IN THE TENNESSEE REGULATORY AUTHORITY
AT NASHVILLE, TENNESSEE

RECEIVED
APR 08 2015
T.R.A.
DOCKET ROOM

IN RE:	)	
	)	
PETITION OF TENNESSEE	)	
WASTEWATER SYSTEMS, INC., FOR	)	DOCKET NO. 14-00136
APPROVAL OF CAPITAL	)	
IMPROVEMENT SURCHARGES AND	)	
FINANCING ARRANGEMENTS	)	

**SUPPLEMENT RESPONSES TO DISCOVERY REQUESTS
FROM THE CONSUMER ADVOCATE**

Tennessee Wastewater Systems, Inc. ("TWSI") submits the following supplemental responses to certain Discovery Requests from the Consumer Advocate:

SUPPLEMENTAL RESPONSE 1:

The Petition asks for approval to borrow $725,000. In order to borrow that amount, TWSI must demonstrate to the lender that TWSI has been authorized by the TRA to increase its rates to recover the amount of the loan. Therefore, the Company also seeks approval of the right to collect assessments and surcharges to repay the full $725,000 loan.

The Company, however, will only borrow and spend the money as it is needed, and will only collect assessments and surcharges as needed to repay the amount actually borrowed. In other words, if the total spent on Summit View is less than estimated, the assessments to property owners will be reduced. Similarly, if the total cost of the Cedar Hill, Maple Green and Smoky Village projects turns out to be less than $725,000, the amount of money borrowed will be reduced and the total surcharges collected by the Company to repay the loan will also be reduced.

SUPPLEMENTAL RESPONSE 2:

TWSI has told the HOA at Summit View that TWSI is seeking permission from the TRA to borrow money to expand the capacity of the treatment facility at that development and is asking the Authority to allow TWSI to recover the costs of the expansion through an assessment on property owners in the development. TWSI has not discussed with the HOA the proposal to collect the assessment based on square footage but has explained that the determination of whether and how TWSI will recover those costs will be up to the TRA.

SUPPLEMENTAL RESPONSE 8:

Without waiving the objection of relevance, TWSI agrees to provide Schedule K-1 for the 2014 tax return filed by Adenus Group, LLC. This information is highly confidential and will be filed separately, under seal, in accordance with the Protective Order.

Confidential Supplemental Response 8

SUPPLEMENTAL RESPONSE 9:

Without waiving TWSI's objection on the grounds of relevance, TWSI agrees to provide the salaries of all employees, including employees of affiliates, for the first quarter of 2015. This information is being filed as a confidential document. TWSI is also providing daily time sheets filled out by all employees including employees of affiliates, who charged time to TWSI during a one month period (January – February, 2014). Those time sheets are attached.

Confidential Supplemental Response 9

TNWW Intercompany Changes
February 2014

Employee Name	Hourly Rate	Billable Hours	Wages Expense	FICA Expense	Total Charges
Raven Barrientos	$14.00	67.00	$938.00	$71.76	$1,009.76
Rhea Cason	$16.83	120.00	$2,019.60	$154.50	$2,174.10
Susan Chaffin	$12.50	120.00	$1,500.00	$114.75	$1,614.75
Charles Hyatt	$55.29	56.00	$3,096.24	$236.86	$3,333.10
Martina Pena	$14.42	39.50	$569.59	$43.57	$613.16
Charles Pickney	$45.00	7.00	$315.00	$24.10	$339.10
Matt Pickney	$32.93	50.00	$1,646.50	$125.96	$1,772.46
Total Billable Salaries/Wages Expense			**$10,084.93**	**$771.50**	**$10,856.43**
TOTAL GROUP OVERHEAD CHARGES					**$10,856.43**

OB

ADENUS

Raven Barrientos

1/25/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/19/2014				
Monday	1/20/2014	2.00	3.00	3.00	8.00
Tuesday	1/21/2014	1.50	3.50	3.00	8.00
Wednesday	1/22/2014	1.00	3.50	3.50	8.00
Thursday	1/23/2014	2.00	4.00	2.00	8.00
Friday	1/24/2014	1.00	3.50	3.50	8.00
Saturday	1/25/2014				0.00
		Total hours	17.50	15.00	40.00

2/1/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/26/2014				0.00
Monday	1/27/2014	2.50	3.00	2.50	8.00
Tuesday	1/28/2014	1.50	3.50	3.00	8.00
Wednesday	1/29/2014	2.00	3.50	2.50	8.00
Thursday	1/30/2014	1.50	3.50	2.50	8.00
Friday	1/31/2014	1/2 PTO	2.00	1.50	8.00
Saturday	2/1/2014				0.00
		Total hours	15.50	12.00	40.00

2-1-14

ADENUS Raven Barrientos

2/8/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/2/2014				
Monday	2/3/2014	2.00	3.00	3.00	8.00
Tuesday	2/4/2014	1.50	3.50	3.00	8.00
Wednesday	2/5/2014	1.00	3.50	3.50	8.00
Thursday	2/6/2014	3.00	3.00	2.00	8.00
Friday	2/7/2014	1.00	3.50	3.50	8.00
Saturday	2/8/2014				0.00
		Total hours	16.50	15.00	40.00

2/15/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/9/2014				0.00
Monday	2/10/2014	2.50	3.00	2.50	8.00
Tuesday	2/11/2014	1.50	3.50	3.00	8.00
Wednesday	2/12/2014	2.00	3.50	2.50	8.00
Thursday	2/13/2014	2.00	3.50	2.50	8.00
Friday	2/14/2014	2.00	4.00	2.00	8.00
Saturday	2/15/2014				0.00
		Total hours	17.50	12.50	40.00

Employee's signature 2-18-14

Biweekly Time Sheet

ADENUS

Rhea Cason

Week ending: 1/11/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/19/2014				0.00
Monday	1/20/2014		6.00	2.00	8.00
Tuesday	1/21/2014		6.00	2.00	8.00
Wednesday	1/22/2014		6.00	2.00	8.00
Thursday	1/23/2014		6.00	2.00	8.00
Friday	1/24/2014		6.00	2.00	8.00
Saturday	1/25/2014				0.00
		Total hours	30.00	10.00	40.00

Week ending: 2/1/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/26/2014				0.00
Monday	1/27/2014		6.00	2.00	8.00
Tuesday	1/28/2014		6.00	2.00	8.00
Wednesday	1/23/2014		6.00	2.00	8.00
Thursday	1/30/2014		6.00	2.00	8.00
Friday	1/31/2014		6.00	2.00	8.00
Saturday	2/1/2014				0.00
		Total hours	30.00	10.00	40.00

Biweekly Time Sheet

ADENUS

Rhea Cason

Week ending: 2/8/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/2/2014				0.00
Monday	2/3/2014		6.00	2.00	8.00
Tuesday	2/4/2014		6.00	2.00	8.00
Wednesday	2/5/2014		6.00	2.00	8.00
Thursday	2/6/2014		6.00	2.00	8.00
Friday	2/7/2014		6.00	2.00	8.00
Saturday	2/8/2014				0.00
		Total hours	30.00	10.00	40.00

Week ending: 2/15/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/9/2014				0.00
Monday	2/10/2014		6.00	2.00	8.00
Tuesday	2/11/2014		6.00	2.00	8.00
Wednesday	2/12/2014		6.00	2.00	8.00
Thursday	2/13/2014		6.00	2.00	8.00
Friday	2/14/2014		6.00	2.00	8.00
Saturday	2/15/2014				0.00
		Total hours	30.00	10.00	40.00

Biweekly Time Sheet

ADENUS

Susan Chaffin

Week ending: 1/25/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/19/2014				
Monday	1/20/2014		6.00	2.00	8.00
Tuesday	1/21/2014		6.00	2.00	8.00
Wednesda	1/22/2014		6.00	2.00	8.00
Thursday	1/23/2014		6.00	2.00	8.00
Friday	1/24/2014		6.00	2.00	8.00
Saturday	1/25/2014				
		Total hours	30.00	10.00	40.00

Week ending: 2/1/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/26/2014				
Monday	1/27/2014		6.00	2.00	8.00
Tuesday	1/28/2014		6.00	2.00	8.00
Wednesda	1/29/2014		6.00	2.00	8.00
Thursday	1/30/2014		6.00	2.00	8.00
Friday	1/31/2014		6.00	2.00	8.00
Saturday	2/1/2014				
		Total hours	30.00	10.00	40.00

Susan Chaffin

Biweekly Time Sheet

ADENUS

Susan Chaffin

Week ending: 2/8/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/2/2014				
Monday	2/3/2014		6.00	2.00	8.00
Tuesday	2/4/2014		6.00	2.00	8.00
Wednesda	2/5/2014		6.00	2.00	8.00
Thursday	2/6/2014		6.00	2.00	8.00
Friday	2/7/2014		6.00	2.00	8.00
Saturday	2/8/2014				
		Total hours	30.00	10.00	40.00

Week ending: 2/15/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/9/2014				
Monday	2/10/2014		6.00	2.00	8.00
Tuesday	2/11/2014		6.00	2.00	8.00
Wednesda	2/12/2014		6.00	2.00	8.00
Thursday	2/13/2014		6.00	2.00	8.00
Friday	2/14/2014		6.00	2.00	8.00
Saturday	2/15/2014				
		Total hours	30.00	10.00	40.00

Susan Chaffin

TENNESSEE WASTEWATER

Week ending: 1/25/2014

Day			Billable Hours	Other Hours	Total	
Sunday	1/19/2014					
Monday	1/20/2014					
Tuesday	1/21/2014		2.00		2.00	Bonding
Wednesday	1/22/2014		3.00		3.00	Assets
Thursday	1/23/2014					
Friday	1/24/2014					
Saturday	1/25/2014					
		Total hours	5.00		5.00	

Week ending: 2/1/2014

Day		Project Code	Billable Hours	Other Hours	Total	
Sunday	1/26/2014					
Monday	1/27/2014					
Tuesday	1/28/2014		8.00		8.00	Paris Landing
Wednesday	1/29/2014					
Thursday	1/30/2014					
Friday	1/31/2014					
Saturday	2/1/2014					
		Total hours	8.00		8.00	

[signature] 2-17-14

Employee signature Date

TENNESSEE WASTEWATER

Week ending: 2/8/2014

Day			Billable Hours	Other Hours	Total	
Sunday	2/2/2014					
Monday	2/3/2014					
Tuesday	2/4/2014		2.00		2.00	Cash
Wednesday	2/5/2014		6.00		6.00	Maple Green
Thursday	2/6/2014		4.00		4.00	Maple Green
Friday	2/7/2014		2.00		2.00	Cash
Saturday	2/8/2014					
		Total hours	14.00		14.00	

Week ending: 2/15/2014

Day		Project Code	Billable Hours	Other Hours	Total	
Sunday	2/9/2014					
Monday	2/10/2014		6.00		6.00	Maple Green
Tuesday	2/11/2014		5.00		5.00	Maple Green
Wednesday	2/12/2014		6.00		6.00	Maple Green
Thursday	2/13/2014		7.00		7.00	Maple Green
Friday	2/14/2014		5.00		5.00	Maple Green
Saturday	2/15/2014					
		Total hours	29.00		29.00	

[signature] 2-17-14

Employee signature Date

ADENUS

Martina Pena

Week ending: 1/25/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/19/2014				
Monday	1/20/2014	3.00	4.00	1.25	8.25
Tuesday	1/21/2014	PTO			0.00
Wednesda	1/22/2014	3.50	2.00	3.00	8.50
Thursday	1/23/2014	4.00	4.00	1.00	9.00
Friday	1/24/2014	3.00			3.00
Saturday	1/25/2014				0.00
		Total hours	10.00	5.25	28.75

Week ending: 2/1/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/26/2014				0.00
Monday	1/27/2014	5.00	2.00	1.00	8.00
Tuesday	1/28/2014	5.00	1.00	1.00	7.00
Wednesda	1/29/2014	4.00	2.00	2.00	8.00
Thursday	1/30/2014	2.00	5.00	1.50	8.50
Friday	1/31/2014	2.00	4.50	2.00	8.50
Saturday	2/1/2014				
		Total hours	14.50	7.50	40.00

Martina Pena

ADENUS Martina Pena

Week ending: 2/8/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/2/2014				
Monday	2/3/2014	3.00	4.00	1.00	8.00
Tuesday	2/4/2014	2.00	4.00	2.00	8.00
Wednesda	2/5/2014	2.00	3.00	3.00	8.00
Thursday	2/6/2014	4.00	4.00		8.00
Friday	2/7/2014	PTO			0.00
Saturday	2/8/2014				0.00
		Total hours	15.00	6.00	32.00

Week ending: 2/15/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/9/2014				0.00
Monday	2/10/2014	PTO			0.00
Tuesday	2/11/2014	PTO			0.00
Wednesda	2/12/2014	PTO			0.00
Thursday	2/13/2014	PTO			0.00
Friday	2/14/2014	PTO			0.00
Saturday	2/15/2014				
		Total hours	0.00	0.00	0.00

Martina Pena

Charles Pickney, Jr.

Biweekly Time Sheet

TENNESSEE WASTEWATER

Week ending: 1/25/2014

Day		Project	TN WW Billable Hours	TN WW Escrow Hours	Other Hours	Total
Sunday	1/19/2014					
Monday	1/20/2014		2.00			2.00
Tuesday	1/21/2014		3.00			3.00
Wednesday	1/22/2014					
Thursday	1/23/2014					
Friday	1/24/2014					
Saturday	1/25/2014					
		Total hours	5.00			5.00

Week ending: 2/1/2014

Day		Project	TN WW Billable Hours	TN WW Escrow Hours	Other Hours	Total
Sunday	1/26/2014					
Monday	1/27/2014					
Tuesday	1/28/2014					
Wednesday	1/29/2014		2.00			2.00
Thursday	1/30/2014					
Friday	1/31/2014					
Saturday	2/1/2014					
		Total hours	2.00			2.00

Emailed
Employee signature

2/4/14
Date

Biweekly Time Sheet

ADENUS

Week ending: 2/25/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/19/2014				
Monday	2/20/2014	3	2.00	3.00	8.00
Tuesday	2/21/2014	2	3.00	3.00	8.00
Wednesday	2/22/2014	3	3.00	2.00	8.00
Thursday	2/23/2014	2	3.00	3.00	8.00
Friday	2/24/2014	3	2.00	3.00	8.00
Saturday	2/25/2014				
		Total hours	13.00	14.00	40.00

Week ending: 2/1/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	1/26/2014				
Monday	1/27/2014	2	3.00	3.00	8.00
Tuesday	1/28/2014	2	3.00	3.00	8.00
Wednesday	1/29/2014	2	3.00	3.00	8.00
Thursday	1/30/2014	2	3.00	3.00	8.00
Friday	1/31/2014	0	1.00		1.00
Saturday	2/1/2014				
		Total hours	13.00	12.00	33.00

Matt Pickney
Employee signature

2/4/14
Date

Biweekly Time Sheet

ADENUS

Week ending: 2/8/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/2/2014				
Monday	2/3/2014	3	2.00	3.00	8.00
Tuesday	2/4/2014	2	3.00	3.00	8.00
Wednesday	2/5/2014	3	3.00	2.00	8.00
Thursday	2/6/2014	2	3.00	3.00	8.00
Friday	2/7/2014	3	2.00	3.00	8.00
Saturday	2/8/2014				
		Total hours	13.00	14.00	40.00

Week ending: 2/15/2014

Day		OPS	TN WW Billable Hours	AL WW Billable Hours	Total
Sunday	2/9/2014				
Monday	2/10/2014	2	2.00	2.00	6.00
Tuesday	2/11/2014	1	3.00	2.00	6.00
Wednesday	2/12/2014	1	3.00	3.00	7.00
Thursday	2/13/2014	VAC (Funeral)			
Friday	2/14/2014	1	3.00	3.00	7.00
Saturday	2/15/2014				
		Total hours	11.00	10.00	26.00

Employee signature: Matt Pickney   2/18/14
Date

SUPPLEMENTAL RESPONSES 11-14:

A detailed estimate of the cost of repairing Cedar Hill has already been provided to the CAPD and the TRA Staff in response to TRA Staff Data Request 72(a). Cost estimates have also been provided for Maple Green (Data Request 46(a)), Summit View (26(b)), and Smoky Village (83). As a courtesy, copies of those cost estimates are attached.

Each estimate lists all of the materials required for the project, the labor and equipment needed for the construction, engineering, management and bonding requirements and a 10% contingency allowance. Each item is priced out and added up to get the total cost of the project.

These estimates were prepared by staff engineer Roy Denney who has substantial experience designing treatment facilities of this type. Moreover, these systems have been used throughout the country for many years. Therefore, the cost of the materials and the cost and time to construct one of these systems are well known.

Supporting documents concerning each of these sites may be found on the TDEC website under "Water Resources Permits Dataviewers" as described in Supplemental Response 24.[1] In addition, TWSI's engineering plans for Maple Green and Cedar Grove are attached here. The plans for Smoky Village are attached to TWSI's responses to the TRA Staff (attachment 85). The plans for Summit View have not been filed at TDEC yet but are expected to be filed by April 10, 2015, and will be provided at that time.

[1] On the TDEC homepage, click "Dataviewers" from the left-hand column; then click "Water Resources Permits Dataviewer." Enter the SOP number or the name of the treatment facility (Maple Green, SOP-01028; Smoky Village, SOP-05033; Summit View, SOP-06035; Cedar Hill, SOP-05039) and one can view all the filings in that docket. Note that when moving from one SOP number to another SOP number, one must back up to the page that has the link to "Water Resources Permits Dataviewer."

ADENUS SOLUTIONS GROUP

TN DEPT OF ENVIRONMENT AND CONSERVATION
MAY 2 1 2014
DIV OF WATER RESOURCES RECEIVED

Free Surface Wetland Design Specifications

For The Maple Green Water Reclamation Facility REVISED

Roy Denney

5/14/2014

...BEARING THIS STAMP HAS BEEN RECEIVED AND REV... ...NESSEE DEPT. OF ENVIRONMENT & CONSERV... DIVISION OF WATER POLLUTION CONTROL AND IS HEREBY APPROVED FOR CONSTRUCTION BY THE COMMISSIONER

JUL 24 2014

...IS APPROVAL SHALL NOT BE CONSTRUED AS CREATING A PRESUMPTION OF COR... ...T OPERATION OR AS WARRANTING BY THE COMMISSIONER THAT THE APPR... ...ES WILL REACH THE DESIGNED GOALS FOR THE COMMISS...

APPROVAL EXPIRES

JUL 24 2015

TN. DEPT. OF ENVIRONMENT & CONSERVATION DIVISION OF WATER POLLUTION CONTROL

ROY CHON DENNEY REGISTERED ENGINEER AGRICULTURE COMMERCE No. 1[illegible] STATE OF TENNESSEE

Design Specifications for the free water surface wastewater treatment wetland at Maple Green. Prepared for Tennessee Wastewater. Reference Case Number OGC14-0019

WPC14-0471

Maple Green Design Specifications

Table of Contents

Section 1 Abstract

Proposal Regarding Constructed Free Water Surface Wetland With Aeration for Treatment of Septic Tank Effluent in Rural Systems.

Roy Denney, PE
Adenus Group

Wetland treatment for wastewater which has already received primary settling and minimal secondary treatment is well establish with systems in the US dating back more than fifty years(EPA, 2000). The two prevailing approaches are Free Water Surface (FWS) and Subsurface Flow (SSF or VSF(vegetated)) wetlands. Conventional wisdom dictates that a VSF with some insulating cover will higher removal efficiencies and be better protected from extended cold periods, however the EPA findings reported in their 2000 manual indicate most constructed FWS wetlands raise their operating level in freezing weather and the increased detention time offsets the decrease in operational efficiency based on atmospheric conditions.

Maintenance of SSF systems is difficult as expected since the water surface is not visible and subsurface fouling can have a dramatic impact on treatment efficiency. FWS wetlands have the ability to be easily maintained and solids accumulation is mitigated by vegetative growth.

In recent years studies and patents regarding the supplemental addition of air to VSB and SSF wetlands shows potential for very high removal efficiencies even in the absence of active vegetation and during cold weather months with weather temperatures near freezing. (Redmond, 2012)

These findings coincide with the current understanding that these systems utilize a small area for BOD removal, approximately the first 25% to 30% of the detention time followed by the nitrification in the last 70% and denitrification in the last 20 to 25% of the wetland flow area.

There are various approaches to support this biological model. The approach we intend to take is to construct a conventional wetland based on existing models and calculations. Influent flow to the wetland will be installed in such a way as to introduce dissolved oxygen by sawtooth weir or a shallow pool overflow. The first 30% of a treatment cell will operate at a sufficiently high elevation to allow overflow by sawtooth weir into the second portion of treatment. Average water depths planned are 2.5 ft and 2 feet. Two treatment cells will be installed with piping to accommodate either parallel or series operation. Most traditional systems rely on anoxic, anaerobic or facultative digestion of solids vastly increasing required sizing of these systems. It is our intent to demonstrate a significantly increased uptake rate in a lightly aerated constructed wetland as opposed to conventional design with the hopes that future designs could be more efficient in space and layout.

Necessary flow diversion and mechanical aeration would be built into the design in the event of sustained freezing conditions or surge flow conditions.

The proposed system will be based on design standards from The EPA Manual Constructed Wetlands Treatment of Municipal Wastewaters 2000 and the WEF/ASCE Design of Wastewater Treatment Plants 2012.

1. EPA. "Constructed Wetlands Treatment of Municipal Wastewater" 2000
2. Redmond, Eric. "Nitrogen removal from wastewater by an Aerated subsurface flow constructed wetland." Master's thesis, University of Iowa, 2012.

Section 2 History and Records

Section ~~2~~ 3 Wetland Construction

Site grade work and preparation will be performed in compliance with the geotechnical report and the liner manufacturer's recommendations for installation.

A geofabric will be installed above the clay liner to protect the synthetic liner.

The synthetic liner shall be installed above the geofabric. The synthetic liner shall be 30 mil PVC single sheet or approved equal.

Grading above the synthetic liner shall be irregular, but provide at least 6 inches of cover above the liner.

Liner installation to be approved by the manufacturer or their authorized representative.

Section ~~3~~ 4 Mechanical Piping

3.1Pipe selection

	Type	Size	Connections
Process Water	PVC SDR 27 or approved	6 inch	Gasket bell ends or Glued couplings
Air	Schedule 40	1.5 inch	Glued connections

Connections

For water piping, gasketed bell end connections and glued coupling or as approved by the engineer.

For air piping, glued couplings or as approved by engineer.

3.2Tubing

For process equipment connections the use of flexible tubing will be permitted. Where exposure to Sunlight is likely UV resistance is required.

Connections shall be barb type connectors with stainless screw drive clamps.

Section ~~4~~5 Equipment

~~3~~5.1Aeration equipment:

~~3~~5.11Blower requirements

Minimum of two blowers required.

Blowers shall be capable of 20CFM at 40 inches of water column.

Blowers shall employ an oil free design.

Blowers shall operate on single phase power.

~~3~~5.12 Diffuser requirements

Because of the shallow nature of the treatment system, low flow rate diffusers will be used.

0.25 to 0.5 CFM air stones are currently planned.

Diffusers shall be located along the bottom of the wetlands in a manner to prevent scouring. or erosion of the bottom of the wetland.

Section ~~5~~ 6 Maintenance and Operations

Bearing replacement on blowers after 26000 run hours as per ~~manufacturers~~manufacturer's recommendations.

Stones are to be acid washed when needed to maintain good air flow.

Vegetation should be culled in the late fall to maintain the light to moderate vegetation. Culling no more than once a year. The site is designed to operate hydraulically under dense vegetation.

Monthly visual ~~I~~inspections to ensure no damage or malfunctions.

Testing:

For the FWS system, a testing protocol measuring BOD removal should be employed. In operation a FWS system operates on the similar principals to a fixed film system. A similar consistency in the process is expected.

Section 6 Design Calculations

The site design considerations are as Follows,

Influent characteristics:

Flow	35000 GPD
BOD	150mg/L
Temperature	1C cold weather capacity

Effluent Characteristics:

BOD	45mg/L

Aeration equipment

BOD peak loading	43.785 lbs per day
Capacity of Aerating equipment	57,600 CF per day
CF air per pound of BOD	1315.51

Sizing Calculations utilized the Design Of Wastewater Treatment Plants Fifth Edition Volume 2: Liquid Treatment Processes, Chapter 18 Section 6.1. Equation 18.17

$$A_{fw} = \frac{q(lnC_o - lnC_e)}{k_t * d * n * (10{,}000)}$$

Where,

A_{fw} = Surface Area of FWS Wetland

q = Wastewater flow, m^3/d

C_o = Influent BOD, mg/L

C_o = effluent BOD, mg/L

n = Porosity, fraction

d = wetted depth

k_t = first order rate coefficient

The sizing does not account for introduced aeration and is designed around vegetation supplying the required oxygen.

See Appendix For Treatment Models.

Section 7 Geotechnical Study

Prior to commencement of construction a subsurface investigation of the proposed site will be performed and the recommendations of the Geotechnical Consultant.

Investigation shall be Seismic Refraction Method as per ASTM D5777.

Section 8 Sources

1. EPA. "Constructed Wetlands Treatment of Municipal Wastewater" 2000
2. Redmond, Eric. "Nitrogen removal from wastewater by an Aerated subsurface flow constructed wetland." Master's thesis, University of Iowa, 2012.
3. wefpress. "Design Of Municipal Wastewater Treatment Plants; FIFTH EDITION" 2012.

Appendix 1 Treatment modeling

Maple Green Free Water Surface Wetland Surface Calculation

Description of sizing calculation for the treatment area for the free water surface wetland proposed at Maple Green Reclamation Facility.

Equation provided by TDEC In comments dated 3/24/14. This equation is the same equation as the one used in the original design submittal.

$$A_S = \frac{Q \times ln\left(\frac{C_O}{C_E)}\right)}{K_T \times y \times n}$$

A_S = Surface Area (ft^2; m^2) (note - ft^2 used in first submittal and this submittal)

Q = Average Flow (ft^3/day ; m^3/day) (note- ft^3 used in first submittal and this submittal)

C_O = Influent BOD concentration = 150 mg/L

C_e = effluent BOD Design with safety factor = 30 mg/L (Note: Permit limit is 45 mg/l, however this is a technology limit for the previous treatment system and not a limit intended for soil loading.)

K_T = Temperature Dependent First Order Rate Reaction constant for BOD_5

y = Depth of Free Surface Wetland

n = Porosity (as defined in Design of Municipal Wastewater Treatment Plants Fifth Edition; Volume 2; Liquid treatment Processes; Chapter 18; section 6.6; ISBN 978-0-07-16358-8)

θ = 1.06 (as suggested by Design of Municipal Wastewater Treatment Plants Fifth Edition; Volume 2; Liquid treatment Processes; Chapter 18; section 6.6; ISBN 978-0-07-16358-8)

K_{20} = 20° C First Order Rate Reaction constant for BOD_5 = 0.678 $Days^{-1}$ (Design of Municipal Wastewater Treatment Plants Fifth Edition; Volume 2; Liquid treatment Processes; Chapter 18; section 6.6; ISBN 978-0-07-16358-8)

1.

$$Q = Current\ approved\ site\ disposal\ capacity$$

$$Q = 35000 \frac{Gallons}{Day}$$

$$Q = 35000 \frac{Gallons}{Day} \times \frac{1}{7.48} \frac{ft^3}{Gallon}$$

$$Q = 35000 \frac{Gallons}{Day} \times 0.1337 \frac{ft^3}{Gallon}$$

$$Q = 4680\ \frac{ft^3}{Day}$$

2.

$$\ln\left(\frac{C_o}{C_e}\right) = \ln\left(\frac{150}{30}\right)$$

$$\ln\left(\frac{C_o}{C_e}\right) = \ln(5)$$

$$\ln\left(\frac{C_o}{C_e}\right) = 1.61$$

3.

$K_T = K_{20} \times (\theta)^{(T-20)}$ (Rate reaction temperature correction as presented in Design of Municipal Wastewater Treatment Plants Fifth Edition; Volume 2; Liquid treatment Processes; Chapter 18; section 6.6; ISBN 978-0-07-16358-8)

T is assumed to be 1°C. (1°C is selected to be a conservative low estimate of the temperature of the wastewater in the system. Surface icing and continual flow would prevent the wetland from entirely freezing. The aeration is also an effective means of deicing shallow bodies of water through the mechanical introduction of energy into the system; in fact the model indicated in the design is actually sold for that express purpose.)

$$K_T = 0.678 \times (1.06)^{(1-20)}$$

$$K_T = 0.678 \times (1.06)^{(-19)}$$

$$K_T = (0.678) \times (0.331)$$

$$K_T = 0.2240\ Day^{-1}$$

4.

Porosity (n) is accepted as 0.7 which is actually representative of a densely vegetated system however it shows a more conservative number. A range of 0.7 to 0.9 porosity is used to indicate the flow restriction of vegetation where 0.7 indicates a densely vegetated wetland with restricted flow and reduced volume and 1.0 represents open water with no vegetation. (Design of Municipal Wastewater Treatment Plants Fifth Edition; Volume 2; Liquid Treatment Processes; Chapter 18; section 6.6; ISBN 978-0-07-16358-8)

$$A_S = \frac{Q \times ln\left(\frac{C_O}{C_E}\right)}{K_T \times y \times n}$$

$$A_S = \frac{4680\ \frac{ft^3}{Day} \times 1.61}{0.2240\ Day^{-1} \times 2.5\ ft \times 0.7}$$

$$A_S = \frac{7534\ \frac{ft^3}{Day}}{0.3921\ \frac{ft}{Day}}$$

$$A_S = 12{,}208.72 \frac{ft^3 * Day}{ft * Day} = 19211 ft^2$$

5.

160

Currently, each proposed wetland cell has a wetted surface area of 60 ft in width by 150 ft in length. This provides in the two cell arrangement the following.

$$A_{Individual\ cell} = 60\ ft \times 160\ ft$$

$$A_{Individual\ cell} = 9600\ ft^2$$

$$A_{Total\ Area} = A_{Individual\ cell} \times Number\ Of\ Cells$$

$$A_{Treatment\ Area} = 9600\ ft^2 \times 2$$

$$A_{Treatment\ Area} = 19200\ ft^2$$

FWS Wetland Sizing

Variables				
			metric	
BOD influent	150	mg/L	150	mg/L
1 cell BOD eff.	67	mg/L	67	mg/L
BOD Limit	30	mg/L	30	mg/L
Flow	35000	GPD	132.08	M^3/Day
depth	2.5	ft	0.76	M
k20 factor	0.678	d^-1		
Theta	1.06			
Aspect Ratio X:1	2.67			
porosity	0.7	d		
Ground Loading	155.96	lb/sq foot		

dense vegitation

design flow

peak loading

single cell treatment requirement								
	Temperature C	1	6	10	15	20	25	30
Sizing		33.8	42.8	50	59	68	77	86
Area	Ha	0.178	0.133	0.105	0.079	0.059	0.044	0.033
Area	acre	0.439	0.328	0.260	0.194	0.145	0.108	0.081
Length	ft	84.64	73.17	65.12	56.29	48.66	42.07	36.36
Width	ft	226.00	195.36	173.87	150.30	129.93	112.31	97.09

sequential treatment requirement								
	Temperature C	1	6	10	15	20	25	30
Sizing								
Area	Ha	0.089	0.067	0.053	0.039	0.029	0.022	0.016
Area	acre	0.220	0.164	0.130	0.097	0.073	0.054	0.041
Length	ft	59.90	51.78	46.08	39.84	34.44	29.77	25.73
Width	ft	159.93	138.25	123.04	106.36	91.94	79.48	68.70

sequential treatment requirement								
	Temperature C	[illegible]	6	10	15	20	25	30
Sizing								
Area	Ha	0.089	0.066	0.053	0.039	0.029	0.022	0.016
Area	acre	0.219	0.164	0.130	0.097	0.072	0.054	0.040
Length	ft	59.81	51.70	46.01	39.77	34.38	29.72	25.69
Width	ft	159.68	138.04	122.85	106.20	91.80	79.36	68.60

HRT: 10.2205 4.520539

Appendix 2 Manufacturer's Data sheets for components.

Provided as examples.

Liner

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PVC liners fabricated by EPI are a single-ply construction with Polyvinyl Chloride as the principle polymer. Only first quality virgin resins are used and all materials meet or exceed the requirements of ASTM D7176 Standard Specification for PVC geomembranes used in buried applications.

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Thickness ± 5%	ASTM D-5199	.030"
Specific Gravity (min)	ASTM D-792	1.20
Tensile (lb/in-width, min)	ASTM D-882	73
Elongation at Break (% min)	ASTM D-882	380
Modulus (lb/in-width, min)	ASTM D-882	30
Tear Resistance (lb/in, min)	ASTM D-1004	8
Resistance to Soil Burial (% change, max)	ASTM G-160	
1. Breaking Factor		5
2. Elongation At Break		20
3. Modulus at 100% Elongation		20
Impact Cold Crack (°C)	ASTM D-1790	-29
Dimensional Stability (% change, max)	ASTM D-1204 (212°F/15 min.)	3
Water Extraction (%,max)	ASTM D-1239	0.15
Volatile Loss (%, max)	ASTM D-1203(A)	0.70
Hydrostatic Resistance (psi, min)	ASTM D-751(A)	100
Plasticizer Min Ave Molec Wt	ASTM 2124	400
Factory Fabricated Seams:		
Peel Strength (lbs/in, min)	ASTM D-882	15
Shear Strength (lbs/in, min)	ASTM D-882	58.4

These data are based on tests believed to be reliable. However, these are laboratory tests that may not simulate actual use conditions. They are provided for your informational purposes only. No warranty, express or implied, including any other further warranty of fitness for a particular purpose or merchantability, is made by this promotional literature.

Preserving water resources for future generations

Blower

Blower Specifications (at Sea Level, 68°F, 60 Hz)

S11_specs.jpg (2280×1283)

Model Number	Cfm Free Air @ Inches Water 20"	30"	40"	50"	Max Duty	Hp	Phase	No. Filters	Running Watts Input @ Inches Water	Max Starting Watts	Voltage	Rated Full Load Amps	Height w/o Filter	Width	Outlet Hose Pipe Size	Weight (lbs)	Price (Including Filter)
S11A ❶❷	13	3	—	—	34"	1/8	1	1	198/20"	900	115/230	2.0/115	10"	8"	1"	23	$ 528.40
S21 ❶❷	27	19	7	—	43"	1/3	1	1	377/30"	1,800	115/230	3.8/115	10"	9"	1"	28	589.19
S31 ❶❷	34	28	21	16	56"	1/2	1	1	471/30"	2,000	115/230	5.6/115	10"	10"	1½"	36	625.81
S313 ❷	34	28	21	16	56"	1/2	3	1	410/30"	4,000	230/460	2.0/230	10"	10"	1½"	36	645.90
S41 ❶❷	70	65	53	36	58"	1	1	1	971/40"	4,000	115/230	9.8/115	12"	12"	1½"	50	762.06
S43 ❷	70	65	53	36	58"	1	3	1	860/40"	5,000	230/460	3.2/230	12"	12"	1½"	50	764.37
S45 ❷	110	100	90	80	65"	1½	1	2	1,430/40"	9,000	115/230	10.4/230	14"	15"	2"	77	1,021.86
S453 ❷	110	100	90	80	65"	1½	3	2	1,500/40"	12,000	230/460	4.9/230	14"	15"	2"	85	1,042.30
S51 ❸	135	120	110	100	65"	2½	1	2	1,760/40"	14,000	115/230	11.9/230	14"	15"	2"	87	1,106.46
S53 ❸	135	120	110	100	65"	2½	3	2	1,750/40"	17,000	230/460	6.9/230	14"	15"	2"	100	1,063.63
S61 ❸	190	180	165	—	45"	2½	1	2	2,600/40"	14,000	115/230	11.8/230	16"	17"	3"	100	1,492.83
S63 ❸	190	180	165	160	80"	3½	3	2	3,260/60"	28,000	230/460	8.8/230	16"	17"	3"	115	1,394.48
S631 ❸❺	190	180	165	160	75"	3½	1	2	3,400/60"	21,000	230	19.0/230	16"	17"	3"	115	1,516.29
S651 ❸	190	180	165	160	100"	5	1	2	3,710/80"	29,000	230	22.3/230	16"	17"	3"	150	1,554.26
S653 ❸	190	180	165	160	110"	5	3	2	3,520/80"	36,000	230/460	12.0/230	16"	17"	3"	150	1,562.03
S56 ❸	120	120	118	117	280"	6	3	2	4,000/150"	38,000	230/460	18.2/230	19"	22"	3"	215	2,917.40
S69 ❸	250	245	230	210	110"	5½	3	2	4,190/60"	48,000	230/460	18.2/230	22"	22"	3"	250	2,185.43
S73 ❸	390	375	350	330	125"	10	3	4	7,640/80"	75,000	230/460	25.0/230	24"	22"	3"	245	2,647.51
2S41 ❹	78	74	70	61	110"	1+1	—	1	800/80"	—	—	19.6/115	—	—	—	—	—
S15	650	640	630	610	125"	15	3	1	11,000/80"	70,000	230/460	50/230	23"	21"	3"	452	5,677.21
S18P	720	710	690	650	105"	18	3	2	12,000/80"	90,000	230/460	52/230	20"	28"	4"	438	5,230.66
S18S	410	405	400	395	200"	18	3	1	12,000/80"	90,000	230/460	52/230	22"	28"	4"	431	5,230.66
S30P	1,275	1,230	1,200	1,190	125"	30	3	2	20,000/80"	140,000	230/460	98/230	23"	32"	5"	630	11,823.49
S30S	650	640	630	625	225"	30	3	1	20,000/80"	140,000	230/460	98/230	23"	33"	5"	606	11,823.49

❶ Standard with 115V or 230V 8' power cord (230V models are also rated for 208V). Add "**230**" to part number for 230V.
❷ **S453** and smaller ship Ground. ❸ **S51** and larger ship via motor freight only. ❹ Blowers in series double the pressure. ❺ No thermal overload protection.

Air diffuser

AS1.gif (750×512)

	Length* in	Length* cm	Width* in	Width* cm	Suggested cfm	aes	Air Supply Connection	Actual Wt
AS1	1.5	4	.50	1.3	.05	1.5	3/16" O.D. (4 mm), ABS	.03 lb
AS2	1.5	4	.75	2	.10	3	3/16" O.D. (4 mm), ABS	.06 lb
AS3	2.0	5	1.0	2.5	.20	5	3/16" O.D. (4 mm), PE	.10 lb
ALS3	2.0	5	1.0	2.5	.20	5	1/4" NPT, PE	.10 lb
AS4	1.5	4	1.5	4	.25	7	3/16" O.D. (4 mm), PE	.21 lb
AS5S	3.0	8	1.0	2.5	.30	8	3/16" O.D. (4 mm), PE	.16 lb
AS5L	3.0	8	1.0	2.5	.30	8	1/4" O.D. (6 mm), PE	.16 lb
ALS5	3.0	8	1.0	2.5	.30	8	1/4" NPT, PE	.16 lb
AS8S	3.0	8	1.5	4	.35	10	3/16" O.D. (4 mm), PE	.39 lb
AS8L	3.0	8	1.5	4	.35	10	1/4" O.D. (6 mm), PE	.39 lb
ALS8	3.0	8	1.5	4	.35	10	1/4" NPT, PE	.39 lb
ALR8	3.0	8	1.5	4	.35	10	1/2" NPT, PE	.39 lb
AS15S	6.0	15	1.5	4	.50	14	1/4" O.D. (6 mm), PE	.75 lb
AS15L	6.0	15	1.5	4	.50	14	3/8" O.D. (9 mm), PE	.75 lb
ALR15	6.0	15	1.5	4	.50	14	1/2" NPT, PE	.75 lb
AS23S	9.0	23	1.5	4	.75	20	1/4" O.D. (6 mm), PE	1.35 lbs
AS23L	9.0	23	1.5	4	.75	20	3/8" O.D. (9 mm), PE	1.35 lbs
ALR23	9.0	23	1.5	4	.75	20	1/2" NPT, PE	1.35 lbs
AS30S	12.0	30	1.5	4	1.00	27	1/4" O.D. (6 mm), PE	1.50 lbs
AS30L	12.0	30	1.5	4	1.00	27	3/8" O.D. (9 mm), PE	1.50 lbs
ALR30	12.0	30	1.5	4	1.00	27	1/2" NPT, PE	1.50 lbs
ASW88S**	3.0	8	3.0	8	.70	19	1/4" O.D. (6 mm), PE	.70 lb
ASW88L**	3.0	8	3.0	8	.70	19	3/8" O.D. (6 mm), PE	.70 lb

*Dimensions of length and width are ±1/8" (3 mm). **Fitting is in center of 3" x 3" dimension. The suggested cfm shown above is typical for aquaculture; higher cfm amounts will create larger bubbles. Nonstandard fittings are available on request. PE is high density linear polyethylene. ABS is green plastic.

ADENUS SOLUTIONS GROUP

TN DEPT OF ENVIRONMENT
AND CONSERVATION
OCT 09 2014
DIV OF WATER RESOURCES
RECEIVED

Free Surface Wetland Design Specifications

For Cedar Hill STP

Roy Denney

9/10/2014

ROY CHON DENNEY
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 114195
STATE OF TENNESSEE

9/10/14

WPC14-0763

Design Specifications for the free water surface wastewater treatment wetland at Cedar Hill STP. Prepared for Tennessee Wastewater.

Maple Green Design Specifications

Table of Contents

Section 1 Abstract

Proposal Regarding Constructed Free Water Surface Wetland With Aeration for Treatment of Septic Tank Effluent in Rural Systems.
Roy Denney, PE
Adenus Group

Wetland treatment for wastewater which has already received primary settling and minimal secondary treatment is well establish with systems in the US dating back more than fifty years(EPA, 2000).
The two prevailing approaches are Free Water Surface (FWS) and Subsurface Flow (SSF or VSF(vegetated)) wetlands. Conventional wisdom dictates that a VSF with some insulating cover will higher removal efficiencies and be better protected from extended cold periods, however the EPA findings reported in their 2000 manual indicate most constructed FWS wetlands raise their operating level in freezing weather and the increased detention time offsets the decrease in operational efficiency based on atmospheric conditions.

Maintenance of SSF systems is difficult as expected since the water surface is not visible and subsurface fouling can have a dramatic impact on treatment efficiency. FWS wetlands have the ability to be easily maintained and solids accumulation is mitigated by vegetative growth.

In recent years, studies and patents regarding the supplemental addition of air to VSB and SSF wetlands shows potential for very high removal efficiencies even in the absence of active vegetation and during cold weather months with weather temperatures near freezing. (Redmond, 2012)

These findings coincide with the current understanding that these systems utilize a small area for BOD removal, approximately the first 25% to 30% of the detention time followed by the nitrification in the last 70% and denitrification in the last 20 to 25% of the wetland flow area.

There are various approaches to support this biological model. The approach we intend to take is to construct a conventional wetland based on existing models and calculations. Influent flow to the wetland will be installed in such a way as to introduce dissolved oxygen by sawtooth weir or a shallow pool overflow. The first 30% of a treatment cell will operate at a sufficiently high elevation to allow overflow by sawtooth weir into the second portion of treatment. Average water depths planned are 2.5 ft and 2 feet. Two treatment cells will be installed with piping to accommodate either parallel or series operation. Most traditional systems rely on anoxic, anaerobic or facultative digestion of solids vastly increasing required sizing of these systems. It is our intent to demonstrate a significantly increased uptake rate in a lightly aerated constructed wetland as opposed to conventional design with the hopes that future designs could be more efficient in space and layout.

Necessary flow diversion and mechanical aeration would be built into the design in the event of sustained freezing conditions or surge flow conditions.

The proposed system will be based on design standards from The EPA Manual Constructed Wetlands Treatment of Municipal Wastewaters 2000 and the WEF/ASCE Design of Wastewater Treatment Plants 2012.

1. EPA. "Constructed Wetlands Treatment of Municipal Wastewater" 2000
2. Redmond, Eric. "Nitrogen removal from wastewater by an Aerated subsurface flow constructed wetland." Master's thesis, University of Iowa, 2012.

Section 2 Construction

A. Wetland Construction

Site grade work and preparation will be performed in compliance with the geotechnical report and the liner manufacturer's recommendations for installation.

A geofabric will be installed above the clay liner to protect the synthetic liner.

The synthetic liner shall be installed above the geofabric. The synthetic liner shall be 30 mil PVC single sheet or approved equal.

Grading above the synthetic liner shall be irregular, but provide at least 6 inches of cover above the liner.

Liner installation to be approved by the manufacturer or their authorized representative.

The first two wetlands will be constructed with the third being constructed after the region reaches 80% of the capacity of the first two wetlands or 40,000 Gallons Per Day.

Section 3 Mechanical Piping

3.1Pipe selection

	Type	Size	Connections
Process Water	PVC SDR 27 or approved	6 inch	Gasket bell ends or Glued couplings

Connections

For water piping, gasketed bell end connections and glued coupling or as approved by the engineer.

3.2Tubing

For process equipment connections the use of flexible tubing will be permitted. Where exposure to Sunlight is likely UV resistance is required.

Connections shall be barb type connectors with stainless screw drive clamps.

Section 4 Reserved

Section 5 Maintenance and Operations

5.1 Reserved

5.2 Vegetation Operations and Maintenance

Vegetation will be culled in the summer. Culling no more than once a year. The site is designed to operate hydraulically under dense vegetation.

5.2.1 Deep Water Planting

In the deeper pools in the wetland cells, vegetation will be deep water vegetation or floating vegetation. These plants will reside as depicted in Drawing 4. Plant types may include Hyacinths, Water Lettuce, Lilies, Duckweed, Parrots Feather, etc. any plant used in the deep portions must be capable of growing in 2.5 to 4 feet of water.

The number of plants shall be determined as follows:

The area being vegetated divided by the average growth area of the plants as provided by the plant supplier multiplied by the porosity fraction n, 0.7. This number may vary based on the type of plant used and the supplier's recommendations.

5.2.2 Shallow Water and Bank Vegetation Planting

A mix of Bulrush, Cattail, Arrow Arum, and Native Wetland grasses will be utilized in shallow areas within the pools and along the edges of the wetland.

5.2.3 Native Species

Where feasible attempt to grow native Tennessee species in the wetlands.

5.2.4 Operations Activities and Routine Maintenance.

The nature of a Free Water Surface Wetland is such that minimal technician input is required.

Level in the wetland will be maintained by the pumping to disposal either by manual or automatic controls.

Site should be visually inspection to ensure no damage or malfunctions on a routine basis.

During summer months when the average temperature is above 69 Degrees Fahrenheit, the loading areal loading rate for the facility dramatically diminishes. As necessary to maintain appropriate vegetation density, the cells can be taken out of service individually and the vegetation can be individually removed.

5.2.5 Testing:

For the FWS system, a testing protocol measuring BOD removal should be employed. In operation a FWS system operates on the similar principals to a fixed film system. A similar consistency in the process is expected.

Section 6 Design Calculations

The site design considerations are as Follows,

Influent characteristics:

Flow	75000 GPD
BOD	150mg/L
Temperature	1C cold weather capacity

Effluent Characteristics:

BOD	45mg/L

Sizing Calculations utilized the Design of Wastewater Treatment Plants Fifth Edition Volume 2: Liquid Treatment Processes, Chapter 18 Section 6.1. Equation 18.17

$$A_{fw} = \frac{q(lnC_o - lnC_e)}{k_t * d * n * (10{,}000)}$$

Where,
A_{fw} = Surface Area of FWS Wetland
q = Wastewater flow, m^3/d
C_o = Influent BOD, mg/L
C_o = effluent BOD, mg/L
n = Porosity, fraction
d = wetted depth
k_t = first order rate coefficient

See Appendix For Sizing Calculations.

Section 7 Geotechnical Study

5010 Linbar Drive,
Suite 153
Nashville, TN 37211
615.331.7770
www.ttlusa.com

July 19, 2013

Mr. Bob Pickney
Adenus Technologies
849 Aviation Parkway
Smyrna, Tennessee 37167

*RE: Report of Seismic Refraction Survey
Tennessee Water Systems, Inc.
Cedar Hill Facility
Cedar Hill, Tennessee
TTL Project No. 100813128*

Dear Mr. Pickney:

We have completed the requested seismic refraction survey of the collapsed feature located at the Tennessee Water System facility in Cedar Hill, Tennessee. Our services were provided in accordance with TTL Proposal No. P01813125 and were authorized by you on June 19, 2013. This report summarizes background information about the project, the site and subsurface conditions encountered, and our conclusions and recommendations.

PROJECT AND BACKGROUND INFORMATION

Information about the project was provided by you during an on-site meeting on June 12, 2013. Adenus Technologies operates a water treatment facility located on the north side of United States Highway 41 in Cedar Hill, Tennessee. The facility includes two basin areas, which are approximately 320 feet by 360 feet (northern basin) and 320 feet by 420 feet (southern basin). The bottom of the basins is about 15 feet lower than the adjacent ground with slopes constructed on an approximate ratio of 3H:1V. Construction of the side slopes reportedly included the placement of 5 to 6 feet of compacted fill and excavation depths of about 5 to 10 feet. Initial construction included the placement of about 2 feet of compacted fill across the bottom of the basins to reduce infiltration.

We understand that the facility was operational for a few years when an apparent sinkhole developed at the northwest corner of the northern basin. Specific information about the size, depth, and exact location of this feature is not available; however, we understand that the sinkhole was repaired with an inverted filter installed in accordance with a permit issued by the Tennessee Department of Environment and Conservation (TDEC) in 2011. Remedial repair also reportedly included the placement of 2 feet of compacted clay across the northern basin bottom in addition to the compacted clay layer placed at the time of initial construction. The facility re-initiated operations once repairs were completed and the northern basin has not experienced any additional sinkholes.

We understand that an apparent sinkhole feature recently developed in the southwestern corner of the southern basin. Site observations revealed the feature has been explored by excavating a test pit but has not yet been repaired. Current plans are to repair the sinkhole in accordance with a TDEC approved permit that was previously prepared by others. Planned repairs also include flattening the southern basins slopes to 4H:1V and placing a synthetic liner across the bottom to reduce infiltration.

We understand that you are concerned about whether or not other incipient sinkhole features are present with the potential to disrupt future operations at the facility. We were asked to gather subsurface data in the southern basin and provide recommendations to reduce the potential for future sinkhole development. Exploration of the northern basin was beyond the scope of this exploration.

SITE CONDITIONS

The northern basin was operational with about ½ to 1 foot of water at the time of our field operations. The southern basin was not operational, but contained ponded water in portions of the basin with depths of less than 6 inches. The ponded water limited our ability to conduct seismic traverses in the eastern portion of the southern basin. A stand pipe is located in the southern portion of the southern basin. Approximate locations of the site features are shown on the attached Seismic Run Location Map.

The apparent sinkhole feature was observed in the southwest portion of the southern basin. An exploration pit had been previously made into the feature with the excavated materials stockpiled nearby at the ground surface. The excavated area was approximately 20 feet deep and 40 feet in diameter. Limestone bedrock was exposed on the south side of the excavation from about 2 feet below the ground surface to the base of the excavation. Materials exposed on the northern face of the excavation consisted of reddish-brown cherty clays.

Photographs of the site conditions observed during our field activities are shown below:

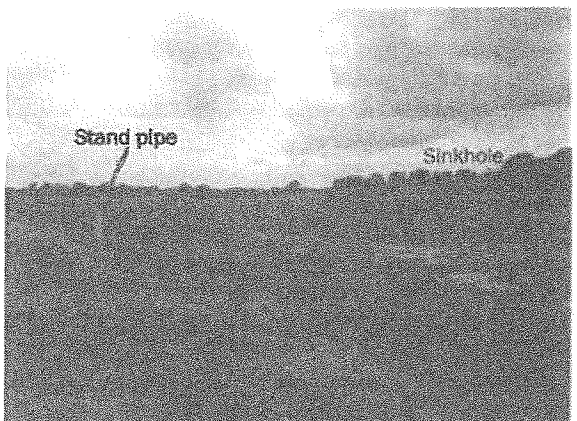


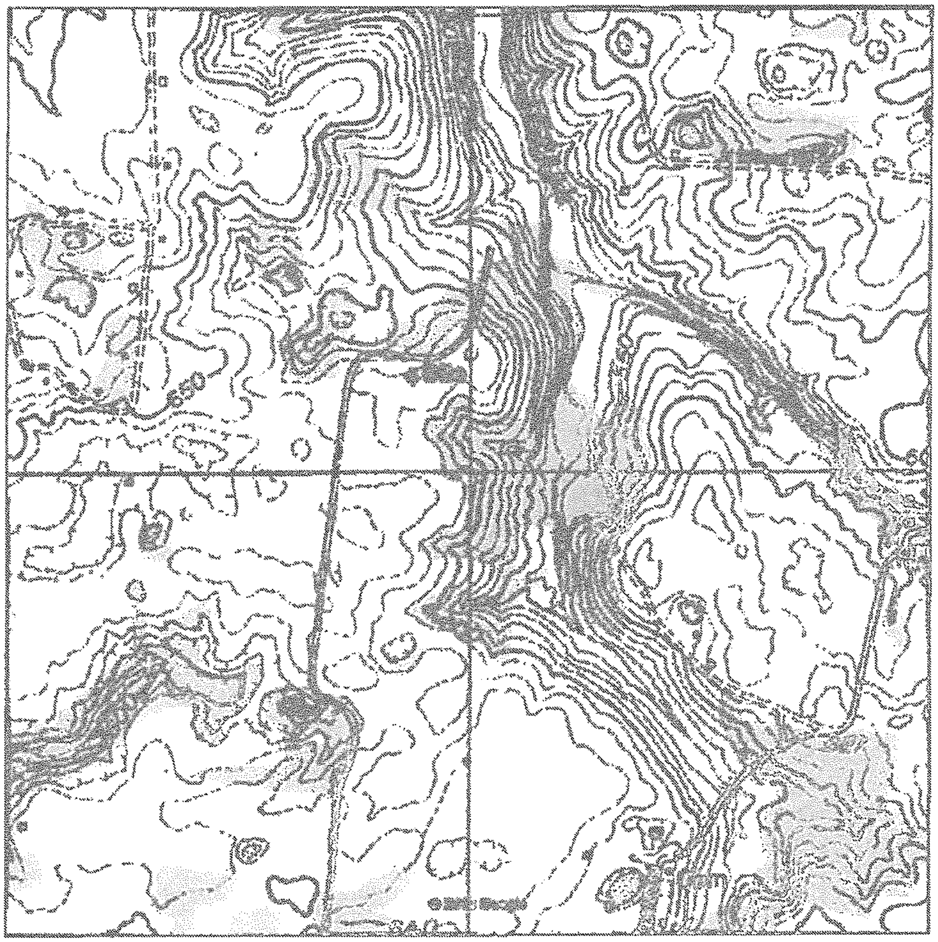
Photo 1: View looking west across the southern basin.

Photo 2: View looking east across the southern basin.

GEOLOGIC CONDITIONS

The Geologic Map of the Tennessee West-Central sheet (Tennessee Department of Environment and Conservation, Division of Geology, 1966) indicates the site is underlain by the Mississippian-aged Warsaw Limestone Formation. This formation is gray, massive, medium- to coarse-grained, cross-bedded limestone. The soil overburden covering the limestone is typically about 20 to 40 feet thick and consists of very cherty, reddish-brown clay of moderate to high plasticity.

The Warsaw Limestone Formation is susceptible to solution weathering and sinkhole development. Review of the USGS Springfield North, Tennessee 7.5-Minute Topographic Quadrangle Map (dated 1952, photorevised 1983) shows a relatively high density of closed depressions (i.e. sinkholes) in the general site area. A section of the map is reproduced on the following page.



The topographic quadrangle map reveals the site is located on a ridge line situated above a relatively deeply eroded V-shaped valley containing Little Buzzard Creek. No sinkholes were mapped at the site, but a sinkhole is shown about 300 feet northwest of the facility.

Sinkholes are typically caused by the erosion of the soil overburden into crevices within the bedrock. This erosion can be caused by water infiltrating downward from the surface or by fluctuations in the groundwater table near the bedrock surface. This erosion process causes a void to form above the bedrock. The clayey soils in this area are typically strong enough to span over small openings; however, with continued erosion, the void can eventually become so large that the overlying soil collapses resulting in a sinkhole. This type of erosional process is likely exacerbated by ponding of water within the facility's basins.

Sinkholes typically occur where two or more joint sets in the bedrock intersect. Thus, joint orientation is useful in interpreting the geophysical data and evaluating locations with higher potential for sinkhole development. Based on the surface topographical features and orientation of existing sinkholes in the local region, three of the primary joint orientations appear to be approximately north 60 degrees east, north 10 degrees west, and north 50 degrees west. The long axis of the ridge line on which the facility is located and the long axis of the basins roughly follow the north 60 degrees east joint.

EXPLORATION METHOD AND RESULTS

A seismic refraction survey was performed to gather data about the subsurface conditions within the southern basin area. This geophysical method is a noninvasive means of gathering information about the depth of soil overburden. It can often locate subsurface anomalies such as zones of deep weathering in the bedrock that may be indicative of incipient sinkholes. This method generally does not directly identify subsurface voids unless they are very large. Thus, this method is used as a screening tool to search for potential weaknesses such as intersecting joint sets that are deeply weathered, but then should be coupled with direct exploration by borings or test pits to further evaluate the nature of the anomaly.

For this project, 16 seismic refraction traverses were performed (reference the attached Seismic Run Location Plan). There were some areas of the basin that we could not place the equipment because of ponded water. Thus, no subsurface information was collected in these areas. The refraction traverses consisted of a single spread of 12 geophones aligned in a linear array with up to 26-foot spacing between geophones. Once the geophones were placed, an external energy source was used to generate an energy wave (sledge hammer striking a metal plate). The generated energy waves penetrated the overburden and subsequently refracted off the bedrock surface. The refracted waves were detected by the geophones that were placed along the traverse with the data transmitted to a seismograph. The recovered data consists of the arrival time of the primary compression waves at each geophone. The data was analyzed using the computer program SeisOpt Picker (© P-wave Optim, Inc., 1998-2007). The travel time and array geometry (energy source and geophone locations, including relative elevations) were compared with algorithmic models to select the best fit for each strike plate hit. Velocity values for each grid point were determined thus allowing for evaluation of lateral and vertical velocity variations. We interpreted the recovered data to identify variations within the subsurface strata. The compression wave velocity profiles are presented in a color spectrum and are appended. Our interpretation of the data is presented in the table below:

Interpretation of the Geophysical Data

Color Range	Compressive Wave Velocity Range (ft/s)	Associated Subsurface Feature
Royal Blue to Light Blue	0 – 4000	Soil Overburden
Teal to Green	4000 – 10,000	Highly to Moderately Weathered Bedrock with Soil Zones
Yellow to Pink	> 10,000	Competent Bedrock

The seismic data indicate that the limestone bedrock within the basin area exhibits a moderate to high degree of weathering. The soil overburden is up to 40 feet thick with the thickest zones occurring below the side slopes at the ends of the basin. There is a prominent area where there appears to be little or no soil overburden near the center of the southern half of the basin. The depth to competent bedrock (little or no weathering) is highly variable as evidenced by pinnacles, narrow depressions, and gradual dipping profiles.

CONCLUSIONS AND RECOMMENDATIONS

The history of sinkhole formation at the facility, relatively high density of sinkholes in the region, and results of the geophysical testing warrant that additional subsurface exploration be performed. The seismic refraction data indicate specific locations and lineaments with a higher potential for sinkhole development in the southern basin. These features are described below:

- On Run 12, there is a well-defined depression in the top of the rock surface and a corresponding depression in the depth to competent rock. This is the only location identified with such a narrow, well-defined depression in the apparent bedrock surface. The deep weathering could represent two or more intersecting joint sets.
- The area of shallower rock is a concern. The infiltration through the bottom of the basin has a relatively short travel distance to reach the rock surface and erode soil into crevices in the

zones with thicker soil zones, but any sinkhole below the basin is problematic for operation of the facility.

- Zones of deep weathering are located below or near the side slopes along the east and west sides of the basin. The weathering appears to generally follow the lineament oriented at north 60 degrees east mentioned earlier. Along the west side, this lineament occurs below the existing sinkhole and may also be the same joint trace where the sinkhole in the north basin occurred. In our opinion, this lineament has a high potential for sinkholes and warrants additional exploration. A potential lineament with the same orientation was also identified in the east side and should be evaluated further.

We recommend that the features and trends described above be further explored by excavating test pits. Our representative should observe the test pits to interpret the subsurface conditions encountered. Additional test pits may be recommended based on the conditions observed in the initial excavations.

We concur with your plan to reduce infiltration by lining the basin. The liner will reduce, but not eliminate infiltration through the bottom. Thus, the liner will reduce the potential for new sinkholes, but not eliminate that possibility. If conditions consistent with incipient sinkholes are found in test pits, then those features can be repaired to further reduce the risks of new sinkhole formations. There are other more expensive measures that can better lessen or eliminate the risks of future sinkhole development. We can discuss these measures if they warrant further consideration after the test pits are performed.

We appreciate this opportunity to be of service and are available to respond to any questions or discuss the details of our findings with you, or others, at your request.

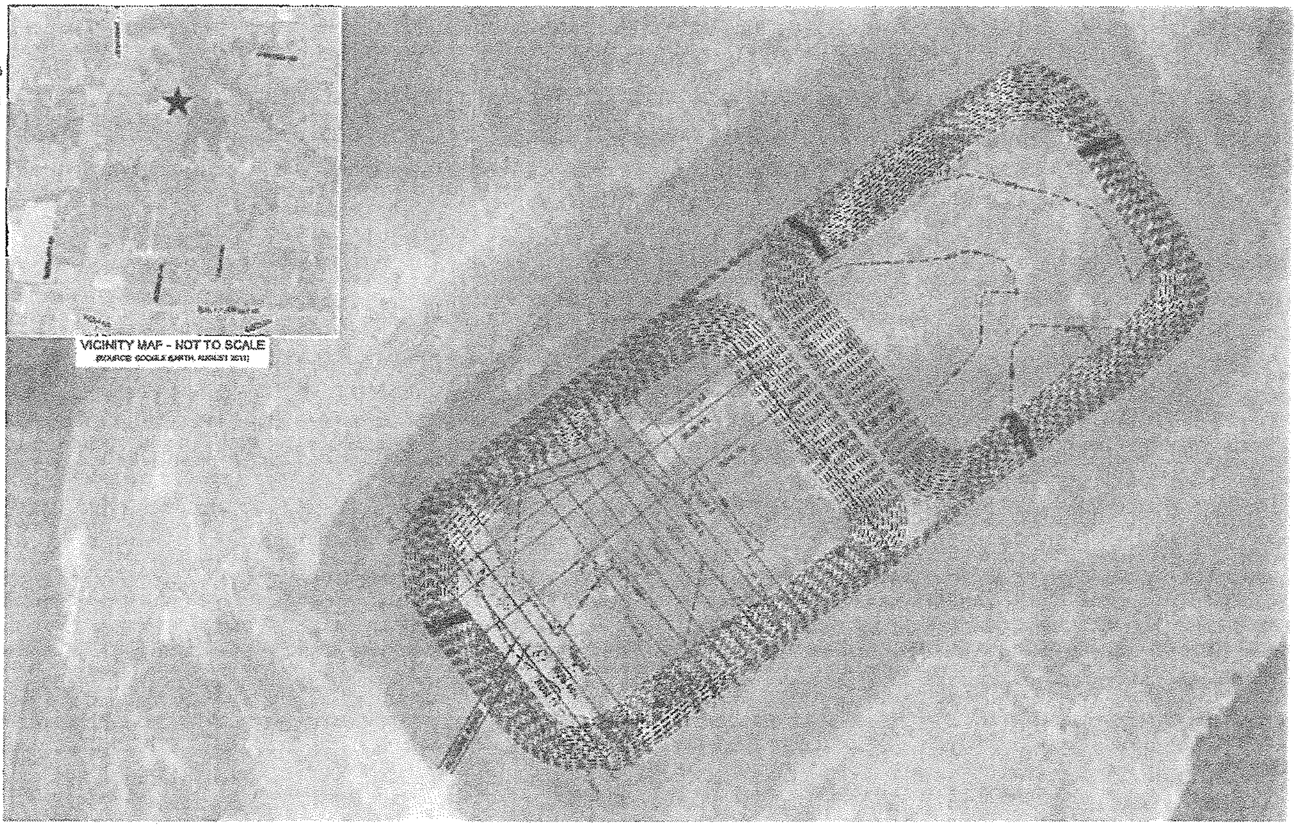
Sincerely,
TTL, Inc.

Steven Fox, EI
Staff Professional

Richard D. Heckel by: kj

Richard D. Heckel, PE
Principal Engineer

Attachment: Seismic Run Location Map



DRAWING SOURCE: PROVIDED BY CLIENT
AERIAL SOURCE: GOOGLE EARTH, AUGUST 2011

Start RUN 16 End — SEISMIC RUN LOCATION AND IDENTIFIER

STOCKPILE / CUT AREA

AREAS HOLDING WATER

SINKHOLE FEATURE

STAND PIPE

0' 80' 160'

TTL

TENNESSEE WATER SYSTEMS, INC.
CEDAR HILL FACILITY
CEDAR HILL, TENNESSEE

Date: JULY 2013

TTL Project Number: 100813129

SEISMIC RUN LOCATION MAP

Section 8 Sources

1. EPA. "Constructed Wetlands Treatment of Municipal Wastewater" 2000

2. Redmond, Eric. "Nitrogen removal from wastewater by an Aerated subsurface flow constructed wetland." Master's thesis, University of Iowa, 2012.

3. wefpress. "Design Of Municipal Wastewater Treatment Plants; FIFTH EDITION" 2012.

Appendix 1 Treatment Sizing

Cedar Hill Free Water Surface Wetland Surface Calculation

Description of sizing calculation for the treatment area for the free water surface wetland proposed at Cedar Hill Facility.

Equation provided by TDEC In comments dated 3/24/14.

$$A_S = \frac{Q \times ln\left(\frac{C_O}{C_E}\right)}{K_T \times y \times n}$$

A_S = Surface Area (ft^2; m^2)

Q = Average Flow (ft^3/day ; m^3/day)

C_O = Influent BOD concentration = 150 mg/L

C_e = effluent BOD Design with safety factor = 30 mg/L

K_T = Temperature Dependent First Order Rate Reaction constant for BOD_5

y = Depth

n = Porosity

θ = 1.06

K_{20} = 20° C First Order Rate Reaction constant for BOD_5 = 0.678 $Days^{-1}$

1.

$$Q = Current\ approved\ site\ treatment\ capacity$$

$$Q = 75000 \frac{Gallons}{Day}$$

$$Q = 75000 \frac{Gallons}{Day} \times \frac{1}{7.48} \frac{ft^3}{Gallon}$$

$$Q = 75000 \frac{Gallons}{Day} \times 0.1337 \frac{ft^3}{Gallon}$$

$$Q = 10027.5 \frac{ft^3}{Day}$$

2.

$$\ln\left(\frac{C_o}{C_e}\right) = \ln\left(\frac{150}{30}\right)$$

$$\ln\left(\frac{C_o}{C_e}\right) = \ln(5)$$

$$\ln\left(\frac{C_o}{C_e}\right) = 1.61$$

3.

$$K_T = K_{20} \times (\theta)^{(T-20)}$$

T is assumed to be 1°C.

$$K_T = 0.678 \times (1.06)^{(1-20)}$$

$$K_T = 0.678 \times (1.06)^{(-19)}$$

$$K_T = (0.678) \times (0.331)$$

$$K_T = 0.2244\ Day^{-1}$$

4.

Porosity (n) is accepted as 0.7 which is actually representative of a densely vegetated system however it shows a more conservative number.

$$A_S = \frac{Q \times ln\left(\frac{C_O}{C_{E)}}\right)}{K_T \times y \times n}$$

$$A_S = \frac{10027.5\ \frac{ft^3}{Day} \times 1.61}{0.2244\ Day^{-1} \times 2.5\ ft \times 0.7}$$

$$A_S = \frac{16144\ \frac{ft^3}{Day}}{0.3927\ \frac{ft}{Day}}$$

$$A_S = 19{,}184 \frac{ft^3 * Day}{ft * Day} = 41{,}110 ft^2$$

Tennessee Wastewater Systems, Inc.
RFP Cost Estimates
Cedar Hill Wetland

Item	Qty	Units	Unit Price	Total
8" Pipe SDR 21		FT	8	
8" Pipe SDR 26	1250	FT	8	10,000
8" Tee	17	Each	105	1,785
8" 90	21	Each	80	1,680
8" Cap	21	Each	6	126
Liner 30 Mil	45000	SQ Ft	0.4	18,000
#357 or #4 stone, washed	10	10 Yd Loads	350	3,500
57 stone, washed		10 Yd Loads	350	
Poultry Net	6000	SQ Ft	0.15	900
GEO Fabric	45000	SQ Ft	0.15	6,750
Plants				
70% cover	10000	SQ Ft	1	10,000
50% cover	10000	SQ Ft	2.5	25,000
Pumps	2	each	3000	6,000
Total Materials				83,741
Instrumentation	1		10000	10,000
Equipment Rental	2	Months	8000	16,000
Power				30,000
Labor	830	Hours	75	62,250
Project Management				30,152
Total Construction				232,143
Engineering	240	Hours	100	24,000
CAI	160	Hours	100	16,000
Bonding	2%			4,643
Construction Contingency	10%			23,214
Total Project Estimated Cost				300,000

Tennessee Wastewater Systems, Inc.
RFP Cost Estimates
Maple Green Wetland

Item	Qty	Units	Unit Price	Total
8" Pipe SDR 21	500	FT	8	4,000
8" Pipe SDR 26	1200	FT	8	9,600
8" Tee	17	Each	105	1,785
8" 90	21	Each	80	1,680
8" Cap	21	Each	6	126
Liner 30 Mil	27000	SQ Ft	0.4	10,800
#357 or #4 stone, washed	5	10 Yd Loads	350	1,750
57 stone, washed	5	10 Yd Loads	350	1,750
Poultry Net	4000	SQ Ft	0.15	600
GEO Fabric	28000	SQ Ft	0.15	4,200
Plants				
70% cover	6300	SQ Ft	1	6,300
50% cover	4500	SQ Ft	2.5	11,250
Pumps	2	each	3000	6,000
Total Materials				59,841
Instrumentation	1		10000	10,000
Equipment Rental	3	Months	8000	24,000
Fencing	800	Ft	17	13,600
Labor	800	Hours	75	60,000
Project Management				20,059
Total Construction				187,500
Engineering	240	Hours	100	24,000
CAI	160	Hours	100	16,000
Bonding	2%			3,750
Construction Contingency	10%			18,750
Total Project Estimated Cost				250,000

Tennessee Wastewater Systems, Inc.
RFP Cost Estimates
Smoky Village

Item	Qty	Units	Unit Price	Total
Soil Mapping	2	Acre	700	1,400
Property Acquisition	2	Acre	21000	51,000
Easements	1	Eacj	1500	1,500
Drip Field	9000	Ft	3.5	31,500
Field Lines	1200	Ft	15	18,000
Total Materials				103,400
Fencing	1200	FT	17	20,400
Project Management				14,350
Total Construction				138,150
Engineering	120	Hours	100	12,000
CAI	80	Hours	100	8,000
Bonding	2%			2,763
Construction Contingency	10%			13,815
Total Project Estimated Cost				174,728

Summitt View				
Design		LS		12,500.00
Soil Mapping		LS		2,000.00
Storm Water SWPP		LS		2,500.00
Sand Filter Expansion	10000	Gal	10	100,000.00
New Drip Supply / RetURn	2000	LF	4.5	9,000.00
Drip Irrigation	25,000	LF	3.5	87,500.00
Recirculation Tank		LS		4,500.00
New Control System		LS		12,000.00
Property Purchase		LS		75,000.00
Contengencies				15,000.00
Contract Adminsitration				10,000.00
				0.00
				0.00
Total				330,000.00

SUPPLEMENTAL RESPONSE 16:

According to staff engineer Roy Denney, it would cost approximately $1 Million to $1.2 Million to install a recirculating sand filter treatment system at Maple Green, four times the estimated cost of using a "free surface wetland" treatment system as proposed by TWSI and as approved by TDEC. Mr. Denney also determined that a free surface wetland system would be more appropriate for this location than a deep cell lagoon because of the possibility of another sinkhole accident. A lagoon contains millions of gallons of water and is typically twenty feet deep. The weight of the water in the lagoon makes a sinkhole accident more likely than using a free water surface wetland, which is only two to two and a half feet deep, contains much less water, and places no more pressure on the ground underneath than a person walking on the surface. Furthermore, if there is a sinkhole accident, the millions of gallons escaping from a lagoon would cause substantially more harm to the environment than the much smaller amount of water escaping from a free surface wetland. For these reasons, Mr. Denney recommended and TDEC approved a free water surface wetland treatment system rather than using a deep cell lagoon. The costs of using a deep cell lagoon or a surface wetland treatment system are approximately the same.

Mr. Denney's analysis is supported by the engineering plans for Maple Green submitted to and approved by TDEC. It is attached to Supplemental Responses 11-14, supra.

SUPPLEMENTAL RESPONSE 17:

Because of the poor drainage conditions at Smoky Village, a larger drip field is needed to disperse the wastewater after it has been treated. The only alternatives to using a drip field would be to spray the treated wastewater in the air, which requires a larger land area, or piping the water to a suitable stream, pond, or lake and obtaining an NPDES permit from the EPA and TDEC.

Obtaining an NPDES is an expensive, multi-year process and disfavored in Tennessee. State law requires that any applicant for an NPDES must first show that the applicant has considered alternatives such as "land application and beneficial reuse of wastewater." T.C.A. § 69-3-108(e).

Even if it were environmentally appropriate to pipe wastewater to a nearby creek, there is no suitable body of water at or near Smoky Village. Furthermore, TWSI would have to install another treatment system to make the wastewater cleaner before it could be discharged into surface water. Taken together, these factors make it environmentally unsound and prohibitively expensive to replace the drip field at Smoky Village with a sole-point discharge system.

This analysis is supported by the engineering plans for Smoky Village which were submitted by Mr. Denney to TDEC and approved by TDEC. Those plans are found under attachment 85 to TWSI's responses to the TRA Staff's data requests.

SUPPLEMENTAL RESPONSE 21:

TWSI has provided the CAPD and the TRA Staff with the following information:

Evidence of purchase of land at Smoky Village by Bob Pickney on March 14, 2013 for $41,000. Data Response 82M.

TWSI contract to buy land from Bob Pickney for the amount Pickney paid plus expenses, including an 8% return. Data Response 82C and D.

TWSI estimate of property acquisition at Smoky Village of $51,000. Data Response 83.

TWSI contract to buy land at Summit View from Jeremy Dison for what Dison paid plus expenses, including an 8% return. Data Response 29.

TWSI estimate of $75,000 to purchase property for Summit View. Data Response 26B.

TWSI provides the following additional information.

Jeremy Dison purchased the land at Summit View for $73,500 on December 1, 2014. See attached.

Card 1 of 1

Location 2229 UPPER MIDDLE CREEK RD	Property Account Number	Parcel ID 085 056.03 000

Old Parcel ID --

Current Property Mailing Address

Owner DISON JEREMY	City NASHVILLE
	State TN
Address 7996 RIVER RD	Zip 37209
	Zoning R-1

Current Property Sales Information

Sale Date 12/1/2014	Legal Reference 4415-308
Sale Price 73,500	Grantor(Seller)

Current Property Assessment

	Card 1 Value
Year 2015	Building Value 0
	Xtra Features Value 0
Land Area 1.950 acres	Land Value 33,800
	Total Value 33,800

Narrative Description

This property contains 1.950 acres of land mainly classified as Residential with a(n) N/A style building, built about , having N/A exterior and N/A roof cover, with 0 unit(s), 0 total room(s), 0 total bedroom(s), 0 total bath(s), 0 total half bath(s), 0 total 3/4 bath(s).

Legal Description

Property Images

SUPPLEMENTAL RESPONSE 23:

The reasons for choosing a drip dispersal method over an NPDES at Smoky Village are explained in the Supplement Response 17.

Similarly, there is no practical alternative to the repair plan proposed by TWSI and approved by TDEC for Summit View. Because of the steep terrain, there is no place to locate a storage facility, which would need to hold a minimum of 100,000 gallons. Putting a tank of that size on a steep hillside would be prohibitively expensive. The construction costs alone (i.e., not including the cost of the tank itself) would exceed the total cost of the solution proposed by TWSI. For that reason, the storage tank option is impractical. Moreover, a storage tank may be appropriate when additional capacity is only needed on an occasional basis. Here, the additional capacity is needed on a continual basis. Therefore, the better solution is to increase the capacity of the recirculating sand filter treatment facility and expanding the size of the drip field.

The proposed engineering plans to repair Smoky Village may be found under attachment 85 to TWSI's response to the TRA Staff's Data Requests.

The plans for Summit Ridge have not yet been submitted to TDEC but will be filed by April 8, 2015, and provided to the CAPD and the TRA at that time.

SUPPLEMENTAL RESPONSE 26.

See Supplemental Response 17. In sum, the weight of the water of a deep cell lagoon increases the likelihood of another sinkhole.

Respectfully submitted,

BRADLEY ARANT BOULT CUMMINGS LLP

By: ______________________________

Henry Walker (B.P.R. No. 000272)
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1600 Division Street, Suite 700
Nashville, TN 37203
Phone: 615-252-2363
Email: hwalker@babc.com

VERIFICATION OF SUPPLEMENTAL INTERROGATORY RESPONSES

I, Charles R. Hyatt, being the authorized representative of TWSI for the purpose of responding to these interrogatories and requests for production of documents, being duly sworn, affirm that the Supplemental Responses set forth above are true, accurate and complete.

____

COUNTY OF Rutherford
STATE OF Tennessee

On this the 8 day of April, 2015, personally appeared before me, the above-named Charles Hyatt (please print or type name of person responding to these interrogatories on behalf of TWSI and identified in Question 33) known to me personally or made known to me by satisfactory proof who was duly sworn and on oath executed the above verification.

____
Notary Public

SUSAN R. CHAFFIN STATE OF TENNESSEE NOTARY PUBLIC RUTHERFORD COUNTY

My Commission Expires:
02/20/2018

7/3621721.1