UNC
ENVIRONMENT
HEALTH & SAFETY

The University of North Carolina at Chapel Hill
Department of Environment, Health & Safety
1120 Estes Drive Ext., CB# 1650
Chapel Hill, North Carolina 27599-1650

November 11, 2011

Mr. Nathaniel D. Thornburg
North Carolina Department of Environment and Natural Resources
Division of Water Quality
Aquifer Protection Section
Land Application Unit
1636 Mail Service Center
Raleigh, NC 27699-1636

RE: Application No. WQ0023896 UNC-CH Bingham Facility
Additional Information Submittal #1
UNC-CH Bingham Facility
Wastewater Irrigation System
Orange County

Dear Mr. Thornburg:

In response to your October 14, 2011 "Request for Additional Information" as well as the subsequent NCDENR "Letter of Clarification" dated October 18, 2011; both in connection with the above referenced application , we have prepared attached response and modified application.

If there are any additional comments, please contact me at 919-843-591.

Sincerely,

Mary Beth Koza

Mary Beth Koza
Director, Environment, Health and Safety

McKIM&CREED

ENGINEERS
SURVEYORS
PLANNERS

November 11, 2011

Mr. Nathaniel D. Thornburg
North Carolina Department of Environment and Natural Resources
Division of Water Quality
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Land Application Unit
1636 Mail Service Center
Raleigh, NC 27699-1636

RE: Application No. WQ0023896 UNC-CH Bingham Facility
Additional Information Submittal #1
UNC-CH Bingham Facility
Wastewater Irrigation System
Orange County

Dear Mr. Thornburg:

We received your October 14, 2011 "Request for Additional Information" as well as the subsequent NCDENR "Letter of Clarification" dated October 18, 2011; both in connection with UNC-CH Application WQ0023896. We have reviewed your comments and have addressed each of your specific comments in the order that you presented them. Your original comments are shown *italicized*, with our responses following each comment in plain text. Copies of NCDENR's comment and clarification letters are included under Tab 1 and the revised Application No. WQ0023896 is included under Tab 2.

Notes:

1. *When providing an additional information response to the Division, please provide a letter addressing each comment and provide a reference as to the location of the requested information in the updated application package.*

Response

We have formatted our responses as requested.

Venture IV Building
1730 Varsity Drive
Raleigh, NC 27606

Application:

1. *Please amend Application Item II.5. to include the submittal data for the Stormwater Management Plan. While the Stormwater Management Plan does not need to be approved prior to issuance of this non-discharge permit modification, the plan shall at least be submitted to the appropriate agency for review.*

Response

We originally submitted the Stormwater Management Plan on March 25, 2011, then revised the application in response to regulatory comments on August 29, 2011 and finally received a NCDWQ approved Stormwater Permit (No. SW5110901) on September 19, 2011. We have updated Application Item II.5 accordingly (Tab 2) and have attached a copy of the permit and final submittal under Tab 3 for your file.

2. *Amend Application Item III.5. to include the estimated influent concentrations for nitrate, nitrite, total nitrogen and total phosphorus. In addition, amend this item to include the designed effluent concentrations for all of the listed parameters, not the 15A NCAC 02T .0505(b) limits. These values can either be based upon the wastewater treatment facility's design calculations to remove the listed parameters, or can be based upon actual sampled measurements. Please note that the Division needs these values to verify the submitted agronomic calculations.*

Response

a) *Estimated Influent Concentrations*: The University has committed to reducing the influent waste strength and volume at the Bingham Facility such that the existing on-site *AdvanTex™* biological treatment process will be capable of producing a complying effluent for secondary land application. As such, the influent concentrations now shown in revised Application Item III.5 (Tab 2) represent the annual average *projected influent loading* after "re-purposing" as described in item b) below). The influent sewage will enter the upstream septic tank with liquid effluent proceeding to biological treatment and chlorine disinfection prior to discharge into the wet weather storage basin for land application. Per your request, we have characterized the *anticipated* influent wastewater flow and have predicted wastewater contaminant concentrations based on "typical" municipal strength wastewater. The results of our analysis appear in Table 1 of this letter. We have also revised Application Item III.5. to include the estimated influent concentrations for all listed parameters including total nitrogen,

organic nitrogen, ammonia nitrogen, nitrate, nitrite, and total phosphorus (Tab 2).

Table 1 - Composite & Design Wastewater Characterization

Item	Qty	Unit Flow (GPD)	Total Flow (GPD)	BOD (mg/l)	TSS (mg/l)	TKN (mg/l)	TP (mg/l)
People	15	35	525	250	180	40	7
Dishwasher	1	375	375	200	50	40	7
Laundry Washer	2	500	1000	200	50	40	7
Cage Washer	1	140	140	20	20	10	7
Wet Lab	2	200	400	200	50	40	7
Softener Brine	2	80	160	25	30	50	7
Boiler Blow-down	2	25	50	50	40	50	7
Calculated Composite			**2650**	**187**	**73**	**39**	**7**
Design			**3556**	**250**	**200**	**40**	**7**

BOD – Biochemical Oxygen Demand, TSS – Total Suspended Solids, TKN – Total Kjeldahl Nitrogen, TP – Total Phosphorus

b) *Effluent Concentrations*: It would not be representative, at present, to utilize effluent wastewater sample results collected from existing wastewater generated at the Bingham Facility because the *current* waste flow contains large volumes of animal wastewater which will be *eliminated* as part of the "re-purposed" facility. "Re-purposing" will involve a conversion to a dry-bedding animal holding facility and will initially house caged to small rodents. Once the conversion is completed, the dry bedding system will capture 98% of all animal waste and prevent it from entering the sewer system. The dry bedding (containing animal waste) will be regularly removed as a solid waste material and properly disposed of in a sanitary landfill. The result of these changes will be to minimize both the wastewater volume and loading such that the resulting wastewater will be more characteristic of standard municipal sewage. Per your request, we have modeled the existing primary settling basin (septic tank), AdvanTex recirculating textile fabric biological filter, and chlorine disinfection system using the composite influent wastewater to predict the design average daily wastewater effluent quality. The results of this analysis are presented in Table 2 of this letter. The detailed process computations used to project design effluent concentrations are included under Tab 4.

Table 2 – Projected Design Effluent Wastewater Concentration Following Each Individual Unit Treatment Process

Wastewater Parameters	ADF (GPD)	BOD_5 (mg/l)	TSS (mg/l)	TN (mg/l)	NH-3 (mg/l)	Org-N (mg/l)	Nitrate /Nitrite (mg/l)	Total Phosphorus
Raw Influent Sewage	3,556	250	200	40	25	15	0	7
Post Primary Settling	3,556	162.5	100	40	35	0	0	5
Post Multi-Pass Textile Fabric AdvanTex Biological Treatment Process	3,556	10	10	25	15	0	10	5
Design Effluent to be Land Applied	3,556	10	10	25	15	0	10	5

BOD – Biochemical Oxygen Demand, TSS – Total Suspended Solids, TN – Total Nitrogen, TP – Total Phosphorus

3. *Amend Application Item IV.2. to include the actual minimum field measured distance from the irrigation system and treatment/storage units to each applicable item listed in 15A NCAC 02T .0506. Distances greater than 500 feet may be marked N/A.*

Response

We have revised information in Application Item IV.2. (Tab 2) to include the actual minimum field measured distance from the irrigation system and treatment/storage units to each applicable item listed in 15A NCAC 02T .0506.

4. *Amend the two tables in Application Item VI.5. to include the correct effective or total volumes for the two storage structures. The current tables list the effective volume as equal to the total volume. Please note that the total volume is the volume between the top of the embankment and the basin bottom. The effective volume is the volume between the two-foot freeboard elevation and the basin bottom or outlet pipe, whichever is higher.*

Response

We have revised the two tables in Application Item VI.5. (Tab 2) to include the correct effective volume provided (125,724 gallons for Basin #1 and 1,122,442 gallons for Basin #2) and total volumes for the two storage structures (207,267 gallons for Basin #1 and 1,471,054 gallons for Basin #2). The total wet weather storage volume available on-site is equivalent to 315 days at ADF.

5. *Application Item VII.7. states that the recommended annual loading rate is 10.28 inches per year (in/yr). However, Page 10 of the soil evaluation recommends an annual loading rate of 8.2 in/yr. Please amend.*

Response

We have re-evaluated the recommended annual loading rate with Edwin Andrews & Associates (Project Hydrogeologist) and Scott Fredrick of Soil, Water, & Environment Group, (the NC-licensed Soil Scientist for this project) in light of NCDENR comments. After adjusting the system Water Balance (refer to Tab 7) to utilize the NCDENR-recommended drainage coefficient of 0.085 for the site, we recalculated the sprayfield safe hydraulic loading rate. Based on these changes, the revised spray application rate should be 10.92 inches per year. As such, we have revised both Application Item VII.7. (Tab 2), and page 10 of the Soils Scientist Evaluation (Tab 5) to be consistent.

6. *Application Item VII.10.a. states that the proposed irrigation area is 249,163 square feet (ft^2). Using the proposed average daily flow of 3,556 gallons per day (GPD), this equates to a design annual loading rate of 8.36 in/yr. Please amend this item to include the correct designed annual loading rate.*

Response

The proposed irrigation area is correctly identified as being 249,163 square feet (5.72 acres) in size on the application. Using the design wastewater loading of 3,556 gpd (1,297,940 gpy) and the net precipitation gain in the two wet weather storage basins over the year (397,568 gpy), the total volume to be applied annually should be 1,695,508 gpy. As such, the correct design annual loading rate to the spray fields should be 10.92 inches per year. We have revised Item VII.10.a. of the Application (Tab 2), the Water Balance (Tab 7) and the Soil Scientist Evaluation to reflect the revised application rate of 10.92 inches/year.

7. *Amend the second table in Application Item VII.10.a. to state the wetted diameter of the nozzles is 80 feet, and that its wetted area is 5,027 ft^2.*

Response

We incorrectly listed the wetted *radius* of the nozzles as 40'. We have therefore corrected Application Item VII.10.a. (Tab 2) to show the wetted *diameter* of the nozzles to be 80' with a wetted area of 5,027 square feet.

8. *Please note that the Division did not verify the calculations in Application Item VII.11. because the proper designed effluent concentrations were not provided in Application Item III.5.*

Response

We understand that NCDENR was not able to verify the calculations in Application VII.11. without the proper design effluent concentrations. We have therefore calculated the requested design effluent concentrations (Tab 4) and have correctly indicated these values in Application Item III.5. (Tab 2) for your review and evaluation. As you will note in Section 3.1.2 of the Agronomist's Report (Tab 6), the proposed UNC Bingham Secondary Land Application Spray Sites currently exhibit both nitrogen and phosphorus deficiencies. As such, the addition of wastewater to the site will *improve* soil fertility and consequently the growing conditions and productivity of the site. Per Section 3.2.1 of the Agronomist's Report, the anticipated maximum 61.9 lbs TN/ac/yr (total nitrogen loading) associated with the wastewater application is less than the 80 to 120 lbs of nitrogen addition recommended by the NCDA for these soils types.

Soil Evaluation:

1. *Table 1 on Page IV states that the irrigation shall be seasonal, however, Application Item VII.7. states annual. Please amend for consistency.*

Response

Table 1 on page IV of the Soil Scientist Evaluation incorrectly indicated that irrigation would be seasonal. We have revised the table to indicate that spray application is intended to be performed throughout the year when weather conditions allow and have included the revised Soil Scientist Evaluation under Tab 5.

2. *Section 4.1 on Page 4 states that spray irrigation shall not occur within 25 feet of non-SA surface waters. Per 15A NCAC 02T .0506(a), this setback shall be 100 feet. Please amend.*

Response

Section 4.1 on Page 4 of the Soil Scientist Evaluation incorrectly listed the spray irrigation setback to non-SA surface waters as 25'. This section of the Soils Report has been revised to reflect the correct setback of 100' (Tab 5).

3. *Section 5.2 on Page 8 makes note of having a Sodium Adsorption Ratio (SAR) of less than 10. Please clarify whether or not excessive salts are anticipated to be in the effluent waste stream.*

Response

We have revised Section 5.2 on Page 8 of the Soil Scientist Evaluation to include a statement by the Soils Scientist that "The proposed effluent is anticipated to have SAR values safe for irrigation".

4. *Page 10 of the soil evaluation recommends an annual loading rate of 8.2 in/yr, however, Application Item VII.7. states that the recommended annual loading rate is 10.28 in/yr. Please amend.*

Response

We have revised both page 11 of the Soil Evaluation (Tab 5) as well as Application Item VII.7 (Tab 2) to reflect the revised annual loading rate of 10.92 in/year or 0.21 inches/week.

5. *Per Application Instruction E and 15A NCAC 02T .0504(b)(4), provide a standard soil fertility analysis for both the Georgeville and Herndon soil series.*

Response

A standard fertility analysis was completed across the site and specifically at each K_{sat} location (includes both Georgeville and Herndon soil series). The fertility data by soil series is presented in Table 2 of the Agronomist Report (Tab 6). The complete fertility analysis for all plots is included as Appendix C of the attached, revised, Agronomist Report (Tab 6).

Agronomist Report:

1. *Please note that the agronomic calculations have not been verified by the Division because the designed effluent concentrations in Application Item III.5. were not provided.*

Response

We understand that the agronomic calculations have not been verified by the Division because the designed effluent concentrations in Application Item III.5. were not provided. We have calculated the *design* effluent nutrient concentrations (Tab 4) and updated Application Item III.5. (Tab 2) accordingly. Agronomic calculations have been revised for annual wastewater loadings of 10.92 in/yr with a design effluent total nitrogen concentration of 25 mg/l and a total phosphorus concentration of 5 mg/l (Tab 6, pages 9-12).

2. *Pages 4 and 5 again make mention of the Sodium Adsorption Ratio (SAR), and recommends that the SAR be analyzed. Accordingly, please clarify whether or not high salt concentrations will be present in the effluent.*

Response

Section 2.2.1 of the Agonomist's Report (Tab 6, Pages 4-5) has been revised to indicate "Recent water quality testing data indicates the UNCBWWTF irrigation water has an SAR of less than 10 (SAR=3.5) (EnviroChem, 2010).

Water Balance:

1. *The submitted water balance was truncated during printing/copying. Accordingly, the Division is unable to determine the temperature and precipitation data used, and therefore the water balance calculations have not been verified. Please resubmit copies of the original water balance that include all of the required data.*

Response

We have revised the Water Balance to incorporate the NCDENR-recommended Drainage Coefficient of 0.085 and have attached the updated Water Balance in its entirety under Tab 7 for your review.

2. *Please provide the top of berm surface areas for both of the wet weather storage basins.*

Response

The correct top of berm surface area for both of the wet weather storage basins is shown on each water balance sheet. However, for clarification, the wet weather surface area (i.e. surface area at the top of berm elevation) for the small storage basin is 11,970 square feet (0.2748 acres) and the surface area of the larger storage basin is 19,829 sf or 0.4552 acres).

3. *Page 2-7 of Ed Andrew's report indicates that runoff was used in the truncated water balance. Please note that the Division respectfully disagrees with the proposed method of determining runoff using a straight 20% runoff calculation, which is not representative of rainfall intensity or soil surface infiltration rates. Therefore, if the Applicant intends to use runoff in the water balance calculations, the following information will need to be submitted:*

   a. *The Division recommends the following equation to determine runoff:*

$$R = \frac{(P - 0.2S)^2}{P + 0.8S}, \text{ where } R = \text{runoff, } P = \text{precipitation and } S = \left(\frac{1000}{CN}\right) - 10$$

   b. *Daily precipitation data from a 30 year time span that is from the same source used in the 80th percentile data in the water balance.*

c. *Submit a copy of a referenced source (e.g., Soil Conservation Service) that includes the following information for North Carolina soils justifying the use of the selected Curve Number (CN):*
   i. *Cover Type and Hydrologic Condition for the proposed site*
   ii. *Hydrologic Soil Groups for North Carolina Soils identifying the soil classifications for Georgeville and Herndon (i.e., A, B, C or D)*
   iii. *Curve Number (CN) for the Hydrologic Soil Group based on the Cover Type and Hydrologic Condition.*
   iv. *Using the justified CN and S value for the appropriate cover type and hydrologic soil condition, determine the potential runoff for each storm event that occurred in the data set (i.e., 30 year period), then sum the calculated runoff per month, and then average into annual monthly runoff values. Once 30-year monthly average runoff values are determined, it may be weighted to 80th percentile to be consistent with the precipitation data in the water balance. Note daily precipitation data may be downloaded from the State Climate Office of North Carolina (http://www.nc-climate.ncsu.edu/).*

Response

We have reviewed our methodology and have agreed to eliminate consideration of rainfall runoff from our analysis of the site. As such, we have reworked the Water Balance per your request and no have a need to incorporate the revised methodology described in your comment letter.

Engineering Calculations:

1. *If actual sample measurements are not available, per Application Instruction Q and 15A NCAC 02T .0504(c)(3), amend the engineering calculations to include pollutant loading calculations for each treatment unit. Using the estimated influent concentrations listed in Application Item III.5., perform pollutant removal calculations for each listed parameter within each treatment unit. Once the final designed effluent concentrations have been determined, input those values into Application Item III.5. as the designed effluent concentrations. Next, use those applicable nutrient concentrations to determine the nitrogen and phosphorous balance calculations in the agronomist evaluation and subsequently listed in Application Item VII.11.*

Response

We have completed the pollutant removal computations by treatment process unit per your request using the design influent pollutant concentrations listed in Application Item III.5. The final design effluent concentrations have been computed (Tab 4) and input into Application Item III.5 (Tab 2). The resulting residual nutrient concentrations were provided to the Agronomist who has incorporated them into the revised Agronomist's Report (Tab 6, Page 10). The updated nutrient information has been included in Application Item VII.11.

2. *Per Application Instruction Q and 15A NCAC 02T .0504(c)(3), amend the Engineering Calculations to include buoyancy calculations for the chlorine contact chamber.*

Response

We have completed buoyancy calculations for the chlorine contact chamber and are including them under Tab 8. No additional ballast is required for this structure.

3. *The storage calculations for the two wet weather storage ponds do not match the provided volumes in Application Item VI.5. Please review these calculations and amend the appropriate document as necessary.*

Response

The storage calculations for the two wet weather storage basins have been checked and now are consistent with the volumes indicated in Application Item VI.5. (Tab 2). The storage rating data are included under Tab 9.

4. *Application Item III.2. states the average daily flow is 3,556 GPD; however, the design calculations for the chlorine contact chamber and the spray field use a flow of 3,500 GPD. Please revise these calculations to be consistent with other portions of the application package.*

Response

We have revised the chlorination/disinfection calculations to reflect the sprayfield design flow of 3,556 gpd and have included the updated computations under Tab 10.

Site Map:

1. *Review of the submitted site map shows that existing MW-1 is between the compliance and review boundaries, and existing MW-2 is outside the compliance boundary. Accordingly, the Applicant shall propose a new groundwater monitoring well network, where at least one upgradient and one downgradient monitoring well is located on the review boundary. In addition, the Applicant should consider the feasibility of installing a groundwater monitoring well network on the review boundary around the wet weather storage basins.*

Response

We have added two new monitoring well locations and have shown them on the revised site map per your request (included under Tab 11). The owner does not wish to construct the groundwater monitoring network on the review boundary at this time, since it is not required by regulation or statute. We are attaching the revised version of the site map to this letter for your review (Tab 11).

Operation and Maintenance Plan:

1. *Please note the final Operation and Maintenance Plans are not required to be submitted until the final Engineering Certification is provided to the Division.*

   Per Application Instruction S and 15A NCAC 02T .0507, provide an Operation and Maintenance (O&M) Plan for the wastewater treatment and irrigation system. At a minimum, the O&M Plan shall include:

   a. *Describe the operation of the system in sufficient detail to show what operations are necessary for the system to function and by whom the functions are to be conducted.*

   b. *Describe anticipated maintenance of the system.*

   c. *Include provisions for safety measures including restriction of access to the site and equipment.*

   d. *Include spill control provisions such as response to upsets and bypasses including control, containment and remediation, as well as contact information for plant personnel, emergency responders and regulatory agencies.*

Response

We are aware of the NCDENR requirement for a complete Operations and Maintenance Manual as part of the final Engineering Certification. The O&M information included in the original application was only added to provide some assurance that UNC is committed to providing quality operations and maintenance of the completed systems.

McKim & Creed is already under contract with UNC-CH to prepare the required O&M manual for submittal with the Engineer's Final Certification. The manual will be completed and submitted for NCDENR review prior to issuing our request for system operation.

Residuals Management Plan:

1. *Please note that per 15A NCAC 02T .0504(j), the Applicant shall obtain a written commitment from a permitted residuals disposal/utilization program and provide it to the Division prior to operation of the permitted system.*

Response

UNC-CH is aware of this requirement and will submit a written commitment from a permitted residuals disposal/utilization program and provide it to the Division prior to operation of the permitted system.

General:

1. *At the recommended annual loading rate of 8.2 in/yr, the proposed irrigation fields will be hydraulically loaded to the proposed permitted capacity, yet well below the assimilative capacity of the soils. The Division is concerned that this design will not allow for operational control of the system, which could present possible future non-compliance. The Division requests that the Applicant either reevaluate the annual loading rate capacity of the proposed irrigation area, or add additional acreage to allow for greater flexibility when operating the system.*

This matter was clarified in NCDENR's October 18, 2011 letter as follows:

One of the issues discussed was language in the next to last paragraph (see General, No.1) that tended to imply that UNC-CH may not be able to operate the spray system in compliance with the permit, if the application rate were to remain at the proposed rate of 8.2 inches per year (in/yr).

Specifically, are letter stated "The Division is concerned that this design will not allow for operational control of the system, which could present possible future non-compliance."

After review of the language in the additional information letter, and discussing the intent of the language with both staff of the Division and UNC-CH, I felt it necessary to send this letter to clarify the intent of the language. It was not the intent of the Division to suggest the UNC-CH could not achieve compliance with the permit. Rather, it was intended to point out that the proposed loading rate of 8.2 in/yr does not provide much operational flexibility in the event the facility receives additional water, such as from prolonged storm events, which may require application rates that exceed 8.2 in/yr.

Response

We are in agreement that the originally proposed annual design loading rate (8.2 in/yr) is conservative as you have indicated. In contrast, however, we strongly disagree with your assertion that *"The Division is concerned that this design will not allow for operational control of the system, which could present possible future non-compliance"* that was addressed in the NCDENR October 18, 2011 letter of clarification (Tab 1).

We have revised our water balance methodology (as described previously under the section titled "Water Balance"), per your suggestions, and the new method allowed us to increase the annual loading rate from 8.2 in/yr to 10.92 in/yr.

Relative to your concern stated in the October 18, 2011 clarification letter *"...the proposed loading rate of 8.2 in/yr does not provide much operational flexibility in the event the facility receives additional water, such as from prolonged storm events, which may require application rates that exceed 8.2 in/yr"*, we would like to point out that our Water Balance (Tab #7) already *incorporates* a total of 52.57 inches of rainfall (i.e. the annual rainfall received during the 8th wettest year in the last decade that will be contributed into the two open wet weather storage basins) into the design of the wet weather storage basins and secondary effluent sprayfield. In addition, the wastewater system design incorporates a number of features that together provide considerable flexibility for operational control of the system.

Specifically, these include:

1. We have incorporated multiple spray zones that can be independently isolated and irrigated separately. As such, University Operators will not have to shutdown the entire

sprayfield to perform maintenance or repairs on individual sprayheads.

2. The existing permit (3,556 gpd) is currently approved for application to only 2.12 acres. We have more than doubled the spray area (5.72 acres total) which will provide more redundancy, not less.

3. We are providing a total of 1,278,160 gallons of effluent storage volume in the two wet weather storage impoundments. This equates to 360 days of storage at the average daily sewage production rate of 3,556 gpd. This provides the Operators with *plenty* of available effluent storage volume in the event they wish to do regular maintenance on any or all portions of the sprayfield. They merely need to turn off the spray irrigation system pumps and let the effluent accumulate in the 1,278,160 gallon storage basin at the design sewage production rate of 3,556 gallons per day. The Operators would then have an entire year available to do maintenance on their 5.72 acre sprayfield.

As the NC Professional Engineering firm responsible for this design, we are uncomfortable with increasing the annual loading rate for secondary effluent above 10.92 in/yr at this time. Further, we are not aware of any statutory or regulatory requirements that require the owner to construct or provide redundant sprayfield area. As such, we respectfully request that NCDENR withdraw its request for redundant sprayfield area or higher application rates.

General:

Please note that the recommended annual loading rate of 8.2 in/yr for Georgeville and Herndon soils is far lower than typical recommendations for these soils. In addition, the submitted water balance uses a K_{SAT} reduction factor of 4%. Since the K_{SAT} reduction factor may be in the range of 4 to 10%, it has been the Division's experience that for well drained soils, such as Georgeville and Herndon, a higher reduction factor is acceptable. Accordingly, the Division recommends that the Applicant consider these facts if reevaluating their water balance.

Response

We are in agreement with your perspective and have modified the Water Balance to reflect a KSAT reduction factor of 8.5% which is within the allowable range of 4 to 10% (Tab 7).

We trust that you will find this additional information submittal to be complete and that it fully addresses all of your comments. However, please feel free to contact me directly at (919) 810-3318 if you have any questions or need additional information.

Sincerely,

McKIM & CREED, INC.

Kevin C. Eberle, PE
Senior Project Manager

cc: Chuck Riley, Jr. PE, McKim & Creed, Inc.

North Carolina Department of Environment and Natural Resources
Division of Water Quality

Beverly Eaves Perdue
Governor

Coleen H. Sullins
Director

Dee Freeman
Secretary

October 18, 2011

Mr. Richard Mann - Vice Chancellor Finance & Administration
University of North Carolina at Chapel Hill
CB #1000 – 302A South Building
Chapel Hill, North Carolina 27599-1000

Subject: Permit Application WQ0023896
UNC-CH Bingham Facility
Wastewater Irrigation System
Orange County

Dear Vice Chancellor Mann,

On October 14, 2011 the Division of Water Quality's (Division) Aquifer Protection Section issued a letter dated October 14, 2011, to the University of North Carolina at Chapel Hill (UNC-CH), regarding the additional information needed in order to complete the evaluation of the subject permit application. The application was for the modification of Non-Discharge Permit No. WQ0023896, associated with the continued operation of a wastewater irrigation system at the Bingham Facility.

Upon receipt of the letter, the Division received a telephone call from Ms. Mary-Beth Koza to discuss the information requested. One of the issues discussed was language in the next to last paragraph (see General, No.1) that tended to imply the UNC-CH may not be able to operate the spray system in compliance with the permit, if the application rate were to remain at the proposed rate of 8.2 inches per year (in/yr). Specifically, our letter stated, "The Division is concerned that this design will not allow for operational control of the system, which could present possible future non-compliance."

After review of the language in the additional information letter, and discussing the intent of the language with both staff of the Division and UNC-CH, I felt it necessary to send this letter to clarify the intent of the language. It was not the intent of the Division to suggest the UNC-CH could not achieve compliance with the permit. Rather it was intended to point out that the proposed loading rate of 8.2 in/yr does not provide much operational flexibility in the event the facility receives additional water, such as from prolonged storm events, which may require application rates that exceed 8.2 in/yr.

It should be noted that prior to seeking modification of the permit, the existing field on site was permitted to receive treated wastewater up to 24.09 in/yr. A majority of this previously permitted field is included in the proposed irrigation area and is to have a reduced loading rate of 8.2 in/yr. The Division is not aware of any situation, such as ponding or run-off due to the over-application of wastewater effluent, where the existing fields had any difficulty assimilating the treated wastewater at the existing annual loading rate of 24.09 in/yr. The soils comprising the proposed new fields are similar to the soils in the previously permitted field, and should be capable of assimilating more than the requested application rate.

Aquifer Protection Section
1628 Mail Service Center, Raleigh, North Carolina 27699-1628
Location: 3800 Barrett Dr., Raleigh, North Carolina 27609
Phone: 919-791-4200 \ FAX: 919-571-4718 \ Customer Service: 1-877-623-6748
Internet: www.ncwaterquality.org

Therefore, in order to provide flexibility related to operation of the spray fields, the Division recommends the UNC-CH reevaluate the proposed irrigation rate of 8.2 in/yr, and determine whether or not a higher loading rate (not to exceed 24.09 in/yr) can be achieved, or include additional wetted acreage.

If you have any questions concerning this matter, please contact me via email at jay.zimmerman@ncdenr.gov or at (919) 791-4200.

Sincerely,

S. Jay Zimmerman
Environmental Program Supervisor

cc: RRO-APS Files
Aquifer Protection Section Central Files
Ms. Mary-Beth Koza –UNC-CH
Charles D. Riley, Jr., PE – McKim & Creed
Scott J. Frederick, LSS – Soil, Water & Environmental Group, PLLC
Edwin Andrews, PG, LSS – Edwin Andrews & Associates

North Carolina Department of Environment and Natural Resources
Division of Water Quality
Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

October 14, 2011

RICHARD L. MANN – VICE CHANCELLOR FINANCE & ADMINISTRATION
THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
CB#1000 – 302A SOUTH BUILDING
CHAPEL HILL, NORTH CAROLINA 27599-1000

Subject: Application No. WQ0023896
Additional Information Request
UNC-CH Bingham Facility
Wastewater Irrigation System
Orange County

Dear Vice Chancellor Mann:

Central and Regional Aquifer Protection Section staff have completed their review of the application package received August 18, 2011. However, additional information is required before the review may be completed. Please address the items on the following pages no later than the close of business on November 13, 2011.

Please be aware that you are responsible for meeting all requirements set forth in North Carolina rules and regulations. Any oversights that occurred in the review of the subject application package are still the Applicant's responsibility. In addition, any omissions made in responding to the outstanding items shall result in future requests for additional information.

Please reference the subject application number when providing the requested information. All revised and/or additional documentation shall be signed, sealed and dated, with **three copies** submitted to my attention at the address below. Please note that failure to provide this additional information on or before the above requested date may result in your application being returned as incomplete.

If you have any questions regarding this request, please do not hesitate to contact me at (919) 715-6160. Thank you for your cooperation.

Sincerely,

Nathaniel D. Thornburg
Environmental Engineer

cc: Matthew D. Fleahman, PG – Raleigh Regional Office, Aquifer Protection Section
Charles D. Riley, Jr., PE – McKim & Creed
Scott J. Frederick, LSS – Soil, Water & Environmental Group, PLLC
Edwin Andrews, PG, LSS – Edwin Andrews & Associates
Permit Application File WQ0023896

AQUIFER PROTECTION SECTION
1636 Mail Service Center, Raleigh, North Carolina 27699-1636
Location: 2728 Capital Boulevard, Raleigh, North Carolina 27604
Phone: 919-733-3221 \ FAX 1: 919-715-0588; FAX 2: 919-715-6048 \ Customer Service: 1-877-623-6748
Internet: www.ncwaterquality.org

Soil Evaluation:

1. Table 1 on Page IV states that the irrigation shall be seasonal, however, Application Item VII.7. states annual. Please amend for consistency.

2. Section 4.1 on Page 4 states that spray irrigation shall not occur within 25 feet of non-SA surface waters. Per 15A NCAC 02T .0506(a), this setback shall be 100 feet. Please amend.

3. Section 5.2 on Page 8 makes note of having a Sodium Adsorption Ratio (SAR) of less than 10. Please clarify whether or not excessive salts are anticipated to be in the effluent waste stream.

4. Page 10 of the soil evaluation recommends an annual loading rate of 8.2 in/yr, however, Application Item VII.7. states that the recommended annual loading rate is 10.28 in/yr. Please amend.

5. Per Application Instruction E and 15A NCAC 02T .0504(b)(4), provide a standard soil fertility analysis for both the Georgeville and Herndon soil series.

Agronomist Report:

1. Please note that the agronomic calculations have not been verified by the Division because the designed effluent concentrations in Application Item III.5. were not provided.

2. Pages 4 and 5 again make mention of the Sodium Adsorption Ratio (SAR), and recommends that the SAR be analyzed. Accordingly, please clarify whether or not high salt concentrations will be present in the effluent.

Water Balance:

1. The submitted water balance was truncated during printing/copying. Accordingly, the Division is unable to determine the temperature and precipitation data used, and therefore the water balance calculations have not been verified. Please resubmit copies of the original water balance that include all of the required data.

2. Please provide the top of berm surface areas for both of the wet weather storage basins.

3. Page 2-7 of Ed Andrew's report indicates that runoff was used in the truncated water balance. Please note that the Division respectfully disagrees with the proposed method of determining runoff using a straight 20% runoff calculation, which is not representative of rainfall intensity or soil surface infiltration rates. Therefore, if the Applicant intends to use runoff in the water balance calculations, the following information will need to be submitted:

   a. The Division recommends the following equation to determine runoff:

   $$R = \frac{(P - 0.2S)^2}{P + 0.8S}$$, where R = runoff, P = precipitation and $$S = \left(\frac{1000}{CN}\right) - 10$$

   b. Daily precipitation data from a 30 year time span that is from the same source used in the 80th percentile data in the water balance.

Operation and Maintenance Plan:

1. Please note the final Operation and Maintenance Plans are not required to be submitted until the final Engineering Certification is provided to the Division.

   Per Application Instruction S and 15A NCAC 02T .0507, provide an Operation and Maintenance (O&M) Plan for the wastewater treatment and irrigation system. At a minimum, the O&M Plan shall include:

   a. Describe the operation of the system in sufficient detail to show what operations are necessary for the system to function and by whom the functions are to be conducted.

   b. Describe anticipated maintenance of the system.

   c. Include provisions for safety measures including restriction of access to the site and equipment.

   d. Include spill control provisions such as response to upsets and bypasses including control, containment and remediation, as well as contact information for plant personnel, emergency responders and regulatory agencies.

Residuals Management Plan:

1. Please note that per 15A NCAC 02T .0504(j), the Applicant shall obtain a written commitment from a permitted residuals disposal/utilization program and provide it to the Division prior to operation of the permitted system.

General:

1. At the recommended annual loading rate of 8.2 in/yr, the proposed irrigation fields will be hydraulically loaded to the proposed permitted capacity, yet well below the assimilative capacity of the soils. The Division is concerned that this design will not allow for operational control of the system, which could present possible future non-compliance. The Division requests that the Applicant either reevaluate the annual loading rate capacity of the proposed irrigation area, or add additional acreage to allow for greater flexibility when operating the system.

   Please note that the recommended annual loading rate of 8.2 in/yr for Georgeville and Herndon soils is far lower than typical recommendations for these soils. In addition, the submitted water balance uses a K_{SAT} reduction factor of 4%. Since the K_{SAT} reduction factor may be in the range of 4 to 10%, it has been the Division's experience that for well drained soils, such as Georgeville and Herndon, a higher reduction factor is acceptable. Accordingly, the Division recommends that the Applicant consider these facts if reevaluating their water balance.

State of North Carolina
Department of Environment and Natural Resources
Division of Water Quality

WASTEWATER IRRIGATION SYSTEMS APPLICATION
INSTRUCTIONS FOR FORM: WWIS 12-06

The Division of Water Quality (Division) will not accept this application package unless all the instructions are followed. Plans, specifications and supporting documents shall be prepared in accordance with 15A NCAC 02T .0100, 15A NCAC 02T .0500 and good engineering practices. Failure to submit all of the required items will lead to additional processing and review time for the permit application.

For more information, links to forms requested in this application, or for an electronic version of this form, visit the Land Application Unit (LAU) web site at: http://portal.ncdenr.org/web/wq/aps/lau

A. **Application Form** (All Application Packages):
- ✓ Submit one (1) original and three (3) copies of the completed and appropriately executed application form. The instructions (Pages 1 through 4) need not be submitted. Any content changes made to this form will result in the application package being returned. The Division will only accept application packages that have been fully completed with all applicable items addressed.
- ✓ If the Applicant is a corporation or company, it must be registered for business with the NC Secretary of State (http://www.secretary.state.nc.us/Corporations/CSearch.aspx).
- ✓ If the Applicant is a partnership, sole proprietorship, trade name, or d/b/a, enclose a copy of the certificate filed with the Register of Deeds in the county of business.
- ✓ The application must be signed appropriately in accordance with 15A NCAC 02T .0106(b). An alternate person may be designated as the signing official, provided that a delegation letter is provided from a person who meets the referenced criteria.
- ✓ The facility name on all forms should be consistent with the facility name on the plans, specifications, agreements, etc.
- ✓ If this project involves a modification of an existing irrigation system, submit four (4) copies of the most recently issued existing permit.
- ✓ If this project is for a renewal without modification, please use the most recent FORM: NDWWSR, which can be downloaded at: http://portal.ncdenr.org/web/wq/aps/lau/applications#Irrigation.

B. **Attachment** (All New or Major Modification Application Packages):
- ✓ Submit a completed and properly executed Watershed Classification Attachment (FORM: WSCA), along with the 8.5" by 11" topographic map locating the facility, for each watershed within the facility location (including irrigation areas). The most recent version of FORM: WSCA may be found at: http://portal.ncdenr.org/web/wq/aps/lau/applications#Agreements.

C. **Application Fee** (All New or Major Modification Application Packages):
- ✓ The appropriate application fee can be determined from the Division's fee schedule found at: http://portal.ncdenr.org/web/wq/aps/lau/fees.
- ✓ Submit a check or money order in the appropriate amount made payable to: North Carolina Department of Environment and Natural Resources (NCDENR).

D. **Cover Letter** (All Application Packages):
- ✓ Submit one (1) original and three (3) copies of a cover letter, which lists all items and attachments included in the application package as well as a brief description of the requested permitting action.
- ✓ If necessary for clarity, include attachments to the application. Such attachments will be considered part of the application package and should be numbered to correspond to the section to which they refer.

E. **Property Ownership Documentation** (All New or Modification Application Packages involving new and/or relocated treatment or irrigation components):
- ✓ Provide either:
  - ✓ Legal documentation of the ownership (such as a contract, deed, article of incorporation, etc.) of the property, or
  - ✓ Written notarized agreement signed by both parties indicating future purchase of the property by the permit applicant and a plat or survey map showing the property, or
  - ✓ Written notarized long term lease agreement signed by both parties and specifically indicating intended use of the property and a plat or survey map showing the property addressed in the lease.

F. **Environmental Assessments** (May be required if public lands and/or monies are used – See 15A NCAC 1C .0100 to .0400):
- ✓ Submit one (1) copy of the Findings of No Significant Impact (FONSI) or Environmental Impact Statement (EIS).
- ✓ Include information on any mitigating factor(s) from the Environmental Assessment (EA) that impact the design and/or construction of the wastewater treatment and disposal system.

G. **Certificates of Public Convenience and Necessity** (All New Application Packages if the applicant is a Privately-Owned Public Utility per determination by the NC Utilities Commission: http://www.ncuc.commerce.state.nc.us/):
- ✓ Submit four (4) copies of the Certificate of Public Convenience and Necessity, which demonstrates that the public utility is authorized to hold the utility franchise for the area to be served by the wastewater system.
- ✓ If a Certificate of Public Convenience and Necessity has not been issued, provide four (4) copies of a letter from the NC Utilities Commission's Public Staff that states that an application for a franchise has been received, that the service area is contiguous to an existing franchised area, and/or that franchise approval is expected.

H. **Operational Agreements** (All New Application Packages if the applicant is a Homeowners' Association, or a Developer and lots are to be sold):
- ✓ Submit one (1) original and three (3) copies of a properly executed operational agreement if the irrigation system will be serving, or currently serves, residential or commercial lots that are to be sold. Appropriate forms can be downloaded at: http://portal.ncdenr.org/web/wq/aps/lau/applications#Agreements.
- ✓ If applicant is a HOMEOWNERS' ASSOCIATION, use the most recent version of FORM: HOA, and submit the following information: articles of incorporation, bylaws, and current or proposed annual budget.
- ✓ If applicant is a DEVELOPER that intends to turn ownership and responsibility of the wastewater system over to a homeowners' association, submit the most recent version of FORM: DEV.

I. **Analysis of Wastewater** (All New Application Packages or Modifications that are not 100% Domestic Waste):
- ✓ Submit four (4) copies of a complete chemical analysis of the effluent wastewater including but not limited to the following parameters: Total Organic Carbon, 5-day Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Nitrate Nitrogen (NO_3-N), Ammonia Nitrogen (NH_3-N), Total Kjeldahl Nitrogen (TKN), pH, Chloride, Total Phosphorus, Phenol, Total Volatile Organic Compounds, Fecal Coliform, Calcium, Sodium, Magnesium, Sodium Adsorption Ratio (SAR), Total Trihalomethanes, Toxicity Test Parameters and Total Dissolved Solids in compliance with 15A NCAC 02T.0504(h).
- ✓ A laboratory certified by the Division shall perform all testing.

J. **Soil Evaluation** (All New Application Packages or Modifications that include new irrigation sites):
- ✓ Submit four (4) copies of a detailed soil evaluation in accordance with 15A NCAC 02T .0504(b) and current Division Policy available at: http://portal.ncdenr.org/web/wq/aps/lau/policies.

K. **Water Balance** (All New Application Packages or Modifications that include new irrigation sites):
- ✓ Submit four (4) copies of a completed and accurate water balance in accordance with 15A NCAC 02T .0504(k) and current Division Policy available at: http://portal.ncdenr.org/web/wq/aps/lau/policies.

Agronomist Evaluation (All New Application Packages or Modifications that include new irrigation sites or new cropping patterns for existing irrigation sites):
- ✓ Submit four (4) copies of a detailed agronomist evaluation in accordance with 15A NCAC 02T .0504(i).

M. **Hydrogeologic Report** (All facilities treating industrial waste, and New Application Packages with Design Flows over 25,000 GPD or Modifications involving increasing the total design flow to over 25,000 GPD):
- ✓ Submit four (4) copies of a detailed hydrogeologic evaluation in accordance with 15A NCAC 02T .0504(e) and current Division Policy available at: http://portal.ncdenr.org/web/wq/aps/lau/policies.

N. **Detailed Plans** (All New or Modification Application Packages):
- ✓ Submit four (4) sets of standard size plans and two (2) sets of 11" by 17" plans (electronic format is acceptable - Adobe PDF only) that have been signed, sealed, and dated by a NC licensed Professional Engineer in accordance with 15A NCAC 02T .0504(c) and (d). For Modifications, submit plans specific to the modification(s) only.
- ✓ Plans must include the following minimum items:
  - ✓ A general location map, a vicinity map and a topographic map.
  - ✓ Plan and profile views of all treatment/storage/disposal units, piping, valves, and equipment (i.e., pumps, blowers, mixers, diffusers, flow meters, etc.) including dimensions and elevations of all treatment/storage/disposal units.
  - ✓ Hydraulic profile from the treatment plant headworks to the highest disposal point.
  - ✓ Highest drip/spray irrigation nozzle/emitter, locations within the irrigation system of air releases and system drains, locations within the irrigation system of all control valves, and other essential equipment.
  - ✓ For automated spray/drip irrigation systems, the design must include equipment to prevent spray/drip irrigation during precipitation events or when the soil is in a condition that the spray/drip irrigation wastewater could not be assimilated.
  - ✓ A map showing the entire irrigation area with an overlay of the suitable irrigation area depicted by the soil scientist's evaluation. The irrigation plans shall show each nozzle/emitter and wetted area (when applicable). Clearly label spray/drip irrigation zones as they will be operated.
  - ✓ Plans must depict a completed design and not be labeled with preliminary phrases (e.g., FOR REVIEW ONLY, NOT FOR CONSTRUCTION, etc.) that indicate that they are anything other than final plans. However, the plans may be labeled with the phrase: FINAL DESIGN - NOT RELEASED FOR CONSTRUCTION.

O. **Site Map** (All New or Modification Application Packages):
- ✓ Submit four (4) copies of a standard size site map and two (2) copies of an 11" by 17" site map (electronic format is acceptable - Adobe PDF only) that have been signed, sealed, and dated by a NC licensed Professional Engineer and/or Professional Land Surveyor in accordance with 15A NCAC 02T .0504(d). For Modifications, submit an updated site map specific to the modification(s) only.
- ✓ The site map shall include the following minimum items:
  - ✓ A scaled map of the site, with topographic contour intervals not exceeding 10 feet or 25 percent of total site relief and showing all facility-related structures and fences within the treatment, storage and disposal areas.
  - ✓ Soil mapping units shown on all disposal sites.
  - ✓ The location of all wells (including usage and construction details if available), streams (ephemeral, intermittent, and perennial), springs, lakes, ponds, and other surface drainage features within 500 feet of all waste treatment, storage, and disposal site(s).
  - ✓ Delineation of the review and compliance boundaries.
  - ✓ Setbacks as required by 15A NCAC 02T .0506.
  - ✓ Site property boundaries within 500 feet of all waste treatment, storage, and disposal site(s).
  - ✓ All habitable residences or places of public assembly within 500 feet of all waste treatment, storage, and disposal site(s).

P. **Specifications** (All New or Modification Application Packages):
- ✓ Submit four (4) sets of specifications that have been signed, sealed, and dated by a NC licensed Professional Engineer in accordance with 15A NCAC 02T .0504(c). For Modifications, submit specifications specific to the modification(s) only.
- ✓ Specifications must include the following minimum items:
  - ✓ Detailed specifications for each treatment/storage/disposal unit, piping, valves, equipment (i.e., pumps, blowers, mixers, diffusers, flow meters, etc.), nozzles/emitters (if applicable), precipitation/soil moisture sensor (if applicable), audible/visual high water alarms, etc.
  - ✓ Site Work (i.e., earthwork, clearing and grubbing, excavation and backfill, fencing, seeding, etc.)
  - ✓ Materials (i.e., concrete, masonry, steel, method of construction, etc.)
  - ✓ Mechanical and Electrical (i.e., control panels, transfer switches, generator, etc.)
  - ✓ Means for ensuring quality and integrity of the finished product including leakage and pressure testing.
  - ✓ Specifications must represent a completed design and not be labeled with preliminary phrases (e.g., FOR REVIEW ONLY, NOT FOR CONSTRUCTION, etc.) that indicate that they are anything other than final specifications. However, the specifications may be labeled with the phrase: FINAL DESIGN - NOT RELEASED FOR CONSTRUCTION.

Q. **Engineering Calculations** (All New or Modification Application Packages):
- ✓ Submit four (4) copies of all design calculations that have been signed, sealed, and dated by a NC licensed Professional Engineer in accordance with 15A NCAC 02T .0504(c). For Modifications, submit calculations specific to the modification(s) only.
- ✓ Calculations must include the following minimum items:
  - ✓ Hydraulic and pollutant loading calculations for each treatment unit (Note: "black box" calculations are unacceptable).
  - ✓ Sizing criteria for each treatment unit and associated equipment.
  - ✓ Friction/total dynamic head calculations and system curve analysis for each pump used.
  - ✓ Pump selection information including pump curves.
  - ✓ Manufacturer's information for all packaged treatment units, pumps, blowers, mixers, diffusers, flow meters, etc.
  - ✓ Flotation calculations for all tanks constructed partially or entirely below grade.
  - ✓ Submit the selected drip/spray irrigation system information including manufacturer's information and recommended installation guidelines.
  - ✓ Irrigation pump capacity should consider reasonable operational control, address multiple zones of the irrigation system, address variability of nozzle sizing as necessary, and include the ability to irrigate all areas in an appropriate amount of time.

R. **Reliability** (All New or Major Modification Application Packages):
- ✓ Submit documentation of system reliability in accordance with 15A NCAC 02T .0505(l).
- ✓ Ensure that the plans and specifications detail the generator, the automatic transfer switch, and how these items interact with the system instrumentation/controls.
- ✓ All generators must be capable of powering all essential treatment units.

S. **Operation and Maintenance Plan** (All New or Major Modification Application Packages):
- ✓ Submit four (4) copies of an operation and maintenance plan in accordance with 15A NCAC 02T .0507 that shall be maintained for all systems and include at a minimum:
  - ✓ Description of the operation of the system in sufficient detail to show what operations are necessary for the system to function and by whom the functions are to be conducted.
  - ✓ Description of anticipated maintenance.
  - ✓ Include safety measures including restriction of access to the site and equipment.
  - ✓ Spill prevention provisions such as response to upsets and bypasses including how to control, contain and remediate.
  - ✓ Contact information for plant personnel, emergency responders and regulatory agencies.

T. **Residuals Management Plan** (All New or Modification Application Packages that include new treatment systems or an expansion of the treatment system):
- ✓ Submit a detailed explanation describing how the residuals (including trash, sediment and grit) that are generated by the wastewater treatment system will be stored, treated, and disposed, in accordance with 15A NCAC 02T .0504(j) and 15A NCAC 02T .0508.
- ✓ An evaluation of the residuals storage requirements for the treatment facility based upon the maximum anticipated residuals production rate and ability to remove residuals.
- ✓ A permit for residuals utilization or a written commitment to the Permittee of a Department approved residuals disposal/utilization program accepting the residuals which demonstrates that the approved program has adequate capacity to accept the residuals, or that an application for approval has been submitted
- ✓ If oil or grease removal and collection is a designed unit process, please submit an oil/grease disposal plan.
- ✓ If an on-site restaurant or other business with food preparation is contributing waste to this system an oil/grease disposal plan will be necessary. Please note that operation and maintenance of all grease traps will be the responsibility of the permittee.

U. **General** (All New or Modification Application Packages):
- ✓ Please ensure that any systems within the Coastal Area as defined in 15A NCAC 2H .0400 meet all requirements required by that Section.
- ✓ Note that all designs and documentation must conform to all state and federal rules and regulations.
- ✓ Note that if other approvals are necessary for the construction of these facilities (i.e. Wetlands, Stormwater, Dam Safety, etc) the Division may hold approval of this application package to coordinate with other approvals.
- ✓ Provide documentation of floodway compliance in accordance with 15A NCAC 02T .0105(c)(8)
- ✓ Sewers tributary to the subject facilities must be applied for separately from this application in accordance with the Surface Water Protection Section's requirements (http://portal.ncdenr.org/web/wq/swp/ps/cs).

THE COMPLETED APPLICATION PACKAGE, INCLUDING ALL SUPPORTING INFORMATION AND MATERIALS, SHOULD BE SENT TO THE FOLLOWING ADDRESS:

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WATER QUALITY
AQUIFER PROTECTION SECTION
LAND APPLICATION UNIT

By U.S. Postal Service:
1636 MAIL SERVICE CENTER
RALEIGH, NORTH CAROLINA 27699-1636

TELEPHONE NUMBER: (919) 733-3221

By Courier/Special Delivery:
2728 CAPITAL BOULEVARD
RALEIGH, NORTH CAROLINA 27604

FAX NUMBER: (919) 715-6048

(THIS FORM MAY BE PHOTOCOPIED FOR USE AS AN ORIGINAL)

Application Number: _____ (to be completed by DWQ)

I. GENERAL INFORMATION:

1. Applicant's name (**See Instruction A**): The University of North Carolina at Chapel Hill

   Applicant type: ☐ Individual ☐ Corporation ☐ General Partnership ☐ Privately Owned Public Utility
   ☐ Federal ☒ State ☐ Municipal ☐ County

   Signature authority's name: Richard L. Mann (per 15A NCAC 02T .0106)Title: Vice Chancellor Finance & Administration

   Applicant's mailing address: The University of North Carolina at Chapel Hill, CB#1000, 302A South Building

   City: Chapel Hill State: NC Zip: 27599-1000

   Telephone number: (919) 962-3795 Fax number: (919) 962-0647 Email Address: rlmann@unc.edu

2. Facility name (name of the subdivision, shopping center, etc.): UNC-CH Bingham Facility

   Facility's physical address: 1907 Orange Chapel Clover Garden Road

   City: Chapel Hill State: NC Zip: 27516-____ County: Orange

   Wastewater Treatment Facility: Latitude: 35° 54′ 09″ Longitude: -79° 14′ 18″ USGS Map Name: White Cross

3. Consulting Engineer's name: Charles D. Riley, Jr. License Number: 013260 Firm: McKim & Creed

   Engineer's mailing address: McKim & Creed, Venture IV Building, Suite 500, 1730 Varsity Drive

   City: Raleigh State: NC Zip: 27606-____

   Telephone number: (919) 233-8091 Fax number: (919) 233-8031 Email Address: criley@mckimcreed.com

4. Consulting Soil Scientist's name: Scott J. Frederick License Number: 1236 Firm: Soil, Water, & Environment Group, PLLC

   Soil Scientist's mailing address: 3216 Byers Drive, Suite B

   City: Raleigh State: NC Zip: 27607-____

   Telephone number: (919) 831-1234 Fax number: (919) 899-9100 Email Address: sjfrederick@swegrp.com

5. Consulting Geologist's name: Edwin Andrews License Number: G-224 Firm: Edwin Andrews & Associates

   Geologist's mailing address: PO Box 30653

   City: Raleigh State: NC Zip: 27622-____

   Telephone number: (919) 851-7844 Fax number: (919) 851-6058 Email Address: andwater@aol.com

6. Consulting Agronomist's name: Scott J. Frederick Firm: Soil, Water, & Environment Group, PLLC

   Agronomist's mailing address: 3216 Byers Drive, Suite B

   City: Raleigh State: NC Zip: 27606-3601

   Telephone number: (919) 831-1234 Fax number: (919) 899-9100 Email Address: sjfrederick@swegrp.com

II. PERMIT INFORMATION:

1. Project is: ☐ New ☒ Major Modification ☐ Minor Modification

2. Fee submitted: $245.00 **(See Instruction C)** → Existing Permit No.: WQ0023896, issue date: February 12, 2007

3. Facility status: ☒ Existing ☐ Proposed
   → Was this system approved for reclaimed disposal under 15A NCAC 2H .0219(k)? ☐ Yes or ☒ No

4. Does this project utilize: ☒ public funds and/or ☐ private funds; ☒ public lands and/or ☐ private lands

5. What is the status of the following appropriate permits/certifications?

Permit/Certification	Submitted	Approved	Permit/Certification No.	Agency Reviewer
Erosion & Sedimentation Control Plan	6-2-11	6-17-11	ORANG-2011-010	DLQ
Nationwide 12 or 404	N/A	N/A	N/A	N/A
Wetlands 401	N/A	N/A	N/A	N/A
Stormwater Management Plan	3/25/11	9/19/11	SW5110901	DWQ
Dam Safety	N/A	N/A	N/A	N/A
Sewer System	N/A	N/A	N/A	N/A
Other:				

6. Does the project comply with all setbacks found in the river basin rules (15A NCAC 2B .0200)? ☒ Yes or ☐ No
   If no, list non-compliant setbacks: _____

7. Is the project in a Coastal Area as defined per 15A NCAC 2H .0403? ☐ Yes or ☒ No
   If yes, verify that the facility will comply with the following requirements in 15A NCAC 2H .404(g) as applicable:
   - ✓ Is aerated flow equalization of at least 25% average daily flow provided? ☐ Yes or ☐ No
   - ✓ How will noise and odor be controlled? _____
   - ✓ Are all essential treatment units provided in duplicate? ☐ Yes or ☐ No
   - ✓ Is there an impounded public surface water supply within 500 feet of the wetted area? ☐ Yes or ☐ No
   - ✓ Is there a public shallow ground water supply (less than 50 feet deep) within 500 feet of the facility? ☐ Yes or ☐ No
   - ✓ Is the disposal loading rate greater than 10 gallons per day per square foot (GPD/ft^2)? ☐ Yes or ☐ No
   - ✓ How much green area is provided? _____ square feet (ft^2)
   - ✓ Is the green area shown on the plans? ☐ Yes or ☐ No

III. INFORMATION ON WASTEWATER GENERATION:

1. What is the origin of the wastewater (i.e., school, subdivision, hospital, municipality, shopping center, industry, apartments, condominiums, etc.)? The UNC-CH Bingham Facility is an animal research facility that has historically housed canines for medical research as well as other animals that were occasionally held at the Bingham Facility for a limited time. As a result, the wastewater treated onsite was a combination of domestic wastewater from employees and animal wastewater. Currently, the Bingham Facility is being re-purposed as a dry-bedding animal holding facility and will initially house caged rodents. However, larger animals may also be housed at the facility under the condition that all liquid and solid waste will be captured via disposable dry bedding such that none of the animal waste will be discharged to the on-site sewer system. With the re-purposing of the facility as a dry bedding animal holding facility, the primary sources of wastewater generated at the facility will be from personnel working at the facility; therefore, the wastewater will be typical domestic strength wastewater. Wastewater sources include toilets, dishwasher, laundry washers, and showers. Other sources include wash water from an animal cage washer, holding room washdown water, wet lab sinks, spent brine from small softener systems, and small amounts of boiler blow-down water.
2. Volume of wastewater flow for this project: 3,556 gallons per day (GPD)
3. Explanation of how wastewater flow was determined (15A NCAC 02T .0114(c)): This is the permitted flow for the existing domestic wastewater treatment and disposal system.

Table 1 - Composite & Design Wastewater Characterization

Wastewater Source	Qty	Unit Flow (GPD)	Total Flow (GPD)	BOD (mg/l)	TSS (mg/l)	TKN (mg/l)	TP (mg/l)
People	15	35	525	250	180	40	7
Dishwasher	1	375	375	200	50	40	7
Laundry Washer	2	500	1000	200	50	40	7
Cage Washer	1	140	140	20	20	10	7
Wet Lab	2	200	400	200	50	40	7
Softener Brine	2	80	160	25	30	50	7
Boiler Blow-down	2	25	50	50	40	50	7
Calculated Composite			**2,650**	**187**	**73**	**39**	**7**
Design			**3,556**	**250**	**200**	**40**	**7**

BOD – Biochemical Oxygen Demand, TSS – Total Suspended Solids, TKN – Total Kjeldahl Nitrogen, TP – Total Phosphorus

4. Nature of wastewater: ☒ 100% Domestic Waste (residential, commercial, etc)
   - ☐ 100% Industrial
   - ☐ Combination of Industrial and Domestic Waste: _____% Domestic _____% Industrial
   - ☐ Municipal waste (town, city, etc.)
     - → Is there a Pretreatment Program in effect? ☐ Yes or ☐ No

5. **Wastewater characteristics (See 15A NCAC 02T .0505(b)):**

Parameter	Estimated Influent Concentration	Designed Effluent Concentration (monthly average)
Biochemical Oxygen Demand (BOD_5)	250 mg/l	10 mg/l
Total Suspended Solids (TSS)	200 mg/l	10mg/l
Ammonia Nitrogen (NH_3-N)	25 mg/l	15 mg/l
Nitrate Nitrogen (NO_3-N)	0 mg/l	10 mg/l
Nitrite Nitrogen (NO_2-N)	0 mg/l	0 mg/l
Total Nitrogen	40 mg/l	25 mg/l
Total Phosphorus	7 mg/l	5 mg/l
Total Kjeldhal Nitrogen (Org N + NH3)	40 mg/l	15 mg/l
Fecal Coliforms	< 14,000 col/100 ml	200 per 100 ml

GENERAL PROJECT INFORMATION:

1. Brief project description: The UNC Bingham Facility is an animal research facility that has historically housed canines for use in medical research as well as other large & small animals that were occasionally held at the Facility for a limited time. Currently, the Bingham Facility is being re-purposed as a dry-bedding animal holding facility and will initially house caged rodents. However, larger animals may also be housed at the facility under the condition that all liquid and solid waste will be captured via disposable dry bedding such that none of the animal waste will be discharged to the on-site sewer system. With the re-purposing of the facility as a dry bedding animal holding facility, the primary sources of wastewater generated at the re-purposed facility will be from personnel working at the facility. Other sources include wash water from a new animal cage washer, holding room washdown water, wet lab sinks, spent brine from small softener systems, and small amounts of boiler blow-down water.
2. This modification includes the following wastewater system improvements:
   a. Gravity sewer collection system improvements to deliver raw wastewater generated from all three existing buildings to the existing 8,000 gallon domestic wastewater septic tank. The effluent from the septic tank will be pumped via the existing pump station to the existing 3,556 GPD AdvanTex domestic wastewater treatment facility.
   b. Refurbish the existing AdvanTex domestic wastewater treatment facility to provide secondary treatment in accordance with 15A NCAC 02T .0500 rules and regulations for wastewater irrigation systems. The existing ultraviolet disinfection system will be removed and replaced with a chlorine contact tank and chlorine chemical feed system to meet disinfection requirements.
   c. A new secondary effluent pump station will be constructed to pump effluent from the treatment facility to the wet weather storage basin via the existing 3 inch PVC forcemain.
   d. The existing "animal" wastewater treatment system effluent upset storage basin, located adjacent to the AdvanTex facility, will be refurbished as an emergency 125,000 gallon effluent storage basin which can be used as supplemental wet weather storage. The effluent storage lagoon will be interconnected with the proposed secondary effluent pump station to pump effluent from the basin to the wet weather storage basin.

e. The existing 1.6 MG wet weather storage basin will be reconstructed to repair the structurally unstable earthen embankments and reconfigured for a wet weather storage capacity of 1.12 million gallons. The basin will be constructed with a cement stabilized compacted clay liner to replace the existing damaged synthetic liner.

f. The existing irrigation pump station will be refurbished with new irrigation pumps, piping, valves, and electrical equipment to pump to the new spray irrigation system.

g. Construct a new low-rate secondary effluent spray irrigation system consisting of four (4) separate spray irrigation zones with a total of approximately 5.72 acres of irrigation area. The spray irrigation system will be designed for dispersal of 3,556 GPD of secondary effluent.

3. In accordance with 15A NCAC 02T .0506, provide the minimum distance in feet from the facility's irrigation system and treatment/storage units to each parameter (distances greater than 500 feet may be marked N/A):

Setback Parameter	Irrigation System	Treatment/Storage Units
Any habitable residence or place of assembly under separate ownership or not to be maintained as part of the project site	406'	320'
Any habitable residence or place of assembly owned by the permittee to be maintained as part of the project site	201'	
Any private or public water supply source	250'	325'
Surface waters (streams – intermittent and perennial, perennial waterbodies, and wetlands)	100'	50'
Groundwater lowering ditches (where the bottom of the ditch intersects the SHWT)	N/A	
Subsurface groundwater lowering drainage systems	N/A	
Surface water diversions (ephemeral streams, waterways, ditches)	100'	
Any well with exception of monitoring wells	250'	325'
Any property line	150'	50'
Top of slope of embankments or cuts of two feet or more in vertical height	N/A	
Any water line from a disposal system	160'	
Any swimming pool	N/A	
Public right of way	150'	
Nitrification field	N/A	
Any building foundation or basement	120'	
Impounded public water supplies	N/A	
Public shallow groundwater supply (less than 50 feet deep)	N/A	

✓ Does the Applicant intend on complying with 15A NCAC 02T .0506(c)? ☐ Yes or ☒ No

If yes, complete the following table:

Parameter	Estimated Influent Concentration	Designed Effluent Concentration (monthly average)	Designed Effluent Concentration (daily maximum)
Biochemical Oxygen Demand (BOD_5)	mg/l	mg/l	mg/l
Total Suspended Solids (TSS)	mg/l	mg/l	mg/l
Ammonia Nitrogen (NH_3-N)	mg/l	mg/l	mg/l
Nitrate Nitrogen (NO_3-N)	mg/l	mg/l	
Fecal Coliforms		per 100 ml	per 100 ml
Turbidity			NTUs

✓ If any setback is not met, how will the project provide equal or better protection of the Waters of the State with no increased potential for health concerns or nuisance conditions? _____

4. The treatment and disposal facilities must be secured to prevent unauthorized entry. Details and notations of restricted access measures shall be shown on submitted plans and specifications. Briefly describe the measures being taken in accordance with 15A NCAC 02T .0505(q): The system is secured by perimeter fencing with locked access gate.
5. What is the 100-year flood elevation? N/A. Source

✓ Are any treatment units or wetted areas located within the 100-year flood plain? ☐ Yes or ☒ No

If yes, briefly describe which treatment units and/or irrigation areas are affected: _____, and the measures being taken to protect them against flooding: _____

If yes, does the Applicant have documentation of compliance with §143 Article 21 Part 6? ☐ Yes or ☐ No

6. Method to provide system reliability per 15A NCAC 02T .0505(l) (**See Instruction R**): The existing treatment system's standby power generator and automatic transfer switch is adequate to provide emergency power to the wastewater treatment and disposal system.
7. What is the specified method of disinfection? Chlorination using liquid sodium hypochlorite

✓ If chlorine, specify detention time provided: 50 minutes (30 minutes minimum required). Please indicate in what part of the wastewater system chlorine contact time occurs (i.e. chlorine contact chamber): Chlorine Contact Chamber

✓ If ultraviolet (UV), specify the number of banks: _____, total lamps: _____ and maximum capacity: _____ gpm.

8. How many days of residuals storage are provided (15A NCAC 02T .0505(o))? No residuals storage is required for the proposed AdvanTex system. The septic tank will require pumping every 3 to 5 years to remove solids.

V. DESIGN INFORMATION FOR NEW OR MODIFIED PORTIONS OF THE WASTEWATER TREATMENT FACILITY

1. Type of treatment system (fixed film, suspended growth, etc): Refurbish existing *AdvanTex* filter system.
2. Provide the number and dimensions of each treatment unit, and provide their location in the specifications and plans. If an item is not applicable, do not fill in the requested information:

   a. PRELIMINARY TREATMENT (i.e., physical operations such as large solids screening and equalization to remove problem characteristics such as abrasive grit and clogging rags, as well as to dampen high flows):

Treatment Unit	Number of Units	Manufacturer or Material	Dimensions (ft) / Spacings (in)	Volume (gallons)	Plan Sheet Number	Specification Page Number
Select						
Select						
Select						
Select						

   b. PRIMARY TREATMENT (i.e., physical operations such as fine screening and sedimentation to remove floating and settable solids):

Treatment Unit	Number of Units	Manufacturer or Material	Dimensions (ft) / Spacings (mm)	Volume (gallons)	Plan Sheet Number	Specification Page Number
Existing Primary Settling Chamber (Septic Tank)	one	Existing-Unknown	10' x 20'	8,000	C04,C09	11100
Septic Tank Effluent Lift Station	one	Existing Unknown	6' ID x 10'deep	2,100	CO4, CO9	11100

   c. SECONDARY / TERTIARY TREATMENT (i.e., biological and chemical processes to remove organics and nutrients)

Treatment Unit	Number of Units	Manufacturer or Material	Dimensions (ft)	Volume (gallons)	Plan Sheet Number	Specification Page Number
Textile Fabric Packed Bed Filter	two	Orenco AdvanTex	7' x 15'x 4' deep	3,150 ea	CO4,CO9	11100
Packed Bed Recirculation Blend Pump Station	one	Orenco AdvanTex	7' x 12' x 6' deep	4,000	CO4,CO9	11100
Select						
Select						
Select						
Select						
Select						
Select						

d. DISINFECTION

Treatment Unit	Number of Units	Manufacturer or Material	Dimensions (ft)	Volume (gallons)	Plan Sheet Number	Specification Page Number
Chlorine Contact Tank	1	Pre-Cast Concrete Tank w/ Baffle Walls	6' x 4' x 4'	525 gallons	M01	03420
Double Wall Containment Chemical Storage Tank	1	High Density Crosslinked Polyethylene	3' φ x 2.5' Overall Height	55 gallons	M01	11232
Select						

e. RESIDUAL TREATMENT

Treatment Unit	Number of Units	Manufacturer or Material	Dimensions (ft)	Volume (gallons)	Plan Sheet Number	Specification Page Number
Select						
Select						
Select						

f. PUMPS

Location	Number of Pumps	Purpose	Manufacturer / Type	Capacity		Plan Sheet Number	Spec. Page Number
				GPM	TDH		
Chemical Feed Area	2	Sodium Hypochlorite Chemical Metering Pumps	Positive Displacement Peristaltic	7.1 GPH	100 psi	M01	11232
Effluent Pump Station	2	Effluent Transfer from Treatment Area to Wet Weather Storage Basin	Non-Clog Submersible Wastewater Pumps	80 GPM	52 ft. TDH	M02	11310
Spray Irrigation Pump Station	2	Spray Irrigation System Pumps	Submersible Well Pumps	Zone 1: 155 GPM Zone 2: 158 GPM Zone 3: 155 GPM Zone 4: 108 GPM	104 ft. 104 ft. 104 ft. 104 ft.	M03	11315

g. BLOWERS

Location	No. of Blowers	Units Served	Manufacturer / Type	Capacity (CFM)	Plan Sheet Number	Specification Page Number

h. MIXERS

Location	No. of Mixers	Units Served	Manufacturer / Type	Power (hp)	Plan Sheet Number	Specification Page Number

i. RECORDING DEVICES & RELIABILITY

Device	Number of Units	Maximum Capacity	Manufacturer	Location	Plan Sheet Number	Specification Page Number
Existing Effluent Flow Meter (Parshall Flume)	one	6,000 gpd	Existing Unknown	Follows chlorine contact tank	C09	11100
Select						
Select						
Select						
Select						

VI. DESIGN INFORMATION FOR STORAGE IMPOUNDMENTS

1. Provide the number of earthen impoundments in the system: 2
2. Are any impoundments designed to receive adjacent surface runoff? ☐ Yes or ☒ No
   If Yes, please specify which impoundment: _____ and the drainage area: _____ ft^2.
3. Are impoundment(s) designed to include a discharge point (pipe, emergency spillway, etc)? ☐ Yes or ☒ No
4. Provide the design measures proposed for impoundment liner protection from wind driven wave action: Basins are proposed to be refurbished by removing existing plastic liners, reconstructing embankments, re-grading side slopes, and installing compacted cement stabilized clay liners. The cement stabilized soil layer consists of a ratio of 4% cement to soil and is placed over the compacted clay liner.
5. Provide the location of each design element in the specifications and engineering plans for each storage unit:

Storage Impoundment: Effluent Storage Lagoon				**Plan Sheet Number**	**Specification Page Number**
Liner material (15A NCAC 02T .0505(e) and (f))?	☐ Synthetic ☐ Concrete	☒ Clay ☐ Steel		C11	02210
Liner installation and testing requirements				C10, C11-	02210
Inside berm surface dimensions (L x W x H)	75 ft	X	29 ft	C10	-
Bottom dimensions (L x W)	48 ft	14 ft		C10	-
Embankment side slope	3 : 1			C11	-
Mean seasonal high water table depth *	> 6 ft. BLS			-	-
Finished grade elevation	485 ft			C10	-
Depth from bottom to top of embankment	9 ft			C10 & C11	-
Total volume	- ft^3	207,267 gallons		C10	ADV-1
Design freeboard	2 ft			C10 & C11	-
Depth of minimum liquid level (above permanent liquid level)	0 ft			C11	-
Effective volume provided **	- ft^3	125,724 gallons		C10	-
Effective storage time provided	35 days			C10	

* NOTE: The liner shall be protected from impacts of the seasonal high water table as necessary.

** NOTE: The storage volume should be calculated between the top of any permanent liquid level (as indicated by outlet pipe) and maximum allowable liquid level in the impoundment.

Storage Impoundment: Wet Weather Storage Basin				**Plan Sheet Number**	**Specification Page Number**
Liner material (15A NCAC 02T .0505(e) and (f))?	☐ Synthetic ☐ Concrete		☒ Clay ☐ Steel	C12	02210
Liner installation and testing requirements				C12	02210
Inside berm surface dimensions (L x W x H)	110 ft	X	41 ft	C12	-
Bottom dimensions (L x W)	90 ft		90 ft	C12	-
Embankment side slope	3 : 1			C12	-
Mean seasonal high water table depth *	> 6 ft. BLS			-	-
Finished grade elevation	495 ft			C12	-
Depth from bottom to top of embankment	12.5 ft			C12	-
Total volume	- ft^3		1,471,050 gallons	C12	ADV-1
Design freeboard	2 ft			C12	-
Depth of minimum liquid level (above permanent liquid level)	0 ft			C12	-
Effective volume provided **	- ft^3		1,122,440 gallons	C12	-
Effective storage time provided	315 days			C12	

* NOTE: The liner shall be protected from impacts of the seasonal high water table as necessary.

** NOTE: The storage volume should be calculated between the top of any permanent liquid level (as indicated by outlet pipe) and maximum allowable liquid level in the impoundment.

VII. DESIGN INFORMATION FOR IRRIGATION SYSTEM

1. The irrigation system is: ☒ Spray ☐ Drip
2. Disposal system is: ☐ existing ☒ proposed.
3. If applicable, provide the location of each design element in the specifications and engineering plans:

Irrigation Pump Tank				**Plan Sheet Number**	**Specification Page Number**
Internal dimensions (L x W x H or φ x H)	-	4 ft φ	16.5 ft	M03	-
Total volume	200 ft^3		1,495 gallons	C12 & M03	-
Dosing volume	ft^3		gallons		
Audible & visual alarms	Pump Failure Alarm			E04 & E07	11950
Equipment to prevent irrigation during rain events	Rain Sensor Cutout			E04 & E07	11950

4. List any equipment (note sheet number of the plans or page number in the specifications) not specifically mentioned above (pump hoist, odor control equipment, etc.):
   - Intake Screen w/ Air Backpulse – Drawing C12, Specification Section 11335
   - Irrigation Controller – Drawing E04 & E07, Specification Section 11950
   - Zone Control Valves – Drawing C13, Specification Section 11950
   - Impact Spray Heads - Drawing C13, Specification Section 11950
5. Minimum depth to mean seasonal high water table within irrigation field(s) per Soil Scientist's Evaluation: ≥ 6 feet below ground surface. Must be at least one-foot vertical separation between SHWT and ground surface per 15A NCAC 02T .0505(p).
6. Are there any artificial drainage or water movement structures within 200 feet of any irrigation area? ☐ Yes or ☒ No
   If Yes, please explain if the soil scientist report addresses artificial structures and please indicate if structures are to be maintained or modified: _____
7. Loading rates recommended by the Soil Scientist Evaluation:

Soil Series	**Fields within Soil Area**	**Recommended Loading Rate (in/hr)**	**Recommended Loading Rate (in/yr)**	**Loading Recommended**	**If Seasonal, list appropriate months**
SA1 - Georgeville	1, 2, 3, 4	0.1 in per dose; 0.21 inch / week avg.;	10.92	☒ Annual ☐ Seasonal	
SA2 - Herndon	1, 2, 3, 4	0.1 in. / dose; 0.21 in. / week avg.	10.92	☒ Annual ☐ Seasonal	
				☐ Annual ☐ Seasonal	
				☐ Annual ☐ Seasonal	
				☐ Annual ☐ Seasonal	

8. Design loading rates are equal or less than the loading rates recommended by Soil Scientist? ☒ Yes or ☐ No
   If No, explain why 15A NCAC 02T .0505(n) is not met: _____

9. Provide the following location information for the approximate center of each irrigation field / zone:

Field / Zone	**Latitude**			**Longitude**		
1	35 °	54 ′	16.29 ″ N	79 °	14 ′	30.52 ″ W
2	35 °	54 ′	15.46 ″ N	79 °	14 ′	26.15 ″ W
3	35 °	54 ′	13.83 ″ N	79 °	14 ′	26.79 ″ W
4	35 °	54 ′	12.03 ″ N	79 °	14 ′	28.71 ″ W
	°	′	″	- °	′	″
	°	′	″	- °	′	″
	°	′	″	- °	′	″
	°	′	″	- °	′	″
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	°	′	″	- °	′	″

- ✓ Level of accuracy? Seconds
- ✓ Method of measurement? MAP
- ✓ Datum? NAD 83

10. Irrigation Design (fill in the appropriate information for either a spray or drip irrigation system):

a. **Spray Irrigation:**

Field / Zone	Design Area (ft^2)	Number of Nozzles	Maximum Irrigation Precipitation Rate (in/hr)	Design Annual Loading Rate (in/yr)
1	66,647	43	0.22 in/hr at 0.1 inch dose	10.92
2	67,518	44	0.22 in/hr at 0.1 inch dose	10.92
3	67,518	43	0.22 in/hr at 0.1 inch dose	10.92
4	47,480	30	0.22 in/hr at 0.1 inch dose	10.92
Total	249,163	160		

Spray Irrigation Design Element		Plan Sheet Number	Specification Page Number
Wetted diameter of nozzles	80 ft	C13	11950
Wetted area of nozzles	5,027 ft^2	C13	-
Nozzle capacity	3.6 gpm	-	11950
Nozzle manufacturer / model	Rain Bird / 25BPJ-ADJ	-	-
Elevation of highest nozzle	518.75 ft	C13	-

b. **Drip Irrigation:**

Field / Zone	Design Area (ft^2)	Number of Emitters	Maximum Irrigation Precipitation Rate (in/hr)	Design Annual Loading Rate (in/yr)
Total				

Drip Irrigation Design Element		Plan Sheet Number	Specification Page Number
Wetted area of emitters	ft^2		
Distance between laterals	ft		
Distance between emitters	ft		
Emitter capacity	gpm		
Emitter manufacturer / model	/		
Elevation of highest emitter	ft		

11. Cover crop information:

Use the Nutrient Management in North Carolina's Realistic Yield Expectations webpage (http://www.soil.ncsu.edu/nmp/ncnmwg/yields/index.php#county) to determine the PAN (lbs/acre) and Phosphorus removal (lbs/acre) rates for each cover crop.

See Agronomist Report for more detailed discussion.

Cover Crop	Soil Series	% Slope	Nitrogen Removal Rate (lbs/acre)	Phosphorus Removal Rate (lbs/acre)
Fescue	SA1 - Georgeville	2-6%	136	51
Coastal Bermuda	SA1 - Georgeville	2-6%	159	46
Forest	SA1 - Georgeville	2-6%	150+	40+
Fescue	SA2 - Herndon	2-6%	174	63
Coastal Bermuda	SA2 - Herndon	2-6%	213	58
Forest	SA2 - Herndon	2-6%	150+	40+

✓ Proposed mineralization rate: 40% and volatilization rate: 50%

✓ Irrigation area based upon the nitrogen balance:

- SA1 Fescue – 70,595 ft^2
- SA1 Coastal Bermuda – 60,383 ft^2
- SA1 Forest – 64,006 ft^2
- SA2 Fescue – 29,581 ft^2
- SA2 Coastal Bermuda – 27,220 ft^2
- SA2 Forest – 38,653 ft^2

✓ Irrigation area based upon the phosphorus balance:

- SA1 Fescue – 37,650 ft^2
- SA1 Coastal Bermuda – 41,743 ft^2
- SA1 Forest – 48,004 ft^2
- SA2 Fescue – 24,158 ft^2
- SA2 Coastal Bermuda – 19,993 ft^2
- SA2 Forest – 28,990 ft^2

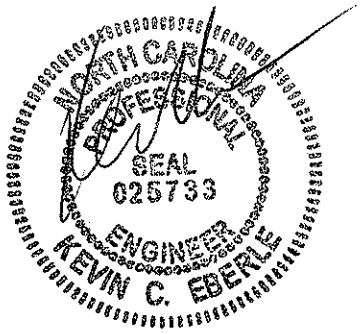
✓ Irrigation area based upon the water balance: 249,163 ft^2

✓ Site is: ☒ hydraulically limited ☐ nutrient limited

Professional Engineer's Certification:

I, Kevin C. Eberle, attest that this application for UNC-CH Bingham Facility Wastewater Improvements Wastewater Surface Irrigation Major Modification has been reviewed by me and is accurate, complete and consistent with the information supplied in the engineering plans, calculations, and all other supporting documentation to the best of my knowledge. I further attest that to the best of my knowledge the proposed design has been prepared in accordance with this application package and its instructions as well as all applicable regulations and statutes. Although other professionals may have developed certain portions of this submittal package, inclusion of these materials under my signature and seal signifies that I have reviewed this material and have judged it to be consistent with the proposed design. **Note:** In accordance with NC General Statutes 143-215.6A and 143-215.6B, any person who knowingly makes any false statement, representation, or certification in any application package shall be guilty of a Class 2 misdemeanor, which may include a fine not to exceed $10,000 as well as civil penalties up to $25,000 per violation.

North Carolina Professional Engineer's seal, signature, and date:



Applicant's Certification (signing authority must be in compliance with 15A NCAC 02T .0106(b)):

I, Richard L. Mann (Signing Authority Name) Vice Chancellor for Finance and Administration (Title)

attest that this application for Wastewater Infrastructure System Improvements for the UNC-CH Bingham Facility (Facility Name)

has been reviewed by me and is accurate and complete to the best of my knowledge. I understand that any discharge of wastewater from this non-discharge system to surface waters or the land will result in an immediate enforcement action that may include civil penalties, injunctive relief, and/or criminal prosecution. I will make no claim against the Division of Water Quality should a condition of this permit be violated. I also understand that if all required parts of this application package are not completed and that if all required supporting information and attachments are not included, this application package will be returned to me as incomplete. I further certify that the applicant or any affiliate has not been convicted of an environmental crime, has not abandoned a wastewater facility without proper closure, does not have an outstanding civil penalty where all appeals have been exhausted or abandoned, are compliant with any active compliance schedule, and do not have any overdue annual fees under Rule 2T .0105. **Note:** In accordance with NC General Statutes 143-215.6A and 143-215.6B, any person who knowingly makes any false statement, representation, or certification in any application package shall be guilty of a Class 2 misdemeanor, which may include a fine not to exceed $10,000 as well as civil penalties up to $25,000 per violation.

Signature: Kevin R Beaty for Richard L. Mann Vice Chancellor for Finance and Administration Date: 11/11/11

North Carolina Department of Environment and Natural Resources
Division of Water Quality

Beverly Eaves Perdue
Governor

Coleen H. Sullins
Director

Dee Freeman
Secretary

September 19, 2011

Sharon Myers,
Environmental and Stormwater Compliance Officer
1120 Estes Drive Extension CB #1650
Chapel Hill, North Carolina 27599-1650

Subject: Stormwater Permit No. SW5110901
The University of North Carolina at Chapel Hill, Bingham Facility
Low Density Stormwater Project
Orange County

Dear Mr. Myers:

The Stormwater Permitting Unit received a complete Stormwater Management Permit Application for The University of North Carolina at Chapel Hill, Bingham Facility on September 9, 2011. Staff review of the plans and specifications has determined that the project, as proposed, will comply with the Stormwater Regulations set forth in Title 15A NCAC 2H.1000 and Session Law 2006-246. We are forwarding Permit No. SW5110901, dated September 19, 2011, for the construction, operation and maintenance of the subject project.

This permit shall be effective from the date of issuance until rescinded and shall be subject to the conditions and limitations as specified therein, and does not supercede any other agency permit that may be required.

If any parts, requirements, or limitations contained in this permit are unacceptable, you have the right to request an adjudicatory hearing upon written request within thirty (30) days following receipt of this permit. This request must be in the form of a written petition, conforming to Chapter 150B of the North Carolina General Statutes, and filed with the Office of Administrative Hearings, P.O. Drawer 27447, Raleigh, NC 27611-7447. Unless such demands are made this permit shall be final and binding.

If you have any questions, or need additional information concerning this matter, please contact Mike Randall at (919) 807-6374, or mike.randall@ncdenr.gov.

Sincerely,

for Coleen H. Sullins

cc: Raleigh Regional Office
SPU Files

Wetlands and Stormwater Branch
1617 Mail Service Center, Raleigh, North Carolina 27699-1617
Location: 512 N. Salisbury St. Raleigh, North Carolina 27604
Phone: 919-807-6300 \ FAX: 919-807-6494 \ Customer Service: 1-877-623-6748
Internet: www.ncwaterquality.org

STATE OF NORTH CAROLINA

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

DIVISION OF WATER QUALITY

STATE STORMWATER MANAGEMENT PERMIT

LOW DENSITY DEVELOPMENT

In accordance with the provisions of Article 21 of Chapter 143, General Statutes of North Carolina as amended, and other applicable Laws, Rules and Regulations

PERMISSION IS HEREBY GRANTED TO

The University of North Carolina at Chapel Hill

Bingham Facility

Orange County

FOR THE

construction, operation and maintenance of a low density development in compliance with the provisions of 15A NCAC 2H .1000 and S.L. 2006-246 (hereafter referred to as the *"stormwater rules"*) and the approved stormwater management plans and specifications, and other supporting data as attached and on file with and approved by the Division of Water Quality and considered a part of this permit.

The Permit shall be effective from the date of issuance until rescinded and shall be subject to the following specific conditions and limitations:

I. DESIGN STANDARDS

1. This permit covers the construction of 154,696 square feet of built-upon area.

2. The overall tract built-upon area percentage for the project must be maintained below 24%, as required by Session Law 2006-246 of the stormwater rules.

3. Approved plans and specifications for projects covered by this permit are incorporated by reference and are enforceable parts of the permit.

4. The only runoff conveyance systems allowed will be vegetated conveyances such as swales with minimum side slopes of 3:1 (H:V) as defined in the stormwater rules and approved by the Division.

5. No piping is allowed except that minimum amount necessary to direct runoff beneath an impervious surface such as a road or to provide access.

6. All roof drains must terminate at least 30 foot from the mean high water mark.

7. The built-upon areas associated with this project shall be located at least 30 feet landward of all perennial and intermittent streams.

8. Level Spreaders are required at the end of any swale prior to discharging to a jurisdictional wetland or any surface water.

II. SCHEDULE OF COMPLIANCE

1. The permittee is responsible for verifying that the proposed built-upon area does not exceed the allowable built-upon area.

2. The Director may notify the permittee when the permitted site does not meet one or more of the minimum requirements of the permit. Within the time frame specified in the notice, the permittee shall submit a written time schedule to the Director for modifying the site to meet minimum requirements. The permittee shall provide copies of revised plans and certification in writing to the Director that the changes have been made.

3. This project may not be sold or subdivided in whole or in part without first receiving a permit modification from the Division.

4. The following deed restrictions must be recorded with the Office of the Register of Deeds:

    a. The following covenants are intended to ensure ongoing compliance with State Stormwater Management Permit Number SW5110901, as issued by the Division of Water Quality under the stormwater rules.
    b. The State of North Carolina is made a beneficiary of these covenants to the extent necessary to maintain compliance with the Stormwater Management Permit.
    c. These covenants are to run with the land and be binding on all persons and parties claiming under them.
    d. The covenants pertaining to stormwater may not be altered or rescinded without the express written consent of the State of North Carolina, Division of Water Quality.
    e. Alteration of the drainage as shown on the approved plans may not take place without the concurrence of the Division of Water Quality.
    f. This project is permitted for a maximum of 154,696 square feet of built-upon area. Construction of additional built-upon area in excess of this amount will require a permit modification.
    g. This project may not be sold or subdivided, in whole or in part, without first receiving a permit modification from the Division.
    h. Construction of additional impervious areas such that low-density requirements are no longer met will require a permit modification prior to construction. An engineered system will be required to collect and treat the runoff from all built-upon area associated with the project, including that area permitted under the low density option.
    i. Filling in or piping of any vegetative conveyances (ditches, swales, etc.) associated with this development, except for average driveway crossings, is strictly prohibited by any persons.
    j. The built-upon areas shall be located a minimum of 30 feet landward of all perennial and intermittent surface waters.

5. Filling in or piping of any vegetative conveyances (ditches, swales, etc.) associated with the permitted development, except for average driveway crossings, is strictly prohibited by any persons.

6. The permittee shall submit to the Director and shall have received approval for revised plans, specifications, and calculations prior to construction, for any modification to the approved plans, including, but not limited to, those listed below:

   a. Any revision to the approved plans, regardless of size.
   b. Project name change.
   c. Transfer of ownership.
   d. Redesign or addition to the approved amount of built-upon area.
   e. Further subdivision, acquisition, or sale of the project area in whole or in part. The project area is defined as all property owned by the permittee, for which Sedimentation and Erosion Control Plan approval was sought.
   f. Filling in, altering or piping any vegetative conveyance shown on the approved plan.

8. Swales and other vegetated conveyances shall be constructed in their entirety, vegetated, and be operational for their intended use prior to the construction of any built-upon surface.

9. During construction, erosion shall be kept to a minimum and any eroded areas of the swales or other vegetated conveyances will be repaired immediately.

10. The permittee shall at all times provide the operation and maintenance necessary to operate the permitted stormwater management systems at optimum efficiency to include:

    a. Inspections
    b. Sediment removal.
    c. Mowing, and re-vegetating of the side slopes.
    d. Immediate repair of eroded areas.
    e. Maintenance of side slopes in accordance with approved plans and specifications.

11. Within 30 days of completion of the project, the permittee shall certify in writing that the project has been constructed in accordance with the approved plans.

12. The permittee shall submit all information requested by the Director or his representative within the time frame specified in the written information request.

III. GENERAL CONDITIONS

1. This permit is not transferable to any person or entity except after notice to and approval by the Director. The Director may require modification or revocation and re-issuance of the permit to change the name and incorporate such other requirements as may be necessary. In the event of a name or ownership change, a completed Name/Ownership Change form, signed by both parties, must be submitted to the Division of Water Quality accompanied by the supporting documentation as listed on page 2 of the form. The approval of this request will be considered on its merits, and may or may not be approved.

2. The permittee is responsible for compliance with all permit conditions until the Director approves a transfer of ownership. Neither the sale of the project nor the transfer of common areas to a third party, such as a homeowner's association, constitutes an approved transfer of the stormwater permit.

3. Failure to abide by the conditions and limitations contained in this permit may subject the Permittee to an enforcement action by the Division of Water Quality, in accordance with North Carolina General Statutes 143-215.6A to 143-215.6C.

4. The issuance of this permit does not prohibit the Director from reopening and modifying the permit, revoking and reissuing the permit, or terminating the permit as allowed by the laws, rules, and regulations contained in Session Law 2006-246, Title 15A of the North Carolina Administrative Code, Subchapter 2H.1000; and North Carolina General Statute 143-215.1 et. al.

5. In the event that the facilities fail to perform satisfactorily, including the creation of nuisance conditions, the Permittee shall take immediate corrective action, including those as may be required by the Division, such as the construction of additional or replacement stormwater management systems.

6. The permittee grants permission to DENR Staff to enter the property during normal business hours, for the purpose of inspecting all components of the stormwater management facility.

7. The permit issued shall continue in force and effect until revoked or terminated. The permit may be modified, revoked and reissued or terminated for cause. The filing of a request for a permit modification, revocation and re-issuance, or termination does not stay any permit condition.

8. Unless specified elsewhere, permanent seeding requirements for the swales must follow the guidelines established in the North Carolina Erosion and Sediment Control Planning and Design Manual.

9. Approved plans and specifications for this project are incorporated by reference and are enforceable parts of the permit.

10. The issuance of this permit does not preclude the Permittee from complying with any and all statutes, rules, regulations, or ordinances, which may be imposed by other government agencies (local, state and federal), which have jurisdiction.

11. The permittee shall notify the Division in writing of any name, ownership or mailing address changes at least 30 days prior to making such changes.

Permit issued this the 19th day of September, 2011.

NORTH CAROLINA ENVIRONMENTAL MANAGEMENT COMMISSION

for Colleen H. Sullins, Director
Division of Water Quality
By Authority of the Environmental Management Commission

LOW DENSITY STORMWATER MANAGEMENT PERMIT APPLICATION AND SUPPORTING DOCUMENTATION

The University of North Carolina at Chapel Hill
Bingham Facility
Orange County, North Carolina
August 29, 2011

Prepared for:

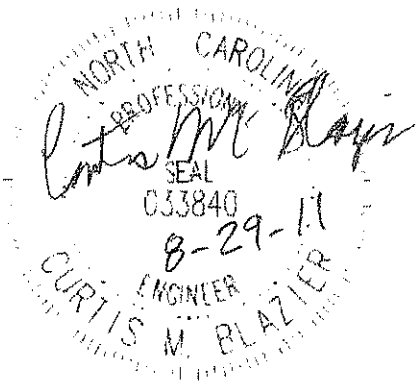
THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

The University of North Carolina at Chapel Hill
300 South Building
Chapel Hill, North Carolina 27599

Prepared By:

McKIM&CREED
1730 Varsity Drive, Suite 500
Raleigh, North Carolina 27606
Phone: (919) 233.8091
Fax: (919) 233.8031

M&C Project No. 01488-0032



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STORMWATER MANAGEMENT PERMIT APPLICATION

DWQ USE ONLY		
Date Received	Fee Paid	Permit Number

Applicable Rules: ☐ Coastal SW – 1995 ☐ Coastal SW – 2008 ☐ Ph II - Post Construction
(select all that apply) ☐ Non-Coastal SW- HQW/ORW Waters ☐ Universal Stormwater Management Plan
☐ Other WQ Mgmt Plan: _____

State of North Carolina
Department of Environment and Natural Resources
Division of Water Quality

STORMWATER MANAGEMENT PERMIT APPLICATION FORM

This form may be photocopied for use as an original

I. GENERAL INFORMATION

1. Project Name (subdivision, facility, or establishment name - should be consistent with project name on plans, specifications, letters, operation and maintenance agreements, etc.):

   The University of North Carolina at Chapel Hill, Bingham Facility

2. Location of Project (street address):

   1907 Orange Chapel Clover Garden Road

   City:Chapel Hill County:Orange Zip:27516-7317

3. Directions to project (from nearest major intersection):

   From the intersection of NC-54 and US 15/501 in Chapel Hill, NC, travel west 10 miles on NC-54. Turn left on Morrow Mill Road (SR 1958) and travel south for 1.3 miles. Bear left on Orange Chapel Clover Garden Road (SR 1956) and travel south for 1.4 miles. The Bingham Facility driveway is on left. The site is gated, and an access card is needed for entry.

4. Latitude:35° 54' 10" N Longitude:79° 14' 23" W of the main entrance to the project.

II. PERMIT INFORMATION:

1.a. Specify whether project is (check one): ☒New ☐Modification

b. If this application is being submitted as the result of a **modification** to an existing permit, list the existing permit number_____, its issue date (if known)_____, and the status of construction: ☐Not Started ☐Partially Completed* ☐ Completed* **provide a designer's certification*

2. Specify the type of project (check one):
   ☒Low Density ☐High Density ☐Drains to an Offsite Stormwater System ☐Other

3. If this application is being submitted as the result of a **previously returned application** or a **letter from DWQ requesting a state stormwater management permit application**, list the stormwater project number, if assigned, _____ and the previous name of the project, if different than currently proposed, _____.

4.a. Additional Project Requirements (check applicable blanks; information on required state permits can be obtained by contacting the Customer Service Center at 1-877-623-6748):

   ☐CAMA Major ☒Sedimentation/Erosion Control: 2.16 ac of Disturbed Area

   ☐NPDES Industrial Stormwater ☒404/401 Permit: Proposed Impacts 0.04 ac of 404 wetland, 3 LF of perennial stream

b. If any of these permits have already been acquired please provide the Project Name, Project/Permit Number, issue date and the type of each permit:SEC Permit No. Orang-2009-004 was issued for the site on January 28, 2009. 404 Permit (Nationwide Permit 39) was issued by the U.S. Army Corps of Engineers for the site on May

18, 2010. DWQ issued a 401 Water Quality Certification (Certification No. 3821) (DWQ Project No. 10-0451) for site on June 25, 2010.

III. CONTACT INFORMATION

1. a. Print Applicant / Signing Official's name and title (specifically the developer, property owner, lessee, designated government official, individual, etc. who owns the project):

Applicant/Organization: The University of North Carolina at Chapel Hill

Signing Official & Title: Richard L. Mann, Vice Chancellor for Finance and Administration

b. Contact information for person listed in item 1a above:

Street Address: 300 South Building

City: Chapel Hill State: NC Zip: 27599

Mailing Address (*if applicable*): Campus Box 1000

City: Chapel Hill State: NC Zip: 27599-1000

Phone: (919) 962-3795 Fax: (919) 962-0647

Email: rlmann@unc.edu

c. Please check the appropriate box. The applicant listed above is:

☒ The property owner (Skip to Contact Information, item 3a)
☐ Lessee* (Attach a copy of the lease agreement and complete Contact Information, item 2a and 2b below)
☐ Purchaser* (Attach a copy of the pending sales agreement and complete Contact Information, item 2a and 2b below)
☐ Developer* (Complete Contact Information, item 2a and 2b below.)

2. a. Print Property Owner's name and title below, if you are the lessee, purchaser or developer. (This is the person who owns the property that the project is located on):

Property Owner/Organization:

Signing Official & Title:

b. Contact information for person listed in item 2a above:

Street Address:

City: State: Zip:

Mailing Address (*if applicable*):

City: State: Zip:

Phone: ( ) Fax: ( )

Email:

3. a. (Optional) Print the name and title of another contact such as the project's construction supervisor or other person who can answer questions about the project:

Other Contact Person/Organization: The University of North Carolina at Chapel Hill

Signing Official & Title: Sharon Myers, Environmental and Stormwater Compliance Officer

b. Contact information for person listed in item 3a above:

Mailing Address: 1120 Estes Drive Extension, CB # 1650

City: Chapel Hill State: NC Zip: 27599-1650

Phone: (919) 962-9752 Fax: (919) 962-0227

Email: samyers@ehs.unc.edu

4. Local jurisdiction for building permits: NA - State Project, reviewed by State Construction Office

Point of Contact:_____ Phone #: (_____)_____

IV. PROJECT INFORMATION

1. In the space provided below, briefly summarize how the stormwater runoff will be treated.

   Low density utilizing existing and proposed grassed swales

2. a. **If claiming vested rights,** identify the supporting documents provided and the date they were approved:
   - ☐ Approval of a Site Specific Development Plan or PUD — Approval Date: _____
   - ☐ Valid Building Permit — Issued Date: _____
   - ☐ Other: _____ — Date: _____

   b. **If claiming vested rights,** identify the regulation(s) the project has been designed in accordance with:
   ☐ Coastal SW – 1995 ☐ Ph II – Post Construction

3. Stormwater runoff from this project drains to the Cape Fear River basin.

4. Total Property Area: 57.56 acres

5. Total Coastal Wetlands Area: n/a acres

6. Total Surface Water Area: 1.17 acres

7. Total Property Area (4) – Total Coastal Wetlands Area (5) – Total Surface Water Area (6) = Total Project Area+: 56.39 acres

   + *Total project area shall be calculated to exclude the following: the normal pool of impounded structures, the area between the banks of streams and rivers, the area below the Normal High Water (NHW) line or Mean High Water (MHW) line, and coastal wetlands landward from the NHW (or MHW) line. The resultant project area is used to calculate overall percent built upon area (BUA). Non-coastal wetlands landward of the NHW (or MHW) line may be included in the total project area.*

8. Project percent of impervious area: (Total Impervious Area / Total Project Area) X 100 = 6.29 %

9. How many drainage areas does the project have? 1 *(For high density, count 1 for each proposed engineered stormwater BMP. For low density and other projects, use 1 for the whole property area)*

10. Complete the following information for each drainage area identified in Project Information item 9. If there are more than four drainage areas in the project, attach an additional sheet with the information for each area provided in the same format as below.

Basin Information	Drainage Area 1	Drainage Area __	Drainage Area __	Drainage Area __
Receiving Stream Name	Collins Creek			
Stream Class *	WS-V; NSW			
Stream Index Number *	16-30-(0.5)			
Total Drainage Area (sf)	2,456,215			
On-site Drainage Area (sf)	2,456,215			
Off-site Drainage Area (sf)	0			
Proposed Impervious Area** (sf)	154,696			
% Impervious Area** (total)	6.29			

Impervious** Surface Area	Drainage Area 1	Drainage Area __	Drainage Area __	Drainage Area __
On-site Buildings/Lots (sf)				
On-site Streets (sf)	4,462			
On-site Parking (sf)				
On-site Sidewalks (sf)				
Other on-site (sf)	5,250			
Future (sf)				
Off-site (sf)				
Existing BUA*** (sf)	144,984			
Total (sf):	154,696			

* *Stream Class and Index Number can be determined at: http://portal.ncdenr.org/web/wq/ps/csu/classifications*

** *Impervious area is defined as the built upon area including, but not limited to, buildings, roads, parking areas, sidewalks, gravel areas, etc.*

*** *Report only that amount of existing BUA that will remain after development. Do not report any existing BUA that is to be removed and which will be replaced by new BUA.*

11. How was the off-site impervious area listed above determined? Provide documentation. NA

Projects in Union County: *Contact DWQ Central Office staff to check if the project is located within a Threatened & Endangered Species watershed that may be subject to more stringent stormwater requirements as per NCAC 02B .0600.*

V. SUPPLEMENT AND O&M FORMS

The applicable state stormwater management permit supplement and operation and maintenance (O&M) forms must be submitted for each BMP specified for this project. The latest versions of the forms can be downloaded from http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

VI. SUBMITTAL REQUIREMENTS

Only complete application packages will be accepted and reviewed by the Division of Water Quality (DWQ). A complete package includes all of the items listed below. A detailed application instruction sheet and BMP checklists are available from http://portal.ncdenr.org/web/wq/ws/su/statesw/forms_docs. The complete application package should be submitted to the appropriate DWQ Office. (The appropriate office may be found by locating project on the interactive online map at http://portal.ncdenr.org/web/wq/ws/su/maps.)

Please indicate that the following required information have been provided by initialing in the space provided for each item. All original documents MUST be signed and initialed in **blue ink. Download the latest versions for each submitted application package** from http://portal.ncdenr.org/web/wq/ws/su/statesw/forms_docs.

		Initials
1.	*Original and one copy* of the Stormwater Management Permit Application Form.	CMB
2.	*Original and one copy* of the signed and notarized Deed Restrictions & Protective Covenants Form. *(if required as per Part VII below)*	N/A
3.	*Original* of the applicable Supplement Form(s) (sealed, signed and dated) and O&M agreement(s) for each BMP.	N/A
4.	Permit application processing fee of $505 *payable to NCDENR.* (For an Express review, refer to http://www.envhelp.org/pages/onestopexpress.html for information on the Express program and the associated fees. Contact the appropriate regional office Express Permit Coordinator for additional information and to schedule the required application meeting.)	CMB
5.	A detailed narrative (one to two pages) describing the stormwater treatment/managementfor the project. This is required in addition to the brief summary provided in the Project Information, item 1.	CMB
6.	A USGS map identifying the site location. If the receiving stream is reported as class SA or the receiving stream drains to class SA waters within ½ mile of the site boundary, include the ½ mile radius on the map.	CMB
7.	Sealed, signed and dated calculations.	CMB
8.	Two sets of plans folded to 8.5" x 14" (sealed, signed, & dated), including:	CMB

   a. Development/Project name.
   b. Engineer and firm.
   c. Location map with named streets and NCSR numbers.
   d. Legend.
   e. North arrow.
   f. Scale.
   g. Revision number and dates.
   h. Identify all surface waters on the plans by delineating the normal pool elevation of impounded structures, the banks of streams and rivers, the MHW or NHW line of tidal waters, and any coastal wetlands landward of the MHW or NHW lines.
      - Delineate the vegetated buffer landward from the normal pool elevation of impounded structures, the banks of streams or rivers, and the MHW (or NHW) of tidal waters.
   i. Dimensioned property/project boundary with bearings & distances.
   j. Site Layout with all BUA identified and dimensioned.
   k. Existing contours, proposed contours, spot elevations, finished floor elevations.
   l. Details of roads, drainage features, collection systems, and stormwater control measures.

m. Wetlands delineated, or a note on the plans that none exist. (Must be delineated by a qualified person. Provide documentation of qualifications and identify the person who made the determination on the plans.
n. Existing drainage (including off-site), drainage easements, pipe sizes, runoff calculations.
o. Drainage areas delineated (included in the main set of plans, not as a separate document).
p. Vegetated buffers (where required).

9. Copy of any applicable soils report with the associated SHWT elevations (Please identify elevations in addition to depths) as well as a map of the boring locations with the existing elevations and boring logs. Include an 8.5"x11" copy of the NRCS County Soils map with the project area clearly delineated. For projects with infiltration BMPs, the report should also include the soil type, expected infiltration rate, and the method of determining the infiltration rate. **(Infiltration Devices submitted to WiRO:** *Schedule a site visit for DWQ to verify the SHWT prior to submittal, (910) 796-7378.)* N/A

10. A copy of the most current property deed. Deed book: 229 Page No: 379 CMB

11. For corporations and limited liability corporations (LLC): Provide documentation from the NC Secretary of State or other official documentation, which supports the titles and positions held by the persons listed in Contact Information, item 1a, 2a, and/or 3a per NCAC 2H.1003(e). The corporation or LLC must be listed as an active corporation in good standing with the NC Secretary of State, otherwise the application will be returned. http://www.secretary.state.nc.us/Corporations/CSearch.aspx N/A

VII. DEED RESTRICTIONS AND PROTECTIVE COVENANTS

For all subdivisions, outparcels, and future development, the appropriate property restrictions and protective covenants are required to be recorded prior to the sale of any lot. If lot sizes vary significantly or the proposed BUA allocations vary, a table listing each lot number, lot size, and the allowable built-upon area must be provided as an attachment to the completed and notarized deed restriction form. The appropriate deed restrictions and protective covenants forms can be downloaded from http://portal.ncdenr.org/web/wq/ws/su/statesw/forms_docs. Download the latest versions for each submittal.

In the instances where the applicant is different than the property owner, it is the responsibility of the property owner to sign the deed restrictions and protective covenants form while the applicant is responsible for ensuring that the deed restrictions are recorded.

By the notarized signature(s) below, the permit holder(s) certify that the recorded property restrictions and protective covenants for this project, if required, shall include all the items required in the permit and listed on the forms available on the website, that the covenants will be binding on all parties and persons claiming under them, that they will run with the land, that the required covenants cannot be changed or deleted without concurrence from the NC DWQ, and that they will be recorded prior to the sale of any lot.

VIII. CONSULTANT INFORMATION AND AUTHORIZATION

Applicant: Complete this section if you wish to designate authority to another individual and/or firm (such as a consulting engineer and/or firm) so that they may provide information on your behalf for this project (such as addressing requests for additional information).

Consulting Engineer: Curt Blazier, PE, LEED AP

Consulting Firm: McKim & Creed, PA

Mailing Address: 1730 Varsity Drive, Suite 500

City: Raleigh State: NC Zip: 27606

Phone: (919) 233-8091 Fax: (919) 233-8031

Email: cblazier@mckimcreed.com

IX. PROPERTY OWNER AUTHORIZATION *(if Contact Information, item 2 has been filled out, complete this section)*

I, *(print or type name of person listed in Contact Information, item 2a)* _____, certify that I own the property identified in this permit application, and thus give permission to *(print or type name of person listed in Contact Information, item 1a)* _____ with *(print or type name of organization listed in Contact Information, item 1a)* _____ to develop the project as currently proposed. A copy of the lease agreement or pending property sales contract has been provided with the submittal, which indicates the party responsible for the operation and maintenance of the stormwater system.

As the legal property owner I acknowledge, understand, and agree by my signature below, that if my designated agent (entity listed in Contact Information, item 1) dissolves their company and/or cancels or defaults on their lease agreement, or pending sale, responsibility for compliance with the DWQ Stormwater permit reverts back to me, the property owner. As the property owner, it is my responsibility to notify DWQ immediately and submit a completed Name/Ownership Change Form within 30 days; otherwise I will be operating a stormwater treatment facility without a valid permit. I understand that the operation of a stormwater treatment facility without a valid permit is a violation of NC General Statue 143-215.1 and may result in appropriate enforcement action including the assessment of civil penalties of up to $25,000 per day, pursuant to NCGS 143-215.6.

Signature:_____ Date:_____

I, _____, a Notary Public for the State of _____, County of _____, do hereby certify that _____ personally appeared before me this ___ day of _____, _____, and acknowledge the due execution of the application for a stormwater permit. Witness my hand and official seal, _____

SEAL

My commission expires_____

X. APPLICANT'S CERTIFICATION

I, *(print or type name of person listed in Contact Information, item 1a)* *Richard L. Mann, Vice Chancellor for Finance and Administration*, certify that the information included on this permit application form is, to the best of my knowledge, correct and that the project will be constructed in conformance with the approved plans, that the required deed restrictions and protective covenants will be recorded, and that the proposed project complies with the requirements of the applicable stormwater rules under 15A NCAC 2H .1000, SL 2006-246 (Ph. II – Post Construction) or SL 2008-211.

Signature:_____ Date:_____

I, _____, a Notary Public for the State of _____, County of _____, do hereby certify that _____ personally appeared before me this ___ day of _____, _____, and acknowledge the due execution of the application for a stormwater permit. Witness my hand and official seal, _____

SEAL

My commission expires_____

STORMWATER NARRATIVE

STORMWATER MANAGEMENT PERMIT APPLICATION (SWU-101 VER 06.07.10)

PART VI. SUBMITTAL REQUIREMENTS
ITEM 5 DETAILED NARRATIVE – Addendum 1

LOW DENSITY STORMWATER MANAGEMENT PLAN
FOR THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL, BINGHAM FACILITY

The University of North Carolina at Chapel Hill (UNC-CH) Bingham Facility is a 57.56 acre property located in rural, unincorporated Orange County. The property is not contiguous to other UNC-CH property and is not covered under UNC-CH's NPDES MS4 Phase II permit. Therefore, a site-specific stormwater permit is required for the Bingham Facility.

This state stormwater permit application covers proposed improvements to the wastewater treatment system and the site, previous Water and Wastewater System improvements (completed in 2009) and Building 3 (completed in 2010). The total existing built upon area (BUA) provided in Section IV Item 10 of the application includes the impervious surface area of the proposed improvements, the 2009 Water and Wastewater System Improvements and Building 3

Because both the 2009 Water and Wastewater System improvements and Building 3 had not previously received a state stormwater permit from the North Carolina Department of Environment and Natural Resources Division of Water Quality (DWQ), this permit application package is also submitted as an after the fact permit application for both of these earlier projects.

The total site area and the total property area for the Bingham Facility are 57.56 acres (see Part IV. 4. of the application). Existing development on the site includes three research buildings, a wastewater treatment system with wet weather storage and spray irrigation fields, additional support structures and buildings, and gravel roads and parking. The site is approximately 85% wooded, including wooded areas that contain spray irrigation systems for the site's wastewater disposal. The total surface water area on the site is 1.17 acres. This is comprised of the area in between top of bank on the streams. There are 0.85 acres of delineated wetlands on the site. Total impervious surface on the project site is 3.5 acres or 6.29% of the project area. Thus, the site is well below the 24% built upon area threshold for low density projects. If the project built upon area was to increase over 24%, the project would be considered high density and therefore have different stormwater treatment requirements. For low density projects, the only BMPs allowed are grassed swales and curb outlets.

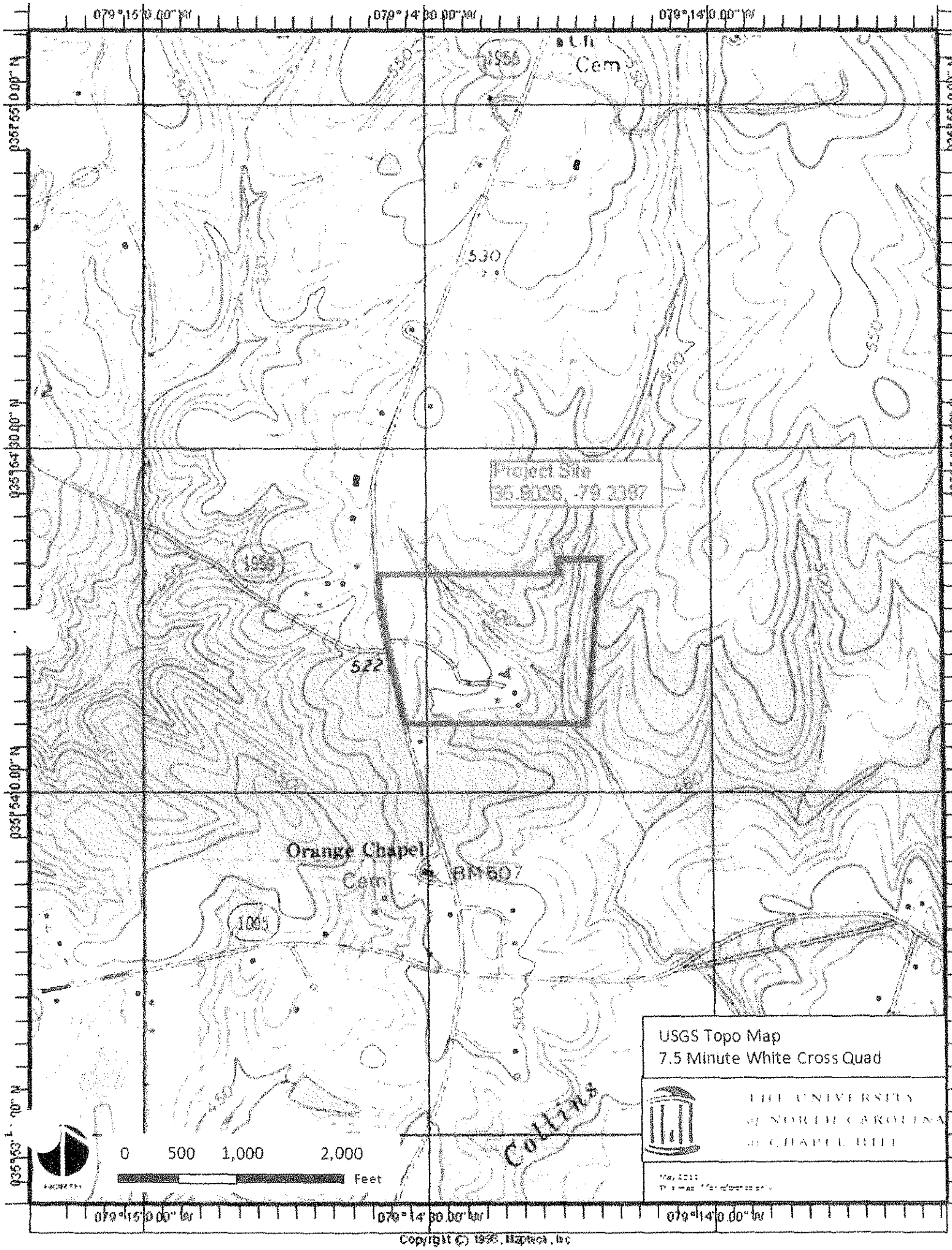
Stormwater runoff at the existing Bingham Facility is primarily sheet flow, with some conveyance through grassed swales, rip-rap channels and stormwater pipes. Gravel roads and driveways on the site are crowned to drain to roadside swales or to sheet flow. A limited number of storm drains and culverts were installed with Building 3. These pipes convey flow under driveways and from the low point created by the loading dock. The two outfalls associated with Building 3 discharge to vegetated areas on the south side of the site that are outside of stream buffers. The Water and Wastewater System Improvements project (2007-2009) installed storm drains to convey flow under the access road to the wet weather storage pond. That storm drain system also discharges outside of the 50 foot stream buffer. Per the February 8, 2011 meeting between Mike Randall (DWQ), UNC-CH staff, and UNC-CH's design consultant, the existing site is consistent with DWQ's low density objectives.

The proposed Wastewater System Improvements (2011) include upgrades to the sanitary sewer collection system, the wastewater treatment system, the wet weather storage and the spray irrigation system. These improvements will occur primarily in previously developed portions of the site, causing little change to the built upon area. Small site improvements are also planned by UNC-CH, such as adding sidewalks and new equipment pads for Building 3. An additional pad may be needed for a future propane gas tank. These improvements will follow the low density development objectives and will use vegetated conveyances to the maximum extent practicable to transport stormwater runoff from the project, specifically:

- Proposed built upon area will drain by sheet flow to vegetated areas when possible.
- No storm drains will be added.
- If existing swales must be reconstructed as part of this project, the new conveyances will be grassed swales with a 3:1 or flatter side slope.

UNC-CH revisited programming for the Bingham Facility in 2010-2011. The proposed overall site plan submitted with this application reflects UNC-CH's most recent plan for build-out at this site and supersedes any previous master plan for the site. As requested by DWQ, if additional construction is planned at the site in the future, UNC-CH will submit an application for permit modification.

MAPS



CALCULATIONS

Current and Proposed Conditions

Parcel Area	57.56	SF	Acres		
Pre-Existing Development					
	Pasture/meadow		8.03		
	Woods		49.53		
Existing Development					
	1. Existing Bingham 1	12,429	0.29		
	2. Existing Bingham 2	5,353	0.12		
	3. Existing Bingham 3	16,000	0.37		
	4. Existing Storage Bldg	3,475	0.08		
	5. Existing Storage Bldg	2,437	0.06		
	8. Existing Well House	368	0.01		
	14. Existing Bldg	1,347	0.03		
	15. Existing Trailer	1,100	0 03		
	16. Existing Transformers	900	0.02		
	17. Existing Chiller Pad	1,075	0.02		
	Gravel	100,500	2.31		
	Total Impervious	**144,984**	**3.33**	**Acres**	**5.78%** Impervious Surface Cover
Proposed Development					
	New WW Facility (Impervious - Other)	365	0.01		
	Chiller Units w/pads (Impervious - Other)	675	0.02		
	Propane Tanks - gravel drive (Impervious - Streets)	4,462	0.10		
	Propane Tanks - pad	4,210	0.10		
	Total Proposed Impervious	**9,712**	**0.22**	**Acres**	
	Total Impervious from Existing and Proposed	**154,696**	**3.55**	**Acres**	**6.17%** Impervious Surface Cover

PROPERTY DEED

Prepared by: C. B. Hodson, Attorney at Law, Chapel Hill, North Carolina

NORTH CAROLINA

ORANGE COUNTY

D E E D

6018

THIS DEED, MADE AND ENTERED INTO THIS THE 6th day of May, 1971, by and between Anthony L. Jacobs and wife, Isabelle M. Jacobs, parties of the first part; and the State of North Carolina, party of the second part;

W I T N E S S E T H:

That for and in consideration of the sum of TEN DOLLARS ($10.00) and other good, valuable and sufficient considerations, to them in hand paid, the receipt of which is hereby fully acknowledged, said parties of the first part have given, granted, bargained and sold and do by these presents, give, grant, bargain, sell and conyey unto the party of the second part, the following tract or parcel of land lying and being in Bingham Township, in Orange County, North Carolina, and more particularly described as follows:

Being ten (10) miles West of the Town of Chapel Hill, North Carolina and on the East side of the Public Road which is State Road 1956 leading in a North-South direction between N. C. highway No. 54 and State Road 1005 and being about 0.5 miles North of said State Road and adjoining said State Road 1956, T. J. Regan, George Maynard, J. J. Thompson, Warren Ray, Edgar Pickard and Paul Hancock, and more particularly described as BEGINNING at a concrete monument in the East right-of-way line of the said State Road and in T. J. Regan's line and running thence North 86° 15' West 30 feet to the center of said State Road; running thence with the center of said road North 9° 46' West 881.3 feet North 6° 54' West 267.1 feet and North 0° 50' West 213.9 feet; running thence South 88° 40' East 30 feet to a concrete monument in the East right-of-way line of the said public road, and continuing in the same direction with Paul Hancock's South line 706.1 feet to a common corner of the Hancock and Edgar Pickard property, a rock monument; running thence with Edgar Pickard's South line South 88° 40' East 907.0 feet to a concrete monument; running thence with Pickard's line North 5° 23' East 94 feet to a concrete monument, Warren Ray's Southwest corner; running thence with the said Ray line South 86° 19' East 140.8 feet to an iron stake; running thence in the same direction with J. J. Thompson's South line 181.7 feet to a rock monument, George Maynard's Northwest corner; running thence with the said Maynard's West line South 7° 02' West 1499 feet to a rock monument; running thence and continuing with the said Maynard line North 86° 15' West 1282.6 feet to an iron pipe in T. J. Regan's Northeast corner; running thence in the same direction with Regan's North line 295.5 feet to the Beginning, containing 57.59 acres, more or less, (0.94 acres being within the right-of-way of the said public road) as surveyed and platted by Hugh B. McFarling, Registered Surveyor, in February, 1963, said plat being recorded in the Office of the Register of Deeds of Orange County in Plat Book 12, at page 17, and being part of the same land conveyed to John Ira Lewis by deed of David M. Lewis, dated September 22, 1937. As recorded in the Office of the Register of Deeds of Orange County in Deed Book 105, at Page 315, and being the same property conveyed to Anthony L. Jacobs and wife, Isabelle M. Jacobs by Deed of John Ira Lewis and wife, Sally Daisy Lewis, dated the 1st day of April, 1963, and as recorded in the Office of the Register of Deeds of Orange County in Deed Book 192, at page 306.

BOOK 229 PAGE 379

Real Estate Excise Tax $31.50

STATE OF NORTH CAROLINA MAY 1971 23.10703

0 1 2 9 0

ORANGE COUNTY

C. B. HODSON
ATTORNEY AT LAW
114 BULLARD BUILDING
CHAPEL HILL, N. C.

TO HAVE AND TO HOLD the aforesaid tract or parcel of land and all privileges and appurtenances thereunto belonging to the said party of the second part in fee simple forever, except the highway right-of-way over 0.94 acre thereof, and that the said party of the first part will forever warrant and defend the said title to the same against the claims of all persons whomsoever.

IN TESTIMONY WHEREOF, the said parties of the first part has hereunto set his hand and seal the day and year first above written.

Anthony L. Jacobs (SEAL)

Isabelle M. Jacobs (SEAL)

NORTH CAROLINA
ORANGE COUNTY

I, Margaret T. Singman, a Notary Public in and for the aforesaid County and State do hereby certify that Anthony L. Jacobs and wife, Isabelle M. Jacobs, personally appeared before me this date and acknowledged the execution of the foregoing Deed.

WITNESS my hand and Notarial Seal this the 6th day of May, 1971.

MARGARET T. SINGMAN NOTARY PUBLIC ORANGE COUNTY, N.C.

Margaret T. Singman
NOTARY PUBLIC

My commission expires: Jan. 17 '76

STATE OF NORTH CAROLINA--ORANGE COUNTY

THE FOREGOING CERTIFICATE OF Margaret T. Singman

A NOTARY PUBLIC OF THE DESIGNATED GOVERNMENTAL UNITS IS CERTIFIED TO BE CORRECT

FILED
BOOK/FILE# 229 PAGE# 379

THIS THE 6th DAY OF May A.D. 19 71

MAY 6 2 54 PM '71

BETTY JUNE HAYES, REGISTER OF DEEDS BY: Lucie B. Homer ASSISTANT/REGISTER OF DEEDS

BETTY JUNE HAYES
REGISTER OF DEEDS
ORANGE COUNTY, N.C.

RETURN: Charlie Hodson, Atty.

BOOK 229 PAGE 380

Betty June Hayes, Register of Deeds.

By: _____

R.E.'S PAID $ 31.50

C. B. HODSON
ATTORNEY AT LAW
114 BULLARD BUILDING
CHAPEL HILL, N. C.

PLANS

McKIM&CREED

Process Design Computations

☐ MEMO
☐ TELEPHONE
☐ FIELD REPORT
☐ CONFERENCE

DATE: 10/28/11 TIME:

AUTHOR: Kevin C. Eberle

PROJECT: UNC Bingham WWTF CLIENT: UNC-CH

SUBJECT: Advantex Process Computations PROJ. NO. 1488.0032

Assumptions

1. Orenco Advantex Textile Fabric Recirculating Filters are biological treatment units which are proprietary in nature.
2. Per Orenco, design effluent Projections are best determined from their Publication AIDA-ATX-COMM-PKG-1 when design influent Concentrations & design loading rates fall within Process design Conditions as on page 3 of 9 of this Publication

Design Criteria

1. Existing Advantex System = (2) AX100 modules each with 100 SF of Textile media

2. Design Influent Wastewater Strength
   a. BOD_5 = 250 mg/L
   b. TSS = 200 mg/L
   c. TKN = 40 mg/L
   d. TP = 7 mg/L

3. ADVANTEX Influent (Post Primary Settling)
   a. USE Peavy, Rowe, Tchobanoglous, Page 228 Figure 5-B Suspended Solids + BOD_5 removal as a function of overflow rate

Primary (septic Tank) = 10' x 20' = 200 sf
Average influent flow = 3556 GPD
Average surface overflow rate = $\frac{3556 \text{ GPD}}{200 \text{ sf}}$ = 17.78 GPD/sf

ACTION

COPY:

CALCULATION

PROJECT _____ PROJ. NO. _____

CLIENT _____ DATE _____

SUBJECT _____ DES. BY _____

CHK. BY _____

REMARKS

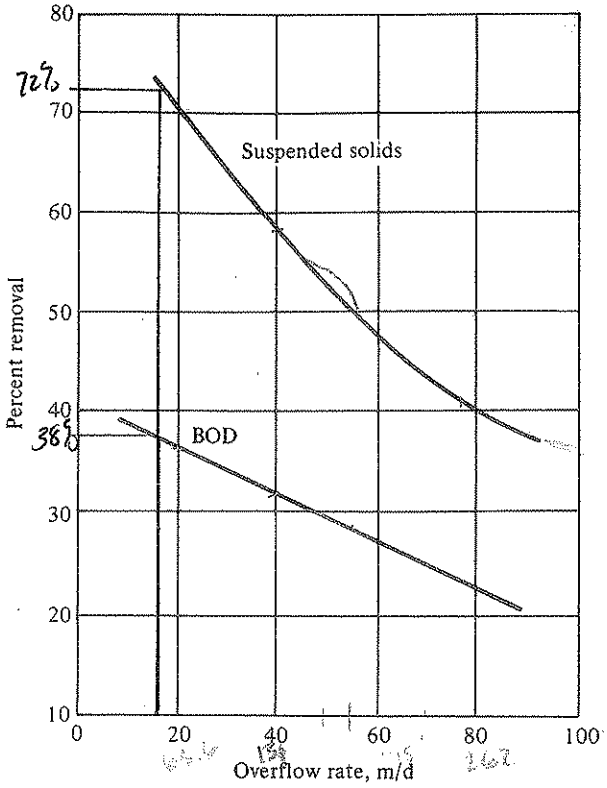


Figure 5-13 Suspended solids and BOD removal as a function of overflow rate. (*Adapted from Steele and McGhee* [5-50].)

For Surface overflow Rate = 17.78 gpd/sf

Use BOD_5 Remvl = 38% and TSS Remvl = 72%

Post Septic Tank

Influent BOD_5 = 250 mg/L X 62% = 155 mg/L Post settling

Influent TSS = 200 mg/L X 28% = 56 mg/L Post settling

Post ~~Advantex~~ Textile Fabric Filter

Advantex Design Loading

1. Hyd Base Loading = 25 gpd/ft²
2. Organic Loading = 0.04 lbs BOD_5/ft²
3. Actual Hyd Design Loading = $\frac{3,556 \text{ gpd}}{200 \text{ sf}}$ = 17.78 gpd/sf
4. Actual organic loading = $(3556 \times 10^{-6}) \times 8.34 \times 155 \text{ mg/L}$ = 4.6 lbs BOD/D

= $\frac{4.6 \text{ lbs BOD}}{200 \text{ sf}}$ = 0.022 lbs BOD_5/ft

CALCULATION

PROJECT UNC - Bingham WWTF
PROJ. NO. 1486.0034
CLIENT UNC - CH
DATE 10/30/11
SUBJECT Advanced Effluent Project
DES. BY KCE
CHK. BY

REMARKS

PER Figure 4 (NDA-ATX-comm-PK6-1) Pag 4 of 9
The ANTICIPATED BOD5 Effluent quality for hydraulic loading = 1.776 GPD/SF = < 5 mg/L BOD5 — ASSUME < 10 mg/L BOD5 in effluent

PER Figure 4, The ANTICIPATED TSS Effluent quality for hydraulic loading = 1.776 GPD/SF = < 5 mg/L TSS
ASSUME < 10 mg/L TSS in effluent

Technical Data Sheet

AdvanTex® – AX100 Textile Filter

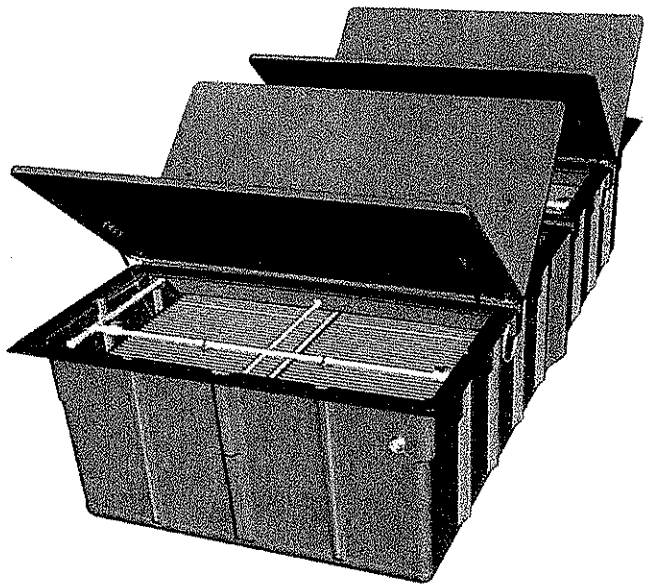
Orenco Systems® Incorporated
800-348-9843

Applications

Orenco's AdvanTex® Treatment System is an innovative technology for onsite treatment of domestic-strength wastewater. The heart of the System is the AdvanTex Textile Filter, a sturdy, watertight fiberglass basin filled with an engineered textile material. This lightweight, highly absorbent textile material treats a tremendous amount of wastewater in a small space. The AdvanTex Treatment System is ideal for:

- New construction
- System upgrades and repairs
- Small sites
- Poor soils
- Pretreatment
- Nitrogen reduction
- Price-sensitive markets

For sizing, see AdvanTex® Design Criteria (NDA-ATX-COMM-2).



The heart of the AdvanTex® AX100 Treatment System is this sturdy, watertight fiberglass basin filled with an engineered textile material.

Features/Specifications

To specify this product, require the following:

- Wastewater treatment to better than "secondary" treatment standards
- Consistent treatment, even during peak flows
- Timer operation for flow monitoring, flow modulation, and surge control
- Fixed-film, engineered textile media, operated in an unsaturated condition
- Consistent media quality
- Low energy consumption
- Low maintenance requirements
- Complete pre-manufactured package, ready to install
- Watertight construction, corrosion-proof materials, and components
- Anti-flotation flanges
- Quiet operation

Standard Model

AX100

Physical Specifications

Approximate Dimensions**

Length, in. (mm)	191 (4851)
Width, in. (mm)	94 (2388)
Height, in. (mm)	42 (1067)
Area (footprint), ft^2 (m^2)	128 (11.9)
Dry Weight, lb (kg)	2000 (907)

*** See AdvanTex® Treatment System drawings for exact dimensions*

**Covered by U.S. patent numbers 6,540,920; 6,372,137; 5,531,894; 5,480,561; 5,360,556*

Design Aid

AdvanTex® Design Criteria

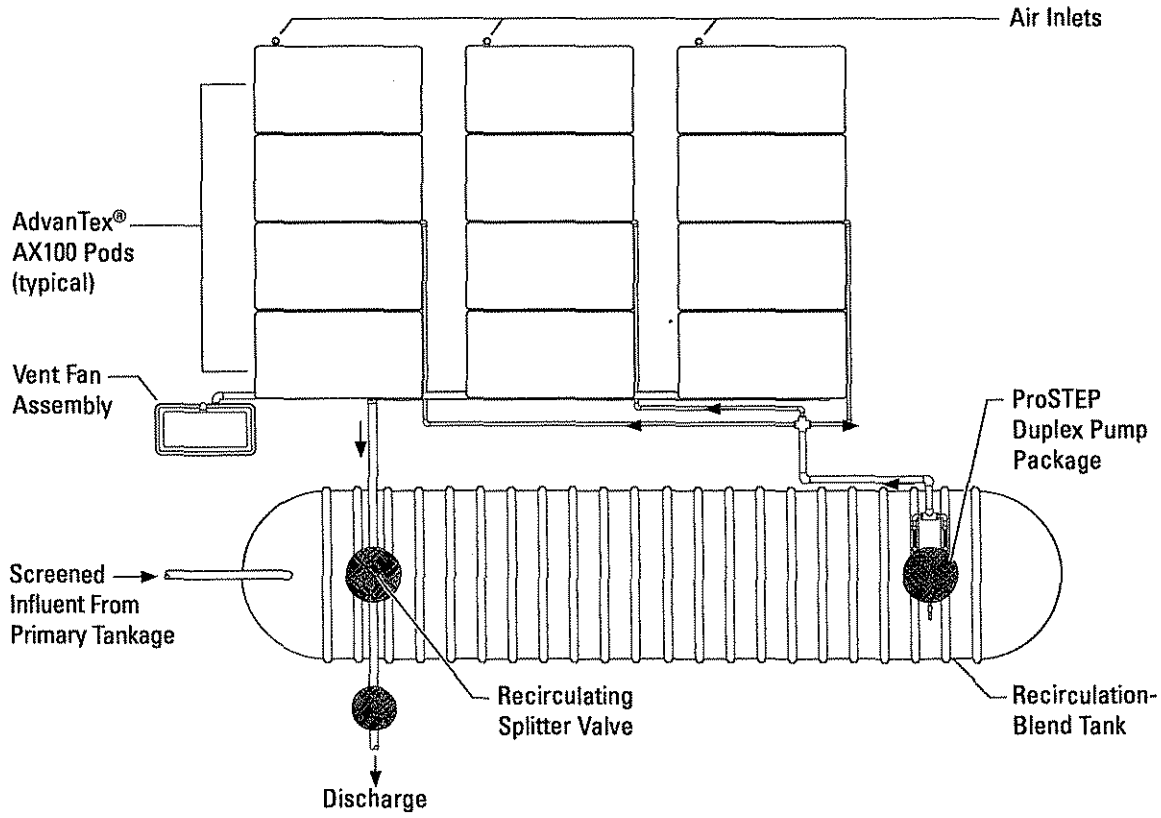
Orenco Systems® Incorporated
800-348-9843

For Commercial and Multi-Family Applications: AX100 and AX20 Models

System Description and Treatment Process

Commercial AdvanTex® AX100 and AX20 Treatment Systems are a multiple-pass, packed bed aerobic wastewater treatment technology specifically designed and engineered for long-term processing of domestic strength wastewater. AdvanTex Treatment Systems are capable of processing typical domestic influent wastewater (see Table 1) to "better than secondary treatment standards." Excellent results with regard to $cBOD_5$ and TSS should be achieved, and total nitrogen reduction will typically exceed 60% on average, assuming sufficient alkalinity is available. Figure 1 shows a standard layout for a commercial AdvanTex AX100 treatment system. (Primary treatment and dispersal not shown.)

Figure 1. Standard Commercial AdvanTex Treatment System: Top View (AX100 Shown)



Prior to the AdvanTex Treatment System, primary treatment of raw sewage is accomplished through appropriately-sized primary septic tanks. After primary treatment, the effluent enters the recirc-blend tank, where it blends with the contents of the tank. ProSTEP™ pump packages in the recirc-blend tank transport blended effluent to a distribution manifold in the AdvanTex filter pod. Effluent percolates down through the textile media, where it is treated by naturally-occurring microorganisms that populate the filter. After passing through the filter media, the treated effluent flows out of the filter pod through the filtrate return line that returns the effluent to the recirculating valve (RSV or MM). The valve automatically splits or diverts the flow between the recirc-blend tank and the final discharge and controls the liquid level within the tank. During extended periods of low forward flow into the system, 100% of the treated effluent is returned to the recirc-blend tank. The recirc-blend tank is set up so that incoming effluent from the primary septic tanks and filtrate from the AdvanTex system pods enter opposite the pump discharge to the pods so that mixing, blending, and dilution of the effluent occurs before being dosed onto the AdvanTex filter pods.

AdvanTex® AX100 & AX20 Commercial Design Criteria

System Selection: Size and Configuration

Commercial AdvanTex Treatment Systems are typically configured as shown in Figure 1. For smaller systems, AX20 pods can be arranged in a similar configuration. If additional nitrogen reduction is desired, a specialty mode in which a portion of the filtrate is routed to recirculate through the primary tank may be considered. This option allows for improved denitrification to enhance the overall nutrient removal. There are several other factors that influence the nitrogen process, and each of these should be considered when developing a plan for achieving significant reductions in this area.

System Requirements: Typical Commercial AdvanTex Influent Wastewater Strength

Wastewater strengths for commercial AdvanTex systems must remain within typical influent limits as shown in Table 1, below. Consult Orenco or an authorized Dealer for applications involving higher-than-domestic waste strength.

Table 1. Typical Commercial AdvanTex Influent Wastewater Strength*

Characteristic	Average (mg/L) †	Weekly Peak (mg/L)	Rarely Exceed (mg/L)
BOD_5	150	250	500
TSS	40	75	150
TKN	65	75	150
G&O	20	25	30
pH	7	6.5 to 7.5	6 to 9
Alkalinity	250-100 (desired) ‡	—	—

** "Typical Commercial AdvanTex Influent Wastewater Strength" is the maximum allowable wastewater strength entering the recirc-blend tank of an AdvanTex Treatment System.*

† Commercial systems will occasionally vary in strength based upon changes in flow characteristics or ownership. As the average influent strength approaches 80% of the weekly peak levels, consideration must be given to providing supplemental pre-treatment, additional treatment units, or process oversight.

‡ Wastewater alkalinity should rarely drop below these levels if nitrogen reduction is necessary.

System Requirements: Recommended Primary Tankage

Typical primary tank sizing will be based on Preferred HRTs (Hydraulic Retention Times) as described in the *Primary Tank Sizing Chart* (NDA-TNK-1) provided as an Appendix to this document. For subdivisions, recommendations assume that design maximum daily flows are typically two times design average daily flows. For commercial establishments such as schools, churches, restaurants, highway rest areas, etc., design maximum daily flows may be much larger than the design average daily flow. Designers should consult local regulations, as well as use their own experience, when estimating flows from these sources. Obtaining flow records from similar existing establishments can be valuable. Also, please feel free to contact Orenco at 800-348-9843 or +1-541-459-4449.

In the primary tank(s), the raw sewage separates into three distinct zones: a scum layer, a sludge layer, and a clear zone. Heavy solids settle to the bottom to form the sludge layer, while the lighter material floats to the top to create the scum layer. Facultative and anaerobic digestion converts the organic matter to volatile organic acids while strict anaerobes ferment the volatile organic acids to gases (methane, carbon dioxide, etc.). Effluent from the clear zone is then passed through a Biotube® effluent filter before being transported to the recirc-blend tank. (See Figure 2.) For the system to operate properly, all tanks must meet minimum structural requirements, be completely watertight, and pass a watertight test including the riser/tank connection. For detailed specifications, see structural and watertightness criteria in Orenco's *Material Specifications* (NDA-ATX-COMM-SPECS-1).

Figure 2. Typical Primary Tank

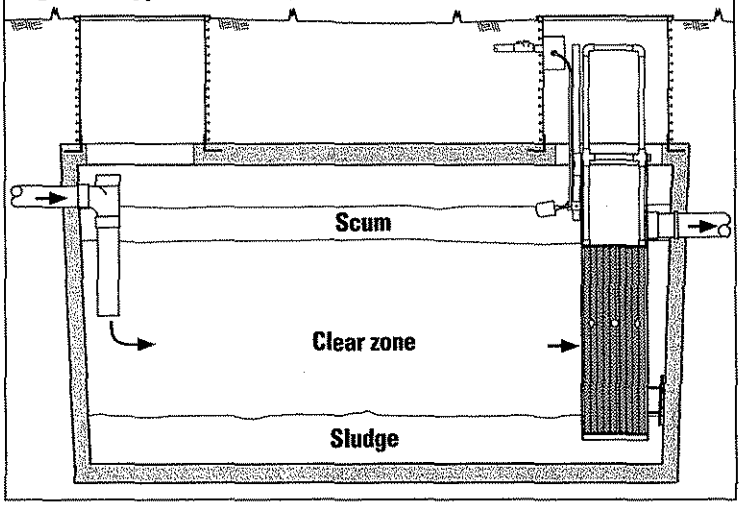


Figure 3. Typical Primary Tanks: Single- and Multiple-Tank Configurations

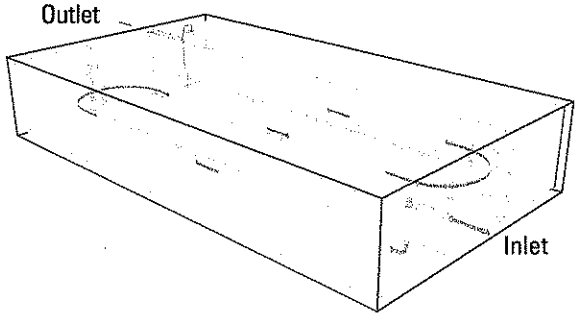


Fig. 3a: Cast-in-Place Primary Meander Tank

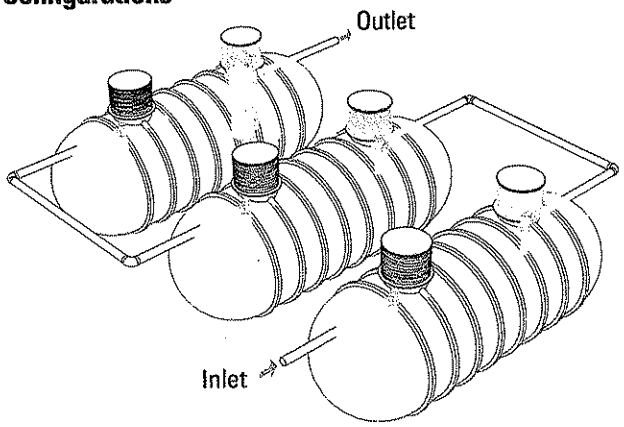


Fig. 3b: Multiple Primary FRP Tanks

When the required tank size exceeds available premanufactured tank capacities, cast-in-place, meander, or multiple FRP or precast tanks (as shown in Figures 3a and 3b) are preferred configurations. Two separate documents, *Septic Tank Sizing for Large Flows*, (NTP-TNK-TRB-2) and *Design and Performance of Septic Tanks*, (NTP-TNK-TRB-3), provide significant background information specific to the primary tank design and configuration.

Recirculation-Blend Tankage

The recirculation-blend tank is sized to equal at least 80% of the design maximum daily flow. A larger tank may be recommended based on the expected organic or peak design hydraulic loads, or to accommodate special surge capacities or operator response capabilities.

For nitrogen-sensitive areas requiring greater than 60% nitrogen reduction, the recirc-blend tankage is sized to equal at least 100% of the peak flow and greater primary tankage is recommended. Where access to a primary waste source is unavailable, this may be provided as two separate tanks, typically an 80% recirc-blend preceded by a 20% denitrification tank. Contact Orenco for details.

Design Loading Rates

Typical loading rates are based on the *AdvanTex Loading Chart for Commercial and Multi-Family Applications*, (NDA-ATX-4) provided as Appendix 3 to this document. Orenco's suggested design loading rates are based on typical per capita flow rates and average strength characteristics expected as listed in Table 1. Performance is a function of the expected typical loads with periodic weekly peaks. The packed bed media filter used in Orenco's AdvanTex AX100 Treatment Systems is configured in the same manner as our AX20 Treatment Systems, which are NSF/ANSI Standard 40 Class I-approved. Typically, the daily mass loading is based on the expected daily flows and parameter strength. Figure 4 shows average loading capacity at 95% confidence level.

The base nominal hydraulic loading rate (HLR) for an AdvanTex Treatment System is 25 gpd/ft^2 with a base organic loading rate (OLR) of 0.04 lbs BOD/ft^2 · day (0.2 kg BOD/m^2 · day). The AdvanTex AX100 has a nominal (plan view) surface area of 100 ft^2/pod (9.3 m^2/pod) and the AdvanTex AX20 (sometimes used in small commercial applications) has a nominal surface area of 20 ft^2/pod (1.9 m^2/pod).

At these loading rates, design criteria target a 10/10 effluent quality in the discharge effluent. Discharge levels may be projected at a 95% confidence level relative to the hydraulic loading rate. Peak HLR's of 50 gpd/ft^2 (2000 Lpd/m^2) or peak OLR's of 0.08 lbs BOD/ft^2 · day (0.4 kg BOD/m^2 · day) can be handled for short periods of time with little effect on performance. Higher loading rates may be applicable relative to higher discharge limits or sufficient operating documentation, but would not be allowed to exceed 50 gpd/ft^2 (2000 Lpd/m^2) at the typical average characteristics presented in Table 1. A thorough evaluation of all the typical wastewater characteristics will guide design limits. High oil and grease concentrations may require pretreatment to ensure maintenance frequencies are not excessive.

If the loading rate (or mass load) needs to be reduced to meet discharge limits, it's a simple matter of adding additional modular units. Operationally, the module's flexible and easily serviceable features make AdvanTex units an ideal, efficient, and effective solution for all wastewater treatment applications with domestic waste characteristics.

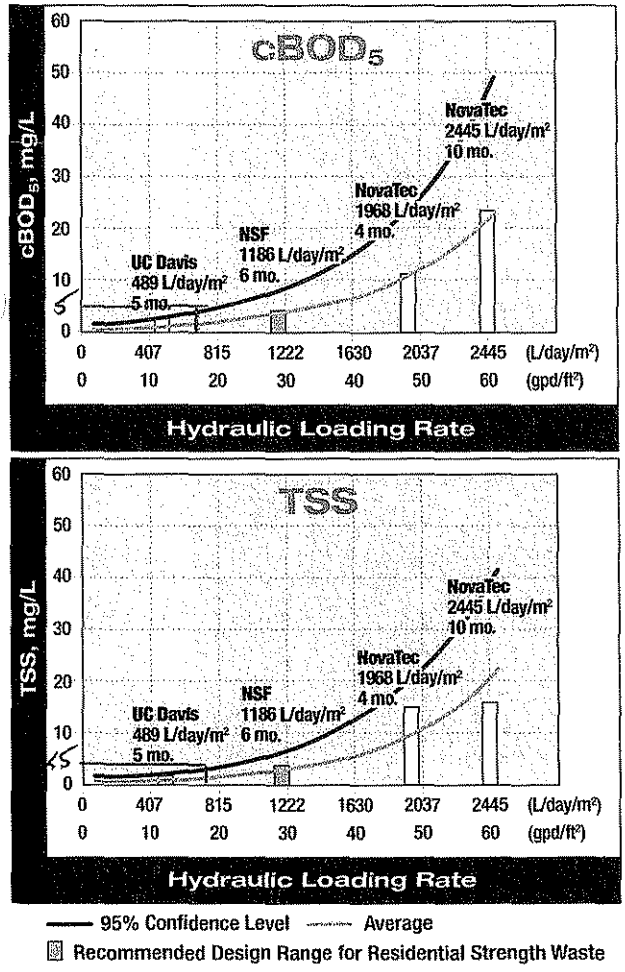
Ventilation

Commercial AdvanTex filters may come with either an active or passive vent system, depending on application type and desired treatment levels. An active vent system utilizing a low wattage fan will typically be used, except for small systems with residential quality influent waste strengths. The internal volume of an AX100 is about 350 ft^3 (10 m^3); typically, air changes occur every other hour. AX20 units typically use passive ventilation.

The inlet plumbing to the recirc-blend tank should allow for natural ventilation back through the building sewer and vent stack. Building sewer lines provide a natural conduit for air movement and exchange throughout the recirc-blend tank and treatment system.

The passive vent provided contains a carbon filter material to mitigate odors. However, a small amount of odor may still occur during a dosing event, as air from the pod is displaced by the dosed effluent. This should be taken into consideration before siting or locating a passive ventilated system in areas where this occasional odor may be perceived as a nuisance.

Figure 4.
Effluent Quality vs. Hydraulic Loading Rates*
(ANSI/NSF Standard 40 and Other Third Party Testing Results)



** Influent concentrations of 162 mg/L BOD_5 and 291 mg/L TSS, with peak influent concentrations of 550 mg/L BOD_5 and 1600 mg/L TSS.*

Typical Effluent Quality

Effluent quality is dependent on a number of factors, including influent characteristics and loading rates. Third party NSF/ANSI Standard 40 testing results are shown in Figure 4. The results demonstrate that low-to-moderate loading rates can produce cBOD and TSS of <5 mg/L, while higher loading rates produce cBOD and TSS in the range of 15-25 mg/L.

Nitrogen reduction in the standard configuration will typically exceed 60 percent. Using a specialty mode, nitrogen reduction will typically exceed 70 percent, depending on wastewater strength and other characteristics like BOD_5, grease and oils, pH, tankage (HRT), temperature, and alkalinity concentrations. Nitrification can be inhibited if the natural buffering capacity (alkalinity) is too low. On a theoretical basis, 7.14 mg/L of alkalinity as $CaCO_3$ is needed to nitrify 1 mg/L of NH_4-N. For more information on nitrogen reducing systems, contact Orenco.

Pumping Equipment

The integrated treatment package includes an Orenco ProSTEP™ pump package. Typically a single pump is necessary to energize the distribution manifold in the an AdvanTex treatment pod. For the AX100, there are four laterals in each filter with two spray nozzles per lateral. The flow can be varied by adjusting the pressure at the pod inlet; however, our baseline operational flow is about 6.0 gpm per nozzle, which puts the pumping rate at about 48.0 gpm per each AX100. Orenco pump models PF5005, PF5007, PF5010, and PF7510 are used for the AX100 units. Duplex or sufficient multiple pumps are required in all commercial applications to ensure operational integrity with one or more pumps out of commission.

Distributing Valves (Optional)

Automatic distributing valve assemblies are used to alternate doses to up to three AX100 pods utilizing a duplex ProSTEP pump package. Orenco often recommends designing without automatic distribution valves if possible, to eliminate extra moving parts in the system. Other configuration options could include a single pump per pod, or two PF5007 pumps coupled to dose three pods simultaneously.

Distribution valves allow for a 4:1 recirc-blend ratio during periods of design maximum daily hydraulic loading without exceeding the maximum daily cycle rating of the pumps. Orenco automatic distributing valve assemblies should be located at the high point between the recirc-blend tank and the AdvanTex pod(s) to ensure proper operation of the valve. For more details on this product, please refer to Orenco *Automatic Distributing Valve Assemblies for Wastewater Effluent Systems* (NTP-VA-1).

Residual Pressures

The residual pressure will typically be set to 3.0 psi (20.7 kPa) to attain the desired 6 gpm (0.38 Lps) per nozzle. Each AX100 pod is supplied with a gauge tap and valve assembly to allow for pressure measurement at the pod inlet.

Recirculation-Blend Ratios and Timer Settings

Typical operating recirculation-blend ratios will vary between 2:1 and 4:1, and the "off" time varies as a function of the recirc-blend ratio. The AdvanTex Treatment System controls are initially set to a 4:1 recirc-blend ratio, and initial timer settings are established based on the design average daily flow. A typical dose event will vary between 1 and 2 minutes and will deliver about 6 to 12 gallons (23 to 45 liters) per nozzle per dose. If, after startup, the actual measured flows vary significantly from estimated design flows, timer settings should be recalculated.

AdvanTex Control System

The method in which the effluent is loaded onto the AdvanTex filter is critical to the successful performance of the AdvanTex Treatment System. Over the past three decades, timer-controlled applications have proven to play an essential role in optimizing the performance of both fixed and suspended growth biological systems. A timer-controlled pump in the recirc-blend chamber periodically doses effluent to a distribution system on top of the AdvanTex filter media. Each time the filter is dosed, effluent slowly percolates through the filter media and is treated by naturally-occurring microorganisms that populate the filter. During periods of high flow, a timer override float will temporarily adjust the timer settings to process the additional flow. The controller can also be programmed to change to an energy economy mode during extended periods of low inflow.

A telemetry-based panel — which can be connected to a land line, cellular service, internet, or satellite service — controls all equipment. Remote telemetry control panels are an integral part of all commercial AdvanTex Treatment System equipment packages. The remote telemetry feature provides real-time operator monitoring and control over system components, as well as data collection of key operational parameters and events. If additional equipment for pretreatment, tertiary treatment, or disinfection are required, the controls for each component can easily be incorporated into the telemetry control panel. This also allows the manufacturer to contact the panel directly to assist the operator in system evaluation and troubleshooting or to manually override operations. Remote telemetry control panels also provide additional alarm functions to automatically page the operator in the event that trend data indicate potential problem conditions (e.g. high flows). Orenco control panels can also integrate into existing SCADA systems.

Surge Volume

AdvanTex tankage design is consistent with that of other packed bed filters. Flow equalization should be designed into the primary tanks with controlled (metered) feed to the recirc-blend tank. If surging needs to be done in the recirc-blend tank, then sizing and timer controls will be programmed to optimize performance and surge capacity. Churches, schools, and assembly halls are typical applications where weekly surge control practices provide optimum filter sizing.

Other Design Considerations

AdvanTex pods are designed for installation in areas that are free of water. If a project requires placement of the pod in a high-water area, contact Orenco for options.

For cold weather applications, AX units are available with insulation attached to the bottom of the lid (1-inch thick; R-5 or 0.2 BTUs/hr/ft^2/°F/inch thickness). Installing insulation around the sides of the filter pods themselves is optional and is done onsite as needed.

Other cold weather considerations include standard practices used with most onsite pump systems, such as allowing all lines to drain, insulating processing tank lids, and backfilling risers with pea gravel if frost-heave is a concern. For extreme climates with long periods of subfreezing weather, a warm air source may be required. Contact Orenco if supplementary options need to be considered.

Appendix 1: Primary Tank Sizing

At Orenco Systems, we believe a structurally sound, watertight, and well-maintained septic tank is one of the most effective and economical wastewater treatment devices available. Adequate septic tankage will anaerobically digest organic material, remove settleable and floatable solids, help modulate flow, and consistently discharge effluent that meets "primary treatment" standards.

The Primary Tank Sizing Chart on the next page lists Orenco's tank sizing recommendations for various applications. The table includes minimum and preferred tankages for a dozen common types of facilities. We acknowledge that both the minimum and preferred tankages listed exceed EPA minimum sizes. After conducting extensive research on septic tankage, we are convinced that the smaller tankage arrived at using the EPA formula will result in suboptimal performance. Moreover, although smaller tanks may cost less initially, long-term cost of ownership is greater when their higher maintenance costs are taken into consideration. From an economic standpoint, ensuring adequate tankage of onsite wastewater treatment systems is an effective way to reduce operational costs. Consequently, we base our numbers on long-term performance satisfaction with regard to nominal quality ("minimum" tankage) and high quality ("preferred tankage") effluent.

Here are a few tips on how to use this chart:

- To calculate the appropriate tank size for your job, multiply the design maximum daily flow in gallons per day specified by your regulatory commission (according to facility type) by the hydraulic retention time (HRT) in days, listed in the Minimum and Preferred columns. For example, if local regulations require a 10,000 gpd system design for an office facility, Orenco recommends primary tankage of 30,000 gpd (minimum) or 40,000 gpd (preferred).
- Because grease and oil can inhibit microbial action and seal the pores in a packed bed filter or soil absorption system, Orenco recommends a grease tank for any facility with a commercial kitchen. A grease tank, which provides the longer retention time required to cool grease and oil to a point at which separation is possible, is an economical means of cooling and removing grease and oil before integrating the kitchen flow into the primary tankage.
- Several types of facilities — such as churches, schools, weekend campsites, etc. — may experience large fluctuations in daily flow; some may even receive all of their weekly flow over the course of one or two days. For facilities like these that need surge control, flow equalization should be included in the tank design.
- For facilities in the upper section of the table (those with restrooms and kitchens), primary tankage volume is determined by multiplying the sum of the design maximum daily flows of the restrooms and kitchens combined by the factor in the Primary Tankage cell. For larger facilities, such as the bottom three categories on the chart, the values are intended to be cumulative.

This table should be used as a general guideline for decentralized wastewater treatment designs. If you have questions about special cases where larger tankage or other measures may be necessary, or if you have general questions about flow equalization, please call Orenco Systems at (800) 348-9843 or +1-541-459-4449.

Primary Tank Sizing Chart

Facility	Minimum		Preferred	
	Grease Tankage[1] HRT (days)	Primary Tankage[2] HRT (days)	Grease Tankage[1] HRT (days)	Primary Tankage[2] HRT (days)
Office/Manufacturing/Light Industrial				
a) restrooms only	n/a	3	n/a	4
Restaurant/Deli				
a) restrooms and kitchen	3	4	5	5
Convenience Store/Gas Station				
a) restrooms only	n/a	3	n/a	4
b) restrooms and kitchen/deli	2	3[3]	4	4[3]
Hotel/Motel/Multiple Dwelling Units				
a) restrooms and kitchens	n/a	3	n/a	4
b) restrooms and restaurant/kitchen	3	3[3]	5	4[3]
Church				
a) restrooms only	n/a	2.5 + Surge[4]	n/a	4 + Surge[4]
b) restrooms and kitchen	2	2.5 + Surge[3,4]	4	4 + Surge[3,4]
School				
a) restrooms only	n/a	3 + Surge[4]	n/a	4 + Surge[4]
b) restrooms and kitchen	3	3 + Surge[3,4]	5	4 + Surge[3,4]
Dog Kennel/Veterinary Clinic				
a) restrooms only	n/a	3	n/a	4
b) restrooms and floor drains	n/a	3 + Surge[3,4,5]	n/a	4 + Surge[3,4,5]
RV Park				
a) RV spaces	n/a	3	n/a	4
b) dump station	n/a	8	n/a	10
Casino				
a) gaming floor	n/a	3	n/a	4
b) hotel/motel	n/a	3	n/a	4
c) restaurant/deli	3	4	5	5
Resort/Camp				
a) bunk houses	n/a	3	n/a	4
b) main houses	n/a	3	n/a	4
c) kitchen	2	3	4	4

1. Grease tankage HRT is based on a separate **kitchen design maximum daily flow**, which is integrated into the main flow prior to the primary septic tanks.
2. Primary tankage HRT is based on the **sum of the design maximum daily flows from all sources.**
3. For facilities with restrooms and kitchen, primary tankage volume is determined by multiplying the sum of the design maximum daily flows of the restrooms and kitchen combined by the factor in the primary tankage cell.
4. To determine surge volume for flow equalization purposes, please call **Orenco Systems** at **(800) 348-9843** or **+1-541-459-4449** for assistance.
5. To reduce septage pumping in these and other specialized applications, we recommend using multiple tanks: The first should be small (0.5 to 0.75 HRT); subsequent tanks should provide the remaining HRT requirements.

Note: Tankages are based on long-term performance satisfaction (with respect to septage removal) and nominal quality (minimum) to high-quality (preferred) effluent. If effluent strength is higher than the expected level or if a higher level of treatment is required, greater tankage will be necessary. To enhance total nitrogen reduction, primary tankage should be increased for AdvanTex Mode 3 Systems. Contact Orenco for specifics.

Appendix 3: AdvanTex® Loading

For Commercial and Multi-Family Applications

At Orenco Systems, we have spent more than two decades researching packed bed filters, a proven wastewater technology. Based on our research, we developed the AdvanTex Treatment System, which has been in use since the mid-1990s. AdvanTex Treatment Systems work like recirculating sand/gravel filters, which treat wastewater through a combination of physical, chemical, and biological processes. AdvanTex produces effluent that exceeds "secondary" treatment standards.

The difference between AdvanTex and sand/gravel filters is AdvanTex Treatment Systems use an inert nonwoven textile material instead of granular media such as sand or gravel. Textile has several advantages over granular media:

- Textile has a larger surface area—five times greater than an equivalent volume of sand—so installations have a much smaller footprint than sand filter systems.
- Textile's higher absorption capacity allows loading rates five-to-twenty times higher than sand (as high as 50 gpd/sq ft).
- Textile media weighs considerably less than granular media, so AdvanTex systems can be prepackaged, which results in reduced installation costs.
- Textile media is washable, allowing for a relatively quick and easy rejuvenation of the treatment system in case of abuse or overloading.

Designing an AdvanTex Treatment System is similar to designing a recirculating sand filter (RSF). Most commercial AdvanTex systems also require a ventilation fan (typically rated at 90 watts). However, the power required to operate this fan twenty-four hours per day is significantly less than the power required to operate packaged treatment systems.

In areas that are not nitrogen-sensitive, the recommended size of the recirculation-blend tank for the AdvanTex system is one that provides an HRT based upon eighty percent (80%) of the maximum daily design flow. For nitrogen-sensitive areas, the recommended size of the recirculation-blend tank is one that provides HRT based upon 100% of the maximum daily design flow.

AdvanTex systems have performed well in residential applications where nitrogen removal is necessary. In commercial applications, nitrogen reduction is much more complex than BOD and TSS reduction, and consequently harder to predict. Nitrogen reduction will be dependent on incoming TKN levels, water and air temperatures, alkalinity, pH, and a number of other factors. While commercial AdvanTex systems can be optimized for nitrogen removal, meeting stringent nitrogen limits on a continuous basis cannot be guaranteed.

The AdvanTex Loading Chart on the next page lists Orenco's loading rate recommendations for various applications. It includes loading rates for both design average daily flow and design maximum daily flow for AdvanTex filters used in commercial and multi-family applications. The loading rates used in the table are based on screened primary-treated residential strength effluent from properly sized septic tanks.

This table should be used as a general guideline for decentralized wastewater treatment designs. If you have questions about special cases where different loading rates or other measures may be necessary, or if you have general questions about the AdvanTex Treatment System, please call Orenco Systems at (800) 348-9843 or +1-541-459-4449

AdvanTex® AX100 & AX20 Commercial Design Criteria

AdvanTex System Loading

Facility	Recommended Commercial AdvanTex Loading Rate[1]	
	Design Average Daily Flow[2] (gpd/sq ft)	Design Maximum Daily Flow[3] (gpd/sqft)
Subdivisions/Multiple Dwelling Units	25	50
Office/Manufacturing/Light Industrial		
a) restrooms only	25	50
Restaurant/Deli		
a) restrooms and kitchen	10	25
Convenience Store/Gas Station		
a) restrooms only	15	40
b) restrooms and kitchen/deli	10	25
Hotel/Motel/Multiple Dwelling Units		
a) restrooms and kitchens	25	50
b) restrooms and restaurant/kitchen	15	35
Church		
a) restrooms only	25	50
b) restrooms and kitchen	15	40
School		
a) restrooms only	25	50
b) restrooms and kitchen	15	40
Dog Kennel/Veterinary Clinic		
a) restrooms only	25	50
b) restrooms and floor drains	15	40
RV Park		
a) RV spaces	25	50
b) dump station	Not recommended	Not recommended
Casino		
a) gaming floor	25	50
b) hotel/motel	25	50
c) restaurant/deli	10	25
Resort/Camp		
a) bunk houses	25	50
b) main houses	25	50
c) kitchen	10	25

1. AdvanTex loading rates assume properly sized primary tankage, as outlined in the Orenco Design Aid, *Primary Tank Sizing*, (NDA-TNK-1). Loading rates are based on nominal wastewater characteristics as described earlier in this document.
2. Design average daily flow is the expected daily flow based on a 30-day average.
3. Design maximum daily flow is the maximum daily flow a facility is expected to produce over a week's time.

Note: Loading rates shown are for systems expected to perform to secondary standards such as ANSI/NSF 40. Higher performance systems require special review and generally feature lower loading rates.

Approvals Summary

Orenco Systems® Incorporated
1-800-348-9843

For Residential AdvanTex® Treatment Systems

Basis for Approvals

AdvanTex® Treatment Systems

Orenco's AdvanTex Treatment System incorporates a packed bed filter unit that uses textile media. The effectiveness of wastewater treatment using packed bed filters has been well documented over the past century.

Orenco Systems has been researching and developing textile packed bed filters since 1996, and about 20,000 textile filters have been installed in the U.S., Canada, and all over the world, on all sorts of sites: single-family homes, commercial properties, and community systems. The company's 30 years of experience with research, design, and construction of all types of intermittent and recirculating sand filters has been invaluable during this process. The principles and practices used in sand filters are very much like those used with textile filters.

Following is a summary of AdvanTex approvals. Currently, AdvanTex is approved in over 100 jurisdictions (states, counties, and provinces). AdvanTex has also been specifically approved for its ability to reduce nitrogen in wastewater in as many as 22 different jurisdictions (see below). Additional supporting information is available. If you have any questions, please call Sam Carter, Orenco Systems, Inc., (800) 348-9843, ext. 327.

Documented Approvals and Installations

AdvanTex Treatment Systems have undergone third-party evaluation and have successfully passed ANSI testing protocols. Our AX20, rated at 500 gpd, successfully passed the NSF/ANSI Standard 40 testing protocol for Class 1 Systems. The AdvanTex System has also undergone multiple third-party field testing evaluations which demonstrate its ability to perform under real life conditions.

Following is a summary of principal approvals and installations, arranged alphabetically by country and state or province, with contact names and phone numbers.

United States:

Alabama: Statewide approval was given to the AdvanTex Treatment System in 2002.
Contact: Billy McLean, Dauphin Environmental, (251) 660-1300.

Alaska: Approval was given to the AdvanTex Treatment System by The Municipality of Anchorage in 2002. AdvanTex is also recognized as a nitrogen-reducing system.
Contact: Jim Jensen, Anchorage Tank, (907) 272-3543.

New Jersey: Statewide approval was given to the AdvanTex Treatment System in 2008 under the Aerobic Systems Guidance Document.
Contact: Bob Johnson, Atlantic Solutions, (401) 293-0176.

New Mexico: Statewide approval was given to the AdvanTex Treatment System in 2001. AdvanTex is also recognized as a nitrogen-reducing system.
Contact: Roger Shafer, SCG Enterprises, (303) 838-0611.

New York: New York does not have a statewide advanced treatment system approvals process. The AdvanTex Treatment system has been approved by several counties.
Contact: Mary Clark, Orenco Systems, Inc., (802) 917-4746.

North Carolina: Statewide approval as an innovative system was given to the AdvanTex Treatment System in 2005. AdvanTex is also recognized as a nitrogen-reducing system.
Contact: Steve Berkowitz, North Carolina Department of Environmental Health, Environmental Engineer, (919) 715-3271.

Ohio: Statewide approval was given to the AdvanTex Treatment System in 2002, and this approval was reissued per the new regulations in 2007. Part of an EPA demonstration project, the first AdvanTex Treatment System was installed in Clermont County in early 1999.
Contact: Rebecca Fugit, Ohio Department of Health, (614) 466-1390.

Oregon: Statewide approval was given to the AdvanTex Treatment System in 2002. AdvanTex was recognized as a nitrogen-reducing system in 2007.
Contacts: Randy Trox, Oregon DEQ, (541) 687-7338; Sam Carter, Orenco Systems, Inc., (800) 348-9843.

Pennsylvania: Alternate System approval was given to AdvanTex in 2009. Approval was granted after successfully completing the third-party field verification testing required by PA DEP. AdvanTex is also recognized as a nitrogen-reducing system.
Contact: Ed Corriveau, Pennsylvania Department of Environmental Protection, (717) 705-4805.

Rhode Island: Statewide approval was given to the AdvanTex Treatment System in 2004. AdvanTex is also recognized as a nitrogen-reducing system. Several systems are part of state or EPA demonstration projects.
Contact: George Loomis, University of Rhode Island, (401) 874-5950.

South Carolina: South Carolina does not have a statewide advanced treatment system approvals process. The AdvanTex Treatment system is allowed to be designed and permitted as an engineered system.
Contact: Eric Taylor, Orenco Systems, Inc., (800) 348-9843.

South Dakota: Statewide approval was given to the AdvanTex Treatment System in 2008.
Contact: Jesse Kloeppner, Orenco Systems, Inc., (763) 633-1766.

Texas: Statewide approval was given to the AdvanTex Treatment System in 2003.
Contact: Eric Taylor, Orenco Systems, Inc., (800) 348-9843.

Utah: Approval was given to the AdvanTex Treatment System in 2003.
Contact: Ben Witt, Alternative Onsite Solutions, (801) 380-0103.

Soil, Water, & Environment Group

Soil, Water, & Environment Group, PLLC
3216 Byers Drive, Suite B
Raleigh, NC 27607
Ph# (919) 831-1234 • Fax# (919) 899-9100 • http://www.swegrp.com

October 28, 2011

Mr. Kevin Eberle, P.E.
McKim & Creed
Venture IV Building, Suite 500
1730 Varsity Drive
Raleigh, NC 27606

Re: Additional Information Request, NCDWQ Aquifer Protection Section (Permit App. No.: WQ0023896)

Dear Mr. Eberle,

Enclosed are comments relating to the additional information request by NCDWQ Aquifer Protection Section concerning the UNC Bingham wastewater treatment facility in Orange County, NC. Specifically, comments are directed toward the Soil Scientist Evaluation Report and Agronomist Report provided by Soil, Water, and Environment Group staff.

Soil Evaluation:

1. Table 1 on Page IV states that the irrigation shall be seasonal, however, Application Item VII.7. states annual. Please amend for consistency.

   Response: Table 1 on Page IV amended to reflect annual application.

2. Section 4.1 on Page 4 states that spray irrigation shall not occur within 25 feet of non-SA surface waters. Per 15A NCAC 02T .0506(a), this setback shall be 100 feet. Please amend.

   Response: Table 4.1 on Page 4 amended to 100 ft. setbacks.

3. Section 5.2 on Page 8 makes not of having a Sodium Adsorption Ration (SAR) of less than 10. Please clarify whether or not excessive salts are anticipated to be in the effluent waste stream.

   Response: The SAR proposed is less than 10 and does not constitute an irrigation hazard or risk of soil damage. Excessive salts in the effluent waste stream are not anticipated.

4. Page 10 of the soil evaluation recommends an annual loading rate of 8.2 in/yr, however, Application Item Vii.7. states that the recommended annual loading rate is 10.28 in/yr. Please amend.

Response: The Soil Scientist Evaluation Report has been amended to propose 10.92 in/yr. as consistent with the revised Water Balance.

5. Per Application Instruction E and 15A NCAC 02T 0504(b)(4), provide a standard soil fertility analysis for both the Georgeville and Herndon soil series.

Response: A standard fertility analysis was completed across the site and specifically at each Ksat location which represents all soil series at the site including Georgeville and Herndon series. A composite of these fertility data is currently provided in the Agronomist Report in Table 2. Table 2 has been revised to include Georgeville and Herndon soil series data separately. The complete fertility analysis for all plots is provided in the Appendix of the revised Agronomist Report.

Agronomist Report:

1. Please note that the agronomic calculations have not been verified by the Division because the designed effluent concentrations in Application Item III.5. were not provided.

Response: Please note agronomic calculations are provided for annual loadings of 10.92 in/yr. Design effluent concentrations are proposed at 25 mg/L total nitrogen and 5 mg/L total phosphorus.

2. Pages 4 and 5 again make mention of the Sodium Adsorption Ratio (SAR), and recommends that the SAR be analyzed. Accordingly, please clarify whether or not high salt concentrations will be present in the effluent.

Response: The SAR proposed is less than 10 and does not constitute an irrigation hazard or risk of soil damage. Excessive salts in the effluent waste stream are not anticipated.

Please let us know if you have any questions about the information provided to complete this process. Thank you.

Sincerely,

Scott J. Frederick, EI, NCLSS
Environmental Scientist
President
Soil, Water, & Environment Group

SOIL SCIENTIST EVALUATION

FINAL

UNC Bingham WWTF

Land Application System Receiver Site

Orange County
North Carolina

Prepared for:

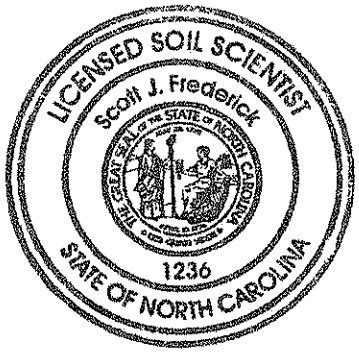
McKim & Creed, PA
Venture IV Building, Suite 500
1730 Varsity Drive
Raleigh, NC 27606

And

North Carolina Division of Water Quality
Aquifer Protection Section
North Carolina Division of Water Quality
1617 Mail Service Center
Raleigh, NC 27699-1617

Prepared by:

Soil, Water, & Environment Group
sjfrederick@swegrp.com



Scott J. Frederick, EI, NCLSS
April 2011
Revised October 2011

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Executive Summary

A soil and site investigation was completed for the UNC Bingham Facility Wastewater Treatment (UNCBWWTF) land application system in Orange County, NC. The purpose of the investigation was to determine the potential of this property to receive secondary treated irrigation water. The soil scientist evaluation was conducted according to mandates set forth by the North Carolina Division of Water Quality (NCDWQ), Aquifer Protection Section and specifically, 15 NCAC 02T .0500. Field investigations were conducted to describe the existing receiver site according to the soils, existing vegetation crop, geologic features, physiographic region, topography, hydrology, wetlands, and landscape position. Water quality data and the most limiting site characteristics were utilized for hydraulic and liquid loading calculations and recommendations. Hydraulic loading recommendations were determined after consideration of site characteristics such as soils, in situ saturated hydraulic conductivity measurements, hydrology, vegetation, landscape position, and any other site limiting factors (Table 1). Loading recommendations are provided in this report for a land application irrigation system on the proposed receiver site and soil areas (Table 2). Hydraulic loadings were calculated based on site specific data and accepted professional guidelines for waste disposal (NCDWQ). Soil fertility was analyzed by a regional agronomic services laboratory (Table 4).

Recommendations in this report are provided for the establishment of a forest or forage land application wastewater irrigation system including results from a detailed water balance and hydraulic loading rate analysis (Edwin Andrews & Assoc., PC, 2011). Soil analyses of the proposed irrigation site indicate there are some nutrient deficiencies on the proposed receiving silt loam and sandy loam soils (Table 4). The existing wastewater irrigation constituents will provide supplemental nutrients and a consistent source of water to growing crops, in this case a mixed hardwood forest and/or forage crop system.

Table 1: Soil Areas, Recommended Hydraulic Loading Rates for the UNCBWWTF Land Application System Receiver Site, Orange County, NC.

Soil Area	acres[1]			
		in/wk[2]	gpd[3][4][5]	Seasonal
1	3.56	.21	2,896	No
2	2.15	.21	1,749	No
Design (SA 1 and SA2) 4,645 gpd	5.71*		4,645	No

1] Acreages account for setbacks from waterways, wetlands, streams, property lines, dwellings, and water supply wells for a 4,645 gpd system.

2] Rate based on recommended application rates calculated by a comprehensive Water Balance (Edwin Andrews & Assoc., PC, 2011).

3] Based on a 7 day irrigation week.

4] Recommended maximum hydraulic loading over an entire irrigation year including constraints from storage.

5] Irrigation rate shown is the maximum that should be used in computing receiver site capacity unless or until a higher loading rate is shown to be sustainable based on actual field performance and storage capacity limitations. Use of forest cover crop may result in higher than estimated transpiration and drainage rates. Operators at a minimum need the permit flexibility to apply irrigation water at

a rate high enough to sustain plant growth without causing runoff or ponding, which during extended dry periods (drought conditions) could exceed the rates shown in the table.
* - Actual irrigable area utilized in Water Balance Report (Edwin Andrews & Assoc., PC, 2011).

Table 2: UNCBWWTF Land Application System Receiver Site Soil Areas, Associated Soils, and Existing Vegetation.

Soil Area	Predominant Soil Series	Existing Vegetation
SA-1	Georgeville	Grass, Mixed Pine/Hardwood
SA-2	Herndon	Grass

Approximately 57 acres of uplands with potential to receive municipal wastewater irrigation were evaluated and similar soils were grouped into Soil Areas (SA). Two different soil areas were identified within these areas, each with specific loading rates totaling 5.71 irrigable acres utilizing a secondary treated water source. Soil Areas account for buffers from waters of the State, property lines, as well as other site limitations such as bedrock, shallow soils, depressions, and disturbed areas.

It should be noted that final hydraulic loading rates are based off a detailed water balance and in situ saturated hydraulic conductivity measurements. This water balance accounts for storage and other factors (Edwin Andrews & Assoc., PC, 2011) and local rainfall conditions. The receiver site investigated for this evaluation was approved by a nationally and state licensed soil scientist in North Carolina. It should be noted that soil systems are quite variable and the actual system performance and operations can be adjusted during operation to accommodate site variabilities. Hydraulic recommendations are based on site specific data, and attempt to account for these site variabilities. With that understanding, maximum hydraulic and nutrient loadings are given. This report is based on the professional recommendations and judgment of a nationally and North Carolina licensed soil scientist (SWE Group, 2011), and reviewed for incorporation into the permit application submittal to NCDWQ by a North Carolina licensed professional engineer (McKim & Creed 2011). Overall, the Bingham Facility Land Application System is a viable alternative to discharging treated wastewater into nearby surface waters. The irrigation of the treated wastewater will ultimately increase soil fertility and productivity of the cover crop vegetation and will enhance adjacent wetlands and low lying areas with increased base flow. The information contained in this report will aid with management of a land application irrigation system for the Bingham Facility receiver site.

1.0 Introduction

Under Section 02T .0500 Rules – Waste Not Discharged to Surface Waters set forth by the North Carolina Division of Water Quality, municipalities, and publicly owned treatment works (POTWs) can divert their treated effluent to land application irrigation receiver sites. Land applying wastewater or reclaimed water will provide additional treatment, and is consistent with the total maximum daily load (TMDL) program promoted by federal and state regulatory agencies. Many county governments, municipalities, and industries are facing similar situations with finding alternatives for wastewater and reclaimed water treatment and disposal in nutrient sensitive regions. The proposed receiver site is a viable alternative to a point source discharge for wastewater produced by the UNC Bingham Wastewater Treatment Facility (UNCBWWTF) and will provide an excellent source of irrigation water for growing forage grasses and/or tree crops.

2.0 Objectives

The objectives of this report are to describe the existing receiver site according to the soils, vegetation and/or crop cover, geologic features, topography, hydrology, wetlands, and landscape position. Recommendations will be provided for the establishment of a land based irrigation system. In addition, a standard soil fertility analysis will be provided and analyzed with an accompanying Agronomist Report (SWE Group, 2011).

3.0 Methodology

Per regulations set forth by the North Carolina Division of Water Quality (NCDWQ) the purpose of this evaluation was to determine the potential and suitability of selected receiver areas to receive treated irrigation water and use this information in the permitting of the facility receiver areas.

The soil scientist evaluation was conducted according to 15A NCAC 02T .0504(b). Field investigations were conducted to describe the potential wastewater receiver site according to the soils, existing vegetation / crop, geologic features, topography, hydrology, wetlands, and location. Anticipated wastewater quality data and the most limiting site characteristics were utilized for hydraulic loading calculations and recommendations. Hydraulic loading recommendations were determined after consideration of site characteristics such as soils, hydrology, vegetation, landscape position, and any other site limiting factors. Hydraulic loadings were calculated based on site specific data and NCDWQ guidelines for waste disposal (Water Balance Report: Edwin Andrews & Assoc. 2011). Soil fertility was analyzed by a regional soils analysis laboratory at NCDA (Table 4).

4.0 Site Description

The UNCBWWTF is located in Orange County near the town of White Cross in the Bingham Township off Orange Chapel Clover Garden Road (SR 1956) (Figure 1). The property consists of several agricultural hay fields currently out of production, adjacent and abutting regenerating and mature pine fringe forest, hardwood forest, and adjacent mature mixed pine and hardwood forest. Existing facility structures occur on the site as well as in entrance road, existing wastewater irrigation system and infrastructure, and a newly constructed expansion wastewater irrigation system, storage lagoon, and irrigation infrastructure. Several intermittent stream, wetland, and floodprone complexes occur on the north and east sides of the receiver site. Several drainages course through the property draining upland areas into Collins Creek, a tributary to the Haw River. The site is located in the Piedmont Physiographic Province in the vicinity of the Haw River that is characterized by rolling topography bisected by narrow perennial and intermittent streams.

The soils present on the proposed receiver sites, according to the Orange County Soil Survey (USDA, GIS 2010), are mapped as Georgeville silt loam, Herndon silt loam, as well as lowland loam soils consisting of Chewacla series soils. These mapping units were found on the site in similar locations indicated by the Orange County Soil Survey. Several small ephemeral, intermittent, and perennial drainages extend away from the receiver site connecting water conveyances on and off the site. These drainages were delineated and appropriate setbacks established to calculate irrigable soil areas (Biohabitats, 2010). These drainage areas will be protected from irrigation application with vegetative buffers that will capture and utilize subsurface irrigation water and rainfall runoff.

Soils in the upland areas are typical of piedmont Carolina Slate Belt series soils with considerable variability within the catena and within each soil series including depth, color, and texture. Topography is rolling near drainages with slopes ranging from 2 to 6 percent. Shallow soils were found on ridges and areas historically farmed and now in pine forest vegetation. Soils in the lowland areas are typical of floodplain soils with periodic flooding and inundation characteristics, but very well drained adjacent to the water conveyance.

The vegetation on the proposed forested land application areas consist of upland pine and hardwoods including: yellow poplar (*Liriodendron tulipifera*), hickory (*Carya* sp.), northern red oak (*Quercus rubra*), white oak (*Quercus alba*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), sugar maple (*Acer saccharum)*, Loblolly pine (*Pinus taeda*), Shortleaf pine (*Pinus echinata*), Virginia pine (*Pinus virginiana*), sassafras (*Sassafras albidum*), and other small understory woody species. Vegetation in the fields and open areas consist of a variety of herbaceous grasses, forbs, and broadleaf species. Fields will either be kept

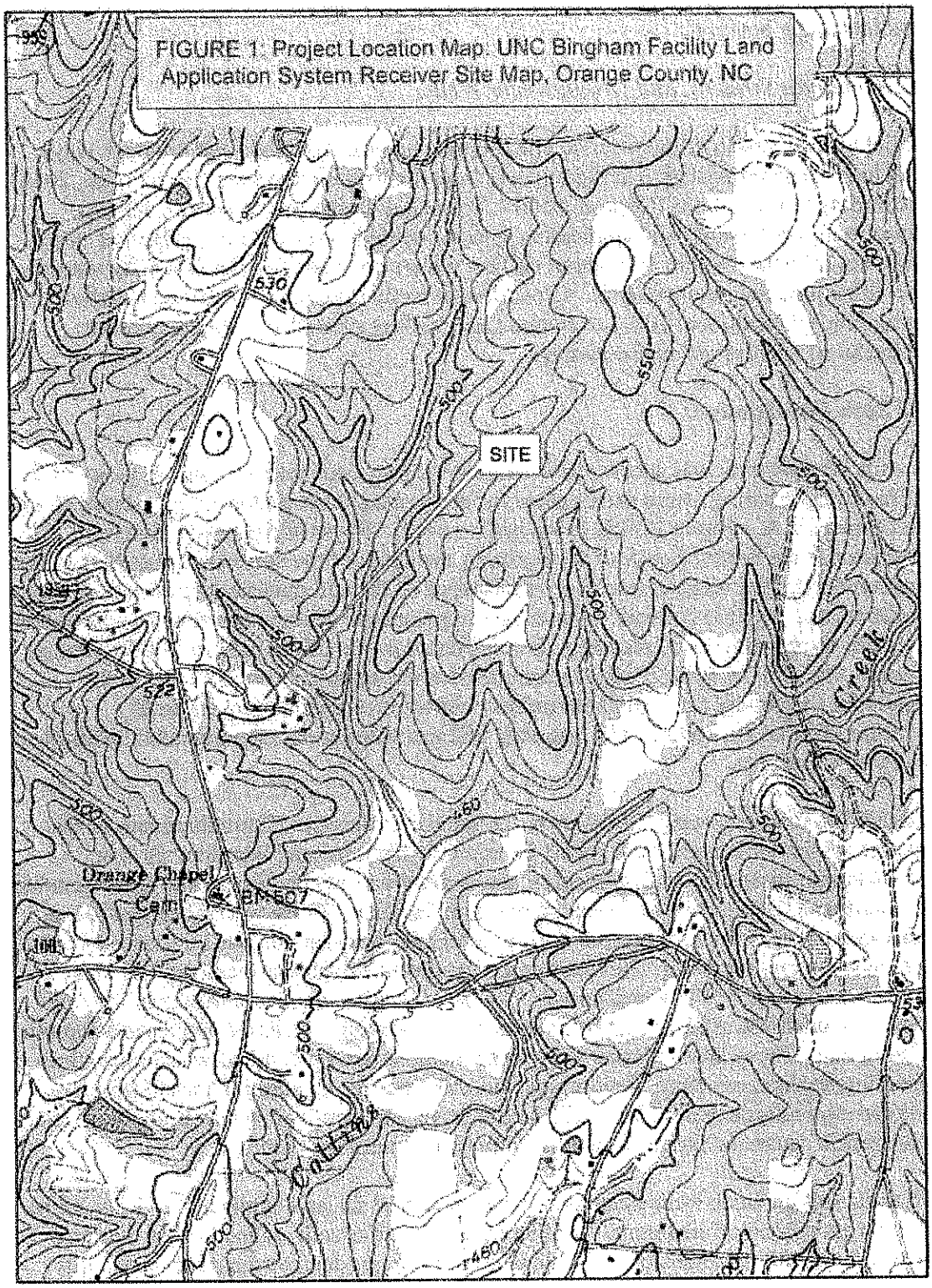

FIGURE 1: Project Location Map: UNC Bingham Facility Land Application System Receiver Site Map, Orange County, NC

Source: NCDOT USGS 1:24,000 (GIS, 2010)

open and planted with perennial forage grasses such as coastal Bermuda or fescue, or will be planted with an appropriate tree species selected for the soil, proposed liquid loadings, and landscape position.

4.1 Wetlands, Streams, and Groundwater Wells:

A field investigation of the receiver site revealed areas of wetlands and drainage ways that have been delineated to avoid impacts from the irrigation system (Biohabitats, 2010). According to regulations (Section .0500 – Waste not discharged to surface waters) concerning wastewater land application systems using treated effluent, irrigation spray shall not influence within 100 feet of surface waters not classified SA (shellfish waters), including jurisdictional wetlands. Groundwater wells have been located and buffered accordingly. Additional 100 foot Jordan Lake buffers were also included in these setbacks on appropriate surface waters.

4.2 Soils Investigation:

A soils investigation was accomplished across the proposed receiver site. A series of 3.5 in. hand auger borings were done across the site to maximum depths ranging from 36 - 84 in. (Appendix A – Figure 2: Site Investigation Map). These borings were done to characterize the depth of each of the horizons, the color of the soil material at each of the various depths, the texture, structure, consistence of the soil material within each of the horizons, and depth to bedrock or other limiting horizon. These augerings were also done to verify the boundaries of mapping units indicated in the USDA soil survey for Orange County, NC (USDA GIS, 2010). Descriptions of the augerings are included in the Appendix (Appendix C: Soils Descriptions) and were utilized to make a field determination of the specific soil mapping unit and subsequent recommended hydraulic and liquid loadings.

The USDA Orange County Soil Survey for the site shows two (2) predominant series present within the irrigable soil areas: Georgeville silt loam and Herndon silt loam. Considerable variability in depth, color, and texture was evident across the site depending on landscape position and historical agricultural land use. These variations resulted in subsequent variations in hydraulic loading potentials between the two soil series but not within soil series sampling. Field investigations revealed similar locations for the soil series relative to the NRCS soil survey. The soils described and delineated in the field were separated into different Soil Areas each representing a different proposed hydraulic loading rate. These loading rates were determined in part by detailed soils descriptions including texture, structure, mineralogy, and consistence. In addition these Soil Areas and corresponding potential hydraulic loadings were determined by site topography and site specific saturated hydraulic conductivity (Ksat) measurements.

Uplands and lowlands were examined for the potential for land application. Soils in the uplands are typical of piedmont Carolina Slate Belt series soils with silt loam textures, deep soils on side and toe slopes, shallow soils on ridges, and considerable variability across the site. Topography is flat to rolling near drainages with slopes ranging from 2 to

6 percent. Potential hydraulic loading rates will be limited by the soil with the lowest Ksat within each proposed Soil Area.

The hand auger borings confirmed that the soils mapped on the site according to NRCS (USDA) are present in the proposed receiver areas. The majority of the soils on the proposed receiver site consist of Georgeville and Herndon silt loam soils, with the remainder of the lowlands consisting of Chewacla loam soils. Soil Area 1 (SA1) soils on the receiver site consist of Georgeville silt loam soils. Slopes range from 2-6%. These soils are very deep, well drained, moderately permeable soils that formed in material mostly weathered from fine-grained metavolcanic rocks of the Carolina Slate Belt. Seasonal high water is typically >6 ft. SA1 soils comprise approximately 62% (3.56 ac) of the total receiver site acreage (5.71 ac).

Soil Area 2 (SA2) soils on the receiver site consist of Herndon silt loam soils. Slopes range from 2-6%. These soils are very deep, well drained, moderately rapid permeability soils that formed in material mostly weathered from fine-grained metavolcanic rock of the Carolina Slate Belt. Seasonal high water is typically >6 ft, however soil variabilities across the site indicate some seasonal perching conditions closer to the surface, probably indicative of slower permeable inclusions. SA2 soils comprise approximately 37% (2.15 ac) of the total receiver site acreage (5.71).

A description of the soil areas including predominant soil series, and existing vegetation is summarized in Table 3.

Table 3: UNCBWWTF Land Application System Receiver Site Soil Area Descriptions.

Soil Area	Predominant Soil Series	Existing Vegetation
SA-1	Georgeville	Grass, Mixed Pine/Hardwood
SA-2	Herndon	Grass

4.3 Soils Analysis:

A composite sample of the top 0-12 inches of soil representing the irrigable upland areas was collected and analyzed for nutrient composition by NCDA (Table 4). Soil analyses of the proposed irrigation site indicate that there are nutrient deficiencies, especially nitrogen and phosphorus. This conclusion is based on the potential crop response to particular nutrients if fertilizer is applied to the site. The cation exchange capacity (CEC) and base saturation (BS%) are low as well. The addition of wastewater to the site will improve soil fertility and consequently the growing conditions and productivity of this site. Additional agronomy recommendations are found in the Agronomist Report (SWE Group, 2011)

Table 4: Composite Soil Analysis of Uplands (N=22) at the UNCBWWTF Receiver Site, Orange County, NC (2010)[1].

Depth	pH	P ppm (Index)[2]	K ppm (Index)	Ca ppm (%)	Mg ppm (%)	CEC[3]	BS%[4]
Georgevillle							
0-6 in.	4.9	6.0 (5. (5.0)	66.0 (33.8)	228.9 (35.1)	115.4 (17.9)	6.1	55.6
6-12 in.	5.1	2.3 (1.9)	47.6 (24.3)	161.4 (29.3)	102.3 (18.6)	5.3	50.1
Herndon							
0-6 in.	4.7	51.3 (42.7)	70.7 (36.1)	212.6 (34.4)	82.2 (13.1)	6.1	50.7
6-12 in.	5.0	9.8 (8.2)	65.2 (33.3)	183.7 (33.0)	96.1 (16.8)	5.5	52.7

[1] Laboratory Soil Test Reports (2010).
[2] Index values reported by NCDA (2010) http://www.ncagr.com/agronomi/pdffiles/ustr.pdf
[3] Cation exchange capacity (meq/100g) – defined as the amount of cations adsorbed on soil-particle surfaces per unit mass of the soil under chemically neutral conditions.
[4] Base saturation – defined as the percentage of the CEC occupied by base cations

5.0 Hydrology

5.1 Liquid Loadings

The liquid loading limit represents the amount of liquid (in/wk), which can be applied to land receiver sites, including nutrients. These values are represented as the annual, monthly, weekly, and hourly maximum loadings that can be assimilated on a wastewater receiver site. A water balance was calculated for each Soil Area to determine suitable liquid loadings according to the in-situ properties of the site that most influence these loadings.

The soils present are generally silt loam soils with slopes ranging from 2-6% on Soil Areas 1 and 2. Wastewater should not be applied at an instantaneous rate exceeding 0.5 in/hr on Soil Area 1 and 2. The maximum instantaneous loading rate was determined utilizing published infiltration rate data for the particular soil and landscape position at the existing wastewater receiver site (Sprinkler Irrigation, 1969). However, these numbers are somewhat conservative given the acceptable range of maximum instantaneous loading rate for these soils and ideal site conditions and can be increased up to 50% under ideal conditions (Table 5).

Table 5: Typical Ranges of Soil Infiltration Rates by Soil Texture and Slope.

	Basic Infiltration Rate (in/hr[1])		
	Slope		
Texture	**0-3%**	**3-9%**	**9+%**

Sands	1.0+	0.7+	0.5+
loamy sands	0.7-1.5	0.5-1.0	0.4-0.7
sandy loams and fine sandy loams	0.5-1.0	0.4-0.7	0.3-0.5
very fine sandy loam and silt loam	0.3-0.7	0.2-0.5	0.15-0.3
sandy clay loam and silty clay loam	0.2-0.4	0.15-0.25	0.1-0.15
clay and silty clay	0.1-0.2	0.1-0.15	<0.1

Source: Sprinkler Irrigation Association, Sprinkler Irrigation (1969)
1. For good vegetative cover, these rates may be 25-50% greater. For poor surface conditions, rates may be as much as 50% less.

During the soils investigation, the most restrictive soil horizons were noted to determine the appropriate Soil Areas and to estimate or measure saturated hydraulic conductivity in these restrictive horizons. Saturated hydraulic conductivity (K_{sat}) values were obtained from 22 sample points across the receiver site using a portable constant head permeameter (CHP) (Table 6). Test locations for soil hydraulic conductivity are shown on the site investigation map in Appendix A. From the site specific data, the Ksats for Soil Areas 1 and 2 were determined to have a geometric mean of 0.04 in/hr and 0.033 in/hr respectively (Appendix B – Saturated Hydraulic Conductivity Data) (Water Balance Report – Edwin Andrews & Assoc., 2011). Due to site variabilities and to improve site operations, the lowest geomean Ksat was selected to represent both soil areas. Therefore, both soil areas will be loaded at the same rate across the site at .033 in/hr (Edwin Andrews and Associates, 2011). These values represented the soil hydraulic characteristics of the irrigable soils and were incorporated into a comprehensive water balance. (Edwin Andrews & Assoc., PC, 2011).

It should also be noted that a forested land application system design was selected for a portion of this receiver site to maximize evapotranspiration, and improve soil quality; including structure and vertical and horizontal hydraulic conductivities. Root channels from the tree cover crop effectively improve the hydraulic conductivities of soils found on site above what can typically be calculated from discreet CHP data points and as reflected in the Ksat values used for each soil area in the water balance.

Table 6: Average Saturated Hydraulic Conductivity (Ksat) Data for the UNCBWWTF Receiver Site.

Soil Area	Horizon	Average Depth (in.)	cm/hr [1]	in/hr *
1	Bt	19.8	.08	0.034
2	Bt	19.3	.07	0.033
SA1 & SA2				.033

1.] Based off Ksat data collected across the project site for each Soil Area (Appendix B – Saturated Hydraulic Conductivity Data) (SWE Group, 2010 and Edwin Andrews & Associates, 2010)
*Water Balance conducted by Edwin Andrews and Associates, 2011.

Depending on zone layout and design it is recommended that some type of automated system be installed to allow efficient use of varying soil areas and irrigable areas. All irrigable soils (Figure 3 – Irrigable Soils Map) should be managed for irrigation according to antecedent rainfall and time of year to minimize ponding and runoff potential.

5.2 Wastewater Characterization:

The proposed secondary effluent irrigation water can be described as containing varying levels of essential plant nutrients, organic compounds, trace minerals, and potentially phytotoxic compounds. Each of these wastewater constituents are assimilated or transformed on a receiver site through physical, chemical, and biological processes. The irrigation water proposed for application on this system will go through a series of pretreatment stages preparatory to slow rate irrigation on a dedicated receiver site.

Additional sampling and monitoring of wastewater and soils on the receiver site is recommended to ensure optimal performance of the proposed irrigation system. Irrigation water should have SAR values ≤ 10 to avoid potential salting problems in the soil. Periodic application of gypsum may be required as a corrective measure if the SAR is consistently above 10. The proposed effluent is anticipated to have SAR values safe for irrigation. Proposed data from the design facility indicates low levels for N and P in treated effluent. Therefore, supplemental nutrients may be required.

5.3 Wastewater Remediation:

Irrigation water will be utilized in several ways on the receiver site. Some water will be lost directly by evaporation of the water from the sprinkler heads. Water will be lost through transpiration by vegetation, evaporation from the vegetation and soils surface, and percolation through the soil profile. Any excess nutrients in the wastewater will be treated through microbial processes, plant uptake, adsorption to soil solids, and biologically mediated chemical transformations (i.e. denitrification). Based on the wastewater analysis, there is little potential for percolation of nutrients below the root zone.

5.4 Water Budget:

A water balance was calculated by Edwin Andrews & Assoc., PC based on specific site data and utilized as an aid for system design. This water balance can be represented by:

Evapotranspiration + Natural Runoff + Drainage = Precipitation and Irrigation

Drainage rate was estimated based on qualitative observations, soil chemical and physical data, and site specific hydraulic conductivity data (K_{sat}). Long-term precipitation values used in the water balance represent the wet-year for the region (Chapel Hill, NC).

Evapotranspiration data was utilized from data determined by the Thornthwaite method for calculating PET, one appropriate method for the Southeastern region.

The estimated water balance calculations illustrate the amount of wastewater that can be applied to the receiver site under wet rainfall year conditions, given there are no nutrient limitations. The facility should be designed to handle larger flow volumes when antecedent moisture conditions allow for additional irrigation such as during dry rainfall years. When irrigation water cannot be sprayed due to weather or site conditions, the water is put into storage. The water balance is used to optimize wastewater loadings and allow removal from storage. The drainage rate used is based on the K_{sat} of the soils. In determining the water balance, the percolation rate (Pw) was estimated to be conservatively, .04% of K_{sat} for Soil Areas 1 and 2. The EPA method (EPA, 1981) adopted by NCDWQ recommends that the drainage rate used is between 4-10% of the saturated hydraulic conductivity (K_{sat}) of the soils. This percolation rate is recommended for this system based on the potential accumulation of organic matter and migration of fine soil particles during the operation of this system, as well as the time of year that saturated hydraulic conductivity measurements occurred. The K_{sat} used to determine drainage represents this expression of organic material and soil fines, as well as the existing soil characteristics such as structure and texture found at the proposed receiver site and soil moisture conditions at the time of measurement.

It should be noted that K_{sat} values for discrete locations in Soil Areas can understate or overstate actual hydraulic dynamics across the site due to extensive tree root systems, root channels, and improved soil quality characteristics from these root systems; such as soil structure, % organic matter, and soil macro fauna channels.

The water losses are evapotranspiration (ET), drainage, and rainfall runoff. The potential additions are rainfall and irrigation. The method used for the water balance uses the wettest conditions over a long-term period as measured by the 80^{th} percentile precipitation data for each month. Actual irrigation rates can double under drier conditions than those used for the water balance. In addition, ET would increase with decreasing rainfall and thus increase the amount of irrigation water that can be utilized. It should be noted that expected ET values for the forest system are much higher than ET data used in water balance calculations. Operators should be given sufficient permit flexibility to allow additional hydraulic loadings to take full advantage of the benefits provided by the forest or forage cover crop and to ultimately meet the maximum potential hydraulic capacity of the system without resulting in runoff or ponding.

6.0 Environmental Effects

When managed properly, there will be no adverse environmental effects from the use and operation of the proposed UNCBWWTF land application system receiver site. The irrigation water used will be effectively treated by the receiver site and growing crops before these waters enter surface and/or groundwaters. The use of this irrigation water will ultimately increase soil fertility and productivity of the site, as indicated by soils

analysis and crop productivity, and will enhance adjacent wetlands and low lying areas with increased base flow. If managed properly, the existing wastewater land application system will have no adverse impacts to groundwater supplies or surface water supplies. The addition of water and nutrients to the site will benefit wildlife through increased biological activity in adjacent wetlands and low lying areas, and the irrigation operation may actually contribute to base flow in this river system.

7.0 Results / Discussion

The soils investigated at the UNCBWWTF land application system receiver site are suitable for wastewater application. The best soils are deep, well-drained, and have moderate permeabilities. The soils were grouped into two (2) separate soil areas, each with specific loading rates (Table 7). A geometric mean loading rate was utilized using the most conservative soils on site thereby combining all soil areas into one design Soil Area.

Table 7: Soils, Irrigable Area, and Recommended Wastewater Loadings for the UNCBWWTF Land Application System Receiver Site.

Soil Area	Predominant Soils	acres[1]			
			in/wk[2]	gpd[3][4][5]	Seasonal
1	Georgeville	3.56	.21	2,896	No
2	Herndon	2.15	.21	1,749	No
Design *	SA1 & 2	5.71	.21	4,645	No

1] Acreages account for setbacks from waterways, wetlands, streams, property lines, dwellings, and water supply wells for a 4,645 gpd system.

2] Rate based on recommended application rates calculated by a comprehensive Water Balance Report (Edwin Andrews & Assoc., PC, 2010) and local wet rainfall year data.

3] Based on a 7 day irrigation week.

4] Recommended hydraulic loading over an entire irrigation year including storage constraints.

5] Irrigation rate shown is the maximum that should be used in computing receiver site capacity unless or until a higher loading rate is shown to be sustainable based on actual field performance and storage capacity limitations. Use of forest cover crop may result in higher than estimated transpiration and drainage rates. Operators at a minimum need the permit flexibility to apply irrigation water at a rate high enough to sustain plant growth without causing runoff or ponding, which during extended dry periods (drought conditions) could exceed the rates shown in the table.

* Actual irrigable area utilized in Water Balance Report (Edwin Andrews & Assoc., PC, 2011).

Saturated hydraulic conductivity tests were performed to determine the permeability of the most restrictive horizon. These measurements were obtained from selected sample points across the site. These values were used to determine the hydraulic loading capacity of the receiver site. The most restrictive horizon in these soils have saturated hydraulic conductivities ranging from .29 to 0.01 in/hr for all Soil Areas. The most restrictive saturated hydraulic conductivities were determined in the Bt horizons of all Soil Areas.

According to the final Water Balance Report (Edwin Andrews & Assoc., PC, 2011) for the selected receiver site, existing soils and vegetation can accept maximum hydraulically

limited liquid loadings of 10.92 in/yr applied to Soil Areas 1 and 2 (4,645 gpd). Recommended weekly application is .21 in/wk for both soil areas based on local wet year rainfall data. Actual loadings may be adjusted in the future according to site specific characteristics, system operation, and storage modifications.

Overall, the site is a viable option for wastewater application. The irrigation water applied will provide supplemental nutrients and a consistent source of water to growing crops capable of producing large amounts of biomass and providing favorable soil conditions to enhance adsorption and denitrification of phosphorous and nitrogen respectively. With proper site management, hydraulic and nutrient loading management, the site will perform as a means to treat and assimilate wastewater irrigation water and protect surface waters entering the nearby river basins.

8.0 References

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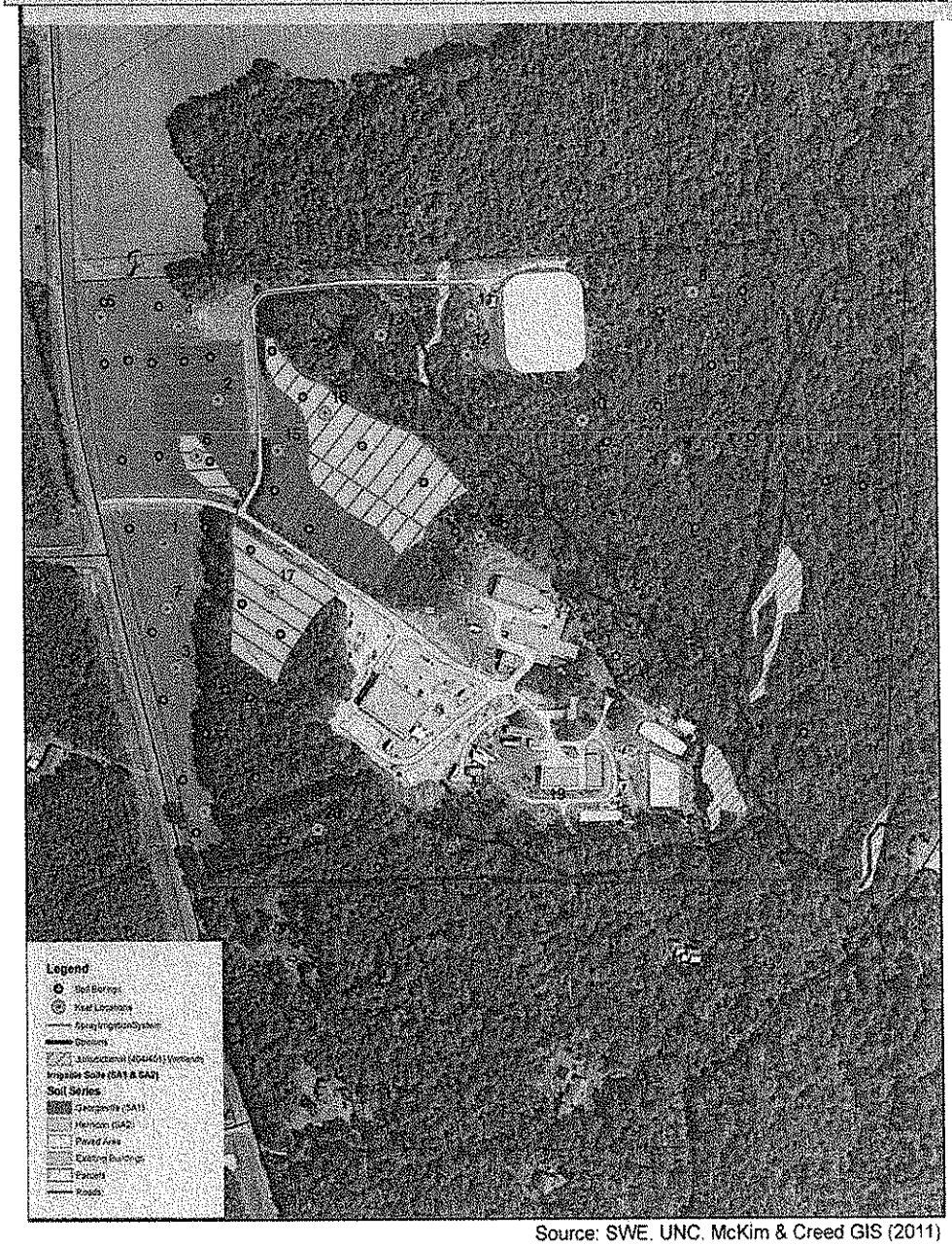
APPENDIX

APPENDIX A

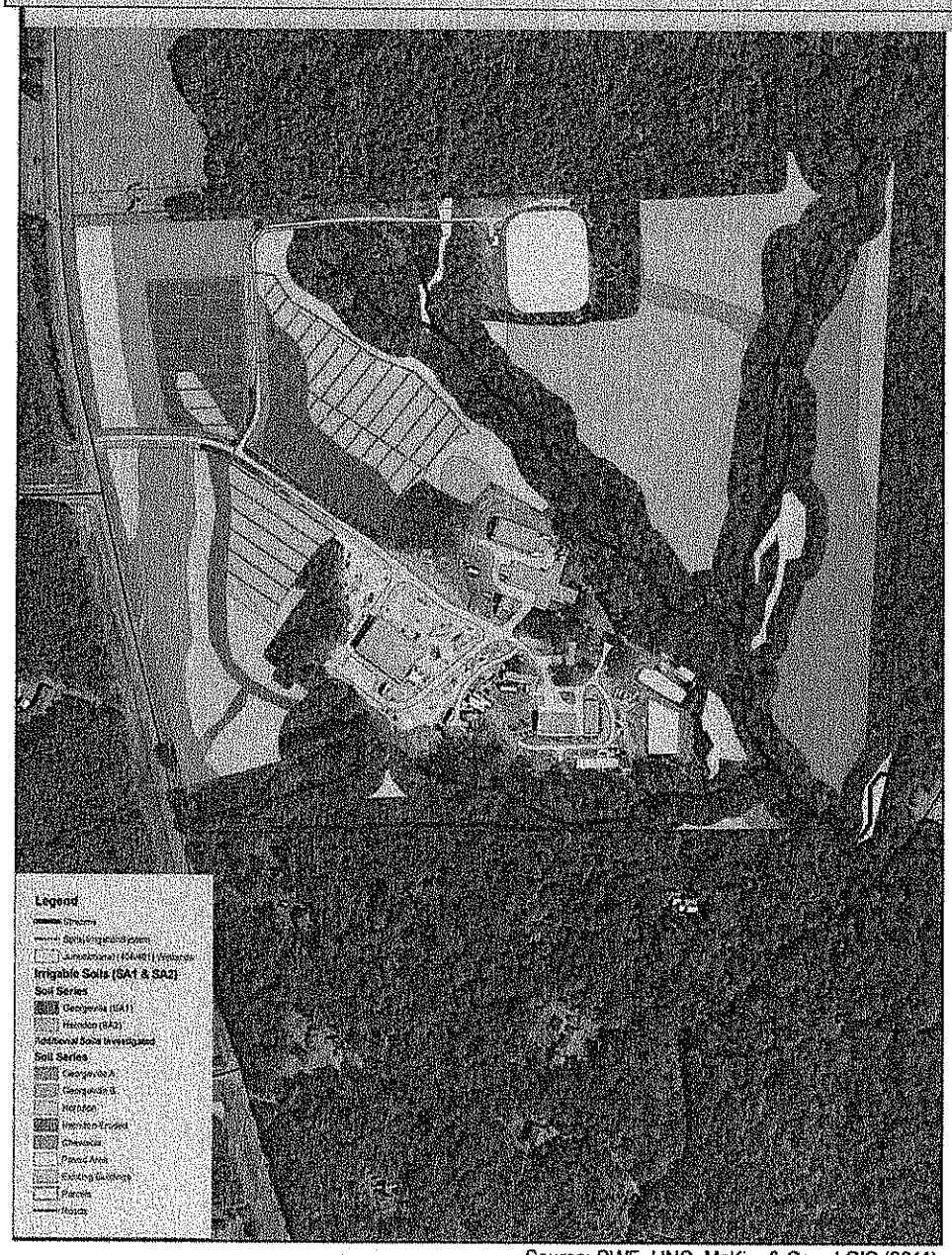
Maps

FIGURE 2: UNC Bingham Facility Land Application System Site Investigation Map



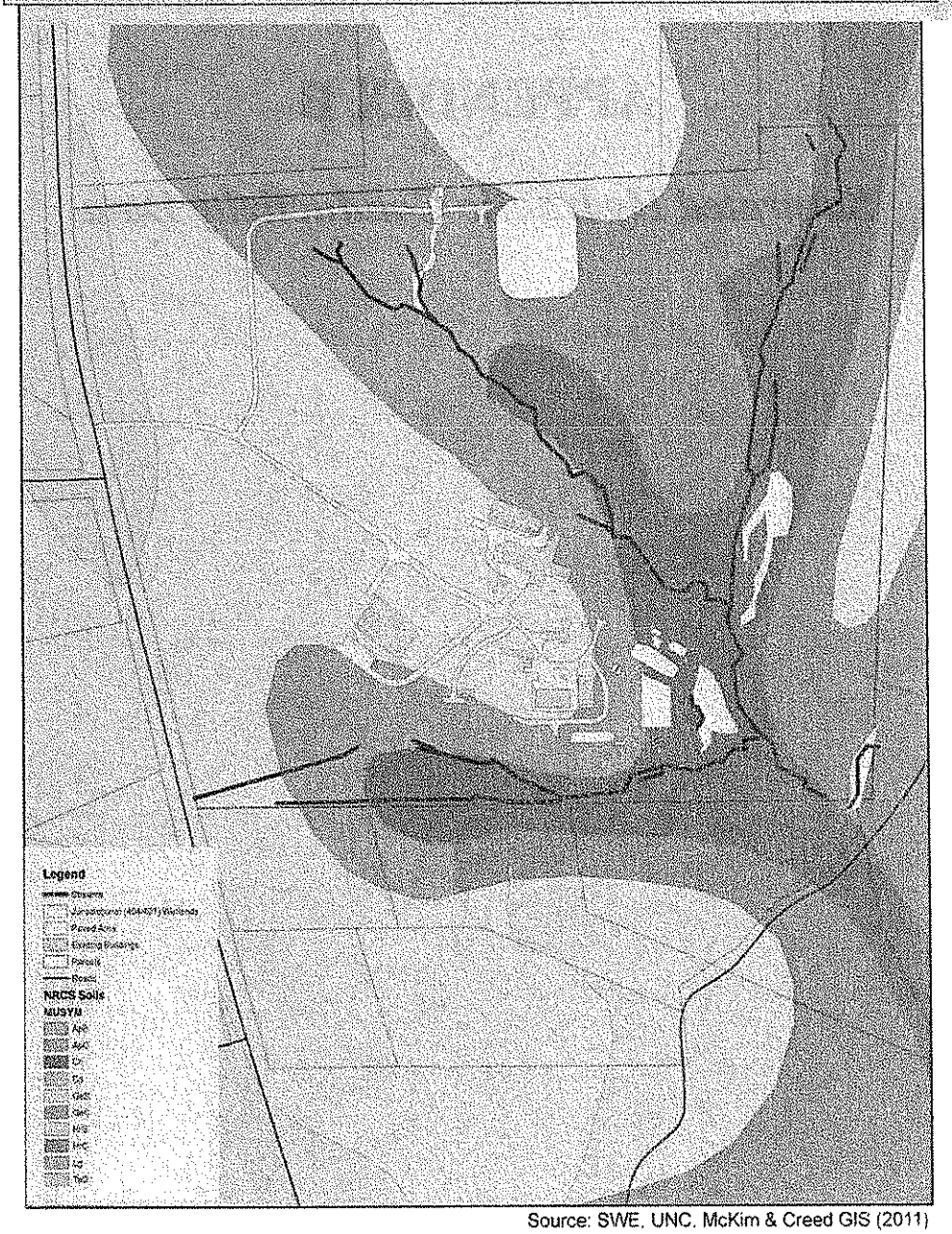
Source: SWE, UNC, McKim & Creed GIS (2011)

FIGURE 3: UNC Bingham Facility Land Application System Irrigable Soils Map



Source: SWE, UNC, McKim & Creed GIS (2011)

FIGURE 4: UNC Bingham Facility Land Application System
NRCS (USDA) Soils Map



Source: SWE, UNC, McKim & Creed GIS (2011)

APPENDIX B

Saturated Hydraulic Conductivity Data

Ksat Data Sheet

Plot:	Ksat-1	Conducted By:	SJF		
Location:	Bingham, road	Date:	4/6/10		
Weather:	sunny	Temp:	75		
Soil Series/Horizon:	Georgeville	Source of Water:	tap		

Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	48	3.0	10	58	15	5	43	33	yes		33	43	15	34.3	10:43:00	32.2	11:13:00	2.1	0:30:00	42	20	1.4	84.0	0.089	2.13	0.03	0.84
	48	3.0	10	58	15	5	43	33	yes		33	43	15	32.2	11:13:00	31.0	11:43:00	1.2	0:30:00	24	20	0.8	48.0	0.051	1.22	0.02	0.48
	48	3.0	10	58	15	5	43	33	yes		33	43	15	31.0	11:43:00	30.5	12:13:00	0.5	0:30:00	10	20	0.3	20.0	0.021	0.51	0.01	0.20
	48	3.0	10	58	15	5	43	33	yes		33	43	15	30.5	12:13:00	29.5	12:43:00	1.0	0:30:00	20	20	0.7	40.0	0.042	1.01	0.02	0.40
	48	3.0	10	58	15	5	43	33	yes		33	43	15	29.5	12:43:00	28.5	13:13:00	1.0	0:30:00	20	20	0.7	40.0	0.042	1.01	0.02	0.40
	48	3.0	10	58	15	5	43	33	yes		33	43	15	28.5	13:13:00	27.5	13:43:00	1.0	0:30:00	20	20	0.7	40.0	0.042	1.01	0.02	0.40
	48	3.0	10	58	15	5	43	33	yes		33	43	15	27.5	13:43:00	26.5	14:13:00	1.0	0:30:00	20	20	0.7	40.0	0.042	1.01	0.02	0.40
																								0.0423	1.0141	0.0166	0.3993
2/Bc	99	3.0	10	109	15	5	94	84		yes	84	94	15	36.8	11:05:00	37.2	11:50:00	1.6	0:45:00	168	105	3.7	224.0	0.237	5.68	0.09	2.24
	99	3.0	10	109	15	5	94	84		yes	84	94	15	37.2	11:50:00	34.2	12:20:00	3.0	0:30:00	315	105	10.5	630.0	0.666	15.97	0.26	6.29
	99	3.0	10	109	15	5	94	84		yes	84	94	15	34.2	12:20:00	30.6	12:50:00	3.6	0:30:00	378	105	12.6	756.0	0.799	19.17	0.31	7.55
	99	3.0	10	109	15	5	94	84		yes	84	94	15	30.6	12:50:00	27.2	13:20:00	3.4	0:30:00	357	105	11.9	714.0	0.754	18.10	0.30	7.13
																								0.7321	17.5694	0.2416	5.7992

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-2	Conducted By:	SJF		
Location:	Bingham - field/road	Date:	4/5/10		
Weather:	sunny	Temp:	75		
Soil Series/Horizon:	Ge	Source of Water:	tap		

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	Mri	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	43	3.0	10	53	15	5	38	28	yes		28	38	15	36.3	11:06:00	35.4	11:36:00	0.8	0:30:00	18	20	0.6	36.0	0.038	0.91	0.01	0.36
	43	3.0	10	53	15	5	38	28	yes		28	38	15	35.4	11:36:00	34.7	12:06:00	0.7	0:30:00	14	20	0.5	28.0	0.030	0.71	0.01	0.28
	43	3.0	10	53	15	5	38	28	yes		28	38	15	34.7	12:06:00	34.1	12:36:00	0.6	0:30:00	12	20	0.4	24.0	0.025	0.61	0.01	0.24
	43	3.0	10	53	15	5	38	28	yes		28	38	15	34.1	12:36:00	33.5	13:06:00	0.6	0:30:00	12	20	0.4	24.0	0.025	0.61	0.01	0.24
	43	3.0	10	53	15	5	38	28	yes		28	38	15	33.5	13:06:00	32.9	13:36:00	0.6	0:30:00	12	20	0.4	24.0	0.025	0.61	0.01	0.24
	43	3.0	10	53	15	5	38	28	yes		28	38	15	32.9	13:36:00	32.3	14:06:00	0.6	0:30:00	12	20	0.4	24.0	0.025	0.61	0.01	0.24
																								0.0254	**0.6085**	**0.0100**	**0.2398**
2/BC	60	3.0	10	70	15	5	55	45		yes	45	55	15	42.9	11:00:00	42.8	11:45:00	0.1	0:45:00	10.5	105	0.2	14.0	0.015	0.35	0.01	0.14
	60	3.0	10	70	15	5	55	45		yes	45	55	15	42.8	11:45:00	42.7	12:15:00	0.1	0:30:00	10.5	105	0.3	21.0	0.022	0.53	0.01	0.21
	60	3.0	10	70	15	5	55	45		yes	45	55	15	42.7	12:15:00	42.6	12:45:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
	60	3.0	10	70	15	5	55	45		yes	45	55	15	42.6	12:45:00	42.3	13:15:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
	60	3.0	10	70	15	5	55	45		yes	45	55	15	42.3	13:15:00	41.9	13:45:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	60	3.0	10	70	15	5	55	45		yes	45	55	15	41.9	13:45:00	24.9	8:57:00	17.0	16:48:00	1785	105	1.6	106.3	0.112	2.69	0.04	1.06
	60	3.0	10	70	15	5	55	45		yes	45	55	15	24.9	8:57:00	24.4	9:27:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	60	3.0	10	70	15	5	55	45		yes	45	55	15	24.4	9:27:00	23.7	10:07:00	0.6	0:40:00	63	105	1.6	94.5	0.100	2.40	0.04	0.94
	60	3.0	10	70	15	5	55	45		yes	45	55	15	24.4	10:07:00	23.7	10:37:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
																								0.1122	**2.69**	**0.0442**	**1.0605**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRI = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat 3				Conducted By:		SJF			
Location:	Bingham - front road				Date:		4/23/10			
Weather:	cloudy				Temp:		60			
Soil Series/Horizon:	Ge				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	52	3.0	10	62	15	5	47	37		yes	37	47	15	42.5	10:18:00	41.6	10:48:00	0.9	0:30:00	94.5	105	3.2	189.0	0.200	4.79	0.08	1.89
	52	3.0	10	62	15	5	47	37		yes	37	47	15	41.6	10:48:00	41.0	11:18:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
	52	3.0	10	62	15	5	47	37		yes	37	47	15	41.0	11:18:00	40.6	11:48:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	52	3.0	10	62	15	5	47	37		yes	37	47	15	40.6	11:48:00	40.2	12:18:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	52	3.0	10	62	15	5	47	37		yes	37	47	15	40.2	12:18:00	39.6	12:48:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
	52	3.0	10	62	15	5	47	37		yes	37	47	15	39.6	12:48:00	39.1	13:18:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	52	3.0	10	62	15	5	47	37		yes	37	47	15	39.1	1:18:00	38.4	1:48:00	0.7	0:30:00	73.5	105	2.5	147.0	0.155	3.73	0.06	1.47
	52	3.0	10	62	15	5	47	37		yes	37	47	15	38.4	1:48:00	38.4	2:18:00	0.0	0:30:00	0	105	0.0	0.0	0.000	0.00	0.00	0.00
																								0.1183	**2.8395**	**0.0466**	**1.1179**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-4				Conducted By:		SJF																				
Location:	Bingham, road				Date:		4/7/10																				
Weather:	sunny				Temp:		75																				
Soil Series/Horizon:	Ge (shallow)				Source of Water:		tap																				
Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	Mri	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	47	3.0	10	57	15	5	42	32		yes	32	42	15	36.0	9:40:00	35.5	10:10:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	47	3.0	10	57	15	5	42	32		yes	32	42	15	35.5	10:10:00	34.9	10:50:00	0.6	0:40:00	63	105	1.6	94.5	0.100	2.40	0.04	0.94
	47	3.0	10	57	15	5	42	32		yes	32	42	15	34.9	10:50:00	34.4	11:20:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	47	3.0	10	57	15	5	42	32		yes	32	42	15	34.4	11:20:00	34.0	11:50:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	47	3.0	10	57	15	5	42	32		yes	32	42	15	34.0	11:50:00	33.6	12:20:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	47	3.0	10	57	15	5	42	32		yes	32	42	15	33.6	12:20:00	33.2	12:50:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	47	3.0	10	57	15	5	42	32		yes	32	42	15	33.2	12:50:00	32.8	13:20:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
																								0.0887	**2.1296**	**0.0348**	**0.8384**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-5				Conducted By:		SJF																		
Location:	Bingham, road				Date:		4/12/10																		
Weather:	sunny				Temp:		60																		
Soil Series/Horizon:	yellow brown (Herndon)				Source of Water:		tap																		
Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	40	3.0	10	50	15	5	35	25		yes	25	35	15	46.0	10:00:00	44.5	10:30:00	1.5	0:30:00	157.5	105	5.3	315.0	0.333	7.99	0.13	3.14
	40	3.0	10	50	15	5	35	25		yes	25	35	15	44.5	10:30:00	43.4	11:00:00	1.1	0:30:00	115.5	105	3.9	231.0	0.244	5.86	0.10	2.31
	40	3.0	10	50	15	5	35	25		yes	25	35	15	43.4	11:00:00	42.3	11:30:00	1.1	0:30:00	115.5	105	3.9	231.0	0.244	5.86	0.10	2.31
	40	3.0	10	50	15	5	35	25		yes	25	35	15	42.3	11:30:00	41.6	12:00:00	0.7	0:30:00	73.5	105	2.4	147.0	0.155	3.73	0.06	1.47
	40	3.0	10	50	15	5	35	25		yes	25	35	15	38.9	12:20:00	38.0	12:50:00	0.9	0:30:00	94.5	105	3.2	189.0	0.200	4.79	0.08	1.89
	40	3.0	10	50	15	5	35	25		yes	25	35	15	38.0	12:50:00	37.3	13:20:00	0.7	0:30:00	73.5	105	2.5	147.0	0.155	3.73	0.06	1.47
	40	3.0	10	50	15	5	35	25		yes	25	35	15	37.3	13:20:00	36.6	13:50:00	0.7	0:30:00	73.5	105	2.4	147.0	0.155	3.73	0.06	1.47
	40	3.0	10	50	15	5	35	25		yes	25	35	15	36.6	13:50:00	35.9	14:20:00	0.7	0:30:00	73.5	105	2.5	147.0	0.155	3.73	0.06	1.47
																								0.1553	**3.7288**	**0.0611**	**1.4673**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-6				Conducted By:		SJF																		
Location:	Bingham, road				Date:		4/12/10																		
Weather:	sunny				Temp:		60																		
Soil Series/Horizon:	ylw. brn. (Herndon)-swale				Source of Water:		tap																		
Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	54	3.0	10	64	15	5	49	39		yes	39	49	15	44.3	10:15:00	43.8	10:45:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	54	3.0	10	64	15	5	49	39		yes	39	49	15	43.8	10:45:00	43.4	11:15:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	54	3.0	10	64	15	5	49	39		yes	39	49	15	43.4	11:15:00	43.2	11:45:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
	54	3.0	10	64	15	5	49	39		yes	39	49	15	43.2	11:45:00	43.0	12:15:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
	54	3.0	10	64	15	5	49	39		yes	39	49	15	43.0	12:15:00	42.8	12:45:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
	54	3.0	10	64	15	5	49	39		yes	39	49	15	42.8	12:45:00	42.6	13:15:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
																								0.0444	**1.0648**	**0.0175**	**0.4192**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-7				Conducted By:		SJF			
Location:	Bingham- road				Date:		4/23/10			
Weather:	Cloudy				Temp:		60			
Soil Series/Horizon:	Ge				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	Mri	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	38	3.0	10	48	15	5	33	23		yes	23	33	15	45.9	10:08:00	44.5	10:38:00	1.4	0:30:00	147	105	4.9	294.0	0.311	7.45	0.12	2.93
	38	3.0	10	48	15	5	33	23		yes	23	33	15	44.5	10:38:00	43.5	11:08:00	1.0	0:30:00	105	105	3.5	210.0	0.222	5.32	0.09	2.10
	38	3.0	10	48	15	5	33	23		yes	23	33	15	43.5	11:08:00	43.1	11:38:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	38	3.0	10	48	15	5	33	23		yes	23	33	15	43.1	11:38:00	42.6	12:08:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	38	3.0	10	48	15	5	33	23		yes	23	33	15	42.6	12:08:00	41.8	12:38:00	0.8	0:30:00	84	105	2.8	168.0	0.177	4.26	0.07	1.68
	38	3.0	10	48	15	5	33	23		yes	23	33	15	41.8	12:38:00	41.3	13:08:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	38	3.0	10	48	15	5	33	23		yes	23	33	15	41.3	1:08:00	40.8	1:38:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	38	3.0	10	48	15	5	33	23		yes	23	33	15	40.8	1:38:00	40.3	2:08:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
																								0.1169	2.66	0.04	1.05

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-8				Conducted By:		SJF			
Location:	Bingham, New site				Date:		4/13/10			
Weather:	sunny				Temp:		65			
Soil Series/Horizon:	Pacolet				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	47	3.0	11	58	15	5	43	32		yes	32	43	15	41.1	10:07:00	40.8	10:40:00	0.3	0:33:00	31.5	105	1.0	57.3	0.061	1.45	0.02	0.57
	47	3.0	11	58	15	5	43	32		yes	32	43	15	40.8	10:40:00	40.5	11:10:00	0.3	0:30:00	31.5	105	1.0	63.0	0.067	1.60	0.03	0.63
	47	3.0	11	58	15	5	43	32		yes	32	43	15	40.5	11:10:00	40.2	11:40:00	0.3	0:30:00	31.5	105	1.0	63.0	0.067	1.60	0.03	0.63
	47	3.0	11	58	15	5	43	32		yes	32	43	15	40.2	11:40:00	39.9	12:10:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
																								0.0650	**1.5609**	**0.0256**	**0.6145**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-9				Conducted By:		SJF			
Location:	Bingham, New site				Date:		4/13/10			
Weather:	sunny				Temp:		65			
Soil Series/Horizon:	Pacolet				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	42	3.0	10	52	15	5	37	27		yes	27	37	15	44.0	10:27:00	43.7	11:00:00	0.3	0:33:00	31.5	105	1.0	57.3	0.061	1.45	0.02	0.57
	42	3.0	10	52	15	5	37	27		yes	27	37	15	43.7	11:00:00	43.3	11:30:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	42	3.0	10	52	15	5	37	27		yes	27	37	15	43.3	11:30:00	42.9	12:00:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	42	3.0	10	52	15	5	37	27		yes	27	37	15	42.9	12:00:00	42.5	12:30:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
																								0.0887	**2.1296**	**0.0349**	**0.8384**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-10				Conducted By:		SJF			
Location:	Bingham - new site				Date:		4/13/10			
Weather:	sunny				Temp:		65			
Soil Series/Horizon:	Pacolet				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	41	3.0	10	51	15	5	36	26		yes	26	36	15	45.9	10:38:00	44.8	11:15:00	1.1	0:37:00	115.5	105	3.1	187.3	0.198	4.75	0.08	1.87
	41	3.0	10	51	15	5	36	26		yes	26	36	15	44.8	11:15:00	44.2	11:45:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
	41	3.0	10	51	15	5	36	26		yes	26	36	15	44.2	11:45:00	43.9	12:15:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
	41	3.0	10	51	15	5	36	26		yes	26	36	15	43.9	12:15:00	43.6	12:45:00	0.3	0:30:00	31.5	105	1.0	63.0	0.067	1.60	0.03	0.63
	41	3.0	10	51	15	5	36	26		yes	26	36	15	43.6	12:45:00	43.3	13:15:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
																								0.0666	**1.5972**	**0.0262**	**0.6288**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-11				Conducted By:		SJF																		
Location:	behind pump house				Date:		4/13/10																		
Weather:	sunny				Temp:		65																		
Soil Series/Horizon:	yellow brown transition				Source of Water:		tap																		
Pkt	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	Mri	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt or Bc ?	62	3.0	10	72	15	5	57	47		yes	47	57	15	36.7	12:30:00	36.3	13:05:00	0.4	0:35:00	42	105	1.2	72.0	0.076	1.83	0.03	0.72
	62	3.0	10	72	15	5	57	47		yes	47	57	15	36.3	13:05:00	36.2	13:35:00	0.1	0:30:00	10.5	105	0.3	21.0	0.022	0.53	0.01	0.21
	62	3.0	10	72	15	5	57	47		yes	47	57	15	36.2	13:35:00	36.1	14:05:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
	62	3.0	10	72	15	5	57	47		yes	47	57	15	36.1	14:05:00	36.0	14:35:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
	62	3.0	10	72	15	5	57	47		yes	47	57	15	36.0	14:35:00	35.8	15:05:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
	62	3.0	10	72	15	5	57	47		yes	47	57	15	35.8	15:05:00	35.7	15:35:00	0.1	0:30:00	10.5	105	0.3	21.0	0.022	0.53	0.01	0.21
																								0.0266	**0.6389**	**0.0105**	**0.2515**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-12				Conducted By:		SJF			
Location:	behind lagoon				Date:		4/13/10			
Weather:	sunny				Temp:		65			
Soil Series/Horizon:	Bt/Bc yellow brown, transition				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	TI	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt or Bc?	58	3.0	10	68	15	5	53	43		yes	43	53	15	39.6	12:50:00	39.3	13:20:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
	58	3.0	10	68	15	5	53	43		yes	43	53	15	39.3	1:20:00	39.1	1:50:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
	58	3.0	10	68	15	5	53	43		yes	43	53	15	39.1	1:50:00	38.8	2:20:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
	58	3.0	10	68	15	5	53	43		yes	43	53	15	38.8	2:20:00	38.4	2:50:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	58	3.0	10	68	15	5	53	43		yes	43	53	15	38.4	2:50:00	38.0	3:20:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
																								0.0813	**1.9522**	**0.0320**	**0.7686**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
TI = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-13				Conducted By:		SJF																		
Location:	across wetlands				Date:		4/13/10																		
Weather:	sunny				Temp:		65																		
Soil Series/Horizon:	Bt/Bc yellow brown red mottles				Source of Water:		tap																		
Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/ Bt or Bc	41	3.0	12	53	15	5	38	26		yes	26	38	15	40.5	1:40:00	40.1	2:10:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	41	3.0	12	53	15	5	38	26		yes	26	38	15	40.1	2:10:00	40.0	2:40:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
	41	3.0	12	53	15	5	38	26		yes	26	38	15	40.0	2:40:00	39.9	3:10:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
	41	3.0	12	53	15	5	38	26		yes	26	38	15	39.9	3:10:00	39.8	3:40:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
																								0.0222	0.5324	0.0087	0.2096

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-14				Conducted By:		SJF			
Location:	Bingham- front road				Date:		4/23/10			
Weather:	cloudy				Temp:		60			
Soil Series/Horizon:	wet silty clay				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	35	3.0	10	45	15	5	30	20		yes	20	30	15	43.4	10:28:00	43.0	10:58:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	35	3.0	10	45	15	5	30	20		yes	20	30	15	43.0	10:58:00	42.6	11:28:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	35	3.0	10	45	15	5	30	20		yes	20	30	15	42.6	11:28:00	41.6	12:58:00	1.0	1:30:00	105	105	1.2	70.0	0.074	1.77	0.03	0.70
	35	3.0	10	45	15	5	30	20		yes	20	30	15	41.6	12:58:00	41.3	13:28:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
	35	3.0	10	45	15	5	30	20		yes	20	30	15	41.3	1:28:00	41.0	1:58:00	0.3	0:30:00	31.5	105	1.0	63.0	0.067	1.60	0.03	0.63
																								0.0666	**1.5972**	**0.0262**	**0.6288**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRI = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-15				Conducted By:		SJF																		
Location:	fence				Date:		4/27/10																		
Weather:	sunny				Temp:		65																		
Soil Series/Horizon:	Ge (shallow)				Source of Water:		tap																		
Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	46	3.0	10	56	15	5	41	31		yes	31	41	15	41.7	11:08:00	38.9	11:38:00	2.8	0:30:00	294	105	9.8	588.0	0.621	14.91	0.24	5.87
	46	3.0	10	56	15	5	41	31		yes	31	41	15	38.9	11:38:00	35.8	12:08:00	3.1	0:30:00	325.5	105	10.9	651.0	0.688	16.50	0.27	6.50
	46	3.0	10	56	15	5	41	31		yes	31	41	15	35.8	12:08:00	33.5	12:38:00	2.3	0:30:00	241.5	105	8.0	483.0	0.510	12.25	0.20	4.82
	46	3.0	10	56	15	5	41	31		yes	31	41	15	33.5	12:38:00	31.3	13:08:00	2.2	0:30:00	231	105	7.7	462.0	0.488	11.71	0.19	4.61
	46	3.0	10	56	15	5	41	31		yes	31	41	15	31.3	13:08:00	29.0	13:38:00	2.3	0:30:00	241.5	105	8.1	483.0	0.510	12.25	0.20	4.82
																								0.5028	**12.0678**	**0.1980**	**4.7511**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-16				Conducted By:		SJF			
Location:	W corner 'old site'				Date:		4/27/10			
Weather:	sunny/cloudy				Temp:		65			
Soil Series/Horizon:	Slope/transition yellow brown				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	Hi/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	50	3.0	10	60	15	5	45	35		yes	35	45	15	43.3	11:28:00	41.5	11:58:00	1.8	0:30:00	189	105	6.3	378.0	0.399	9.58	0.16	3.77
	50	3.0	10	60	15	5	45	35		yes	35	45	15	41.5	11:58:00	41.3	12:28:00	0.2	0:30:00	21	105	0.7	42.0	0.044	1.06	0.02	0.42
	50	3.0	10	60	15	5	45	35		yes	35	45	15	41.3	12:28:00	40.5	12:58:00	0.8	0:30:00	84	105	2.8	168.0	0.177	4.26	0.07	1.68
	50	3.0	10	60	15	5	45	35		yes	35	45	15	40.5	12:58:00	39.7	13:28:00	0.8	0:30:00	84	105	2.8	168.0	0.177	4.26	0.07	1.68
	50	3.0	10	60	15	5	45	35		yes	35	45	15	39.7	13:28:00	38.9	13:58:00	0.8	0:30:00	84	105	2.8	168.0	0.177	4.26	0.07	1.68
																								0.1775	**4.2592**	**0.0699**	**1.6769**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
Hi/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-17				Conducted By:		SJF			
Location:	inside fence				Date:		4/27/10			
Weather:	cloudy				Temp:		65			
Soil Series/Horizon:	yellow brown (shellow)				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	Mri	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	42	3.0	10	52	15	5	37	27		yes	27	37	15	40.9	11:50:00	40.5	12:20:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	42	3.0	10	52	15	5	37	27		yes	27	37	15	40.5	12:20:00	40.1	12:50:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	42	3.0	10	52	15	5	37	27		yes	27	37	15	40.1	12:50:00	39.7	13:20:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	42	3.0	10	52	15	5	37	27		yes	27	37	15	39.7	13:20:00	39.4	13:50:00	0.3	0:30:00	31.5	105	1.1	63.0	0.067	1.60	0.03	0.63
																								0.0832	1.9966	0.0328	0.7860

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-18				Conducted By:	SJF				
Location:	Old site				Date:	4/27/10				
Weather:	cloudy				Temp:	65				
Soil Series/Horizon:	Bt Pacolet				Source of Water:	tap				

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	Mri	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1	42	3.0	10	52	15	5	37	27		yes	27	37	15	24.2	2:34:00	23.6	3:04:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
	42	3.0	10	52	15	5	37	27		yes	27	37	15	23.6	3:04:00	23.0	3:34:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
	42	3.0	10	52	15	5	37	27		yes	27	37	15	23.0	3:34:00	22.4	4:04:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
	42	3.0	10	52	15	5	37	27		yes	27	37	15	22.4	4:04:00	21.8	4:34:00	0.6	0:30:00	63	105	2.1	126.0	0.133	3.19	0.05	1.26
																								0.1331	**3.1944**	**0.0524**	**1.2576**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-19				Conducted By:	SJF			
Location:	Grounds				Date:	4/27/10			
Weather:	cloudy				Temp:	65			
Soil Series/Horizon:	Ud				Source of Water:	tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Ud	33	3.0	10	43	15	5	28	18		yes	18	28	15	36.7	2:49:00	36.3	3:19:00	0.4	0:30:00	42	105	1.4	84.0	0.089	2.13	0.03	0.84
	33	3.0	10	43	15	5	28	18		yes	18	28	15	36.3	3:19:00	36.2	3:49:00	0.1	0:30:00	10.5	105	0.3	21.0	0.022	0.53	0.01	0.21
	33	3.0	10	43	15	5	28	18		yes	18	28	15	36.2	3:49:00	36.1	4:19:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
	33	3.0	10	43	15	5	28	18		yes	18	28	15	36.1	4:19:00	36.0	4:49:00	0.1	0:30:00	10.5	105	0.4	21.0	0.022	0.53	0.01	0.21
																								0.0222	0.5324	0.0087	0.2096

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf - Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Ksat Data Sheet

Plot:	Ksat-20				Conducted By:		SJF			
Location:	Neighbor fence				Date:		4/27/10			
Weather:	cloudy				Temp:		65			
Soil Series/Horizon:	transition/yellow brown				Source of Water:		tap			

Plot	hd	r	rs	D	Hi	H/r	di	$dsur_i$	1-ON	2-ON	$dsur_f$	df	Hf	MRi	Ti	MRf	Tf	Δ MR	Δ T	V	CF	Q (cm^3/min)	Q (cm^3/h)	Ksat (cm/h)	Ksat (cm/d)	Ksat (in/h)	Ksat (in/d)
1/Bt	46	3.0	10	56	15	5	41	31		yes	31	41	15	35.9	3:00:00	35.5	4:00:00	0.4	1:00:00	42	105	0.7	42.0	0.044	1.06	0.02	0.42
	46	3.0	10	56	15	5	41	31		yes	31	41	15	34.4	4:00:00	33.9	4:30:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
	46	3.0	10	56	15	5	41	31		yes	31	41	15	33.9	4:30:00	33.4	5:00:00	0.5	0:30:00	52.5	105	1.8	105.0	0.111	2.66	0.04	1.05
																								0.0887	**2.1295**	**0.0349**	**0.8384**

hd = Hole depth (cm)
r = Radius of the hole (dia./2) (cm)
rs = Distance between reference level and soil surface (cm)
D = Distance from the hole bottom to the reference level (hd+rs) (cm)
Hi = Initial desired water depth (head) in hole (cm)
H/r = Ratio of head to radius of hole (must be ≥ 5)
di = Constant-head tube setting, initial d measured in hole (di = D-Hi) (cm) - usually 1 cm less than calculated di
$dsur_i$ = Initial distance from water surface to ground (hd - Hi)
1-ON = 3-way valve turned to 1-ON (CF = 20, multiply CF times Δ MR to obtain volume of flow)
2-ON = 3-way valve turned to 2-ON (CF = 105, multiply CF times Δ MR to obtain volume of flow)
$dsur_f$ = Final distance from water surface to ground (steady state)
df = Final d measured in hole ($dsur_f$ + rs) (cm) - should be within 1-2 cm of di
Hf = Final water depth in hole (Hf = D-df) (cm)
MRi = Initial measuring reservoir reading (cm)
Ti = Initial time to record measuring reservoir level drop (min.)
MRf = Final measuring reservoir reading (cm)
Tf = Final time to record measuring reservoir level drop (min.)
Δ MR = Change in measuring reservoir level (cm)
Δ T = Change in time for measuring reservoir water drop (min.)
V = flow volume (cm^3)

Saturated Hydraulic Conductivity Data - DRAFT (UNC Bingham)

IB*	Soil Series	Horizon	Soil Area	Depth (cm)	Depth (in)	Ksat (cm/hr)	Ksat (in/hr)	Gpd/ft^2	SHWT (in)	
New Site										
1	Ge	Bt	1	48.0	18.9	**0.04**	0.02	0.25	>84 in	
1a	Ge	BC	1	98.0	39.0	**0.73**	0.29	4.31	>84 in	
2	Ge	Bt	1	43.0	16.9	**0.03**	0.01	0.15	>84 in	
2a	Ge	BC	1	60.0	23.6	**0.11**	0.04	0.66	>84 in	16 hr test
3	Ge	Bt	1	52.0	20.5	**0.12**	0.05	0.70	>84 in	
4	Ge (shallow)	Bt	1	47.0	18.5	**0.09**	0.03	0.52	>84 in	
5	Herndon	Bt	2	40.0	15.7	**0.16**	0.06	0.91	>84 in	
6	Herndon (swale)	Bt	2	54.0	21.3	**0.04**	0.02	0.26	>84 in	
7	Ge	Bt	1	38.0	15.0	**0.11**	0.04	0.65	>84 in	
14 (new)	Herndon (swale)	Bt	3	35.0	13.8	**0.07**	0.03	0.39	~24-30 in	
Old Site										
8	Ge	Bt	1	47.0	18.5	**0.07**	0.03	0.38	>84 in	
9	Ge	Bt	1	42.0	16.5	**0.09**	0.03	0.52	>84 in	
10	Ge	Bt	1	41.0	16.1	**0.07**	0.03	0.39	>84 in	
11	Herndon	Bt	2	62.0	24.4	**0.03**	0.01	0.16	>36 in	
12	Herndon	Bt	2	58.0	22.8	**0.08**	0.03	0.48	>36 in	
13	Herndon	Bt	2	41.0	16.1	**0.02**	0.01	0.13	>36 in	
17	Herndon	Bt	2	42.0	16.5	**0.08**	0.03	0.49	>84 in	
18	Ge	Bt	1	42.0	16.5	**0.13**	0.05	0.78	>84 in	
Inside Facility										
15	Ge (shallow)	Bt	1	46.0	18.1	**0.50**	0.2	3.0	>84 in	
16	Herndon	Bt	2	50.0	19.7	**0.18**	0.1	1.0	>48 in.	
19	Ud	Ud	4	33.0	13.0	**0.02**	0.009	0.1	>24 in.	
20	Herndon	Bt	2	46.0	18.1	**0.09**	0.035	0.5	>36 in.	
			Avg	SA1	19.8					
			Avg	SA2	19.3					

	New Site			
GEOMEAN	SA1	**0.07**	0.03	0.39
	SA2	**0.08**	0.03	0.49
	Old Site			
	SA1	**0.07**	0.03	0.43
	SA2	**0.04**	0.01	0.21
	Inside Facility			
	SA1	**0.50**	0.20	2.96
	SA2	**0.07**	0.03	0.41
	SA1	**0.11**	**0.04**	
	SA2	**0.07**	**0.03**	
	GEOMEAN	**0.09**	**0.03**	

APPENDIX C

Soils Descriptions

UNCBWWTF Land Application System Soils Descriptions

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-1		
Location:	Bingham road	Date:	4/6/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	2%
Classification:	Ge	Vegetative Cover:	fallow field
Aspect:	SE	Water Table:	>7'
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/6 dark yellowish brown	-	silt loam	moderate	fine	subangular blocky	friable	-	-	many fine roots, thick root mat
E	2-8	10YR 5/6 yellowish brown	-	silty clay	moderate	fine	subangular blocky	friable	-	-	few rocks/pebbles
Bt1	8-22	5YR 4/6 yellowish red	-	clay	moderate	medium	subangular blocky	friable/silt firm/slightly sticky plastic	-	-	few fine roots
Bt2	22-38	5YR 4/6 yellowish red	10YR 7/6 yellow	silty clay	moderate	medium	subangular blocky	friable/slightl y firm	-	-	
BC	38-52	5YR 4/6 yellowish red	7.5YR 6/8 yellowish red	silty clay loam	moderate	medium	subangular blocky	friable	-	-	~25% saprolitic, deep profile
C	52-84+	10YR 6/6 brownish yellow	7.5YR 5/8 strong brown	silty clay loam	weak	fine	subangular blocky	friable	-	-	good structure, multi-colored, manganese nodules/hematite

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-2		
Location:	Bingham road	Date:	4/6/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	1%
Classification:	Georgeville	Vegetative Cover:	fallow field
Aspect:	SE	Water Table:	>7'
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	5YR 5/3 red brown	-	loam	moderate	fine	subangular blocky	friable	-	-	thick root mat, many fine roots
Bt1	2-8	2.5YR 4/8 red	7.5YR 6/6 red/yellow	silty clay loam	moderate	medium	subangular blocky	slightly firm/friable	-	-	disturbed
Bt2	8-22	2.5YR 4/8 red	7.5YR 8/6 red/yellow	clay	moderate	medium	subangular blocky	firm, slightly sticky, slightly plastic	-	-	many fine, distinct red yellow mottles
BC	22-40	2.5YR 6/8 light red	2.5YR 7/3 light reddish brown	silty clay loam	moderate	fine	subangular blocky	friable	-	-	~35% saprolite
CR	40-56	7.5YR 6/2 reddish yellow	7.5YR 8/3 pink, 7.5YR 5/8 strong brown, 5YR 4/6 yellowish red	silty clay loam	weak	fine	subangular blocky	friable	-	-	multi-colored
CR2	56-84+	multi-colored saprolite	-	silty clay loam	weak	fine	subangular blocky	friable	-	-	good structure, mottled, multicolored rock

Soil, Water, & Environmental Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-3		
Location:	Bingham front road	Date:	4/23/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Ge	Vegetative Cover:	fallow field
Aspect:	SE	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-3	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, trafficked
E	3-8	10YR 5/4 yellowish brownn	-	sandy loam	weak	fine	subangular blocky	friable	-	-	
Bt1	8-18	10YR 6/6 brownish yellow	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	fine roots
Bt2	18-28	5YR 5/8 ylws. red	10YR 7/6 yellow	sandy clay	moderate	medium	subangular blocky	slightly sticky	yes	-	
BC	28-66	7.5YR 5/6 strong brn	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	15-20% saprolite
C	66-84+	5YR 5/3 reddish brn	2.5Y 7/6 pale yellow	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	multicolored rock

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-4		
Location:	Bingham road	Date:	4/7/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	State	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Ge (shallow)	Vegetative Cover:	fallow field
Aspect:	East	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Horizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots
E	2-10	10YR 5/4 yellowish brownn	-	sandy loam	weak	fine	subangular blocky	friable	-	-	gravelly 10-15% large sb b/k gravel quartz
Bt1	10-22	10YR 6/8 brownish yellow	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	some fine roots
Bt2	22-38	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red	sandy clay	moderate	medium	subangular blocky	slightly sticky	yes	-	
BC	38-60	5YR 5/8 yellowish red	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	25-30% saprolite
C	60-84+	2.5Y 7/6 yellow	2.5Y 7/6 pale yellow	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	multicolored rock, black Mn fragments

Soil, Water, & Environmental Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-5		
Location:	Bingham road	Date:	4/12/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Herndon	Vegetative Cover:	fallow field
Aspect:	East	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T.:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Horizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, shallow
E	2-10	10YR 5/4 yellowish brownn	-	silt loam	weak	fine	subangular blocky	friable	-	-	
BE	10-18	10YR 5/6 ylws brn	-	silt loam	moderate	fine	subangular blocky	friable			
Bt1	18-26	5YR 5/8 ylws red	few 10YR 7/6 ylw	silty clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	26-36	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red	clay	moderate	medium	subangular blocky	friable	yes	-	
Bt3	36-60	7.5YR 6/6 reddish ylw		silty clay	moderate	medium	subangular blocky	friable	yes	-	
C	60-84+	10YR 8/6 yellow	5 YR 5/8 red, 7.5YR 5/8 stng brn	silt loam	weak	fine	granular/ subangular blocky	friable	-	-	multicolored rock, >50% sap

Soil, Water, & Environmental Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-6		
Location:	Bingham road (field)	Date:	4/12/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	

Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Herndon (swale)	Vegetative Cover:	fallow field
Aspect:	East	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Horizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, shallow
E	2-7	10YR 5/4 yellowish brownn	-	silt loam	weak	fine	subangular blocky	friable	-	-	
BE	7-20	10YR 5/6 ylws brn	-	silt loam	moderate	fine	subangular blocky	friable			
Bt1	20-26	5YR 5/8 ylws red	few 10YR 7/6 ylw	silty clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	26-48	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red	clay	moderate	medium	subangular blocky	friable	yes	-	
Bt3	48-60	10YR 6/4 light ylws brn		silty clay	moderate	medium	subangular blocky	friable	yes	-	
C	60-84+	10YR 6/3 pale brn	10YR 8/2 v pal brn	silt loam	weak	fine	granular/ subangular blocky	friable	-	-	crushed rock

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-7		
Location:	Bingham road	Date:	4/23/2010
County:	Orange	investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Ge	Vegetative Cover:	fallow field
Aspect:	East	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Horizon Boundary	Other Remarks
Ap	0-3	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots
E	3-10	10YR 5/4 yellowish brownn	-	sandy loam	weak	fine	subangular blocky	friable	-	-	
Bt1	10-23	10YR 6/8 brownish yellow	5YR 5/8 yiws red	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	23-38	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red	sandy clay	moderate	medium	subangular blocky	slightly sticky	yes	-	
BC	38-52	5YR 5/8 yellowish red	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	15% sap
C	52-84+	2.5Y 7/6 yellow	2.5Y 7/6 pale yellow	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	fine crushed rock

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-8		
Location:	New Spray Site	Date:	4/13/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Ge or Pacolet	Vegetative Cover:	forest
Aspect:	South	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

				Structure							
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots
E	2-8	10YR 5/4 yellowish brownn	5 YR 5/6 ylws red	sandy loam	weak	fine	subangular blocky	friable	-	-	fine and med. roots
Bt1	8-24	10YR 5/8 ylws red	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	fine and med. roots
Bt2	24-50	5YR 5/8 ylws red	10YR 7/6 yellow	sandy clay	moderate	medium	subangular blocky	slightly sticky	yes	-	
BC	50-76	5YR 5/8 yellowish red	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	
C	76-84+	5 YR 6/1 gray	2.5Y 7/6 pale yellow	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	fine crushed rock

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-9		
Location:	New Spray Site	Date:	4/13/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	

Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	4%
Classification:	Ge (shallow)	Vegetative Cover:	forest
Aspect:	South	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-4	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots
Bt1	4-18	5 YR 4/6 ylws red	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	18-40	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red, 5 YR 8/1 white	sandy clay	moderate	medium	subangular blocky	friable	yes	-	crushed rock fragments
BC	40-78	5YR 7/4 pink	5YR 8/1 white, 7.5YR 5/6	sandy clay loam	moderate	medium	subangular blocky	friable	yes	-	crushed rock fragments, floaters, 25% sap
C	78-84+	2.5Y 7/6 yellow	5 YR 8/1 white	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	crushed rock, small floaters

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-10		
Location:	New Spray Site	Date:	4/13/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	4%
Classification:	Ge	Vegetative Cover:	forest
Aspect:	SW	Water Table:	>48" auger refusal
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots
E	2-13	10YR 6/3 pale brn	5 YR 5/6 ylws red	sandy loam	weak	fine	subangular blocky	friable	-	-	fine and med. roots
Bt1	13-28	10YR 5/8 ylws red	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	fine and med. roots
Bt2	28-34	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red, 5 YR 8/1 white	sandy clay	moderate	medium	subangular blocky	friable	yes	-	crushed rock fragments
BC	34-48	5YR 5/8 yellowish red	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	
C	48-84+	5 YR 6/1 gray	2.5Y 7/6 pale yellow	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	fine crushed rock, auger refusal at 50 in.

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-11		
Location:	New Spary Site	Date:	4/13/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	

Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Herndon	Vegetative Cover:	forest
Aspect:	West	Water Table:	>36" ? auger refusal
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, shallow
E	2-10	10YR 6/2 lt ylws gray	-	silt loam	weak	fine	subangular blocky	friable	-	-	fine roots
BE	10-20	10YR 7/4 v pale brn	-	silt loam	moderate	fine	subangular blocky	friable			
Bt1	20-34	10YR 6/4 lt ylws brn		silt loam	weak/mod	fine/med	subangular blocky	friable	yes	-	auger refusal, few quartz rocks

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-12		
Location:	New Spray Site	Date:	4/13/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Herndon	Vegetative Cover:	forest
Aspect:	West	Water Table:	>48" auger refusal
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, shallow
E	2-10	10YR 6/2 lt ylws gray	-	silt loam	weak	fine	subangular blocky	friable	-	-	fine roots
BE	10-18	10YR 7/4 v pale brn	-	silt loam	moderate	fine	subangular blocky	friable			
Bt1	18-34	10YR 6/4 lt ylws brn	10YR 8/1 white	silt loam	weak/mod	fine/med	subangular blocky	friable	yes	-	auger refusal, few quartz rocks
Bt2	34-46	7.5YR 5/6 strong brown	10YR 7/6 yellow, 10YR 8/1 white	clay	moderate	medium	subangular blocky	friable	yes	-	
Bt3	46-50+	7.55YR 8/6 reddish ylw		silty clay	moderate	medium	subangular blocky	friable	yes	-	auger refusal

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-13		
Location:	New Spray Site	Date:	4/13/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	2%
Classification:	Herndon	Vegetative Cover:	forest
Aspect:	SW	Water Table:	~34" perched
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, shallow
E	2-10	10YR 5/4 yellowish brownn	-	silt loam	weak	fine	subangular blocky	friable	-	-	
BE	10-18	10YR 5/6 ylws brn	-	silt loam	moderate	fine	subangular blocky	friable/sticky			
Bt1	18-34	5YR 5/8 ylws red	few 10YR 7/6 ylw	silty clay	moderate	medium	subangular blocky	friable/firm	yes	-	evidence of perched WT at 34 in.
Bt2	34-45	10YR 8/2 v pale brn	10YR 7/6 yellow 5YR 5/8 yellowish red	clay	moderate	medium	subangular blocky	friable/sticky	yes	-	water movement
Bt3	45-50+	10YR 6/6 brns ylw	10YR 7/6 yellow 5YR 5/8 yellowish red, 10YYR 8/1 white	silty clay	moderate	medium	subangular blocky	friable	yes	-	auger refusal at 50 in., rock

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-14		
Location:	Bingham road	Date:	4/14/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	State	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Herndon	Vegetative Cover:	fallow field
Aspect:	SE	Water Table:	>48"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Horizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine grass roots
E	2-6	10YR 5/4 yellowish brownn	-	silt loam	weak	fine	subangular blocky	friable	-	-	fine roots
BE	6-18	10YR 5/6 ylws brn	-	silt loam	moderate	fine	subangular blocky	friable			fine roots
Bt1	18-30	5YR 5/8 ylws red	few 10YR 7/6 ylw	silty clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	30-38	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red	clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt3	38-62	7.55YR 8/6 reddish ylw		silty clay	moderate	medium	subangular blocky	friable	yes	-	evd of water movement
C	62-84+	10YR 8/6 yellow	5 YR 5/8 red, 7.5YR 5/8 stng brn, 10YR 8/1 white	silt loam	weak	fine	granular/ subangular blocky	fiable	-	-	multicolored rock, >50% sap

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-15		
Location:	Near Old Site	Date:	4/27/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	<1%
Classification:	Ge (shallow)	Vegetative Cover:	forest
Aspect:	NE	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, duff
E	2-8	10YR 5/4 ylws brn	-	sandy loam	weak	fine	subangular blocky	friable	-	-	
Bt1	8-28	5YR 5/4 reddish brown	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	some fine roots, saprolite floaters
Bt2	28-38	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red, 10YR 8/2 v pale brn	sandy clay	moderate	medium	subangular blocky	slightly sticky	yes	-	
BC	38-65	5YR 5/8 yellowish red	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	25-30% saprolite
C	65-84+	2.5Y 7/6 yellow	2.5Y 7/6 pale yellow	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	multicolored rock

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-16		
Location:	Old Site (W corner	Date:	4/27/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	4-8%
Classification:	Herndon	Vegetative Cover:	forest
Aspect:	East	Water Table:	>84"
Landscape Position:	side slope transition	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Horizon Boundary	Other Remarks
Ap	0-3	10 YR 3/1 v dk gray	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, dark, fibrous duff
E	3-8	2.5Y 7/1 lt gray	-	silt loam	weak	fine	subangular blocky	friable	-	-	fine roots
BE	8-38	2.5Y 6/4 lt ylws brn	2.5Y 7/1 lt gray, 2.5Y 8/1 white, charcoal	silt loam	moderate	fine	subangular blocky	friable			charcoal fragments, disturbed soil
Bt1	38-50	7.5YR 6/6 reddish ylw	10YR 6/4 lt ylws brn	silty clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	50-74	2.5YR 7/4 lt reddish brn		silty clay	moderate	medium	subangular blocky	friable	yes	-	
Bt3	74-84+	7.5YR 5/6 strong brown		silty clay	moderate	medium	subangular blocky	friable	yes	-	saprolite fragments

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-17		
Location:	Old Spray Site	Date:	4/27/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	6%
Classification:	Herndon	Vegetative Cover:	forested
Aspect:	SE	Water Table:	>72" auger refusal
Landscape Position:	side slope	S.H.W.T.:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, shallow
E	2-10	10YR 7/6 yellow	-	silt loam	weak	fine	subangular blocky	friable	-	-	very dry, fine roots
BE	10-20	10YR 5/6 ylws brn	-	silt loam	moderate	fine	subangular blocky	friable			very dry
Bt1	20-30	10YR 6/4 lt ylws brn		silty clay	moderate	medium	subangular blocky	friable/firm	yes	-	
Bt2	30-60	2.5Y 7/3 pale ylw	2.5Y 8/1 white	silty clay	moderate	medium	subangular blocky	friable	yes	-	
Bt3	60-70+	2.5Y 6/4 lt ylws brn		silty clay	moderate	medium	subangular blocky	friable	yes	-	

Soil, Water, & Environmental Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-18		
Location:	Bingham road	Date:	4/27/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Ge (shallow)	Vegetative Cover:	fallow field
Aspect:	East	Water Table:	>84"
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots
E	2-10	10YR 5/4 yellowish brownn	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine and med roots
Bt1	10-36	5YR 5/8 yellowish red	-	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	some fine roots
Bt2	36-58	7.5YR 5/6 strong brown	10YR 7/6 yellow 5YR 5/8 yellowish red	sandy clay	moderate	medium	subangular blocky	slightly sticky	yes	-	
BC	58-73	7.5YR 5/6 strong brown	10YR 7/6 yellow	sandy clay loam	moderate	medium	subangular blocky	friable/firm	yes	-	15-25% saprolite
C	73-84+	2.5Y 7/6 yellow	2.5Y 7/4 pale yellow, 7.5YR 5/6 stng brn	sandy loam	weak	fine	granular/ subangular blocky	fiable	-	-	multicolored rock, >50% saprolite

Soil, Water, & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-19		
Location:	Facility Grounds	Date:	4/27/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	

Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Ud Ge	Vegetative Cover:	landscaped area
Aspect:	South	Water Table:	<36 in. disturbed
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ud1	0-2	5YR 5/8 ylws red	-	sandy clay	moderate	medium	subangular blocky	friable	-	-	fine roots, very disturbed
Ud2	2-14	2.5Y 6/6 olive ylw	5YR 5/8 ylws red	sandy clay	moderate	medium	subangular blocky	friable/firm	-	-	buried roots, debris
Ud3	14-24+	10YR 6/3 pale ylw	multi colored	sandy clay	moderate	medium	subangular blocky	friable/firm	yes	-	some fine roots

Soil, Water & Environment Group

Soil Investigation Data Sheet

Soil Boring:	Ksat-20		
Location:	Bingham road	Date:	4/27/2010
County:	Orange	Investigator(s):	SJF
Lat./Long.:		Elev.:	
Parent Material:	Slate	Drainage (Wetness) Class:	well
Moisture Status:	moist	Slope (%):	3%
Classification:	Herndon	Vegetative Cover:	fallow field
Aspect:	East	Water Table:	>60" auger refusal at 5.5 '
Landscape Position:	side slope	S.H.W.T:	

					Structure						
Horiz.	Depth (in.)	Main Colors (moist)	Mottles	Texture	Grade	Class	Type	Moist & Wet Consist.	Ped Coatings	Hoizon Boundary	Other Remarks
Ap	0-2	10YR 4/3 brown	-	sandy loam	weak	fine	subangular blocky	friable	-	-	fine roots, med roots, OM
E	2-8	10YR 5/4 yellowish brownn	-	silt loam	moderate	medium	subangular blocky	friable	-	-	
BE	8-18	10YR 5/6 ylws brn	-	silt loam	moderate	fine	subangular blocky	friable			
Bt1	18-26	10YR 5/6 ylws brn	few 10YR 7/6 ylw, 5YR 5/6 ylws red	silty clay	weak/mod	medium	subangular blocky	friable/firm	yes	-	saprolite floaters
Bt2	26-36	5YR 5/2 reddish gry	10YR 7/6 yellow 5YR 5/8 yellowish red	clay	weak/mod	medium	subangular blocky	friable	yes	-	
BC	36-60+	5YR 5/1 gry		silty clay	weak/mod	medium	subangular blocky	friable	yes	-	auger refusal at 5.5 ft on soft rock

AGRONOMIST REPORT

FINAL

UNC Bingham WWTF

Land Application System Receiver Site

Orange County
North Carolina

Prepared for:

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Executive Summary

The objective of this report is to provide the UNC Bingham Wastewater Treatment Facility (UNCBWWTF) with recommendations for the installation, maintenance, and management of a forested and forage grass land application system on their wastewater receiver site in accordance with accepted professional guidance. This forested land application system utilizes existing tree species that are capable of producing large amounts of biomass and providing favorable soil conditions to enhance adsorption of phosphorus and denitrification of nitrogen.

The UNCBWWTF proposes to land apply wastewater to a forest and forage grass land application system on approximately 5.71 acres out of 57 acres of total land area consisting of two Soil Areas (SA) (SA1 and SA2). Specific Soil Areas were determined by the Soil Scientist Evaluation, SWE Group, 2011. According to the Soil Scientist Evaluation Report, and Water Balance Report (Edwin Andrews & Assoc., PC), approximately 4,645 gpd is available for irrigation and can be applied to all Soil Areas at one rate of .21 in/wk. based on 80%tile wet-year rainfall data. Final hydraulic loadings were determined by the Water Balance Report (Edwin Andrews & Assoc., PC, 2011) in coordination with the Soil Scientist Report (SWE Group, 2011) and this report.

Soil, Water & Environment Group (SWE Group) personnel completed a comprehensive Agronomist Report of the wastewater irrigation areas at the existing and proposed UNCBWWTF land application system receiver site. Recommendations are provided in this report concerning hydraulic loadings, nutrient loadings, as well as site and irrigation system management of this system. Cropping scenarios, species/system selection, fertilizer recommendations, vegetation establishment and management, and vegetation harvesting regimes are provided.

The wastewater proposed for application will provide supplemental nutrients and a consistent source of water to growing crops, in this case a combination of trees, forage grasses, and understory vegetation. Due to the soils, site conditions, and anticipated hydraulic and liquid loadings, the receiver site is hydraulically limited on all Soil Areas. The maximum average concentrations of nutrients (mg/L) in the wastewater at the proposed UNCBWWTF receiver site will be ~25.0 mg/L total nitrogen (TN) and estimated ~5.0 mg/L total phosphorus (TP) as reported by the system designers (McKim & Creed, 2011). This would supply at most 61.9 lbs TN/ac/yr and 12.3 lbs TP/ac/yr based on the most limiting characteristics for the soil series present. Based on effluent and site characteristics, plant available nitrogen equates to 53.2 lbs PAN/ac/yr for all soil areas. Assuming 75% availability, plant available phosphorus (PAP) would be at most approximately 9.3 lbs PAP/ac/yr for all soil areas.

These total plant available nitrogen concentrations are conservative estimates for the irrigation water and do not take into consideration denitrification occurring in the storage ponds or soil microbial interactions on the receiver site. Therefore actual plant available nitrogen (PAN) will be lower than the PAN concentrations presented.

Soil analyses at the proposed irrigation site indicate there are potential nutrient deficiencies. The wastewater will provide supplemental nutrients and a consistent source of water to growing crops. Recommendations for any nutrient amendments are provided in Table 2. Annual soil testing and monthly analysis of the wastewater should be

accomplished to determine if there are continued nutrient deficiencies at the site. This will help insure proper management of the site and optimize growing conditions.

The combination of mixed hardwood/pine forest and forage grass system at the UNCBWWTF Land Application receiver site will provide sufficient treatment and cycling of the waste irrigation water. Trees transpire large quantities of water from deep in the soil profile and also support large leaf areas for transpiration. Even in the winter, photosynthesis and transpiration continue to remove water and nutrients from the site, albeit at a reduced rate. This land application system exemplifies the effectiveness of a combination forage grass and forest system at renovating wastewater and reducing nutrient loadings to nearby river basins.

1.0 Introduction

Under Section .0500 2T Rules – Waste Not Discharged to Surface Waters set forth by the North Carolina Division of Water Quality Aquifer Protection Section, municipalities, and publicly owned treatment works (POTWs) can divert their highly treated effluent to land application irrigation receiver sites. The concept of land applying wastewater will provide additional treatment, and is consistent with the total maximum daily load (TMDL) program promoted by federal and state regulatory agencies. Many county governments, municipalities, and industries are facing similar situations with finding alternatives for wastewater and wastewater treatment and disposal in nutrient sensitive regions. The proposed receiver sites is a viable point source discharge alternative for wastewater irrigation from the UNC Bingham Wastewater Treatment Facility (UNCBWWTF) and will provide an excellent source of irrigation water for growing forage grasses and/or tree crops.

1.1 Objectives

Soil, Water & Environment Group, PLLC (SWE Group) personnel completed a comprehensive Agronomist Report and site investigation of the proposed receiver site irrigation areas. Recommendations are provided in this report concerning hydraulic loadings, nutrient loadings, as well as site and irrigation system management. Cropping scenarios, species/system selection, fertilizer recommendations, vegetation establishment and management, and vegetation harvesting regimes are provided.

1.2 Methodology

Field investigations were conducted to describe the proposed wastewater receiver site according to the soils, geologic features, hydrology, and wetlands. Nutrient concentrations for irrigation water were analyzed and recommendations are provided for the establishment and maintenance of a wastewater irrigation system on the site. Recommendations are given according to site characteristics including soils, hydrology, vegetation, and any site limiting factors. Also recommendations concerning cover crops and their ability to accept the proposed rates of liquids, solids, minerals, and other wastewater constituents, and appropriate application months as well as maintenance are included in this report.

1.3 Site Description

The UNCBWWTF is located in Orange County near the town of White Cross in the Bingham Township off Orange Chapel Clover Garden Road (SR 1956) (Figure 1). The property consists of several agricultural hay fields currently out of production, adjacent and abutting regenerating and mature pine fringe forest, hardwood forest, and adjacent mature mixed pine and hardwood forest. Existing facility structures occur on the site as

FIGURE 1: Project Location Map: UNC Bingham Facility Land Application System Receiver Site Map, Orange County, NC

Source: NCDOT USGS 1:24,000 (GIS, 2010)

well as an entrance road, existing wastewater irrigation system and infrastructure, and newly constructed expansion irrigation system, storage lagoon, and irrigation infrastructure. Several intermittent stream, wetland, and floodprone complexes occur on the north and east sides of the receiver site. Several drainages course through the property draining upland areas into Collins Creek, a tributary to the Haw River. The site is located in the Piedmont Physiographic Province in the vicinity of the Haw River that is characterized by rolling topography bisected by narrow perennial and intermittent streams.

The soils present on the proposed receiver sites, according to the Orange County Soil Survey (USDA, GIS 2010), are mapped as Georgeville silt loam, Herndon silt loam, as well as lowland loam soils consisting of Chewacla series soils. The vegetation on the proposed forested land application areas consist of upland pine and hardwoods including: yellow poplar (*Liriodendron tulipifera*), hickory (*Carya* sp.), northern red oak (*Quercus rubra*), white oak (*Quercus alba*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), sweetgum (*Liquidambar styraciflua*), sugar maple (*Acer saccharum)*, Loblolly pine (*Pinus taeda*), Shortleaf pine (*Pinus echinata*), Virginia pine (*Pinus virginiana*), sassafras (*Sassafras albidum*), other small understory woody species. Vegetation in the fields and open areas consist of a variety of herbaceous grasses, forbs, and broadleaf species. Fields will either be kept open and planted with perennial forage grasses such as coastal Bermuda or fescue, or will be planted with an appropriate tree species selected for the soil, proposed liquid loadings, and landscape position.

2.0 Irrigation Water Remediation/Application

Waste irrigation water applied to the receiver site will be utilized in several ways. Water will be lost through transpiration by vegetation, evaporation from the vegetation and soils surface, and percolation through the soil profile. This water will also enter nearby surface waters in wetlands and streams via lateral flow. Any excess nutrients in the wastewater will be treated through microbial processes, plant uptake, adsorption to soil solids, and biologically mediated chemical transformations (i.e. denitrification).

The primary objective of establishing a wastewater receiver site using tree species and forage grasses is to effectively renovate the water through the plant-soil system to prevent nutrients, BOD and other unwanted constituents from entering groundwater and nearby surface waters. Forest and forage systems under wastewater irrigation create a soil/plant system that effectively renovates wastewater through nutrient use and concentration, adsorption, and fixation. This has been demonstrated at facilities throughout the southeastern U.S.

Nutrients promote plant growth and microbiological activity in the soil. Municipal wastewater is a fertilizer to these organisms and they respond by increasing metabolism and growth. Because there is a decreased need to use machinery on the site for competition control and mowing in the plantation forest system, soil structure is maintained or improved while at the same time soil microbiological activity is increased due to litter accumulation. This results in a gradual improvement in soil conditions for wastewater absorption, infiltration, and renovation.

The estimated average annual nitrogen uptake of forested ecosystems for southern forests is 250 lb/ac/yr for 40-60 year old mixed hardwood species, 200 lb/ac/yr for 20-year old loblolly pine with no understory, and 250 lb/ac/yr for 20-year old loblolly pine with understory (Crites et al, 2000). According to other publications (Rubin, 1994, EPA, 1981), the maximum total nitrogen that can be applied to forested sites is 200-400 lb/ac/yr. Other research indicates that forest plantations with canopy closure can assimilate nitrogen levels in excess of the 200 lb/ac/yr (Rubin and Frederick, 1994). In a particular study near Helen Ga., a southern mixed hardwood forest on a 30% slope was given a loading rate of 3.0 in/wk. The nitrogen loading rate was 608 lb/acre and the percolate nitrate concentration was 3.7 mg/L (Nutter et al, 1978).

Trees transpire large quantities of water from much deeper soil depths compared to grass cover. Trees also support much larger leaf areas for transpiration. Even in the winter, photosynthesis and transpiration continue to remove water and nutrients from the site, albeit at a reduced rate. Irrigation water should not be applied to the site whenever icing of trees can cause physical damage. Such conditions may predispose the trees to disease and insect damage.

2.1 Irrigation Water Characterization

Wastewater can be described as containing varying levels of essential plant nutrients, organic compounds, trace minerals, and potentially phytotoxic compounds. Each of these typical wastewater constituents are assimilated or transformed on a receiver site through physical, chemical, and biological processes. The proposed maximum concentrations of nutrients (mg/L) in the proposed irrigation water using an AdvanTex system at the UNCBWWTF are anticipated to be ~25.0 mg/L TN, and ~10.0 mg/L TP (McKim & Creed, 2011).

2.2 Micronutrients and Trace Metals in Soils / Wastewater

Once the irrigation system is established, annual soil testing must be instituted. The soil test results will provide recommendations that will enable proper maintenance. Once soil testing begins, tests must be accomplished annually to determine trace metals, particularly zinc and copper, as well as exchangeable sodium percentage (ESP) and concentrations of macro and micro nutrients in the soil.

2.2.1 Salt Loadings

Imbalances with nutrients such as sodium, calcium, and magnesium may occur in a spray irrigation system and cause degradation in soil structure, lower soil permeability, lower soil water infiltration, and lower uptake of nutrients in plants. One way to evaluate the potential soil problems that may occur on a site receiving irrigation water is to calculate the sodium adsorption ratio (SAR) for the irrigation water.

The SAR of any irrigation water must be determined and monitored. The SAR is calculated as the ratio of sodium (Na) to one half the square root of calcium (Ca) and magnesium (Mg) with all concentrations expressed as equivalents. The SAR calculation is:

$SAR = Na/(Ca/2 + Mg/2)^{½}$ (units in meq/L)

Generally an SAR in excess of 10 is considered to be a hazard on most soils for irrigation purposes and system operators must take special precautions to monitor salt levels of sodium in both irrigation water and soil. In a sandy soil, however, the SAR of irrigation waters is less of a concern because of the limited exchange capacity of the receiver soils. Traditionally an SAR in excess of 7.5 is considered to be a mild hazard to irrigation and system operators should consider establishing a similar monitoring program. If the level of sodium in the soil exchange complex increases to a level over 10, then corrective measures such as gypsum addition or injection of magnesium hydroxide into the irrigation water should be implemented.

Continuing operations with high levels of sodium can result in problems with soil infiltration and nutrient imbalances. Nutrient imbalances can be controlled through gypsum application. The sodium in the wastewater and soil should be closely monitored to prevent future problems with the land application receiver site.

The second concern regarding the SAR is potential adverse impact to plant materials. Irrigation waters with high SAR values may change the osmotic potential in the soil solution and this often results in adverse impact to plant materials. For these reasons, the SAR must be monitored closely. For example, irrigation with liquid containing an SAR of 20 is permissible, provided system monitoring indicates no long-term adverse consequence to the soil and the plant material (Rubin, 2003). Recent water quality testing data indicates the UNCBWWTF irrigation water has an SAR of less than 10 (SAR = 3.5) (Envirochem, 2010). The proposed effluent is anticipated to have SAR values safe for irrigation.

2.2.2 Soil Sodium

Another measure of sodium, completed for the soil, to determine potential problems with irrigation systems, is called the exchangeable sodium percentage (ESP). ESP is calculated as follows:

$ESP = Na/CEC * 100$

Where: Na is an index value for sodium

This calculation should result in data no greater than 10-15%. Soils with ESP values > 10-15% can be remediated through under draining and adding soluble sources of Ca such as gypsum ($CaSO_4$), being careful of Mg deficiencies in plants. Ca/Mg ratios should be kept in balance. The Ca/Mg ratio should not exceed 10/1 to 15/1 based on routine soil testing.

If ESP values exceed 15% then amendments such as gypsum or another calcium substitute should be added to correct the situation. A prescription of 1 ton/2units ESP is recommended to address this problem.

Excessive sodium in the soil system can lead to management problems in the future and affect the overall capacity of the site. The ESP at the UNCBWWTF receiver site is ~2.0 %, so no corrective measures are necessary.

2.2.3 Trace Metals

The USEPA regulates the levels to which selected metals can accumulate on any waste receiver site. Most metal levels in domestic wastewater are sufficiently low that accumulation in the soil is not an issue. Zinc (Zn) and copper (Cu) concentrations, however, are frequently monitored in municipal wastewater at levels of 0.5 to 1.0 mg/l (Nutter, 1986; Rubin, 1996). The irrigation water received at the UNCBWWTF is anticipated not to exceed domestic wastewater concentrations and recent effluent samples revealed a copper concentration of .021 mg/L and zinc concentration of .82 mg/L.

The levels of zinc and copper anticipated in this wastewater should not limit the potential for irrigation onto forested sites. The maximum cumulative levels permitted for the life of the land application site are 1,338 lb./ac Cu and 2,498 lb./ac Zn (USEPA, 1981). The site life (existing fields and new fields) based on these regulated metals and current concentrations found in the effluent, is in excess of 19,000 years for copper and 949 years for zinc for the maximum liquid application rate proposed (Edwin Andrews & Assoc., 2011, USEPA, 2002).

3.0 Site Specific Soils/Nutrients

3.1 Existing Soil and Site Conditions

A soils investigation was accomplished across the proposed receiver site. A series of 3.5 in. hand auger borings were done across the site to maximum depths ranging from 36 - 84 in. These borings were done to characterize the depth of each of the horizons, the color of the soil material at each of the various depths, the texture, structure, consistence of the soil material within each of the horizons, and depth to bedrock or other limiting horizon. These augerings were also done to verify the boundaries of mapping units indicated in the USDA soil survey for Orange County, NC (USDA GIS, 2010).

The USDA Orange County Soil Survey for the site shows two (2) predominant series present within the irrigable soil areas: Georgeville silt loam and Herndon silt loam. Considerable variability in depth, color, and texture was evident across the site depending on landscape position and historical agricultural land use. These variations resulted in subsequent variations in hydraulic loading potentials between the two soil series but not

within soil series sampling. Field investigations revealed similar locations for the soil series relative to the NRCS soil survey.

The hand auger borings confirmed that the soils mapped on the site according to NRCS (USDA) are present in the proposed receiver areas. The majority of the soils on the proposed receiver site consist of Georgeville and Herndon silt loam soils, with the remainder of the lowlands consisting of Chewacla loam soils. Soil Area 1 (SA1) soils on the receiver site consist of Georgeville silt loam soils. Slopes range from 2-6%. These soils are very deep, well drained, moderately permeable soils that formed in material mostly weathered from fine-grained metavolcanic rocks of the Carolina Slate Belt. Seasonal high water is typically >6 ft. SA1 soils comprise approximately 62% (3.56 ac) of the total receiver site acreage (5.71 ac).

Soil Area 2 (SA2) soils on the receiver site consist of Herndon silt loam soils. Slopes range from 2-6%. These soils are very deep, well drained, moderately rapid permeability soils that formed in material mostly weathered from fine-grained metavolcanic rock of the Carolina Slate Belt. Seasonal high water is typically >6 ft, however soil variabilities across the site indicate some seasonal perching conditions closer to the surface, probably indicative of slower permeable inclusions. SA2 soils comprise approximately 37% (2.15 ac) of the total receiver site acreage (5.71).

A description of the soil areas including predominant soil series, and existing vegetation is summarized in Table 3.

Table 1: UNCBWWTF Land Application System Receiver Site Soil Area Descriptions.

Soil Area	Predominant Soil Series	Existing Vegetation
SA-1	Georgeville	Grass, Mixed Pine/Hardwood
SA-2	Herndon	Grass

3.1.2 Soils Analysis

A composite sample of the top 0-12 inches of soil representing the irrigable upland areas was collected and analyzed for nutrient composition by NCDA (Table 4). Soil analyses of the proposed irrigation site indicate that there are nutrient deficiencies, especially nitrogen and phosphorus. This conclusion is based on the potential crop response to particular nutrients if fertilizer is applied to the site. The cation exchange capacity (CEC) and base saturation (BS%) are low as well. The addition of wastewater to the site will improve soil fertility and consequently the growing conditions and productivity of this site. Additional agronomy recommendations are found in the Agronomist Report (SWE Group, 2011)

Table 2: Composite Soil Analysis of Uplands (N=22) at the UNCBWWTF Receiver Site, Orange County, NC (2010)[1].

Depth	pH	P ppm (Index)[2]	K ppm (Index)	Ca ppm (%)	Mg ppm (%)	CEC[3]	BS%[4]
Georgevillle							
0-6 in.	**4.9**	**6.0 (5. (5.0)**	**66.0 (33.8)**	**228.9 (35.1)**	**115.4 (17.9)**	**6.1**	**55.6**
6-12 in.	**5.1**	**2.3 (1.9)**	**47.6 (24.3)**	**161.4 (29.3)**	**102.3 (18.6)**	**5.3**	**50.1**
Herndon							
0-6 in.	**4.7**	**51.3 (42.7)**	**70.7 (36.1)**	**212.6 (34.4)**	**82.2 (13.1)**	**6.1**	**50.7**
6-12 in.	**5.0**	**9.8 (8.2)**	**65.2 (33.3)**	**183.7 (33.0)**	**96.1 (16.8)**	**5.5**	**52.7**

[1] Laboratory Soil Test Reports (2010).
[2] Index values reported by NCDA (2010) http://www.ncagr.com/agronomi/pdffiles/ustr.pdf
[3] Cation exchange capacity (meq/100g) – defined as the amount of cations adsorbed on soil-particle surfaces per unit mass of the soil under chemically neutral conditions.
[4] Base saturation – defined as the percentage of the CEC occupied by base cations

Table 3: Range of Nutrient and Lime Recommendations as lbs/ac or tons/ac for Lime, for the UNCBWWTF Land Application Receiver Site, Orange County, NC (2010) [1].

	Recommended Application			
	Soil Area 1	**Soil Area 2**	**Soil Area 3**	**Soil Area 4**
Lime	0.5-1.0	0.5-1.0	0.5-1.0	0.5-1.0
N	80-120	80-120	80-120	80-120
P	40-90	40-90	40-90	40-90
K	0-60	0-60	0-60	0-60
Trace	-	-	-	-

1. Nutrient and Lime Recommendations provided by the NCDA - Agronomic Division (2010)

Maintenance of soil fertility is an important component of any land treatment operation. Without vegetation, the effectiveness of any land application operation is compromised. In general the soils mapped by NRCS and SWE Group at the UNCBWWTF land application receiver site are well suited for land application. The soil depth is sufficient to allow irrigation of water in addition to rainfall for the best soils. The lower horizons are deep and the forest cover and vegetation provides a means for nutrient and water cycling.

The irrigation water applied will provide supplemental nutrients and a consistent source of water to growing crops. Soil testing should be done on an annual basis, and additional nutrient applications should be consistent with the recommendations to maintain crop productivity and maximize wastewater irrigation.

3.2 Nutrient Loadings

The supplemental nutrients in the proposed irrigation water will enhance the soil fertility on the receiver site. Soil testing provides site specific lime and fertilizer recommendations for specific crops and field conditions and to optimize growth.

The management of soil fertility without soil testing is not recommended since soil nutrient and pH relationships are complex. Acid soils, for example, can limit root growth and cause certain nutrients to be unavailable for plants. Unless soil acidity and pH are corrected through liming, applying fertilizer may not correct the problem. Soil testing measures the soil's nutrient-holding capacity and provides a sound basis for land management decisions. Fertilizer recommendations based on soil test information optimize crop yield, save money, and protect the environment from excess fertilizer runoff. Following recommendations for lime application can produce similar benefits.

It is recommended and often a permit condition to test the soils on an annual basis in order to fine-tune irrigation events on the receiver sites. Sampling should be done during the same time of the year and samples need to be analyzed by a lab certified for the testing of soil.

3.2.1 Nitrogen Loadings

The nitrogen content of a wastewater source and the current volume irrigated are utilized to determine the amount of plant available nitrogen applied to a site. The total nitrogen level in a wastewater source is determined by measuring the levels of total Kjeldahl nitrogen (TKN), ammonia nitrogen (NH_3), and nitrate/nitrite nitrogen ($N0_3/N0_2$) in the irrigation water. $N0_3/N0_2$ and NH_3 are the inorganic forms of nitrogen and total Kjeldahl Nitrogen (TKN) is the organic form of nitrogen. In most domestic wastewater facilities, including the UNCBWWTF, the biological activity in the storage lagoons will break down the organic matter releasing and or consuming the nitrogen as energy in the process. It is estimated that the nitrogen in the wastewater will primarily be in the inorganic fraction, and of this amount, a large portion will occur in the NH_3 form.

It should be noted that the following approximate PAN calculations do not account for the microbiological transformations in the soil and storage lagoons such as mineralization and immobilization or ammonium volatilization. When accounted, actual plant available nitrogen loadings will be less than calculated approximate PAN loadings.

Proposed design nitrogen concentrations for the UNCBWWTF wastewater were used for estimating PAN loadings. Liquid irrigated onto the receiver sites will contain approximate levels of nitrogen reported as ~25.0 mg/l total nitrogen (TN).

Potential Hydraulic Loadings:

Soil Area 1 (3.56 ac) (.21 in/wk)
2,896 gpd
Soil Area 2 (2.15 ac) (.21 in/wk)
1,749 gpd

Liquid Loadings:

Soil Area 1 (.21 in/wk) – (80^{th} %tile)
25.0 mg/L TN * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 3.56 ac = 61.9 lbs TN/ac/yr

Soil Area 2 (.21 in/wk) – (80^{th} %tile)
25.0 mg/L TN * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 2.15 ac = 61.9 lbs TN/ac/yr

Soil Area 1&2 (.21 in/wk) – (80^{th} %tile)
25.0 mg/L TN * (1,695,508 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 5.71 ac = 61.9 lbs TN/ac/yr

PAN
PAN= MR(TKN-NH3)+[(1-VR)*(NH3)]+(NO3+NO2)= 21.5 ppm
Where
PAN= Plant Available Nitrogen
MR= Mineralization Rate (40%)
VR= Volatilization Rate (50%)
*TKN= Total Kjeldhal Nitrogen (~25.0 ppm)
*NH3= Ammonia Nitrogen (~ 15.0 ppm)
*NO3= Nitrate Nitrogen (~10.0 ppm)
*NO2= Nitrite Nitrogen (~ 0.0 ppm)
*Source: McKim & Creed (2011) - Proposed AdvanTex System

Soil Area 1 (.21 in/wk) – (80^{th} %tile)
21.5 mg/L TN * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 3.56 ac = 53.2 lbs PAN/ac/yr

Soil Area 2 (.21 in/wk) – (80^{th} %tile)
21.5 mg/L TN * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 2.15 ac = 53.2 lbs PAN/ac/yr

Soil Area 1&2 (.21 in/wk) – (80^{th} %tile)
21.5 mg/L TN * (1,695,508 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 5.71 ac = 53.2 lbs PAN/ac/yr

This annual approximate PAN nitrogen loading rate is calculated by multiplying the amount of ~PAN nitrogen in the wastewater by the gallons of wastewater applied. This number is then converted to pounds of ~PAN nitrogen being applied on the entire site and subsequently divided by the total acreage to yield pounds of ~PAN nitrogen per acre per year. The final numbers show that the annual average hydraulic loadings anticipated by the current design will result in a maximum annual average application of approximately 53.2 lbs PAN/ac/yr during an 80%tile wet rainfall year for all soil areas.

This number is higher than actual plant available nitrogen loadings because, as previously stated it does not account for soil microbiological interactions and potential denitrification processes occurring in the storage ponds prior to application. These numbers were used to provide a conservative estimate of total plant available nitrogen to meet the agronomic needs of the receiver crops and to protect adjacent streams and groundwater from nutrient

enrichment. The anticipated liquid loadings are within acceptable nutrient loadings for the proposed land application systems as indicated by state water quality agencies and demonstrated in other permitted natural forest/forage land application systems in the southeast. In fact, these PAN loadings are very low and supplemental N will be required to optimize crop production.

3.2.2 Phosphorus Loadings

Domestic wastewater contains low levels of phosphorus as total phosphorus (TP), phosphate (PO_4) or (P_2O_5). Each of these forms of phosphorus can be essential as nutrients for plants. Plants generally require phosphorus at a rate of 25% to 50% of the nitrogen application rate. The TP concentration for the UNCBWWTF will have a proposed design concentration of ~5.0 mg/L. Liquid irrigated onto the receiver site will contain a TP level calculated as:

Potential Hydraulic Loadings:

Soil Area 1 (3.56 ac) (.21 in/wk)
2,896 gpd

Soil Area 2 (2.15 ac) (.21 in/wk)
1,749 gpd

Liquid Loadings:

Soil Area 1 (.21 in/wk) – (80^{th} %tile)
5.0 mg/L TP * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 3.56 ac = 12.3 lbs TP/ac/yr

Soil Area 2 (.21 in/wk) – (80^{th} %tile)
5.0 mg/L TP * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 2.15 ac = 12.3 lbs TP/ac/yr

Soil Area 1&2 (.21 in/wk) – (80^{th} %tile)
5.0 mg/L TP * (1,695,508 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 5.71 ac = 12.3 lbs TP/ac/yr

Under acidic soil conditions, phosphorus fixation will be dominated by Al and Fe compounds. A regular soil testing regime, and liming program, should be followed to allow maximum agronomic availability of both native and fertilizer applied phosphorus. The efficiency of phosphate uptake by plants will be higher if lime is applied to the site prior to irrigation. Assuming 75% availability, PAP will be ~9.3 lbs/ac/yr for both soil areas. These phosphorus loadings can be assimilated by the cover crops and soils specified. In fact, P loadings are low and supplemental P may be required to optimize crop production.

The assimilative capacity for phosphorus is below that for nitrogen and the existing levels of phosphorus can be assimilated by the forest crops and soils specified provided an effective sedimentation and erosion control program is in place. The sedimentation and erosion program in place for the facility is necessary to reduce the loss of phosphorus, which exits a site adsorbed to fine soil particles lost with runoff during storm events. Riparian buffers are also important sinks for phosphorus transported in overland flow

during periods of unusually high precipitation. The UNCBWWTF receiver site will have vegetated buffers around waters of the state adjacent to irrigation fields to help trap and sequester phosphorus moving toward surface waters.

3.2.3 Organic Loadings

Average monthly BOD (biochemical oxygen demand) and TDS (total dissolved solids) in the effluent is anticipated to be between <10 mg/L and <5 mg/L respectively, based on design effluent concentrations.

Given that a site with moderately drained soils can accommodate up to 10,000 lb/ac/yr organic loadings (Carlile et al., 1974 Crites et al., 2000, EPA, 1981, Rubin, 2002), the organic loadings at the proposed receiver site will be within the site limitations.

3.2.4 RYE Calculations (NCDWQ)

NCDWQ aquifer protection section permit application guidance requires an analysis of nutrient uptake by crops using software and a database developed by N.C. State University, the Natural Resource Conservation Service, the North Carolina Department of Agriculture and Consumer Services, and the North Carolina Division of Soil and Water Conservation. This nutrient management software allows an analysis of the nutrient requirements of proposed crops at the receiver site. Nutrients analyzed include nitrogen and phosphorus.

The analysis for the UNCBWWTF included a variety of soils and two crop regimes; forage grass and natural forest. The forage grass nutrient requirements were calculated for fescue and Coastal Bermuda grass. No data is currently available in the nutrient management software for forest systems. So, nutrient recommendations were based on current literature, site and soil conditions, and historical permitted forest systems in the State. Nutrient management recommendations are given in Table 4 below.

Table 4: Nutrient uptake and removal and yields for proposed cover crops at the UNCBWWTF receiver site.

Soil	Crop	RYE (tons) [1.]	Nitrogen Application Rate (lb/ac/yr) [1.]	Irrigation Area (ft^2)	Phosphorus Removal (lb/ac/yr) [1.]	Irrigation Area (ft^2)
SA1	Fescue	3.2	136	70,595	51	37,650
Georgeville	Coastal Bermuda	3.8	159	60,383	46	41,743
	Forest	-	150 +	64,006	40 +	48,004
SA2	Fescue	3.9	174	29,581	63	24,158
Herndon	Coastal Bermuda	4.8	213	27,220	58	19,993
	Forest	-	150 +	38,653	40 +	28,990

1.] Based off management recommendations from NCSU et al. (http://nutrients.soil.ncsu.edu/yields/)

The anticipated nutrient loadings at the UNCBWWTF are within economic-based agronomic limits supported by NCDWQ at this time. The site is limited by hydraulics and therefore nitrogen and phosphorus can be assimilated by the system within both soil areas. Overall, the UNCBWWTF will function as a viable receiver site for treated wastewater and enhance growth of established and new cover crops based on RYE application rates.

3.2.5 Recommendations

A composite wastewater sampling program should be instituted to address the various inputs to the land application system irrigated through the UNCBWWTF program. The wastewater parameters to be monitored include as a minimum the following: total nitrogen and plant available nitrogen (Kjeldahl-N (organic) and NH_3-N, nitrate, and ammonium (inorganic)), total phosphorus, potassium, sodium, calcium, magnesium, copper, zinc, BOD, and TSS. These are all critical parameters in a forage or forested land application system. The sodium adsorption ratio (SAR) of the liquid irrigated should be less than 10-15, however spraying is not precluded should an SAR value higher than 10 occur. Only when an SAR value higher than 10 occurs, additional site management steps may be necessary, such as adding gypsum directly to the fields or injecting magnesium hydroxide into the irrigation water should plant or plant-soil relationships become compromised. The operator of the WWTF must be informed of the results obtained through the monitoring effort. The operator may be required to modify management operations as a result of the monitoring data, and quick, timely responses to impending soil fertility changes will avert long term problems in this program. Optimization of land treatment operations will require addition of supplements as determined by soil test data.

4.0 Forest System Site and Species Selection

Forest systems have a variety of attributes favorable for treatment and cycling of municipal wastewater including: 1.) Most natural forest stands sites are nutrient deficient and capable of assimilating large amounts of nutrients through biotic conversion and soil adsorption, and 2.) Trees have perennial root systems, which allow year round uptake of nutrients and enhance infiltration.

Detailed knowledge of site history and soil characteristics is necessary for proper design and maintenance recommendations of wastewater application systems. Ideal wastewater application sites will have deep (>1m) soils with loam to sandy loam surface horizons over silt loam to sandy clay loam subsurface horizons. Soils well suited for high nutrient and hydraulic loading rates will be well drained (water table >1m deep) with pH values between 5.5 and 7.0 (Frederick et al., 1994). Soils that are very clayey or very sandy are somewhat limited for wastewater applications, although waste characteristics and application rate are important mitigating factors. The soils present at the UNCBWWTF receiver site are well-suited for forest establishment and wastewater land application.

Hardwood (deciduous) species tolerant of saturated soils are generally preferred for wastewater application. Hardwood species are generally preferred because of high nutrient uptake, rapid early growth rates, ability to resprout after harvest, and tolerance of saturated conditions as compared with most *Pinus* (pine) species. However, well established pine stands are tolerant of increased soil wetness due to irrigation.

4.1 Site Selection

Site selection is critical when establishing a wastewater application system. Existing published data (i.e. soil surveys, hydraulic conductivities, etc.) are useful to determine general site characteristics, but detailed information may be necessary for proper design of the system. Detailed field study provides data regarding microsite variation, existing soil fertility, in-situ soil texture and morphology, and water table depth. This site specific data are essential to establish proper loading rates, species recommendations, and maintenance recommendations.

4.2 Species Selection

In the case of plantation establishment, species selection is dependent on the anticipated hydraulic loading, waste characteristics, soil characteristics, seedling availability, and desired rotation length (i.e. final product desired). Several hardwood tree species have been successfully used throughout the Southeast for biomass plantations and wastewater application (Table 4). These species vary in their tolerance to flooding and soil saturation, and exhibit different growth potential according to soil characteristics. The objective of species selection is to maximize growth and nutrient uptake for a given wastewater application.

Based on the anticipated hydraulic loading rates, wastewater characteristics, soil and site characteristics, several tree species are recommended for the moderate to well drained soil areas (SA1 and SA2) (Appendix – Figure 4). Hardwood species are generally preferred because of high nutrient uptake, rapid early growth rates, ability to resprout after harvest, and tolerance of saturated conditions as compared with most *Pinus* (pine) species. Further, the potential for coppice woodland operations enhances potential for nutrient removal and hydraulic loading to sites.

Many of the bottomland oak species do not exhibit good growth with prolonged soil saturation and subsequent rhizosphere hypoxia (Gardiner et al., 1993). In addition to site considerations, the growth pattern and length of rotation should be considered. Growth patterns of sweetgum (*Liquidambar styraciflua)*, sycamore (*Platanus occidentalis*), and oaks (*Quercus* sp.) vary considerably (Frederick et al., 1994). On a good site, sycamore will grow very fast at first, then taper off after age 6 to 12 years without intermediate thinning. Oak species generally grow slowly at first, followed by a period of rapid growth. Sweetgum exhibits intermediate growth usually equivalent to pine species. However all hardwood species are able to resprout (i.e. coppice) following harvest, producing multiple

rotations from one rootstock and maintaining high nutrient and hydraulic assimilation capacity of the system.

We recommend establishing the irrigation system with different species within the existing hardwood forest and maintain the existing vegetation until harvest. Open fields can be managed exclusively for forage species, or combined with forest crops in a tree plantation. When and if harvesting of the existing forest cover occurs, we then recommend replanting the forested areas with a variety of tree species which prefer moderately well-drained soils (SA1 and SA2) and moderate pH levels at 1.8 x 3.0 m (6 x 10 ft) spacings. Sycamore, sweetgum, green ash, and hybrid poplar (*Populus deltoides* X *P. nigra*) have been utilized successfully at several existing wastewater irrigation sites in the southeast (Table 4). These species are ideal for the soil and site characteristics found at the UNCBWWTF receiver site (Appendix – Figure 4).

Buffer plantings can be established, if desired, as a screen between the irrigation fields and roads, and in buffers between the irrigable and non-irrigable areas with seedling spacings similar to the other planting areas. These plantings may include wax myrtle (*Myrica cerifera*) or other fast-growing vegetation suitable for buffers or natural screening. Portions of the proposed buffer zones that are not currently forested should be planted with a variety of native tree species that are adapted to grow on similar sites.

5.0 Vegetation Maintenance and Monitoring

Data obtained through the investigation of the soils and site characteristics at the UNCBWWTF receiver site were utilized to determine the best suitable receiver crop or combination of crops. Recommendations are provided for vegetation maintenance and monitoring on the existing wastewater receiver site.

5.1 Forest System Maintenance

Forest systems used for wastewater application require less maintenance as compared with crop and forage systems. However, periodic inspection and early maintenance are important to ensure the success of forest plantations. Equipment traffic on saturated soils may cause rutting, increase surface ponding, and alter the hydraulic conductivity of the soil and should be avoided. Herbaceous competition should be controlled between planting rows using mowing equipment until canopy closure at year 4 or 5, sooner for recently

Table 5: Characteristics of Common Tree Species Used in Wastewater Land Application Systems.

Species	Flooding tolerance [1,2,3,5]	Preferred soil texture [4,6]	Preferred soil pH range [4,6,7,8,9]
Platanus occidentalis (sycamore)	mod. tolerant	sandy-silt loam (coarse)	5.50-7.50
Liquidambar styraciflua (sweetgum)	tolerant	silt-clay loam (fine)	5.50-7.50

Fraxinus pennsylvanica (green ash)	very tolerant	moderate to coarse	4.15-7.50
Acer negundo (boxelder)	tolerant	v. coarse to v. fine	5.00-7.10
Quercus sp. (oaks)	v. tolerant – mod. tolerant	moderate to fine	4.50-5.50
Nyssa aquatica (water tupelo)	very tolerant	moderate to v. fine	4.00-5.50
Populus heterophylla (swamp cottonwood)	very tolerant	heavy clays (fine)	4.60-5.90
Populus deltoides (cottonwood)	v. tolerant – tolerant	f.sandy loam – silt loam	5.50-7.50
Populus deltoides X *P. nigra* (hybrid poplar)	tolerant – mod. tolerant	medium texture	6.00-7.00
Taxodium distichum (bald cypress)	very tolerant	silty clay-loam	4.60-6.90
Pinus elliottii (slash pine)	mod. tolerant	coarse to fine	-----
Pinus taeda (loblolly pine)	intolerant – mod. tolerant	sand-clay	4.50-6.50 (moderately acid)

[1] Baker, 1977; [2] Hook, 1984; [3] Gill, 1970; [4] Willett and Bilan, 1993; [5] Gardiner et al., 1993; [6] Burns and Honkala, 1990; [7] Harrington, 1991; [8] Baker and Broadfoot, 1979; [9] Broadfoot, 1976

Table 6: Recommended Vegetation Species for Vegetation Areas at the UNCBWWTF Land Application System Receiver Site, Orange County, NC.

Vegetation Area (Soil Area)	**Species**	**Comments**
1	green ash sycamore sweetgum hybrid poplar bald cypress	- plant better drained areas with one or more of these species - species planting depends on seedling availability
2	green ash sweetgum bald cypress	- species planting depends on seedling availability

harvested trees. It should be noted that any equipment trafficking should only take place when the irrigation site is adequately drained. Equipment traffic on saturated soils may cause rutting, increase surface ponding, and alter hydraulic conductivity of the soil. No herbaceous competition control is required at this time with the existing pine and mixed hardwood forest on the receiver site. Herbaceous competition control will be necessary on the open forage grass fields prior to establishment. Following harvest, and replanting, herbaceous competition should be controlled until canopy closure. The following discussion below applies to the system following replanting of hardwood trees.

Irrigation equipment and infrastructure should also be maintained to ensure proper application of wastewater. Herbaceous plants and vines grow rapidly with wastewater applications and may interfere with stationary sprinkler operation. Sprinklers should be routinely inspected and herbaceous/vine growth should be removed. In addition to infrastructure maintenance, periodic inspections of wastewater plantations are necessary to identify and control specific problem areas. Insects, disease, deer browsing, and rodents can damage wastewater plantations and are difficult to anticipate. Early identification of these problems is important to minimize the effects on the system and maximize plantation yield.

5.2 Forest Harvesting Recommendations

Forest Plantation Stands

Thinning and pruning of plantations may be necessary between 5-10 years initially and following harvesting, and pulpwood harvest may occur at 8-20 years depending on wastewater loading, species, and site characteristics. Plantation maintenance recommendations for the UNCBWWTF forested plantation areas include:

- Regular mowing of the forage grass fields and between planting rows within the spray field with low ground pressure equipment (2-4 times/yr.) following adequate drainage/dry down of the spray zone.
- Sprinkler inspection to ensure adequate coverage and adjust for areas where ponding and/or surface runoff may occur such as installing hand valves to fine-tune irrigation events.
- Periodic inspections after severe rainfall events to locate isolated depressions and fill using appropriate loam or sandy loam material to facilitate vertical drainage.

Existing Natural Forest Stands

Both natural stands and plantations irrigated with municipal wastewater exhibit accelerated growth. Since the primary objective of this land application system is nutrient and water uptake, forest stands should be harvested near growth peak to maximize the nutrient removal capacity and evapotranspiration (ET) of the system.

Harvesting can be accomplished using standard mechanized equipment such as feller-bunchers and skidders. Harvesting contractors should be instructed to operate equipment with caution when working around permanent irrigation systems. Site operators should also allow sufficient time for a wastewater site to dry out prior to traffic by heavy logging equipment. Soil rutting, soil compaction and physical damage to irrigation equipment are expensive to repair.

Predominantly Mixed Pine/ Hardwood Stands

It is recommended that no forestry activities such as precommercial thinning cutting be done on these areas for the next 20-25 years. Trees will be competing among themselves

and there is no point in doing any stocking reduction until a final canopy height is reached (about 20-30 years). At year 25 it is recommended a thinning be completed to improve quality, species composition and spacing (access). This thinning could be followed by another thinning at about 35 years. This is optional but would help to greatly improve the species composition, quality, and value of the stand. The forest stand could then be clearcut at age 50 or it could be carried on to an older age 60 – 80 years. The latter option will result in higher quality wood and add more value to the stand as well as increasing biodiversity values (wildlife, aesthetics, green space etc).

Overall, the proposed wastewater receiver site is ideal for a forest system. This system will result in the most effective wastewater treatment and assimilation system based on the existing site conditions, hydraulic loading rates, wastewater characteristics, and soil characteristics. A tree system will only require periodic mowing, brushing, and/or herbiciding between planting rows until canopy closure and the inspection of the spray field operation to ensure proper functioning. Following harvest of the trees at peak growth, vegetation will sprout from remnant stumps and the functioning of the system will continue. The long term presence of forest cover and reduced vehicle traffic with forest systems will greatly improve infiltration and other soil characteristics important for renovation of wastewater and recharge of groundwater.

The success of either natural or plantation tree systems depends on the routine operation, maintenance, and optimal performance of the irrigation system. Tree establishment, maintenance, and harvesting should be accomplished by qualified professionals. Routine maintenance should be performed by the certified system operator. Success of the system should result in additional income from the sale of pulpwood and/or sawtimber.

Forested Land Application System Maintenance SUMMARY

Following are recommendations for maintenance of a hardwood spray field plantation at the UNCBWWTF receiver site:

- Maintain a minimum of 10-15 ft. separation between spray heads and tree rows. Spray pressures < 80 psi will not harm or debark planted trees. Trees have been selected for smooth bark to eliminate this problem.

- Band-apply an herbicide such as Oust, Garlan 3, Garlan 4, or Roundup to planting rows if necessary to control herbaceous weeds and vines.

- Follow up inspection and replanting as necessary (within one year following replanting).

- Regularly mow the fields and between planting rows within the spray field with low ground pressure equipment (2-4 times/yr.) following adequate drainage/dry down of the spray zone. Maintain rows and keep track of supplementally planted trees with pin

flagging for each row at a minimum. Flagging of individual trees may be necessary during the early stages of growth for one to two years.

- Inspect sprinklers to ensure adequate coverage and adjust for areas where ponding and/or surface runoff may occur. Remove any climbing vines from sprinkler risers.

- Prune trees no more than 60% bole (tree trunk/stem) and 40% crown (remaining branches/leaves) to allow for equipment access and for wood quality as needed annually.

- Maintain site drainage such as road side and adjacent ditches.

6.0 Receiver Site Forage Species Selection

Forage/grass systems are viable options for the UNCBWWTF land application irrigation project. The receiver sites may contain a combination of forage/grass species in the open fields. The forage/grass system will utilize a combination of a variety of shade tolerant and sun favoring forage grass species. These areas will be managed for nutrient and water assimilation.

Selection of this system and location was determined by the soils, existing site conditions, proposed crops, topography, and location of surface waters. Figure 3 (Appendix A) details the proposed receiver site areas and recommended land use. Detailed recommendations for the initial establishment, maintenance, management, and harvesting of vegetation on this system are provided in Section 7.

6.1 Forage Grass System

Forage grass systems can be established on a variety of soils and exhibit characteristics to effectively treat reuse water and assimilate nutrients in growing vegetation. These characteristics include:

1. Forage grasses tolerate a wide range of soil moisture levels.
2. Forage grasses utilize significant levels of nutrients.
3. Forage grasses develop perennial root systems and consume nutrients throughout the growing season.
4. Forage grasses may be perennial and remain productive for several years without replanting.

6.1.1 Site Selection

Site selection is critical when establishing a forage grass reuse water application system. Existing published data (i.e. soil surveys, hydraulic conductivities, etc.) are useful to determine general site characteristics, but detailed site specific information may be necessary for proper design of the system. Detailed field study provides data regarding microsite variation, existing soil fertility, in-situ soil texture and morphology, and water table depth. Site specific data is essential to establish proper loading rates, species recommendations, and maintenance recommendations. This report utilizes site specific data as well as existing soil and land use data.

6.1.2 Species Selection

Forage grass species may be utilized for some of the irrigation water land application system for the proposed project. A variety of forage grass species are compatible with the proposed system including coastal Bermuda grass (*Cynodon* sp.)(only in very open, sunny areas), fescue (*Fetescue* sp.), eastern gamma grass (*Tripsicum* sp.), bent grass (*Agrostis* sp.) and dallisgrass (*Paspalum dilatatum*). All forage grass species will be established and managed to meet the nutrient and hydraulic demands of the growing crop.

Table 7: Recommended Vegetation Crop for Forage/Grass Areas at the Proposed UNCBWWTF Receiver Site, Orange County, NC.

Vegetation Area (Soil Area)	Crop	Comments
SA1 & SA2	Forest and/or Coastal Bermuda grass and other perennial grasses (i.e. tall fescue, or hybrid fescue)	- managed for nutrient and water assimilation.

7.0 Forage Vegetation Establishment, Management, and Harvesting

Data obtained from the investigation of the soils and site characteristics at the UNCBWWTF receiver site were utilized to determine the best suitable receiver crop or combination of crops for the proposed irrigation water. Recommendations are provided for vegetation establishment, management, and harvesting on the proposed water receiver site.

7.1 Fertility

Based on soil fertility samples, fertilizer recommendations for the forage grass receiver crops are provided in Table 3. Fertilizers should be applied to the site at the recommended rates prior to vegetation establishment and management. This is essential to the success of

the vegetation and the overall success of the land application system. According to recent soil sampling (NCDA, 2010), supplemental nutrients will be required prior to establishment of a forage grass system, and following system establishment should be continually determined through annual soil testing:

A. .5-1.0 tons lime/ac – Soil pH is moderate to low. pH influences the availability of essential plant nutrients. The lime recommended is required to facilitate the uptake of essential plant nutrients. This should be supplied in the form of dolomitic lime to insure Ca/Mg ratios stay in balance.

B. 80-120 lbs nitrogen/ac – This is generally supplied in the form of urea, ammoniacal nitrogen, or nitrate nitrogen in inorganic fertilizers.

C. 40 to 90 lbs phosphorus/ac – This is generally supplied as a phosphate compound. The phosphorus recommended is essential for root development.

D. 0 to 60 lbs potassium/ac – Generally this is supplied as a salt of potassium such as potassium chloride. Potassium is essential for development of root, stem, and leaf tissue.

E. 5 lbs copper/ac – Bermuda grass requires trace minerals to prosper. If copper levels in the soil are very low supplemental copper must be supplied. Generally this is supplied through the addition of copper sulfate.

F. 0 lbs zinc/ac – Bermuda grass requires this trace mineral to grow and prosper. If zinc levels in the soil are very low supplemental zinc must be supplied. This is usually added in the form of chelated zinc or zinc sulfate.

7.2 Forage Grass System Establishment, Management, and Harvesting

7.2.1 Forage Grass System Establishment

Coastal Bermuda grass can be established on most sun exposed areas using live sprigs at a sprigging rate of 40 bushels per acre. Sprigs should be placed 2 to 3 inches apart with 24 to 30 inch rows during the months of early **March through April**. Sprigging can be completed later in the growing season provided **irrigation is available** to the newly established plants. Establishment of the forage system species should proceed as follows:

1. Disk and subsoil to a depth of 12-18 inches, remove existing vegetation and incorporate chemical controls for existing vegetation for establishment only.

2. Adjust soil fertility with lime and nutrients.
3. Disk and pulverize soil in seedbed.
4. Incorporate seed or sprigs at rates recommended.
5. Irrigate to assure crop germination or sprig development.

Eastern gamma grass, fescue, and dallisgrass should be established on shaded areas and areas with higher slopes using pure live seeds at 15 lbs/ac. Seeds should be placed between 0.75 and 1.0 inches apart during the months of **April through mid June**. Fescue can be established as well. This can be accomplished by disking in a cover crop of fescue in the fall **(Sept.-Nov.)** (broadcast 10-15 lb/ac or drilled at 6 lb/ac). Establishment of a fescue crop is possible in the early spring as well **(Mar.-Apr.)**.

7.2.2 Forage Grass System Management

Forage grass system management recommendations for the UNCBWWTF receiver site include:

- Follow up monitoring of forage plantings within one year after planting.
- Regular cutting of the receiver sites with low ground pressure equipment following adequate drainage/dry down of the spray zone.
- Grass clippings should be mowed on a regular basis left in place to provide organic matter and nutrients for the regenerating crop. Clippings left on the receiver sites provide important carbon and nutrient sources for continued vegetation growth and soil quality improvement.
- Sprinkler inspection to ensure adequate coverage.

Irrigation operations on the forage/grass areas should be limited to times from the very early morning, to late afternoon or early evening. This assures that the crop is irrigated during or near daytime hours and this minimizes the potential for plant diseases to impact the forage crop. Turf and other grass crops are susceptible to fungal infections if irrigated extensively during nighttime hours. The irrigation operations must be scheduled primarily during daytime or near daytime hours. Irrigation in the late evening followed by long periods of dark is not a recommended reuse practice.

7.2.3 Forage Grass Harvesting

The forage system (all species) should produce a yield of 3 to 8 tons/ac/yr, provided nutrient loadings, fertilization, and irrigation is provided. The grass should be mowed on a regular basis and left in place to provide organic matter and nutrients for the regenerating crop. As mentioned before, clippings left on the receiver sites provide important carbon and nutrient sources for continued vegetation growth and soil quality improvement. Mowing on the fields should be done with low ground pressure equipment when the soil is dry or cannot be compacted.

Forage Grass Land Application System Establishment Summary

Following are recommendations for establishment of a forage grass receiver site system at the UNCBWWTF:

- Delineate access corridors for sprinkler system and anticipated maintenance areas.
- Lime and fertilize receiver site to improve early growth and survival of groundcover according to recommendations provided in Table 3 and Section 7.1 of this report.
- Rip planting areas and/or disk to improve infiltration and incorporate any surficial organic material, lime, and fertilizer.
- Seed the receiver site with a groundcover consisting of Bermuda grass, tall fescue, gamma grass, dallisgrass and/or annual ryegrass.
- Band-apply a preemergent herbicide to planting areas if necessary to control herbaceous weeds (i.e. 2% glyphosphate sln.).
- Plant forage species within proposed planting areas shortly after site preparation has been completed in early spring or fall. Seeding rates as recommended by Cooperative Extension for fescue are typically 20 to 40 pounds of seed/ac. Rates for Bermuda grass sprigs are typically 40 bushels/ac with incorporation and 60 bu/ac with broadcast distribution. Incorporation is recommended to support sprig survival.
- All planting areas should be irrigated immediately following planting and regularly throughout the first two growing seasons (i.e. March 1 through November 30) to ensure initial survival and growth.

Follow up inspection and replanting as necessary (within one year following planting).

8.0 Conclusions / Summary

Overall, the proposed land application receiver site system is a viable option for wastewater irrigation and remediation at the UNCBWWTF. These systems are also compatible with achieving water quality standards set forth by state agencies for nutrient

sensitive regions. This system will result in the most effective wastewater treatment and assimilation system based on the existing site conditions, hydraulic loading rates, wastewater characteristics, and soil characteristics.

Utilizing a combination tree and forage system will require less maintenance than a forage system alone. The long term presence of forest cover and reduced vehicle traffic with forest systems will greatly improve infiltration and other soil characteristics important for renovation of wastewater and recharge of groundwater. When implemented and managed properly, the forested land application system will utilize hardwood tree species capable of producing large amounts of biomass, while providing favorable soil conditions to enhance adsorption and denitrification of phosphorous and nitrogen respectively.

The overall success of the tree system depends on the routine operation, maintenance, and optimal performance of the irrigation system. Tree establishment, management, and harvesting should be accomplished by qualified professionals. Routine maintenance should be performed by the certified system operator.

With proper site management, hydraulic and nutrient loading management, the site will perform as a means to treat wastewater and protect surface waters entering nearby river basins. Site, soil, vegetation, and water quality all combine to support the existing wastewater land application system. Continuous monitoring of the quality of the irrigation water applied to the receiver site as well as annual soil testing must be accomplished as an ongoing part of this project. The results of the water quality monitoring must be communicated to all personnel involved with this land application system, **including landscape managers**, as well as regulatory agency personnel responsible for assuring compliance with environmental mandates.

9.0 Environmental Effects

If managed properly there should be no adverse environmental effects from the establishment and management of a wastewater land application system at the proposed receiver site. Site, soil, vegetation, and water quality all combine to support the existing system. Continuous monitoring of the quality of the wastewater applied as well as annual soil testing combined with adherence to the recommendations in this report will ensure the system is successful.

The irrigation of this wastewater will increase soil fertility and productivity at the UNCBWWTF receiver site. The existing system will enhance adjacent wetlands and low lying areas with increased base flow. If managed properly, there will be no adverse impacts to groundwater supplies or surface water supplies. The addition of water and nutrients to the site may benefit wildlife through increased biological activity in adjacent wetlands and low lying areas.

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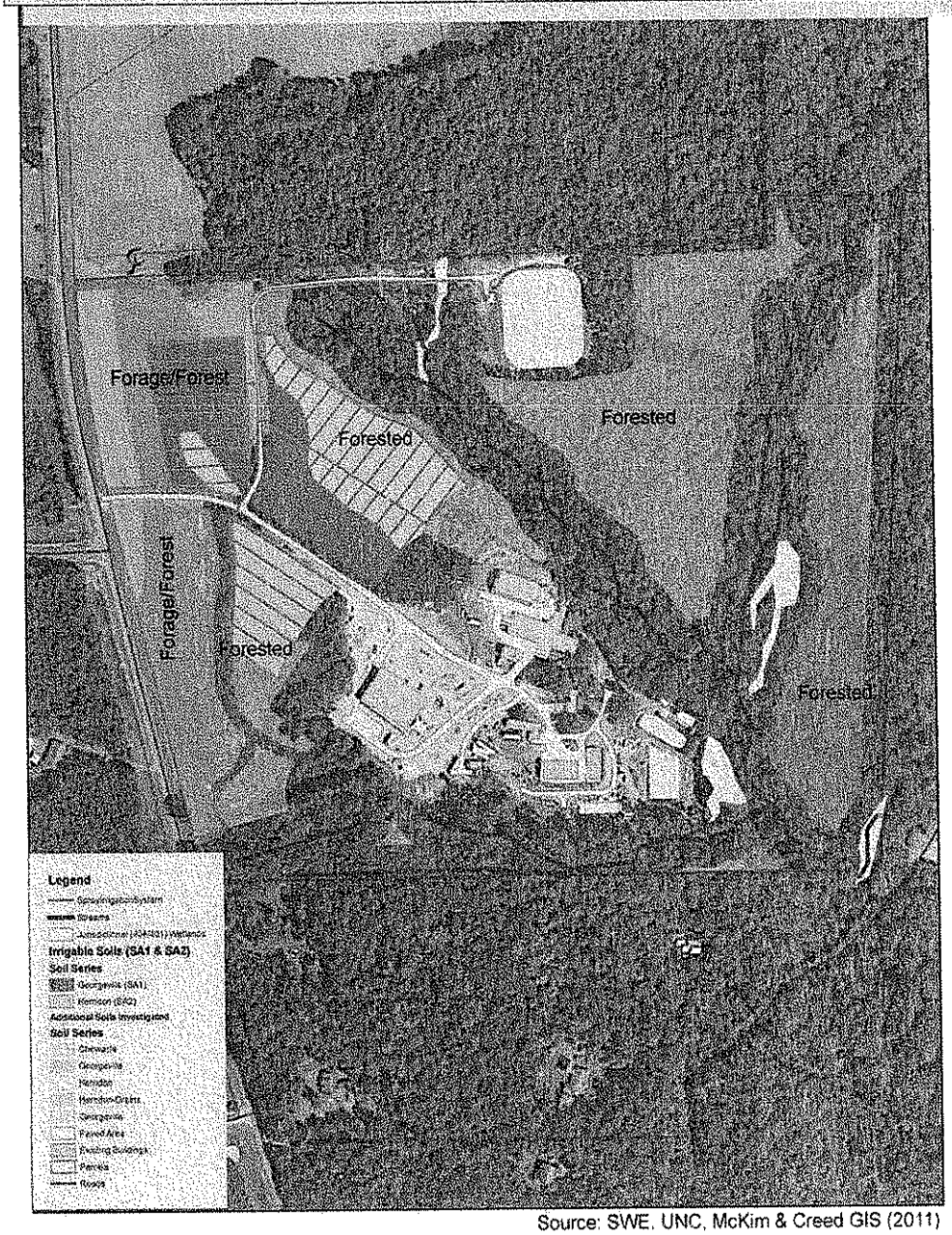
APPENDIX

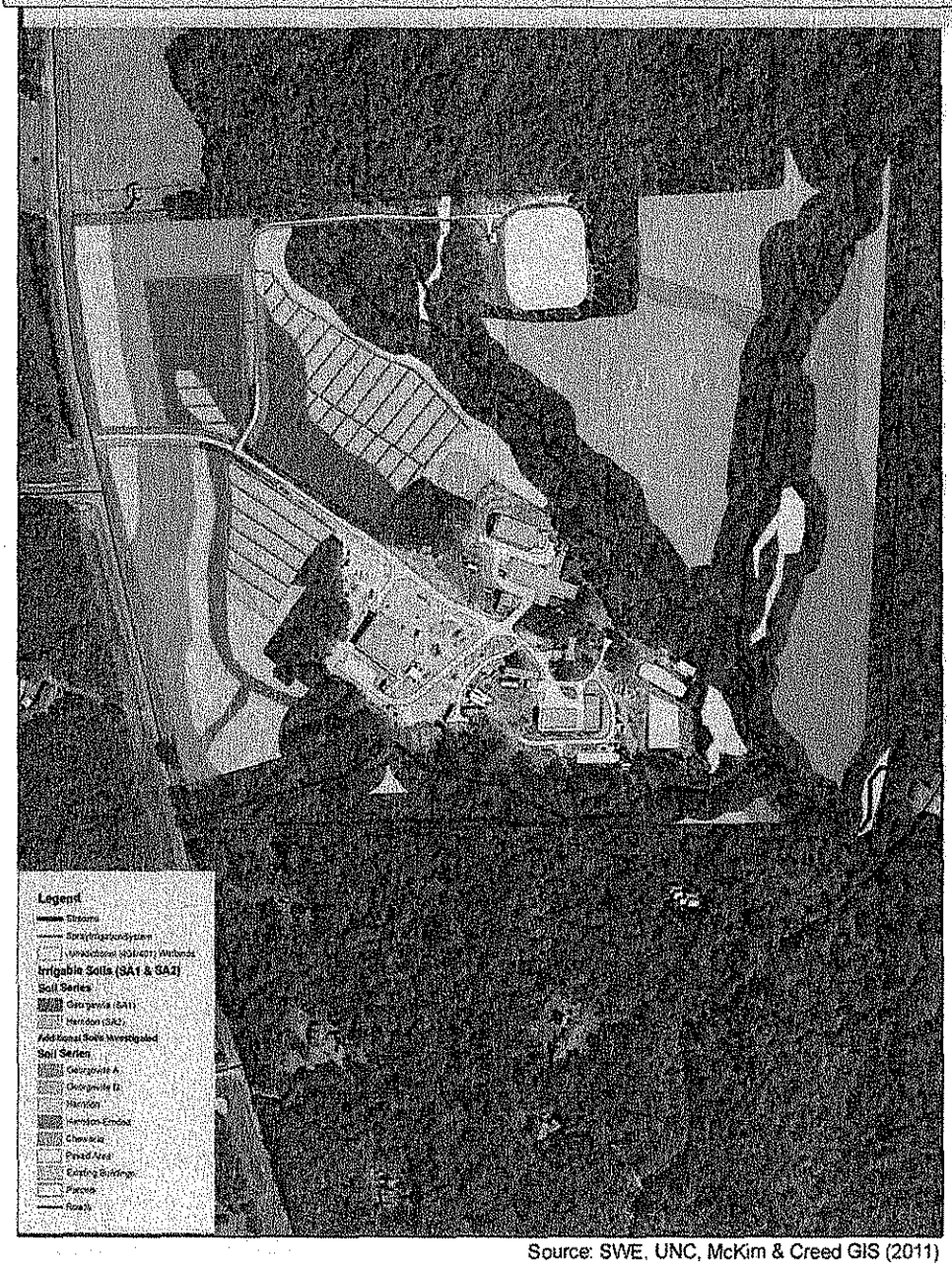
APPENDIX A
Receiver Site Maps

FIGURE 2: UNC Bingham Facility Land Application System Vegetation Map



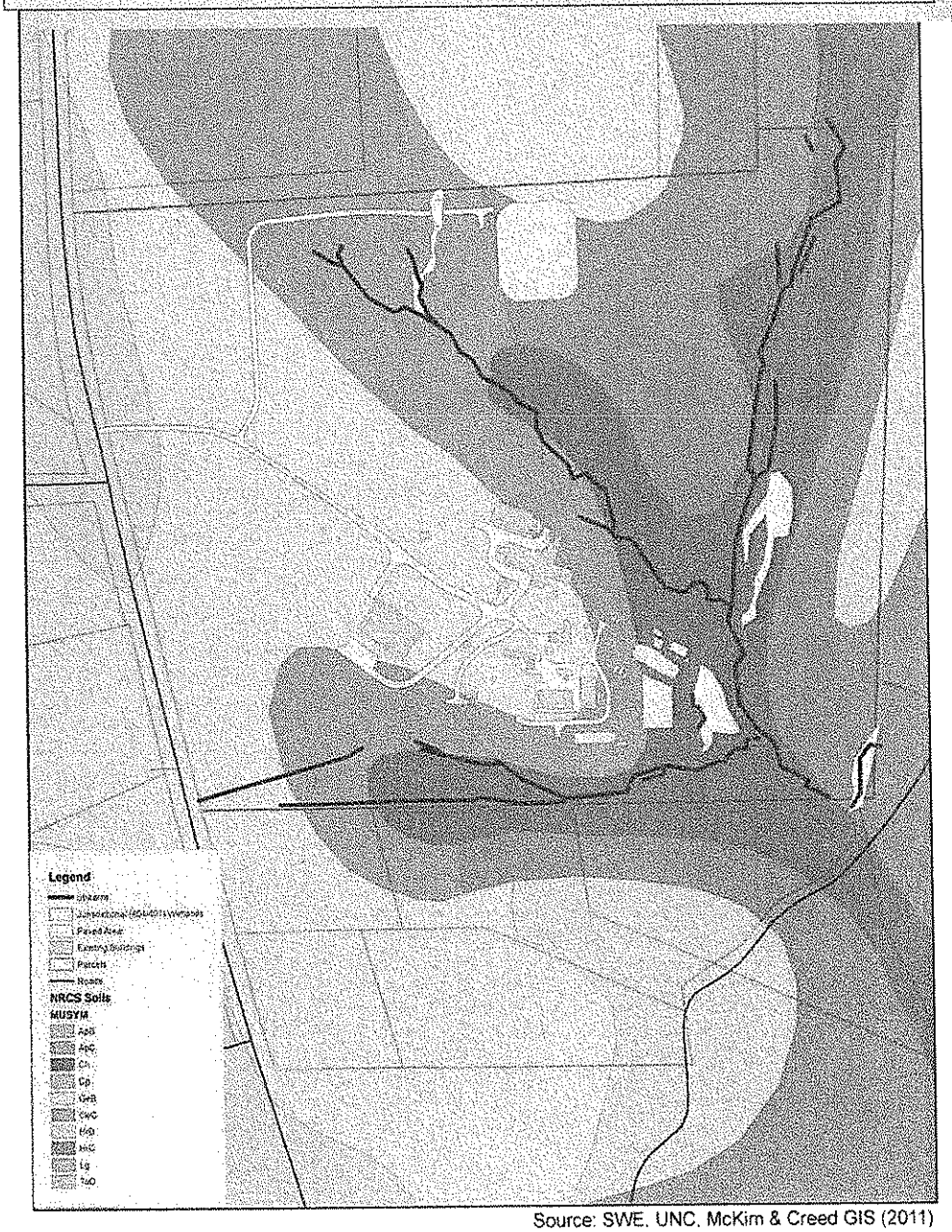
Source: SWE, UNC, McKim & Creed GIS (2011)

FIGURE 3: UNC Bingham Facility Land Application System Irrigable Soils Map



Source: SWE, UNC, McKim & Creed GIS (2011)

FIGURE 4: UNC Bingham Facility Land Application System
NRCS (USDA) Soils Map



Source: SWE, UNC, McKim & Creed GIS (2011)

APPENDIX B

PAN, Nitrogen and Phosphorus Balance Calculations

(Page 18, Item 11. Cover crop information, NCDWQ Form: WWIS 12-06)

Reuse Water Characterization

The anticipated effluent will meet reuse water quality standards set forth by NCDWQ. Levels of BOD and total suspended solids (TSS) must be ≤ 10 mg/L and 5 mg/L respectively and meet the federal shellfish standard for coliform of < 14 counts/100mL. Total nitrogen concentrations and total phosphorus concentrations are anticipated to be approximately ~25.0 mg/L and ~5.0 mg/L respectively by means of the current treatment design.

Plant available nitrogen (PAN) can be calculated using the formula below. For purposes of this report, a mineralization rate (40%) and volatilization rate (50%) are utilized. This allows for carryover from previous years and provides a conservative estimate of nitrogen loadings to the forest and/or forage/ornamental vegetation system.

PAN

PAN= MR(TKN-NH3)+[(1-VR)*(NH3)]+(NO3+NO2)= 21.5 ppm

Where

PAN= Plant Available Nitrogen
MR= Mineralization Rate (40%)
VR= Volatilization Rate (50%)
*TKN= Total Kjeldhal Nitrogen (~25.0 ppm)
*NH3= Ammonia Nitrogen (~ 15.0 ppm)
*NO3= Nitrate Nitrogen (~10.0 ppm)
*NO2= Nitrite Nitrogen (~ 0.0 ppm)

*Source: McKim & Creed (2011) - Proposed AdvanTex System

Table 4: Nutrient uptake and removal and yields for proposed cover crops at the UNCBWWTF receiver site.

Soil	Crop	RYE (tons) [1.]	Nitrogen Application Rate (lb/ac/yr) [1.]	Irrigation Area (ft^2)	Phosphorus Removal (lb/ac/yr) [1.]	Irrigation Area (ft^2)
SA1	Fescue	3.2	136	70,595	51	37,650
Georgeville	Coastal Bermuda	3.8	159	60,383	46	41,743
	Forest	-	150 +	64,006	40 +	48,004
SA2	Fescue	3.9	174	29,581	63	24,158
Herndon	Coastal Bermuda	4.8	213	27,220	58	19,993
	Forest	-	150 +	38,653	40 +	28,990

1.] Based off management recommendations from NCSU et al. (http://nutrients.soil.ncsu.edu/yields/)

EXAMPLE CALCULATIONS:

Nitrogen Balance to Determine Irrigation Acres if N is Limiting

Soil Area 1

Fescue

TN (.21 in/wk liquid loading: 25.0 mg TN/L annual avg.)

25.0 mg/L TN * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 136 lbs TN/ac/yr = 1.6 ac

Coastal Bermuda grass

TN (.21 in/wk liquid loading: 25.0 mg TN/L annual avg.)

25.0 mg/L TN * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 159 lbs TN/ac/yr = 1.3 ac

Forest
TN (.21 in/wk liquid loading: 25.0 mg TN/L annual avg.)
25.0 mg/L TN * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 150 lbs TN/ac/yr = 1.4 ac

Soil Area 2
Fescue
TN (.21 in/wk liquid loading: 25.0 mg TN/L annual avg.)
25.0 mg/L TN * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 196 lbs TN/ac/yr = .68 ac

Coastal Bermuda grass
TN (.21 in/wk liquid loading: 25.0 mg TN/L annual avg.)
25.0 mg/L TN * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 213 lbs TN/ac/yr = .62 ac

Forest
TN (.21 in/wk liquid loading: 25.0 mg TN/L annual avg.)
25.0 mg/L TN * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 150 lbs TN/ac/yr = .89 ac

Phosphorus Balance to Determine Irrigation Acres if P is Limiting

Soil Area 1
Fescue
TP (.21 in/wk liquid loading: 5.0 mg TP/L annual avg.)
5.0 mg/L TP * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 51 lbs TP/ac/yr = .86 ac

Coastal Bermuda grass
TP (.21 in/wk liquid loading: 5.0 mg TP/L annual avg.)
5.0 mg/L TP * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 46 lbs TP/ac/yr = .95 ac

Forest
TP (.21 in/wk liquid loading: 5.0 mg TP/L annual avg.)
5.0 mg/L TP * (1,057,113 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 40 lbs TP/ac/yr = 1.1 ac

Soil Area 2
Fescue
TP (.21 in/wk liquid loading: 5.0 mg TP/L annual avg.)
5.0 mg/L TP * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 48 lbs TP/ac/yr = .55 ac

Coastal Bermuda grass
TP (.21 in/wk liquid loading: 5.0 mg TP/L annual avg.)
5.0 mg/L TP * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 58 lbs TP/ac/yr = .45 ac

Forest
TP (.21 in/wk liquid loading: 5.0 mg TP/L annual avg.)
5.0 mg/L TP * (638,395 gal/yr) * 8.34 (lb/10^6 gal/mg/L) / 40 lbs TP/ac/yr = .66 ac

Water Balance

Soils	Soil Area	Maximum Irrigation Rate (in/yr) [1.]	Irrigation Area (ft2)
Georgeville/Herndon	SA1/SA2	10.92	249,163

1.] Based on Water Balance (Edwin Andrews & Assoc., PA, 2011)
* Note: This site is hydraulically limited

APPENDIX C

Soil Fertility Analysis

Background Soil Samples at the Proposed Receiver Properties (March, 2010).

Soil Test Report

2010

Sample No.	Soil	Depth	Crop	HM%	W/V	CEC	BS%	Ac	pH	P-I	P (ppm)	K-I	K (ppm)	Ca%	Ca (ppm)	Mg%	Mg (ppm)	Mn-I	Mn (ppm)	Zn-I	Zn (ppm)	Cu-I	Cu (ppm)	S-I	S (ppm)	Na-I	Na (ppm)	ESP	
UNC Bingham WWRF Site																													
SB1A	1	0-6 in.	Establishment hardwood	0.13	0.89	5.5	71	1.6	6.5	2	2.4	39	76.2	40	220.0	27	148.5	91	14.6	18	0.6	28	0.5	118	17.2	0.1	23.0	1.82	
SB1B	1	6-12 in.	Establishment hardwood	0.09	0.92	5.4	59	2.2	5.2	1	1.2	28	36.7	30	162.0	27	145.8	25	4.0	8	0.3	20	0.4	200	80.0	0.1	23.0	1.85	
SB2A	1	0-6 in.	Establishment hardwood	0.36	1.04	8	80	1	6.8	6	7.2	23	45.0	53	265.0	25	130.0	344	55.0	18	0.7	25	0.5	28	11.2	0.1	23.0	2.00	
SB2B	1	6-12 in.	Establishment hardwood	0.13	1.08	4.9	84	0.8	5.9	2	2.4	15	29.3	51	255.0	32	156.8	212	33.9	9	0.4	23	0.5	54	21.6	0.1	23.0	2.04	
SB3A	1	0-6 in.	Establishment hardwood	0.71	0.69	9.5	75	2.4	6.3	10	12.0	62	121.2	47	235.5	24	228.6	231	37.0	91	3.6	49	1.0	40	16.0	0.1	23.0	1.05	
SB3B	1	6-12 in.	Establishment hardwood	0.22	0.93	6.6	78	1.5	6.5	0	0.0	20	39.1	45	227.0	29	184.8	133	21.3	19	0.8	49	1.0	34	13.6	0.1	23.0	1.52	
SB4A	1	0-6 in.	Establishment hardwood	0.48	0.85	4.0	80	1.4	5.8	7	8.4	35	68.4	50	245.0	28	193.2	333	53.3	51	2.0	36	0.7	30	12.0	0.1	23.0	1.45	
SB4B	1	6-12 in.	Establishment hardwood	0.18	0.95	4.9	87	0.8	6.2	0	0.0	19	37.1	58	352.5	31	195.3	426	68.2	28	1.1	44	0.9	19	7.6	0.1	23.0	1.59	
SB5A	2	0-6 in.	Establishment hardwood	0.32	0.87	6.9	75	1.9	6.0	2	2.4	42	82.1	48	331.2	28	193.2	216	34.9	25	1.0	20	0.4	27	10.8	0.1	23.0	1.45	
SB5B	2	6-12 in.	Establishment hardwood	0.13	0.95	7.3	80	2.5	5.5	4	4.8	28	54.7	38	277.4	26	189.8	237	37.9	26	1.0	38	0.8	44	17.6	0.1	23.0	1.37	
SB6A	2	0-6 in.	Establishment hardwood	0.46	0.83	5.8	71	1.7	5.4	6	7.2	28	54.7	48	265.8	22	127.6	293	46.4	23	0.9	27	0.5	31	12.4	0.1	23.0	1.72	
SB6B	2	6-12 in.	Establishment hardwood	0.27	1.05	6.7	72	1.9	5.8	4	4.8	15	29.3	48	323.0	24	172.8	335	54.1	12	0.5	22	0.4	22	8.8	0.1	23.0	2.13	
SB7A	1	0-6 in.	Establishment hardwood	0.41	0.86	5.4	37	3.4	4.5	5	6.0	17	33.2	25	135.0	10	59.0	116	18.6	187	0.7	11	0.2	32	12.8	0.1	23.0	1.85	
SB7B	1	6-12 in.	Establishment hardwood	0.27	1.13	3.7	27	2.7	4.6	2	2.4	11	21.5	18	66.6	9	33.2	70	11.2	25	1.0	14	0.3	34	13.6	0.1	23.0	2.70	
SB8A	1	0-6 in.	Establishment hardwood	0.36	0.91	4.2	19	3.1	4.1	3	3.6	27	52.8	15	63.0	9	37.8	37	5.9	26	1.0	17	0.3	42	16.8	0.1	23.0	2.38	
SB8B	1	6-12 in.	Establishment hardwood	0.18	1.04	2.1	22	4	4.4	2	2.4	28	54.7	11	56.1	8	30.8	16	2.6	20	0.8	29	0.6	76	30.4	0.1	23.0	1.96	
SB9A	1	0-6 in.	Establishment hardwood	0.56	0.98	4.3	33	2.9	4.4	4	4.8	19	37.1	22	94.0	9	38.7	187	29.9	23	0.9	30	0.6	43	17.2	0.1	23.0	2.33	
SB9B	1	6-12 in.	Establishment hardwood	0.18	1.2	4.8	38	3.1	5.1	2	2.4	22	43.0	21	100.9	11	52.9	420	67.2	14	0.6	21	0.4	30	12.0	0.1	24.0	2.08	
SB10A	1	0-6 in.	Establishment hardwood	0.66	0.75	5.8	27	4.1	4.2	5	6.0	32	62.6	15	84.0	8	50.4	201	32.2	52	2.1	33	0.7	45	18.0	0.1	23.0	1.79	
SB10B	1	6-12 in.	Establishment hardwood	0.13	0.94	5.2	31	3.6	4.8	2	2.4	38	76.2	14	77.0	13	71.5	116	18.6	27	1.1	30	0.6	49	19.6	0.1	23.0	1.82	
SB11A	2	0-6 in.	Establishment hardwood	0.6	0.67	7.7	58	3.4	4.6	5	6.0	41	80.5	42	323.4	11	84.7	388	62.1	56	2.2	41	0.9	45	18.0	0.1	23.0	1.30	
SB11B	2	6-12 in.	Establishment hardwood	0.18	0.68	5.8	58	3	4.7	2	2.4	45	88.0	38	238.4	14	95.2	222	35.5	22	0.9	30	0.6	43	17.2	0.1	23.0	1.47	
SB12A	2	0-6 in.	Establishment hardwood	0.6	0.84	5.6	35	3.6	4.2	3	3.6	27	52.8	21	121.8	9	52.2	62	10.1	23	0.9	21	0.4	46	18.4	0.1	23.0	1.72	
SB12B	2	6-12 in.	Establishment hardwood	0.18	0.91	6.6	43	3.5	4.5	2	2.4	30	58.7	28	145.6	15	84.0	69	11.0	18	0.7	29	0.6	57	22.8	0.1	23.0	1.79	
SB13A	2	0-6 in.	Establishment hardwood	0.97	0.92	8.3	32	4.3	4.6	13	15.6	42	82.1	21	132.3	7	44.1	149	23.8	45	1.8	27	0.5	44	17.6	0.1	23.0	1.59	
SB13B	2	6-12 in.	Establishment hardwood	0.09	0.89	9	39	3.2	4.8	1	1.2	58	113.4	18	90.0	12	60.0	58	9.0	15	0.6	23	0.5	143	57.2	0.1	23.0	2.00	
SB14A	3	0-6 in.	Establishment hardwood	0.6	0.87	7.2	44	4	4.9	7	8.4	42	82.1	26	201.6	13	93.6	303	48.5	45	1.8	38	0.7	41	16.4	0.1	23.0	1.39	
SB14B	3	6-12 in.	Establishment hardwood	0.18	1.15	7	84	2.5	5	1	1.2	47	91.9	33	231.0	28	196.0	615	98.4	21	0.8	33	0.7	62	24.8	0.1	23.0	1.43	
SB15	1	0-6 in.	Establishment hardwood	0.13	0.98	4.2	71	2.4	5.1	3	3.6	50	97.8	49	400.7	16	151.7	263	42.1	24	1.0	42	0.8	116	46.4	0.1	23.0	1.20	
SB16A	2	0-6 in.	Establishment hardwood	0.71	0.68	4.3	44	2.4	4.6	114	136.8	43	84.1	31	133.3	8	54.4	210	33.6	28	1.1	202	4.0	58	23.2	0.2	46.0	4.65	
SB16B	2	6-12 in.	Establishment hardwood	0.51	1.08	3.5	43	2	4.6	36	43.2	24	46.9	30	105.0	10	35.0	402	64.3	40	1.6	108	2.1	80	32.0	0.2	46.0	5.71	
SB17	2	0-6 in.	Establishment hardwood	0.6	0.88	5.6	41	2.4	4.5	154	184.8	30	58.7	32	179.2	7	39.2	111	17.8	40	1.6	134	2.7	40	16.0	0.2	46.0	3.57	
SB18A	2	0-6 in.	Establishment hardwood	0.66	0.88	6.7	36	4.3	4.3	11	13.2	48	93.8	25	167.5	7	46.2	117	18.7	38	1.4	27	0.5	67	26.8	0.2	46.0	2.99	
SB18B	1	6-12 in.	Establishment hardwood	0.32	0.89	5	30	2.5	4.5	6	7.2	36	70.4	16	90.0	8	48.0	47	7.5	20	0.8	26	0.5	70	28.0	0	0.0	0.00	
SB18A	4	0-6 in.	Establishment hardwood	0.71	0.82	5.4	29	3.9	4.3	8	9.6	25	48.9	19	102.5	7	37.8	465	74.4	30	1.2	32	0.6	51	20.4	0.1	23.0	1.85	
SB18B	4	6-12 in.	Establishment hardwood	0.22	1.11	4.4	18	3.6	4.4	1	1.2	12	23.5	11	58.4	5	27.0	85	13.6	11	0.4	21	0.4	51	20.4	0.1	23.0	2.27	
	AVG:	0-6 in.		0.5	0.9	6.1	50.7	2.9	4.8	19.5	23.4	35.4	69.1	33.1	211.6	14.7	94.3	217.7	34.8	43.1	1.7	44.1	0.9	49.7	19.9	0.1	26.6	2.0	
		6-12 in.		0.2	1.0	5.4	49.9	2.6	5.0	4.0	4.8	28.1	55.0	29.8	166.7	17.7	108.9	285.2	32.8	19.7	0.8	32.8	0.7	62.8	25.1	0.1	23.0	2.0	
	Soil Area 1 (Ge)	0-6 in.		0.4	0.9	6.1	55.6	2.5	4.9	5.0	6.0	33.8	66.0	35.1	228.9	17.9	115.4	200.3	32.1	52.0	2.1	30.0	0.6	54.9	22.0	0.1	23.0	1.8	
		6-12 in.		0.2	1.0	5.3	50.1	2.5	5.1	1.9	2.3	24.3	47.6	29.3	161.4	18.6	182.3	162.8	26.0	18.9	0.8	28.4	0.6	52.9	25.2	0.1	20.4	1.7	
	Soil Area 2 (Herndon)	0-6 in.		0.6	0.9	6.1	50.7	2.9	4.7	42.7	51.3	36.1	70.7	34.4	212.6	13.1	82.2	206.9	33.1	34.3	1.4	67.4	1.3	41.6	16.6	0.1	29.6	2.3	
		6-12 in.		0.2	1.0	5.5	52.7	2.5	5.0	8.2	9.8	33.3	65.2	33.0	183.7	16.8	96.1	220.7	35.3	22.2	0.9	41.3	0.8	64.8	25.9	0.1	26.8	2.4	

Multiplication Factors for Converting Soil Test Index Values to a Quantitative Equivalent

Nutrient	mg/dm3 = ppm
P-I	1.2
K-I	1.955
(Ca-%*CEC)	200
(Mg-%*CEC)	121.6
Na	230
Mn-I	0.16
Zn-I	0.04
Cu-I	0.02
S-I	0.4

Table 6A, Water Balance: UNC Bingham

Soil 1 - Secondary Effluent - 3556 GPD Total

Input ==>

Output =>

Thornthwaite Potential Evapotranspiration Method

Enter Site Latitude: 35.91 degrees Latitude

	Average Monthly Temp. (degrees F)	Daylight Hours divided by 12	Heat Index (i)	Calculated PET (degrees F)	Manually entered PET data: Potential ET (in/mo)
January	38.3	0.86	0.58	0.20	0.93
February	41.4	0.85	1.07	0.36	1.40
March	49.3	1.03	2.69	1.13	2.17
April	57.9	1.09	4.95	2.24	3.30
May	65.8	1.22	7.41	3.78	4.34
June	73.5	1.22	10.12	5.20	4.80
July	77.6	1.24	11.67	6.11	4.65
August	76.0	1.16	11.05	5.45	4.03
September	69.7	1.03	8.75	3.79	3.30
October	58.2	0.97	5.04	2.03	1.86
November	49.7	0.85	2.78	0.97	1.20
December	41.6	0.84	1.10	0.37	0.62
TOTAL =			67.22	31.64	32.60

☑ << == Check Box to use Thornthaite Method

☐ <<== Check Box to use Manually entered PET data.

PAN Evaporation Data (used for RainFall IN and Evaporation Out of Lagoon)

Location of PAN Data: Chapel Hill

Enter PAN Multiplication Factor: 0.70 <<== 0.70 recommended

	PAN Evaporation Data (in/mo)	PAN Evap. Data X Mult. Factor (in/mo)
January	1.55	1.09
February	1.84	1.29
March	3.58	2.51
April	4.85	3.40
May	5.60	3.92
June	6.14	4.30
July	6.20	4.34
August	5.64	3.95
September	4.48	3.14
October	3.15	2.21
November	1.99	1.39
December	1.43	1.00
TOTAL =	46.45	32.52

☑ <<== Check Box to account for Rain - Evap. in/out of Lagoon

Spray Irrigation Area = 3.56435 acres

Lagoon Area = 0.4552 acres

Avg. Loading 0.210 in/wk

WWTP Design Flow = 2,217 GPD

Limiting Soil Ksat = 0.0330 inch/hour

Drainage Coefficient = 0.085

Kv = Ksat * (Drainage Coeff.) = 0.06732 inch/day

	# of Days in Month (days)	Average Monthly Rain (in/mo)	Rainfall Excess 0.00 (in/mo)	RainFall Infiltrating Soil (in/mo)	Potential ET (in/mo)	Constant Vertical Drainage (in/mo)	Maximum Allowable Irrigation (in/mo)	Ratio Monthly Influent to Irrigation	Actual WWTP Monthly Irrigation Flow (GPD)	Actual "RainFall - ET" Accumulated into/out of Lagoon itself: in (GPD ave.)	Actual "RainFall - ET" Accumulated into/out of Lagoon itself: in (Gallons)	Monthly WWTP Accumulated Volume to be disposed of: in (Gallons)	Monthly WWTP Accumulated Volume to be disposed of: in (in/mo)
January	31	4.93	0.00	4.93	0.20	2.09	0.00	1.000	2,217.0	1,533.2	47,529.7	U	1.20
February	28	3.73	0.00	3.73	0.36	1.88	0.00	1.000	2,217.0	1,078.1	30,186.6	92,262.6	0.95
March	31	5.24	0.00	5.24	1.13	2.09	0.00	1.000	2,217.0	1,090.2	33,796.1	102,523.1	1.06
April	30	3.73	0.00	3.73	2.24	2.02	0.53	1.000	2,217.0	138.0	4,141.1	70,651.1	0.73
May	31	4.89	0.00	4.89	3.78	2.09	0.97	1.000	2,217.0	386.8	11,990.6	80,717.6	0.83
June	30	4.45	0.00	4.45	5.20	2.02	2.77	1.000	2,217.0	62.6	1,878.9	68,388.9	0.71
July	31	5.42	0.00	5.42	6.11	2.09	2.78	1.000	2,217.0	430.7	13,350.3	82,077.3	0.85
August	31	4.26	0.00	4.26	5.45	2.09	3.27	1.000	2,217.0	124.4	3,856.8	72,583.8	0.75
September	30	4.87	0.00	4.87	3.79	2.02	0.94	1.000	2,217.0	714.5	21,434.7	87,944.7	0.91
October	31	4.15	0.00	4.15	2.03	2.09	0.00	1.000	2,217.0	775.6	24,043.0	92,770.0	0.96
November	30	3.52	0.00	3.52	0.97	2.02	0.00	1.000	2,217.0	876.4	26,292.8	92,802.8	0.96
December	31	3.38	0.00	3.38	0.37	2.09	0.00	1.000	2,217.0	948.6	29,407.8	98,134.8	1.01
TOTAL =	365	52.57	0.00	52.57	31.64	24.57	11.28		2,217.0		247,908.4	940,856.7	10.92

Max. Allowable Irrigation Application Factor	Unfactored Monthly Spray (in/mo)	Actual Monthly Spray Irrigation Rate: Factored Monthly Spray (in/mo)	Actual Monthly Spray Irrigation Rate: Max. Irrig. Rate (Y or N)	Actual Monthly Spray Irrigation Rate: Monthly Monthly Accumul. Gallons	Total Storage Required (inch)	Total Storage Required (gallons)
1.00	0.00000	0.00000	N	0	4.13214	399,964
1.00	0.00000	0.00000	N	0	5.08532	492,227
1.00	0.00000	0.00000	N	0	6.14452	594,750
1.00	0.53351	0.53351	Y	51,640	6.34092	613,761
1.00	0.97452	0.97452	Y	94,327	6.20032	600,151
1.00	2.77363	2.77363	Y	268,470	4.13323	400,070
1.00	2.78125	2.78125	Y	269,207	2.19994	212,941
1.00	2.94983	2.94983	N	285,524	0.00000	0
1.00	0.90858	0.90858	N	87,945	0.00000	0
1.00	0.00000	0.00000	N	0	0.95843	92,770
1.00	0.00000	0.00000	N	0	1.91720	185,573
1.00	0.00000	0.00000	N	0	2.93106	283,708
	10.92	10.92		1,057,113		

☑ <<== Check "Spray Factors Box" if any Factors OTHER than 1.00 used.

☐ <<== Check "Factors Reset Box" to reset all Factors back to 1.00

Results:

Total Storage Required of **6.34** inches = **276.8** days of Storage

Notes:

Spray Irrigation Monthly Application Factor = a forcing factor by which the "normally" Actual Spray Irrigation Rate is multiplied by, with the Storage Required being re-calculated to account for this factor.

Formulas:

{Max. Allowable Irrigation} = {ET} + {Drainage} - {Rain}

{Monthly Excess} = {Max. Allowable Irrigation} - {Monthly Influent Waste Volume}

where: { - Monthly Excess} = water that must be stored in Storage Pond

where: { + Monthly Excess} = extra water that can be spray irrigated out of Storage Pond

Table 6B, Water Balance: UNC Bingham

Soil 2 - Secondary Effluent - 3556 GPD Total

Input ==>

Output =>

Thornthwaite Potential Evapotranspiration Method

Enter Site Latitude: 35.91 degrees Latitude

	Average Monthly Temp. (degrees F)	Daylight Hours divided by 12	Heat Index (I)	Calculated PET (degrees F)	Manually entered PET data: Potential ET (in/mo)
January	38.3	0.86	0.58	0.20	0.93
February	41.4	0.85	1.07	0.36	1.40
March	49.3	1.03	2.69	1.13	2.17
April	57.9	1.09	4.95	2.24	3.30
May	65.8	1.22	7.41	3.78	4.34
June	73.5	1.22	10.12	5.20	4.80
July	77.6	1.24	11.67	6.11	4.65
August	76.0	1.16	11.05	5.45	4.03
September	69.7	1.03	8.75	3.79	3.30
October	58.2	0.97	5.04	2.03	1.86
November	49.7	0.85	2.78	0.97	1.20
December	41.6	0.84	1.10	0.37	0.62
TOTAL =			67.22	31.64	32.60

☑ << == Check Box to use Thornthaite Method

☐ <<== Check Box to use Manually entered PET data.

PAN Evaporation Data (used for RainFall IN and Evaporation Out of Lagoon)

Location of PAN Data: Chapel Hill

Enter PAN Multiplication Factor: 0.70 <<== 0.70 recommended

	PAN Evaporation Data (in/mo)	PAN Evap. Data X Mult. Factor (in/mo)
January	1.55	1.09
February	1.84	1.29
March	3.58	2.51
April	4.85	3.40
May	5.60	3.92
June	6.14	4.30
July	6.20	4.34
August	5.64	3.95
September	4.48	3.14
October	3.15	2.21
November	1.99	1.39
December	1.43	1.00
TOTAL =	46.45	32.52

☑ <<== Check Box to account for Rain - Evap. in/out of Lagoon

Spray Irrigation Area = 2.152746 acres

Lagoon Area = 0.2748 acres

Avg. Loading 0.210 in/wk

WWTP Design Flow = 1,339 GPD

Limiting Soil Ksat = 0.0330 inch/hour

Drainage Coefficient = 0.085

Kv = Ksat * (Drainage Coeff.) = 0.06732 inch/day

	# of Days in Month (days)	Average Monthly Rain (in/mo)	Rainfall Excess 0.00 (in/mo)	RainFall Infiltrating Soil (in/mo)	Potential ET (in/mo)	Constant Vertical Drainage (in/mo)	Maximum Allowable Irrigation (in/mo)	Ratio Monthly Influent to Irrigation	Actual WWTP Monthly Irrigation Flow (GPD)	Actual "RainFall - ET" Accumulated into/out of Lagoon itself: in (GPD ave.)	Actual "RainFall - ET" Accumulated into/out of Lagoon itself: in (Gallons)	Monthly WWTP Accumulated Volume to be disposed of: in (Gallons)	Monthly WWTP Accumulated Volume to be disposed of: in (in/mo)	Max. Allowable Irrigation Application Factor	Unfactored Monthly Spray (in/mo)	Actual Monthly Spray Irrigation Rate: Factored Monthly Spray (in/mo)	Actual Monthly Spray Irrigation Rate: Max. Irrig. Rate (Y or N)	Actual Monthly Spray Irrigation Rate: Monthly Monthly Accumul. Gallons	Total Storage Required (inch)	Total Storage Required (gallons)
January	31	4.93	0.00	4.93	0.20	2.09	0.00	1.000	1,339.0	925.6	28,693.2	70,202.2	1.20	1.00	0.00000	0.00000	N	0	4.13155	241,531
February	28	3.73	0.00	3.73	0.36	1.88	0.00	1.000	1,339.0	650.8	18,223.4	55,715.4	0.95	1.00	0.00000	0.00000	N	0	5.08460	297,246
March	31	5.24	0.00	5.24	1.13	2.09	0.00	1.000	1,339.0	658.1	20,402.4	61,911.4	1.06	1.00	0.00000	0.00000	N	0	6.14364	359,157
April	30	3.73	0.00	3.73	2.24	2.02	0.53	1.000	1,339.0	83.3	2,499.9	42,669.9	0.73	1.00	0.53351	0.53351	Y	31,189	6.34003	370,638
May	31	4.89	0.00	4.89	3.78	2.09	0.97	1.000	1,339.0	233.5	7,238.6	48,747.6	0.83	1.00	0.97452	0.97452	Y	56,970	6.19937	362,416
June	30	4.45	0.00	4.45	5.20	2.02	2.77	1.000	1,339.0	37.8	1,134.3	41,304.3	0.71	1.00	2.77363	2.77363	Y	162,147	4.13228	241,573
July	31	5.42	0.00	5.42	6.11	2.09	2.78	1.000	1,339.0	260.0	8,059.5	49,568.5	0.85	1.00	2.78125	2.78125	Y	162,592	2.19894	128,550
August	31	4.26	0.00	4.26	5.45	2.09	3.27	1.000	1,339.0	75.1	2,328.3	43,837.3	0.75	1.00	2.94880	2.94880	N	172,387	0.00000	0
September	30	4.87	0.00	4.87	3.79	2.02	0.94	1.000	1,339.0	431.3	12,939.9	53,109.9	0.91	1.00	0.90848	0.90848	N	53,110	0.00000	0
October	31	4.15	0.00	4.15	2.03	2.09	0.00	1.000	1,339.0	468.2	14,514.5	56,023.5	0.96	1.00	0.00000	0.00000	N	0	0.95832	56,024
November	30	3.52	0.00	3.52	0.97	2.02	0.00	1.000	1,339.0	529.1	15,872.7	56,042.7	0.96	1.00	0.00000	0.00000	N	0	1.91697	112,066
December	31	3.38	0.00	3.38	0.37	2.09	0.00	1.000	1,339.0	572.7	17,753.2	59,262.2	1.01	1.00	0.00000	0.00000	N	0	2.93069	171,328
TOTAL =	365	52.57	0.00	52.57	31.64	24.57	11.28		1,339.0		149,660.0	638,395.0	10.92		10.92	10.92		638,395		

☑ <<== Check "Spray Factors Box" if any Factors OTHER than 1.00 used.

☐ <<== Check "Factors Reset Box" to reset all Factors back to 1.00

Results:

Total Storage Required of 6.34 inches = 276.8 days of Storage

Notes:

Spray Irrigation Monthly Application Factor = a forcing factor by which the "normally" Actual Spray Irrigation Rate is multiplied by, with the Storage Required being re-calculated to account for this factor.

Formulas:

{Max. Allowable Irrigation} = {ET} + {Drainage} - {Rain}

{Monthly Excess} = {Max. Allowable Irrigation} - {Monthly Influent Waste Volume}

where: { - Monthly Excess} = water that must be stored in Storage Pond

where: { + Monthly Excess} = extra water that can be spray irrigated out of Storage Pond

McKIM&CREED

☐ MEMO
☐ TELEPHONE
☐ FIELD REPORT
☐ CONFERENCE

DATE: 10/28/11 TIME:

AUTHOR: Kevin C. Eberle

PROJECT: Bingham WW System Improv. CLIENT: UNC-CH

SUBJECT: Chlorine Contact TANK Flotation Calcs PROJ. NO. 1488-0032

Chlorine Contact TANK Dimensions
5'-0" wide x 7'-0" Long x 5'-0" deep

TANK TO be installed w/ Top elevation = 489.75
Finished Grade = 489.00

Assumptions: 1. groundwater elevation = 1.0' below finished grade
2. Chlorine Contact tank to be buried to subgrade = 484.75

Displaced Volume = 5' x 7' x 4.25' = 148.75 cf

Buoy Force $_{H_2O}$ ↑ = 62.4 lb/ft³ x 148.75 cf
= 9,282 lbs

Vol concrete =
2 walls x 6" x 5' x 5' = 25 cf
2 walls x 6" x 6' x 5' = 30 cf
1 Top Slab x 6" x 5' x 6' = 15 cf
1 bottom slab x 6" x 5' x 6' = 15 cf
3 Baffle walls x 4' x 3.5" x 4'-0" = 14.8 cf
99.8 cf

Wt concrete ↓ = 150 lb/ft³ x 99.8 cf
= 14,981 lbs

(↑ F water) 9,282 lbs − 14,981 lbs (F conc ↓) = Excess 5699 lbs

→ NO additional ballast is required ←

ACTION

COPY:

Wet Weather Storage Basin (LARGE)
Stage-Storage Data

Project: Bingham Facility Wastewater System Improvements
Project No.: 1488-0032

Date: 20-Jul-11 HWL: 504.0

Contour ID	Stage	Area [sq. ft.]	Area [acres]	Incremental Area [sq. ft.]	Incremental Area [acres]	Incremental volume [cu. ft]	Incremental volume [acre-ft]	Cumulative volume [cu. ft]	Cumulative volume [gallons]	Cumulative volume [acre-ft]
493.5	0	7,963.81	0.183	7,963.810	0.183	0.000	0.000	0.000	0.000	0.000
494	0.5	8,473.36	0.195	509.550	0.012	4,109.293	0.094	4,109.293	30,737.508	0.094
495	1.5	9,535.27	0.219	1,061.910	0.024	9,004.315	0.207	13,113.608	98,089.784	0.301
496	2.5	10,654.03	0.245	1,118.760	0.026	10,094.650	0.232	23,208.258	173,597.766	0.533
497	3.5	11,829.94	0.272	1,175.910	0.027	11,241.985	0.258	34,450.243	257,687.814	0.791
498	4.5	13,063.02	0.300	1,233.080	0.028	12,446.480	0.286	46,896.723	350,787.484	1.077
499	5.5	14,353.00	0.329	1,289.980	0.030	13,708.010	0.315	60,604.733	453,323.399	1.391
500	6.5	15,699.75	0.360	1,346.750	0.031	15,026.375	0.345	75,631.108	565,720.684	1.736
501	7.5	17,103.49	0.393	1,403.740	0.032	16,401.620	0.377	92,032.728	688,404.802	2.113
502	8.5	18,564.24	0.426	1,460.750	0.034	17,833.865	0.409	109,866.593	821,802.112	2.522
503	9.5	20,082.05	0.461	1,517.810	0.035	19,323.145	0.444	129,189.738	966,339.237	2.966
504	**10.5**	**21,656.86**	**0.497**	**1,574.810**	**0.036**	**20,869.455**	**0.479**	**150,059.193**	**1,122,442.760**	**3.445**
505	11.5	23,288.67	0.535	1,631.810	0.037	22,472.765	0.516	172,531.958	1,290,539.042	3.961
506	12.5	24,977.53	0.573	1,688.860	0.039	24,133.100	0.554	196,665.058	1,471,054.630	4.515

Secondary Effluent Storage Basin
Stage-Storage Data

Project Bingham Facility Wastewater System Improvements
Project No. 1488-0032

Date 20-Jul-11 HWL 482.0

Contour ID	Stage	Area [sq. ft.]	Area [acres]	Incremental Area [sq. ft.]	Incremental Area [acres]	Incremental volume [cu. ft]	Incremental volume [acre-ft]	Cumulative volume [cu. ft]	Cumulative volume [gallons]	Cumulative volume [acre-ft]
475	0	636.46	0.015	636.460	0.015	0.000	0.000	0.000	0.000	0.000
476	1	1,029.71	0.024	393.250	0.009	833.085	0.019	833.085	6,231.476	0.019
477	2	1,486.63	0.034	456.920	0.010	1,258.170	0.029	2,091.255	15,642.587	0.048
478	3	1,999.74	0.046	513.110	0.012	1,743.185	0.040	3,834.440	28,681.611	0.088
479	4	2,571.51	0.059	571.770	0.013	2,285.625	0.052	6,120.065	45,778.086	0.140
480	5	3,196.99	0.073	625.480	0.014	2,884.250	0.066	9,004.315	67,352.276	0.207
481	6	3,887.80	0.089	690.810	0.016	3,542.395	0.081	12,546.710	93,849.391	0.288
482	**7**	**4,634.93**	**0.106**	**747.130**	**0.017**	**4,261.365**	**0.098**	**16,808.075**	**125,724.401**	**0.386**
483	8	5,436.93	0.125	802.000	0.018	5,035.930	0.116	21,844.005	163,393.157	0.501
484	9	6,294.21	0.144	857.280	0.020	5,865.570	0.135	27,709.575	207,267.621	0.636

McKIM&CREED

☐ MEMO
☐ TELEPHONE
☐ FIELD REPORT
☐ CONFERENCE

DATE: Revised KCE 10/26/11 TIME:

AUTHOR: Kevin C. Eberle

PROJECT: UNC - BINGHAM CLIENT:

SUBJECT: CHLORINATION SYSTEM PROJ. NO. 1488.0032

DESIGN CHLORINE DOSAGE: 10 mg/L

DESIGN CAPACITY: ~~3500~~ 3,556 GPD (2.5gpm) GPD, 2.5 GPM (MAX); PF = 10 x ADF

CHLORINE REQ'D: 10 x 8.34 x ~~0.0035~~ 0.003556 = ~~0.3~~ 0.297 lbs/D ≈ 0.3 lbs/D LBS/DAY

PEAK FLOW REQ'D: $\frac{25\text{GPM} \times 1440}{100} \times 10 \times 8.34 = 3$ LBS/DAY

NaOCl @ 5.25% : 9 LBS/GAL x 0.0525 = 0.47 LBS Cl_2/GAL

METERING PUMP CAP (AVG): $\frac{0.3}{0.47} =$ 0.64 GAL/DAY = 0.027 GPH

" " " (PEAK): 0.027 x 10 = 0.27 GPH

CHEMICAL TANK CAPACITY (MIN): 0.64 x 30 DAYS = 19.2 GAL
USE STD DOUBLE-WALL CONTAINMENT TANK w/ HEAT TRACE & INSULATION)

METERING PUMPS: WATSON-MARLOW 520 UN/REH (2 PUMPS)
FLOW: UP TO 420 ml/min (2200:1 SPEED)
PROVIDE INSULATED & HEATED ENCLOSURE

ACTION

COPY:

McKIM&CREED

☐ MEMO
☐ TELEPHONE
☐ FIELD REPORT
☐ CONFERENCE

DATE: 10/28/11 (Rev 1) TIME:

AUTHOR: Kevin C. Eberle

PROJECT: UNC Bingham CLIENT: UNC-CH

SUBJECT: Chlorination / Disinfection Syst PROJ. NO. 1488.0032

AVG. FLOW : 10 GPM CT REQ'D : 30 MIN.
PEAK FLOW : 25 GPM CT REQ'D (10 STATE STDS) = 15 minutes
TANK CAPACITY : 10 GPM X 30 MIN. = 300 GAL
: 25 GPM X 15 MIN = 375 GAL
USE STD PRECAST CONCRETE, 525 GAL CAPACITY ✓

ACTUAL CT @ PEAK FLOW = $\frac{550 \text{ GAL}}{10}$ = 55 MIN. CT

$\frac{525 \text{ GAL}}{25}$ = 21 MIN CT ✓

ACTION

COPY:

Bingham Facility Wastewater System Improvements

Orange County, NC

McKIM&CREED

05/2011

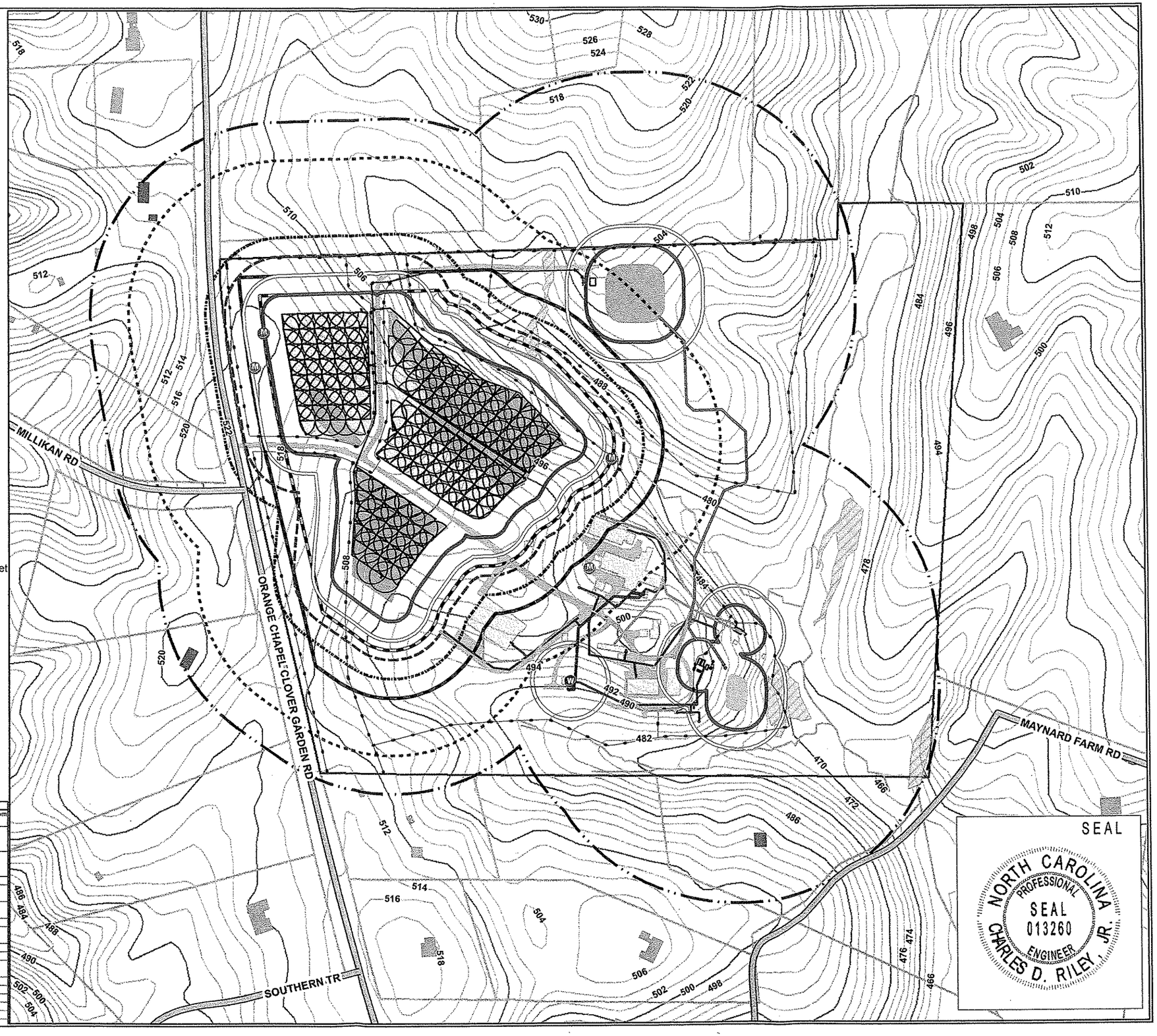
1 inch = 250 feet

- Existing Monitoring Wells
- New Monitoring Wells
- Potable Wells
- Sanitary Sewer
- Potable Water Piping
- 2-ft Contour
- 10-ft Contour
- Effluent Forcemain
- Fenceline
- Stream (survey)
- Streets
- IrrigationLayout
- Compliance Boundary
- Review Boundary
- Wetlands (survey)
- Existing Building Footprints
- Existing Paved Area
- Bingham Property Boundary
- Orange County Parcels
- WellSetback
- 50' Setback
- 100' Setback
- 150' Setback
- 200' Setback
- 400' Setback
- 500' Area of Interest
- CN-WWTP; CX-WWTP
- Effluent Storage Basin
- Irrigation Pump Station
- Wet Weather Storage Basin
- Habitable Residences Not Within 500 feet
- Habitable Residences Within 500 feet
- Georgeville Soils
- Herndon Soils

Revision 1 10/2011

SETBACKS (Per 15A NCAC 02T.00.506 (a) and (b) - Rev September 1, 2006)				
Description	Treatment Units/Storage	Irrigation System	Minimum Distance From Treatment Units/Storage**	Minimum Distance From Irrigation System**
Any habitable residence or place of public assembly under separate ownership or not to be maintained as part of the project site	100 feet	400 feet	320 feet	406 feet
Any habitable residence or place of public assembly under separate ownership to be maintained as part of the project site	–	200 feet	–	201 feet
Any private or public water supply source	100 feet	100 feet	325 feet	250 feet
Surface Waters (streams- intermittent and perennial, perennial water bodies, and wetlands)	50 feet	100 feet	50 feet	100+ feet
Groundwater lowering ditches (where the bottom of the ditch intersects the SHWT)	–	100 feet	–	N/A
Subsurface groundwater lowering drainage systems	–	100 feet	–	N/A
Surface water diversions (ephemeral streams, waterways, ditches)	–	25 feet	–	100+ feet
Any well with the exception of monitoring wells	100 feet	100 feet	325 feet	250 feet
Any property line	50 feet	150 feet	50+ feet	150+ feet
Top of slope of embankments or cuts of 2-ft or more in vertical height	–	15 feet	–	N/A
Any water line from a disposal system	–	10 feet	–	160 feet
Any swimming pool	–	100 feet	–	N/A
Public right of way	–	50 feet	–	150+ feet
Nitrification field	–	20 feet	–	N/A
Any building foundation or basement	–	15 feet	–	120 feet

impoundment Public water supplies



SEAL

NORTH CAROLINA PROFESSIONAL SEAL 013260 ENGINEER CHARLES D. RILEY, JR.