.94	5.46	12.26		
TP_{rem} =	0.63	1.47	1.34	0.67	1.50		
TP_{rem} (%) =	11	11	11	11	11		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	5.11	12.04	0.75	5.46	0.84	k_{20}	14
TP_{runoff} =	7.90	6.99	0.44	3.17	0.49	C*	0.05
TP_{FWM} =	5.87	19.03	1.19	8.63	1.33	θ	1.00
TP_{out} =	1.13	3.64	0.23	1.65	0.26		
TP_{rem} =	4.75	15.38	0.96	6.98	1.08		
TP_{rem} (%) =	81	81	81	81	81		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	10%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					76.9	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	4	174,240	1.62	16,187

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	1.0	372	419	2.6	9.4
Q_{out} =	0.111	77	1.0	372	419	2.6	9.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	7.29	1.82	3.31	2.04	C*	0.05
TP_{FWM} =	7.90	7.29	1.82	3.31	2.04	θ	1.00
TP_{out} =	2.72	2.51	0.63	1.14	0.70		
TP_{rem} =	5.18	4.78	1.20	2.17	1.34		
TP_{rem} (%) =	66	66	66	66	66		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	3.1	135,036	1.25	12,545

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	1.3	480	419	3.3	12.2
Q_{runoff} =	0.086	60	1.0	372	325	2.6	9.4
Q_{out} =	0.196	136	2.3	852	744	5.9	21.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.72	2.51	0.81	1.14	0.91	k_{20}	10.2
TP_{runoff} =	7.90	5.65	1.82	2.56	2.04	C*	0.05
TP_{FWM} =	4.98	8.16	2.63	3.70	2.95	θ	1.00
TP_{out} =	3.13	5.12	1.65	2.32	1.85		
TP_{rem} =	1.85	3.04	0.98	1.38	1.10		
TP_{rem} (%) =	37	37	37	37	37		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	3.3	1,201	744	8.4	30.5
Q_{runoff} =	0.086	60	1.4	524	325	3.6	13.3
Q_{out} =	0.282	196	4.7	1,725	1,068	12.0	43.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.13	5.12	2.33	2.32	2.61	k_{20}	10.2
TP_{runoff} =	7.90	5.65	2.57	2.56	2.88	C*	0.05
TP_{FWM} =	4.58	10.78	4.90	4.89	5.49	θ	1.00
TP_{out} =	3.64	8.56	3.89	3.88	4.36		
TP_{rem} =	0.94	2.21	1.01	1.00	1.13		
TP_{rem} (%) =	21	21	21	21	21		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.64	8.56	0.54	3.88	0.60	k_{20}	14
TP_{runoff} =	7.90	6.99	0.44	3.17	0.49	C*	0.05
TP_{FWM} =	4.80	15.55	0.97	7.05	1.09	θ	1.00
TP_{out} =	0.93	3.00	0.19	1.36	0.21		
TP_{rem} =	3.87	12.55	0.78	5.69	0.88		
TP_{rem} (%) =	81	81	81	81	81		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	50%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	37.2	37.2	37.2	46.0	124.0	220.1	316.2	435.0
Annual Average Runoff Rate (gpm)					77	136	196	270

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	20	871,200	8.09	80,937

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	0.2	74	419	0.5	1.9
Q_{out} =	0.111	77	0.2	74	419	0.5	1.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	7.90	7.29	0.36	3.31	0.41	C*	0.05
TP_{FWM} =	7.90	7.29	0.36	3.31	0.41	θ	1.00
TP_{out} =	0.09	0.08	0.00	0.04	0.00		
TP_{rem} =	7.81	7.21	0.36	3.27	0.40		
TP_{rem} (%) =	99	99	99	99	99		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	15.5	675,180	6.27	62,726

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	0.3	96	419	0.7	2.4
Q_{runoff} =	0.086	60	0.2	74	325	0.5	1.9
Q_{out} =	0.196	136	0.5	170	744	1.2	4.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.09	0.08	0.01	0.04	0.01	k_{20}	10.2
TP_{runoff} =	7.90	5.65	0.36	2.56	0.41	C*	0.05
TP_{FWM} =	3.50	5.73	0.37	2.60	0.41	θ	1.00
TP_{out} =	0.38	0.62	0.04	0.28	0.04		
TP_{rem} =	3.12	5.11	0.33	2.32	0.37		
TP_{rem} (%) =	89	89	89	89	89		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	11	479,160	4.45	44,515

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	0.7	240	744	1.7	6.1
Q_{runoff} =	0.086	60	0.3	105	325	0.7	2.7
Q_{out} =	0.282	196	0.9	345	1,068	2.4	8.8

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.38	0.62	0.06	0.28	0.06	k_{20}	10.2
TP_{runoff} =	7.90	5.65	0.51	2.56	0.58	C*	0.05
TP_{FWM} =	2.66	6.27	0.57	2.84	0.64	θ	1.00
TP_{out} =	0.87	2.04	0.19	0.92	0.21		
TP_{rem} =	1.80	4.23	0.38	1.92	0.43		
TP_{rem} (%) =	67	67	67	67	67		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.282	196	0.6	237	1,068	1.7	6.0
Q_{runoff} =	0.106	74	0.2	89	402	0.6	2.3
Q_{out} =	0.388	270	0.9	326	1,470	2.3	8.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.87	2.04	0.13	0.92	0.14	k_{20}	14
TP_{runoff} =	7.90	6.99	0.44	3.17	0.49	C*	0.05
TP_{FWM} =	2.79	9.03	0.56	4.09	0.63	θ	1.00
TP_{out} =	0.56	1.80	0.11	0.82	0.13		
TP_{rem} =	2.23	7.23	0.45	3.28	0.51		
TP_{rem} (%) =	80	80	80	80	80		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S
Terrace 1	40	89	1.24
Terrace 2	31	89	1.24
Terrace 3	22	89	1.24
Marsh	16	98	0.20
Total	109		

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	86.9	86.9	86.9	97.2	289.7	514.2	673.5	803.1
Annual Average Runoff Rate (gpm)					180	319	417	498

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.259	180	0.2	87	979	0.6	2.2
Q_{out} =	0.259	180	0.2	87	979	0.6	2.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	7.55	0.19	3.42	0.21	C*	0.05
TP_{FWM} =	3.50	7.55	0.19	3.42	0.21	θ	1.00
TP_{out} =	0.08	0.18	0.00	0.08	0.01		
TP_{rem} =	3.42	7.37	0.18	3.34	0.21		
TP_{rem} (%) =	98	98	98	98	98		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	31	1,350,360	12.55	125,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	0.3	112	979	0.8	2.8
Q_{runoff} =	0.200	139	0.2	87	759	0.6	2.2
Q_{out} =	0.459	319	0.5	199	1,737	1.4	5.1

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.08	0.18	0.01	0.08	0.01	k_{20}	10.2
TP_{runoff} =	3.50	5.85	0.19	2.65	0.21	C*	0.05
TP_{FWM} =	1.58	6.03	0.19	2.74	0.22	θ	1.00
TP_{out} =	0.25	0.97	0.03	0.44	0.03		
TP_{rem} =	1.32	5.06	0.16	2.30	0.18		
TP_{rem} (%) =	84	84	84	84	84		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	22	958,320	8.90	89,030

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.459	319	0.8	280	1,737	2.0	7.1
Q_{runoff} =	0.142	99	0.2	87	538	0.6	2.2
Q_{out} =	0.601	417	1.0	367	2,276	2.6	9.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.25	0.97	0.04	0.44	0.05	k_{20}	10.2
TP_{runoff} =	3.50	4.15	0.19	1.88	0.21	C*	0.05
TP_{FWM} =	1.02	5.12	0.23	2.32	0.26	θ	1.00
TP_{out} =	0.38	1.88	0.09	0.85	0.10		
TP_{rem} =	0.65	3.24	0.15	1.47	0.16		
TP_{rem} (%) =	63	63	63	63	63		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.601	417	1.4	505	2,276	3.5	12.8
Q_{runoff} =	0.116	80	0.3	97	438	0.7	2.5
Q_{out} =	0.717	498	1.7	602	2,714	4.2	15.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.38	1.88	0.12	0.85	0.13	k_{20}	14
TP_{runoff} =	3.50	3.38	0.21	1.53	0.24	C*	0.05
TP_{FWM} =	0.88	5.26	0.33	2.39	0.37	θ	1.00
TP_{out} =	0.38	2.29	0.14	1.04	0.16		
TP_{rem} =	0.50	2.97	0.19	1.35	0.21		
TP_{rem} (%) =	57	57	57	57	57		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	5%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	86.9	86.9	86.9	97.2	289.7	514.2	673.5	803.1
Annual Average Runoff Rate (gpm)					180	319	417	498

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	2	87,120	0.81	8,094

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.259	180	4.8	1,738	979	12.1	44.1
Q_{out} =	0.259	180	4.8	1,738	979	12.1	44.1

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	7.55	3.77	3.42	4.23	C*	0.05
TP_{FWM} =	3.50	7.55	3.77	3.42	4.23	θ	1.00
TP_{out} =	2.79	6.01	3.01	2.73	3.37		
TP_{rem} =	0.71	1.54	0.77	0.70	0.86		
TP_{rem} (%) =	20	20	20	20	20		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	1.55	67,518	0.63	6,273

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	6.1	2,243	979	15.6	57.0
Q_{runoff} =	0.200	139	4.8	1,738	759	12.1	44.1
Q_{out} =	0.459	319	10.9	3,981	1,737	27.7	101.1

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.79	6.01	3.88	2.73	4.35	k_{20}	10.2
TP_{runoff} =	3.50	5.85	3.77	2.65	4.23	C*	0.05
TP_{FWM} =	3.10	11.86	7.65	5.38	8.58	θ	1.00
TP_{out} =	2.81	10.74	6.93	4.87	7.77		
TP_{rem} =	0.29	1.12	0.72	0.51	0.81		
TP_{rem} (%) =	9	9	9	9	9		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	1	47,916	0.45	4,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.459	319	15.4	5,609	1,737	39.0	142.5
Q_{runoff} =	0.142	99	4.8	1,738	538	12.1	44.1
Q_{out} =	0.601	417	20.1	7,347	2,276	51.1	186.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.81	10.74	9.77	4.87	10.94	k_{20}	10.2
TP_{runoff} =	3.50	4.15	3.77	1.88	4.23	C*	0.05
TP_{FWM} =	2.97	14.89	13.54	6.75	15.17	θ	1.00
TP_{out} =	2.82	14.11	12.83	6.40	14.38		
TP_{rem} =	0.16	0.78	0.71	0.35	0.79		
TP_{rem} (%) =	5	5	5	5	5		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.601	417	1.4	505	2,276	3.5	12.8
Q_{runoff} =	0.116	80	0.3	97	438	0.7	2.5
Q_{out} =	0.717	498	1.7	602	2,714	4.2	15.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.82	14.11	0.88	6.40	0.99	k_{20}	14
TP_{runoff} =	3.50	3.38	0.21	1.53	0.24	C*	0.05
TP_{FWM} =	2.93	17.49	1.09	7.93	1.23	θ	1.00
TP_{out} =	1.20	7.18	0.45	3.26	0.50		
TP_{rem} =	1.72	10.31	0.64	4.67	0.72		
TP_{rem} (%) =	59	59	59	59	59		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	10%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	86.9	86.9	86.9	97.2	289.7	514.2	673.5	803.1
Annual Average Runoff Rate (gpm)					179.6	319	417	498

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	4	174,240	1.62	16,187

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.259	180	2.4	869	979	6.0	22.1
Q_{out} =	0.259	180	2.4	869	979	6.0	22.1

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	7.55	1.89	3.42	2.11	C*	0.05
TP_{FWM} =	3.50	7.55	1.89	3.42	2.11	θ	1.00
TP_{out} =	2.22	4.79	1.20	2.17	1.34		
TP_{rem} =	1.28	2.75	0.69	1.25	0.77		
TP_{rem} (%) =	36	36	36	36	36		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	3.1	135,036	1.25	12,545

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	3.1	1,121	979	7.8	28.5
Q_{runoff} =	0.200	139	2.4	869	759	6.0	22.1
Q_{out} =	0.459	319	5.5	1,990	1,737	13.9	50.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.22	4.79	1.55	2.17	1.73	k_{20}	10.2
TP_{runoff} =	3.50	5.85	1.89	2.65	2.11	C*	0.05
TP_{FWM} =	2.78	10.64	3.43	4.83	3.85	θ	1.00
TP_{out} =	2.28	8.73	2.82	3.96	3.16		
TP_{rem} =	0.50	1.91	0.62	0.87	0.69		
TP_{rem} (%) =	18	18	18	18	18		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	2	95,832	0.89	8,903

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.459	319	7.7	2,805	1,737	19.5	71.2
Q_{runoff} =	0.142	99	2.4	869	538	6.0	22.1
Q_{out} =	0.601	417	10.1	3,674	2,276	25.6	93.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.28	8.73	3.97	3.96	4.45	k_{20}	10.2
TP_{runoff} =	3.50	4.15	1.89	1.88	2.11	C*	0.05
TP_{FWM} =	2.57	12.89	5.86	5.84	6.56	θ	1.00
TP_{out} =	2.31	11.58	5.26	5.25	5.90		
TP_{rem} =	0.26	1.31	0.59	0.59	0.67		
TP_{rem} (%) =	10	10	10	10	10		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.601	417	1.4	505	2,276	3.5	12.8
Q_{runoff} =	0.116	80	0.3	97	438	0.7	2.5
Q_{out} =	0.717	498	1.7	602	2,714	4.2	15.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.31	11.58	0.72	5.25	0.81	k_{20}	14
TP_{runoff} =	3.50	3.38	0.21	1.53	0.24	C*	0.05
TP_{FWM} =	2.50	14.95	0.93	6.78	1.05	θ	1.00
TP_{out} =	1.03	6.17	0.39	2.80	0.43		
TP_{rem} =	1.47	8.79	0.55	3.98	0.62		
TP_{rem} (%) =	59	59	59	59	59		

Lamb Island Dairy
Estimated Performance for Overland Flow Area

Location	Area (ac)	CN	S		Area Factor	50%
Terrace 1	40	89	1.24			
Terrace 2	31	89	1.24			
Terrace 3	22	89	1.24			
Marsh	16	98	0.20			
Total	109					

	Runoff (inches)				Cumulative Runoff (ac-ft)			
	Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Total	86.9	86.9	86.9	97.2	289.7	514.2	673.5	803.1
Annual Average Runoff Rate (gpm)					180	319	417	498

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	20	871,200	8.09	80,937

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.259	180	0.5	174	979	1.2	4.4
Q_{out} =	0.259	180	0.5	174	979	1.2	4.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	7.55	0.38	3.42	0.42	C*	0.05
TP_{FWM} =	3.50	7.55	0.38	3.42	0.42	θ	1.00
TP_{out} =	0.39	0.85	0.04	0.38	0.05		
TP_{rem} =	3.11	6.70	0.34	3.04	0.38		
TP_{rem} (%) =	89	89	89	89	89		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	15.5	675,180	6.27	62,726

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	0.6	224	979	1.6	5.7
Q_{runoff} =	0.200	139	0.5	174	759	1.2	4.4
Q_{out} =	0.459	319	1.1	398	1,737	2.8	10.1

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.39	0.85	0.05	0.38	0.06	k_{20}	10.2
TP_{runoff} =	3.50	5.85	0.38	2.65	0.42	C*	0.05
TP_{FWM} =	1.75	6.70	0.43	3.04	0.48	θ	1.00
TP_{out} =	0.67	2.56	0.17	1.16	0.19		
TP_{rem} =	1.08	4.13	0.27	1.87	0.30		
TP_{rem} (%) =	62	62	62	62	62		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	11	479,160	4.45	44,515

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.459	319	1.5	561	1,737	3.9	14.2
Q_{runoff} =	0.142	99	0.5	174	538	1.2	4.4
Q_{out} =	0.601	417	2.0	735	2,276	5.1	18.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.67	2.56	0.23	1.16	0.26	k_{20}	10.2
TP_{runoff} =	3.50	4.15	0.38	1.88	0.42	C*	0.05
TP_{FWM} =	1.34	6.71	0.61	3.05	0.68	θ	1.00
TP_{out} =	0.80	3.99	0.36	1.81	0.41		
TP_{rem} =	0.54	2.72	0.25	1.23	0.28		
TP_{rem} (%) =	41	41	41	41	41		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.601	417	1.4	505	2,276	3.5	12.8
Q_{runoff} =	0.116	80	0.3	97	438	0.7	2.5
Q_{out} =	0.717	498	1.7	602	2,714	4.2	15.3

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.80	3.99	0.25	1.81	0.28	k_{20}	14
TP_{runoff} =	3.50	3.38	0.21	1.53	0.24	C*	0.05
TP_{FWM} =	1.23	7.37	0.46	3.34	0.52	θ	1.00
TP_{out} =	0.52	3.13	0.20	1.42	0.22		
TP_{rem} =	0.71	4.24	0.26	1.92	0.30		
TP_{rem} (%) =	58	58	58	58	58		

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MEMORANDUM

Lamb Island Dairy Remediation Project - Estimated Performance of Overland Flow Terraces

TO: Terry Horan/HSA

COPIES: File

FROM: Bob Knight/WSI
Chris Keller/WSI

DATE: December 3, 2003

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Executive Summary

HSA Engineers and Scientists (HSA) prepared a design report for the Lamb Island Dairy Remediation Project that included a large overland flow area as part of the treatment system (HSA, 2003). The South Florida Water Management District (District) has proposed modifications to the design that include subdividing the overland flow area into three terraces and a treatment wetland at the downstream end of the system. Wetland Solutions, Inc. (WSI) has been tasked to update previous total phosphorus (TP) removal estimates for the overland flow area that incorporates the District's proposed design modifications.

Performance estimates for the proposed terrace/wetland system indicate that inflow TP concentrations can be reduced from an assumed existing runoff concentration of 3.5 mg/L to less than 0.2 mg/L as an annual average outflow, assuming an even distribution of runoff across the terraces, and a final treatment wetland with an effective area of 16 acres. Inefficient use of the terraces and wetland area will likely reduce TP removal performance. WSI recommends that collection and distribution features be included at the inlet and outlet ends of each compartment to maximize the effective use of the available treatment area.

Introduction

WSI prepared a previous technical memorandum summarizing the expected TP removal performance for proposed treatment wetland cells and overland flow areas at the Lamb Island Dairy in Okeechobee County (WSI, 2003a). Since then, the District has proposed an alternative layout for the overland flow area that incorporates terraced compartments and a terminal wetland cell. This memorandum presents a revised performance estimate for the 109-acre overland flow area.

Modeling Approach and Results

Exhibit 1 shows the revised layout of the overland flow area. The 109-acre area will be subdivided into four compartments separated by low earthen berms. The northern terrace (approximately 40 acres) will receive direct rainfall during average years, and may also receive overflows from the High Intensity Area (HIA) during extreme wet conditions. The central terrace (approximately 31 acres) and southern terrace (approximately 22 acres) receive direct rainfall and runoff from upstream terraces. The 16-acre wetland area will receive direct rainfall and runoff from the three upstream terraces.

Annual average runoff volumes were determined for each compartment based upon curve numbers (89 for terraces and 98 for wetland) and rainfall records provided by HSA (HSA, 2003). Exhibit 2 shows the runoff depths and cumulative runoff volumes for the revised overland flow system. HSA also provided an assumed runoff TP concentration of 3.5 mg/L.

The k-C* model of Kadlec and Knight (1996) was used to estimate annual average performance of the terraces and the wetland area. Model parameters for surface-flow, marsh wetlands north of Lake Okeechobee were used in this model for the wetland cell (WSI, 2003). Because the terraces are bermed, it is assumed that they will remain at least partially inundated and can be modeled as shallow emergent wetlands. A reduced removal rate (k) of 10.2 m/yr was used for the terraced areas to reflect the assumption that portions of these areas will be intermittently flooded.

The modeling approach assumes that inflows to each compartment consist of the runoff from upstream cells and the runoff generated by direct rainfall over the compartment. The initial TP concentration in the first terrace was assumed to be 3.5 mg/L. The k-C* model was used to estimate the reduction in TP concentration with passage through the compartment. Subsequent compartments receive the upstream flow, with a reduced TP concentration, and the direct runoff for the compartment with an assumed TP concentration of 3.5 mg/L. The flow-weighted mean TP concentration was applied to the k-C* model to determine the effluent TP concentration for each compartment.

Exhibit 3 summarizes the results of the performance assessment for the revised terrace/wetland design in comparison to the earlier overland flow design approach. Detailed results are provided in Appendix A. The results indicate that a final effluent TP concentration below 0.2 mg/L is estimated based on the assumption of effective use of the available land area. The revised design provides for lower estimated outflow TP concentrations and greater mass reductions than the previous overland flow system. The improved performance is primarily due to lower assumed inflow TP concentrations (3.5 mg/L versus 8.0 mg/L) and the selection of a more efficient treatment system (wetlands versus overland flow).

Exhibit 4 shows the estimated effect of the final cell treatment wetland area on the effluent TP concentration. Estimated final effluent TP concentrations range from about 0.7 mg/L to less than 0.2 mg/L as the effective wetland area increases.

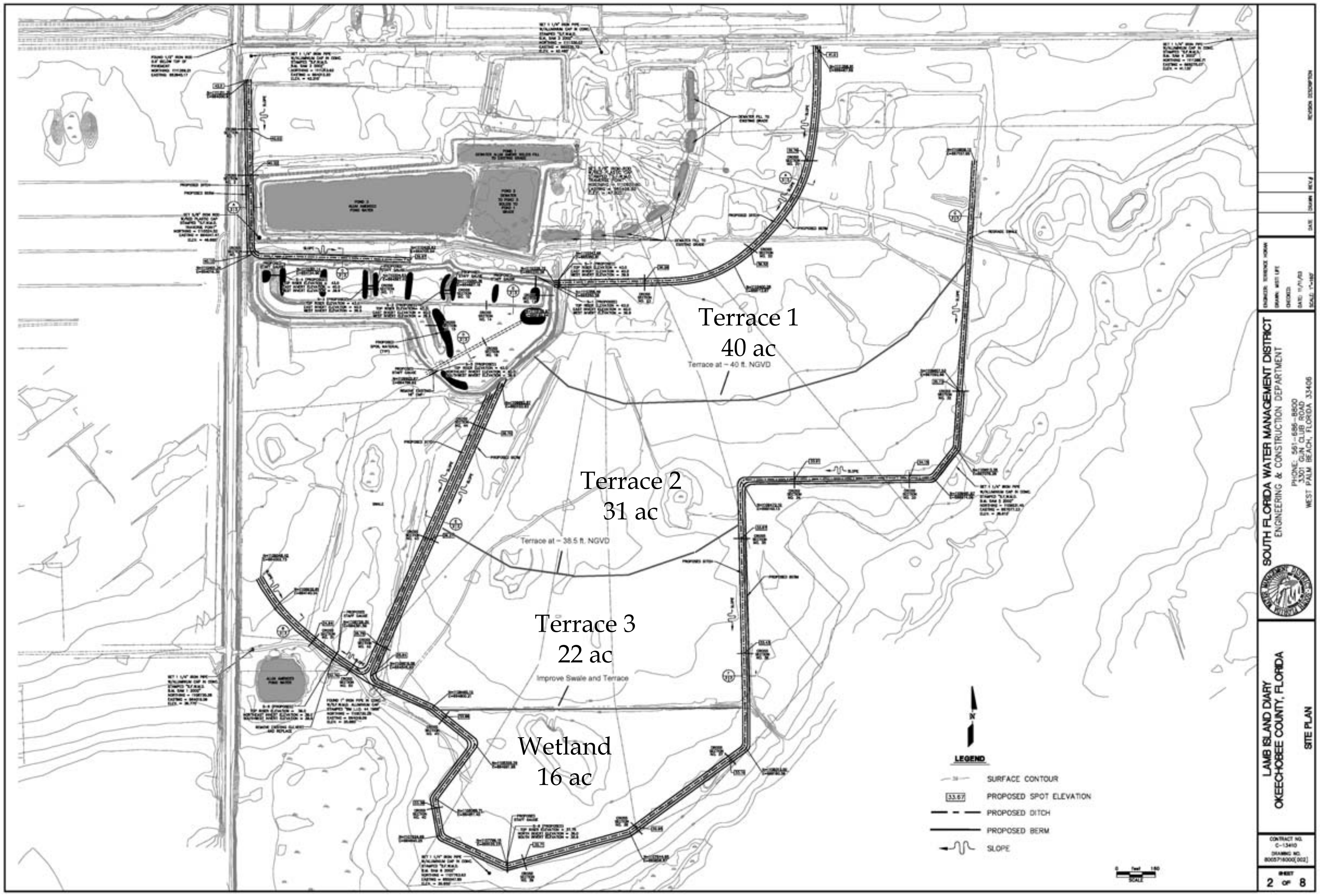


EXHIBIT 1
Proposed Terrace/Wetland Design, Lamb Island Dairy Remediation Project (Source: HSA)

EXHIBIT 2
Estimated Annual Average Runoff, Lamb Island Dairy Terrace/Wetland Cells

Month	Rainfall (inches)	Estimated Runoff (inches)				Estimated Cumulative Runoff (ac-ft)			
		Terrace 1	Terrace 2	Terrace 3	Marsh	Terrace 1	Terrace 2	Terrace 3	Marsh
Jan	2.7	1.6	1.6	1.6	2.5	5.4	9.7	12.6	15.9
Feb	2.5	1.5	1.5	1.5	2.3	4.9	8.6	11.3	14.3
Mar	4.0	2.8	2.8	2.8	3.8	9.4	16.7	21.9	26.9
Apr	3.2	2.1	2.1	2.1	3.0	6.9	12.3	16.1	20.1
May	3.8	2.6	2.6	2.6	3.6	8.8	15.6	20.4	25.2
Jun	7.1	5.8	5.8	5.8	6.9	19.4	34.4	45.0	54.1
Jul	5.8	4.5	4.5	4.5	5.6	15.1	26.9	35.2	42.6
Aug	7.9	6.6	6.6	6.6	7.7	22.0	39.0	51.1	61.3
Sep	6.3	5.0	5.0	5.0	6.1	16.8	29.7	39.0	47.0
Oct	4.2	3.0	3.0	3.0	4.0	10.0	17.8	23.3	28.6
Nov	1.7	0.8	0.8	0.8	1.5	2.6	4.6	6.1	8.1
Dec	1.7	0.8	0.8	0.8	1.5	2.6	4.6	6.1	8.1
Total	50.9	37.1	37.1	37.1	48.5	123.9	219.9	288.1	352.2
Annual Average Runoff Rate (gpm)						77	136	179	218

Source for Rainfall Data: HSA, 2003.

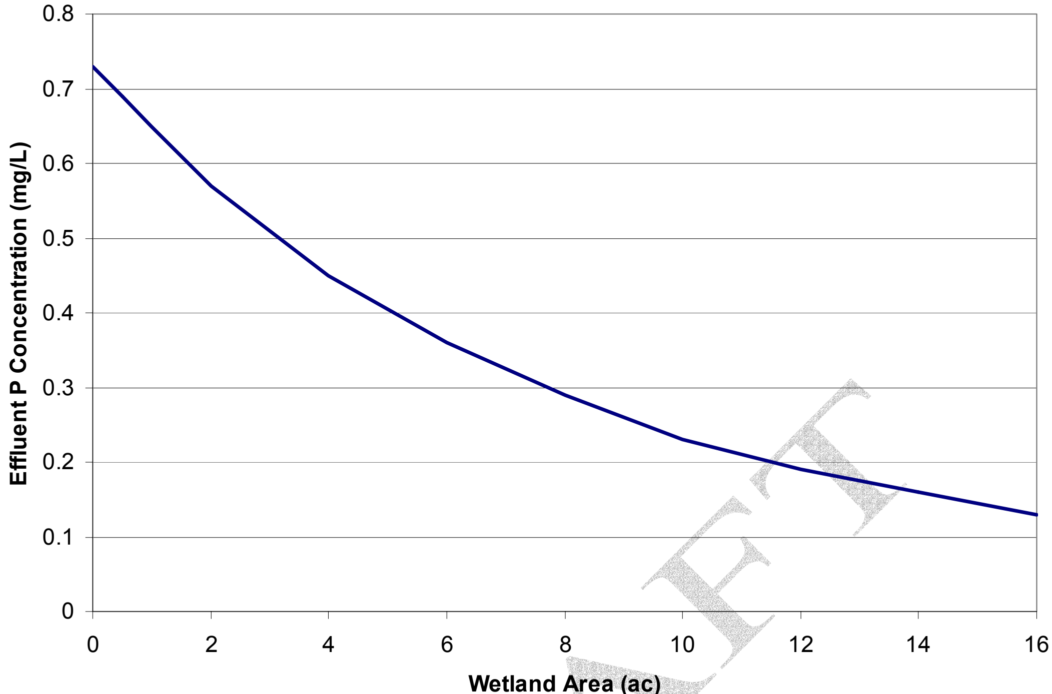
EXHIBIT 3
Estimated TP Removal Performance of the Lamb Island Dairy Terrace/Wetland Areas

Parameter	**Current Design**[1]	**Previous Design**[2]
Annual Average Inflow TP Concentration (mg/L)	3.5	8.0
Runoff Flow Rate (gpm)	218	209
Annual Average TP Mass Load (kg)	1,518	3,325
Estimated Outflow TP Concentration (mg/L)	0.13	5.6
Annual Average TP Mass Discharged (kg)	56	2,328
Concentration Reduction (%)	96	30
TP Mass Removed (kg)	1,462	997
Mass Reduction (%)	96	30

[1]Current Design: Partially inundated terraces (93 acres) followed by treatment wetland (16 acres); k-C* model used for TP removal estimates.
[2]Previous Design: Overland flow pasture (109 acres); assumed 30% TP concentration reduction based on overland flow literature.

EXHIBIT 4

Estimated Effect of Wetland Area on Final Effluent P Concentration



Conclusions and Recommendations

This analysis indicates that substantial reductions in runoff TP concentrations may be achieved with the combined terrace/wetland system, based on the stated assumptions and as long as the available area is effectively used. Reductions in TP removal efficiency can be expected to result from berm erosion that could cause hydraulic short-circuiting. WSI recommends that the final design include features such as shallow collector swales at the upstream toe of each terrace berm and stabilized (i.e. concrete) distribution notches along the length of each berm.

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Appendix A – Detailed Results

Terrace Compartment 1

Parameter	acres	ft^2	hectares	m^2
Area =	40	1,742,400	16.19	161,873

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.000	0	0.0	0	0	0.0	0.0
Q_{runoff} =	0.111	77	0.1	37	419	0.3	0.9
Q_{out} =	0.111	77	0.1	37	419	0.3	0.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.00	0.00	0.00	0.00	0.00	k_{20}	10.2
TP_{runoff} =	3.50	3.23	0.08	1.46	0.09	C*	0.05
TP_{FWM} =	3.50	3.23	0.08	1.46	0.09	θ	1.00
TP_{out} =	0.05	0.05	0.00	0.02	0.00		
TP_{rem} =	3.45	3.18	0.08	1.44	0.09		
TP_{rem} (%) =	99	99	99	99	99		

Terrace Compartment 2

Parameter	acres	ft^2	hectares	m^2
Area =	31	1,350,360	12.55	125,452

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	0.1	48	419	0.3	1.2
Q_{runoff} =	0.086	60	0.1	37	324	0.3	0.9
Q_{out} =	0.196	136	0.2	85	743	0.6	2.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.05	0.05	0.00	0.02	0.00	k_{20}	10.2
TP_{runoff} =	3.50	2.50	0.08	1.13	0.09	C*	0.05
TP_{FWM} =	1.56	2.55	0.08	1.16	0.09	θ	1.00
TP_{out} =	0.06	0.10	0.00	0.05	0.00		
TP_{rem} =	1.49	2.44	0.08	1.11	0.09		
TP_{rem} (%) =	96	96	96	96	96		

Terrace Compartment 3

Parameter	acres	ft^2	hectares	m^2
Area =	22	958,320	8.90	89,030

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.196	136	0.3	120	743	0.8	3.0
Q_{runoff} =	0.061	42	0.1	37	230	0.3	0.9
Q_{out} =	0.257	179	0.4	157	973	1.1	4.0

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.06	0.10	0.00	0.05	0.01	k_{20}	10.2
TP_{runoff} =	3.50	1.78	0.08	0.81	0.09	C*	0.05
TP_{FWM} =	0.88	1.88	0.09	0.85	0.10	θ	1.00
TP_{out} =	0.11	0.24	0.01	0.11	0.01		
TP_{rem} =	0.76	1.63	0.07	0.74	0.08		
TP_{rem} (%) =	87	87	87	87	87		

Wetland Compartment

Parameter	acres	ft^2	hectares	m^2
Area =	16	696,960	6.47	64,749

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.257	179	0.6	216	973	1.5	5.5
Q_{runoff} =	0.057	40	0.1	48	217	0.3	1.2
Q_{out} =	0.314	218	0.7	264	1,190	1.8	6.7

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.11	0.24	0.02	0.11	0.02	k_{20}	14
TP_{runoff} =	3.50	1.67	0.10	0.76	0.12	C*	0.05
TP_{FWM} =	0.73	1.92	0.12	0.87	0.13	θ	1.00
TP_{out} =	0.13	0.35	0.02	0.16	0.02		
TP_{rem} =	0.60	1.56	0.10	0.71	0.11		
TP_{rem} (%) =	82	82	82	82	82		

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MEMORANDUM

Estimated Performance of the Proposed Lamb Island Dairy Remediation Project

TO: Terry Horan/HSA

COPIES: File

FROM: Bob Knight/WSI
Chris Keller/WSI

DATE: November 10, 2003

Contents

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Executive Summary

This memorandum provides a revised evaluation of the efficacy of a system of treatment ponds and wetlands at the former Lamb Island Dairy in Okeechobee County, Florida. HSA Engineers and Scientists are in the process of developing a final design for water quality remediation at the site to control off-site releases of total phosphorus (TP) and other pollutants.

This memorandum provides an updated estimate of the likely performance of four Eco-Reactor (constructed wetland) cells and a receiving swale operating in series and a separate overland flow area. Based on the assumptions used for this analysis, it is estimated that the annual average outflow TP from the proposed wetland treatment train will be about 0.16 mg/L. The estimated hydraulic residence time in the system is about 51 days. The overland flow area is expected to reduce TP concentrations from about 8.0 mg/L to about 5.6 mg/L.

There are numerous considerations for engineering design and operations and management that could affect actual performance of the proposed project.

Introduction

This memorandum describes estimates of removal of TP from a proposed dairy remediation project in south Florida. The Lamb Island Dairy property includes 808 acres in Okeechobee County, Florida, north of Lake Okeechobee. Water flows from this property into Cypress Slough and Chandler Slough. The property was owned and operated as a dairy from about

1981 until 1994, when it was purchased by the South Florida Water Management District (District). Beef cattle were kept on the property until about 1998.

HSA Engineers and Scientists (HSA) were retained to implement a TP remediation program on the former dairy site. HSA retained Wetland Solutions, Inc. (WSI) to provide estimates of phosphorus removals in natural treatment processes included in the remediation plan, including constructed wetland cells called "Eco-Reactors," an existing swale, and a large overland flow area. This memorandum describes the methods and results of WSI's performance evaluation.

This performance evaluation is based on existing information when available, and on best professional judgment when information is incomplete.

The primary proposed remediation system consists of four Eco-Reactor cells and a vegetated swale:

- Eco-Reactor Tank 1 (0.98 ac)
- Eco-Reactor Tank 2 (1.12 ac)
- Eco-Reactor Tank 3 (1.38 ac)
- Eco-Reactor Tank 4 (3.01 ac)
- Swale (12.0 ac; effective area 5.0 ac)

The effective area for the swale was reduced from the 12.0 acres provided by HAS. If expected to function as an emergent wetland system, the maximum standing water elevation in the swale should not exceed 3 feet. The effective swale area was estimated from site topography to be approximately 5.0 acres. A 109-acre portion of the site will be bermed to create an overland flow area that will provide additional treatment of excess runoff.

For the purposes of this evaluation it is assumed that the Eco-Reactor cells and swale will be maintained with relatively shallow water depths (12 to 18 inches for the cells, and up to a maximum of 3 feet for the swale) so they will be covered with a full stand of emergent vegetation such as cattails. It is also assumed that these cells will be reconfigured and modified to provide effective sheetflow and even distribution by incorporation of new inlet/outlet structures, deep zones, and re-grading. The overland flow area will be maintained with extremely shallow water depths so they will be covered with grass species suitable for hay production.

Methods

Historical records have been used as the basis to anticipate future flows and constituent mass loads to the remediation project. An annual average inflow to the Eco-Reactor/Swale system of 420 m^3/d (77 gpm) was provided to WSI by HSA. The annual average inflow TP was taken from recent water quality data gathered by HSA and is estimated to be 8.0 mg/L. A mass balance spreadsheet was been developed to illustrate the estimated flows and loads to each of the project components.

Total runoff from the 109-acre terraced area was calculated using the same runoff coefficients as for the high intensity area (HIA) that feeds the Eco-Reactor cells. The annual total runoff, under average rainfall conditions, was estimated to be 338 acre-feet (209 gpm).

Annual average water balances for each of the project components were estimated based on long-term average rainfall from SWET (2002) of 51 in/yr and estimated evapotranspiration (ET) of 54 in/yr based on pan evaporation data from Station ID 858950 (NCDD, 1995) and a pan factor of 0.70 from Kadlec and Knight (1996) for treatment wetlands.

The k-C* model of Kadlec and Knight (1996) was used for estimating performance of the Eco-Reactor cells and vegetated swale. Model parameters for surface-flow, marsh wetlands north of Lake Okeechobee ($k = 14$ m/yr; $C^* = 0.05$ mg/L) were used in this model (WSI, 2003). Overland flow performance was estimated using an assumed TP removal efficiency of 30 percent. This value was based on a review of overland flow and vegetated filter strip literature (Doyle, 1977; Edwards et al., 1978, Dillaha et al., 1989) and best professional judgment.

Results

Exhibit 1 summarizes the performance assessment for the proposed Lamb Island Dairy project. Appendix Tables A-1 through A-5 provide detailed flow and mass balance estimates for each cell in the treatment train. Appendix Table A-6 provides detailed flow and mass balance estimates for the overland flow area. Based on the methods and assumptions described above, the Eco-Reactor is expected to reduce the annual average TP concentration from 8.0 mg/L to about 0.8 mg/L, with a nominal detention time of 13 days. The swale is expected to further reduce the TP concentration to 0.16 mg/L, with an additional detention time of 22 days, based upon an average depth of 1.5 feet. Flow is expected to decrease slightly based on long-term average climatic conditions from about 420 to 409 m^3/d (77 to 75 gpm). The overland flow area is expected to reduce TP concentrations from 8.0 mg/L to about 5.6 mg/L.

The methods employed in this analysis do not provide estimates of associated uncertainty in these figures. However, the analysis was rerun with the maximum monthly flows (Appendix Tables A-7 through A-11) and average conditions, but lower background concentrations (Appendix Tables A-12 through A-16) to bracket the range of performance that might be achieved. The average flow, based on maximum monthly runoff volumes was 190 gpm. The resulting final TP concentration discharged from the swale is estimated to be 0.47 mg/L. Using the average flow (77 gpm) and assuming that a lower background concentration can be achieved ($C^* = 0.02$ mg/L), the final swale discharge concentration was estimated to be 0.13 mg/L. Background TP levels between 0.01 and 0.02 mg/L have been measured at Boney Marsh, just north of Lake Okeechobee (WSI, 2003).

Based on these observed performance values, it appears that a reasonable range of average estimates around the final Eco-reactor/swale performance estimate of 0.16 mg/L is 0.13 to 0.47 mg/L.

Other Considerations

Actual flows and loads to the proposed remediation system are likely to be variable due to periodic rainfall and seasonally-varying ET rates. These flow and mass load variations are likely to result in variable system performance. In addition, higher flows may result in hydraulic head loss differences and time-varying water depths in the wetland cells. Excessive water depths in the wetland cells may affect plant community structure and ultimately, treatment performance. For this reason a hydraulic profile for system water control structures and cell configurations over the range of possible flow rates must be evaluated during system design.

The DMSTA model has recently been explored as a tool for treatment wetland design in areas north of Lake Okeechobee (WSI, 2003). This platform may provide a better approximation of expected system performance than the methods used for this analysis, as long as reasonable inflow hydrographs and time-varying pollutant loads can be developed.

Pond/open water areas are not as effective as densely-vegetated emergent wetlands for TP removal (Kadlec and Knight, 1996). For these reasons it is important to insure that water depths will not exceed the growth requirements for the rooted macrophytes in the Eco-Reactor cells, resulting in significant areas of open water.

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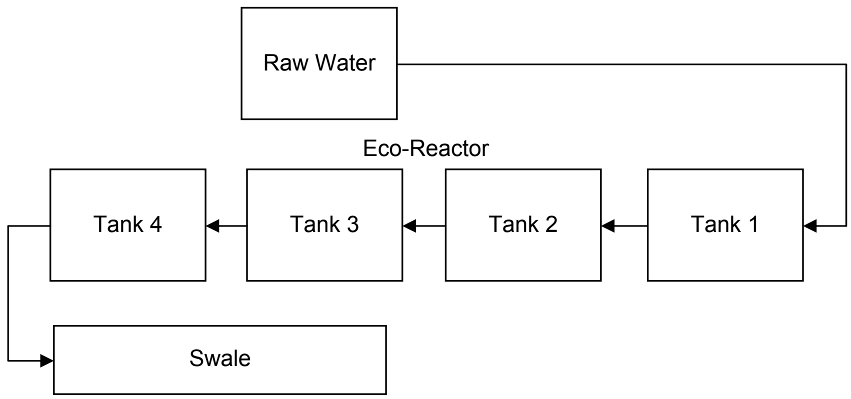
EXHIBIT 1

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance



Raw Water Inflow (m^3/d) =	420	TP In (mg/L) =	8.00

Unit	Area (ac)	Depth (m)	Detention Time (d)	Cumulative Detention Time (d)	Q_{in} (m^3/d)	Q_{delta} (%)	TP_{in} (mg/L)	TP_{in} (lb/d)	TP_{in} (lb/ac/d)	TP_{rem} (%)
Eco-Reactor										
Tank 1	0.98	0.46	4	4	420	-0.22	8.00	7.40	7.55	30
Tank 2	1.12	0.46	5	9	419	-0.26	5.58	5.15	4.60	34
Tank 3	1.38	0.46	6	15	418	-0.32	3.70	3.41	2.47	40
Tank 4	3.01	0.46	13	29	416	-0.69	2.24	2.05	0.68	66
Swale	5.0	0.46	23	51	414	-1.16	0.76	0.69	0.14	79
Discharge	---	---	---	---	409	---	0.16	0.14	0.03	---

Eco-Reactor Constructed Wetland Removals [a]	
k-C* Model Parameters	
k_{20}	14
C*	0.05
θ	1.00
k	14

Design temperature (C^o): 25

Water Balance	
rain (in/yr) =	51.0
ET (in/yr) =	54.4
perc (in/yr) =	0

Note(s):

Rainfall Period-of-Record: 1988-99 (SWET, 2002)

Pan Evaporation Period-of-Record: 1956-93 Stn ID: 858950 (NCDD, 1995)

ET = Pan Evaporation * 0.7

[a] Constructed surface flow treatment wetlands from Kadlec and Knight, 1996

Appendix A

Detailed Flow and Mass Balance Tables

APPENDIX A-1

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #1

Parameter	acres	ft^2	hectares	m^2
Area =	0.98	42,689	0.40	3,966

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	4.2	1,521	420	10.6	38.6
Q_{rain} =	0.004	2.6	0.140	51.0	14.1	0.355	1.295
Q_{ET} =	0.004	2.8	0.149	54.4	15.0	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.111	77	4.2	1,517	419	10.6	38.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	8.00	7.40	7.55	3.36	8.47	k_{20}	14
TP_{out} =	5.58	5.15	5.26	2.34	5.90	C*	0.05
TP_{rem} =	2.42	2.25	2.29	1.02	2.57	θ	1.00
TP_{rem} (%) =	30.2	30.4	30.4	30.4	30.4	k	14

APPENDIX A-2

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #2

Parameter	acres	ft^2	hectares	m^2
Area =	1.12	48,787	0.45	4,532

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	3.6	1,328	419	9.2	33.7
Q_{rain} =	0.004	3.0	0.140	51.0	16.1	0.355	1.295
Q_{ET} =	0.005	3.1	0.149	54.4	17.2	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.110	77	3.6	1,324	418	9.2	33.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	5.58	5.15	4.60	2.34	5.16	**k_{20}**	14
TP_{out} =	3.70	3.41	3.04	1.55	3.41	**C***	0.05
TP_{rem} =	1.88	1.74	1.56	0.79	1.75	**θ**	1.00
TP_{rem} (%) =	33.7	33.8	33.8	33.8	33.8	**k**	14

APPENDIX A-3

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #3

Parameter	acres	ft^2	hectares	m^2
Area =	1.38	60,113	0.56	5,585

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.110	77	2.9	1,075	418	7.5	27.3
Q_{rain} =	0.005	3.6	0.140	51.0	19.8	0.355	1.295
Q_{ET} =	0.006	3.9	0.149	54.4	21.1	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.110	76	2.9	1,071	416	7.5	27.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.70	3.41	2.47	1.55	2.77	k_{20}	14
TP_{out} =	2.24	2.05	1.49	0.93	1.67	C*	0.05
TP_{rem} =	1.47	1.36	0.98	0.62	1.10	θ	1.00
TP_{rem} (%) =	39.6	39.8	39.8	39.8	39.8	k	14

APPENDIX A-4

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #4

Parameter	acres	ft^2	hectares	m^2
Area =	3.01	131,116	1.22	12,181

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.110	76	1.3	491	416	3.4	12.5
Q_{rain} =	0.011	7.9	0.140	51.0	43.2	0.355	1.295
Q_{ET} =	0.012	8.5	0.149	54.4	46.1	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.109	76	1.3	488	414	3.4	12.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.24	2.05	0.68	0.93	0.76	k_{20}	14
TP_{out} =	0.76	0.69	0.23	0.32	0.26	C*	0.05
TP_{rem} =	1.48	1.36	0.45	0.62	0.51	θ	1.00
TP_{rem} (%) =	65.9	66.2	66.2	66.2	66.2	k	14

APPENDIX A-5

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Swale

Parameter	acres	ft^2	hectares	m^2
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.109	76	0.8	294	414	2.0	7.5
Q_{rain} =	0.019	13.2	0.140	51.0	71.8	0.355	1.295
Q_{ET} =	0.020	14.1	0.149	54.4	76.6	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.108	75	0.8	290	409	2.0	7.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.76	0.69	0.14	0.32	0.16	**k_{20}**	14
TP_{out} =	0.16	0.14	0.03	0.07	0.03	**C***	0.05
TP_{rem} =	0.60	0.55	0.11	0.25	0.12	θ	1.00
TP_{rem} (%) =	79.1	79.4	79.4	79.4	79.4	**k**	14

APPENDIX A-6

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Overland Flow Area

Parameter	acres	ft^2	hectares	m^2
Area =	109	4,748,040	44.11	441,104

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.301	209	0.1	37	1,140	0.3	0.9
Q_{rain} =	0.414	287.2	0.140	51.0	1,565.5	0.355	1.295
Q_{ET} =	0.441	306.3	0.149	54.4	1,669.9	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.274	190	0.1	34	1,036	0.2	0.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d
TP_{in} =	8.00	20.11	0.18	9.12	0.21
TP_{out} =	5.60	12.79	0.12	5.80	0.13
TP_{rem} =	2.40	7.32	0.07	3.32	0.08
TP_{rem} (%) =	30.0	36.4	36.4	36.4	36.4

Percent Removal 30%

APPENDIX A-7

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #1

Parameter	acres	ft^2	hectares	m^2
Area =	0.98	42,689	0.40	3,966

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	9.7	3,555	981	24.7	90.3
Q_{rain} =	0.004	2.6	0.140	51.0	14.1	0.355	1.295
Q_{ET} =	0.004	2.8	0.149	54.4	15.0	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.259	180	9.7	3,552	980	24.7	90.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	8.00	17.31	17.66	7.85	19.79	**k_{20}**	14
TP_{out} =	6.86	14.82	15.12	6.72	16.95	**C***	0.05
TP_{rem} =	1.14	2.48	2.53	1.13	2.84	θ	1.00
TP_{rem} (%) =	14.3	14.4	14.4	14.4	14.4	**k**	14

APPENDIX A-8

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #2

Parameter	acres	ft^2	hectares	m^2
Area =	1.12	48,787	0.45	4,532

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	8.5	3,108	980	21.6	78.9
Q_{rain} =	0.004	3.0	0.140	51.0	16.1	0.355	1.295
Q_{ET} =	0.005	3.1	0.149	54.4	17.2	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.259	180	8.5	3,104	979	21.6	78.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	6.86	14.82	13.23	6.72	14.83	**k_{20}**	14
TP_{out} =	5.75	12.42	11.09	5.63	12.43	**C***	0.05
TP_{rem} =	1.11	2.40	2.15	1.09	2.41	θ	1.00
TP_{rem} (%) =	16.1	16.2	16.2	16.2	16.2	**k**	14

APPENDIX A-9

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #3

Parameter	acres	ft^2	hectares	m^2
Area =	1.38	60,113	0.56	5,585

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.259	180	6.9	2,520	979	17.5	64.0
Q_{rain} =	0.005	3.6	0.140	51.0	19.8	0.355	1.295
Q_{ET} =	0.006	3.9	0.149	54.4	21.1	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.258	179	6.9	2,516	978	17.5	63.9

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	5.75	12.42	9.00	5.63	10.08	k_{20}	14
TP_{out} =	4.63	9.98	7.24	4.53	8.11	C*	0.05
TP_{rem} =	1.12	2.43	1.76	1.10	1.98	θ	1.00
TP_{rem} (%) =	19.5	19.6	19.6	19.6	19.6	k	14

APPENDIX A-10

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #4

Parameter	acres	ft^2	hectares	m^2
Area =	3.01	131,116	1.22	12,181

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.258	179	3.2	1,154	978	8.0	29.3
Q_{rain} =	0.011	7.9	0.140	51.0	43.2	0.355	1.295
Q_{ET} =	0.012	8.5	0.149	54.4	46.1	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.258	179	3.2	1,150	975	8.0	29.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	4.63	9.98	3.32	4.53	3.72	**k_{20}**	14
TP_{out} =	2.89	6.21	2.06	2.82	2.31	**C***	0.05
TP_{rem} =	1.74	3.77	1.25	1.71	1.40	θ	1.00
TP_{rem} (%) =	37.6	37.8	37.8	37.8	37.8	**k**	14

APPENDIX A-11

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Swale

Parameter	acres	ft^2	hectares	m^2
Area =	12	522,720	4.86	48,562

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.258	179	0.8	289	975	2.0	7.3
Q_{rain} =	0.046	31.6	0.140	51.0	172.3	0.355	1.295
Q_{ET} =	0.049	33.7	0.149	54.4	183.8	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.255	177	0.8	285	963	2.0	7.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.89	6.21	0.52	2.82	0.58	k_{20}	14
TP_{out} =	0.47	1.00	0.08	0.45	0.09	C*	0.05
TP_{rem} =	2.42	5.21	0.43	2.37	0.49	θ	1.00
TP_{rem} (%) =	83.7	83.9	83.9	83.9	83.9	k	14

APPENDIX A-12

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #1

Parameter	acres	ft^2	hectares	m^2
Area =	0.98	42,689	0.40	3,966

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	4.2	1,521	420	10.6	38.6
Q_{rain} =	0.004	2.6	0.140	51.0	14.1	0.355	1.295
Q_{ET} =	0.004	2.8	0.149	54.4	15.0	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.111	77	4.2	1,517	419	10.6	38.5

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	8.00	7.40	7.55	3.36	8.47	k_{20}	14
TP_{out} =	5.57	5.15	5.25	2.33	5.89	C*	0.02
TP_{rem} =	2.43	2.26	2.30	1.02	2.58	θ	1.00
TP_{rem} (%) =	30.3	30.5	30.5	30.5	30.5	k	14

APPENDIX A-13

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #2

Parameter	acres	ft^2	hectares	m^2
Area =	1.12	48,787	0.45	4,532

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.111	77	3.6	1,328	419	9.2	33.7
Q_{rain} =	0.004	3.0	0.140	51.0	16.1	0.355	1.295
Q_{ET} =	0.005	3.1	0.149	54.4	17.2	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.110	77	3.6	1,324	418	9.2	33.6

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	5.57	5.15	4.59	2.33	5.15	k_{20}	14
TP_{out} =	3.69	3.40	3.03	1.54	3.40	C*	0.02
TP_{rem} =	1.89	1.75	1.56	0.79	1.75	θ	1.00
TP_{rem} (%) =	33.9	34.0	34.0	34.0	34.0	k	14

APPENDIX A-14

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #3

Parameter	acres	ft^2	hectares	m^2
Area =	1.38	60,113	0.56	5,585

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.110	77	2.9	1,075	418	7.5	27.3
Q_{rain} =	0.005	3.6	0.140	51.0	19.8	0.355	1.295
Q_{ET} =	0.006	3.9	0.149	54.4	21.1	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.110	76	2.9	1,071	416	7.5	27.2

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	3.69	3.40	2.46	1.54	2.76	k_{20}	14
TP_{out} =	2.22	2.03	1.47	0.92	1.65	C*	0.02
TP_{rem} =	1.47	1.36	0.99	0.62	1.11	θ	1.00
TP_{rem} (%) =	39.9	40.1	40.1	40.1	40.1	k	14

APPENDIX A-15

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Eco-Reactor Tank #4

Parameter	acres	ft^2	hectares	m^2
Area =	3.01	131,116	1.22	12,181

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.110	76	1.3	491	416	3.4	12.5
Q_{rain} =	0.011	7.9	0.140	51.0	43.2	0.355	1.295
Q_{ET} =	0.012	8.5	0.149	54.4	46.1	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.109	76	1.3	488	414	3.4	12.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	2.22	2.03	0.68	0.92	0.76	k_{20}	14
TP_{out} =	0.74	0.67	0.22	0.30	0.25	C*	0.02
TP_{rem} =	1.48	1.36	0.45	0.62	0.51	θ	1.00
TP_{rem} (%) =	66.8	67.1	67.1	67.1	67.1	k	14

APPENDIX A-16

Lamb Island Dairy Conceptual Treatment Process Estimated Annual Average Performance for Swale

Parameter	acres	ft^2	hectares	m^2
Area =	5	217,800	2.02	20,234

Parameter	mgd	gpm	in/d	in/yr	m^3/d	cm/d	m/yr
Q_{in} =	0.109	76	0.8	294	414	2.0	7.5
Q_{rain} =	0.019	13.2	0.140	51.0	71.8	0.355	1.295
Q_{ET} =	0.020	14.1	0.149	54.4	76.6	0.379	1.382
Q_{perc} =	0.000	0.0	0.000	0	0.0	0.000	0.000
Q_{out} =	0.108	75	0.8	290	409	2.0	7.4

Parameter	mg/L	lb/d	lb/ac/d	kg/d	kg/ha/d	Model Parameters	
TP_{in} =	0.74	0.67	0.13	0.30	0.15	k_{20}	14
TP_{out} =	0.13	0.12	0.02	0.05	0.03	C*	0.02
TP_{rem} =	0.61	0.55	0.11	0.25	0.12	θ	1.00
TP_{rem} (%) =	82.4	82.6	82.6	82.6	82.6	k	14

APPENDIX F

BENCH SCALE TREATABILITY STUDY DATA

Lamb Island Dairy Chemical testing September 25-26, 2002

For testing of SRP used Hach Spectrophotometer and diluted 1ml sample in 100 ml DI Water.

Pond 1 Testing Results:

200ml pond 1 water

µl of Alum	P (mg/L
Raw - 0	0.21
60	0.03
100	0.08
150	0.04
200	0.07
250	0.05
300	0
60 - repeat	0.03

Observations:

60 µl – slight color change, little settling
100 µl – floc throughout with tea color, slight settling
150 µl – floc throughout, good settling, yellowish color
200 µl – better settling weak tea color
250 µl – Excellent settling weaker tea color, some suspended floc
300 µl – Water clear total settling

Re-run of pond 1 water sampling at 30, 60 and 100 µl of alum:

µl of Alum	pH	P (mg/L
30	7.09	0.26
60	6.44	0.07
100	6.82	0.14

Observations:

60 µl – Better settling at 60 µl almost clear
100 – floc throughout with yellow color

Pond 1 Sludge:

50g of sludge was mixed with 200 ml water. Each mixture was then mixed with a volume of alum below and allowed to settle for 45 minutes:

µl alum	pH	P (mg/L
Raw sludge - 0	6.98	0.14
100	5.84	0.03
150	5.29	0.02
200	4.82	0.05
250	4.61	0
300	4.43	0
55		0.02

Pond 2 Water:
200 ml of pond 2 water was mixed with a volume of alum below and allowed to settle:

µl alum	pH	P (mg/L
Raw – 0	8.15	0.10
30	7.51	0.01
60	7.19	0.02
100	7.09	0.02
150	6.87	0
200	6.55	0.02
250	6.42	0.03
60 – repeat		0.02

Observations:

30 µl – cloudy floc throughout slight settling
60 µl – Larger particulate floc throughout, slight settling
100 µl – very similar to 60, better clarity
150 µl – clear top 2/3rds defined floc, visible settling
200 µl – water clear, more settling
250 µl – Larger, more floc on bottom

Pond 2 Sludge:
50 g of sludge was mixed with 200 ml of water. Various volumes of alum shown below were mixed with each mixture of sludge.

µl of alum	pH	P (mg/L
Raw – 0	7.86	0.21
100	6.85	0
150	6.5	0

Observations:

100 µl – good settling, still cloudy
150 µl – 250 µl – clear water total settling

Results for treated sludge amended to soil

50 g of sludge treated with 250µl of alum was amended to 250g of soil
Results:

	P (mg/L)
	0.09

100g sludge treated with 250µ of alum was amended to 500g soil and mixed with 400 ml of DI water. Results:

	P (mg/L)
	0.13

50g of sludge treated with 55µ of alum was amended to 250g of soil:

	P(mg/L)
	0.14

Raw Soil Analysis:

10 g of soil was mixed with 100ml of DI water

P - .02 mg/L
P_2O_5 - .04 mg/L
PO_4 - .05 mg/L

250g of soil was mixed with 200 g of DI water and allowed to filter through a Whatman 25 filter for a few minutes and overnight. Results:

	P (mg/L)
Immediate sample	0.08
Overnight sample	0.18

HCA Amended soil Analysis:

250 g of soil was amended with various amounts of HCA(High Clay Aluminum) and mixed with 100 ml DI water. Results:

Grams of HCA	P (mg/L)
2	0.11
4	0.04
8	0.07
16	0.22

Alum Amended soil Analysis:

250 grams soil was amended with various amounts of alum below and mixed with 100 ml of DI water. Results:

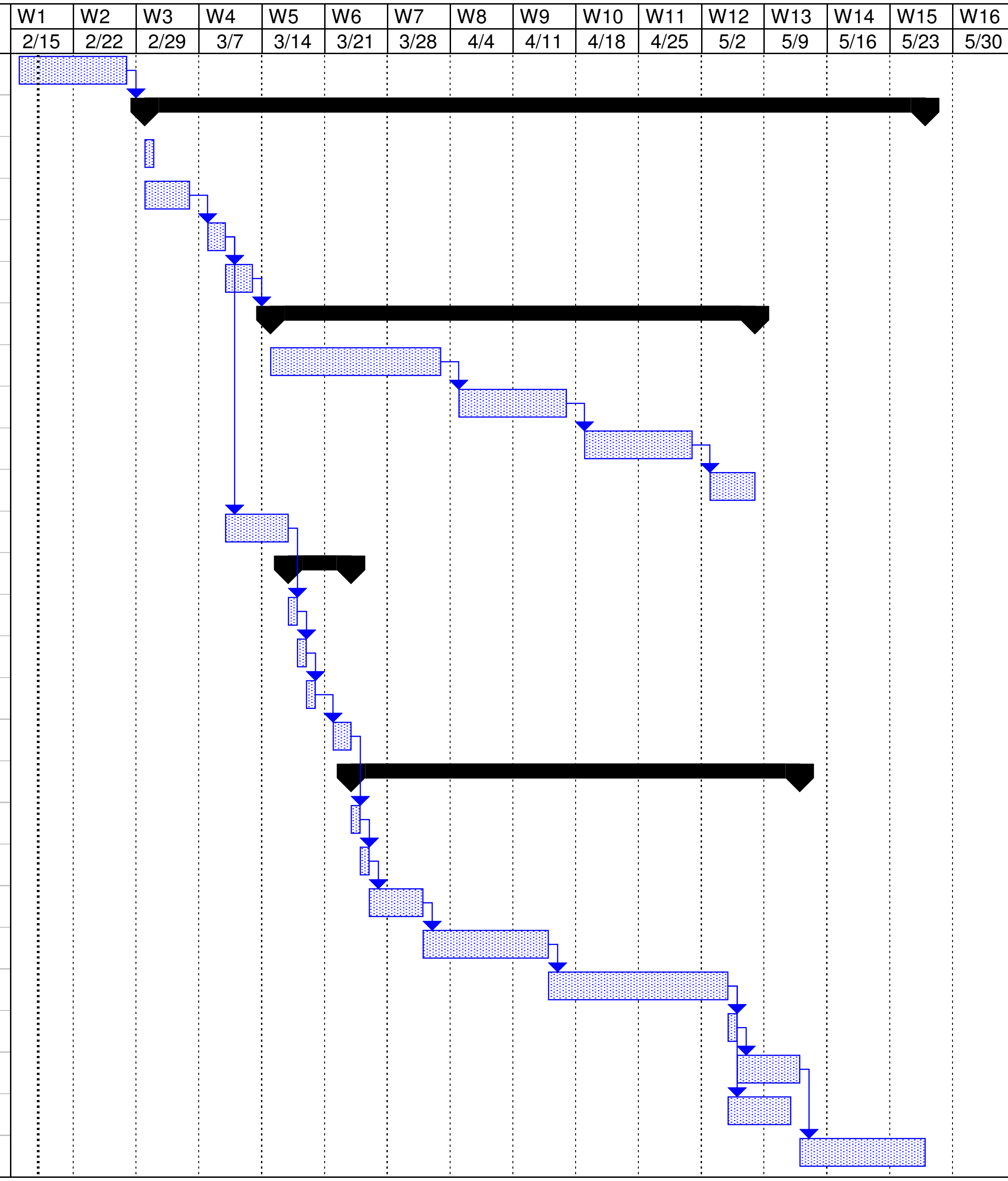
µl Alum added	P (mg/L)
60	0.05
150	0.13
250	0.13

APPENDIX G

PROJECT COMPLETION SCHEDULE

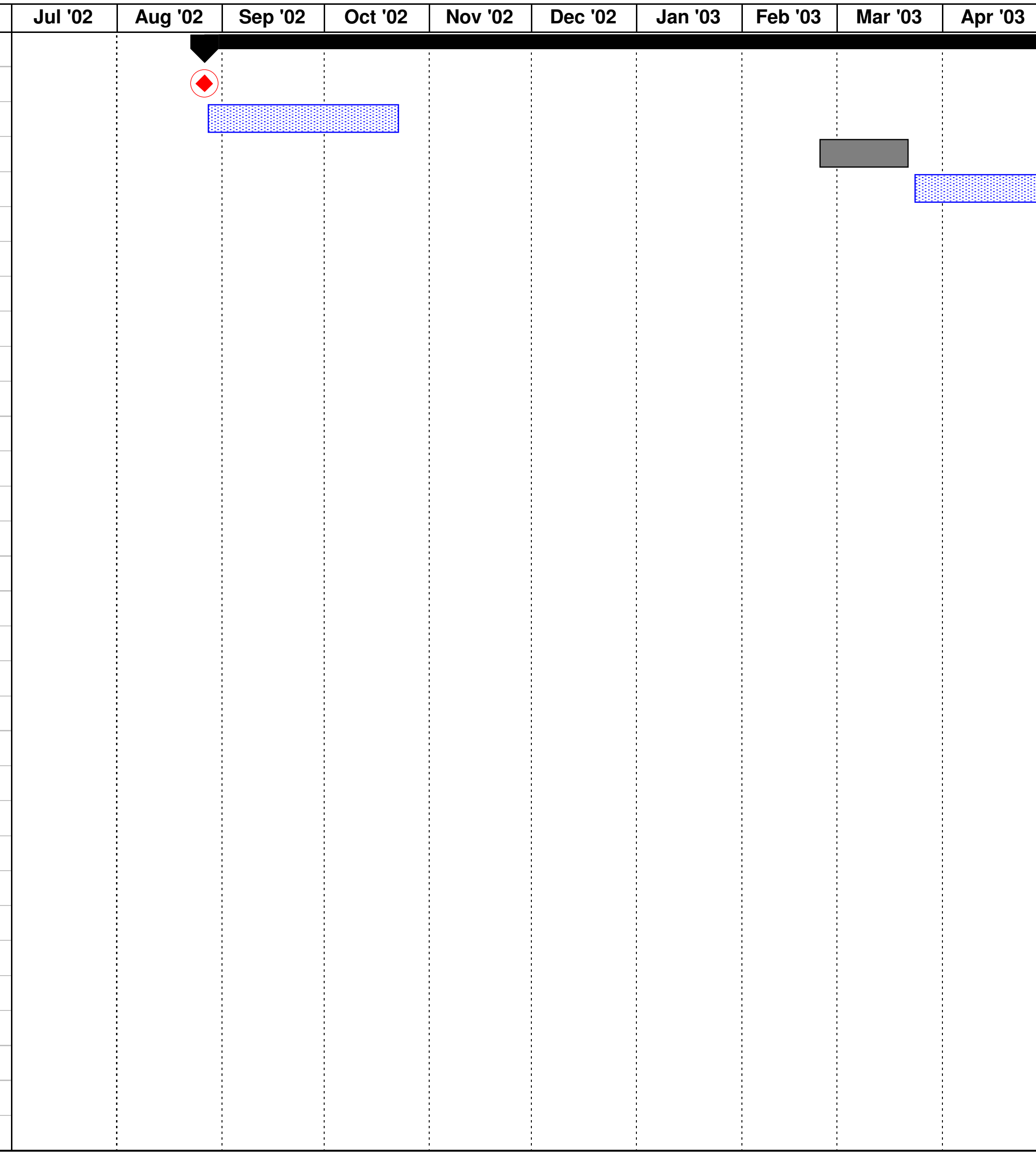
SFWMD Contract No. C-13410 Lamb Island Dairy Remediation
Construction Schedule

ID	Task Name
1	**Subcontracts and Procurement**
2	**Construction**
3	Kick-off meeting
4	Project Mobilization/ surveying
5	Erosion Control Measures
6	Clearing and grubbing
7	**Berm construction and culvert replacement/installation**
8	Outer pasture berm
9	HIA berms
10	Eco-reactor berms
11	seed berms
12	**Dewater and fill HIA ditches**
13	**Pond 2**
14	Set-up dewatering equipment
15	Dewater
16	Move residual solids to Pond 1
17	Knock down berms
18	**Pond 1**
19	Set-up dewatering equipment
20	Dewater
21	Dewater -continue
22	Alum amendment
23	Maintain dewater and allow to dry
24	Install filter fabric
25	Knock down berms and backfill pond
26	**Pond water alum amendment**
27	**Demobilization**



SFWMD Contract No. C-13410 Lamb Island Dairy Remediation
Project Completion Schedule

ID	Task Name
1	**Detailed Design for Selected Alternatives**
2	1.1 Project kick-off meeting
3	1.2 Draft Preliminary 30% Design Package
4	1.3 Final Preliminary Design Package
5	1.4 Detailed 90% Design Package
6	1.5 Final Detailed Design & Specification Package
7	1.6 Construction Deliverables
8	**Project Implementation & Performance Monitoring**
9	Site Construction
10	2.1 Draft Performance Monitoring Plan
11	2.1 Draft Performance Monitoring Plan - review period
12	2.2a Final Performance Monitoring Plan
13	2.2bPerformance Monitoring (15 events)
14	2.3 Quarterly Reports (total of 6 quarters)
15	2.3 Quarterly Reports 1
16	2.3 Quarterly Reports 2
17	2.3 Quarterly Reports 3
18	2.3 Quarterly Reports 4
19	2.3 Quarterly Reports 5
20	2.3 Quarterly Reports 6
21	2.4 Quarterly Site Meetings (total of 6 meetings)
22	2.4 Quarterly Site Meeting 1 (Construction Kick-off Meeting)
23	2.4 Quarterly Site Meeting 2
24	2.4 Quarterly Site Meeting 3
25	2.4 Quarterly Site Meeting 4
26	2.4 Quarterly Site Meeting 5
27	2.4 Quarterly Site Meeting 6
28	**Project Performance Evaluation**
29	3.1 Draft O&M Manual
30	3.2 Final O&M Manual
31	3.3 Draft Final Report
32	3.4 Final Project Report



Tasks in BLUE will receive Interagency Team review and comment.

SFWMD Contract No. C-13410 Lamb Island Dairy Remediation
Project Completion Schedule

ID	Task Name
1	**Detailed Design for Selected Alternatives**
2	1.1 Project kick-off meeting
3	1.2 Draft Preliminary 30% Design Package
4	1.3 Final Preliminary Design Package
5	1.4 Detailed 90% Design Package
6	1.5 Final Detailed Design & Specification Package
7	1.6 Construction Deliverables
8	**Project Implementation & Performance Monitoring**
9	Site Construction
10	2.1 Draft Performance Monitoring Plan
11	2.1 Draft Performance Monitoring Plan - review period
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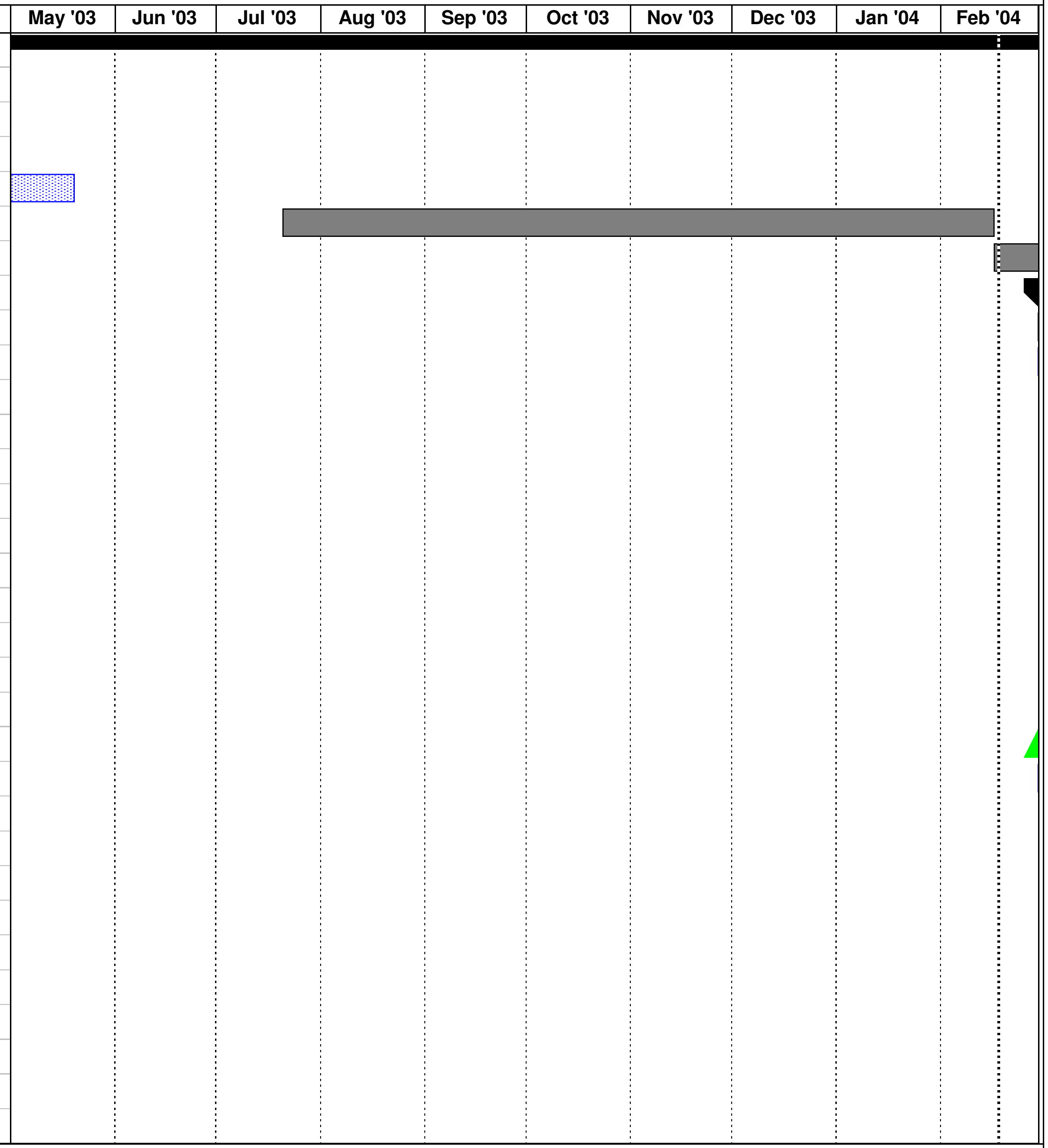
13	2.2bPerformance Monitoring (15 events)
14	2.3 Quarterly Reports (total of 6 quarters)
15	2.3 Quarterly Reports 1
16	2.3 Quarterly Reports 2
17	2.3 Quarterly Reports 3
18	2.3 Quarterly Reports 4
19	2.3 Quarterly Reports 5
20	2.3 Quarterly Reports 6
21	2.4 Quarterly Site Meetings (total of 6 meetings)
22	2.4 Quarterly Site Meeting 1 (Construction Kick-off Meeting)
23	2.4 Quarterly Site Meeting 2
24	2.4 Quarterly Site Meeting 3
25	2.4 Quarterly Site Meeting 4
26	2.4 Quarterly Site Meeting 5
27	2.4 Quarterly Site Meeting 6
28	**Project Performance Evaluation**
29	3.1 Draft O&M Manual
30	3.2 Final O&M Manual
31	3.3 Draft Final Report
32	3.4 Final Project Report



Tasks in BLUE will receive Interagency Team review and comment.

SFWMD Contract No. C-13410 Lamb Island Dairy Remediation
Project Completion Schedule

ID	Task Name
1	**Detailed Design for Selected Alternatives**
2	1.1 Project kick-off meeting
3	1.2 Draft Preliminary 30% Design Package
4	1.3 Final Preliminary Design Package
5	1.4 Detailed 90% Design Package
6	1.5 Final Detailed Design & Specification Package
7	1.6 Construction Deliverables
8	**Project Implementation & Performance Monitoring**
9	Site Construction
10	2.1 Draft Performance Monitoring Plan
11	2.1 Draft Performance Monitoring Plan - review period
12	2.2a Final Performance Monitoring Plan
13	2.2bPerformance Monitoring (15 events)
14	2.3 Quarterly Reports (total of 6 quarters)
15	2.3 Quarterly Reports 1
16	2.3 Quarterly Reports 2
17	2.3 Quarterly Reports 3
18	2.3 Quarterly Reports 4
19	2.3 Quarterly Reports 5
20	2.3 Quarterly Reports 6
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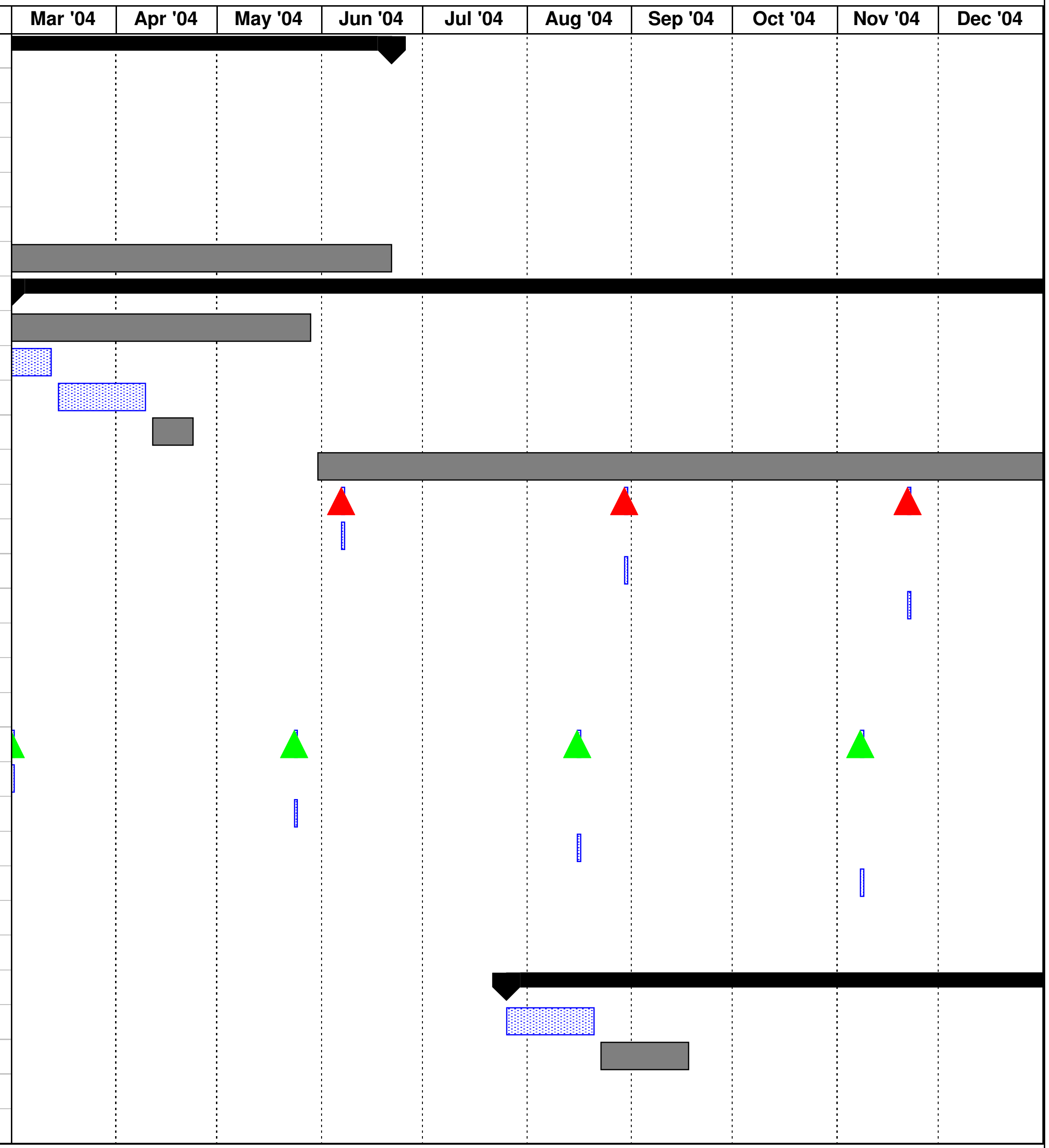
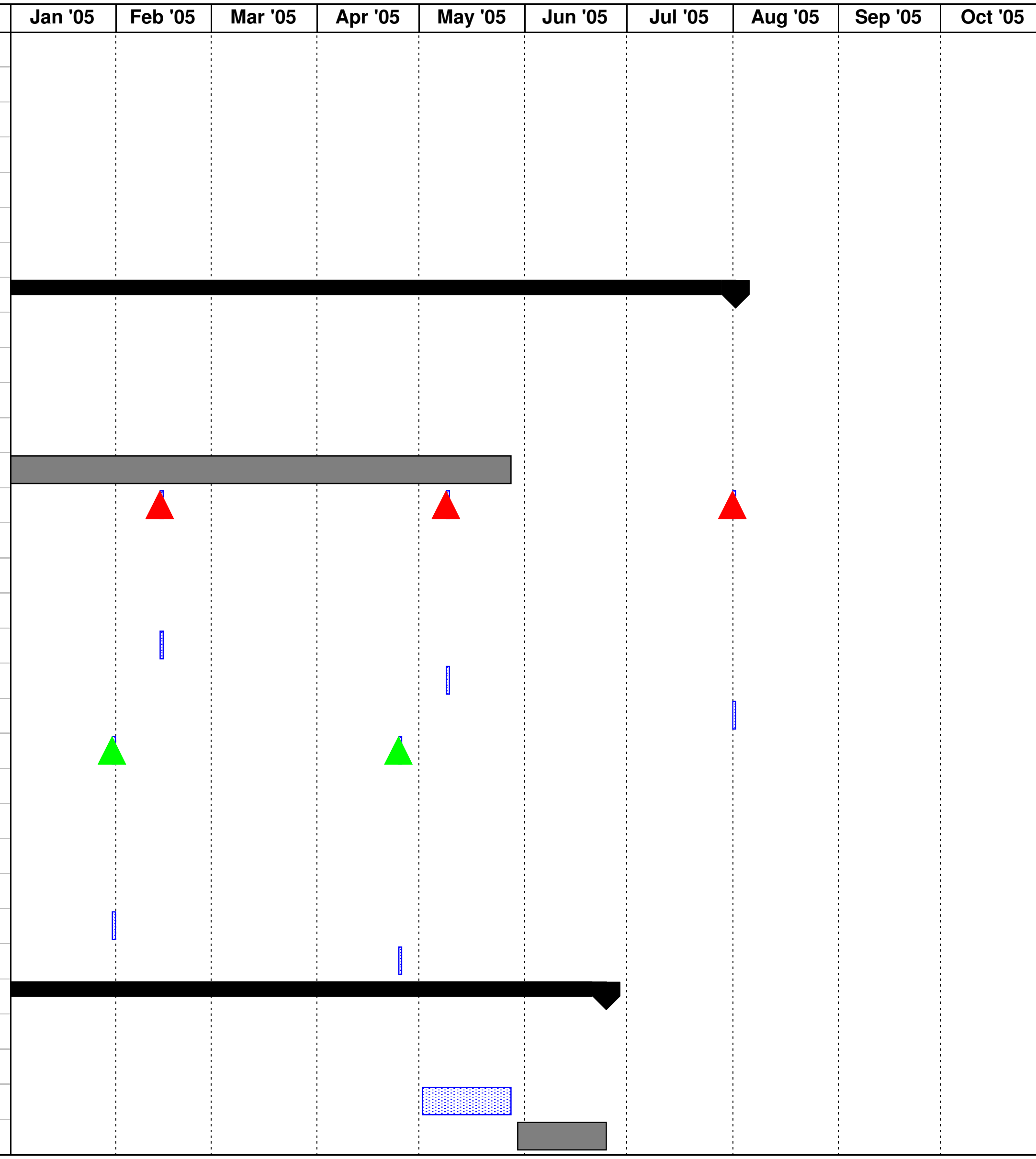
24	2.4 Quarterly Site Meeting 3
25	2.4 Quarterly Site Meeting 4
26	2.4 Quarterly Site Meeting 5
27	2.4 Quarterly Site Meeting 6
28	**Project Performance Evaluation**
29	3.1 Draft O&M Manual
30	3.2 Final O&M Manual
31	3.3 Draft Final Report
32	3.4 Final Project Report



Tasks in BLUE will receive Interagency Team review and comment.

SFWMD Contract No. C-13410 Lamb Island Dairy Remediation
Project Completion Schedule

ID	Task Name
1	**Detailed Design for Selected Alternatives**
2	1.1 Project kick-off meeting
3	1.2 Draft Preliminary 30% Design Package
4	1.3 Final Preliminary Design Package
5	1.4 Detailed 90% Design Package
6	1.5 Final Detailed Design & Specification Package
7	1.6 Construction Deliverables
8	**Project Implementation & Performance Monitoring**
9	Site Construction
10	2.1 Draft Performance Monitoring Plan
11	2.1 Draft Performance Monitoring Plan - review period
12	2.2a Final Performance Monitoring Plan
13	2.2bPerformance Monitoring (15 events)
14	2.3 Quarterly Reports (total of 6 quarters)
15	2.3 Quarterly Reports 1
16	2.3 Quarterly Reports 2
17	2.3 Quarterly Reports 3
18	2.3 Quarterly Reports 4
19	2.3 Quarterly Reports 5
20	2.3 Quarterly Reports 6
21	2.4 Quarterly Site Meetings (total of 6 meetings)
22	2.4 Quarterly Site Meeting 1 (Construction Kick-off Meeting)
23	2.4 Quarterly Site Meeting 2
24	2.4 Quarterly Site Meeting 3
25	2.4 Quarterly Site Meeting 4
26	2.4 Quarterly Site Meeting 5
27	2.4 Quarterly Site Meeting 6
28	**Project Performance Evaluation**
29	3.1 Draft O&M Manual
30	3.2 Final O&M Manual
31	3.3 Draft Final Report
32	3.4 Final Project Report



Tasks in BLUE will receive Interagency Team review and comment.

APPENDIX H

CONSTRUCTION COSTS

Construction Costs
Lamb Island Dairy Remediation Project

ITEM	QTY	Description	Unit Cost	Unit	Bare Mat.	Bare Labor	Bare Equip.	Total
1	1	Mobilization and demobilization	$ 7,560.00	L.S.	$ -	$ 2,721.60	$ 4,838.40	$ 7,560.00
2	25	clearing and grubbing	$ 693.00	acres	$ -	$ 5,197.50	$ 12,127.50	$ 17,325.00
3	12,865	Berms/ditches	$ 2.12	C.Y	$ -	$ 7,085.99	$ 20,167.81	$ 27,253.80
4	3,750	Berms no ditches	$ 2.12	C.Y	$ -	$ 2,063.88	$ 5,874.12	$ 7,938.00
5	3,870	Berms - EcoReactor	$ 2.12	C.Y	$ -	$ 2,132.68	$ 6,069.92	$ 8,202.60
6	550	Berms - terracing: 4:1 slope, 9" height	$ 2.07	C.Y	$ -	$ 297.08	$ 841.96	$ 1,139.04
7	120	Install (5) 24" CMP culvert with riser, including excavation and back fill, remove 2 existing culverts, new culverts to be supplied by Others	$ 98.69	L.F.	$ 5,794.74	$ 2,540.16	$ 3,507.84	$ 11,842.74
8	60	Install (3) 36" CMP culvert with riser, including excavation and back fill, remove 2 existing culverts, new culverts to be supplied by Others	$ 139.73	L.F.	$ 4,604.04	$ 1,587.60	$ 2,192.40	$ 8,384.04
9	1	Dewatering (ditches and ponds) Using 8" pumps	$ 20,160.00	L.S.	$ -	$ 6,652.80	$ 13,507.20	$ 20,160.00
10	3200	Fill/grade ditches with site soil	$ 3.75	C.Y	$ -	$ 3,476.05	$ 8,510.33	$ 11,986.38
11	10,000	Alum amendment of manure solids	$ 5.47	C.Y	$ 25,051.32	$ 14,578.20	$ 15,031.80	$ 54,661.32
12	32	Alum amendment of pond water	$ 311.06	MGAL	$ 5,670.00	$ 2,570.40	$ 1,713.60	$ 9,954.00
13	9000	Fill/grade pond 1 with site soil and Fill/grade pond 2 with site soil or sufficient for maintaining a crop	$ 3.78	C.Y	$ -	$ 10,035.90	$ 23,984.10	$ 34,020.00
14	23,000	Seed berms	$ 0.95	S.Y.	$ 3,694.95	$ 13,475.70	$ 4,564.35	$ 21,735.00
15	3	staff gauges	$ 746.55	ea	$ 595.35	$ 1,347.57	$ 296.73	$ 2,239.65
16	6,000	Install and maintain erosion control, silt fence, polypropylene 3' high	$ 2.05	L.F.	$ 1,360.80	$ 8,769.60	$ 2,192.40	$ 12,322.80
17	1	Professional Services (surveying and analytical), including ground control		Total	$ -	$ 2,772.00	$ 630.00	$ 3,402.00
18	1	Labor (Project management and resident services)						$ 18,992.00
19	10	Construction plans fees	$ 50.00	PLAN				$ 500.00
20	40	Per diem, mileage, etc. (resident/PM services)	$ 150.00	DAY				$ 6,000.00
TOTAL								$ 285,618.37

Construction Payment Schedule
Lamb Island Dairy Remediation Project

		Month 1		Month 2		Month 3		Project
ITEM	Description	% complete	Payment Required	% complete	Payment Required	% complete	Payment Required	Total
1	Mobilization and demobilization	100%	$ 7,560.00					$ 7,560.00
2	clearing and grubbing	100%	$ 17,325.00					$ 17,325.00
3	Berms/ditches							
3.1	Preliminary construction	60%	$ 16,352.28					$ 16,352.28
3.2	Final grading/compaction			100%	$ 10,901.52			$ 10,901.52
4	Berms no ditches			100%	$ 7,938.00			$ 7,938.00
5	Berms - EcoReactor			100%	$ 8,202.60			$ 8,202.60
6	Berms - terracing: 4:1 slope, 9" height			100%	$ 1,139.04			$ 1,139.04
7	Install (5) 24" CMP culvert with riser, including excavation and back fill, remove 2 existing culverts, new culverts to be supplied by Others							
7.1	Procurement	49%	$ 5,802.94					$ 5,802.94
7.2	Installation			100%	$ 6,039.80			$ 6,039.80
8	Install (3) 36" CMP culvert with riser, including excavation and back fill, remove 2 existing culverts, new culverts to be supplied by Others							
8.1	Procurement	54%	$ 4,527.38					$ 4,527.38
8.2	Installation			100%	$ 3,856.66			$ 3,856.66
9	Dewatering (ditches and ponds) Using 8" pumps			100%	$ 20,160.00			$ 20,160.00
10	Fill/grade ditches with site soil			100%	$ 11,986.38			$ 11,986.38
11	Alum amendment of manure solids							
11.1	Procure materials (alum, pump rental, filter fabric)	46%	$ 25,051.32					$ 25,051.32
11.2	Alum amendment			100%	$ 29,610.00			$ 29,610.00
12	Alum amendment of pond water			100%	$ 9,954.00			$ 9,954.00
13	Fill/grade pond 1 with site soil and fill/grade pond 2 with site soil or sufficient for maintaining a crop							
13.1	move material to pond 1			50%	$ 17,010.00			$ 17,010.00
13.2	fill/grade ponds, final compaction					100%	$ 17,010.00	$ 17,010.00
14	Seed berms			100%	$ 21,735.00			$ 21,735.00
15	Install (3) staff gauges							
15.1	Procurement	26%	$ 582.31					$ 582.31
15.2	Installation, including surveying			100%	$ 1,657.34			$ 1,657.34
16	Install and maintain erosion control, silt fence, polypropylene 3' high	100%	$ 12,322.80					$ 12,322.80
17	Professional Services (surveying and analytical), including ground control							
17.1	surveying - project layout	50%	$ 1,701.00					$ 1,701.00
17.2	surveying - during construction			85%	$ 1,190.70			$ 1,190.70

Construction Payment Schedule
Lamb Island Dairy Remediation Project

		Month 1		Month 2		Month 3		Project
ITEM	**Description**	**% complete**	**Payment Required**	**% complete**	**Payment Required**	**% complete**	**Payment Required**	**Total**
17.3	Final surveying, as-built construction drawings					100%	$ 510.30	$ 510.30
18	Labor (Project management and resident services) - hours are spread evenly through course of project, 12 week construction schedule	33%	$ 5,288.88	67%	$ 5,288.88	100%	$ 5,288.88	$ 15,866.63
19	Construction plans fees (as-builts)					100%	$ 500.00	$ 500.00
20	Per diem, mileage, etc. (resident/PM services) - costs spread evenly through course of project, 12 week construction schedule	32%	$ 2,000.00	64%	$ 2,000.00	100%	$ 2,000.00	$ 6,000.00
	TOTAL		$98,513.91		$ 158,669.91		$ 25,309.18	$ 282,493.00

Professional Engineer Certification

Construction Specifications for: **Lamb Island Dairy Remediation**
Okeechobee, Florida

In accordance with Chapter 471, Florida Statues, I hereby certify that to the best of my knowledge that all engineering plans, specifications and calculations included herein are in accordance with standard and appropriate engineering practices.

Terrence R. Horan, P.E. #54815
Project Engineer

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SECTION 01010 SUMMARY OF WORK

PART 1 - GENERAL

1.01 SUMMARY:

The former Lamb Island Dairy Farm (Site) ceased active dairy and cattle grazing operations more than six years ago and the 808 acre property is currently owned by the South Florida Water Management District (DISTRICT). HSA Engineers & Scientists (HSA), ENGINEER, was retained by the DISTRICT to develop and implement one or more remedial alternatives with the primary objective of minimizing P discharges from the Site. The Site is located in the southeast corner of Section 36 or Township 35 South, Range 33 East and in the southwest corner of Section 31 of Township 35 South, Range 34 East of Okeechobee County, Florida.

1.02 PROJECT DESCRIPTION:

1. Project startup including mobilization to the Site.
2. Maintenance of temporary silt fencing.
3. Construction of surface water containment berms and ditches around the HIA.
4. Construction of containment berms and ditches at the edge of farm.
5. Removal of existing culverts and installation of new culverts and risers.
6. Installation of staff gauges.
7. Alum amendment of the dairy waste (residual manure solids) material contained in Ponds 1 and 2 and leaving the material in-place. The residual solids will be consolidated in Pond 1 and then amended with alum. Filter fabric will be placed across the surface of Pond 1 after alum amendment. Fill Pond 1 to slightly above grade with existing berm soil material and material transported from the wetland/marsh area.

across the

8. Dewater the onsite perimeter ditch. Regrade the area in the vicinity of the ditch to bring the resulting surface to match surrounding grade.
9. Demobilization and closeout.

1.03 WORK PERFORMED BY OTHERS:

A. L&L Worldwide will procure project materials and provide rental items including but not limited to (culvert pipes and appurtenances, alum, silt fencing, filter fabric, chopper pump, chemical storage tanks, etc).
B. Aqua Biologists, or equivalent, will provide pond water alum amendment services.
C. HSA and BPC Group will provide field engineering.

1.04 CONTRACTOR'S USE OF PREMISES:

A. Limit use of the Site to allow work by Others.
B. Construction Operations: Limited to areas noted on the Drawings.
C. Hours of Operation: Limit on-Site hours of operation to the hours of 7 a.m. to 6 p.m.
D. When unfavorable weather, soil, drainage, or other unsuitable construction conditions exist, continue operations which will not be adversely affected by such conditions. Do not construct or cause to be constructed any portion of the Works under conditions which would adversely affect the quality of the Works, unless special means or precautions are taken to perform the Works in a proper and satisfactory manner.

1.05 DISTRICT'S USE OF PREMISES:

A. Partial DISTRICT Occupancy: The DISTRICT reserves the right to occupy and to place and install equipment in areas of the Project, prior to Substantial Completion provided that such occupancy does not interfere with completion of the Work. Such placing of equipment and partial occupancy shall not constitute acceptance of the Work.

1.06 WORK SEQUENCE, COORDINATION ACTIVITIES AND SCHEDULED DATES:

A. General: The CONTRACTOR will coordinate its work with other adjacent contractors, landowners and DISTRICT activities, with specific attention to access and staging areas. Construction sequence shall be determined by CONTRACTOR subject to the following needs for continuous access and operation by others.

1. The CONTRACTOR will discuss their co-ordination responsibilities with the ENGINEER.
2. The CONTRACTOR will coordinate project startup including mobilization with delivery and installation of silt fencing supplied by Others.
3. The CONTRACTOR will coordinate manure solids alum amendment Work with delivery and/or temporary storage of: liquid alum, filter fabric, rental equipment, etc. to be supplied by Others.
4. The CONTRACTOR will coordinate the culvert installation with delivery and/or temporary storage of pipe and appurtenances to be supplied by Others.

B. Suggested Construction Sequence: A suggested sequence of construction has been prepared by the ENGINEER and is presented in the Contract Documents. CONTRACTOR may suggest modifications to the sequence provided the access and operation requirements are satisfied and compliance with the overall contract period is achieved.

C. Scheduled Events: Schedule the Work to conform to the following events and dates, and to provide for coordination with the work performed by Others.

1. The Work at the Site shall be commenced within 14 days after the date of the Notice to Proceed.
2. The Work shall be substantially completed on or before January 30, 2004.
3. The Work shall be fully completed and ready for final payment on or before March 1, 2004.

1.08 COPIES OF DOCUMENTS:

1. Final Detailed Design
2. Technical Specifications
3. Bid Form

1.09 LIST OF DRAWINGS:

A. Contract Drawings issued with and forming part of the Contract Documents are listed below:

Drawing No.	*Rev. No.*	*Date of Drawing or Latest Revision*	*Title*
1.	0	01/08/04	Cover Sheet
2.	0	01/08/04	Site Plan
3.	0	01/08/04	Details
4.	0	01/08/04	Cross Sections
5.	0	01/08/04	Cross Sections
6.	0	01/08/04	Cross Sections
7.	0	01/08/04	Cross Sections
8.	0	01/08/04	Cross Sections
9.	0	01/08/04	Cross Sections

B. Perform the Works in accordance with the Drawings issued "Approved for Construction" by ENGINEER. Such Drawings will be issued to CONTRACTOR with the Notice to Proceed and will consist of bid Drawings revised as required by ENGINEER and additional Drawings if required by ENGINEER.

C. Revised "Approved for Construction" Drawings may be issued from time to time by ENGINEER and such Drawings will supersede previous revisions.

1.10 SUBCONTRACTING OF WORK

A. CONTRACTOR shall self-perform work activities, except those identified to be completed by Subcontractors, and approved by ENGINEER as part of CONTRACTOR's bid. No additional work activities may be completed by Subcontractors except by prior written approval by ENGINEER.

END OF SECTION

SECTION 01020 MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.01 LUMP SUM CONTRACT: Unless indicated on the Contract Documents, all work indicated on the Contract Drawings and specified in the Bid Documents and Contract shall be included in the Contract Sumindicated on the Bid Form.

A. Related Work Specified Elsewhere:

1. Project Meetings, Schedules and Reports: SECTION 01200.

1.02 BASIS FOR PAYMENTS: The various major items of Work will be paid for in the lump sum amounts listed in the Bid Form and in accordance with Paragraph 1.03. The following is a description of the Work listed in the Bid Form and is not intended to be complete and all-inclusive of the required work items. The Work shall include all miscellaneous and ancillary items necessary to construct a complete and functional Project.

A. Bid Item A. Project startup including mobilization;

B. Bid Item B. Maintenace of erosion control, silt fencing;

C. Bid Item C. HIA berms and ditches;

D. Bid Item D. Outer pasture (edge of farm) berms and ditches;

E. Bid Item E. Remove 2 existing culverts and install 8 new culverts with risers, mitered finish, and rip-rap slope protection;

F. Bid Item F. Dewatering, grading, backfilling/compacting perimeter ditches;

G. Bid Item G. Amending residual solids with alum, and grading, backfilling/compacting ponds; and,

H. Bid Item H. Seeding the new berms.

1.03 PAYMENTS:

A. Payment for the Works will be made in accordance with Agreement.

B. ENGINEER will take all measurements and compute quantities accordingly. Notify ENGINEER sufficiently in advance of operations to permit required measurements for payment. Assist by providing necessary equipment, workers, and survey personnel as required. Provide reasonable and necessary opportunities and facilities for making measurements.

C. ENGINEER will take all measurements and compute quantities accordingly. Notify ENGINEER sufficiently in advance of operations to permit required measurements for payment. Assist by providing necessary equipment, workers, and survey personnel as required. Provide reasonable and necessary opportunities and facilities for making measurements.

D. Quantities indicated in the Contract Documents are for bidding purposes and are approximate. Quantities of material furnished and/or work performed as verified by ENGINEER will determine payment.

E. ENGINEER will measure or quantify the amount of work eligible for progress payment purposes. Items will be measured in units such as time, weight, volume, area, or linear means, or combination as appropriate as a completed item or unit of the Works. Such measurements will serve as a basis for estimating payments for partially completed work.

F. Non-payment for Rejected Products: Payment will not be made for any of the following:

1. Products wasted or disposed of in a manner that is not acceptable.

2. Products determined as unacceptable before or after placement.

3. Products not completely unloaded from the transporting vehicle.

4. Products placed beyond the lines and levels of the required Works.

5. Products remaining on hand after completion of the Works.

6. Loading, hauling, and disposing of rejected products.

1.04 APPLICATIONS FOR PAYMENT:

A. Submit each Application for Payment on the form furnished in the Contract Documents. Obtain electronic version from ENGINEER.

B. Submit 1 signed original of each Application for Payment. Include electronic version with each application.

C. Execute certification by signature of authorized officer.

D. List each authorized Change Order on the Application for Payment, listing Change Order number and dollar amount as for an original item of the Works.

E. Prepare Application for Final Payment as specified in Agreement.

F. Payment Period: Submit at intervals stipulated in Agreement.

G. Submit releases and waivers as stipulated in Agreement.

H. When ENGINEER requires substantiating information, submit data justifying dollar amounts in question.

1.05 CONTRACT MODIFICATION PROCEDURES:

A. Changes in the Works or the requirement for extra work will be made by ENGINEER in accordance with General Conditions, and with the change procedures as specified herein.

B. Field Order: ENGINEER will advise of minor changes in the Works not involving an adjustment to the Contract Price or the Contract Times as authorized by the General Conditions by issuing supplemental instructions in the form of a Field Order. Promptly execute such minor changes and supplemental instructions.

C. Proposal Request: ENGINEER may issue a proposal request, which includes a detailed description of a proposed change with supplementary or revised Drawings and Specifications, and schedule for executing the change in the Works. Prepare and submit a written itemized quotation of changes in the Contract Price or the Contract Times that would result from the proposed change in the Project by the due date stipulated in the proposal request.

D. Documentation of Change in Contract Price and Contract Times:

1. Maintain detailed records of work done on a time and material or force account basis. Provide full information required for evaluation of proposed changes, and to substantiate costs of changes in the Works.

2. Document each quotation for a change in cost or time with sufficient data to allow evaluation of the quotation by ENGINEER.

3. On request, provide additional data to support computations including:

    1. Quantities of products, labor, and equipment.

    2. Taxes, insurance, and bonds.

    3. Overhead and profit.

    4. Justification for any change in the Contract Times.

    5. Credit for deletions from the Contract, similarly documented.

4. Support each claim for additional costs, and for work done on a time and material or force account basis, with additional information including:

    1. Origin and date of claim.

    2. Dates and times work was performed, and by whom.

    3. Time records and wage rates paid.

    4. Invoices and receipts for products, equipment, and subcontracts, similarly documented.

E. CONTRACTOR may propose a change by submitting a request for change to ENGINEER, describing the proposed change and its full effect on the Works, with a statement describing the reason for the change, and the effect on the Contract Price and Contract Times with full documentation (including itemization of costs for labor, material, taxes, subcontracts, bonds, insurance, and overhead and profit) and a statement describing the effect on the Works by Other Contractors.

F. Work Change Directive: ENGINEER may issue a document, signed by the DISTRICT, instructing CONTRACTOR to proceed with a change in the Works, for subsequent inclusion in a Change Order. The document will describe changes in the Works, and will designate method of determining any change in the Contract Price or the Contract Times. Promptly execute the change in the Works.

G. Lump Sum Price Change Order: Based on proposal request and CONTRACTOR's fixed lump sum price quotation or CONTRACTOR's request for a Change Order as approved by ENGINEER.

H. Unit Price Change Order: Based on proposal request and CONTRACTOR's fixed unit price quotation and estimated quantities or CONTRACTOR's request for a Change Order as approved by ENGINEER.

I. Time and Material or Force Account Change Order: Submit itemized account and supporting data after completion of change, within time limits indicated in the Contract Documents. ENGINEER will determine the change allowable in the Contract Price and the Contract Times as provided in the Contract Documents. Maintain detailed records of work done on a time and material or force account basis. Provide full information required for evaluation of proposed changes, and to substantiate costs for changes in the Works.

J. ENGINEER will issue Change Orders for signatures of parties as provided in the Contract Documents.

K. Promptly revise progress schedules to reflect any approved change in the Contract Times (or Milestones), revise sub-schedules to adjust times for other items of work affected by the change, and promptly resubmit to ENGINEER.

L. Promptly enter changes in the Project record documents.

M. Promptly revise Applications for Payment forms to record each authorized Change Order as a separate line item.

END OF SECTION

SECTION 01050 FIELD ENGINEERING

PART 1 - GENERAL

1.01 The CONTRACTOR'S will coordinate with the ENGINEER and/or Florida licensed P.E. to perform engineering services for temporary facilities including the design of shoring systems, shores, earth and water retaining systems, forms, temporary erection supports, and similar items provided by the CONTRACTOR as part of its means and methods of construction.

PART 2 - CONTRACTOR CONSTRUCTION STAKING

2.01 DESCRIPTION: In connection with this Work, CONTRACTOR shall:

A. Perform all construction layout and reference staking necessary for the proper control and satisfactory completion of the Work.

B. Run a level circuit between vertical control points indicated to check plan benchmarks and establish new benchmarks where necessary.

2.02 CONSTRUCTION REQUIREMENTS:

A. The CONTRACTORS personnel performing the construction staking shall work under the direct supervision of a Florida licensed land surveyor. Submit name and address of individual responsible for surveying to the ENGINEER prior to start of survey activities.

B. The CONTRACTOR shall be solely and completely responsible for the accuracy of the line and grade of all features of the Work. Any errors or apparent discrepancies found in previous surveys, plans, or specifications or shall be called to the attention of the ENGINEER by the CONTRACTOR for correction or interpretation prior to proceeding with the work.

C. Field notes shall be kept in standard, bound field notebooks in a clear, orderly, and neat manner consistent with standard engineering practices.

D. The CONTRACTOR shall be responsible for the placement and preservation of adequate ties and reference to all control points, whether established by him or found on the project, necessary for the accurate reestablishment of all base lines or centerlines shown on the Plans. All land ties (i.e. section corners, fractional section corners, and similar items) that may be lost or destroyed during construction shall be carefully referenced and replaced.

E. The supervision of the CONTRACTOR'S construction personnel shall be the responsibility of the CONTRACTOR; and, any deficient construction work which may be the result of inaccuracies in his staking operations or of his failure to report inaccuracies found in work previously done by the ENGINEER shall be corrected at the expense of the CONTRACTOR.

F. Station Identification: On linear elements of construction (such as levees, canals, and similar items) the CONTRACTOR shall place temporary identifying signs at intervals no greater than 500 feet using 4-foot sections of 1-inch by 4-inch lumber driven into the ground. The signs shall identify the station at that location.

G. In order to expedite the commencement of construction operations, the staking operation may commence prior to the issuance of the Notice to Proceed. The Contractor shall obtain written approval of the ENGINEER prior to commencing staking.

2.03 RECORDS AND SUBMITTALS:

A. Submittal:

1. Provide ENGINEER a copy of the designs described in Paragraph 1.01.

2. Provide ENGINEER the data required for the individual responsible for layout and records as required in Paragraph 2.02 A.

B. Records: At the end of the Project, coordinate with the ENGINEER to generate a certified site survey showing coordinates and elevations of the completed Work. Submit a copy of the field notes required in Paragraph 2.02.C.

C. Cross-sections: Canal and Levee cross-sections shall be submitted as specified in SECTION 02200.

END OF SECTION

SECTION 01200 PROJECT MEETINGS, SCHEDULES, AND REPORTS:

PART 1 - GENERAL

1.01 <u>SUMMARY</u>: This Section includes the following administrative and procedural requirements:

A. Project Meetings:

1. Preconstruction conference.
2. Coordination schedules.
3. Progress meetings.

B. Schedules and Reports:

1. Initial coordination submittals.
2. Construction progress schedule.
3. Procurement schedule.
4. Construction progress reports.
5. Schedule of values.
6. Special reports.

1.02 <u>PROJECT MEETINGS:</u>

A. Pre-construction Conference

1. ENGINEER will administer a meeting within 10 days after the Effective Date of the Agreement, to review items stated in the following agenda and to establish a working understanding between the parties as to their relationships during conduct of the Work.

2. Preconstruction conference shall be attended by:

a. CONTRACTOR and his superintendent.

b. Representatives of principal Subcontractors and Suppliers.

c. ENGINEER and his Resident Project Representative if any.

d. DISTRICT or his representative.

e. Other affected parties determined by the DISTRICT.

3. Agenda:

a. Projected construction schedules.

b. Critical Work sequencing.

c. Designation of responsible personnel.

d. Project coordination.

e. Procedures and Processing of:

(1) Field decisions.
(2) Substitutions.
(3) Submittals.
(4) Change Orders.
(5) Applications for payment.

f. Procedures for testing.

g. Procedures for maintaining record documents.

h. Use of Premises:

(1) Office, work and storage areas.
(2) DISTRICT's requirements.

i. Construction facilities, controls, and construction aids.

j. Temporary utilities.

k. Safety and first aid.

l. Security.

m. Requirements of any permits obtained by the DISTRICT.

4. Location of Meeting: South Florida Water Management District, Okeechobee Field Station, Okeechobee, Florida or alternate location provided by ENGINEER.

B. Coordination Schedules:

1. ENGINEER will administer a meeting at least 10 days before submission of the first Application for Payment to finalize the initial coordination schedules requested under Article 1.03 this Section.

2. The meeting shall be attended by:

a. CONTRACTOR and his superintendent.
b. Representatives of Principal Subcontractors and Suppliers.
c. ENGINEER and his Resident Project Representative if any.
d DISTRICT or his representative.

C. Progress Meetings:

1. ENGINEER will administer a meeting a minimum of twice each month (every two weeks) or other times requested by ENGINEER. CONTRACTOR, ENGINEER and all Subcontractors active on the site shall be represented at each meeting. CONTRACTOR may request attendance by representatives of his Suppliers and other Subcontractors, or other entities concerned with current program or involved with planning, coordination or performance of future activities. All participants in the meeting shall be familiar with the Project and authorized to conclude matters relating to the Work.

2. CONTRACTOR and each Subcontractor shall be prepared to discuss the current construction progress report, any anticipated future changes to the schedule, and advise if their current progress or future anticipated schedules are compatible with the Work.
3. If one Subcontractor is delaying another, CONTRACTOR shall direct such changes as are necessary for those involved to mutually agree on schedule changes in the best interest of construction progress.

4. Agenda.

a. Review of construction progress since previous meeting.

b. Field observations, interface requirements, conflicts.

c. Problems which impede construction schedule.

d. Off-site fabrication.

e. Delivery schedules.

f. Submittal schedules and status.

g. Site utilization.

h. Temporary facilities and services.

i. Hours of Work.

j. Hazards and risks.

k. Housekeeping.

l. Quality and Work standards.

m. Change orders.

n. Documentation of information for payment request.

o. Corrective measures and procedures to regain projected schedule if necessary.

p. Revisions to construction schedule.

q. Progress and schedule during succeeding Work period.

r. Review proposed changes for:

(1) Effect on construction schedule and on completion date.
(2) Effect on other contracts of the Project.

s. Other business.

5 Location of Meetings: On Site, Former Lamb Island Dairy, Okeechobee, Florida.

6. Reporting: After each meeting, minutes of the meeting will be distributed to each party present and to parties who should have been present.

1.03 <u>SCHEDULES AND REPORTS:</u>

A. Initial Coordination Schedules:

1. Within 10 days after the Effective Date of Agreement, CONTRACTOR shall submit to ENGINEER for review and acceptance:

a. A tentative procurement schedule of equipment and materials.
b. A tentative schedule of values for partial pay purposes.
c. A tentative schedule of Submittals, as stated in SECTION 01300.
d. Certification of insurance or copies of policies if not previously submitted.

B. Construction Progress Schedule:

1. A detailed proposed construction progress schedule shall be submitted within 5 days after the Effective Date of Agreement. Submit to ENGINEER for review and acceptance.

a. The CONTRACTOR'S planning, scheduling and execution of the contract work shall be presented to the ENGINEER and subsequently to the DISTRICT by submission of the progress schedule information and data specified in this Section.

b. The CONTRACTOR is responsible for coordinating its own schedules (including subcontractors).

The Contract Schedules shall expressly identify Contract Time, milestones, critical path(s), and all activities. The schedule shall also show the Work broken down into major phases and key items with the date Work is expected to begin and be completed. Sequence of listings shall be in the chronological order of the start of each item of Work. Each work Activity shall show the Quantity of Work to be performed, Duration of Activity, Daily Rate of Production Required.

2. ENGINEER will review and comment on schedule and, upon agreement with CONTRACTOR on any necessary changes, ENGINEER will furnish CONTRACTOR prints of the accepted schedule. CONTRACTOR shall not change the accepted construction progress schedule without prior concurrence of the ENGINEER.

3. Submit a construction progress report with each application for partial payment. Work reported complete but not readily apparent to ENGINEER must be substantiated with supporting data.

E. Schedule of Values:

1. Submit as specified in GENERAL CONDITIONS.

2. Content:

a. Schedule shall list the installed value of the component parts of the Work in sufficient detail to serve as a basis for computing values for progress payments during construction. Each Work Activity shall be priced, and the total shall equal the Contract Total.

b. Follow the table of contents of these Contract Documents as the format for listing component items.

(1) Identify each line item with the number and title of the respective major Division or Section of the Specifications.
(2) For each major line item list subvalues of major products or operations under the item.
(3) Each item shall include a directly proportional amount of the CONTRACTOR'S overhead and profit.

c. The sum of all values listed in the schedule shall equal the total Contract Price.

d. Each schedule monthly update shall indicate the Actual Start Date, Actual or Projected Finish Date, and percentage of completion for each Work Activity. The Percentage of Completion times the completed value of each work item will support the CONTRACTOR'S pay request and must be submitted attached to each pay request.

F. Special Reports:

1. When an event of an unusual and significant nature occurs at the site, prepare and submit a special report. List the chain of events, persons participating, response by Contractor's personnel, an evaluation of the results or effects, and similar pertinent information. Advise the DISTRICT in advance when such events are known or predictable.

END OF SECTION

SECTION 01300 SUBMITTALS

PART 1 - GENERAL

1.01 SUMMARY:

A. This Section includes definitions, descriptions, transmittal, and review of "Compliance" and "Miscellaneous" Submittals.

1.02 GENERAL INFORMATION:

A. Definitions:

1. Compliance Submittals include shop drawings, product data, and samples which are prepared by the CONTRACTOR, Subcontractor, manufacturer, or Supplier and submitted by the CONTRACTOR to the ENGINEER as a basis for approval of the use of Equipment and Materials proposed for incorporation in the Work or needed to describe installation, operation, maintenance, or technical properties.

   a. Shop drawings include custom-prepared data of all types including drawings, diagrams, performance curves, material schedules, templates, instructions, and similar information not in standard printed form applicable to other projects.

   b. Product data includes standard printed information on materials, products and systems; not custom-prepared for this Project, other than the designation of selections from available choices.

   c. Samples include both fabricated and unfabricated physical examples of materials, products, and Work; both as complete units and as smaller portions of units of Work; either for limited visual inspection or (where indicated) for more detailed testing and analysis. Mock-ups are a special form of samples which are too large to be handled in the specified manner for transmittal of sample Submittals.

2. Miscellaneous Submittals are those technical reports, administrative Submittals, certificates, and guarantees not defined as shop drawings, product data, or samples.

   a. Technical reports include laboratory reports, tests, technical procedures, technical records, CONTRACTOR'S design analysis and CONTRACTOR'S survey field notes for construction staking, before cross-sections and after cross-sections.

   b. Administrative Submittals are those nontechnical Submittals required by the Contract Documents or deemed necessary for administrative records. These Submittals include maintenance agreements, workmanship Bonds, Project photographs, physical work records, statements of applicability, copies of industry standards, as-constructed data, security/protection/safety data, and similar type Submittals.

   c. Certificates and guarantees are those Submittals on Equipment and Materials where a written certificate or guarantee from the manufacturer or Supplier is called for in the Specifications.

   d. Reports as required by Contract describing CONTRACTOR'S means and methods for items such as dewatering, earth and water retaining, erosion/turbidity control, and safety plans.

3. Refer to ARTICLE 1.03 of this Part for detailed lists of documents and specific requirements.

B. Quality Requirements:

1. Submittals such as shop drawings and product data shall be of the quality for legibility and reproduction purposes. Every line, character, and letter shall be clearly legible. Drawings such as reproducibles shall be useable for further reproduction to yield legible hard copy.

2. Documents submitted to the ENGINEER that do not conform to these requirements shall be subject to rejection by the ENGINEER, and upon request by ENGINEER, CONTRACTOR shall resubmit conforming documents. If conforming Submittals cannot be obtained, such documents shall be retraced, redrawn, or photographically restored as may be necessary to meet such requirements. CONTRACTOR'S (or his Subcontractor's) failure to initially satisfy the legibility quality requirements will not relieve CONTRACTOR (or his Subcontractors) from meeting the required schedule for Submittal of shop drawings and product data.

C. Language and Dimensions:

1. All words and dimensional units shall be in the English language.

2. Metric dimensional unit equivalents may be stated in addition to the English units.

D. Submittal Completeness:

1. Submittals shall be complete with respect to dimensions, design criteria, materials of construction, and other information specified to enable the ENGINEER to review the information effectively.

2. Where standard drawings are furnished which cover a number of variations of the general class of equipment, each such drawing shall be individually annotated to describe exactly which parts of the drawing apply to the equipment being furnished. Use hatch marks to indicate variations that do not apply to the Submittal. The use of "highlighting markers" is not an acceptable means of annotating Submittals. Such annotation shall also include proper identification of the Submittal permanently attached to the drawing.

1.03 <u>COMPLIANCE SUBMITTALS</u>:

A. Items shall include, but not be limited to, the following:

1. Manufacturer's specifications.

2. Catalogs, or parts thereof, of manufactured equipment.

3. Shop fabrication and erection drawings.

4. Detailed equipment installation drawings, showing foundation details, anchor bolt sizes and locations, baseplate sizes; and all clearances required for erection, operation, and disassembly for maintenance.

5. Bills of material and spare parts list.

6. All drawings, catalogs or parts thereof, manufacturer's specifications and data, samples, instructions, and other information specified or necessary:

a. For ENGINEER to determine that the Equipment and Materials conform with the design concept and comply with the intent of the Contract Documents.

b. Make all modifications noted or indicated by ENGINEER and return revised prints, copies, or samples until accepted.

1.04 MISCELLANEOUS SUBMITTALS:

A. Miscellaneous Submittals are comprised of technical reports, administrative Submittals, and guarantees which relate to the Work, but do not require ENGINEER'S approval prior to proceeding with the Work. Miscellaneous Submittals may include but are not limited to (At ENGINEER'S discretion):

1. Field test reports.
2. Soil test reports.
3. Equipment and Material delivery schedules.
4. Warranties and guarantees.
5. Surveying field notes.

B. ENGINEER'S Review:

1. ENGINEER will review Miscellaneous Submittals for indications of Work or material deficiencies.
2. ENGINEER will respond to CONTRACTOR on those Miscellaneous Submittals which indicate Work or material deficiency.

END OF SECTION

SECTION 01541 JOBSITE SAFETY PROGRAM

PART 1 - GENERAL

1.01 DESCRIPTION:

A. The CONTRACTOR shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work.

B. The ENGINEER'S and DISTRICT'S involvement concerning safety reporting, precautions or procedures will not relieve the CONTRACTOR of any responsibilities or obligations imposed by the Contract Documents.

1.02 WORK INCLUDED:

A. The Contract shall take all precautions and follow all procedures for the safety of, and shall provide all protection to prevent injury to, all persons involved in any way in the Work and all other persons, including, without limitation, the employees, agents, guests, visitors, invitees, and licensees of DISTRICT.

B. The CONTRACTOR shall develop a Safety Manual detailing accident, fire, and safety procedures to be rigorously followed. The safety policies and guidelines presented in this Manual shall comply with or exceed all applicable laws relating to the safety of persons and their protection against injury, including but not limited to all OSHA requirements. A copy of the Manual must be kept at the Project site and a copy of the Manual must be provided to ENGINEER.

C. It is the CONTRACTOR'S responsibility to ensure that personal safety consciousness is stressed to employees of the CONTRACTOR and all of its Subcontractors on a full-time, continuous basis during on-going construction and throughout the duration of the Work.

1.04 SUBMITTALS:

A. Safety Manual:

1. A project specific Safety Manual shall be developed meeting the requirements of ANSI A10.33-1992 with the following exception:

a. Delete Para. 3.1.2 ANSI A10.33-1992 and the above deletion shall be incorporated into the Safety Manual.

2. The Safety Manual shall also meet the requirements of ANSI A10.38 for construction work/activities.

B. Job Accidents and Safety Reports:

1. When any type of accident or damage occurs at the job site, the CONTRACTOR must notify ENGINEER. All such incidents must be reported by the CONTRACTOR in writing and should be listed in the Superintendent's Daily Log.

2. Accident or Incident Reports:

a. In the event of an accident involving personal injury or damage to property, the Accident Report shall be prepared to thoroughly document the occurrence. The Accident Report should be prepared by and issued under signature of the

CONTRACTOR’S Project Safety Representative. The Report should include:

(1) An objective description of the facts.

(2) Witness statements.

(3) Related information which can be evaluated to prevent recurrence.

(4) Photographs and/or video.

3. CONTRACTOR, if directly or indirectly involved in the incident through their employees, equipment, installation, temporary facilities, or other related involvement, shall be required to prepare an independent accident report in accordance with the CONTRACTOR’S procedures and submit copies to ENGINEER within 48 hours of the incident.

4. An accident report will be completed for every accident or incident that occurs on the site.

5. The incident will be investigated immediately upon receipt of the initial report by:

   a. The CONTRACTOR’S Safety Representative.

   b. Supervisor in charge for the injured worker or work area.

6. The Accident Report shall be prepared on a Report Form containing applicable Federal, State, Local or DISTRICT required information.

7. A copy of the report shall be transmitted to ENGINEER.

8. If the incident involved police, fire department, or rescue squad response, copies of official reports should be obtained and attached to the report provided to ENGINEER. Copies of all reports shall be retained in the CONTRACTOR’S files.

9. The report shall be completed within 24 hours of the incident and prepared with the input of the CONTRACTOR’S Field Superintendent and any involved field staff.

10. Description of Incident: State what happened (accident, injury, damage, etc.), including the location and description of activities occurring when the incident transpired. The statement shall be purely factual and not contain opinion, conjecture, or surmise.

   a. Primary Cause:

      1. Description of any obvious cause or a combination of actions which resulted in the incident. A cause can be unsafe personal action, hazardous violations of safety regulations, or similar action. Avoid unfounded speculation or conjecture in the event that an obvious cause is not apparent.

   b. CONTRACTOR’S Personnel or Equipment:

      1. Clearly describe who was injured and/or what was damaged, and the extent of such damages as can be determined at the time of investigation. If possible, photographs should be taken and attached to the incident report.

   c. Safety Information:

      1. Describe any personal protective equipment or any safety devices, which contributed to the incident, which were either not used or improperly used.

d. Identify any specific Project Safety Program requirements, or requirements of any applicable Federal, State, or local safety regulations that were violated.

e. Identify any corrective actions which shall be implemented as a result of the investigation to prevent future similar incidents. Be specific in defining what actions should or have been taken and identify the responsible party.

11. Accident Summary

a. The CONTRACTOR shall maintain a summary list of every reported accident or incident. This information will be recorded on any approved Accident Summary Form, in addition to the statutory reporting requirements of OSHA.

12. First Aid Reporting:

a. The CONTRACTOR shall be required to provide first aid personnel and equipment, and maintain a log of each case treated at their first aid station. Each log entry will be recorded on a form that will include the following information:

(1) Date of Treatment.

(2) Time of Arrival at the First Aid Station.

(3) Time of Departure from the First Aid Station.

(4) Case Number.

(5) Patient's Name.

(6) Patient's Employer.

(7) Description of the Injury.

(8) Description of the Treatment Given.

(9) Name of Person Giving Treatment.

This log will be made available by the CONTRACTOR for inspection by ENGINEER upon request.

13. Safety Violation Reporting:

A. Safely violations or hazardous conditions may be identified and reported by various individuals on the project. Any reports received by the CONTRACTOR shall immediately be reported to the CONTRACTOR Project Safety Representative for investigation. These reports shall be responded to in the following manner:

1. When any CONTRACTOR'S personnel observe safety violations, they shall immediately verbally advise the CONTRACTOR responsible to correct the condition. The incident shall be noted on the Safety Inspection to include:

(a) Date of Notification.

(b) Description of the Violation.

(c) The CONTRACTOR and Employee Notified.

(d) Time of the Notification.

(e) If the violation represents a significant potential for personal injury or property damage, the CONTRACTOR will be directed to stop work immediately until the unsafe condition is rectified.

2. If the violation is relatively minor and corrected that day, no other reports are required other than an entry on the Safety Inspection Form indicating that corrective action was taken. If the violation is not corrected that day, a formal Safety Violation Report shall be prepared by the CONTRACTOR and issued to all involved parties. Copies of this report will be sent to the CONTRACTOR'S home office, and filed on site.

3. Upon completing corrective action, the CONTRACTOR shall submit written notification to ENGINEER that the violation has been corrected.

4. A record of all formal Safety Violation Notices issued shall be provided by the CONTRACTOR to ENGINEER.

5. The CONTRACTOR shall maintain a record copy of all Safety Violation Notices.

PART 2 - PRODUCTS (Not Applicable.)

PART 3 - EXECUTION

3.01 The CONTRACTOR'S responsibilities for job site safety include, but are not limited to, the following services and duties:

A. Arrange for communication among all responsible parties.

B. Provide a log, to be kept at the Project site of activities to comply with these rules and regulations, for inspection at any time during the course of construction and for the period thereafter required by Law.

C. Develop a plan for periodic inspection to ensure site safety.

D. Develop a fire evacuation plan.

E. Ensure that OSHA requirements are strictly followed.

F. Ensure that key on-site personnel have working knowledge of industry practices and operation standards so that one-to-one communication with local authorities will facilitate immediate response to questions raised by safety officials.

G. Provide on-site first aid facilities staffed with person (s) qualified to administer first aid to the employees and visitors of the CONTRACTOR, and the DISTRICT.

H. Post danger signs and personal notification to all affected persons of the existence of a hazard.

I. Use or store required explosives or other hazardous materials only under the supervision of qualified personnel after first obtaining permission of the applicable fire chief or his/her duly authorized representative.

J. Maintain adequate quantities of both operable fire extinguishers and water hoses at the Project site.

K. Designate a responsible member of the CONTRACTOR'S organization to be responsible to enforce the CONTRACTOR'S Safety Program on the Project site and to prevent accidents.

L. The CONTRACTOR shall require each of its Subcontractors and their Subcontractors to designate a responsible supervisory representative to assist the CONTRACTOR'S Safety Representative in the performance of his/her duties.

M. Provide or cause each worker of the jobsite to be provided proper safety equipment for the duties he/she is required to perform.

N. Deny access to the Jobsite to any worker who fails or refuses to use proper safety equipment provided for the duties he/she is required to perform.

O. Send home for the day or discharge any worker who fails to comply with safe practices.

P. The CONTRACTOR must establish a training and information dissemination program for all workers that could be exposed to hazardous chemicals in their work area at the beginning of the assignment and whenever a new assignment is introduced.

3.02 <u>OSHA INSPECTION PROCEDURES</u>:

A. These procedures shall be strictly followed when OSHA representatives visit the Project site:

1. Ask to see credentials and identification. Ask the compliance officer(s) why OSHA is there; i.e., scheduled, complaint, or referral inspection. If a complaint, ask for a copy which they are required to provide.

2. Immediately notify ENGINEER, which will make every effort to arrive at the Project prior to the actual start of the inspection.

3. The CONTRACTOR'S Safety Representative shall accompany the OSHA Compliance Officer(s) during the inspection and all other times OSHA is on site. This also applies if OSHA is on site to inspect a Subcontractor.

4. The CONTRACTOR'S report of the OSHA Inspection shall be started at the beginning of and completed immediately after each OSHA Inspection. Accurate and complete reporting is very important. Report on everything the Compliance Officer writes down. If OSHA takes a photograph, the CONTRACTOR shall take the same photograph.

5. Do not agree or disagree with any alleged safety violation that the Compliance Officer(s) may find.

6. Follow up for prompt correction of all safety hazards and unsafe acts found before, during, and after the OSHA inspection.

7. Do not give OSHA copies of any ENGINEER documents without the express approval of ENGINEER.

8. Copies of all OSHA correspondence to the CONTRACTOR and/or copies of Citations issued to the CONTRACTOR shall be sent directly to ENGINEER.

9. Complete the report of the OSHA Inspection as soon as possible after the inspection has been completed and send a copy of the report to ENGINEER.

END OF SECTION

SECTION 02100 - REV 11/02 SITE PREPARATION

PART 1 - GENERAL

1.01 SCOPE:

A. Summary of Work: The CONTRACTOR shall furnish all labor, materials, and equipment necessary for complete and proper site preparation within the areas shown on the Drawings and specified herein and observe permit conditions.

1.02 APPLICABLE PUBLICATIONS:

A. Applicable Standards:

1.03 DEFINITIONS: (Not Used)

1.04 SUBMITTALS: (Not Used)

1.05 QUALIFICATIONS: (Not Used)

1.06 RESPONSIBILITIES:

A. The CONTRACTOR shall make all excavations for piping and appurtenant structures in any material encountered to the depth and grades required, shall backfill such excavations and dispose of excess or unsuitable materials from excavation, and shall provide and place necessary borrow material to properly backfill excavations, all as indicated on the drawings, specified herein, or as directed by the ENGINEER.

B. Excavation, dewatering, sheeting and bracing required shall be carried out so as to prevent any possibility of undermining or disturbing the foundations of any existing structure or work, and so that all work may be accomplished and inspected in the dry, except as directed by the ENGINEER. Aqueous construction may be performed only with prior approval of the ENGINEER.

1.07 CERTIFICATIONS AND TESTINGS: (Not Used)

1.08 INSPECTION COORDINATION: (Not Used)

1.09 WARRANTY: (Not Used)

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 TRAFFIC CONTROL: The CONTRACTOR shall provide proper warning devices and barriers for protection of the public and workmen in accordance with FDOT Specification Section 102-3 Traffic Control and local regulations.

3.02 STANDARD CLEARING AND GRUBBING: Standard site clearing and grubbing, in accordance with FDOT Specification Section 110.2, shall be performed within the areas shown on the Drawings or otherwise noted in the above referenced specification.

3.03 EROSION CONTROL: The CONTRACTOR shall prevent and control erosion and water pollution as per FDOT Specification Sections 104-1, 2, 3, 4, 6 and 7 and Florida Department of Environmental Protection (FDEP) regulations and permit conditions.

3.04 PROTECTION AND/OR RELOCATION OF EXISTING FACILITIES: Existing facilities such as storm drains, roadways, water lines, light poles, conduits, fences, utility and telephone lines, etc. are to be carefully protected from damage during all phases of the construction. The CONTRACTOR shall make all necessary arrangements with the owner of the facility and be responsible for all costs involved in the proper protection, relocation or other work that such owners deem necessary. See General Specification.

3.05 UNDERGROUND UTILITIES: The CONTRACTOR shall provide all necessary liaisons with other utilities (underground) by notification, 48 hours in advance, of any digging by telephoning the appropriate Utility Notification Center and local utilities.

END OF SECTION

PART 1 - GENERAL

1.01 SCOPE:

A. Summary of Work: The CONTRACTOR shall furnish all labor, equipment, and materials for all excavating, trenching, filling, embankment of construction, backfilling, compacting, grading and all related items of earthwork necessary to complete the work indicated or specified.

1.02 APPLICABLE PUBLICATIONS:

A. American Society of Testing Materials, (ASTM):

1. D698-00a – Standard Test Methods for Laboratory compaction Characteristics of Soil Using the Standard Effort (12,400 ft-lbf/ ft^3 (600 kN-m/m^3)).

2. D1557-00 - Standard Test Methods for Laboratory compaction Characteristics of Soil Using the Modified Effort (56,000 ft-lbf/ ft^3 (2,700 kN-m/m^3)).

3. D2487-00 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

4. D4253-00 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

5. D4254-00 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

B. Florida Department of Transportation (FDOT)

1. "Standard Specifications for Road and Bridge Construction," latest edition,

(FDOT).

C. Miscellaneous Project Data:

1. Subsurface soil data logs are provided for the CONTRACTOR's reference:

1.03 DEFINITIONS:

A. Random Fill:

a. Graded
b. Shall be clean material free from organic material, clods, and stones greater than 2 inches.
c. Compacted to specified density.

1.04 SUBMITTALS: The Contractor shall submit cross-sections for record purposes for canal excavations and levee embankments as described in this Section.

1.05 QUALIFICATIONS: (Not Used)

1.06 RESPONSIBILITIES: (Not Used)

1.07 CERTIFICATIONS AND TESTINGS: Field density tests in accordance with ASTM Standards, for each type of material used in backfilling may be required. Failure to meet the specified density will require the CONTRACTOR to recompact and retest, at his own expense, those areas directed by the ENGINEER

1.08 INSPECTION COORDINATION: The CONTRACTOR shall provide access to the WORK for the ENGINEER as requested for inspection. The CONTRACTOR shall provide 48 hours notice of its intention to begin new WORK activities.

1.09 Warranty (Not Used)

PART 2 - PRODUCTS

2.01 MATERIALS ENCOUNTERED:

A. The CONTRACTOR shall excavate materials consisting of predominantly sandy, poorly drained spodsols (NRCS Soil Survey).

B. The CONTRACTOR shall consider all materials encountered in excavations, excluding peat unless the quantities are less than 25 percent of the total volume, as suitable fill, providing that they consist of two or more well graded soils to achieve the required compaction as specified in this SECTION.

C. The CONTRACTOR shall use only material that is free of debris, roots, and organic matter.

D. The CONTRACTOR shall furnish materials for each type of fill indicated.

1. Random Backfill: Random backfill shall be material that is well graded, free of debris, roots, organic matter and peat. Random backfill shall be material excavated for the WORK (native) or may be imported. The CONTRACTOR may blend native materials to achieve a material that meets the requirements for Random Backfill. Random backfill shall be free from seeds of nuisance or exotic species. Random Backfill shall meet the following Unified Soil Classification System (ASTM D2487) designations in addition to the classifications identified for Select Backfill: CH.

2. Unclassified Backfill: Material excavated for the WORK of imported that can be compacted to the required density. Unclassified backfill shall be free for seeds of nuisance or exotic species.

E. The CONTRACTOR shall consider all materials encountered, regardless of type, character, composition and condition thereof unclassified other than as indicated above. The CONTRACTOR shall estimate the quantity of various materials included prior to submitting Bid Form. Rock encountered shall be handled at no additional cost to ENGINEER.

PART 3 - EXECUTION

3.01 SITE PREPARATION:

A. CLEARING AND GRUBBING

1. Delineate areas to be cleared a minimum of 48 hours prior to clearing. Do not commence clearing without written authorization from ENGINEER.

2. Clear areas required for access to the Site and execution of the Works.

3. Cut off stumps, roots, brush, and other vegetation in areas to be cleared, within 0.5 feet of ground surface, except such trees and vegetation as shown on the Drawings or directed by ENGINEER to be left standing.

4. Remove and dispose of structures that obtrude, encroach upon, or otherwise obstruct work.

5. Remove shrubs within marked areas. Remove stumps, main root ball, and surface rock.

6. Clear undergrowth and deadwood, without disturbing subsoil.

7. Fill depressions made by grubbing with suitable fill material and compact to make the surface conform with the original adjacent surface of the ground.

8. Remove debris, rock, and extracted plant life.

9. Dispose of stumps, roots, brush, rotten wood, and other refuse from the clearing and grubbing operations as directed by ENGINEER.

3.02 EXCAVATION AND TRENCHING:

A. Sheeting and Bracing: The CONTRACTOR shall provide sheeting and bracing as required or shown in accordance with the following provisions.

1. Use when required by the specifications or drawings and where resulting slopes from excavation or trenching might endanger in-place or proposed structures.

2. Provide materials on site prior to start of excavation. Adjust spacing and arrangement as required by conditions encountered.

3. Remove sheeting and bracing as backfill progresses. Fill voids left after withdrawal with sand or other approved material.

4. Comply with all applicable sections of OSHA.

5. Comply with all requirements of the Florida Trench Safety Law as specified in the GENERAL CONDITIONS.

B. Excavation for Structures: The CONTRACTOR shall perform excavation for structures as shown, required and specified below:

1. Excavate area adequate to permit efficient erection and removal of forms.

2. Excavate by hand in areas where space and access will not permit use of machines.

3. Notify the ENGINEER immediately when excavation has reached the depth indicated.

5. Restore bottom of excavation to proper elevation with random fill in areas over excavated.

3.03 EMBANKMENT:

A. Berm Embankment:

1. Berm embankment shall consist of random backfill unless otherwise indicated and shall be placed to the lines and grades indicated. Levee side slopes indicated are nominal, and may be varied. Completed side slopes shall be uniform from top to toe of the levee, and shall be smoothly transitioned.

2. Material deposited during ditch excavation will have a high moisture content, and shall be dried, prior to final incorporation in the berm to obtain suitable moisture content (within plus or minus five percent of optimum moisture density) to permit placement and compaction. Drying may consist of allowing

the material to drain for a sufficient period to achieve the necessary moisture content or by mechanical means. Following the drying period, organic and non-organic materials shall be completely mixed.

3. Following mixing, materials shall be placed in horizontal layers not in loose thickness and compacted as indicated. Final compaction will be completed with a 16,000 pound vibratory roller (or equivalent).

4. Side slopes indicated are nominal, and may be varied. Completed side slopes shall be uniform from top to toe of the levee, and shall be smoothly transitioned. Final compaction will be completed with a 16,000 pound vibratory roller (or equivalent). The CONTRACTOR shall perform embankment work as shown on the Drawings, required and in accordance with these specifications.

   a. Materials suitable for fill shall be placed in the central core of the berm in horizontal layers in loose thickness and compacted as indicated.

   b. Random fill shall be placed to its final position on each side of the select fill concurrent with select fill placement.

   c. Rocks not exceeding the acceptable size shall be distributed throughout the embankment such that rock to rock contact is avoided. Rock particles greater than 2 inches inches in average diameter shall not be used.

D. Final Dressing of Slopes: Following completion of embankment placement and compaction, the CONTRACTOR shall grade embankment slopes and adjacent transition areas reasonably smooth and free from irregular surface changes. The CONTRACTOR shall comply with the following:

1. Degree of finish shall be that ordinarily obtained from blade grader or similar operations.

2. Provide roundings at bottom of slopes and other breaks in grade.

3. Final compaction will be completed with a 16,000 pound vibratory roller (or equivalent).

E. Cross-Sections: Provide field measured cross-sections of the final embankments to the ENGINEER for record purposes, plotted at the same stations as the detailed cross-sections shown on the plans, not to exceed **500** feet.

F. A tolerance of 0.3 feet above or below the lines and grades indicated will be permitted; however, the area of material left above the lines and grades indicated shall not exceed the area of the material removed below the lines and grades indicated.

   a. Provide field measured cross-sections of the "As-Built" conditions to the ENGINEER, plotted at the same stations as the detailed cross-sections shown on the plans to show the above specified tolerance has been met.

3.04 BACKFILLING:

A. Pipe Embedment and Backfill: The CONTRACTOR shall perform pipe embedment and backfill as required, shown and specified in accordance with Section 02221.

B. Structures: The CONTRACTOR shall perform backfilling for structures in accordance with the following:

1. Structure backfill shall be constructed using material suitable for use in select fill, except that stones or rocks greater than two inches in any dimension shall not be placed within 12 inches of the structure.

2. Backfill adjacent to structures only after a sufficient portion of the structure has been built to resist the imposed load.

3. Remove all debris from excavation prior to placement of material.

4. Place backfill in level layers of thickness within compacting ability of equipment used.

5. Perform backfilling simultaneously on all sides of structures.

6. Do not dump directly against structure.

C. Backfill shall be placed to the lines and grades shown on the drawings or as approved by the ENGINEER. The CONTRACTOR shall compact backfill to a density approximating the density of surrounding native material and in a manner that will not allow settlement of the completed area. Final compaction will be completed with a 16,000 pound vibratory roller (or equivalent).

3.05 MAINTENANCE:

A. The CONTRACTOR shall protect newly graded areas from actions of the elements.

B. The CONTRACTOR shall fill, repair and re-establish grades to the required elevations and slopes for any area that shows settling or erosion occurring prior toseeding .

END OF SECTION

SECTION 02434 – REV 11/02 CULVERTS

PART 1 - GENERAL

1.01 SCOPE:

A. Summary of Work: The CONTRACTOR shall furnish all labor, material, and equipment necessary for the installation of culverts as shown on the Drawings and specified herein, except for those services provided by Others as directed by ENGINEER.

1.02 APPLICABLE PUBLICATIONS:

A. American Society for Testing and Materials, (ASTM):

1. A978/A978M-97(2002)e1- Standard Specification for Composite Ribbed STEEL PIPE, Pre coated and Polyethylene Lined for Gravity Flow Sanitary Sewers, Storm Sewers, and Other Special Applications
2. B788/B788M-00 -Standard Practice for Installing Factory-Made CORRUGATED ALUMINUM Culverts and Storm Sewer PIPE

B. Florida Department of Transportation (FDOT): Standard Specifications for Road and Bridge Construction, latest edition, (FDOT).

C. Local City and County Codes.

1.03 DEFINITIONS: (Not Used)

1.04 SUBMITTALS:

A. The CONTRACTOR shall make submittals for culverts in accordance with SECTION 01300 and the following provisions. The CONTRACTOR shall be responsible for coordination of materials, equipment, and installation regardless of if the submittals are made together or separately.

1. The CONTRACTOR shall submit dimensional drawings of culverts showing all dimensions and details of construction and installation including wall reinforcing and joint details.

1.05 QUALIFICATIONS: (Not Used)

1.06 RESPONSIBILITIES: (Not Used)

1.07 CERTIFICATIONS AND TESTING: The CONTRACTOR shall provide a Certificate of Compliance from manufactures.

1.08 INSPECTION COORDINATION: The CONTRACTOR shall provide access to the Work for the ENGINEER as requested for inspection. The CONTRACTOR shall provide 48 hours notice of its intention to begin new Work activities.

1.09 WARRANTY: (Not Used)

PART 2 - PRODUCTS

2.01 MATERIALS:

A. General Requirements: The CONTRACTOR shall furnish culverts as shown.

1. CORRUGATED ALUMINUM PIPE, including round culvert pipe, pipe arch and under drain and coupling bands for each type shall conform to ASTM specifications.

2. BACKFILL MATERIAL: Backfill shall be as specified in SECTION 02200.

2.02 JOINTS FOR CORRUGATED METAL PIPE: The CONTRACTOR shall provide joints for pipe as required by the FDOT Standard Specifications for Road and Bridge Construction Section 942, and Article 942-1 except that the following shall be required:

A. Joints shall be made with bands of the same base metal and corrugation as the pipe. Bands shall not be less than 12" wide for pipe up to and including 36-inch diameter, and not less than 24" for pipes larger than 36-inch diameter. Bands may be one or two-piece lap type. Joints shall include an asphalt base sealer or neoprene gasket with 12-inch width. The band shall be tightened in a manner such that all joints are watertight. Helical pipe shall have re-rolled annular ends.

2.03 PIPE THICKNESS: The CONTRACTOR shall provided corrugated metal pipe and arch pipe fabricated from sheets corresponding to the following U.S. Gauge Numbers unless otherwise shown on the Drawings:

PIPE SIZE (INCHES)	U.S. GAUGE NO.	PIPE SIZE (INCHES)	U.S. GAUGE NO.	CONNECTING BAND
15"	16	17" x 13"	16	16
18"	16	21" x 15"	16	16
21"	16	24" x 18"	14	16
24"	16	28" x 20"	14	16
30"	14	35" x 24"	14	16
36"	14	42" x 29"	12	14
42"	12	49" x 33"	12	14
48"	12	57" x 38"	10	14
54"	12	64" x 43"	10	14
60"	10	71" x 47"	8	12
66"	10	77" x 52"	8	12
72"	10		8	12
78"	8			12
84"	8			12
96"	8			12

PART 3 - EXECUTION

3.01 EXCAVATION:

A. General: The CONTRACTOR shall perform all excavation of every description and of whatever substances encountered to the depths indicated on the Drawings, or as necessary. Excavation shall be unclassified regardless of material encountered. This shall include all necessary clearing and grubbing of any foreign substances encountered within the structure or trench area. No separate payment for excavation as such will be made. The cost thereof shall be included in the prices for the pipe installation. The CONTRACTOR shall stockpile excavated material suitable for backfill in an orderly manner at a sufficient distance from the trench to avoid overloading and to prevent slides or cave-ins. The CONTRACTOR shall perform excavation in accordance with the following:

1. Excavation in rock shall be made by a method accepted by the ENGINEER.
2. All muck below storm drain pipes and structures shall be completely removed to the width of the trenches at the pipe center line and to the depths where sand or other acceptable material is encountered. After removal of all muck, the trench shall be filled to the invert of the pipe with fill placed and tamped in not greater than eight-inch layers. Each layer shall be compacted to not less than 95 percent of the maximum density as required by ENGINEER.
3. The CONTRACTOR shall dispose of the excavated materials onsite not required or suitable for backfill, and shall perform such grading as may be necessary to prevent surface water from flowing into the trenches. Hauling or disposal of the material will be the responsibility of the CONTRACTOR. Sheeting and shoring shall be installed as may be necessary for the protection of the Work, for the preservation of adjoining property and structures, and for the safety of the employees. Unless otherwise indicated, excavation shall be by open cut.
4. The CONTRACTOR shall provide adequate equipment for the removal of storm or subsurface waters that may accumulate in the excavated areas. If subsurface water is encountered, the CONTRACTOR shall utilize approved means to adequately dewater the excavation so that it will be dry for working and pipe laying. A wellpoint system or other approved dewatering method shall be utilized, if necessary, to maintain the excavation in a dry condition for preparation of the trench bottom and for pipe laying. All existing improvements such as pavements, conduits, poles, pipes and other structures shall be carefully supported and fully protected from injury and, in case of damage; they shall be restored by the CONTRACTOR without compensation. Existing utilities and other underground obstructions are shown on the plans, but the accuracy of the locations and depths is not guaranteed. The CONTRACTOR shall be responsible for all utilities prior to the commencement of excavation. The CONTRACTOR shall be responsible for damages to these existing utilities and shall, in case they are damaged, restore them to their original condition.

B. Trench Excavation: The CONTRACTOR shall excavate trenches to such a width as is necessary for proper laying of the pipe with banks as nearly vertical as practicable, but at all times maintaining a safe trench condition for workers and the WORK. The bottom of trenches shall be accurately graded by the CONTRACTOR to provide uniform bearing on undisturbed soil for the entire length of each section of pipe, except where it is necessary to excavate for pipe bells and for the proper sealing of joints. Bell holes and depressions shall be excavated after the trench bottom has been graded and such holes and depressions shall not be made larger than is necessary for properly making the particular type of joint. The width of the trench at and below the top of the pipe shall not be greater than necessary but shall be adequate to permit jointing and thorough tamping of the backfill around the pipe. The width of the trench above the level may be as wide as necessary for sheeting and bracing and the proper performance of the work. Unauthorized overdepths shall be backfilled with loose, granular, moist earth, thoroughly tamped by the CONTRACTOR at its sole cost. Whenever the presence of incipient slides is noted during excavation, the trench walls shall be restrained with adequate sheeting, shoring and bracing. Either steel or wood sheeting shall protect trench excavation in the proximity of certain existing culverts and utility lines. Should used sheet pile be used, it will be the CONTRACTOR'S responsibility to guarantee the integrity of the used sheet piles. A professional engineer retained by the CONTRACTOR shall certify the used sheet piles.

C. Removal of Rock: Where rock is encountered, the CONTRACTOR shall remove the rock and replace it with suitable selected materials. Select materials shall be placed in such manner as to provide a compacted earth cushion having a thickness under the pipe of not less than eight inches or one half inch per foot height of fill over the top of the pipe which ever is greater.

D. Removal of Unstable Material: The CONTRACTOR shall provide all pipe and appurtenances with a stable foundation. Any material encountered at the elevation shown on the Drawings or specified for pipe that will not or cannot be improved to provide a stable foundation for the pipe, shall be considered unsuitable and removed and replaced by the CONTRACTOR. All unsuitable material below the grade line of the pipe shall be removed for the full width of the trench and replaced with suitable select material compacted as specified elsewhere in these specifications. For the purpose of this specification, muck, peat, other highly organic soils, and any other materials with high plasticity shall be considered to be unsuitable materials. Unless otherwise specifically approved by the ENGINEER, any soil which is or might become wet to such a degree that its moisture content is equal to or greater than 90% of its liquid limit will be considered unsuitable and shall removed and replaced with suitable material.

E. Bedding: The CONTRACTOR shall provide native bedding material for the pipe that shall provide a firm foundation of uniform density throughout the entire length of the pipe. The pipe shall be carefully bedded in a soil foundation that has been accurately shaped and rounded to conform to the lowest quarter of the outside circular portion of the pipe for its entire length and, when necessary, bedding shall be tamped to secure uniform, firm support.

3.02 INSTALLATION OF PIPE:

A. General: The CONTRACTOR shall install piping and appurtenances for culverts that are of the type and material specified in these specifications or on the Drawings. All pipe, fittings, jointing materials, grates, manhole frames and covers, and other appurtenances and materials shall be new material to be included in the work and, if not specifically described herein, shall be of the best quality and entirely suitable for the service intended. The CONTRACTOR shall submit all such materials for the ENGINEER's approval, prior to installation.

B. Handling and Storage: The CONTRACTOR shall protect the pipe during shipping, storage, handling, and installation against impact shocks, free fall or other damage. Any damaged pipe shall be removed from the job site immediately.

C. Pipe Laying: The CONTRACTOR shall execute pipe laying as required and specified herein:

1. The trench shall be prepared as specified herein and each pipe section shall be laid in strict conformance to the line and grade shown on the Drawings.

2. As pipe laying progresses, the interior of the pipe shall be cleaned of all dirt and superfluous materials. The CONTRACTOR shall at all times take whatever measures are necessary to prevent the entrance of dirt and other foreign matter into the drainage system. In the event that it is necessary to clean the pipe before final acceptance, the CONTRACTOR shall do so without additional compensation.

D. Open Trench: In no instance shall any trench be left open for more than 24 hours before backfilling in accordance with these specifications.

3.03 BACKFILLING:

A. Under Pipe: The CONTRACTOR shall backfill trenches from the bottom of the trench to the centerline of the pipe with predominantly sandy material free from rocks or stones. The CONTRACTOR shall place the material in no greater than six-inch layers prior to compaction. The CONTRACTOR shall compact the material to 95 percent of the maximum density. The CONTRACTOR shall use appropriate equipment, under and on each side of the pipe and between the pipe and wall of trench. The CONTRACTOR shall take care to prevent pipe movement during pipe installation.

B. Over Pipe: From the centerline of the pipe, fittings and appurtenances, to an elevation one foot above the top of the pipe, the CONTRACTOR shall backfill the by hand or by approved mechanical methods. The backfill material shall be as specified in (a) above, and shall be consolidated by use of tampers.

3.04 WATER CONTROL: Unless specifically authorized by the ENGINEER, the CONTRACTOR shall lay all pipes in the dry, and the CONTRACTOR shall do such pumping as is required for proper execution of the WORK and to dispose of the water without damage or undue inconvenience of the work, the surrounding area or the public. The CONTRACTOR shall not dam, divert or cause water to flow in excess in existing gutters, pavements or other structures, and to this end may be required to conduct the water to a suitable place of discharge. Wellpoint system or other approved equipment shall be used to maintain excavations in a dry condition for pipe laying.

END OF SECTION

SECTION 02486 GRASSING

PART 1 - GENERAL

1.01 SUMMARY:

A. The Work covered by this Section consists of furnishing all the necessary equipment, materials and labor associated with the establishment and maintenance of grass in all areas as specified herein and in the drawings. These include, but are not limited to seeding, mulching and fertilizing newly grassed areas and maintenance.

1.02 SUBMITTALS:

A. Certificates:

1. Seed and fertilizer shall be certified that they meet requirements of these specifications, stating botanical name, percentage by weight, percentage of purity, germination, and weed seed for each grass seed species.

PART 2 - MATERIALS

2.01 GRASS SEED:

A. Provide fresh, clean, new crop seed complying with tolerance for purity and germination established by Official Seed Analysts of North America and as required below.

B. Be labeled according to the U.S. Department of Agriculture Federal Seed Act and shall be furnished in containers with tags showing seed mixture, purity, germination, weed content, name of seller, and date on which seed was tested.

1. Seed Mixtures: Meet the following minimum percentage requirements for purity and germination:

Seed Name	Purity	Germination	Pounds Per 100 lbs. of Mixture
Argentine Bahia	95	80	70
Brown Top Millet	90	85	30

2. Moldy seed or seed that has been damaged in storage will not be accepted.

3. When seasonal conditions mandate, substitute a winter grass such as rye grass for the brown top millet.

2.02 FERTILIZER:

A. Commercial fertilizer of neutral character, with some elements derived from organic sources, containing not less than 12 percent total nitrogen, 8 percent available phosphoric acid, and 8 percent water-soluble potash. At least 50 percent of the phosphoric acid shall be from normal super phosphate or an equivalent source that will provide a minimum of two units of sulfur.

B. Deliver to site in unopened, labeled bags or containers.

2.03 MULCH:

A. Vegetative Anti-Erosion Mulch: Seed free, salt hay or straw of wheat, rye or oats, or of pangola, peanut, coastal Bermuda or Bahia grass hay.

B. Only undeteriorated mulch that can readily be cut into the soil shall be used.

C. Green mulch will not be accepted.

PART 3 - EXECUTION

3.01 SOIL PREPARATION:

A. Any growth, rocks, or other obstructions which might interfere with tilling, seeding, or later maintenance operations shall be removed and disposed of properly. Remove stones over 2 inches in any dimension and sticks, roots, rubbish and other extraneous matter.

B. Areas to be seeded are to be graded to a smooth, even surface with loose, uniformly fine texture. Roll and rake, remove ridges and fill depressions, to meet finish grades. Limit fine grading to areas which can be planted within immediate future.

C. Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting.

D. If prepared areas are eroded or otherwise disturbed after fine grading and prior to planting they shall be restored to specified condition prior to planting.

E. Immediately upon completion of construction, grass shall be planted in all disturbed areas and as designated in the drawings. Method of planting shall be either hydroseeding or dry seeding.

3.02 FERTILIZING:

A. Apply fertilizer at the rate of 700 pounds per acre to prepared seedbeds.

B. Incorporate fertilizer into the soil to a depth of at least 2 inches by discing, harrowing or raking, except on slopes steeper than 2 horizontal to 1 vertical.

3.03 SEEDING:

A. Do not use wet seed or seed that is moldy or otherwise damaged in transit or storage.

B. Do not seed when wind velocity exceeds 5 miles per hour. Distribute seed evenly over entire area by sowing equal quantity in two directions at right angles to each other.

C. Sow not less than rate of 100 pounds per acre.

D. Rake seed lightly into top 1/8-inch of soil, roll lightly, and water with fine spray.

E. Methods of Application:

1. Dry Seeding: Spreader or seeding machine.

2. Hydraulic Seeding: Mix seed with water and constantly agitate. Do not add seed to water more than 4 hours before application.

a. On slopes of 2 horizontal to 1 vertical or flatter, apply seed separately from fertilizer. Cover seed with soil to an average depth of ½-inch by raking or other approved methods.

b. On slopes steeper than 2 horizontal to 1 vertical, seed and fertilizer may be applied to a single operation. Incorporation into the soil will not be required.

3.04 <u>HYDROSEEDING</u>: All slopes shall be moistened to a ½-inch depth prior to application. The rates shall be as follows:

A. 200 LBS/AC of scarified Argentine Bahia Grass seed.

B. 50 LBS/AC of Brown Top Millet.

C. 2,000 LBS/AC of 100% virgin wood fiber.

D. 60 LBS/AC of takifier.

1. Fertilizer shall be included in all applications at a rate of .75 pounds of nitrogen/1,000 SF.

3.05 <u>MULCHING</u>:

A. Apply a mulch covering to all seeded areas.

B. Apply vegetative mulch to loose depth of 2 inches, by means of a mechanical spreader or other approved methods.

C. Mulch material shall be cut into the soil so as to produce a loose-mulched thickness of three to four inches. The use of harrows will not be permitted.

D. Immediately following the application of the mulch, water the seeded area in one watering, in sufficient amount to penetrate the seedbed to a minimum depth of 2 inches. Perform so as not to cause erosion or damage to the seeded surface.

E. Protect seeded areas against hot, dry weather or drying winds by applying mulch not more than 24 hours after completion of seeding operations.

3.06 <u>MAINTENANCE</u>:

A. Perform maintenance until 8 weeks after all areas have been seeded.

B. Requirements:

1. Water as required by good practice, and as necessary to obtain a flourishing cover.

2. Repair any portion of the seeded surface which becomes gullied or otherwise damaged, or the seeding becomes damaged or destroyed.

3. Replace mulch when washed or blown away.

C. If, at the end of the 8-week maintenance period, a satisfactory stand of grass has not been produced, renovate and reseed the grass or unsatisfactory portions thereof immediately.

3.07 <u>ACCEPTANCE OF GRASSING</u>:

A. When grassing work is substantially completed, including maintenance, ENGINEER will, upon request, make an inspection to determine acceptability.

1. Seeded areas may be inspected for acceptance in parts agreeable to ENGINEER, provided work offered for inspection is complete, including maintenance.

B. Replant rejected work and continue specified maintenance until reinspected by ENGINEER and found to be acceptable.

1. A satisfactory stand is defined as a grass or section of grass that has:

a. No bare spots larger that 3 square feet.

b. Not more than 5 percent of total area with bare spots larger than 6 inches.

c. Not more than 10 percent of total area with bare spots larger than 2 inches square.

2. If the grassing is still unsatisfactory upon inspection of replanted area, the Contractor will sod those areas that are unacceptable. Acceptance of the sodded areas is dependent upon satisfactory coverage criteria established in I.2.A above.

END OF SECTION

SECTION 02781 REV11/02 STAFF GAUGES

PART 1 GENERAL

1.01 SCOPE:

A. Summary of work: The CONTRACTOR shall provide all necessary equipment, labor and materials and perform all the work necessary to complete installation of staff gauges, including timber support piles for staff gauges.

1.02 APPLICABLE PUBLICATIONS:

A. American Society for Testing and Materials, (ASTM):

1. D25-99e1 - Round Timber Piles

2. D2555-98 - Establishing Clear Wood Strength Values

1.03 DEFINITIONS: (Not Used)

1.04 SUBMITTALS: (Not Used)

A. Submit manufacturer's certification that timber piles and preservative furnished for use in the work complies with the requirements of this specification.

B. Submit manufacturer's data for gauge strips and figure plates for approval if other than as referenced in this specification.

1.05: QUALIFICATIONS: (Not Used)

1.06: RESPONSIBILITIES: (Not Used)

1.07: CERTIFICATIONS: (Not Used)

1.08: INSPECTION COORDINATION: The CONTRACTOR shall provide access to the WORK for the ENGINEER as requested for inspection. The CONTRACTOR shall provide 48 hours notice of its intention to begin new WORK activities.

1.09: WARRANTY: (Not Used)

PART 2 PRODUCTS

2.01 GAUGE AND LUMBER: Others will furnish the CONTRACTOR with the staff gauges and treated lumber.

PART 3 PERFORMANCE

3.01 GAUGE BOARDS:

A. Gauge boards and gauge strips shall be oriented to face the water control structure-operating platform.

3.02 TIMBER PILES:

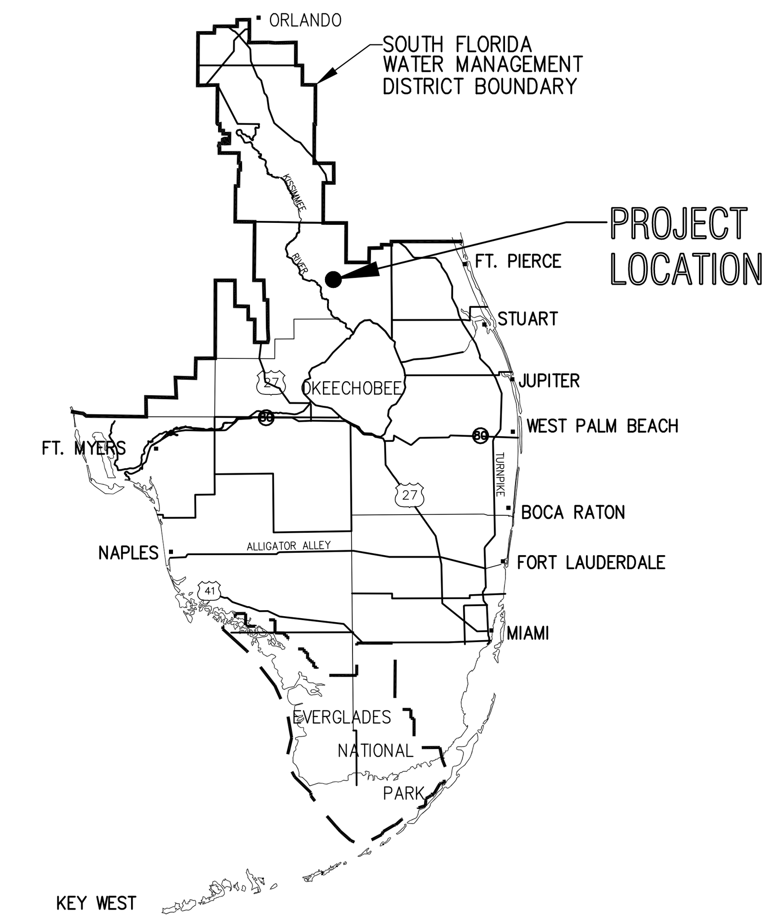
A. The CONTRACTOR shall be provided timber piles by Others for support of gauge boards shall be located where indicated and shall be furnished with steel pile shoes.

B. The CONTRACTOR shall select equipment for driving timber piles and steel pile shoes.

C. The CONTRACTOR shall level staff gages to $\pm$ 0.01 feet or better, based on NGVD29. All leveling will be performed under the direct supervision of a Florida registered land surveyor. Level runs will meet or exceed the National Geodetic Survey Standards for third order leveling (12mm√k). Field notes for each site will be reviewed by the land surveyor and certified as meeting the leveling standards. A copy of the field notes and the certification will be supplied to the ENGINEER to provide a traceable elevation for data verification.

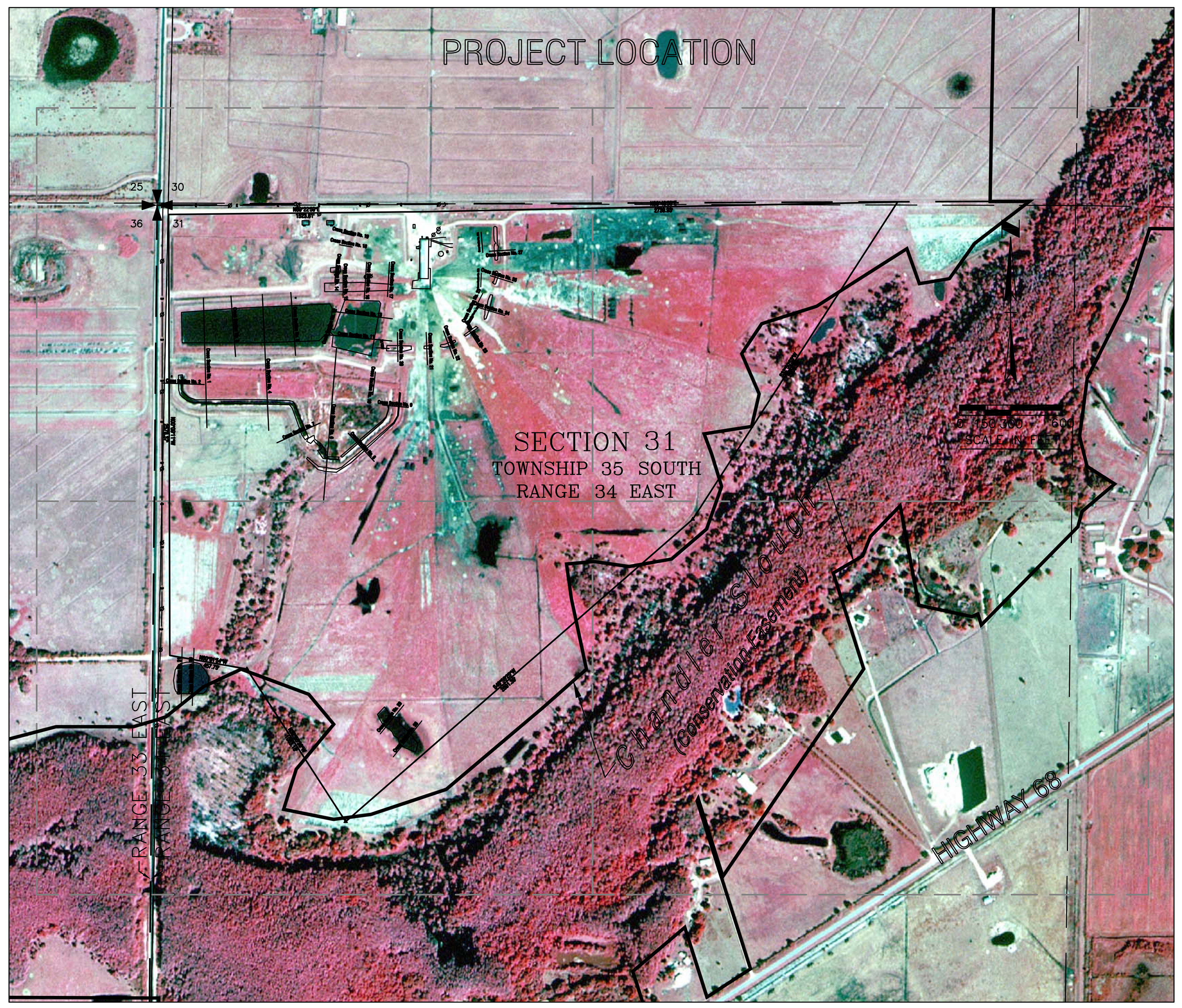
END OF SECTION

SOUTH FLORIDA WATER MANAGEMENT DISTRICT



LAMB ISLAND DAIRY REMEDIATION

OKEECHOBEE COUNTY, FLORIDA



LOCATION MAP

GOVERNING BOARD

NICHOLAS GUTIERREZ
CHAIRMAN

PAMELA BROOKS-THOMAS
VICE-CHAIRMN

LENNART LINDAHL
IRELA BAGUE
HUGH ENGLISH
KEVIN McCARTY
MICHAEL COLLINS
HARKLEY R. THORNTON
TRUDI K. WILLIAMS
BOARD MEMBERS

EXECUTIVE OFFICE

HENRY DEAN
EXECUTIVE DIRECTOR

INDEX OF SHEETS

1. COVER SHEET AND LOCATION MAP
2. SITE PLAN
3. DETAILS
4. CROSS SECTIONS
5. CROSS SECTIONS
6. CROSS SECTIONS
7. CROSS SECTION
8. CROSS SECTION

CONTRACT NO. C-13410

REVISION DESCRIPTION | DATE | DRAWN | REV.#

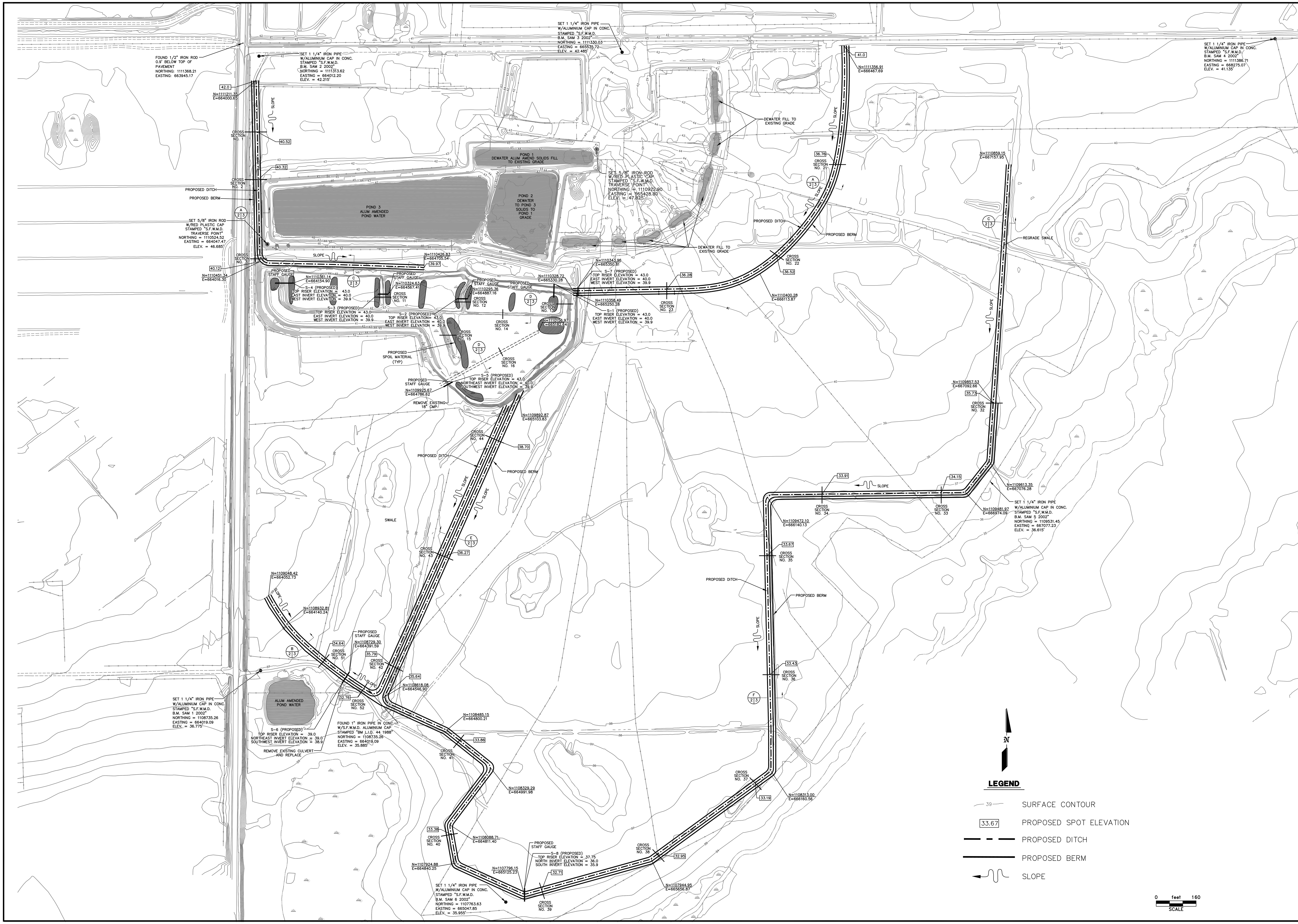
ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
CHECKED:
DATE: 11/1/03
SCALE: AS SHOWN

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
PHONE: 561-686-8800
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

LAMB ISLAND DIARY
OKEECHOBEE COUNTY, FLORIDA
COVER SHEET AND PROJECT LOCATION MAP

CONTRACT NO. C-13410
DRAWING NO. 8005716000[001]

SHEET 1 OF 8



REVISION DESCRIPTION

DATE	DRAWN	REV.#

ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
CHECKED:
DATE: 11/1/03
SCALE: 1"=160'

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
PHONE: 561-686-8800
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

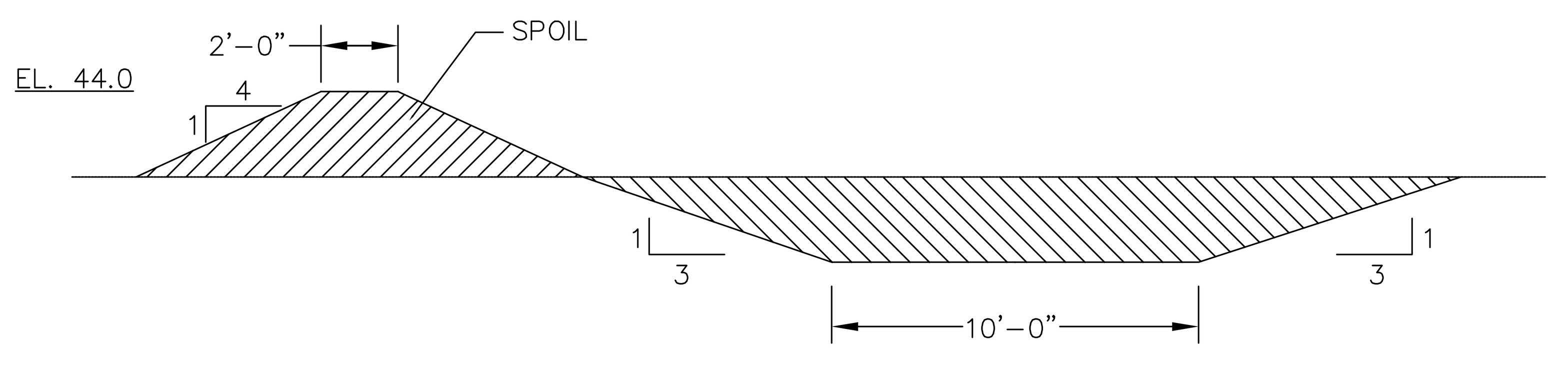
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

LAMB ISLAND DIARY
OKEECHOBEE COUNTY, FLORIDA

SITE PLAN

CONTRACT NO.
C-13410
DRAWING NO.
8005716000[002]

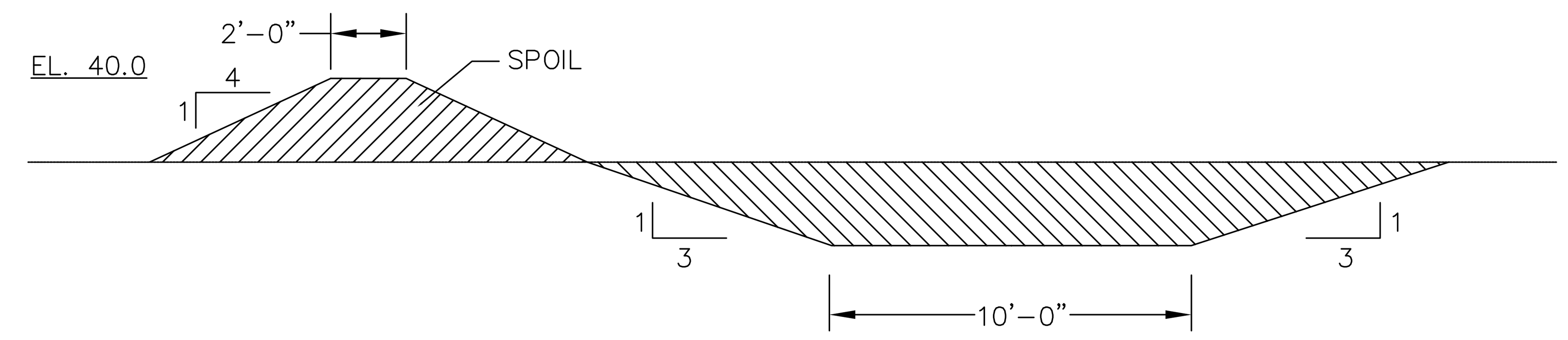
SHEET
2 OF 8



SEE PLAN AND CROSS
SECTION FOR ELEVATION

TYP. SWALE SEC A

NOT TO SCALE



SEE PLAN AND CROSS
SECTION FOR ELEVATION

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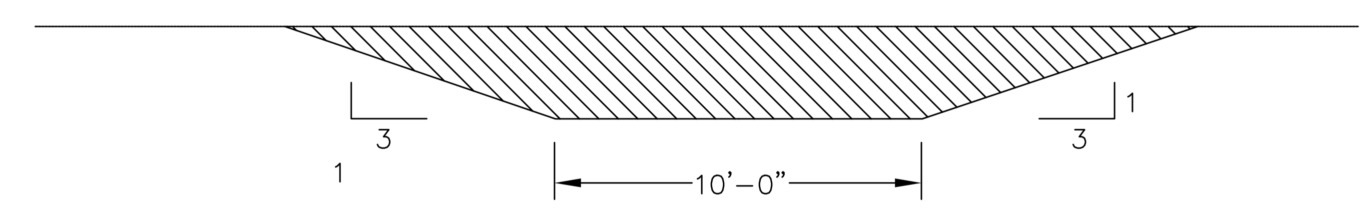

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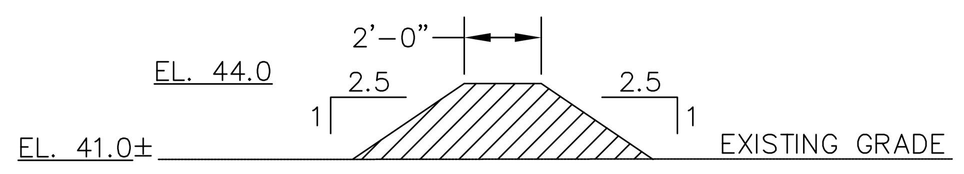

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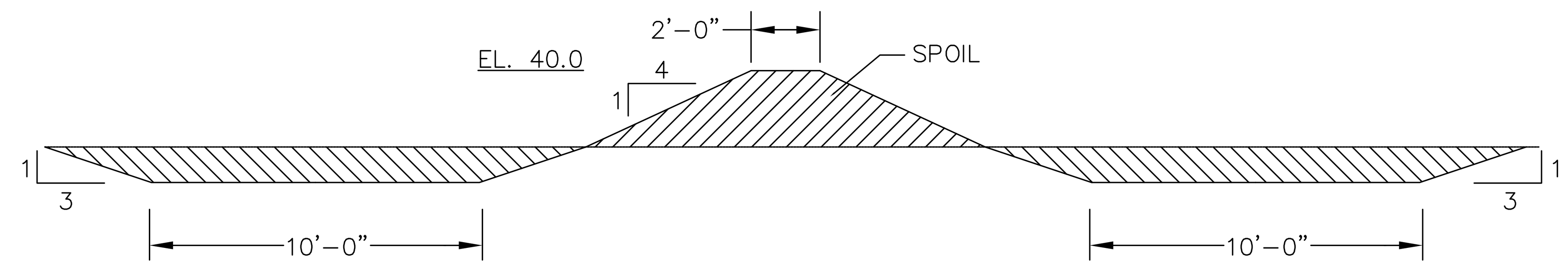

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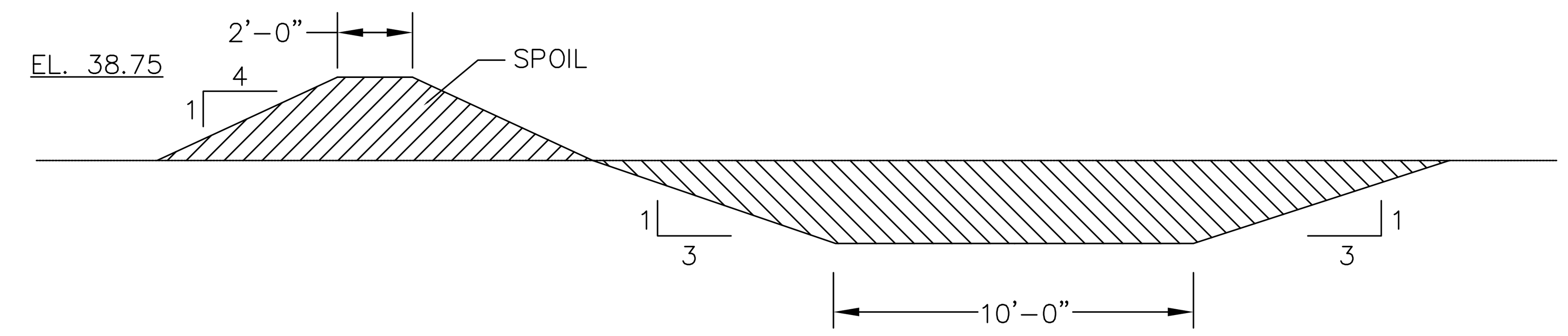

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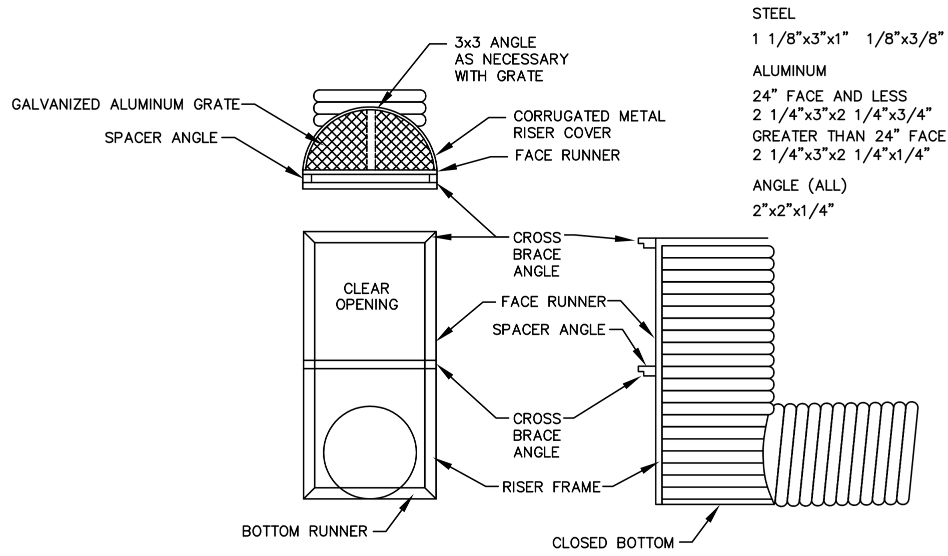


CHANNEL

STEEL

1 1/8"x3"x1" 1/8"x3/8"

ALUMINUM

24" FACE AND LESS
2 1/4"x3"x2 1/4"x3/4"
GREATER THAN 24" FACE
2 1/4"x3"x2 1/4"x1/4"

ANGLE (ALL)

2"x2"x1/4"

NOTES:

1. RISER GREATER THAN 5' HIGH HAVE CROSS BRACE ANGLE IN CENTER OF RISER FACE.
2. RISERS LESS THAN 1' CLEAR OPENING HAVE ONLY ONE BRACE AT TOP OF RISER.
3. DIMENSIONS & SPECIFICATIONS PER SOUTHERN CULVERT OR APPROVED EQUAL.

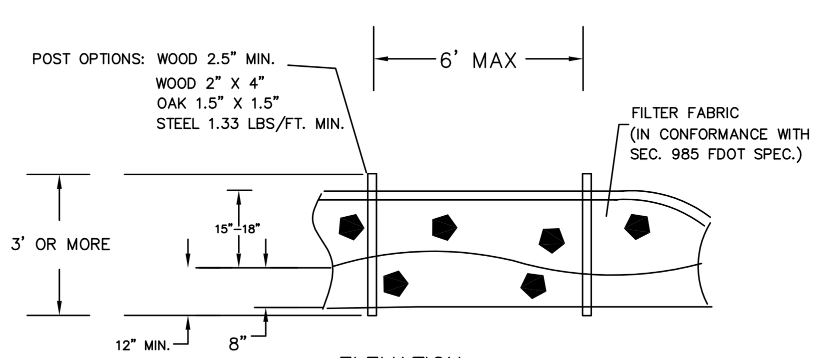
SINGLE FACE RISER

NOT TO SCALE

△ ALUMINUM RISER DETAIL (A/–)

STUB. DIA.	STUB. DIA.	RISER COVER			FRAME WIDTH
		FACE WIDTH	GA.	SHEET LENGTH	
12"	16	21	16	35	23
15"	16	24	16	40	26
18"	16	27	16	45	29
21"	16	30	16	50	32
24"	16	36	16	57.5	38
30"	14	42	14	68	44
36"	14	48	14	78	50
17"x33"	16	24	16	40	26
21"x15"	16	27	16	40	29
24"x18"	16	30	16	53	32
28"x20"	16	36	16	57.5	38
36"x24"	14	42	14	68	44
42"x29"	14	48	14	78	50

STRUCTURE	PIPE DIA.	TOP RISER ELEVATION	INVERT ELEVATION	LENGTH (FEET)
S–1	24"	43.0	40.0	20
S–2	24"	43.0	40.0	20
S–3	24"	43.0	40.0	20
S–4	24"	43.0	40.0	40
S–5	24"	43.0	40.0	20
S–6	24"	39.0	39.0	20
S–7	36"	43.0	40.0	20
S–8	24"	37.75	36.0	20



ELEVATION

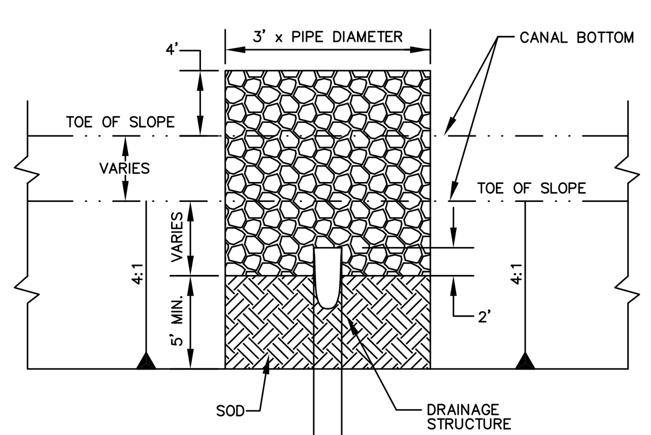
TYPE III SILT FENCE
(F.D.O.T. INDEX NO. 102)

△ SILT FENCE DETAIL (C/–)

NOT TO SCALE

PROPOSED GRADE 2 STONE RUBBLE RIP–RAP D50 10" ROCK SIZE (CONTRACTOR TO SUBMIT SHOP DRAWING WITH GRADATION AND PERCENT PASSING.

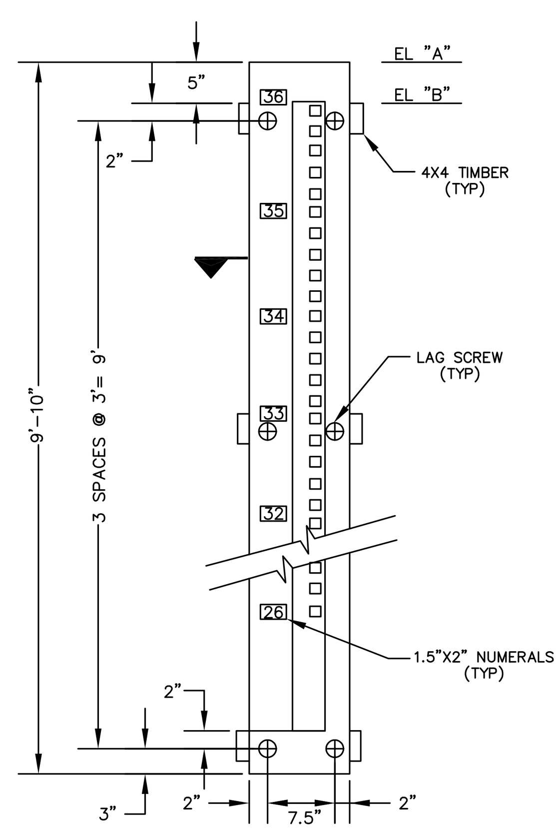
RUBBLE RIP–RAP SHALL MEET THE REQUIREMENTS OF SECTION 530 OF THE STANDARD SPECIFICATIONS.



RUBBLE RIP–RAP			
STRUCTURE	APPROXIMATE DIMENSIONS	AREA (S.Y.)	TONS
S–1	6' x 10'	7	7.8
S–2	6' x 10'	7	7.8
S–3	6' x 10'	7	7.8
S–4	6' x 10'	7	7.8
S–5	6' x 10'	7	7.8
S–6	6' x 10'	7	7.8
S–7	10' x 20'	22	24.4
S–8	6' x 10'	7	7.8

RUBBLE RIP–RAP OUTLET PROTECTION (B/–)

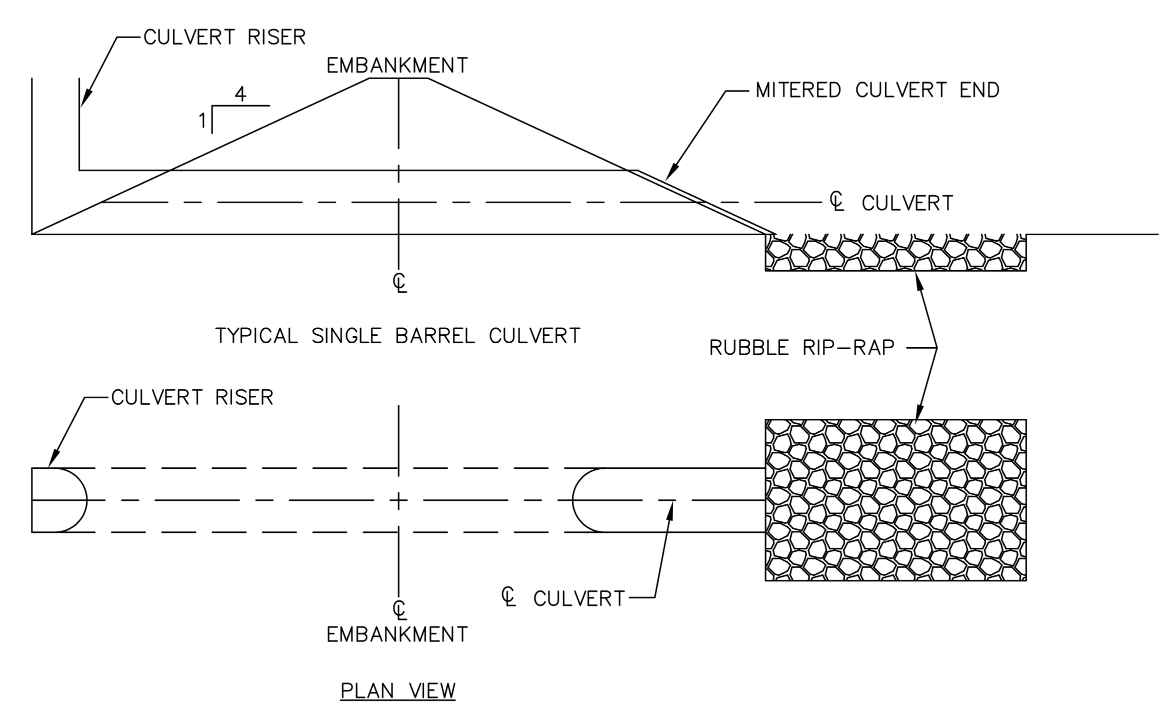
NOT TO SCALE



NOTE:
1.) NUMBERS MAY VARY FROM THOSE SHOWN HERE.

△ STAFF GAUGE (C/–)

NOT TO SCALE



CULVERT DETAIL

NOT TO SCALE

REVISION DESCRIPTION

DATE	DRAWN	REV.#

ENGINEER: TERRENCE HORAN
DRAWN: MISTI LIFE
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SOUTH FLORIDA WATER MANAGEMENT DISTRICT
ENGINEERING & CONSTRUCTION DEPARTMENT
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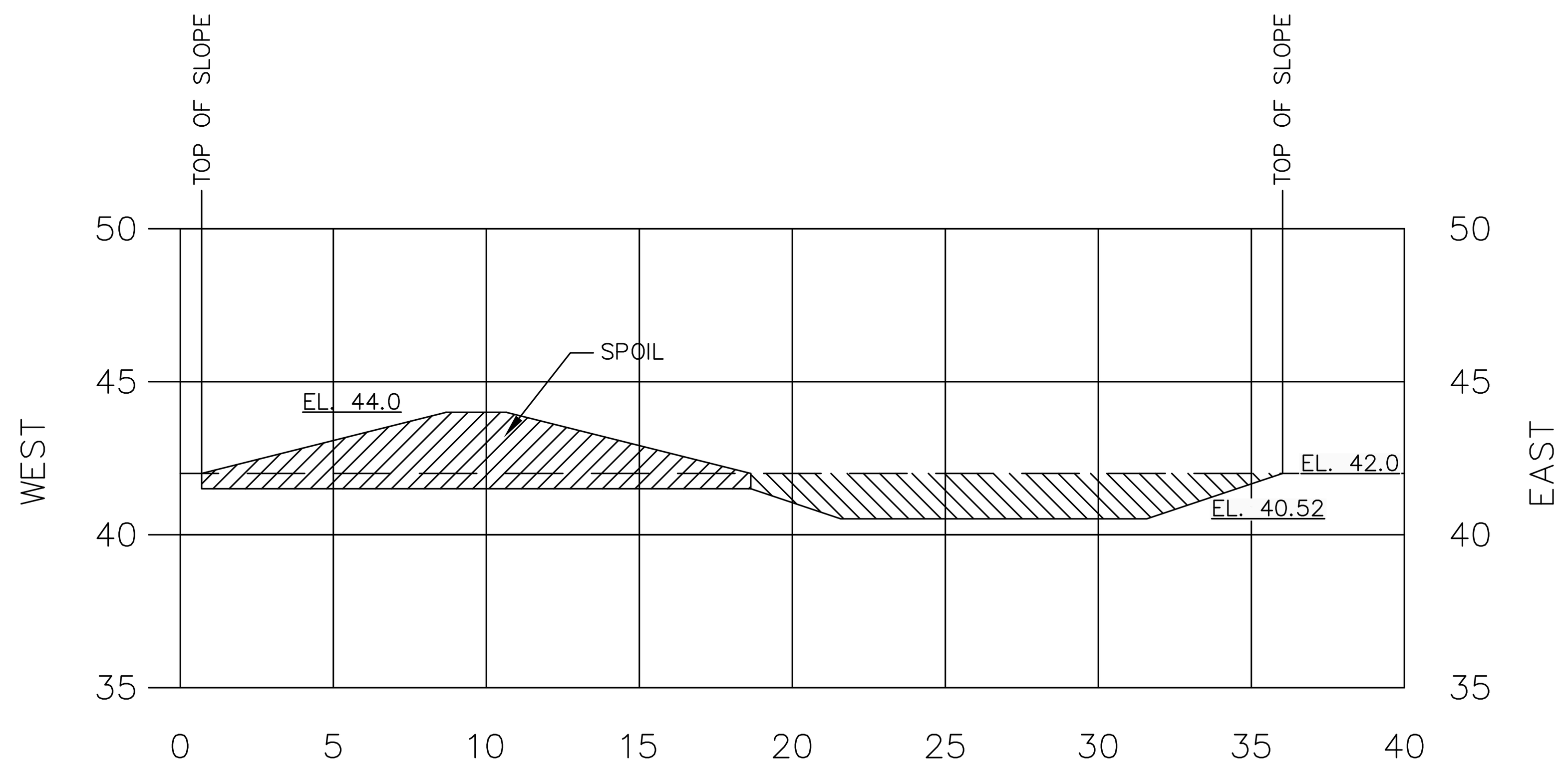
3301 GUN CLUB ROAD
WEST PALM BEACH, FLORIDA 33406

LAMB ISLAND DIARY
OKEECHOBEE COUNTY, FLORIDA

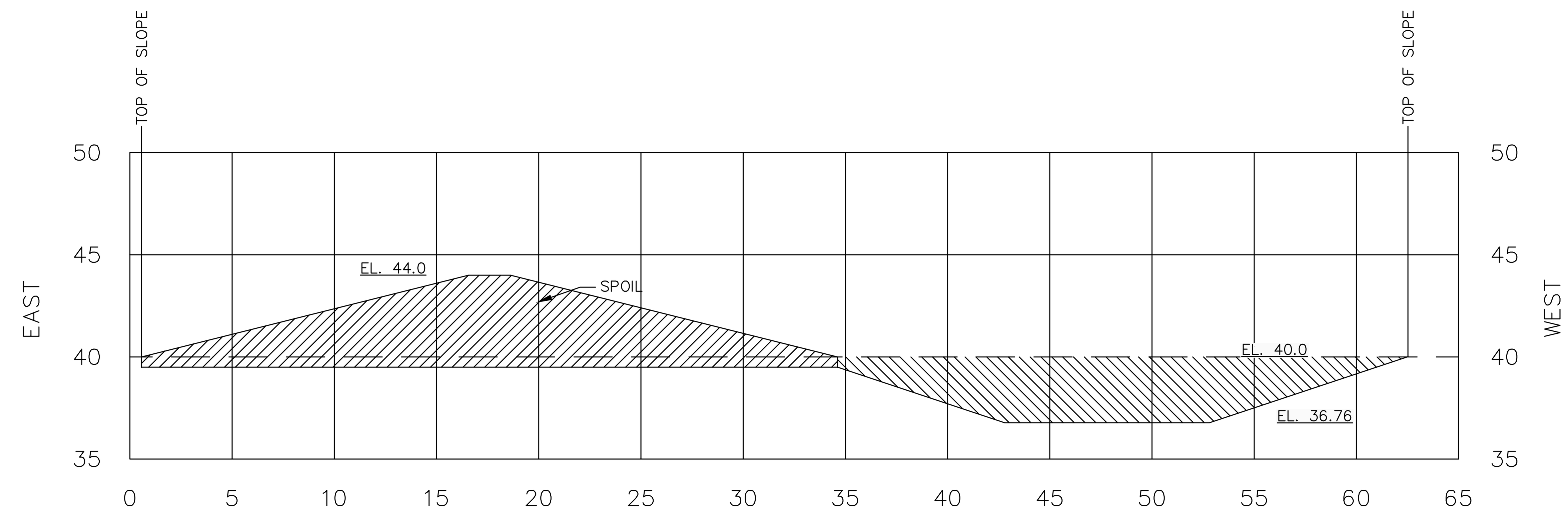
DETAILS

CONTRACT NO.
C–13410
DRAWING NO.
8005716000[003]



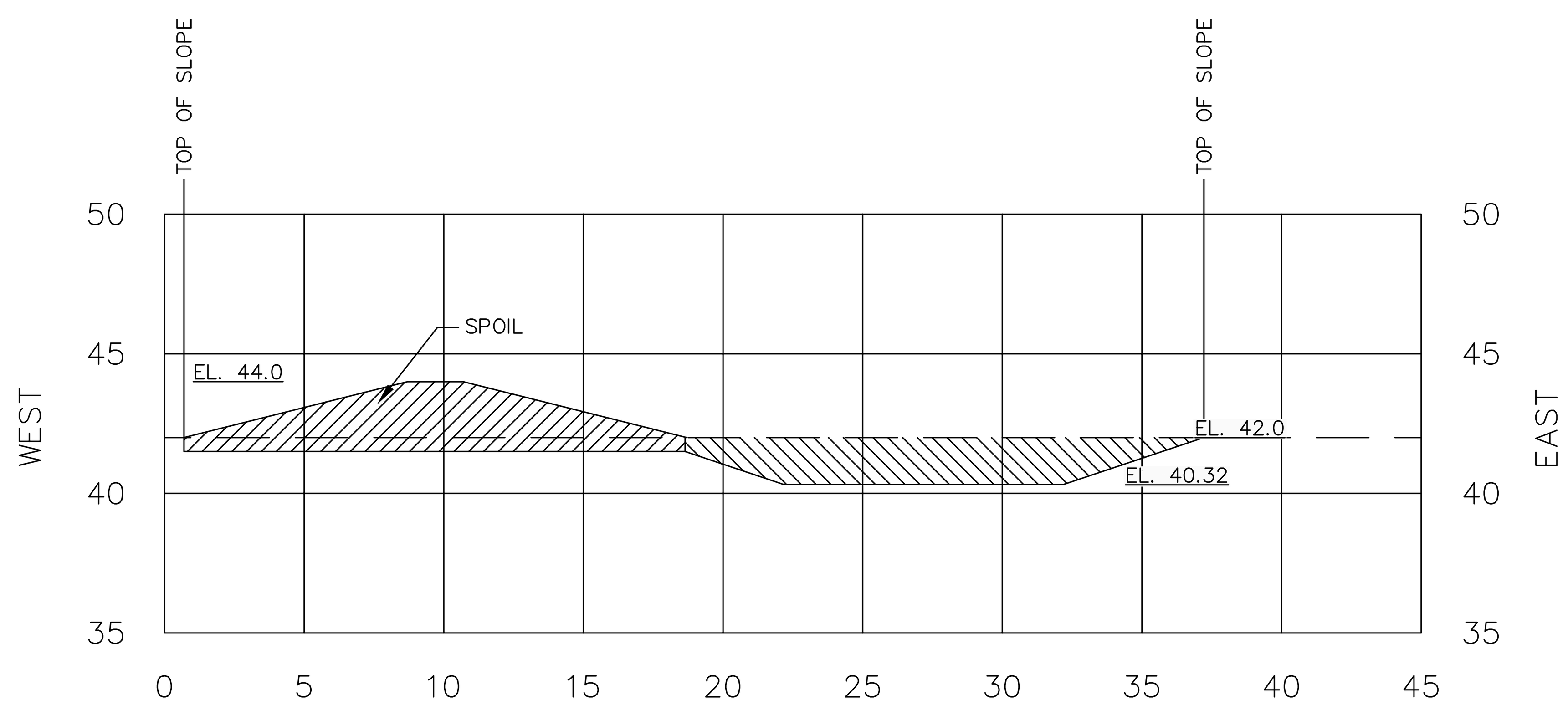
CROSS SECTION NO. 1 (TYP. SEC A)

NORTH SOUTH DRAINAGE DITCH
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



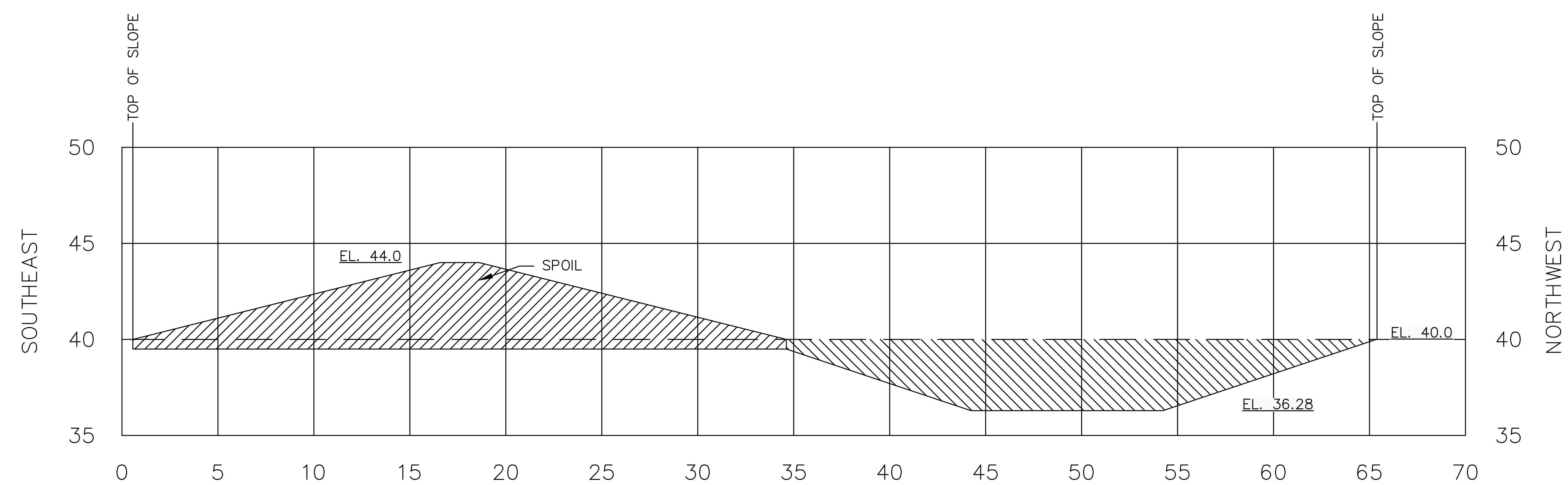
CROSS SECTION NO. 21 (TYP. SEC A)

NORTH SOUTH CONTAINMENT AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



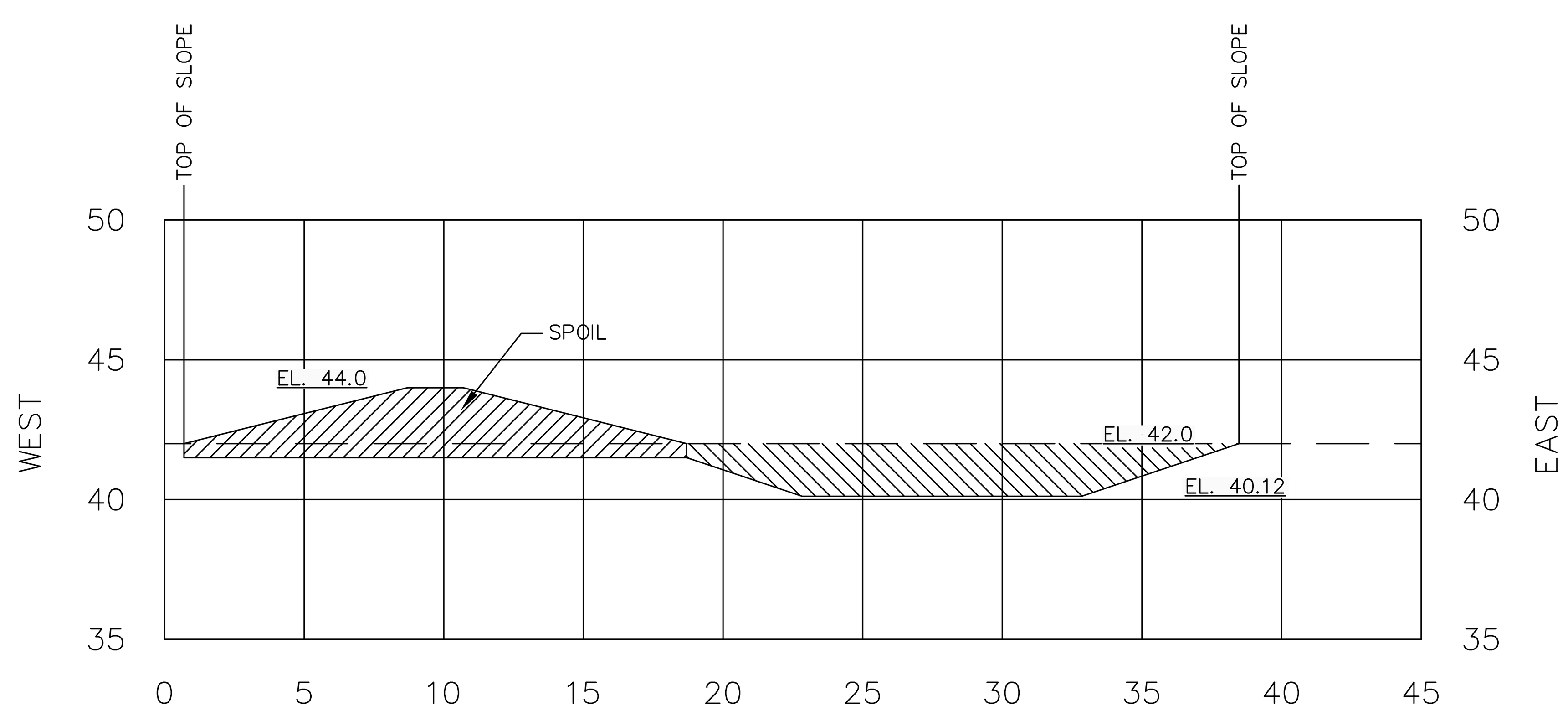
CROSS SECTION NO. 2 (TYP. SEC A)

NORTH SOUTH CONTAINMENT AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



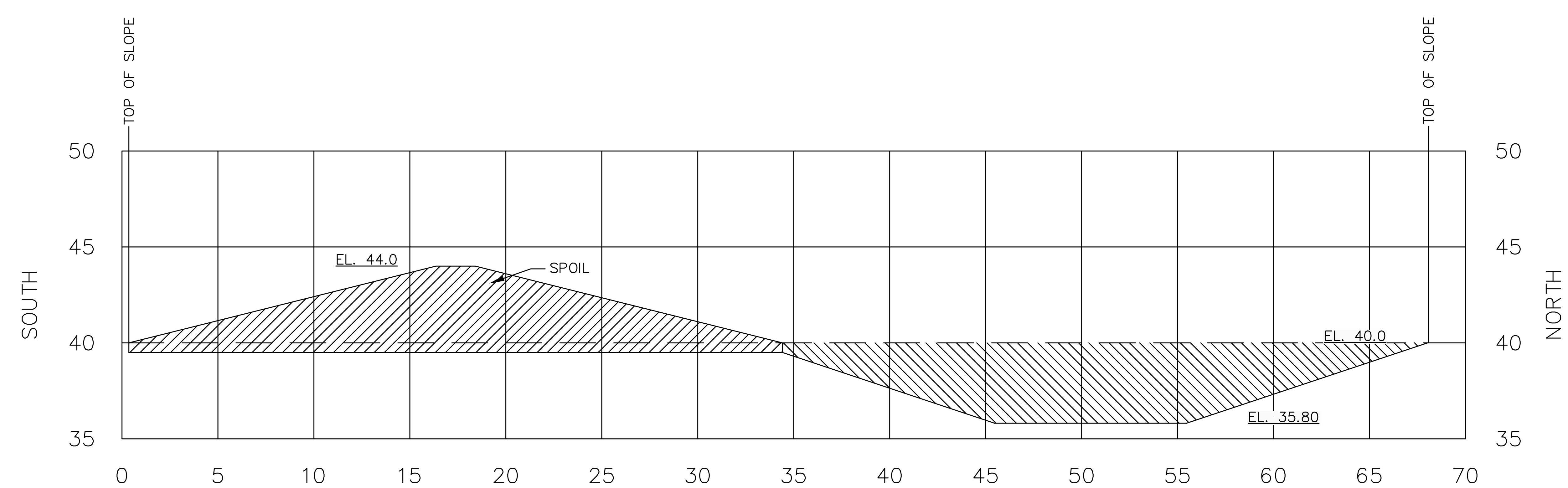
CROSS SECTION NO. 22 (TYP. SEC A)

EAST WEST CONTAINMENT AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 3 (TYP. SEC A)

NORTH SOUTH DRAINAGE DITCH
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 23 (TYP. SEC A)

EAST WEST CONTAINMENT AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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ENGINEER: TERRENCE HORAN
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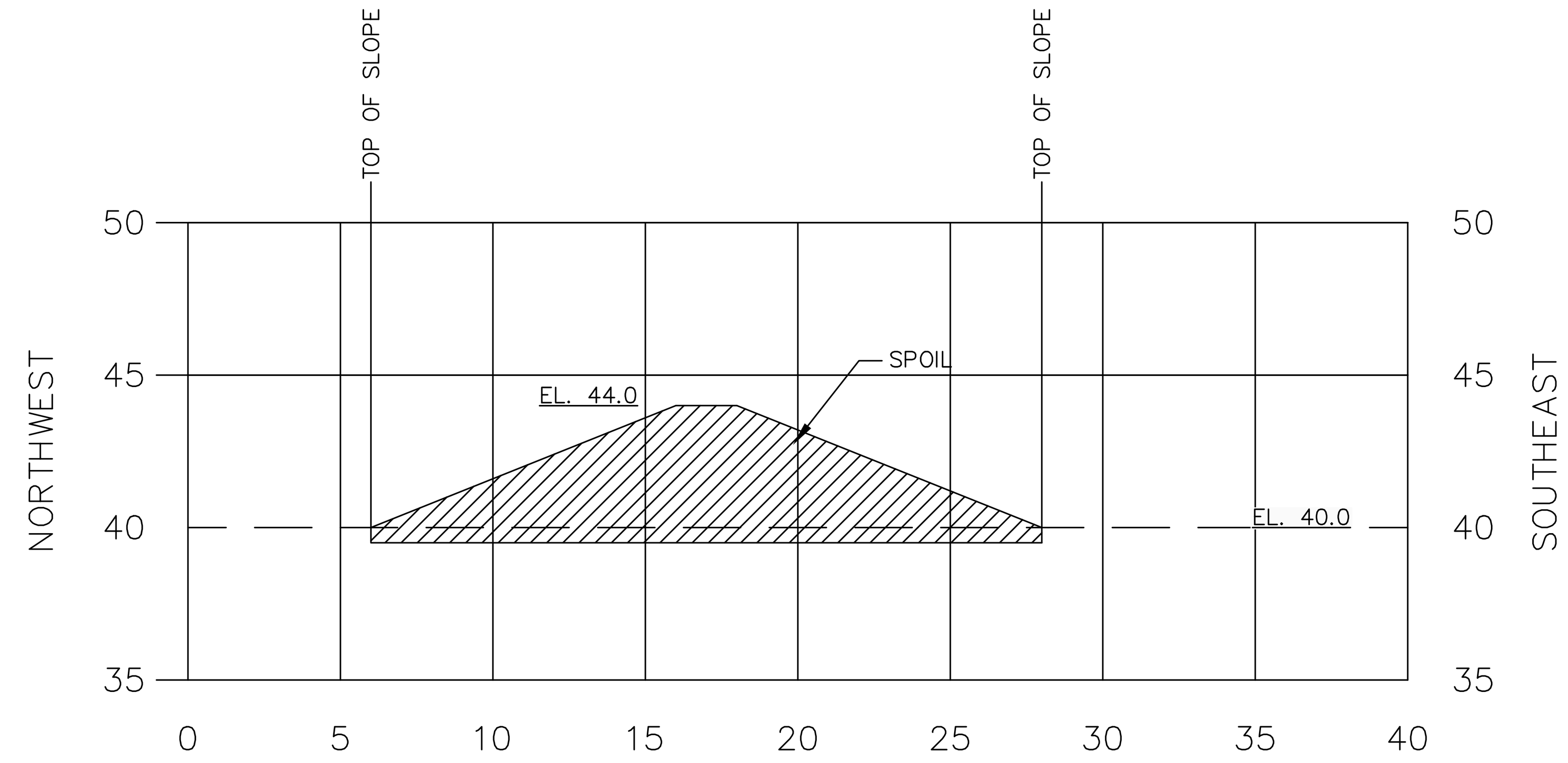
OKEECHOBEE COUNTY, FLORIDA

CROSS SECTIONS

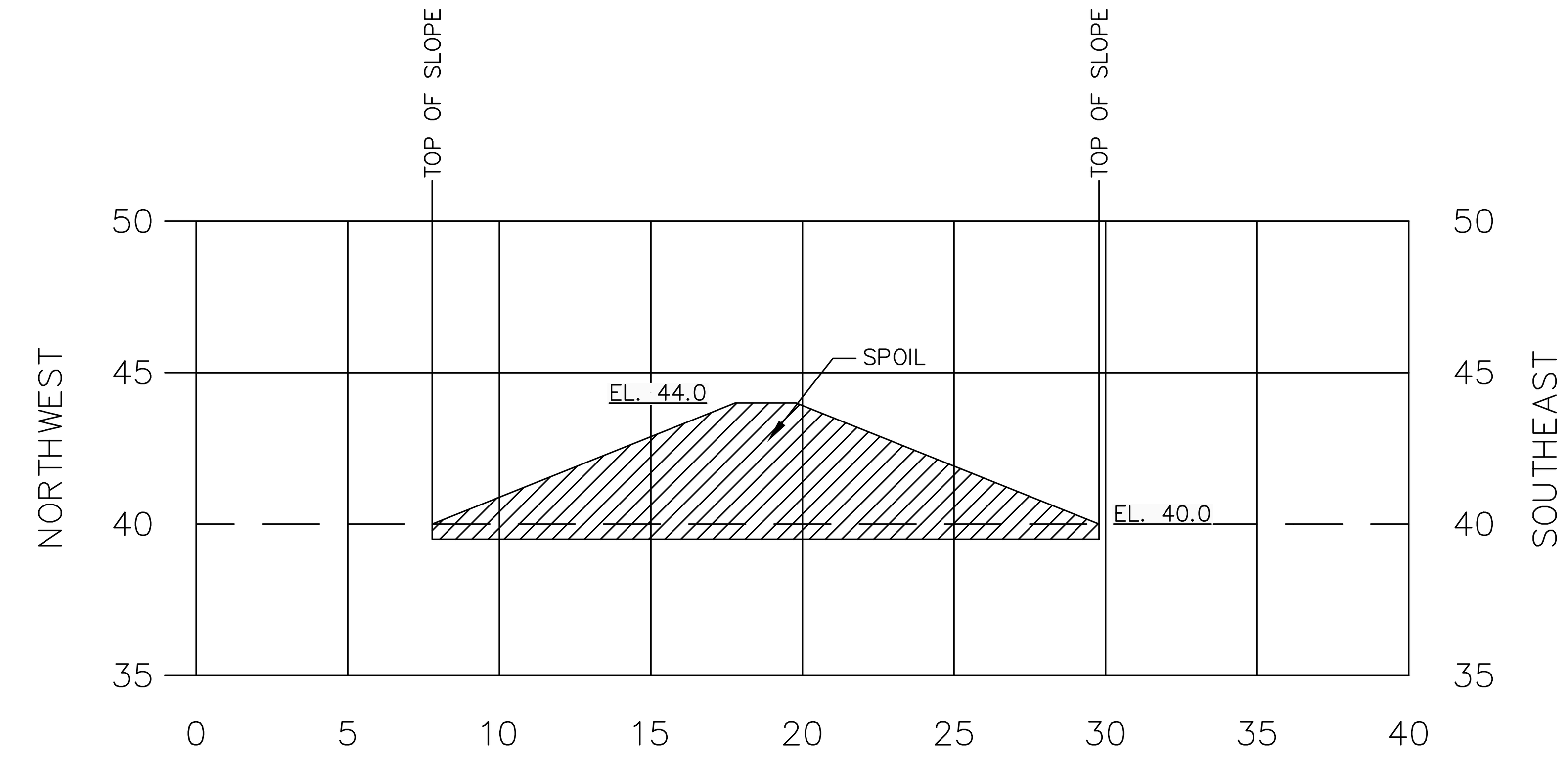
CONTRACT NO.
C-13410
DRAWING NO.
8005716000[004]

SHEET
4 OF 8



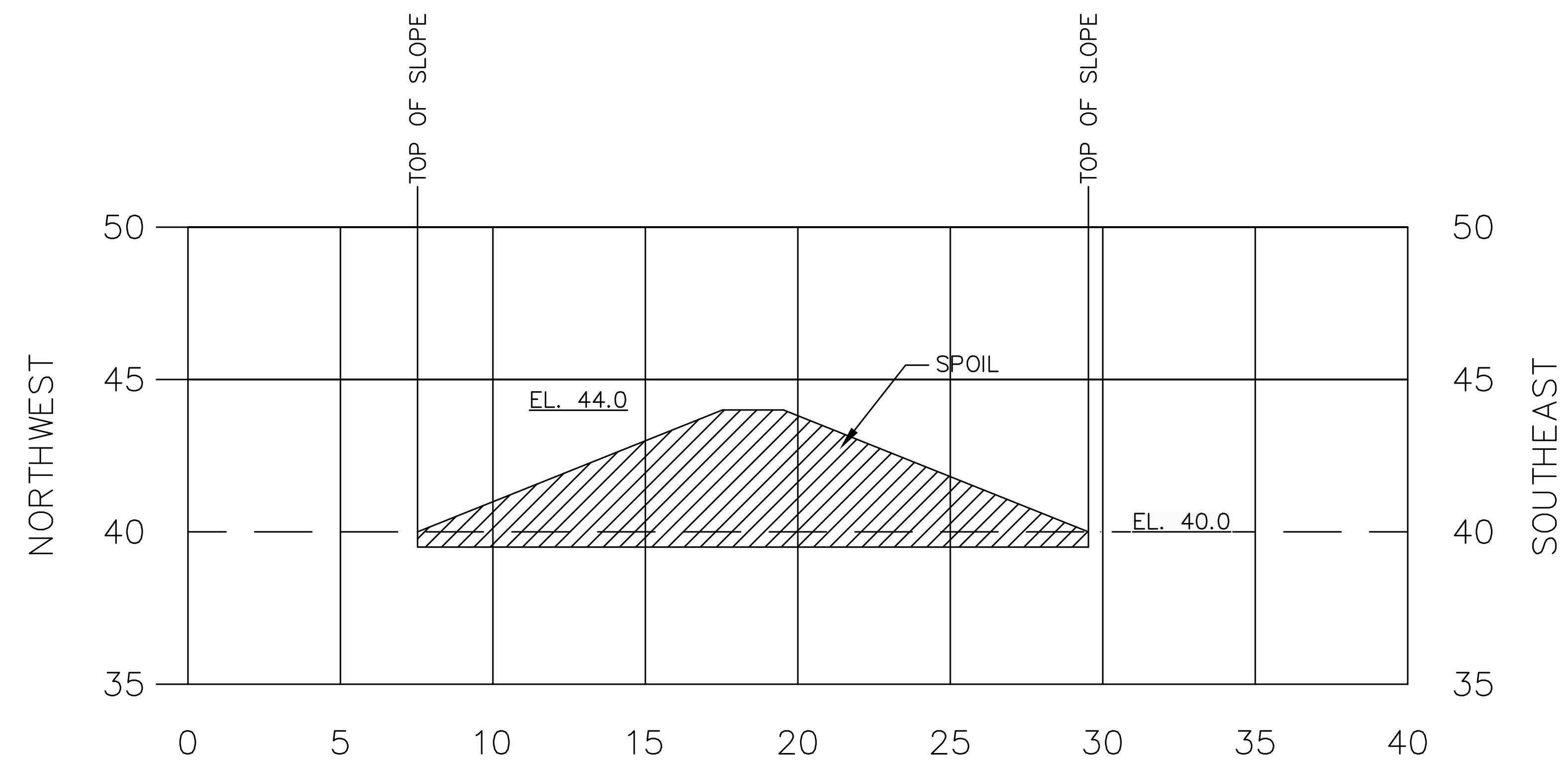
CROSS SECTION NO. 11 (TYP. SEC D)

TREATMENT SYSTEM BERM
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



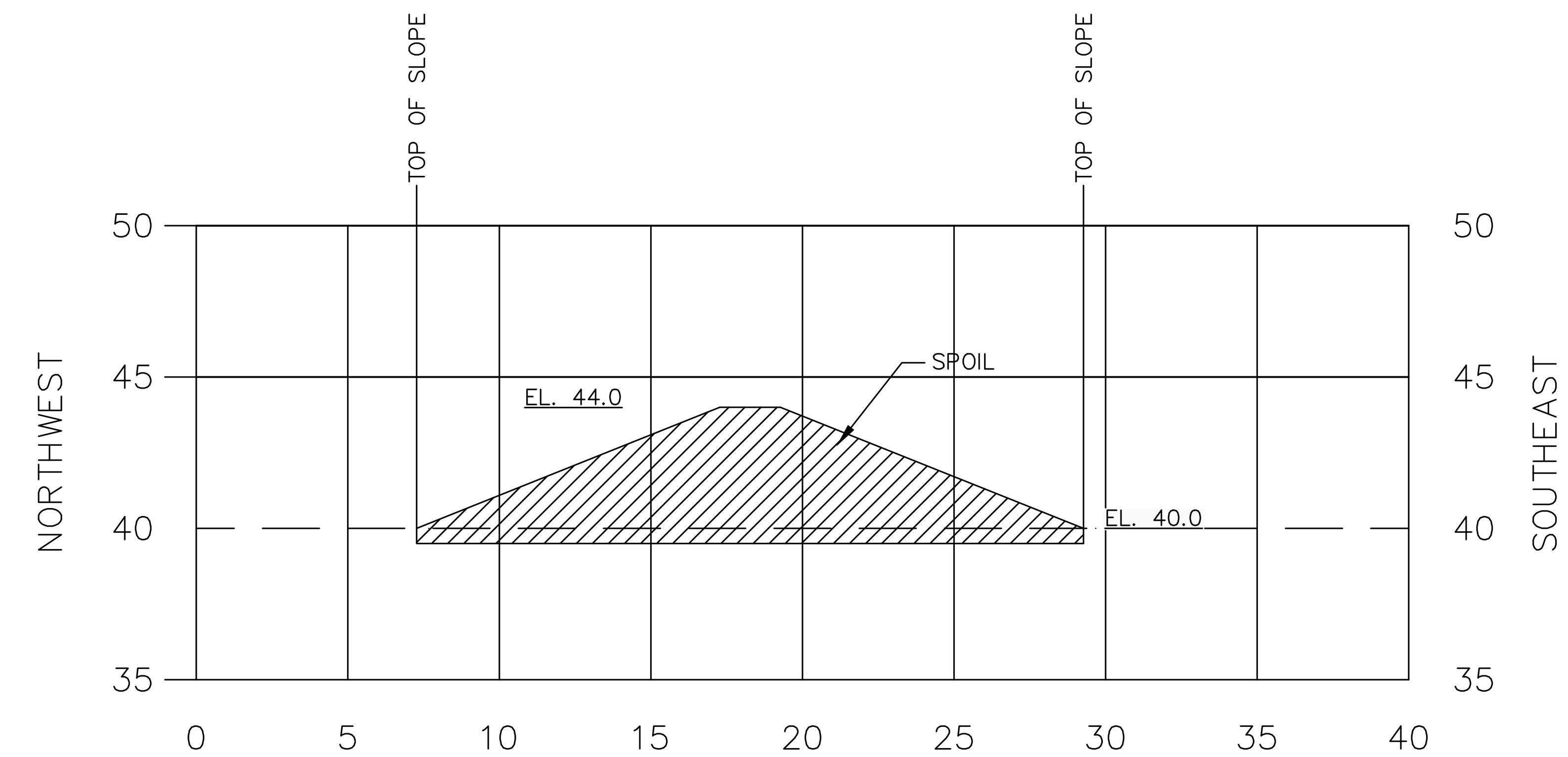
CROSS SECTION NO. 14 (TYP. SEC D)

TREATMENT SYSTEM BERM
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



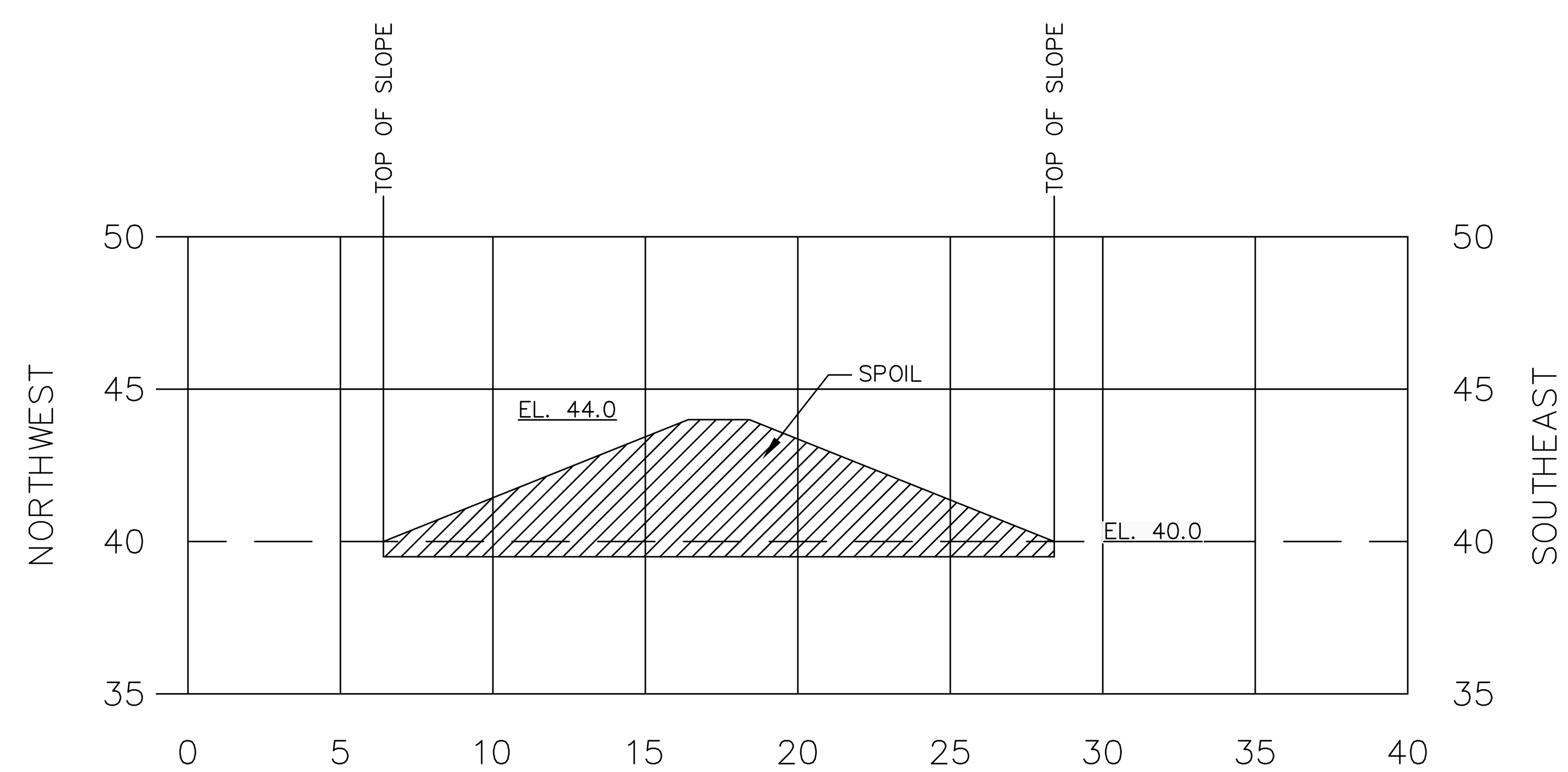
CROSS SECTION NO. 12 (TYP. SEC D)

TREATMENT SYSTEM BERM
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



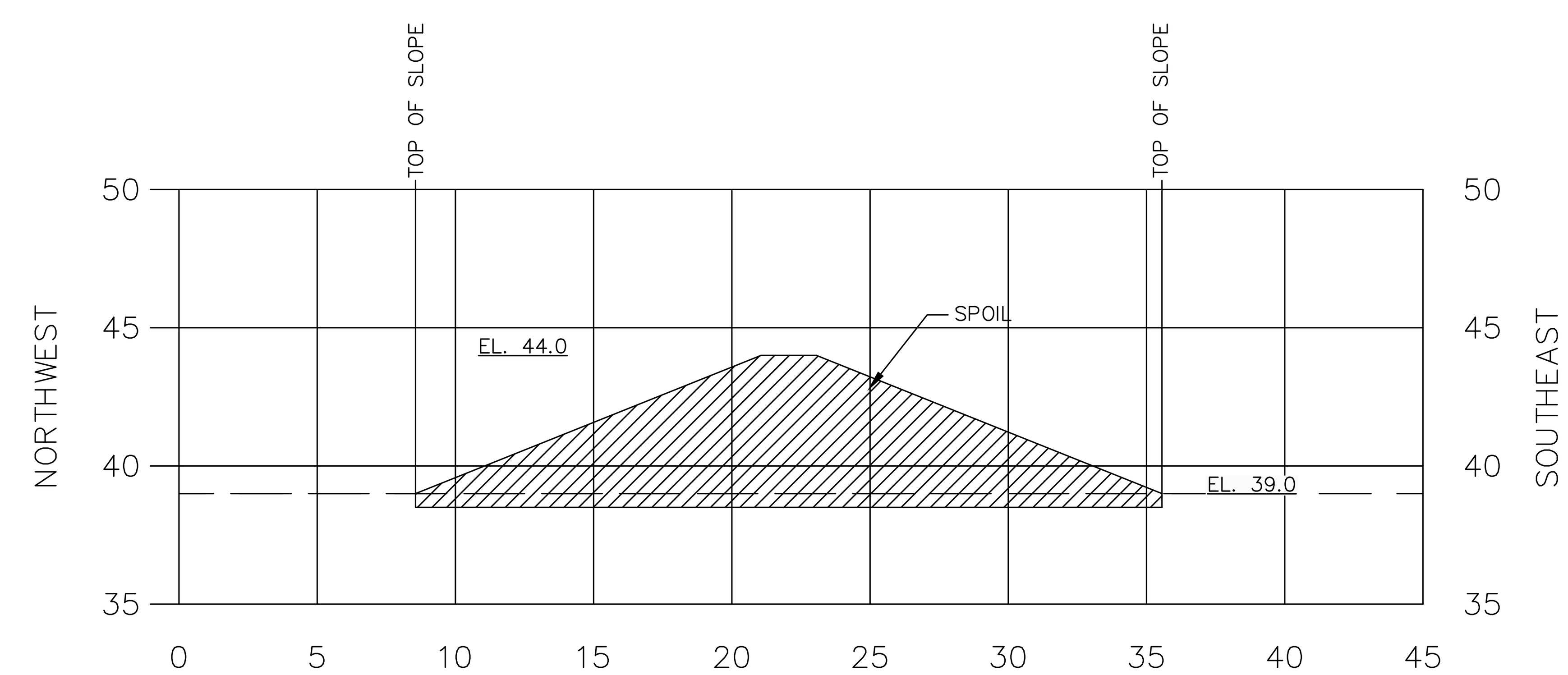
CROSS SECTION NO. 15 (TYP. SEC D)

TREATMENT SYSTEM BERM
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 13 (TYP. SEC D)

TREATMENT SYSTEM BERM
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 16 (TYP. SEC D)

TREATMENT SYSTEM BERM
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

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DRAWN: MISTI LIFE
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DATE: 11/11/03
SCALE: AS SHOWN

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CROSS SECTIONS

CONTRACT NO.
C-13410
DRAWING NO.
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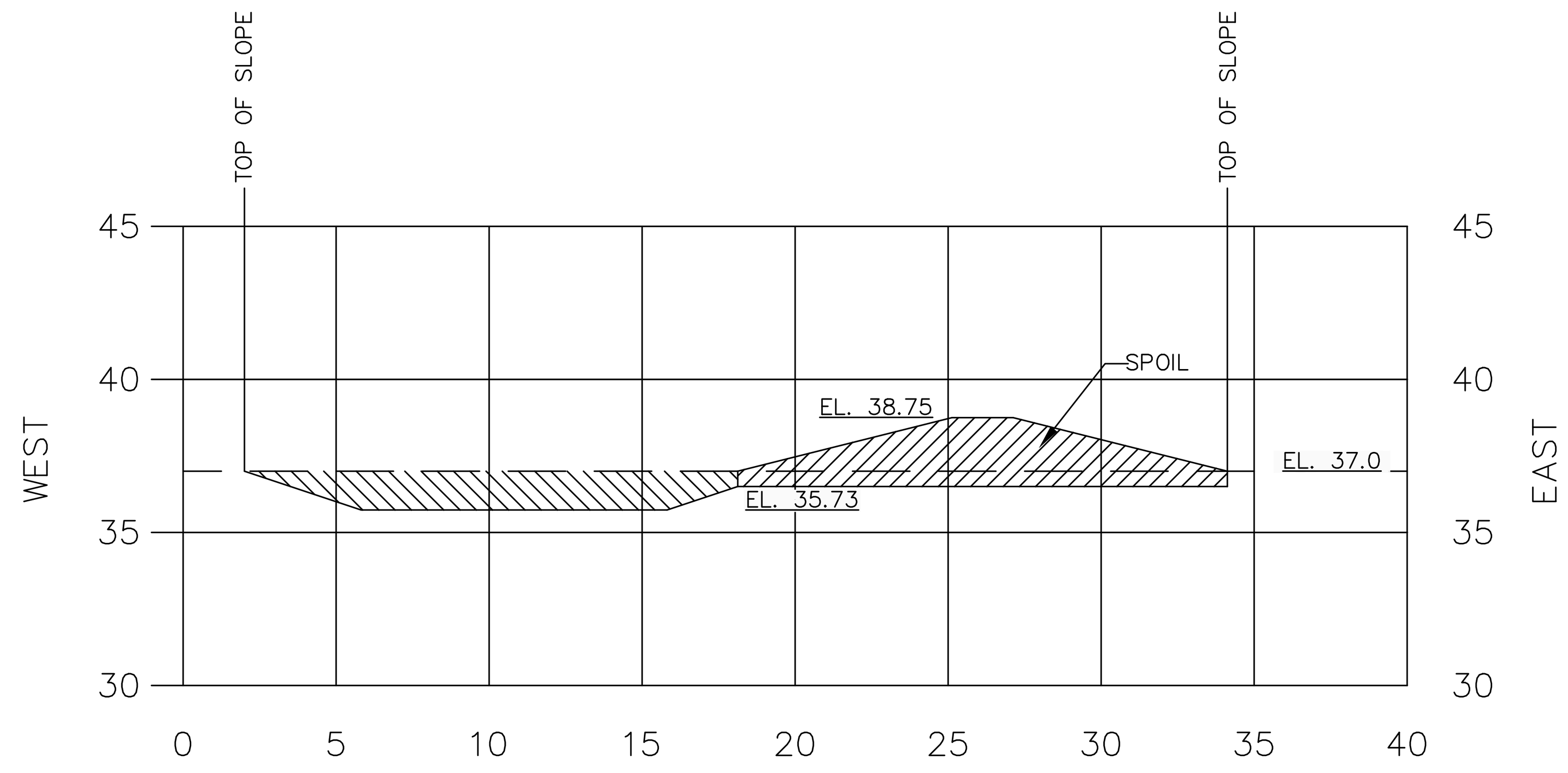
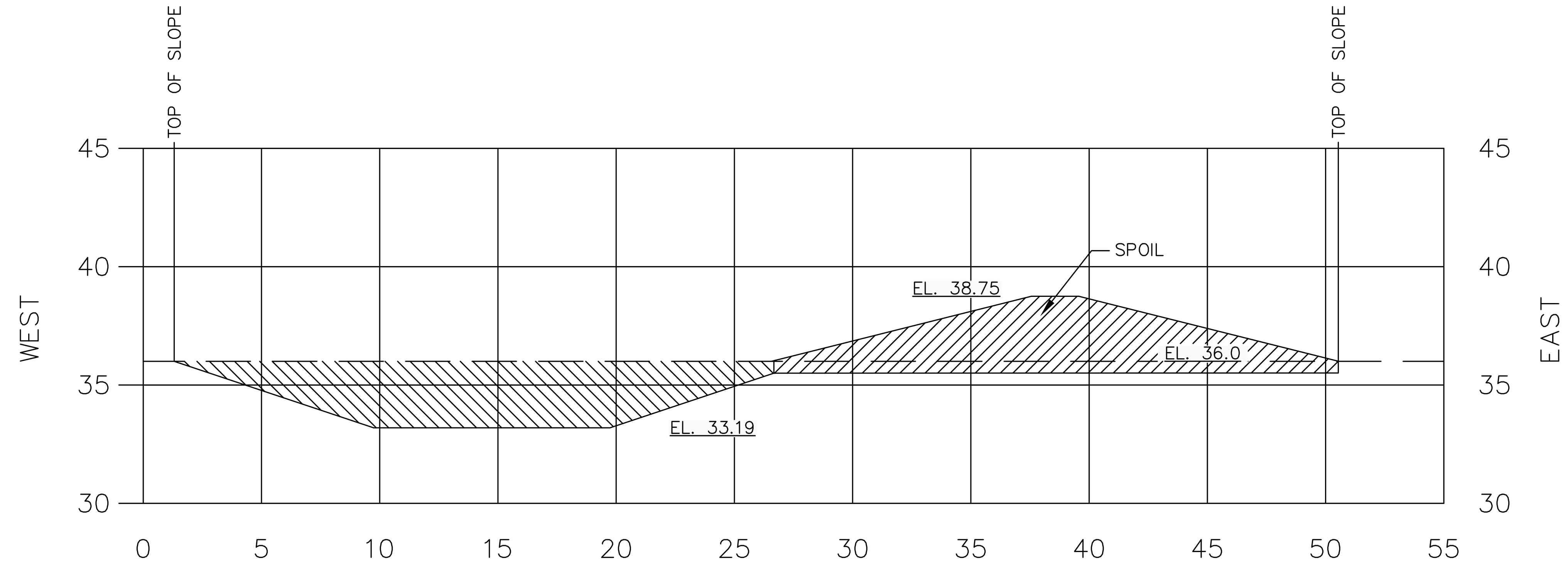
SHEET
5 OF 8



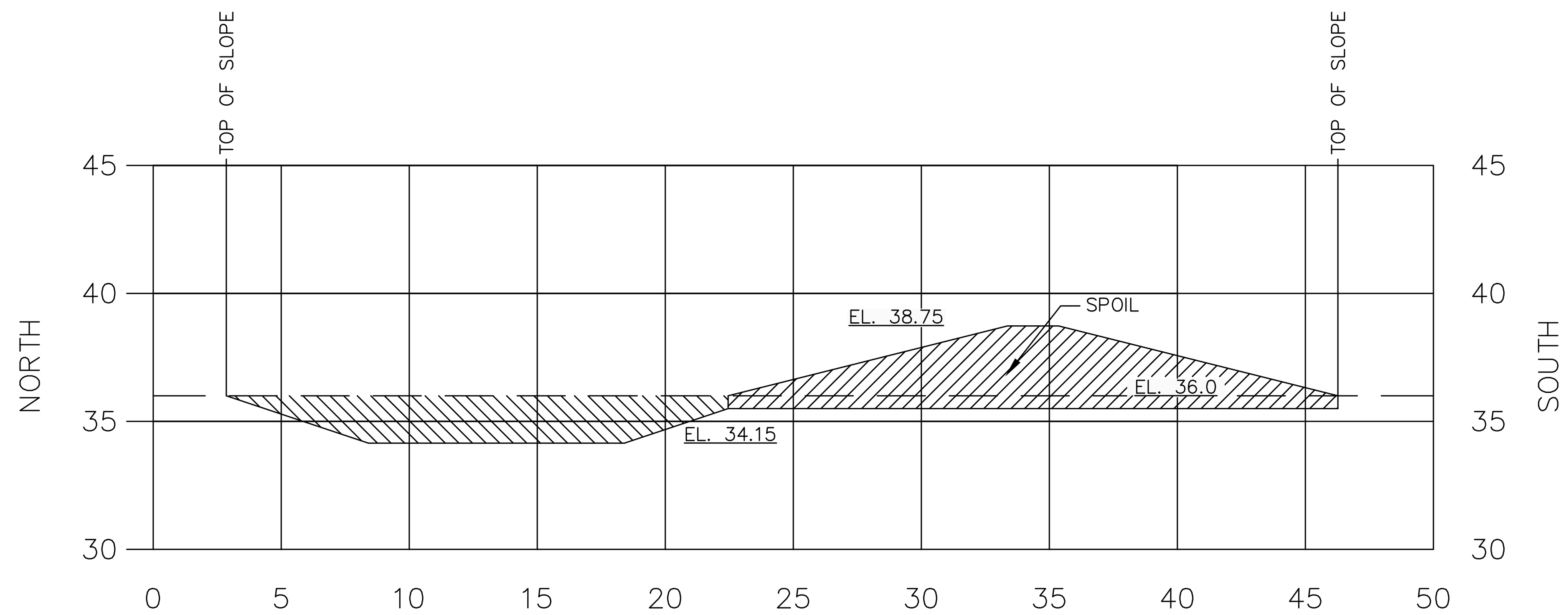
CROSS SECTION NO. 32 (TYP. SEC F)

NORTH SOUTH COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



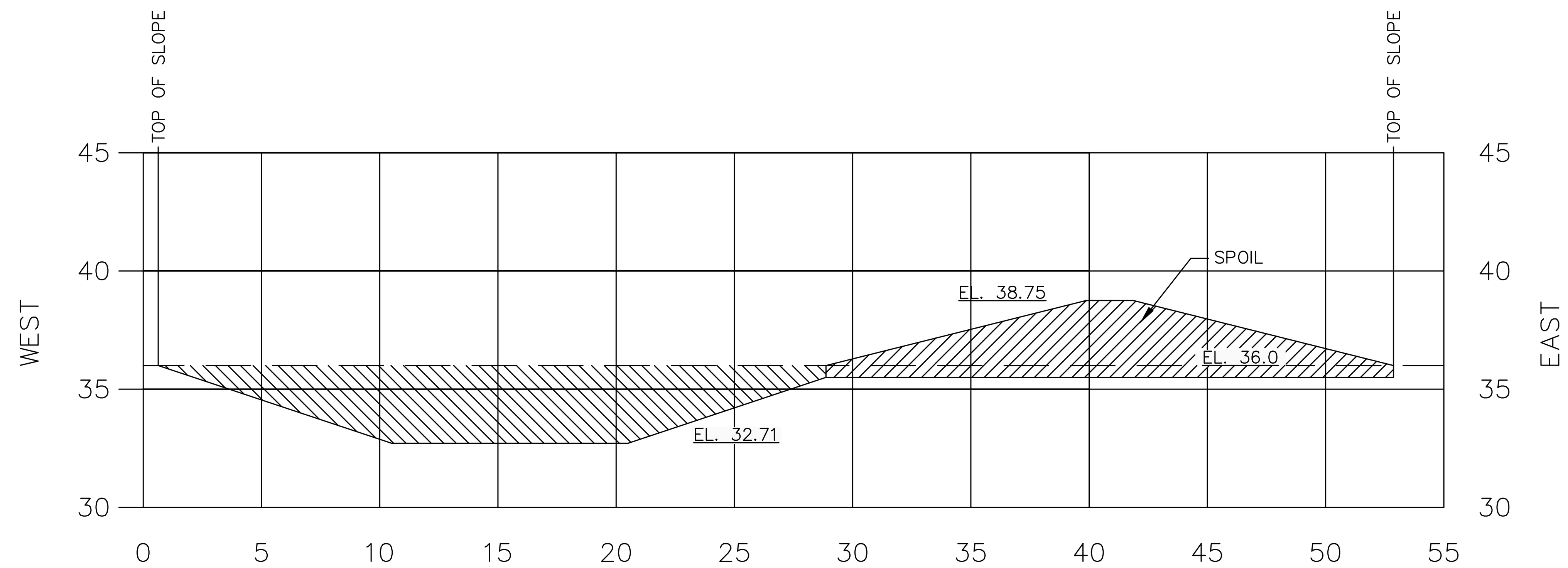
CROSS SECTION NO. 35 (TYP. SEC F)

NORTH SOUTH COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



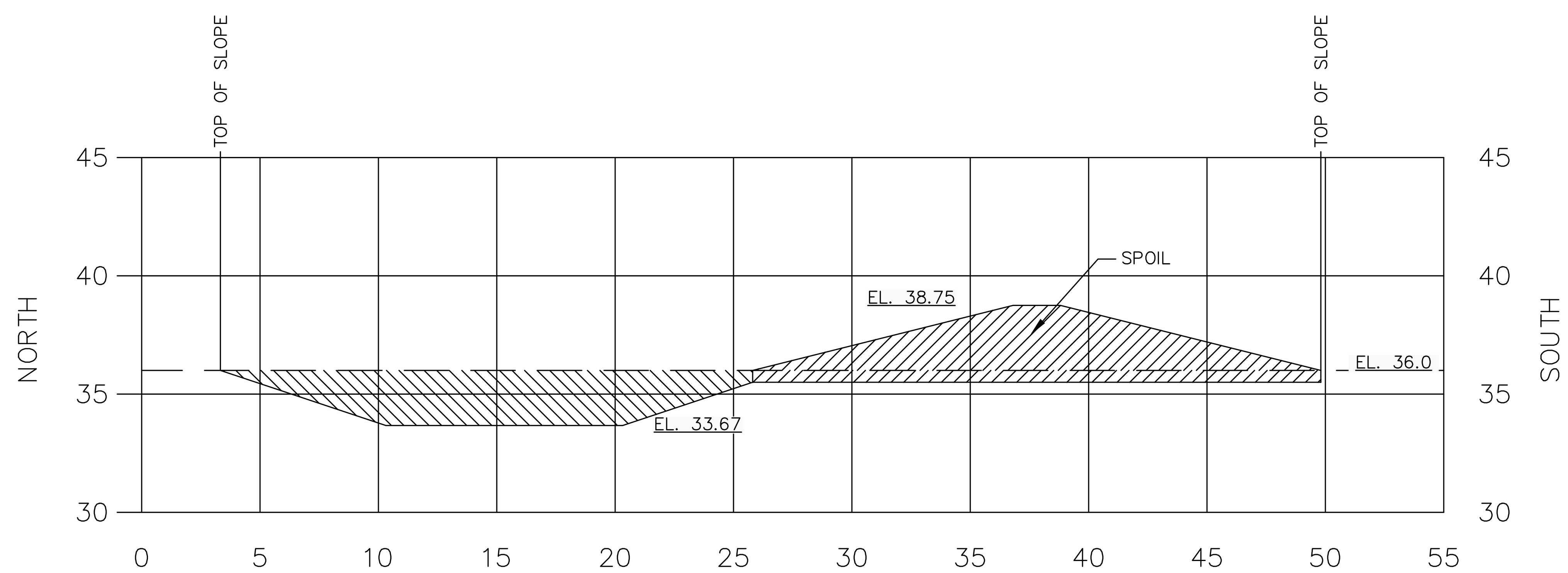
CROSS SECTION NO. 33 (TYP. SEC F)

EAST WEST COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



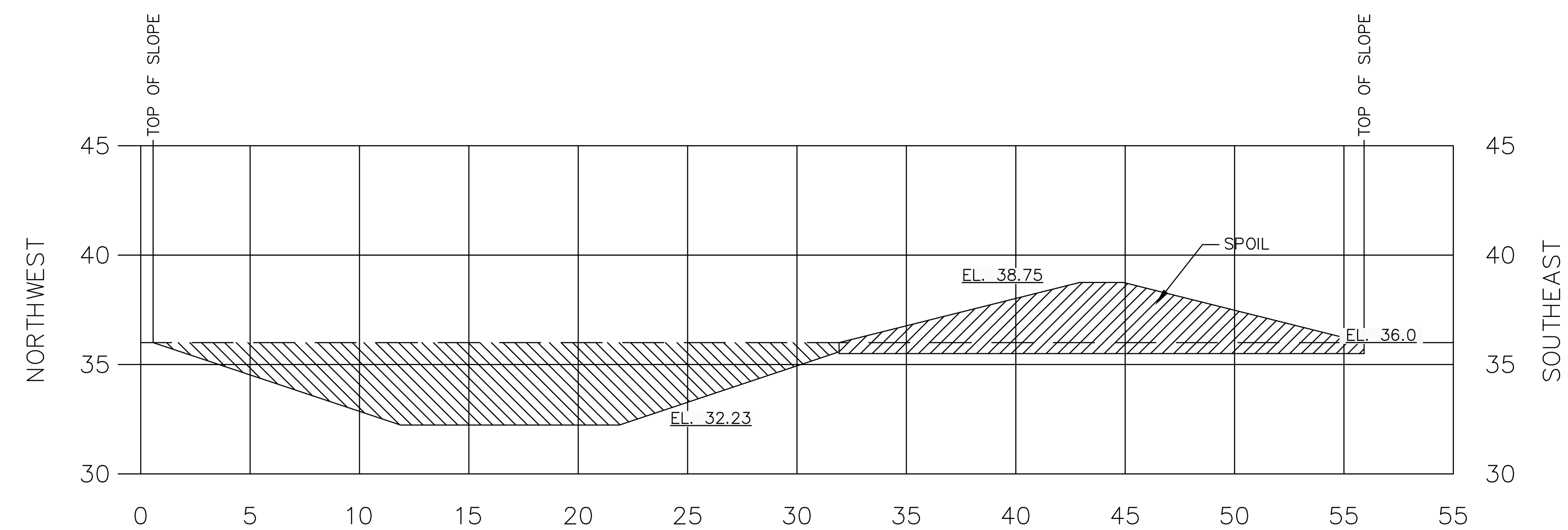
CROSS SECTION NO. 36 (TYP. SEC F)

NORTH SOUTH COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 34 (TYP. SEC F)

EAST WEST COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 37 (TYP. SEC F)

NORTH SOUTH COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

REVISION DESCRIPTION
REV.#
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DATE

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DATE: 11/1/03
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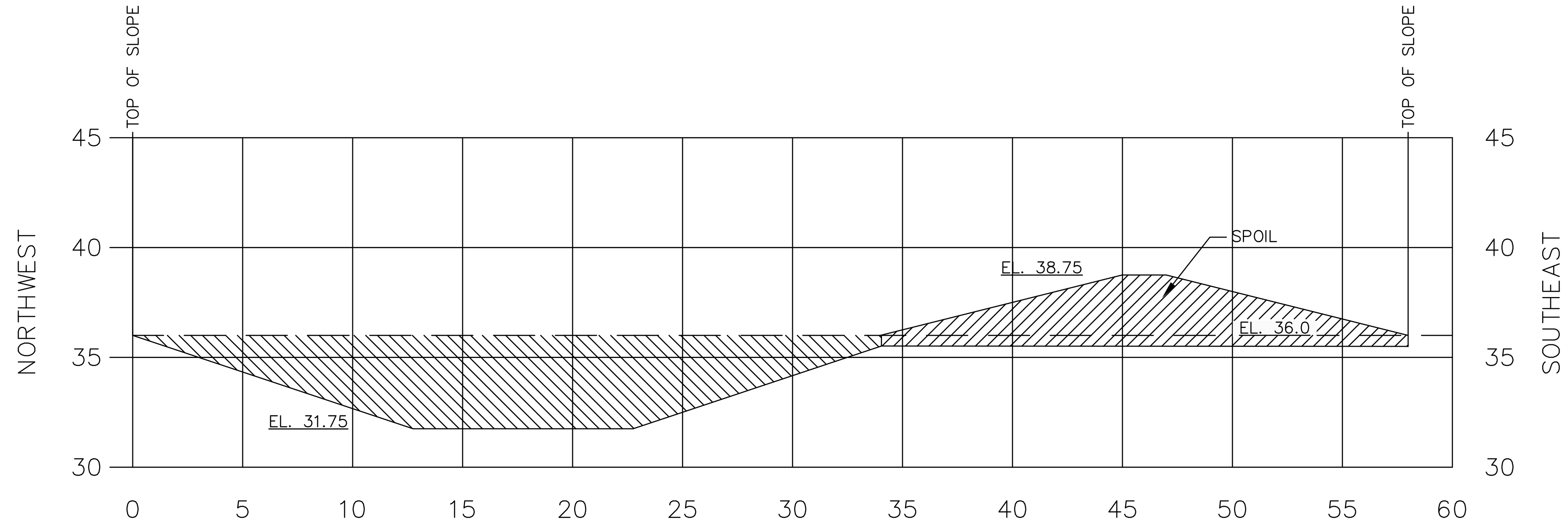
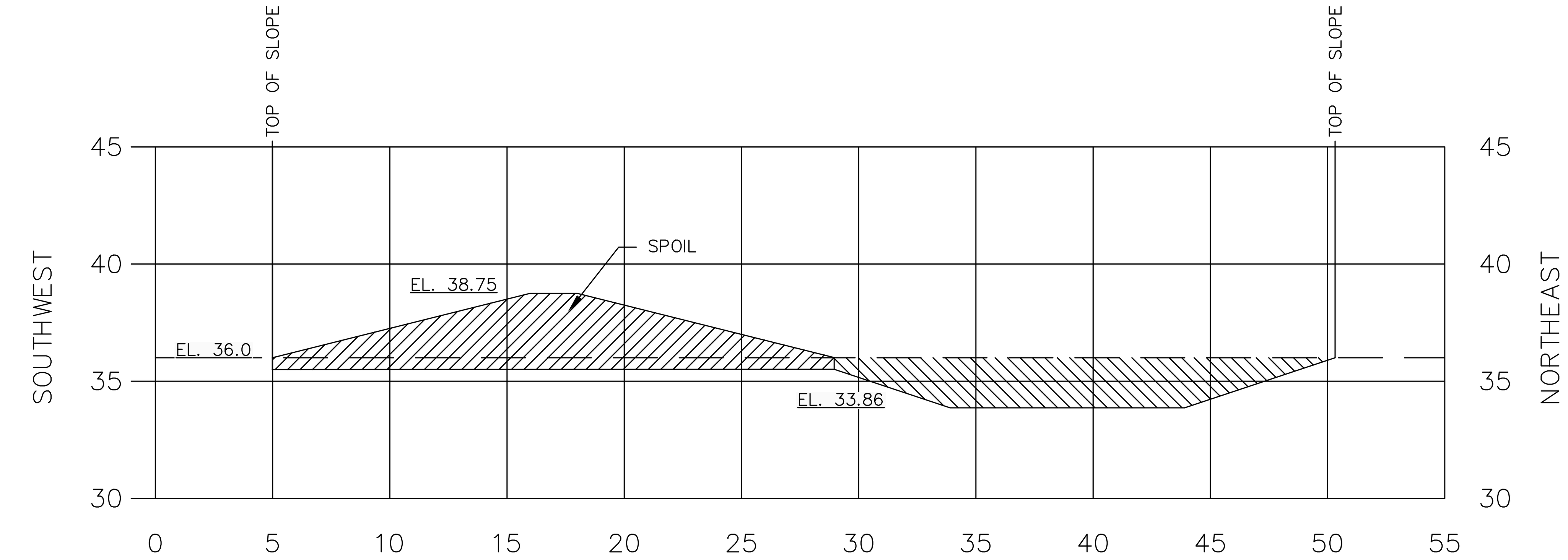
8005716000[006]

SHEET
6 OF 8



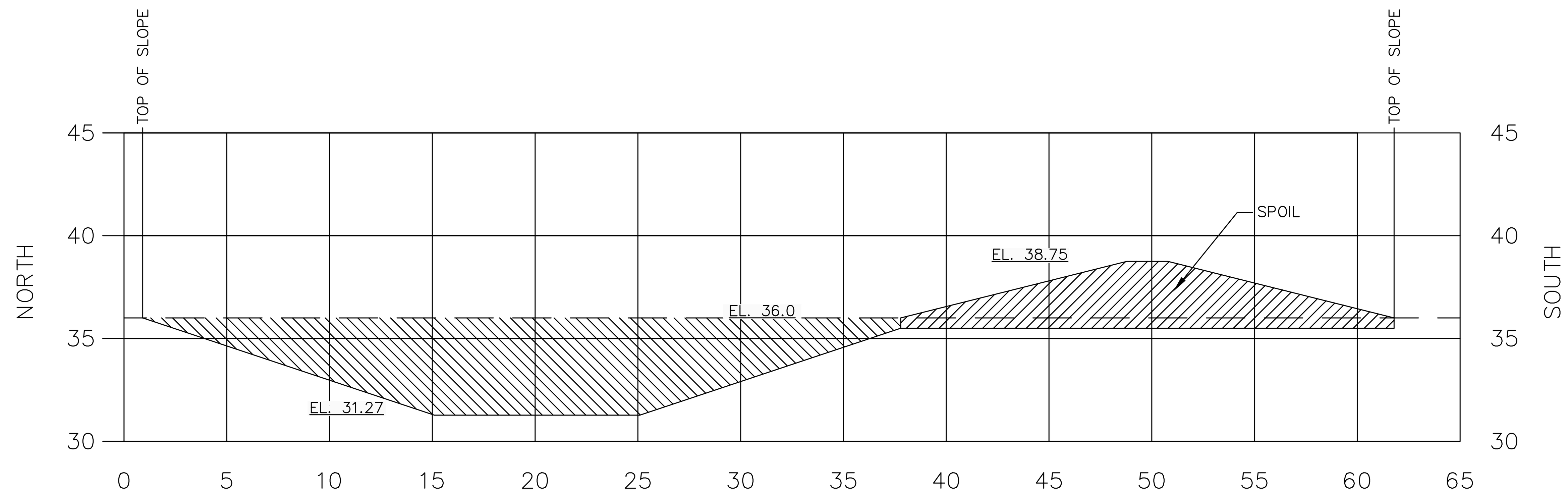
CROSS SECTION NO. 38 (TYP. SEC F)

NORTH SOUTH COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



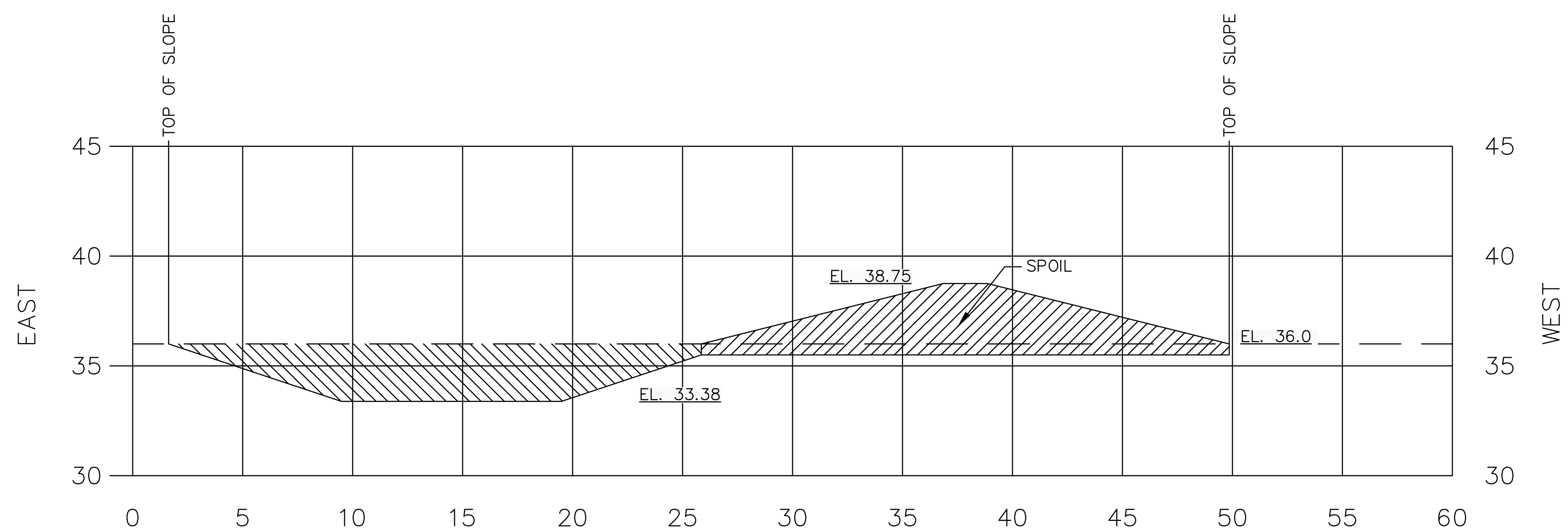
CROSS SECTION NO. 41 (TYP. SEC F)

EAST WEST COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 39 (TYP. SEC F)

EAST WEST COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'



CROSS SECTION NO. 40 (TYP. SEC F)

NORTH SOUTH COLLECTION AREA
SCALE: HORIZONTAL: 1"–5'
VERTICAL: 1"–5'

DATE	DRAWN	REV.#	REVISION DESCRIPTION

ENGINEER: TERRENCE HORAN
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DATE: 11/11/03
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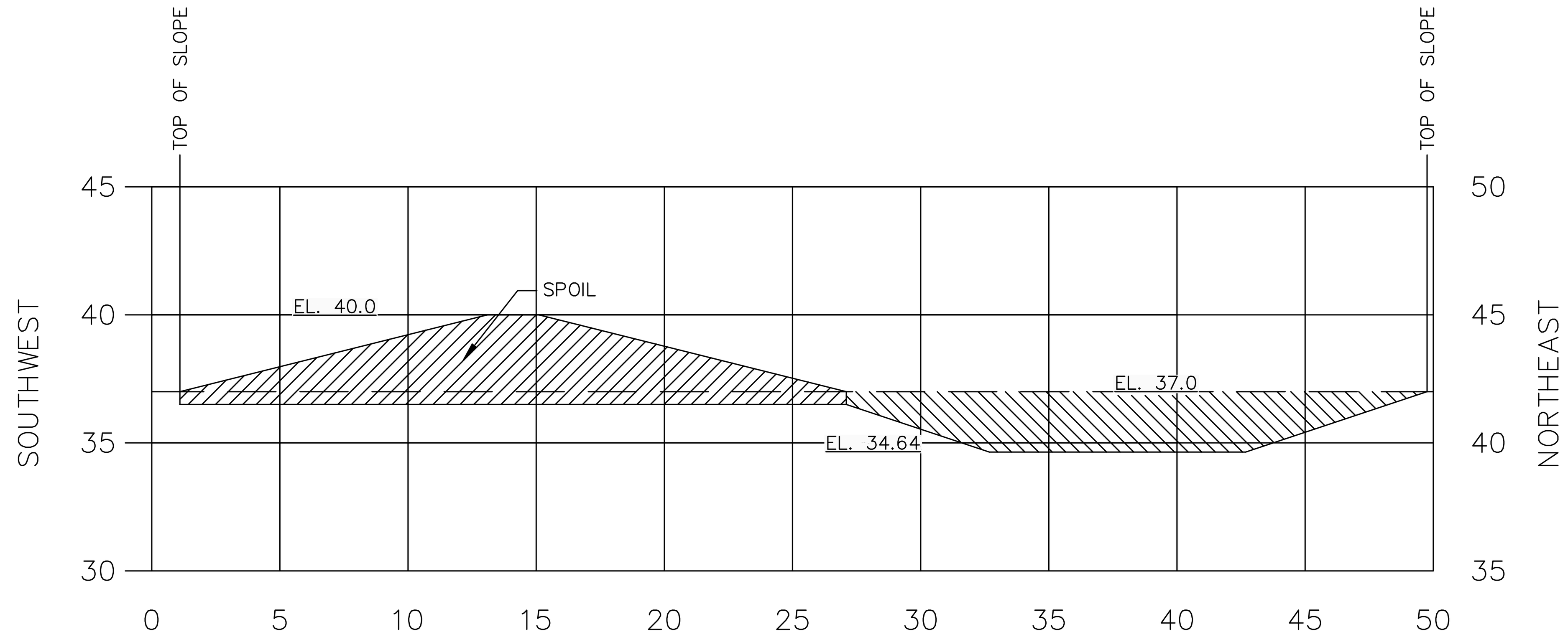
OKEECHOBEE COUNTY, FLORIDA
CROSS SECTIONS

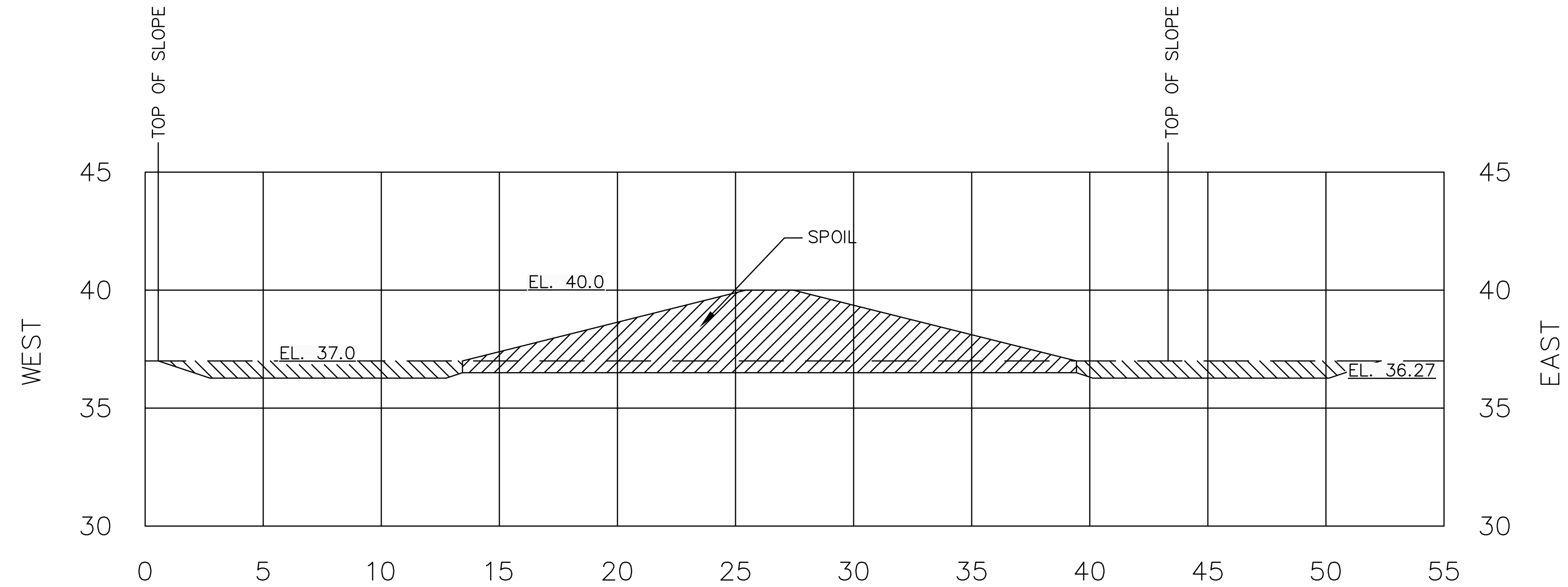
CONTRACT NO. C-13410
DRAWING NO. 8005716000[007]

SHEET 7 OF 8



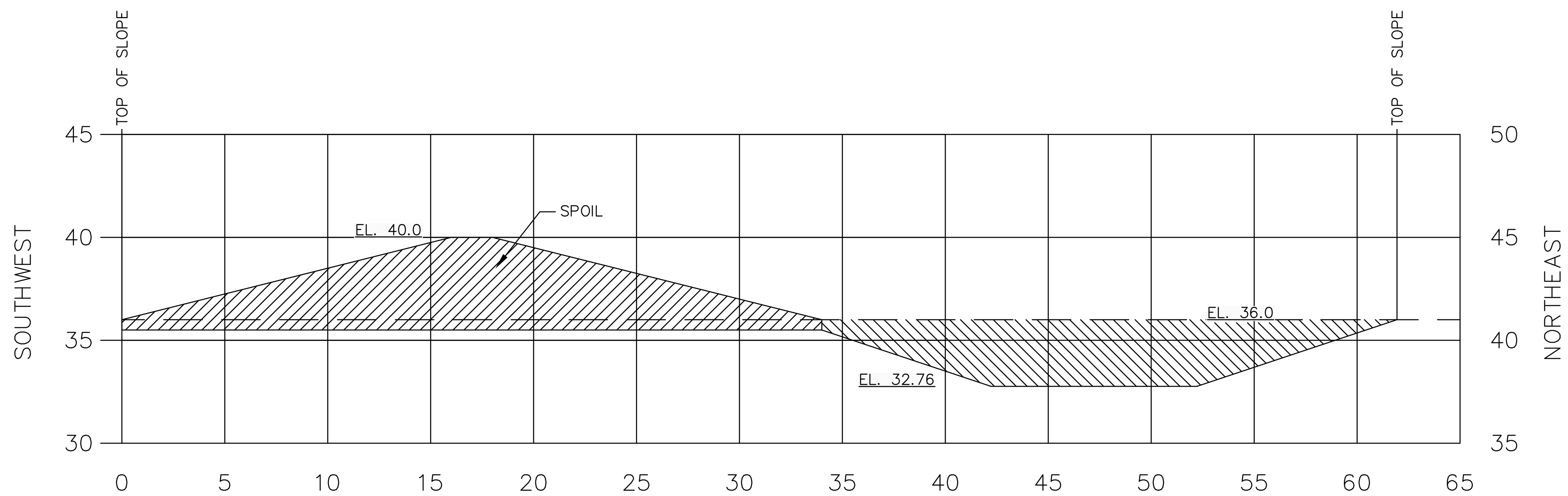
CROSS SECTION NO. 51 (TYP. SEC B)

SCALE: HORIZONTAL: 1"-5'
VERTICAL: 1"-5'



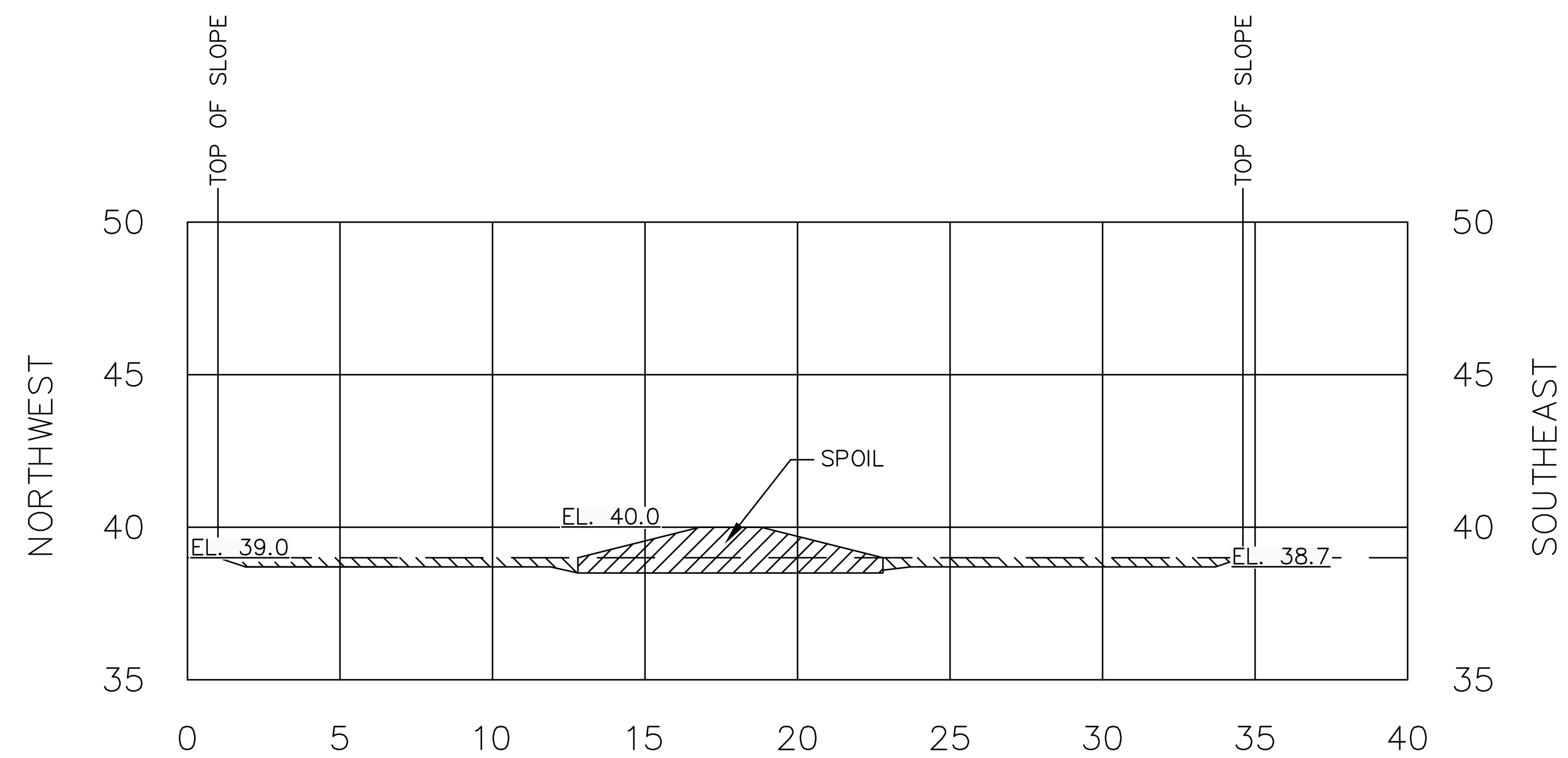
CROSS SECTION NO. 43 (TYP. SEC E)

SCALE: HORIZONTAL: 1"-5'
VERTICAL: 1"-5'



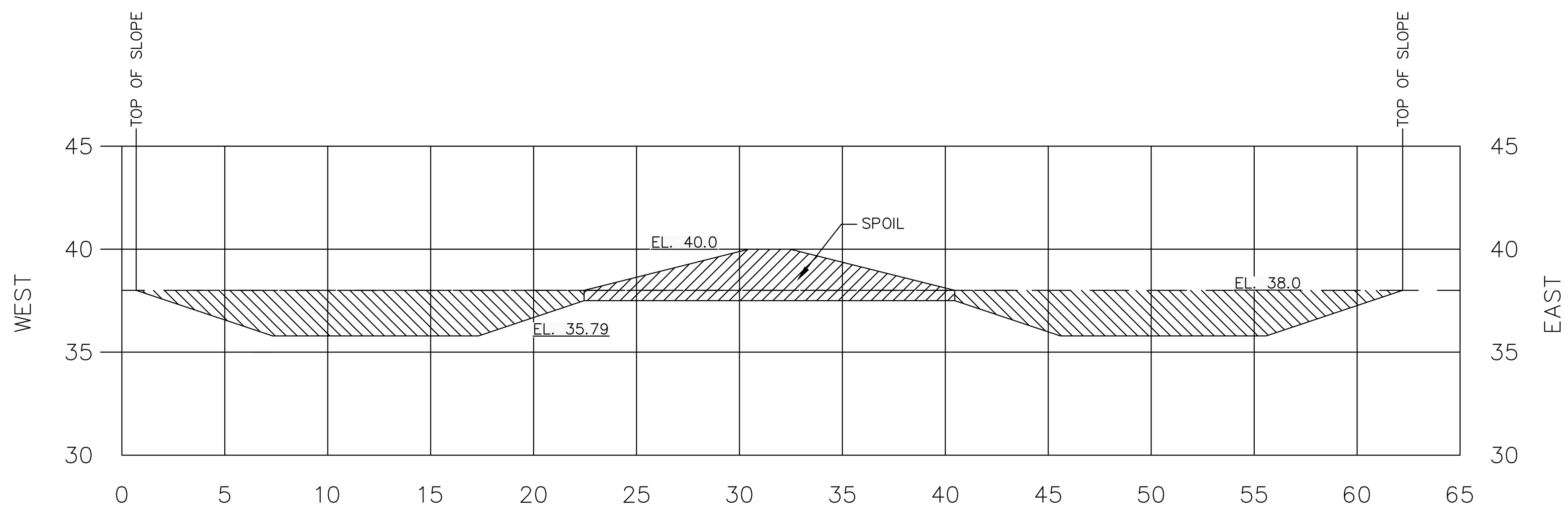
CROSS SECTION NO. 52 (TYP. SEC B)

SCALE: HORIZONTAL: 1"-5'
VERTICAL: 1"-5'



CROSS SECTION NO. 44 (TYP. SEC E)

SCALE: HORIZONTAL: 1"-5'
VERTICAL: 1"-5'



CROSS SECTION NO. 42 (TYP. SEC E)

SCALE: HORIZONTAL: 1"-5'
VERTICAL: 1"-5'

REVISION DESCRIPTION

DATE | DRAWN | REV.#

ENGINEER: TERRENCE HORAN
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SCALE: AS SHOWN

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CROSS SECTIONS

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SHEET 8 OF 8