1

16

Johnston Co.

5103 2001

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

FAX TRANSMITTAL SHEET

51-03

PLEASE DELIVER THE FOLLOWING TO:

NAME: Ed Mussler

COMPANY: NC DWM

FAX NUMBER: 715-3605

FROM: Pieter Scheer

DATE: 11/13/01 TIME:

REFERENCE: Johnston County - Phase 4A

COMMENTS: Ed: F.Y.I. - please see the attached resolution regarding Phase 4A and the joining of Permits 51–01 and 51-02. Per our previous discussions, we have addressed your comments of 10/2/01 and are waiting to see if you will have additional comments which will affect the facility plan before getting these responses back to you. Per our discussions with Bobby, we do plan to extend the double liner system across the bottom of Phase 4A and add another leak detection point in the sump. This will be addressed in the next pass through as well. Please let me know if you have any questions or comments. Thanks!

Total number of pages including cover sheet: 2

Please call if there are problems with this fax.

JOHNSTON COUNTY

RESOLUTION TO MERGE EXISTING SOLID WASTE UNITS and APPROVE PHASE 4A OF THE JOHNSTON COUNTY LANDFILL

WHEREAS, T15A, NCAC 13B.1618 (c)(5)(A) requires approval of a proposed landfill site by the governing Board of County Commissioners; and,

WHEREAS, existing and adjacent solid waste units currently permitted under North Carolina Solid Waste Permits #51-01 and #51-02 will be joined under a new North Carolina Solid Waste Permit; and,

WHEREAS, the proposed Phase 4A landfill is a Subtitle D municipal solid waste (MSW) facility consisting of approximately 31.4 acres of lined waste footprint between and partially overlying existing Phases 3 and 4 (existing permit #51-01); and,

WHEREAS, the proposed Phase 4A landfill unit meets all County zoning requirements and is consistent with the current Johnston County Solid Waste Management Plan; and,

WHEREAS, the proposed Phase 4A will provide up to 2,100,000 cubic yards of net volume of waste which is projected to last up to 11 years; and,

WHEREAS, this increases the total lined cell acreage and volume of air space in the Johnston County Solid Waste Management Plan to 149.3 acres and 8,600,000 cubic yards respectively; and,

WHEREAS, this provides Johnston County, at current and projected County MSW disposal rates, approximately 30-years of MSW disposal capacity.

NOW, THEREFORE, BE IT RESOLVED that the County Commissioners of Johnston County hereby approve the merging of existing North Carolina Solid Waste Permits #51-01 and #51-02 and the proposed Phase 4A landfill cell.

Adopted by the Johnston County Board of Commissioners during regular session on this 5th day of November 2001.

James H. Langdon, Jr., Chairman
Johnston County Board of Commissioners

Attest:

Joyce H. Ennis, Clerk to the
Board of County Commissioners

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

October 30, 2001

Mrs. Joan Smyth, P.G.
G.N. Richardson & Associates
425 N. Boylan Avenue
Raleigh, N.C. 27603

RE: Hydrogeologic Review Of The Revised Design Hydrogeologic Report, Johnston Co. MSWLF Phase 4A, Permit No. ~~51-02~~ 51-03

Dear Mrs. Smyth,

This letter provides comments from the hydrogeologic review of the above referenced document. There are a still some items that need additional clarification and/or revisions. Please respond to the following questions and comments:

Page 1 On the first line of page 1, the "piggy-back" expansion phase is between unlined MSWLF units, not "lined".

Page 1 The last line of page 1 should be deleted. Because I am not familiar with the details of the water quality assessment, and because of the dynamic nature of doing an assessment, I am not comfortable with stating that the Water Quality Monitoring Plan for this project supersedes previous plans.

Page 3 Inert debris is defined differently from Construction and Demolition debris. Therefore the word "Inert" should be deleted from the last sentence of the first paragraph of section 2.4.

Page 4 There is an erroneous statement that "a Water Quality Monitoring Plan is not included in this document".

Page 4 The statement is made that "this phase (Phase 4A) will be constructed as a double-lined landfill for *portions* of the landfill..." If it is not possible for Phase 4A to be monitored separately from Phases 3 and 4, then the entire Phase 4A will need to be double-lined in order to effectively monitor this Phase distinctly.

Page 5 Section 3.4 should read: There are no Holocene *age* fault zones...

Pages 9 and 10 Section 4.3.3 should reference the proposed spray irrigation plan for the landfill site and how this could influence ground-water levels.

Page 10 Section 4.3.4 references the "Geophex Report is provided in Appendix G", however the Table of Contents references Appendix I.

Page 11 For Section 4.4.1, refer to previous comment above regarding the second comment for Page 4.

Page 11 Section 4.4.2 is somewhat confusing in the usage of the terms "units" and "aquifers". It should be made clear that there is only one aquifer system which includes the unconsolidated soils and the fractured bedrock. Reference to a "second aquifer" should be deleted.

Page 12 The last paragraph of Section 4.4.2 is also confusing. While the fracture flow is different for the porous flow, it is my understanding that there is one interconnected aquifer system. Comments of the "aquifer thickness" need to be clarified and revised.

Page 12 Section 4.4.3 discusses ground-water recharge and discharge conditions. The report seems to accurately conclude that there is ground-water discharge to the lower portion of the unnamed tributary that drains the Phase 4A area. If this is the case, I again raise the question of the need for a french drain system for the lower portion of this drainage. (The need for this would be augmented by the proposed spray irrigation program at the landfill site.)

Page 14 There is still some confusion on how effective porosity values were determined. There are some references to empirical values from Groundwater and Wells and other references to values based on soil analyses and the use of the Textual Classification Triangle. The effective porosity values that appear in Tables 5 and 6 do not appear consistent with soils data plotted on the Textual Classification Triangle.

Page 14 As previously referenced, if the Phase 4A area can not be monitored separately from the unlined landfill units, then the entire Phase 4A unit needs to have a leak detection system using the double-liner system. What is the basis for establishing an Action Leakage Rate of 3,000 gallons per day? The water quality of the Leakage should be monitored at least semi-annually, at the time of water quality monitoring. The mouth of the drainage feature for Phase 4A is a critical ground-water monitoring location. Ground-water monitoring needs to be included for this area.

Figure 4 The Aerial Photograph is not legible.

Figures 15 and 16 The ground-water contours in the vicinity of well CDLMW-5 are still inconsistent with the data on both figures. The ground-water contours are still somewhat questionable in the vicinity of the MW-9 well cluster. While the contours are consistent with the wells, they cross over topographic contours indicating above ground flow. (Some of the problem may result from the plotting of the well locations. For example MW-10 is plotted on the figures at an ground surface elevation of about 168, while Table 1 indicates an elevation of over 173.) Comparing the ground-water contours with the topographic contours, both figures indicate surface water flow fairly far up all three drainage features. This may need to be re-evaluated.

Table 2 The Top of Casing Elevation (and ground surface elevation) on the revised Borehole Log for MW-8D is still inconsistent with the data on Table 2.

Table 5 and Table 6 It is still not clear how the Effective Porosity Values were determined. It appears that some are still based upon empirical book values and others are stated to be based upon soil analyses and use of the Textual Classification Triangle. It is not clear which values were arrived at by which method. I was not able to match any data I plotted on Textual Classification Triangles with data reported in the Tables. Site specific samples are preferred, however the samples should be representative of the saturated portion of the formation being referenced. The Table of Contents should reference Table 5A.

Apx. F Refer to previous comments regarding well MW-8D.

Apx. G In the Table at the beginning of Appendix G, the value for the % Passing # 200 for the first PZ-5S sample should be 25.9.

Water Quality Monitoring Plan:

Pg. 2 An additional monitoring well is needed at the mouth of the drainage feature downgradient of Phase 4A. The well should be located below the sump for Phase 4A, but above the sedimentation basin.

Pg. 5 The well identification should be the first item listed in the field log, as discussed on the top of Page 5.

Page 6 If MicroPurge is to be used additional details are needed on the sampling equipment, pump locations, pumping rates, sampling techniques, etc.

Page 6 More detail is needed in the discussion of stabilized field parameters including number of consecutive samples taken and time separating samples, etc.

Page 6 If disposable Teflon bailers are to be used they must be certified to have been cleaned according to the approved EPA protocol.

Page 7 In the second paragraph on Page 7, wells slow to recharge should still be sampled. Field logs should note slow recharge conditions and difficulty sampling and propose a remedy for the problem.

Page 7 All monitoring wells in the approved monitoring system need to be sampled in as short a time period as possible, generally within a period of 24 to 48 hours.

Page 8 EPA requires all RCRA metals samples to be unfiltered for total metals analyses. Filtered samples for dissolved metals analyses would be supplemental to those normally required by the Solid Waste Section. Therefore, references to filtering should be deleted. (Also delete references on Pages 11 and 12.)

Page 9 By "Metal containers", I assume it is meant containers for metals analyses samples.

Page 9 The "Equipment Decontamination" procedure outlined in Section 2.6 is not consistent with either the protocol for decontaminating Teflon *or* Stainless Steel sampling equipment, as found in the North Carolina Water Quality Monitoring Guidance Document For Solid Waste Facilities.

Page 10 The surface water sampling location identification should be the first item recorded in the field book.

Page 14 "Chemical cold packs" are not recommended for cooling water samples.

Page 17 The last paragraph on Page 17 should be deleted.

Page 21 It is my understanding that three additional wells have been approved by the Solid Waste Section (wells MW-14D, MW-15D, and MW-16D.) If the Monitoring Plan is to continue referencing monitoring for all the unlined landfill phases, rather than just monitoring for Phase 4A, then these additional wells need to be referenced. As previously discussed, at least one additional well is needed at the mouth of the drainage for Phase 4A.

Table 2 An additional surface water monitoring location is needed at the mouth of the tributary draining the central part of the landfill site, immediately before the tributary drains into Middle Creek.

Please provide the information and revisions as referenced above. If you, other representatives of G. N. Richardson, or Johnston County have any questions regarding this letter, or you would like to arrange a meeting to discuss this letter, you may contact me at (919) 733-0692 extension 258.

Sincerely,

Bobby Lutfy

Bobby Lutfy
Hydrogeologist
Solid Waste Section

cc: Jim Coffey, Solid Waste Section
Ed Mussler, Solid Waste Section
Robert Hearn, Solid Waste Section
Mark Poindexter, Solid Waste Section

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

October 30, 2001

Mr. Haywood Phthisic
Director of Public Utilities
Johnston County
P.O. Box 2263
Smithfield, NC 27577

51-03

Re: Irrigation of Reclaimed Wastewater at the Johnston County Municipal Solid Waste Landfills, Modification to Permits 51-01 and 51-02

Dear Mr. Phthisic:

The Solid Waste Section (Section) has completed its review of the proposed modification to the permits for the referenced facilities. In accordance with the Solid Waste Management Rules and Condition 9, Appendix 4, Permit to Operate Number 51-02, the Section hereby approves the modification which allows the irrigation of reclaimed wastewater consistent with the Operations Manual dated October 2001, submitted on behalf of Johnston County by G. N. Richardson & Associates. The modification will be incorporated into the permit for the new MSWLF facility, which combines both existing landfills into one permitted facility.

The following document will be included, by reference, in the list of approved documents for Permits 51-02 and 51-01, and any new permit prepared by the Section. The document is referenced as:

> *Operations Manual- Addendum. (Irrigation of Reclaimed Wastewater). Johnston County MSW Landfill. Johnston County, North Carolina.* Prepared for: Johnston County Department of Public Utilities. Prepared by: G. N. Richardson & Associates, Inc. Raleigh, NC. August 2001. Revised October 2001.

The county has prepared, and submitted to the Division of Water Quality, drawings and details of elements of the irrigation system that will be installed at the two landfill facilities, i.e. pump stations and force mains. The proposed location and construction details of permanent systems must be included with the facility drawings that are being prepared for the permitting process currently under review by the Section. In addition, any construction activities that are completed before issuance of a permit to construct by the Section for Phase 4A, must be documented with as-built drawings, submitted to the Section. This will be a requirement of any Solid Waste permit issued by the Division of Waste Management.

It should be understood by the County that the irrigation activities proposed in the modification could affect the development of future municipal solid waste landfill units within the facility and could result in a reduction in total landfill disposal capacity.

If you have any further questions, please do not hesitate to contact me at (919) 733-0692, extension 256. Specific questions about permitting and the current status of the permit application can be directed to Ed Mussler, the permitting engineer.

Sincerely,

James C Coffey

James C. Coffey, Acting Chief
Solid Waste Section

cc: Ed Mussler, DWM
Mark Fry, DWM
Robert Hearn, DWM
Jim Barber, DWM
Kenneth Pohlig, DWQ
Greg Richardson, GNRA

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If you have any further questions, please do not hesitate to contact me at (919) 733-0692, extension 256. Specific questions about permitting and the current status of the permit application can be directed to Ed Mussler, the permitting engineer.

Sincerely,

James C Coffey

James C. Coffey, Acting Chief
Solid Waste Section

cc: Ed Mussler, DWM
Mark Fry, DWM
Robert Hearn, DWM
Jim Barber, DWM
Kenneth Pohlig, DWQ
Greg Richardson, GNRA

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

October 2, 2001

Mr. Haywood Phthisic
Public Utilities Director
Johnston County Department of Public Utilities
P.O. Box 2263
Smithfield, NC 27577

5103

Re: Johnston County Landfill, Cell 4A, Site Study Process, New Facility Designation, Permits 5101 and 5102

Dear Mr. Phthisic,

The Solid Waste Section (Section) of the Division of Waste Management is conducting a permit review of the Cell 4A proposal at the Johnston County Landfill. As was previously stated in a letter to the county manager, dated June 15, 2001, the proposed development of Cell 4A qualifies the existing facilities (5101 and 5102) as a new facility. Rule .1603(a)(1)(E) defines a new facility as one that has a substantial change to the waste stream defined in the effective permit.

Your consultant, G.N. Richardson and Associates, Inc., of Raleigh, NC, has filed a permit to construct application for Cell 4A with the Section. Included in this permit application are demonstrations to update the existing site study of the landfill locale. A detailed site study was performed in 1995 for facility 5102 which is adjacent to the original landfill, 5101. Documentation presented by your consultant indicates that there have not been significant changes in the study area.

The Section is performing a technical review on the permit application that has been submitted. The following items need to be addressed to complete the site study portion of the application.

1. Vol. 2- Section 3.1-Airport Safety- The airports, State and Federal FAA need to be notified in accordance with Rule .1622 (1)(b). Please verify that the smaller airport does not meet the definition as supplied in .1622 (1)(d)(i). The airports are within the six mile limit of the new FAA regulations. Please discuss.
2. Vol. 2- Section 3.3- Wetlands- The wetlands need to be addressed in accordance with Rule .1622 (3)(a)(i)-(v). Some of this information may have been submitted to the Division of Water Quality or the Army Corps of Engineers, but should be summarized in the solid waste permit.
3. A facility plan revision needs to be supplied. This plan should include the capacity of the

entire proposed facility (i,e, Cells 4A, 5-8), the phase capacity and remaining capacity. An expression of the monthly disposal rate is needed. Johnston County has substantial growth projections. A rate expression, for permitting purposes, is needed. A growth factor or standard deviation could be employed.

4. The decision to locate a solid waste management facility is the responsibility of the unit of local government having jurisdiction over the proposed site. Johnston County needs to provide a resolution/vote on motion, of the county commissioners, in accordance with Rule .1618(c)(5)(A). The Section advises that the resolution/motion be clear as to its intent. The proposed facility plan's requirements are specified in Rule .1618(c)(6), and specifically the requirements of Rule .1619(e)(1) and (2) provide guidance for the elements that the commissioners need to be cognizant of.
5. The Section Hydrogeologist has made previous comments on the site study documentation that has been submitted. The Section has been supplied a response which is under review. Johnston County will be supplied additional comments, if necessary, under separate cover from the Section Hydrogeologist.

The above comments are intended to expedite the Section's review of the submitted application. They in no way limit the Section from requesting additional information, should it be deemed necessary. Please include a header or footer showing the revision and date of revision for any pages of the application that are amended.

If there are any questions, please do not hesitate to contact the Section. Our phone number is 919.733.0692. My extension is 343.

Sincerely,

Edward Mussler, P.E.
Environmental Engineer
Solid Waste Section.

cc: Pieter Scheer, P.E., GNRA
Mark Fry, DWM
Jim Barber, DWM
Robert Hearn DWM

Subject: Johnston County Permit App Comments
Date: Thu, 27 Sep 2001 10:59:50 -0400
From: Edward Mussler <Ed.Mussler@ncmail.net>
To: Pieter Scheer <pieter@gnra.com>, tim.broome@mail.co.johnston.nc.us, haywood.phthisic@mail.co.johnston.nc.us

51-03

Gentlemen,
I am sending this email to alert you to some things that will be included in my review letter of the Johnston County MSW permit application. A comprehensive letter will be forthcoming next week. I plan to deal with "site study" issues first, followed by the detailed engineering design review.

1. Airports- The airports, state and fed FAA need to be notified in accordance with .1622(1)(b) and verification that the smaller airport does not meet the definition as supplied in .1622 (1)(d)(i)

2.the wetlands need to be addressed in accordance with .1622(3)(a)(i)-(v).

3. Within the facility plan write up, an expression of the average monthly disposal rate and variance is needed. I realize that substantial growth is occurring and is projected for the county. Some sort of rate expression is needed with a growth factor or standard deviation etc.

4. The above ties to capacity. The capacity of each phase is discussed. Can it be put in a table to show,gross/net, life and total site life, please.

5. The major point is that the resolution/vote on motion, of the county commissioners is needed in accordance with Rule .1618(c)(5)(A). Documentation of a public meeting has been provided. We would advise that the resolution/motion be clear and point you in the direction of the franchise requirements for guidance. i.e. it should state the size, rate, life and service area.

6. The application and permit file should be put in the library in accordance with .1618(c)(5)(A)(iv), just to be sure.

As I find additional items that can be forwarded prior to an "official" letter I will forward them to you. If you have any questions please contact me.
Thanks
ed

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

September 24, 2001

Mr. Timothy G. Broome, P.E.
Department of Public Utilities
Johnston County
P.O. Box 2263
Smithfield, NC 27577

51-03

RE: Permit 51-01, Johnston County Landfill- Letter of Approval for Site Maintenance and Grading Activities

Dear Mr. Broome,

Johnston County has a permitted municipal solid waste (msw) landfill, Permit number 51-01. This landfill has closed municipal solid waste landfill units, and is currently permitted to accept construction and demolition debris on top of a closed msw unit.

Johnston County has approached the Section for approval to conduct earthmoving activities at the landfill, primarily in the area between closed msw units 3 and 4. The purpose of this activity is to improve site drainage, install new sedimentation and erosion control devices and otherwise improve site handling of stormwater and surface water drainage.

The area between the closed units has evolved, over time, into a low quality wetlands, as determined by the Division of Water Quality. This area was not a wetland at initial site operation, but gradually evolved as site operations altered the surface water drain pattern. The site also has groundwater contamination, common to unlined landfills in the state, that may be improved by better management of water at the site.

Approval is granted to conduct the site maintenance and grading activities, in accordance with the plan prepared by your consultant, G.N.Richardson & Associates, of Raleigh NC.

Johnston County has also filed a permit application for a new lined unit at the landfill. The unit, Cell 4A, is a unique one in that it is to be constructed in a "piggy back" fashion, between existing units 3 and 4 of the facility. This first-of-its-kind design, in North Carolina, is currently under review by the Section. The Section feels that any issues pertaining to the permit can be adequately addressed to ensure that the design and operation of the new unit will be in accordance with North Carolina regulations.

North Carolina Solid Waste Management Rules do not allow beginning construction for a solid waste management facility until a construction permit has been issued. In this case,

Johnston County has a valid permit (51-01) for a solid waste management facility. Approval of the grading and site maintenance plan does not constitute an approval of the pending permit application. By performing these activities the overall site performance and protection of the environment will be enhanced, including improvement of the existing groundwater under the facility.

If there are any further questions please contact the Section at 919.733-0692. The Section staff are reviewing the pending permit application and should have technical reviews for the county in the near future.

Sincerely,

James C Coffey

James C. Coffey
Acting Section Chief
Solid Waste Section

cc: Haywood Physic, Johnston County
Pieter Scheer, GNRA
Ed Mussler, DWM
Bobby Lutfy, DWM
Mark Fry, DWM
Jim Barber, DWM

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services

TRANSMITTAL FORM

If enclosures are not as noted or
if you require additional information,
please notify us immediately

51-03

September 19, 2001

Mr. Ed Mussler, P.E.
NC DENR Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, NC 27605

SUBJECT: **Johnston County MSW Landfill - Property Maps**

GNRA PROJECT NO: **JOHNSTON-9**

We are sending you the following items:

COPIES	ITEM	DESCRIPTION
1	Maps	2 Property Maps Referencing Deed Information

These are transmitted as checked below:

[X] **For Information**
[ ] As Requested
[ ] For Review and Comments
[ ] For Revision
[ ] For Approval
[ ] Approved
[ ] Approved as Noted
[ ] Approved as Noted-Revise and Resubmit
[ ] Not Approved-Revise and Resubmit
[ ] For Record and File
[ ] Submittal
[ ] For Recording

REMARKS: Ed: Let me know if these maps meet your needs related to deed information. Note that the small map is for additional property purchased due to the results of the groundwater assessment.

cc:

Pieter K. Scheer, P.E.

425 N. BOYLAN AVENUE • RALEIGH, NORTH CAROLINA 27603 • TEL. 919-828-0577 • FAX. 919-828-3899

Johnston County
DEPARTMENT OF PUBLIC UTILITIES

FACSIMILE TRANSMITTAL SHEET

TO: Ed Mussler	FROM: Timothy G. Broome, P.E.
COMPANY: Solid Waste Management	DATE: 09/06/01
FAX NUMBER: ~~571 4718~~ 715-3605	TOTAL NO. OF PAGES INCLUDING COVER: 1
RE: Site Preparation for Cell 4A	CC: Haywood Phthisic

☐ URGENT ☐ FOR REVIEW ☐ PLEASE COMMENT X PLEASE REPLY ☐ PLEASE RECYCLE

NOTES/COMMENTS: 51-03

Ed:

Johnston County must invest $110,000(+/-) in mitigation plus the cost of initial site preparation for Cell 4A. We believe to move forward with some level of comfort, a letter from Solid Waste should indicate that the Solid Waste Section approves our proceeding with initial site preparation for Cell 4A and is in agreement with the piggyback concept, as proposed. Further, that although technical review remains to be completed, no major issues have been identified or are anticipated prior to issuance of a permit to construct.

Thank you,

Tim Broome

IF YOU HAVE ANY DIFFICULTIES READING OR RECEIVING THIS FAX,
PLEASE CONTACT US AT: TEL (919) 989-5075 FAX 934-7174

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

August 28, 2001

Mr. Bobby Lutfy
NCDENR
Department of Waste Management
Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

RE: Response to Comments Johnston Co. Permit to Construct Application
Volume 2 of 2 - Design Hydrogeologic Report
Johnston Co. Landfill
Smithfield, North Carolina

Dear Mr. Lutfy:

Enclosed please find a copy of our Final Permit Version of the Design Hydrogeologic Report for the Johnston Co. Landfill Permit to Construct. This version incorporates all previous and recent comments into one document as you requested. The following outlines your recent comments and where the revised information may be found in the attached document.

Comment #1
Figure 10 indicates the drainage feature located between PZ-9 and PZ-10 is a flowing stream. Figure 11 indicates this same drainage feature, located further downstream between PZ-10 and MW-8, is not a flowing stream. Please reconcile this inconsistency. It would appear that under seasonal high conditions the lower section of this drainage feature could be a flowing stream. Are there plans to provide a french drain in this are to control water during seasonal high conditions?

Response
Figures 10 and 11 have been revised. Intermittently portions of this stream may be flowing during high water level conditions. In regards to plans for a french drain, we are not planning on installing a french drain. At this time a significant amount of run-off from other portions of the site influence ground water levels in this area . The plan for surface water diversion at this site (as stated on page 10 of the document) will divert surface water run-on away from this area. This, in conjunction with the liner system proposed over this area should be sufficient to lower ground water in this area during seasonal high water conditions.

Comment #2
Figure 16: The data in Table 2 are plotted on Figure 16 is inconsistent with the ground water contours in the vicinity of wells MW-7, MW-9d and CDLMW-5.

425 N. BOYLAN AVENUE • RALEIGH, NC 27603 • TEL. 919-828-0577 • FAX 919-828-3899 • WWW.GNRA.COM

Response
Figure 16 has been revised.

Comment #3
Table 2: The Top of Casing Elevation on the revised Borehole log for MW-8d is inconsistent with the data on Table 2.

Response
The borehole log has been revised.

Comment #4
Table 3: The % passing #4 for PZ-1 appears to be incorrect. The values for % passing for one PZ-5 sample appear to be mismatched and the values for the second sample are missing. The values for % passing #200 appear to be switched for PZ-6s and PZ-6d.

Response
Table 3 has been corrected.

Comment #5
Table 5: It is still not clear how the Effective Porosity Values were determined. What is the basis for distinguishing between the 0.20 and 0.17 values being assigned. I do not see any pattern between the values for total porosity and effective porosity and the soil descriptions. Normally, site specific values for total porosity and effective porosity are provided where possible. Are any such values available? Typically soil grain size analyses along with the Fetter Textural Classification Triangle are used to approximate effective porosity values based on site specific tests.

Response
Table 5 has been revised. All sieve analyses were analyzed using a US Soil Conservation Service textural classification triangle. Based upon this analysis, effective porosities were assigned based upon soil grain size as evaluated by the sieve analysis. No other site data is available.

Comment #6
Table 5a: Based on the diagrams some of the paired wells do not appear to be located close enough together to be true well nests. If the paired wells are more than about ten feet from each other it is difficult to make an accurate evaluation of vertical gradients. The ground surface elevations for MW-13 and MW-13d are significantly different.

Response
Monitoring wells MW-9c and MW-9d as well as MW-7 and MW-7d are not close enough for vertical gradient analysis, therefore these wells have been removed from Table 5a. As for the ground surface elevations at MW-13 and MW-13d, these are correct. These wells are located in the former borrow area. Approximately 6 to 8 feet of borrow was removed from this area

between the installation of MW-13 and MW-13d. Therefore, the ground surface elevations are different.

Comment #7
Table 6: The conductivity values do not appear to be accurate for wells MW-5, MW-8, MW-4d and MW-9d.

Response
Table 6 has been revised.

Comment #8
Appendix F: The ground surface elevation and top of casing elevation for revised borehole log MW-8d are inconsistent with other references in the report.

Response
The borehole log for this well has been revised.

Comment #9
Water Quality Monitoring Plan Page 2: Provide reference to monitoring of the leachate lagoon. An additional monitoring well is needed at the mouth of the drainage feature downgradient of Phase 4A.

Response
Reference to the monitoring wells associated with the leachate lagoon has been added. The location of proposed monitoring well MW-8a (as shown in Appendix I) has been slightly modified so that this well will serve as a replacement for MW-8 (which is currently dry), as a shallow well to nest with MW-8d, and as a shallow monitoring well at the mouth of the drainage feature downgradient of Phase 4a.

Comment #10
WQMP - Page 3: The reference to the figure for well locations should be to Figure 7 rather than to Figure 1.

Response
A Figure 1 showing the well locations has been added to the WQMP.

Comment #11
WQMP Page 5 - For well purging three to five well volumes is the minimum purging amount.....

Response
This change has been made to the WQMP.

Comment #12
WQMP Page 5: Provide more detail on stabilization of field parameters for determining adequate purging.

Response
More information on the MicroPurge Well Wizard system has been added to the WQMP.

Comment #13
WQMP Pages 6 and 9 - it is not clear what type of equipment is being referred to in the discussion of equipment decontamination.....

Response
This has been clarified on Pages 6 and 9 of the WQMP.

Comment #14
WQMP Pages 9 and 10 - Discussion of NAPLs is not necessary as this is not usually necessary for routine detection monitoring.

Response
This discussion has been removed from the document.

Comment #15
WQMP Page 22 - The final sentence should be deleted. The assessment monitoring schedule should be included in the Assessment Work Plan to be approved by the Solid Waste Section.

Response
This change has been made.

We hope this answers your questions. If you have any additional questions, or require further information, please contact us at your earliest convenience.

Sincerely,
G. N. Richardson and Associates, Inc.

Joan A. Smyth

Joan A. Smyth, P.G.
Project Hydrogeologist

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

August 27, 2001

Mr. Edward F. Mussler, P.E.
NC DENR Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605

RE: Permit to Construct Application Addendum - Local Government Approval
Johnston County MSW Landfill - Phase 4A
Smithfield, North Carolina

Dear Mr. Mussler:

On behalf of Johnston County, G.N. Richardson & Associates, Inc. would like to submit for your review two (2) copies of this addendum to the Permit to Construct Application for Phase 4A of the County's Subtitle D MSW Landfill. This addendum provides the following attached documentation related to satisfying Rule 15A NCAC 13B.1618(c)(5) regarding local government approval:

1. Certified Affidavit of Legal Advertisement
2. Certified Copy of Public Hearing Minutes
3. Two (2) Letters from the Johnston County Department of Public Utilities
   - Verification of Conformance with Zoning Requirements
   - Verification of Consistency with Solid Waste Management Plan.

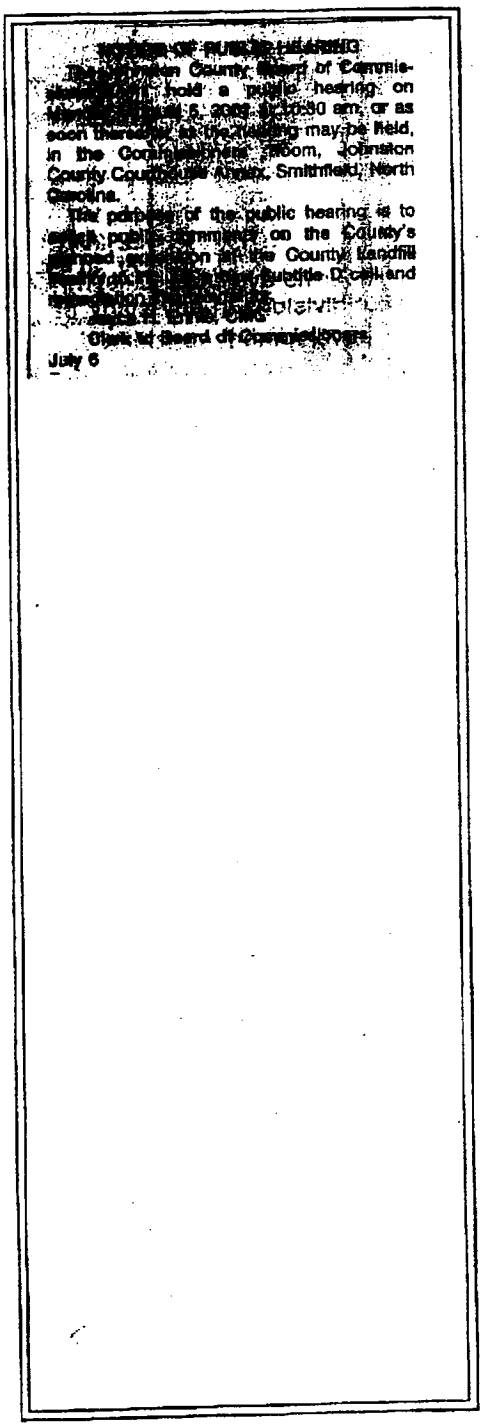
Should you have any questions or require clarification, please contact us at your earliest convenience.

Sincerely,
G.N. Richardson & Associates, Inc.

Pieter K. Scheer, P.E.
Project Engineer

Attachments

cc: Haywood Phthisic, Johnston County
Tim Broome, P.E., Johnston County
Rick Proctor, Johnston County



NOTICE OF PUBLIC HEARING

The Johnston County Board of Commissioners will hold a public hearing on [illegible] 6, 2001 @ 10:30 am, or as soon thereafter as the hearing may be held, in the Commissioners' Room, Johnston County Courthouse Annex, Smithfield, North Carolina.

The purpose of the public hearing is to solicit public comment on the County's proposed application for the County Landfill [illegible] Subtitle D Cell and [illegible]

[illegible]
Clerk to Board of Commissioners

July 6

NORTH CAROLINA
JOHNSTON COUNTY

AFFIDAVIT OF PUBLICATION

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified, and authorized by law to administer oaths, personally appeared

Barbara H Lucas, who being first duly sworn, deposes and says: that he (she) is

(Owner, ~~partner, publisher, or other officer or~~ employee authorized to make this affidavit)

of THE SMITHFIELD HERALD, a newspaper published, issued, and entered as second class mail in the City of Smithfield in said County and State; that he (she) is authorized to make this affidavit and sworn statement; that the notice or other legal advertisement, a true copy of which is attached hereto, was published in The Smithfield Herald on the following dates:

July 6, 2001

and that the said newspaper in which such notice, paper, document, or legal advertisement was published was, at the time of each and every such publication, a newspaper meeting all of the requirements and qualifications of Section 1-597 of the General Statues of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina.

This 6th day of July, 2001

Barbara H Lucas
(Signature of person making affidavit)

Sworn to and subscribed before me, this 10th day of July, 2001.

Bertina E Sowell
Notary Public

My Commission expires: 5/7/02

51-03

Operations Manual - Addendum
(Irrigation of Reclaimed Wastewater)
Johnston County MSW Landfill
Aug, 2001

5103 permit

Johnston County
DEPARTMENT OF PUBLIC UTILITIES
POST OFFICE BOX 2263
SMITHFIELD, N.C. 27577
(919) 989-5075

August 24, 2001

Mr. Edward F. Mussler, P.E.
N.C. DENR
Division of Waste Management
Solid Waste Section
1646 Mail Service Center
Raleigh, N.C. 27699-1646

Re: Johnston County Landfill
Cell 4A

Dear Mr. Mussler:

This letter is to assure you that the proposed Cell 4A site development for the Johnston County Landfill meets the applicable zoning requirements of the Johnston County Zoning Ordinance.

If you have any questions, please feel free to contact me at (919) 989-5075.

Sincerely,

Timothy G. Broome

Timothy G. Broome, P.E.
Director of Infrastructure and Engineering

TGB/pw

Cc: Mr. Haywood M. Phthisic
Mr. Pieter K. Scheer, P.E.

Printed on recycled paper

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

August 20, 2001

Mr. Edward F. Mussler, P.E.
NC DENR Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605

RE: Request for Permit Modification - Irrigation of Reclaimed Wastewater
Johnston County MSW Landfill - Permit Nos. 51-01 and 51-02
Smithfield, North Carolina

Dear Ed:

On behalf of Johnston County, G.N. Richardson & Associates, Inc. (GNRA) would like to submit for your review two (2) copies of an operations manual addendum (see **Attachment A**) covering the planned irrigation of reclaimed wastewater at the County's landfill facility. This plan is proposed as a modification to the County's current Permit to Operate.

Per your request, GNRA has completed a number of HELP Model runs which address your concerns regarding the irrigation of closed landfill units. HELP Model (v. 3.07) evaluations for each final cover condition were performed assuming the daily irrigation of 0.1 inches of water during the months of April through October, except on days that rainfall exceeded 0.2 inches. The results of which are tabulated below:

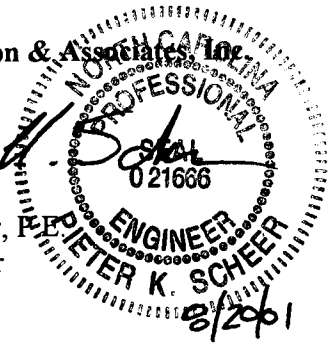
Table 1: HELP Model Results

Final Cover Design	Average Annual Infiltration (Inches)
1. Top - Phases 1, 2, and 4 (South End)	0.9 (Without Irrigation) 1.1 (With Irrigation)
2. Top - Phase 3	0.08 (Without Irrigation) 0.09 (With Irrigation)
3. Side Slopes	11.3 (Without Irrigation) 17.5 (With Irrigation)

As shown above, the irrigation of top areas with 0.1 inches of water results in a negligible increase in infiltration. For side slope areas, infiltration is greater. Thus, the attached operations manual addendum states that if irrigation is to be done on landfill side slopes, or other areas which do not have a synthetic barrier, moisture sensors must be employed, which would turn off the irrigation system to that area if the upper 9 inches of cover becomes saturated. Attached are results of the HELP Model runs plus rainfall input data that was used in the modeling (see **Attachments B and C**, respectively).

Should you have any questions or require clarification, please contact us at your earliest convenience.

Sincerely,
G.N. Richardson & Associates, Inc.



Pieter K. Scheer, P.E.
Project Engineer

Gregory N. Richardson, Ph.D., P.E.
President

Attachments

cc: Haywood Phthisic, Johnston County
Tim Broome, Johnston County
Rick Proctor, Johnston County

ATTACHMENT A

OPERATIONS MANUAL ADDENDUM

Operations Manual - Addendum
(Irrigation of Reclaimed Wastewater)

Johnston County MSW Landfill
Johnston County, North Carolina

Prepared for:
Johnston County
Department of Public Utilities

August 2001

PERMIT ISSUE DOCUMENTS

G.N. Richardson & Associates, Inc.
Engineering and Geological Services
425 N. Boylan Avenue
Raleigh, North Carolina 27603

JOHNSTON COUNTY
JOHNSTON COUNTY MSW LANDFILL

OPERATIONS MANUAL - ADDENDUM
(IRRIGATION OF RECLAIMED WASTEWATER)

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3.2 Periods of Operation 2
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3.4.2 Closed Landfill Areas 2
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3.4.4 Borrow Areas 3
3.4 System Maintenance and Inspections 3

JOHNSTON COUNTY
JOHNSTON COUNTY MSW LANDFILL

OPERATIONS MANUAL - ADDENDUM
(IRRIGATION OF RECLAIMED WASTEWATER)

1.0 OVERVIEW

This Operations Manual Addendum was prepared for the Johnston County MSW Landfill located off of Highway 210 on County Home Road for the purpose of describing the operation of an irrigation system for reclaimed wastewater, which is proposed for the site. The system will be owned and operated by Johnston County.

2.0 CONTACT INFORMATION

All correspondence and questions concerning the operation of the reclaimed wastewater irrigation system should be directed to the appropriate County personnel listed below:

Johnston County Department of Public Utilities
204 S. Second Street, P.O. Box 2263
Smithfield, NC 27577
Phone: (919) 989-5075 (Downtown); (919) 934-4576 (Landfill)
Fax: (919) 934-7174 (Downtown); (919) 989-7152 (Landfill)

Solid Waste Manager:	Rick Proctor
Public Utilities Director:	Haywood Phthisic
Director of Engineering:	Tim Broome, P.E.

3.0 IRRIGATION SYSTEM OPERATION

3.1 Areas to be Irrigated

Areas to be irrigated and order of priority (1 being the highest) include the following:

Priority 1:

- Wooded area behind (east of) NC Forest Service building;
- Area behind (west of) landfill office including the current yard waste processing area;
- Agricultural fields to the south of the landfill office and yard waste area on newly acquired land; and
- Wooded area south of the leachate storage lagoon (future Phase 7 and Phase 8 area).

Priority 2:

- Closed landfill areas on Phase 1&2, 3, and 4 (Also, Phase 5 in future).

Priority 3:

- Inactive borrow areas.

In addition to these areas, the County plans to use reclaimed wastewater for the control of dust within the facility.

3.2 Periods of Operation

The irrigation system will be operated during the months of April through October. In addition, irrigation will be discontinued on any day that rainfall exceeds 0.2 inches.

3.3 Irrigation Amounts

Irrigation amounts will be in accordance with the agronomic rates determined for the landfill site in an analysis performed by Robert Evans, Ph.D., P.E. of N.C. State University and entitled "Hydrologic Wastewater Reuse Irrigation Analysis for Johnston County". Restrictions to these amounts are as stated herein.

3.4 Irrigation Restrictions

3.4.1 Monitoring Wells

No irrigation will occur within 100 feet of an actively monitored site monitoring well.

3.4.2 Closed Landfill Areas

Irrigation over closed landfill areas shall only take place over closed areas which have at least 2 feet of soil cover or at least 1.5 feet of soil cover and a synthetic barrier. In addition, irrigation over these areas will be limited to the following rates:

Top Areas with Synthetic Barrier: 0.1 inches per day.

Side Slopes: At a rate less than that which would cause saturation of the upper 9 inches of soil cover and no more than 0.1 inches per day. This will be controlled by the use of soil moisture devices, which will automatically shut off the irrigation system when the upper 9 inches become saturated.

3.4.3 Future Landfill Areas

Irrigation over areas designated as future landfill areas (or areas within 300 feet of future landfill areas) will be discontinued within 2 years before the anticipated start of construction for that area unless it is demonstrated by use of piezometers, monitoring wells, or other method that irrigation rates are not creating an artificial rise in groundwater levels. Closed landfill areas, if to be lined over as part of a future landfill area (i.e. Phase 4A) may be irrigated in accordance with **Section 3.4.2** within 2 years prior to construction.

3.4.4 Borrow Areas

No irrigation will be performed in active borrow areas. Irrigation may be performed in inactive borrow areas as long as the ground surface is prepared to promote vegetation (soil type, nutrients, etc.).

3.5 System Maintenance and Inspections

Inspection of the irrigation system during periods of operation will be performed by landfill staff on a weekly basis for the closed landfill areas. Other areas may be inspected less frequently, but not less than once per month. As much of the proposed system will be above ground, inspection for damaged piping, valves, sprinklers, etc. will be done on a mostly visual basis. Should maintenance be required to any portion of the irrigation system, that part of the system will be shut off until adequate repairs are made.

ATTACHMENT B

HELP MODEL RESULTS

Avg. Perc = 0.86"/yr

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**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY      **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************

PRECIPITATION DATA FILE:     C:\HELP307\johnston.D4
TEMPERATURE DATA FILE:       C:\HELP307\johnston.D7
SOLAR RADIATION DATA FILE:   C:\HELP307\johnston.D13
EVAPOTRANSPIRATION DATA:     C:\HELP307\johnston.D11
SOIL AND DESIGN DATA FILE:   C:\HELP307\johnston.D10
OUTPUT DATA FILE:            C:\HELP307\johnston.OUT

TIME:   9: 6     DATE:   8/14/2001

**********************************************************************

     TITLE:  Johnston County - No surface Irrigation - Phase 1/2 + 4

**********************************************************************

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


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  10
          THICKNESS                     =     18.00   INCHES
          POROSITY                      =      0.3980 VOL/VOL
          FIELD CAPACITY                =      0.2440 VOL/VOL
          WILTING POINT                 =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.3860 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     = 0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.02	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	3.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT	

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2382	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	86.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	6.948	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.164	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.448	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.806	INCHES
TOTAL INITIAL WATER	=	9.806	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	39.15	142114.484	100.00
RUNOFF	3.694	13410.958	9.44
EVAPOTRANSPIRATION	34.785	126269.477	88.85
PERC./LEAKAGE THROUGH LAYER 2	0.668629	2427.122	1.71
AVG. HEAD ON TOP OF LAYER 2	7.2757		
PERC./LEAKAGE THROUGH LAYER 3	0.655309	2378.770	1.67
CHANGE IN WATER STORAGE	0.015	55.282	0.04
SOIL WATER AT START OF YEAR	10.538	38252.379	
SOIL WATER AT END OF YEAR	10.553	38307.660	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.012	0.00

****

****

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.90	162986.984	100.00
RUNOFF	9.633	34967.336	21.45
EVAPOTRANSPIRATION	34.399	124870.070	76.61
PERC./LEAKAGE THROUGH LAYER 2	0.991559	3599.359	2.21
AVG. HEAD ON TOP OF LAYER 2	10.7566		
PERC./LEAKAGE THROUGH LAYER 3	0.878860	3190.261	1.96
CHANGE IN WATER STORAGE	-0.011	-40.722	-0.02
SOIL WATER AT START OF YEAR	10.553	38307.660	
SOIL WATER AT END OF YEAR	10.542	38266.941	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.048	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.74	224116.172	100.00
RUNOFF	24.952	90576.344	40.41
EVAPOTRANSPIRATION	35.778	129872.992	57.95
PERC./LEAKAGE THROUGH LAYER 2	1.050058	3811.712	1.70
AVG. HEAD ON TOP OF LAYER 2	11.3702		
PERC./LEAKAGE THROUGH LAYER 3	1.046031	3797.091	1.69
CHANGE IN WATER STORAGE	-0.036	-130.238	-0.06
SOIL WATER AT START OF YEAR	10.542	38266.941	
SOIL WATER AT END OF YEAR	10.506	38136.703	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.13	3.08	4.68	1.88	3.88	5.56

	5.52	7.91	2.60	5.26	1.36	2.74
STD. DEVIATIONS	3.78	1.00	1.72	1.20	3.64	1.71
	1.90	7.72	2.24	2.42	0.65	1.72

RUNOFF

TOTALS	2.650	1.018	1.486	0.069	0.972	0.228
	0.300	2.661	1.097	0.962	0.576	0.741
STD. DEVIATIONS	3.331	0.748	1.223	0.116	1.674	0.161
	0.147	4.413	1.900	1.256	0.615	0.608

EVAPOTRANSPIRATION

TOTALS	1.531	1.946	2.897	2.805	3.948	5.192
	6.141	4.622	2.184	1.623	1.139	0.961
STD. DEVIATIONS	0.220	0.138	0.137	0.916	1.523	1.324
	0.881	1.581	1.573	0.335	0.106	0.117

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.1243	0.1089	0.1211	0.0891	0.0757	0.0345
	0.0188	0.0299	0.0301	0.0576	0.0966	0.1168
STD. DEVIATIONS	0.0145	0.0089	0.0023	0.0092	0.0244	0.0322
	0.0227	0.0505	0.0521	0.0257	0.0493	0.0152

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0704	0.0924	0.1154	0.1268	0.1075	0.0764
	0.0432	0.0200	0.0227	0.0494	0.0609	0.0750
STD. DEVIATIONS	0.0411	0.0280	0.0121	0.0081	0.0063	0.0370
	0.0405	0.0174	0.0392	0.0241	0.0209	0.0564

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	15.8008	15.3586	15.4244	11.8790	9.7479	4.4846
	2.3683	3.7522	3.9978	7.2937	12.6541	14.8488
STD. DEVIATIONS	1.7162	1.1709	0.2719	1.1747	3.1104	4.2991
	2.9344	6.3940	6.9245	3.3295	6.4712	1.9143

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.60	(11.740)	176405.9	100.00
RUNOFF	12.760	(10.9684)	46318.21	26.257
EVAPOTRANSPIRATION	34.987	(0.7111)	127004.18	71.995
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.90342	(0.20542)	3279.398	1.85901
AVERAGE HEAD ON TOP OF LAYER 2	9.801	(2.208)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.86007	(0.19604)	3122.041	1.76981
CHANGE IN WATER STORAGE	-0.011	(0.0256)	-38.56	-0.022

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	3.619	13136.8232
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.004622	16.77797
AVERAGE HEAD ON TOP OF LAYER 2	18.000	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.005010	18.18675
SNOW WATER	1.49	5412.6704

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1360

****

****

FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	6.7860	0.3770
2	0.0000	0.0000
3	2.9879	0.2490
SNOW WATER	0.000	

****
****

Avg. Perc = 1.06"/yr

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**                                                                  **
**                                                                  **
**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE            **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY               **
**                USAE WATERWAYS EXPERIMENT STATION                 **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY         **
**                                                                  **
**                                                                  **
**********************************************************************
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PRECIPITATION DATA FILE:     C:\HELP307\johnirr.D4
TEMPERATURE DATA FILE:       C:\HELP307\johnirr.D7
SOLAR RADIATION DATA FILE:   C:\HELP307\johnirr.D13
EVAPOTRANSPIRATION DATA:     C:\HELP307\johnirr.D11
SOIL AND DESIGN DATA FILE:   C:\HELP307\johnston.D10
OUTPUT DATA FILE:            C:\HELP307\johnston.OUT

TIME:   9:10     DATE:   8/14/2001

**********************************************************************

     TITLE:  Johnston County - ~~NC~~ Surface Irrigation - Phase 1/2 + 4

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


                              LAYER  1
                              --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  10
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.3980 VOL/VOL
          FIELD CAPACITY               =      0.2440 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3891 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.02	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	3.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	2 - EXCELLENT	

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2488	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	86.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.004	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.164	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.448	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.989	INCHES
TOTAL INITIAL WATER	=	9.989	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	8.91	9.87	9.66
10.58	10.64	9.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.65	183859.297	100.00
RUNOFF	6.931	25160.031	13.68
EVAPOTRANSPIRATION	42.814	155413.922	84.53
PERC./LEAKAGE THROUGH LAYER 2	0.904948	3284.963	1.79
AVG. HEAD ON TOP OF LAYER 2	9.7705		
PERC./LEAKAGE THROUGH LAYER 3	0.905828	3288.155	1.79
CHANGE IN WATER STORAGE	-0.001	-2.541	0.00
SOIL WATER AT START OF YEAR	10.721	38918.605	
SOIL WATER AT END OF YEAR	10.721	38916.066	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.264	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	57.50	208724.609	100.00
RUNOFF	13.380	48568.094	23.27
EVAPOTRANSPIRATION	43.094	156430.016	74.95
PERC./LEAKAGE THROUGH LAYER 2	1.127365	4092.336	1.96
AVG. HEAD ON TOP OF LAYER 2	12.1814		
PERC./LEAKAGE THROUGH LAYER 3	1.117342	4055.953	1.94
CHANGE IN WATER STORAGE	-0.091	-329.141	-0.16
SOIL WATER AT START OF YEAR	10.721	38916.066	
SOIL WATER AT END OF YEAR	10.630	38586.926	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.317	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	73.24	265860.969	100.00
RUNOFF	29.723	107893.680	40.58
EVAPOTRANSPIRATION	42.359	153761.906	57.84
PERC./LEAKAGE THROUGH LAYER 2	1.180264	4284.359	1.61
AVG. HEAD ON TOP OF LAYER 2	12.7483		
PERC./LEAKAGE THROUGH LAYER 3	1.174132	4262.101	1.60
CHANGE IN WATER STORAGE	-0.016	-56.469	-0.02
SOIL WATER AT START OF YEAR	10.630	38586.926	
SOIL WATER AT END OF YEAR	10.614	38530.457	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.239	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.13	3.08	4.68	3.68	5.88	6.93

	6.62	9.47	4.83	6.92	1.49	2.74
STD. DEVIATIONS	3.78	1.00	1.72	0.88	3.12	1.55
	2.06	6.86	1.92	2.24	0.85	1.72

RUNOFF

TOTALS	2.761	1.178	1.610	0.082	1.268	0.621
	0.317	3.334	1.105	1.891	0.774	1.737
STD. DEVIATIONS	3.427	0.823	1.282	0.125	2.169	0.770
	0.151	5.540	1.914	1.297	0.772	1.630

EVAPOTRANSPIRATION

TOTALS	1.386	1.838	2.778	4.318	6.241	5.772
	6.556	5.852	3.865	2.493	0.863	0.794
STD. DEVIATIONS	0.197	0.123	0.137	0.426	0.406	1.368
	0.967	0.583	0.666	0.453	0.094	0.110

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.1279	0.1135	0.1232	0.0918	0.0791	0.0384
	0.0342	0.0525	0.0477	0.1014	0.1262	0.1349
STD. DEVIATIONS	0.0123	0.0052	0.0023	0.0102	0.0363	0.0518
	0.0321	0.0565	0.0612	0.0257	0.0078	0.0031

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.1253	0.1128	0.1271	0.1306	0.1134	0.0714
	0.0651	0.0570	0.0430	0.0421	0.0714	0.1064
STD. DEVIATIONS	0.0017	0.0131	0.0023	0.0049	0.0071	0.0552
	0.0557	0.0291	0.0463	0.0553	0.0465	0.0267

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	16.2185	15.9638	15.6684	12.2275	10.1156	4.9853
	4.3867	6.5891	6.2237	12.8529	16.5207	17.0486
STD. DEVIATIONS	1.4374	0.6825	0.2817	1.3024	4.6060	6.9287
	4.1631	7.2622	8.1028	3.3129	0.9356	0.3595

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	60.46 (11.583)	219481.6	100.00
RUNOFF	16.678 (11.7483)	60540.60	27.583
EVAPOTRANSPIRATION	42.755 (0.3703)	155201.95	70.713
PERCOLATION/LEAKAGE THROUGH LAYER 2	1.07086 (0.14610)	3887.219	1.77109
AVERAGE HEAD ON TOP OF LAYER 2	11.567 (1.581)		
PERCOLATION/LEAKAGE THROUGH LAYER 3	1.06577 (0.14139)	3868.736	1.76267
CHANGE IN WATER STORAGE	-0.036 (0.0482)	-129.38	-0.059

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	4.893	17760.7266
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.004622	16.77797
AVERAGE HEAD ON TOP OF LAYER 2	18.000	
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.005038	18.28641
SNOW WATER	1.49	5412.6704

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3980
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1383

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	6.8814	0.3823
2	0.0000	0.0000
3	3.0011	0.2501
SNOW WATER	0.000	

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Avg. Rec = 0.086"/yr

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**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     C:\HELP307\johnston.D4
TEMPERATURE DATA FILE:       C:\HELP307\johnston.D7
SOLAR RADIATION DATA FILE:   C:\HELP307\johnston.D13
EVAPOTRANSPIRATION DATA:     C:\HELP307\johnston.D11
SOIL AND DESIGN DATA FILE:   C:\HELP307\johnston.D10
OUTPUT DATA FILE:            C:\HELP307\johnston.OUT

TIME:   9:22     DATE:   8/14/2001

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     TITLE:  Johnston County - No surface Irrigation - Phase 3

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


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  10
          THICKNESS                      =     18.00   INCHES
          POROSITY                       =      0.3980 VOL/VOL
          FIELD CAPACITY                 =      0.2440 VOL/VOL
          WILTING POINT                  =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT     =      0.2457 VOL/VOL
          EFFECTIVE SAT. HYD. COND.      = 0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2310	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.40	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2229	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A

FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	86.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.2	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.469	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.334	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.449	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	7.444	INCHES
TOTAL INITIAL WATER	=	7.444	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.2	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90

77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	39.15	142114.484	100.00
RUNOFF	0.739	2681.305	1.89
EVAPOTRANSPIRATION	32.919	119496.031	84.08
DRAINAGE COLLECTED FROM LAYER 2	5.4793	19889.705	14.00
PERC./LEAKAGE THROUGH LAYER 3	0.013133	47.671	0.03
AVG. HEAD ON TOP OF LAYER 3	0.0200		
PERC./LEAKAGE THROUGH LAYER 4	0.107235	389.263	0.27
CHANGE IN WATER STORAGE	-0.094	-341.751	-0.24
SOIL WATER AT START OF YEAR	7.443	27019.840	
SOIL WATER AT END OF YEAR	7.349	26678.088	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.079	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.90	162986.984	100.00
RUNOFF	2.672	9698.219	5.95

EVAPOTRANSPIRATION	31.956	115998.937	71.17
DRAINAGE COLLECTED FROM LAYER 2	10.5022	38122.914	23.39
PERC./LEAKAGE THROUGH LAYER 3	0.020259	73.539	0.05
AVG. HEAD ON TOP OF LAYER 3	0.0381		
PERC./LEAKAGE THROUGH LAYER 4	0.087706	318.373	0.20
CHANGE IN WATER STORAGE	-0.317	-1151.426	-0.71
SOIL WATER AT START OF YEAR	7.349	26678.088	
SOIL WATER AT END OF YEAR	7.032	25526.662	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.022	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.74	224116.172	100.00
RUNOFF	7.880	28604.057	12.76
EVAPOTRANSPIRATION	33.604	121983.500	54.43
DRAINAGE COLLECTED FROM LAYER 2	20.2546	73524.359	32.81
PERC./LEAKAGE THROUGH LAYER 3	0.026927	97.744	0.04
AVG. HEAD ON TOP OF LAYER 3	0.0745		
PERC./LEAKAGE THROUGH LAYER 4	0.065676	238.404	0.11
CHANGE IN WATER STORAGE	-0.065	-234.240	-0.10
SOIL WATER AT START OF YEAR	7.032	25526.662	
SOIL WATER AT END OF YEAR	6.968	25292.422	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	0.095	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.13	3.08	4.68	1.88	3.88	5.56
	5.52	7.91	2.60	5.26	1.36	2.74
STD. DEVIATIONS	3.78	1.00	1.72	1.20	3.64	1.71
	1.90	7.72	2.24	2.42	0.65	1.72
RUNOFF						
TOTALS	0.350	0.069	0.213	0.000	0.296	0.203
	0.315	1.445	0.395	0.441	0.015	0.020
STD. DEVIATIONS	0.402	0.042	0.289	0.001	0.513	0.149
	0.173	2.303	0.685	0.459	0.026	0.025
EVAPOTRANSPIRATION						
TOTALS	1.564	1.975	2.930	2.881	3.561	3.691
	5.283	4.622	2.334	1.689	1.287	1.009
STD. DEVIATIONS	0.222	0.143	0.132	0.981	1.885	1.220
	1.302	1.578	1.399	0.157	0.128	0.113
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.1896	0.9333	1.3850	0.2060	0.6780	0.4207
	0.2098	1.7959	0.8333	1.3442	0.8106	1.2722
STD. DEVIATIONS	2.5146	0.9199	0.4672	0.2044	1.1743	0.7287
	0.2484	3.0388	1.4433	1.7188	0.8090	1.3184
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0033	0.0017	0.0029	0.0008	0.0007	0.0005
	0.0007	0.0016	0.0007	0.0018	0.0027	0.0027
STD. DEVIATIONS	0.0012	0.0014	0.0001	0.0007	0.0012	0.0009
	0.0007	0.0022	0.0013	0.0014	0.0012	0.0013

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0181	0.0071	0.0162	0.0037	0.0022	0.0020
	0.0027	0.0040	0.0013	0.0088	0.0108	0.0099
STD. DEVIATIONS	0.0082	0.0028	0.0090	0.0033	0.0038	0.0035
	0.0026	0.0035	0.0022	0.0096	0.0022	0.0053

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0945	0.0446	0.0598	0.0092	0.0293	0.0188
	0.0091	0.0790	0.0372	0.0580	0.0362	0.0549
STD. DEVIATIONS	0.1085	0.0440	0.0202	0.0091	0.0507	0.0325
	0.0107	0.1337	0.0644	0.0742	0.0361	0.0569

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.60	(11.740)	176405.9	100.00
RUNOFF	3.763	(3.6937)	13661.19	7.744
EVAPOTRANSPIRATION	32.826	(0.8282)	119159.49	67.548
LATERAL DRAINAGE COLLECTED FROM LAYER 2	12.07869	(7.51279)	43845.660	24.85499
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.02011	(0.00690)	72.985	0.04137
AVERAGE HEAD ON TOP OF LAYER 3	0.044	(0.028)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.08687	(0.02079)	315.347	0.17876
CHANGE IN WATER STORAGE	-0.159	(0.1381)	-575.81	-0.326

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.799	10162.0166
DRAINAGE COLLECTED FROM LAYER 2	0.89702	3256.19263
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000444	1.61103
AVERAGE HEAD ON TOP OF LAYER 3	1.339	
MAXIMUM HEAD ON TOP OF LAYER 3	2.004	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	16.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001287	4.67165
SNOW WATER	1.49	5412.6704

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3379
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1346

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	4.1475	0.2304
2	0.0458	0.2288
3	0.3000	0.7500

4	2.4745	0.2062
SNOW WATER	0.000	

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Avg. Rate = 0.08"/hr

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**                                                                  **
**                                                                  **
**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE            **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY               **
**               USAE WATERWAYS EXPERIMENT STATION                  **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY         **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     C:\HELP307\johnirr.D4
TEMPERATURE DATA FILE:       C:\HELP307\johnirr.D7
SOLAR RADIATION DATA FILE:   C:\HELP307\johnirr.D13
EVAPOTRANSPIRATION DATA:     C:\HELP307\johnirr.D11
SOIL AND DESIGN DATA FILE:   C:\HELP307\johnston.D10
OUTPUT DATA FILE:            C:\HELP307\johnston.OUT

TIME:   9:20     DATE:   8/14/2001

**********************************************************************

     TITLE:  Johnston County - ~~N~~ Surface Irrigation - Phase 3

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


                                LAYER  1
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  10
          THICKNESS                      =     18.00   INCHES
          POROSITY                       =      0.3980 VOL/VOL
          FIELD CAPACITY                 =      0.2440 VOL/VOL
          WILTING POINT                  =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT     =      0.2446 VOL/VOL
          EFFECTIVE SAT. HYD. COND.      = 0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2305	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	100.0	FEET

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.40	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2172	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A

FAIR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	86.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.2	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.450	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.334	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.449	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	7.357	INCHES
TOTAL INITIAL WATER	=	7.357	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	18.2	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	78.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	8.91	9.87	9.66
10.58	10.64	9.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90

77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.65	183859.297	100.00
RUNOFF	0.809	2935.975	1.60
EVAPOTRANSPIRATION	40.694	147719.078	80.34
DRAINAGE COLLECTED FROM LAYER 2	9.1284	33136.027	18.02
PERC./LEAKAGE THROUGH LAYER 3	0.019273	69.961	0.04
AVG. HEAD ON TOP OF LAYER 3	0.0333		
PERC./LEAKAGE THROUGH LAYER 4	0.098774	358.551	0.20
CHANGE IN WATER STORAGE	-0.080	-290.144	-0.16
SOIL WATER AT START OF YEAR	7.356	26703.982	
SOIL WATER AT END OF YEAR	7.277	26413.840	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.193	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	57.50	208724.609	100.00
RUNOFF	2.671	9694.363	4.64

EVAPOTRANSPIRATION	40.620	147449.453	70.64
DRAINAGE COLLECTED FROM LAYER 2	14.3876	52226.879	25.02
PERC./LEAKAGE THROUGH LAYER 3	0.025820	93.726	0.04
AVG. HEAD ON TOP OF LAYER 3	0.0522		
PERC./LEAKAGE THROUGH LAYER 4	0.075420	273.774	0.13
CHANGE IN WATER STORAGE	-0.253	-919.561	-0.44
SOIL WATER AT START OF YEAR	7.277	26413.840	
SOIL WATER AT END OF YEAR	7.023	25494.279	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.302	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	73.24	265860.969	100.00
RUNOFF	7.828	28417.002	10.69
EVAPOTRANSPIRATION	40.091	145529.937	54.74
DRAINAGE COLLECTED FROM LAYER 2	25.2679	91722.578	34.50
PERC./LEAKAGE THROUGH LAYER 3	0.032206	116.907	0.04
AVG. HEAD ON TOP OF LAYER 3	0.0936		
PERC./LEAKAGE THROUGH LAYER 4	0.058669	212.967	0.08
CHANGE IN WATER STORAGE	-0.006	-21.237	-0.01
SOIL WATER AT START OF YEAR	7.023	25494.279	
SOIL WATER AT END OF YEAR	7.017	25473.041	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	-0.0001	-0.278	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.13	3.08	4.68	3.68	5.88	6.93
	6.62	9.47	4.83	6.92	1.49	2.74
STD. DEVIATIONS	3.78	1.00	1.72	0.88	3.12	1.55
	2.06	6.86	1.92	2.24	0.85	1.72
RUNOFF						
TOTALS	0.324	0.068	0.199	0.003	0.284	0.198
	0.324	1.465	0.372	0.494	0.018	0.021
STD. DEVIATIONS	0.358	0.039	0.269	0.003	0.491	0.142
	0.192	2.311	0.644	0.472	0.032	0.023
EVAPOTRANSPIRATION						
TOTALS	1.410	1.854	2.794	4.296	5.333	5.172
	6.035	5.499	3.846	2.489	0.912	0.827
STD. DEVIATIONS	0.201	0.124	0.128	0.470	0.480	1.317
	1.031	0.162	0.703	0.457	0.093	0.106
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.3356	1.1205	1.4855	0.2610	1.0437	0.5020
	0.4790	2.1734	1.0550	2.8690	1.1447	1.7919
STD. DEVIATIONS	2.7043	0.8574	0.5419	0.2381	1.8077	0.8694
	0.7192	3.5938	1.5008	1.5056	0.8325	1.6095
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0035	0.0020	0.0032	0.0009	0.0012	0.0007
	0.0009	0.0019	0.0016	0.0033	0.0033	0.0034
STD. DEVIATIONS	0.0011	0.0013	0.0000	0.0008	0.0020	0.0011
	0.0010	0.0024	0.0016	0.0004	0.0005	0.0005

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0129	0.0061	0.0124	0.0029	0.0027	0.0016
	0.0023	0.0039	0.0048	0.0087	0.0101	0.0092
STD. DEVIATIONS	0.0060	0.0019	0.0064	0.0027	0.0048	0.0028
	0.0022	0.0038	0.0045	0.0050	0.0034	0.0023

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.1008	0.0535	0.0641	0.0116	0.0450	0.0224
	0.0207	0.0990	0.0471	0.1238	0.0511	0.0773
STD. DEVIATIONS	0.1167	0.0410	0.0234	0.0106	0.0780	0.0388
	0.0310	0.1641	0.0669	0.0650	0.0371	0.0695

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES		CU. FEET	PERCENT
PRECIPITATION	60.46	(11.583)	219481.6	100.00
RUNOFF	3.769	(3.6365)	13682.45	6.234
EVAPOTRANSPIRATION	40.468	(0.3290)	146899.50	66.930
LATERAL DRAINAGE COLLECTED FROM LAYER 2	16.26129	(8.23130)	59028.496	26.89450
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.02577	(0.00647)	93.531	0.04261
AVERAGE HEAD ON TOP OF LAYER 3	0.060	(0.031)		
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.07762	(0.02014)	281.764	0.12838
CHANGE IN WATER STORAGE	-0.113	(0.1270)	-410.31	-0.187

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.837	10298.0566
DRAINAGE COLLECTED FROM LAYER 2	0.95584	3469.68994
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000493	1.78902
AVERAGE HEAD ON TOP OF LAYER 3	1.531	
MAXIMUM HEAD ON TOP OF LAYER 3	2.120	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	17.1 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000823	2.98890
SNOW WATER	1.49	5412.6704

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3293

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1367

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	4.2203	0.2345
2	0.0459	0.2294
3	0.3000	0.7500

4	2.4514	0.2043

SNOW WATER 0.000

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Avg. Perc = 11.3 in/yr

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**
** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) **
** DEVELOPED BY ENVIRONMENTAL LABORATORY **
** USAE WATERWAYS EXPERIMENT STATION **
** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
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PRECIPITATION DATA FILE: C:\HELP307\johnston.D4
TEMPERATURE DATA FILE: C:\HELP307\johnston.D7
SOLAR RADIATION DATA FILE: C:\HELP307\johnston.D13
EVAPOTRANSPIRATION DATA: C:\HELP307\johnston.D11
SOIL AND DESIGN DATA FILE: C:\HELP307\johnston.D10
OUTPUT DATA FILE: C:\HELP307\johnston.OUT

TIME: 9:29 DATE: 8/14/2001

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TITLE: Johnston County - No surface Irrigation - Side Slopes

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

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	36.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2734	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 3.00 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	200.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2996	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	87.20	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	28.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.429	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	11.144	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.808	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	69.756	INCHES
TOTAL INITIAL WATER	=	69.756	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	28.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%

AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	2.91	3.67	3.66
4.38	4.44	3.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	39.15	142114.484	100.00
RUNOFF	0.862	3127.416	2.20
EVAPOTRANSPIRATION	33.591	121935.437	85.80
PERC./LEAKAGE THROUGH LAYER 2	4.687248	17014.709	11.97
CHANGE IN WATER STORAGE	0.010	36.945	0.03
SOIL WATER AT START OF YEAR	69.756	253213.609	
SOIL WATER AT END OF YEAR	69.766	253250.547	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.031	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.90	162986.984	100.00
RUNOFF	2.763	10030.844	6.15
EVAPOTRANSPIRATION	33.881	122989.719	75.46
PERC./LEAKAGE THROUGH LAYER 2	10.762234	39066.910	23.97
CHANGE IN WATER STORAGE	-2.507	-9100.451	-5.58
SOIL WATER AT START OF YEAR	69.766	253250.547	
SOIL WATER AT END OF YEAR	67.259	244150.094	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.031	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	61.74	224116.172	100.00
RUNOFF	8.248	29940.584	13.36
EVAPOTRANSPIRATION	34.584	125539.227	56.02
PERC./LEAKAGE THROUGH LAYER 2	18.476704	67070.437	29.93
CHANGE IN WATER STORAGE	0.431	1566.052	0.70

SOIL WATER AT START OF YEAR	67.259	244150.094	
SOIL WATER AT END OF YEAR	67.690	245716.156	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.118	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.13	3.08	4.68	1.88	3.88	5.56
	5.52	7.91	2.60	5.26	1.36	2.74
STD. DEVIATIONS	3.78	1.00	1.72	1.20	3.64	1.71
	1.90	7.72	2.24	2.42	0.65	1.72
RUNOFF						
TOTALS	0.362	0.088	0.238	0.002	0.321	0.215
	0.322	1.543	0.384	0.427	0.026	0.031
STD. DEVIATIONS	0.391	0.045	0.292	0.003	0.556	0.160
	0.158	2.450	0.664	0.409	0.044	0.033
EVAPOTRANSPIRATION						
TOTALS	1.541	1.962	2.911	2.854	3.991	4.387
	5.626	4.594	2.359	1.660	1.160	0.972
STD. DEVIATIONS	0.224	0.144	0.131	0.998	1.451	1.582
	0.932	1.541	1.372	0.339	0.104	0.108
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	1.3953	1.5405	1.7702	1.4131	0.4200	0.5870
	0.0730	0.0904	0.9033	1.3919	0.9159	0.8081
STD. DEVIATIONS	0.8802	0.8306	1.2407	1.4229	0.4239	0.9720
	0.1265	0.1565	1.5646	2.1579	0.9301	0.5199

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.60 (11.740)	176405.9	100.00
RUNOFF	3.958 (3.8354)	14366.28	8.144
EVAPOTRANSPIRATION	34.019 (0.5104)	123488.13	70.002
PERCOLATION/LEAKAGE THROUGH LAYER 2	11.30873 (6.91095)	41050.684	23.27059
CHANGE IN WATER STORAGE	-0.688 (1.5889)	-2499.15	-1.417

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.975	10800.3574
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.181485	658.79041
SNOW WATER	1.49	5412.6704

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3048

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1360

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	9.0891	0.2525
2	58.6013	0.2930
SNOW WATER	0.000	

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Avg. Perc = 17.5"/yr

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**                                                                  **
**                                                                  **
**                                                                  **
**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE           **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)            **
**             DEVELOPED BY ENVIRONMENTAL LABORATORY                **
**              USAE WATERWAYS EXPERIMENT STATION                   **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY         **
**                                                                  **
**                                                                  **
**********************************************************************
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PRECIPITATION DATA FILE:     C:\HELP307\johnirr.D4
TEMPERATURE DATA FILE:       C:\HELP307\johnirr.D7
SOLAR RADIATION DATA FILE:   C:\HELP307\johnirr.D13
EVAPOTRANSPIRATION DATA:     C:\HELP307\johnirr.D11
SOIL AND DESIGN DATA FILE:   C:\HELP307\johnston.D10
OUTPUT DATA FILE:            C:\HELP307\johnston.OUT

TIME:   9:31     DATE:   8/14/2001

**********************************************************************

     TITLE:  Johnston County - ~~N~~ Surface Irrigation - Side Slopes

**********************************************************************

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


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  10
          THICKNESS                     =     36.00   INCHES
          POROSITY                      =      0.3980 VOL/VOL
          FIELD CAPACITY                =      0.2440 VOL/VOL
          WILTING POINT                 =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.2686 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.119999997000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  5.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	200.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3053	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #10 WITH AN EXCELLENT STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 120. FEET.

SCS RUNOFF CURVE NUMBER	=	80.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	32.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	8.457	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.736	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.352	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	70.738	INCHES
TOTAL INITIAL WATER	=	70.738	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM RALEIGH NORTH CAROLINA

STATION LATITUDE	=	35.87	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	86	
END OF GROWING SEASON (JULIAN DATE)	=	310	
EVAPORATIVE ZONE DEPTH	=	32.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00	%

AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 78.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.55	3.43	3.69	8.91	9.87	9.66
10.58	10.64	9.29	2.73	2.87	3.14

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
39.60	41.60	49.30	59.50	67.20	73.90
77.70	77.00	71.00	59.70	50.00	42.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR RALEIGH NORTH CAROLINA
AND STATION LATITUDE = 35.87 DEGREES

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	50.65	183859.297	100.00
RUNOFF	0.139	503.328	0.27
EVAPOTRANSPIRATION	41.856	151935.875	82.64
PERC./LEAKAGE THROUGH LAYER 2	8.650573	31401.580	17.08
CHANGE IN WATER STORAGE	0.005	18.805	0.01
SOIL WATER AT START OF YEAR	70.738	256780.453	
SOIL WATER AT END OF YEAR	70.744	256799.266	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.291	0.00

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	57.50	208724.609	100.00
RUNOFF	0.736	2670.997	1.28
EVAPOTRANSPIRATION	42.587	154592.375	74.07
PERC./LEAKAGE THROUGH LAYER 2	17.330345	62909.152	30.14
CHANGE IN WATER STORAGE	-3.154	-11447.494	-5.48
SOIL WATER AT START OF YEAR	70.744	256799.266	
SOIL WATER AT END OF YEAR	67.590	245351.766	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.408	0.00

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	73.24	265860.969	100.00
RUNOFF	3.934	14279.538	5.37
EVAPOTRANSPIRATION	41.367	150163.266	56.48
PERC./LEAKAGE THROUGH LAYER 2	26.521626	96273.500	36.21
CHANGE IN WATER STORAGE	1.417	5144.845	1.94

SOIL WATER AT START OF YEAR	67.590	245351.766	
SOIL WATER AT END OF YEAR	69.007	250496.609	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.180	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.13	3.08	4.68	3.68	5.88	6.93
	6.62	9.47	4.83	6.92	1.49	2.74
STD. DEVIATIONS	3.78	1.00	1.72	0.88	3.12	1.55
	2.06	6.86	1.92	2.24	0.85	1.72
RUNOFF						
TOTALS	0.080	0.008	0.057	0.000	0.117	0.039
	0.080	0.889	0.192	0.138	0.002	0.000
STD. DEVIATIONS	0.073	0.008	0.098	0.000	0.203	0.059
	0.052	1.518	0.333	0.121	0.003	0.000
EVAPOTRANSPIRATION						
TOTALS	1.391	1.849	2.795	4.340	5.902	5.512
	6.401	5.734	3.858	2.502	0.861	0.790
STD. DEVIATIONS	0.198	0.123	0.135	0.427	0.146	1.395
	1.002	0.439	0.665	0.442	0.100	0.104
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	1.7164	2.0942	2.1385	1.8867	0.5575	0.8867
	0.7142	0.1739	1.8978	1.8903	1.6049	1.9397
STD. DEVIATIONS	0.9570	0.8152	1.3179	1.2997	0.6924	1.5214
	1.2370	0.3013	3.2870	2.2040	0.2240	1.3611

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	60.46 (11.583)	219481.6	100.00
RUNOFF	1.603 (2.0407)	5817.95	2.651
EVAPOTRANSPIRATION	41.937 (0.6142)	152230.52	69.359
PERCOLATION/LEAKAGE THROUGH LAYER 2	17.50085 (8.93675)	63528.082	28.94460
CHANGE IN WATER STORAGE	-0.577 (2.3404)	-2094.61	-0.954

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	5.22	18948.600
RUNOFF	2.076	7536.5913
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.277618	1007.75415
SNOW WATER	1.49	5412.6704

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3023

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1372

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	9.0417	0.2512
2	59.9656	0.2998
SNOW WATER	0.000	

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ATTACHMENT C

HELP MODEL - RAINFALL INPUT DATA

Rainfall w/o Irrigation

2
1
ALEIGH NORTH CAROLINA
3.55 3.43 3.69 2.91 3.67 3.66 4.38 4.44 3.29 2.73 2.87 3.14

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			1
1	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.02			2
1	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.21	0.56	0.00			3
1	0.00	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	0.21			4
1	0.00	0.00	0.00	0.00	0.09	0.37	0.19	0.26	0.40	0.00			5
1	0.01	0.00	0.17	0.11	1.09	0.04	0.49	0.00	0.57	0.00			6
1	0.02	0.00	0.00	0.53	0.07	0.00	0.00	0.00	0.00	0.00			7
1	0.01	0.01	0.00	0.00	0.21	0.00	0.00	0.98	0.00	0.00			8
1	0.00	0.02	0.00	0.00	0.00	0.00	0.42	0.59	0.04	0.00			9
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			10
1	0.29	0.00	0.00	0.14	0.00	0.04	0.00	0.00	0.01	0.00			11
1	0.00	0.00	0.00	0.32	0.09	0.00	0.00	0.39	0.04	0.09			12
1	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			13
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79			14
1	0.25	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00			15
1	0.00	0.06	0.00	0.32	0.20	0.00	0.00	0.67	0.16	0.04			16
1	0.61	0.00	0.00	0.00	0.00	0.00	0.24	1.17	0.00	0.00			17
1	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.34	0.65	0.21			18
1	0.43	0.30	0.13	0.02	0.23	0.00	0.02	0.10	0.00	0.19			19
1	0.00	0.15	0.24	0.22	0.10	0.22	0.05	0.55	0.00	0.00			20
1	0.02	0.02	0.23	0.00	0.07	0.00	0.05	2.01	0.00	0.00			21
1	0.10	0.07	0.01	0.04	0.00	0.13	0.51	1.21	0.36	0.14			22
1	0.24	0.10	0.00	0.00	0.10	0.57	0.00	0.00	0.00	0.00			23
1	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.00			24
1	0.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			25
1	0.00	0.00	0.00	0.13	0.16	0.00	0.00	0.00	0.00	0.00			26
1	0.00	0.00	0.00	0.43	0.04	0.00	0.00	0.00	0.00	0.00			27
1	0.64	0.36	0.00	0.13	0.63	0.00	1.10	0.19	0.46	0.00			28
1	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.02	0.00			29
1	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.00			30
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			31
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			32
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			33
1	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.78	0.43	0.00			34
1	0.58	0.00	0.00	0.00	0.01	0.45	0.00	0.31	0.37	0.02			35
1	0.00	0.00	0.00	0.59	0.96	0.00	0.00	0.00	0.00	0.00			36
1	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00			37
2	0.18	0.01	0.00	0.14	0.00	0.00	0.00	0.09	0.00	0.00			1
2	0.00	0.00	0.03	0.47	0.18	0.00	1.36	0.00	0.00	0.00			2
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			3
2	0.00	0.02	0.00	0.06	0.54	0.00	0.00	0.00	0.00	0.00			4
2	0.00	0.00	0.00	0.00	0.00	0.07	1.07	0.06	0.20	0.00			5
2	0.00	0.00	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.00			6
2	0.48	0.00	0.00	0.27	0.83	0.00	0.00	0.00	0.19	0.00			7
2	0.98	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.10	0.00			8
2	0.00	0.22	0.00	0.11	0.00	0.27	0.38	0.33	0.32	0.00			9
2	0.00	0.47	0.21	0.08	0.00	0.00	0.00	0.26	0.19	0.00			10
2	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			11
2	0.00	0.00	0.00	0.00	0.88	0.29	0.00	0.00	0.39	0.10			12
2	0.85	0.00	0.00	0.00	0.00	0.00	0.83	0.36	0.00	0.00			13
2	0.00	0.30	0.21	0.00	0.35	0.00	1.89	1.05	0.19	0.14			14
2	0.00	1.76	0.04	0.00	0.00	0.00	0.00	0.11	0.00	0.00			15
2	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			16
2	0.00	0.00	0.48	1.25	0.00	1.01	0.00	0.58	0.56	0.73			17
2	0.00	0.15	0.00	0.00	0.74	0.08	1.01	0.16	0.12	0.00			18
2	0.25	0.00	0.00	0.00	0.00	0.00	0.50	0.05	0.32	0.12			19

2	0.07	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	20
2	0.00	0.00	0.00	0.00	0.18	0.00	0.38	0.39	1.49	0.14	21
2	0.16	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.04	0.00	22
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
2	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	24
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.00	26
2	0.00	0.00	0.00	0.00	0.00	0.03	0.29	0.00	0.00	0.00	27
2	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	28
2	0.62	0.05	1.68	0.08	0.44	0.00	0.00	0.00	1.60	0.76	29
2	1.29	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.19	0.00	30
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	31
2	0.00	0.00	0.15	0.30	0.49	0.21	0.00	0.00	0.00	0.00	32
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33
2	0.12	0.00	0.00	0.11	0.43	0.00	0.00	0.00	0.00	0.00	34
2	0.00	0.00	0.08	0.52	0.00	0.00	0.31	0.00	0.05	0.00	35
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36
2	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	37
3	0.00	0.15	0.00	0.22	0.23	0.00	0.00	0.00	0.00	0.00	1
3	0.00	0.39	0.00	1.22	0.08	1.32	0.29	0.00	0.00	0.00	2
3	0.00	0.95	0.00	0.00	0.12	1.40	0.76	0.67	0.04	0.62	3
3	0.00	0.11	0.49	0.00	0.00	0.00	0.00	0.02	0.27	1.12	4
3	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.34	0.34	0.13	5
3	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
3	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.66	0.00	0.00	7
3	1.48	0.73	0.97	0.09	0.00	0.00	0.31	0.00	0.00	0.22	8
3	0.00	0.00	0.00	0.29	0.27	0.00	0.00	0.00	0.64	0.34	9
3	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	10
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.00	0.00	12
3	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
3	0.00	0.00	0.00	0.32	0.00	0.17	0.00	0.52	0.00	0.00	15
3	0.11	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.01	16
3	0.38	0.13	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	17
3	0.00	0.00	0.00	0.38	0.00	2.12	0.19	0.00	0.41	0.00	18
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.08	0.10	19
3	1.19	0.00	0.00	1.38	0.21	1.63	0.00	0.00	0.00	0.00	20
3	0.95	0.67	0.00	0.00	0.00	0.37	0.47	0.00	0.00	0.34	21
3	0.00	0.00	0.00	0.00	0.00	0.93	0.51	0.00	0.36	0.23	22
3	2.14	0.00	0.00	0.00	0.00	0.82	0.00	5.22	0.00	0.32	23
3	1.18	0.00	1.38	0.22	0.00	0.16	1.76	0.00	0.00	0.00	24
3	0.68	0.17	0.34	2.36	1.17	0.00	0.00	0.00	0.00	0.00	25
3	0.02	0.11	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26
3	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.15	0.16	0.00	27
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.00	28
3	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.03	0.00	29
3	0.00	0.00	0.51	0.00	0.07	0.16	0.00	1.71	0.07	0.13	30
3	0.03	0.31	0.03	0.03	0.33	0.00	0.00	0.00	0.00	0.56	31
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	32
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34
3	0.71	0.15	0.12	0.72	0.00	0.00	0.00	0.00	0.00	0.00	35
3	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	36
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37

Rainfall w/ Irrigation

2
1
ALEIGH NORTH CAROLINA
3.55 3.43 3.69 8.91 9.87 9.66 10.58 10.64 9.29 2.73 2.87 3.14

1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		1
1	0.00	0.00	0.00	0.16	0.03	0.00	0.00	0.00	0.00	0.02		2
1	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.21	0.56	0.00		3
1	0.00	0.00	0.00	0.08	0.00	0.00	0.05	0.00	0.00	0.21		4
1	0.00	0.00	0.00	0.00	0.09	0.37	0.19	0.26	0.40	0.00		5
1	0.01	0.00	0.17	0.11	1.09	0.04	0.49	0.00	0.57	0.00		6
1	0.02	0.00	0.00	0.53	0.07	0.00	0.00	0.00	0.00	0.00		7
1	0.01	0.01	0.00	0.00	0.21	0.00	0.00	0.98	0.00	0.00		8
1	0.00	0.02	0.00	0.00	0.00	0.00	0.42	0.59	0.04	0.00		9
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		10
1	0.59	0.00	0.10	0.34	0.00	0.44	0.00	0.10	0.11	0.10		11
1	0.10	0.10	0.10	0.52	0.09	0.00	0.10	0.39	0.24	0.29		12
1	0.60	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10		13
1	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.79		14
1	0.25	0.00	0.10	0.10	0.14	0.00	0.10	0.10	0.10	0.10		15
1	0.10	0.16	0.10	0.32	0.10	0.00	0.10	0.67	0.16	0.04		16
1	0.61	0.00	0.10	0.10	0.10	0.10	0.24	1.17	0.00	0.10		17
1	0.10	0.10	0.10	0.10	0.70	0.00	0.10	0.34	0.65	0.21		18
1	0.43	0.30	0.13	0.02	0.23	0.00	0.02	0.10	0.00	0.19		19
1	0.00	0.15	0.24	0.22	0.10	0.22	0.05	0.55	0.00	0.00		20
1	0.02	0.02	0.23	0.10	0.07	0.10	0.05	2.01	0.00	0.00		21
1	0.10	0.07	0.01	0.04	0.00	0.13	0.51	1.21	0.36	0.14		22
1	0.24	0.10	0.00	0.00	0.10	0.57	0.00	0.00	0.10	0.10		23
1	0.10	0.10	0.10	0.10	0.10	1.02	0.00	0.10	0.10	0.10		24
1	0.10	1.52	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10		25
1	0.10	0.10	0.10	0.13	0.16	0.00	0.10	0.10	0.10	0.10		26
1	0.10	0.10	0.10	0.43	0.04	0.10	0.10	0.10	0.10	0.10		27
1	0.64	0.36	0.00	0.13	0.63	0.00	1.10	0.19	0.46	0.00		28
1	0.10	0.10	0.10	0.10	0.10	0.14	0.00	0.10	0.22	0.10		29
1	0.10	0.10	0.10	0.10	0.79	0.00	0.10	0.10	0.10	0.10		30
1	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00		31
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		32
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		33
1	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.78	0.43	0.00		34
1	0.58	0.00	0.00	0.00	0.01	0.45	0.00	0.31	0.37	0.02		35
1	0.00	0.00	0.00	0.59	0.96	0.00	0.00	0.00	0.00	0.00		36
1	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00		37
2	0.18	0.01	0.00	0.14	0.00	0.00	0.00	0.09	0.00	0.00		1
2	0.00	0.00	0.03	0.47	0.18	0.00	1.36	0.00	0.00	0.00		2
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		3
2	0.00	0.02	0.00	0.06	0.54	0.00	0.00	0.00	0.00	0.00		4
2	0.00	0.00	0.00	0.00	0.00	0.07	1.07	0.06	0.20	0.00		5
2	0.00	0.00	0.11	0.02	0.00	0.00	0.00	0.00	0.00	0.00		6
2	0.48	0.00	0.00	0.27	0.83	0.00	0.00	0.00	0.19	0.00		7
2	0.98	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.10	0.00		8
2	0.00	0.22	0.00	0.11	0.00	0.27	0.38	0.33	0.32	0.00		9
2	0.00	0.47	0.21	0.08	0.00	0.00	0.00	0.26	0.19	0.00		10
2	0.10	0.38	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10		11
2	0.10	0.10	0.10	0.10	0.88	0.29	0.00	0.10	0.39	0.10		12
2	0.85	0.00	0.10	0.10	0.10	0.10	0.83	0.36	0.00	0.10		13
2	0.10	0.30	0.21	0.00	0.35	0.00	1.89	1.05	0.19	0.14		14
2	0.00	1.76	0.04	0.10	0.10	0.10	0.10	0.31	0.00	0.10		15
2	0.10	0.22	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10		16
2	0.10	0.10	0.48	1.25	0.00	1.01	0.00	0.58	0.56	0.73		17
2	0.00	0.15	0.00	0.10	0.74	0.08	1.01	0.16	0.12	0.00		18
2	0.25	0.00	0.10	0.10	0.10	0.10	0.50	0.05	0.32	0.12		19

2	0.07	0.00	0.10	0.10	0.10	0.28	0.10	0.10	0.10	0.10	20
2	0.10	0.10	0.10	0.10	0.18	0.00	0.38	0.39	1.49	0.14	21
2	0.16	0.00	0.10	1.06	0.00	0.10	0.10	0.10	0.24	0.10	22
2	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	23
2	0.10	0.10	0.10	0.10	0.25	0.00	0.10	0.10	0.10	0.10	24
2	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	25
2	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.58	0.00	26
2	0.00	0.10	0.10	0.10	0.10	0.23	0.29	0.00	0.10	0.10	27
2	0.10	0.10	0.10	0.10	0.10	0.32	0.00	0.10	0.10	0.10	28
2	0.62	0.05	1.68	0.08	0.44	0.00	0.10	0.10	1.60	0.76	29
2	1.29	0.00	0.10	0.10	0.10	0.10	0.98	0.00	0.19	0.00	30
2	0.10	0.10	0.10	0.10	0.00	0.00	0.00	0.00	0.01	0.00	31
2	0.00	0.00	0.15	0.30	0.49	0.21	0.00	0.00	0.00	0.00	32
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33
2	0.12	0.00	0.00	0.11	0.43	0.00	0.00	0.00	0.00	0.00	34
2	0.00	0.00	0.08	0.52	0.00	0.00	0.31	0.00	0.05	0.00	35
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36
2	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	37
3	0.00	0.15	0.00	0.22	0.23	0.00	0.00	0.00	0.00	0.00	1
3	0.00	0.39	0.00	1.22	0.08	1.32	0.29	0.00	0.00	0.00	2
3	0.00	0.95	0.00	0.00	0.12	1.40	0.76	0.67	0.04	0.62	3
3	0.00	0.11	0.49	0.00	0.00	0.00	0.00	0.02	0.27	1.12	4
3	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.34	0.34	0.13	5
3	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
3	0.00	0.00	0.00	0.00	0.00	0.17	0.17	0.66	0.00	0.00	7
3	1.48	0.73	0.97	0.09	0.00	0.00	0.31	0.00	0.00	0.22	8
3	0.00	0.00	0.00	0.29	0.27	0.00	0.00	0.00	0.64	0.34	9
3	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	10
3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	11
3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.77	0.00	0.10	12
3	0.66	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	13
3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	14
3	0.10	0.10	0.10	0.32	0.00	0.17	0.00	0.52	0.00	0.10	15
3	0.11	0.00	0.10	0.10	0.10	0.10	0.09	0.00	0.10	0.11	16
3	0.38	0.13	0.00	0.04	0.10	0.10	0.10	0.10	0.10	0.10	17
3	0.10	0.10	0.10	0.38	0.00	2.12	0.19	0.00	0.41	0.00	18
3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.21	0.08	0.10	19
3	1.19	0.00	0.10	1.38	0.21	1.63	0.00	0.10	0.10	0.10	20
3	0.95	0.67	0.00	0.10	0.10	0.37	0.47	0.00	0.10	0.34	21
3	0.00	0.10	0.10	0.10	0.10	0.93	0.51	0.00	0.36	0.23	22
3	2.14	0.00	0.10	0.10	0.10	0.82	0.00	5.22	0.00	0.32	23
3	1.18	0.00	1.38	0.22	0.00	0.16	1.76	0.00	0.10	0.10	24
3	0.68	0.17	0.34	2.36	1.17	0.00	0.10	0.10	0.10	0.10	25
3	0.02	0.11	0.48	0.10	0.10	0.10	0.10	0.10	0.10	0.10	26
3	0.10	0.68	0.00	0.10	0.10	0.10	0.10	0.15	0.16	0.00	27
3	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.86	0.00	28
3	0.10	0.10	0.10	0.10	0.10	0.36	0.00	0.10	0.03	0.10	29
3	0.10	0.10	0.51	0.00	0.07	0.16	0.00	1.71	0.07	0.13	30
3	0.03	0.31	0.03	0.03	0.33	0.10	0.10	0.10	0.10	0.56	31
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	32
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34
3	0.71	0.15	0.12	0.72	0.00	0.00	0.00	0.00	0.00	0.00	35
3	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	36
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37

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Executive Summary

A soil and site investigation was completed for several properties in Johnston County that will potentially receive supplemental irrigation water from the Central Johnston County Regional Wastewater Treatment System. These properties included the Johnston County Country Club, Johnston County Landfill and surrounding properties, as well as several agricultural fields. The objectives of this investigation were to describe the various reclaimed water receiver properties according to the soils, geologic features, hydrology, and wetlands. Site investigations and reports will be utilized to meet permitting requirements set forth by NCDWQ for reclaimed wastewater. The wastewater to be irrigated will be analyzed and recommendations will be provided for the establishment and maintenance of a reuse wastewater irrigation system including a detailed water budget and hydraulic loading rates. In addition, specific resource management plans will be addressed for the County Landfill property. The information outlined in this report will aid in the design and management of a reclaimed wastewater irrigation system for the Phase I properties.

Work completed was conducted according to NCAC 2H .0219(k)(B-C) rules for wastewater reuse. Field investigations were conducted to describe the potential reuse sites according to the soils, geologic features, hydrology, and wetlands. Reclaimed wastewater will be analyzed by the County and hydraulic loading recommendations will be provided for the reuse wastewater irrigation system on each specific site. More specific recommendations for the establishment and maintenance of forest systems will be provided for the County Landfill areas. Hydraulic loading recommendations will vary among sites according to site characteristics including soils, hydrology, vegetation, and any site limiting factors. These loadings can be found in Table 3 of this report. Additional information on hydraulic loadings, irrigation scheduling, and other hydrologic information can be found in Appendix D – Hydrologic Report.

Overall, the concept of conjunctive permitting with the County Treatment System is a viable alternative to discharging wastewater into nearby surface waters. The sites selected for wastewater reuse generally have well drained soils and cover crops to utilize the water and nutrients in the reuse water.

1.0 Introduction

Municipalities and industries are adopting innovative methods for utilizing treated wastewater through irrigation and industrial reuse in order to increase economic efficiency and conserve our water resources in North Carolina.

The Central Johnston County Regional Wastewater Treatment System is in the process of completing an extensive reuse project for their municipal wastewater treatment plant along the Neuse River. The facility is unable to meet the future required limits for nitrogen and other nutrient discharges in the Neuse River without the addition of special treatment processes and they will be implementing the infrastructure for reclaimed wastewater as an alternative for wastewater treatment using the recommendations from this report.

Under Section .0200 Rules – Waste Not Discharged to Surface Waters set forth by the North Carolina Division of Water Quality (NCDWQ), municipalities, and privately owned treatment works (POTWs) can divert their highly treated effluent to reclaimed wastewater sites. Since the Johnston County Wastewater Treatment Facility has an NPDES permit to discharge and treat their wastewater to meet State water quality standards before discharging, the quality of water is very high and there are fewer limitations on end uses of the reuse water.

The concept of conjunctive permitting that allows reuse coupled with permitted discharge is consistent with the total maximum daily load (TMDL) program promoted by federal and state regulatory agencies. Wastewater, reused or recycled on sites that have the potential for contact with humans, must receive very high levels of treatment. This treated wastewater is usually of high quality, i.e. minimal pathogens and nutrients, and of higher quality than storage pond water typically used in irrigation systems for golf courses. Levels of Biological oxygen demand (BOD) and total suspended solids (TSS) must be at most 10 mg/L and 5 mg/L respectively and meet the federal shellfish standard for coliform of less than 14 counts per 100mL.

Many County governments, municipalities, and industries are facing similar situations with finding alternatives for wastewater treatment in nutrient sensitive regions. Reuse is a viable alternative for the County and will provide an excellent source of water for local farmers, golf courses, forestlands, landfill buffers, and other cropping systems.

Several end-users have been identified within Johnston County to receive reclaimed water from the Johnston County Wastewater Treatment System through a project partly funded by a Clean Water Management Trust Fund Grant along with matching funds from the County.

One end-user identified is the Johnston County Golf & Country Club, which uses water from existing irrigation ponds as their source of irrigation. A reuse system would provide an excellent alternative to using potable water. The Johnston County Landfill and surrounding County lands were also selected to receive reclaimed water. This property is

approximately 550 acres including the capped and active landfill cells. Reclaimed water can be irrigated on this property to meet the discharge objectives of the Wastewater Treatment Plant and the resource management objectives of the County Landfill. Two agricultural properties were also selected to receive reclaimed water, which will provide a valuable resource for the farmers who grow crops such as soybeans and corn on these fields.

2.0 Objectives

The objectives of this report are to describe the various reclaimed water receiver properties according to the soils, geologic features, hydrology, and wetlands. These lands are a part of the Phase I reuse plan for the Central Johnston County Regional Wastewater Treatment System. Site investigations and reports will be utilized to meet permitting requirements set forth by NCDWQ for reclaimed wastewater. The wastewater to be irrigated will be analyzed and recommendations will be provided for the establishment and maintenance of a reuse wastewater irrigation system including a detailed water budget and hydraulic loading rates. In addition, specific resource management plans will be addressed for the County Landfill property. The information outlined in this report will aid in the design and management of a reclaimed wastewater irrigation system for the Phase I properties.

3.0 Methodology

Work completed was conducted according to NCAC 2H .0219(k)(B-C) rules for wastewater reuse. Field investigations were conducted to describe the potential reuse sites according to the soils, geologic features, hydrology, and wetlands. Reclaimed wastewater will be analyzed by the County and hydraulic loading recommendations will be provided for the reuse wastewater irrigation system on each specific site. More specific recommendations for the establishment and maintenance of forest systems will be provided for the County Landfill areas. Hydraulic loading recommendations will vary among sites according to site characteristics including soils, hydrology, vegetation, and any site limiting factors.

Johnston County Landfill

1.0a Site Description

The proposed wastewater reuse irrigation system site is located north of Highway 210, northeast of the City of Smithfield in Johnston County, North Carolina, within the Upper Coastal Plain physiographic province (Figure 1). The project area consists of rolling terrain with high sand ridges leading down to wet stream bottoms. The soils present at the site are mapped as State, Wehadkee, Varina, Cecil, Norfolk, Uchee, Marlboro, Rion, Gilead, Bonneau, and Blanton.

1.1a Soil Analysis

The soils present on the landfill were investigated and verified with the USDA soil survey for Johnston County. A series of augerings were completed across the landscape to characterize the soils according to depth of horizons, the color of the soil material at each of the various depths, the texture, structure, and consistence of the soil material within each of the horizons (Appendix C – Soil Descriptions). Only slight differences in the depths and color of the E and Bt horizons were evident for several soil series across the landscape. Areas with the deepest surface horizons were dedicated as Priority 1 spray areas (Appendix A – Site Investigation Maps). Disturbed areas or soils with shallow surface horizons received a lower priority level rating. The majority of the soils were well drained with a few areas of moderately well drained and poorly drained soils (i.e. borrow pit).

A composite sample of the top 12 inches of soil representing the sprayable areas was collected and analyzed for nutrient composition (Table 1 – Soil Analysis). From these data, it is evident that the soils representing this site are somewhat low in nutrients such as potassium (K), calcium (Ca), and magnesium (Mg) with elevated phosphorus levels in some areas. This conclusion is based on the potential crop response to particular nutrients if fertilizer is applied to the site. The pH is adequate for crops, however the base saturation (BS%) is low. Optimum growing conditions for topsoil require a BS% of 60-80% of the cation exchange capacity (CEC). The addition of treated wastewater to this site will ultimately improve soil fertility and consequently the growing conditions and productivity of this site.

Table 1: Summary of Average Soil Fertility at the Proposed Johnston County Landfill Reclaimed Wastewater Receiver Site, Johnston County, NC

Depth	pH	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	CEC [1]	BS% [2]
0-12 in.	5.4	130.0	34.5	178.5	30.8	2.8	38.3

[1] 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.

[2] Base saturation – defined as the percentage of the CEC occupied by base cations

Figure 1: Proposed Johnston County Reclaimed Wastewater Receiver Sites
Johnston County, North Carolina

1.2a Wetlands, Streams, and Groundwater Wells

According to regulations (Section.0200 – Waste not discharged to surface waters) concerning reclaimed water systems using treated municipal effluent, irrigation spray shall not influence within 25 feet of surface waters not classified SA (shellfish waters), including jurisdictional wetlands. Under the same regulations, wastewater shall not influence areas within 100 feet of a water supply well and within 10 feet of nonpotable wells.

A field investigation was conducted to locate wetlands, streams, and drainage ways that need to be buffered by a 25 foot "no spray zone". The Johnston County Landfill property revealed several areas that need to be buffered. Four streams flow through and adjacent to the property with accompanying wetlands and floodplain zones. Approximately 20-25% of the landfill acreage is wetlands, streams, and floodplains. No water supply wells or non-potable wells were located within the sprayable areas of the property. All wetlands, streams, and groundwater wells that had potential for spray influences were located, flagged, and mapped using GIS (Appendix A – Site Investigation Map).

2.0a Hydrology

2.1a Wastewater Characterization

The water proposed for this reuse system has undergone treatment via an activated sludge process which includes secondary treatment clarifiers to remove suspended solids from the liquid to improve the secondary effluent disinfection process and ultra violet disinfection to eliminate pathogens and other organisms. Overall, the treated wastewater has concentrations of nutrients, including nitrogen and phosphorus, which would not cause adverse environmental effects when land applied (Table 2).

Table 2: Wastewater Analysis (mg/L) at the Johnston County Wastewater Treatment Plant (August, 1999)

TSS	BOD	DO [1.]	$N\text{-}NH_3$ [2.]	Total P [3.]	Total N [4.]
6.0	3.0	5.49	.38	.58	6.6

1.] Dissolved oxygen
2.] Ammonia nitrogen
3.] Total inorganic and organic phosphorus
4.] Total inorganic and organic nitrogen

2.1.1a 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:

$$SAR = Na/(Ca/2 + Mg/2)^{1/2} \text{ (units in meq/L)}$$

An SAR in excess of 10 is considered as an irrigation hazard and system operators must take special precautions to monitor salt levels of sodium in both irrigation water and soil. An SAR in excess of 7.5 is considered a mild irrigation hazard and 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 should be implemented.

The SAR of the Johnston County treated municipal wastewater is approximately **5.9**, which does not indicate a risk of developing soil infiltration problems and nutrient imbalances. However, levels of sodium in the wastewater and soil should be closely monitored. Actual sodium levels applied at the County landfill may vary. Additional sampling and monitoring of Na, Ca, and Mg in both wastewater and soils is recommended to ensure optimal performance of the proposed irrigation system. Periodic application of gypsum may be required as a corrective measure if the SAR is consistently above 10 Irrigation wastewater should have SAR values ≤ 10 to avoid potential salting problems in the soil.

2.1.2a 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 (North Carolina Agronomic Division – Soil Testing Indices)

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 manganese (Mn) & Mg deficiencies in plants. Ca/Mn and Ca/Mg ratios should be kept in balance. The average ESP for the soils at the landfill is < 1.0 %. Therefore there is no risk of infiltration and nutrient imbalance problems resulting from existing exchangeable sodium ions in the soil.

2.2a Wastewater Remediation

Treated municipal wastewater 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).

2.3a Irrigable Areas

Sprayable areas on the landfill property have been prioritized according to soil characteristics, vegetation, location of adjacent wetlands and streams, topography, and accessibility with irrigation equipment. Areas were prioritized as levels 1, 2, or 3 with level 1 being the highest priority for irrigation due to site characteristics.

Following the site investigation it was determined that the County land closest to the entrance road to the east behind the NC Forest Service building would have the highest priority for spraying (Appendix A – Site Investigation Maps). In addition, land adjacent to the active yard waste cell to the west would also be ideal for wastewater application. These areas have good soil characteristics to accommodate wastewater, are close to access roads, have level to moderately level topography, and have minimal buffer requirements from adjacent wetlands, streams, and groundwater wells.

An additional Priority Level 1 area is located at the back of the property, which includes the majority of the pine plantations, and is not as accessible to equipment as the aforementioned areas. However, due to the soil characteristics, topography, and

vegetation, this area would be ideal for reuse wastewater application. These Priority Level 1 areas total approximately **260 acres**.

Priority Level 2 areas include the landfill caps and can accommodate much less hydraulic loadings than adjacent forestlands. At most, agronomic rates will be applied to maintain a cover crop on the landfill caps. These areas total approximately **78 acres**.

One area is marked as Priority Level 3 and is not currently suitable for wastewater application. This area is severely degraded in the ability to sustain vegetation and transmit water vertically through the soil due to excavation of the topsoil horizons for cap material. Management recommendations for this area are provided below. However, at this time, it is not recommended to use this area for wastewater application. This area is approximately **28 acres**.

2.4a Water Budget

A water budget for the landfill properties was calculated using methods established by EPA, 1981 and long term weather data as well as the simulation model DRAINMOD (Skaggs, 1978). A detailed hydrologic analysis can be found in Appendix D.

2.5a Hydraulic Loading/Liquid Loadings

Following a detailed hydrologic analysis, hydraulic loadings have been calculated for the landfill and adjoining properties (Table 3). These areas are designated as LF1, LF2, LF3, Borrow Pit, LF4, LF cap1&2, LF cap 3, and LF cap 4. An executive summary along with a detailed hydrologic report describing hydraulic loadings, irrigation scheduling, and related information can be found in Appendix D.

3.0a Site Management

Forest systems have a variety of attributes favorable for treatment of wastewater including: 1.) A large reserve of well-drained forestland exists in the eastern U.S. 2.) Most natural forest stands sites are nutrient deficient and capable of assimilating large amounts of nutrients and water through biotic conversion and soil adsorption. 3.) Trees have perennial root systems, which allow year round uptake of nutrients and water 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 from 5.5 to 7.0 (Frederick et al., 1994). Soils that are very clayey or very sandy are somewhat limited for wastewater applications, although waste characteristics and

Table 3: Recommended design and permitted annual irrigation amounts (cm/yr).

Field	Vegation	Irrigation Window	Driest YR Permit Amount	10%tile	20%tile Minimum Design Amount	Average (2 RYI)	80%tile (5 YRI)	90 %tile (10 YRI)	Wettest (46 YRI)
LF1	Trees	A1S30	**77.5**	68.0	**64.3**	53.6	43.5	41.6	35.9
		J1D31	**90.7**	81.3	**77.5**	66.3	56.7	52.9	49.1
LF2	BG/nos	A1S30	**76.9**	69.3	**66.8**	58.2	51.7	49.1	39.1
	BG/wos	F1D15	**97.0**	93.2	**85.7**	74.7	66.8	60.5	56.7
	Trees	A1S30	**88.8**	79.4	**73.7**	63.8	54.8	52.9	41.6
	Trees	J1D31	**109.6**	98.3	**92.6**	80.3	69.9	68.0	60.5
LF3	Trees	A1S30	**64.3**	54.8	**49.1**	41.6	34.0	30.2	24.6
Borrow Pit	Trees	J1D31	**73.7**	66.2	**58.6**	49.1	41.6	37.8	32.1
LF4	Trees	A1S30	**77.5**	71.8	**64.3**	55.9	47.3	45.4	35.9
	Trees	J1D31	**92.6**	85.1	**79.4**	69.4	60.5	54.8	51.0
LF cap 1	mixed grass	A1S30	**36.5**	29.0	**26.5**	17.8	10.1	7.6	5.0
LF cap 3	mixed grass	A1S30	**35.3**	27.7	**26.5**	17.2	11.3	7.6	6.3
LF cap 4	mixed grass	A1S30	**36.5**	30.2	**26.5**	18.0	10.1	7.6	5.0
JCCC	BG	A1S30	**69.3**	64.8	**60.3**	54.4	47.7	46.7	39.2
	BG/wos	F1D15	**88.2**	82.8	**81.5**	69.2	62.6	57.6	56.3
	Greens	J1D31	**105.3**	103.5	**102.0**	99.1	97.2	96.6	94.2
BJT1F1	Corn	J1A31	**35.3**	27.7	**20.2**	15.1	8.8	6.3	2.5
	Soybean	J1O15	**30.2**	21.4	**18.9**	11.5	5.0	2.5	0.0
	Corn/Wheat	J1D15	**32.8**	26.5	**21.4**	14.0	6.3	3.8	1.3
	Wheat/Soy	F1O15	**40.3**	30.2	**26.5**	18.1	11.3	10.1	2.5
BJT1F2	Corn	J1A31	**37.8**	32.8	**26.5**	19.5	12.6	10.1	2.5
	Soybean	J1O15	**37.8**	27.7	**25.2**	16.4	10.1	5.0	2.5
	Corn/Wheat	J1D15	**46.6**	36.5	**35.2**	24.5	17.6	13.9	2.5
	Wheat/Soy	F1O15	**42.8**	35.3	**31.5**	19.9	10.1	6.3	1.3
BJT2F1	Corn	J1A31	**42.8**	37.8	**31.5**	23.3	16.4	13.9	2.5
	Soybean	J1O15	**37.8**	60.2	**27.7**	18.1	12.6	7.6	1.3
	Corn/Wheat	J1D15	**52:9**	44.1	**40.3**	29.8	22.7	18.9	3.9
	Wheat/Soy	F1O15	**49.1**	42.8	**35.3**	24.1	15.1	12.6	5.0

BG/nos = bermudagrass with no overseed, BG/wos = bermudagrass with winter overseed
A1S30 = irrigation window beginning April 1 and ending September 30
LF1, LF2, LF3, Borrow Pit, LF4, LF cap1&2, LF cap3, LF cap4 = Landfill Areas, JCCC = (Johnston County Country Club), BJT1F1/F2, & BFT2F1 = (Bolton Jones Properties)

application rate are important mitigating factors. Although hardwood (deciduous) species are generally preferred for wastewater application, existing natural stands and plantations of evergreen (coniferous) species have shown excellent response to fertilization (i.e. wastewater application) if hydraulic loads are reasonable (Fisher and Garbett, 1980; Lutrick et al., 1986; Red and Nutter, 1986). 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.

Forest systems used for wastewater application have the potential to rapidly generate large quantities of biomass. Forest management activities associated with wastewater irrigated systems are similar to management activities associated with natural forests and may include thinning, pruning, whole tree harvesting for chips, or sawtimber harvest. Unlike non-irrigated forests, management activities associated with wastewater irrigated systems usually occur at an accelerated schedule due to the rapid biomass accumulation. This biomass can be marketed as pulpwood chips or on longer rotations for sawtimber. The market for hardwood chips and roundwood in the eastern U.S. is growing and hardwood species now account for 33% of the total consumption of roundwood by the pulp industry, as compared with 11% in 1952 (Bechtold and Sheffield, 1991). Pulpwood consumption is expected to increase 43% from 1990 to 2010 (Haynes et al., 1995). In addition, environmental regulations affecting timber harvest on public lands in the Pacific Northwest are expected to result in increased demand and stumpage prices for both hardwood and softwood forest products (Haynes, 1990; Wagner et al., 1994).

3.1a Nutrient Transformations

The primary function of any wastewater treatment system is to remove excess nutrients and other pollutants. Regulatory agencies are particularly concerned with discharges of nitrogen (N), phosphorus (P), BOD (biochemical oxygen demand), and fecal coliform. Fecal coliform is largely removed during the disinfection process and BOD is primarily removed during settling and facultative treatment in lagoons prior to land application. Additional compounds present in wastewater may be of concern to regulators or may limit biological treatment options (i.e. high salt or metal content). Forest systems are particularly efficient at removing N and P since most natural forests are deficient in these nutrients (Table 3). In addition, forest plantation systems can be designed to include species that are tolerant of high hydraulic loads and exhibit high nutrient assimilation rates through rapid early growth (Table 4).

Nutrient removal from wastewater and accumulation in forest systems is affected by stand age, site characteristics, and species composition. In general, hardwoods accumulate more nutrients and biomass at a faster rate than pines. Hardwood nutrient accumulation rates are higher in young stands (i.e. < 20 years) and gradually decrease with age, particularly for nitrogen and phosphorus (Messina et al.,1994). Due to the latter trend, several short rotations (< 20 years each) will result in cumulatively higher nutrient removal than one long rotation. However, if nutrient loadings are low, longer rotations

may be satisfactory and can result in the production of a higher quality, more valuable crop such as sawtimber.

Table 4: Relative nutrient and biomass accumulation rates for forest systems

Land Application System	Average nutrient accumulation rate [kg/ha/yr. (lb./ac/yr.)]					
	N	P	K	Ca	Mg	Biomass (dry)
Edenton, NC *Platanus occidentalis* (sycamore) [2]	22.0 (19.6)	6.0 (5.3)	17.8 (15.8)	31.0 (27.6)	3.0 (2.7)	8.2 t/ha/yr.
Edenton, NC *Liquidambar styraciflua* (sweetgum) [2]	21.6 (19.2)	2.6 (2.3)	11.2 (10.0)	36.0 (32.0)	10.8 (9.6)	5.9 t/ha/yr.

[1] Frederick et al., 1994

3.2a 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. In addition, pine species may be used if hydraulic loading is low and/or soils are well-drained. The objective of species selection is to maximize growth and nutrient uptake for a given wastewater application.

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.

Table 5: Characteristics of common tree species used in wastewater 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 sp. (hybrid poplar)	tolerant - mod. tolerant	medium texture	6.00-7.00
Taxodium distichum (baldcypress)	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

Both natural pine stands and plantations have been successfully utilized for wastewater irrigation, however, hydraulic loadings must be limited on most sites because pine species are generally less tolerant of anaerobic soil conditions.

3.3a Plantation establishment

The Priority Level 1 (Field LF2) area behind the yard waste site is suitable for forest plantation establishment. The soils are ideal for a variety of hardwood trees and a minimal amount of site preparation is required to ensure the survival of planted trees. The site should be bush-hogged and ripped to establish planting rows. In addition, an application of a preemergent herbicide to control herbaceous competition is recommended before planting. It is recommended that a plantation of sycamore (*Platanus occidentalis*) trees be on this site. This selection and location is based on

existing soil characteristics and accessibility to the site with site preparation equipment. Trees should be planted at a 6x10 ft. spacing (726 trees/ac.) within ripped planting rows.

Establishing a forest plantation on the borrow areas (Priority Level 3, Field LF3) within the landfill property may be feasible with the addition of topsoil and/or other soil amendments. These extreme areas are low in nutrients and have minimal to no organic matter and would take a great effort to restore the soil quality needed for tree production. The addition of lime stabilized sludge or other organic material to this site is recommended to help increase nutrients, infiltration, and productivity of the soil. At the present there are runoff problems from rainfall on this site which further limits this area for land application. There is potential for establishing a forested plantation on these areas following the application of soil amendments and organic material. Once the site is restored with amendments, a plantation of a mixture of sycamore and sweetgum (*Liquidambar styraciflua*) is recommended with a 6x10 ft. spacing.

For forest system establishment, spacings which yield 6.5 to 7.4 m^2 (70 to 80 ft^2) per seedling are recommended for most species (i.e. 2.1 x 3.0m or 2.4 x 3.0m [7 x 10ft or 8 x 10ft]) (Briscoe, 1969; Kennedy, 1975). Spacings suitable for pulpwood rotations are suitable for most wastewater applications (6 x 10ft). If longer rotations are desired, intermediate thinning may be appropriate.

3.4a Forest Plantation Maintenance

Forest systems used for wastewater application require little maintenance as compared with crop 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.

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.

Thinning and pruning of plantations may be necessary between 5-10 years, and pulpwood harvest may occur at 8-20 years depending on wastewater loading, species, and site characteristics.

Plantation maintenance recommendations for the Johnston County Landfill newly established plantation sites include:

- Follow up monitoring of plantations within one year after planting
- Sprinkler inspection to ensure adequate coverage and adjust for areas where ponding and/or surface runoff may occur

3.5a Forest Harvesting Recommendations

Both natural stands and plantations irrigated with wastewater exhibit accelerated growth. Since the primary objective of this land application systems 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. Crown closure and growth peak for wastewater irrigated plantations at Edenton, NC occurred between 5-7 years (Frederick et al., 1994). Trees at the Edenton site averaged 12.7 cm (5 in) diameter and 13.7 m (45 feet) height for sycamore, and 10 cm (4 in) diameter and 10.7 m (35 ft) height for sweetgum (Frederick et al., 1994).

Hardwood stands are regenerated by coppicing (stump sprouts), so there is no need to replant following initial harvest. Multiple sprouts will quickly arise from the cut stumps and continue to assimilate nutrients from the wastewater. These multiple sprouts will naturally thin themselves as 2 to 3 stems become dominant from each stump (Kennedy, 1975).

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.

3.6a Existing Forest Maintenance and Harvesting Recommendations

Hardwood Cutover Areas

It is recommended that no forestry activities such as precommercial thinning cutting be done on these areas for the next 20 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 years). At year 20 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).

Pine Plantations

Pine plantations on these sites should be thinned at about age 15 and age 24, then harvested at age 35 - 40 years. Depending on the initial spacing (trees / acre), the first

thinning should leave about 300 - 350 trees / acre. If the trees were planted at a 6 x 10 spacing = 726 trees, the first thinning removes about one-half of the original trees. Some trees have died, so the exact number of trees cut may be somewhat less. The first thinning could be a row thin (every 5th row removed with selective thinning in the remaining 3 rows. The second thinning would be a selective thinning removing about one-half of the trees. This thinning would leave around 150 trees per acre as the final crop. These trees could be grown until 35 - 40 years or they could be left until 50 or 60 years to produce large-diameter sawtimber and higher value. Hardwoods will regenerate in the understory after each thinning and thus maintain a good cover for water and nutrient uptake.

5.0a Environmental Effects

There are no adverse environmental effects from the implementation of this reuse system. The water used is very high quality and meets regulated levels of TSS, BOD, and other nutrients as well as federal shellfish coliform limits required for point source discharges. The use of this wastewater will ultimately increase soil fertility and productivity of the landfill property and will enhance adjacent wetlands and low lying areas with increased base flow. Borrow areas and other areas with low fertility will be enhanced from the increase in nutrients. Land application of wastewater in conjunction with management recommendations given in this report will help to restore some of the soils and vegetation impacted from excavation, trafficking, and other disturbances.

There will be no impacts to groundwater supplies or surface water supplies. The addition of water and nutrients to the site may indirectly benefit wildlife through increased biological activity in adjacent wetlands and low lying areas.

Johnston County Golf & Country Club

1.0b Site Description

The proposed wastewater reuse irrigation system site is located west of Highway 301, southwest of the City of Smithfield in Johnston County, North Carolina and is located in the Upper Coastal Plain physiographic province (Figure 1). The project area consists of rolling terrain with high sand ridges leading down to wet stream bottoms. The soils present at the site are mapped as Wagram, Goldsboro, State, Nason, Norfolk, and Faceville on the upland areas and Pantego in the low lying areas.

The Johnston County Golf Course was established in the 1930s as a nine-hole course and expanded to eighteen holes in the 1960s. Throughout the history of the course, there have been many disturbances to the existing soils, surrounding vegetation, wetlands, and stream corridors. There is an unnamed tributary to Holts Pond flowing through the middle of the course along with several other drainages and intermittent/ephemeral streams. Vegetation consists of 50-75 year-old trees on the course grounds surrounded by a mix of open pasture, young, and middle-aged class trees on adjacent properties.

1.1b Soil Analysis

The soils present on the golf course were investigated and verified with the USDA soil survey for Johnston County. A series of augerings were completed across the landscape to characterize the soils according to depth of horizons, the color of the soil material at each of the various depths, the texture, structure, and consistence of the soil material within each of the horizons (Appendix C – Soil Descriptions). In addition to the soil series mapped, other areas were present that have been disturbed as a result of grading and moving soil during construction and maintenance of the golf course. The majority of the soils present were well drained with the exception of some poorly drained soils in the low lying areas near streams.

A composite sample of the top 0-12 inches of soil representing the sprayable areas was collected and analyzed for nutrient composition (Table 5 – Soil Analysis). From these data, it is evident that the soils representing this site are somewhat low in nutrients such as potassium (K), calcium (Ca), and magnesium (Mg) with elevated phosphorus levels in some areas. This conclusion is based on the potential crop response to particular nutrients if fertilizer is applied to the site. The pH is a little low as well as the base saturation (BS%). Optimum growing conditions for topsoil require a BS% of 60-80% of the cation exchange capacity (CEC). A target pH for turfgrass is 6.2 (NCDA, 2000) which can be obtained through the addition of lime not to exceed 2 tons per acre. Addition of treated wastewater to this site will ultimately improve soil fertility and consequently the growing conditions and productivity of this site.

Table 6: Summary of Average Soil Fertility at the Proposed Johnston County Golf & Country Club Reclaimed Wastewater Receiver Site Johnston County, NC							
Depth	pH	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	CEC [1]	BS% [2]
0-6 in.	4.8	72.5	52.5	145.8	28.6	3.4	32.9
6-12 in.	4.9	22.3	41.9	54.5	13.5	2.1	28.4

[1] 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.
[2] Base saturation – defined as the percentage of the CEC occupied by base cations

1.2b Wetlands, Streams, and Groundwater Wells

According to regulations (Section.0200 – Waste not discharged to surface waters) concerning reclaimed water systems using treated municipal effluent, irrigation spray shall not influence within 25 feet of surface waters not classified SA (shellfish waters), including jurisdictional wetlands. Under the same regulations, wastewater shall not influence areas within 100 feet of a water supply well and within 10 feet of nonpotable wells.

A field investigation was conducted to locate wetlands, streams, and drainage ways that need to be buffered by a 25 foot no spray zone (Appendix A – Site Investigation Map). The Johnston County Golf and Country Club property revealed several areas that need to be buffered. One area located was an unnamed tributary to Holts Pond that flows through the middle of the course connecting several decorative ponds and wetland areas. This stream has been impacted in several locations through the installation of culverts, installation of rip-rap, channel straightening, and channel rerouting. Several other wetland and intermittent/ephemeral streams were located on the course grounds.

Approximately < 5% of the golf course acreage is wetlands, streams, and floodplains. Water supply wells and nonpotable wells were also located and buffers established. Existing water supply wells on the golf course will be capped. Necessary adjustments to irrigation plans will be completed to meet buffer requirements for course wetlands and streams, as well as adjacent property water supply wells. (Appendix A – Site Investigation Map).

All areas that had potential for spray influences were located, flagged, and mapped using GIS (Appendix A – Site Investigation Map).

2.0b Hydrology

2.1b Wastewater Characterization

The water proposed for this reuse system has undergone treatment via an activated sludge process which includes secondary treatment clarifiers to remove suspended solids from the liquid to improve the secondary effluent disinfection process and ultra violet disinfection to eliminate pathogens and other organisms. Overall, the treated wastewater has concentrations of nutrients, including nitrogen and phosphorus, which would not cause adverse environmental effects when land applied (Table 6).

Table 7: Wastewater Analysis (mg/L) at the Johnston County Wastewater Treatment Plant (August, 1999)

TSS	BOD	DO [1.]	$N\text{-}NH_3$ [2.]	Total P [3.]	Total N [4.]
6.0	3.0	5.49	.38	.58	6.6

1.] Dissolved oxygen
2.] Ammonia nitrogen
3.] Total inorganic and organic phosphorus
4.] Total inorganic and organic nitrogen

2.2b 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)

An SAR in excess of 10 is considered as an irrigation hazard and system operators must take special precautions to monitor salt levels of sodium in both irrigation water and soil. An SAR in excess of 7.5 is considered a mild irrigation hazard and 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 should be implemented.

The SAR of the Johnston County treated municipal wastewater is approximately **5.9**, which does not indicate a risk of developing soil infiltration problems and nutrient

imbalances. However, levels of sodium in the wastewater and soil should be closely monitored. Actual sodium levels applied at the County landfill may vary. Additional sampling and monitoring of Na, Ca, and Mg in both wastewater and soils is recommended to ensure optimal performance of the proposed irrigation system. Periodic application of gypsum may be required as a corrective measure if the SAR is consistently above 10 Irrigation wastewater should have SAR values ≤ 10 to avoid potential salting problems in the soil.

2.3b 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 (North Carolina Agronomic Division – Soil Testing Indices)

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 manganese (Mn) & Mg deficiencies in plants. Ca/Mn and Ca/Mg ratios should be kept in balance. The average ESP for the soils at the golf course is < 1.0 %. Therefore there is no risk of infiltration and nutrient imbalance problems resulting from existing exchangeable sodium ions in the soil.

2.4b Wastewater Remediation

Treated municipal wastewater 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).

2.5b Water Budget

A water budget for the landfill properties was calculated using methods established by EPA, 1981 and long term weather data as well as the simulation model DRAINMOD (Skaggs, 1978). A detailed hydrologic analysis can be found in Appendix D.

2.6b Hydraulic Loadings

Following a detailed hydrologic analysis, hydraulic loadings have been calculated for the landfill and adjoining properties (Table 3). The irrigation system currently in operation at the Johnston County Golf and Country Club irrigates approximately 64 acres of greens

and tees. The total area on the golf course is approximately 100 acres. An executive summary along with a detailed hydrologic report describing hydraulic loadings, irrigation scheduling, and related information can be found in Appendix D.

3.0b Environmental Effects

There are no adverse environmental effects from the implementation of this reuse system. The water used is very high quality and meets regulated levels of TSS, BOD, and other nutrients as well as federal shellfish coliform limits required for point source discharges. The use of this wastewater will ultimately increase soil fertility and productivity of the golf course turf grasses and will enhance adjacent wetlands and low lying areas with increased base flow. There will be no impacts to groundwater supplies or surface water supplies. The addition of water and nutrients to the site may indirectly benefit wildlife through increased biological activity in adjacent wetlands and low lying areas as well as the golf course fringes.

Bolton Jones Properties Tract 1

1.0C Site Description

The proposed wastewater reuse irrigation system site is located west of S.R 1341, southwest of the city of Smithfield in Johnston County, North Carolina and is located in the Upper Coastal Plain physiographic province (Figure 1). The project area consists of two sloping agricultural fields divided by a perennial stream. The soils present at the site are mapped as Wedowee in the upland areas and Bibb in the lowland stream divides. Vegetation consists of seasonal vegetation on the cropland with adjacent regenerating upland hardwood/pine forest. Surrounding properties have similar site characteristics.

1.1c Soil Analysis

The soils present on this property were investigated and verified with the USDA soil survey for Johnston County. A series of augerings were completed across the landscape to characterize the soils according to depth of horizons, the color of the soil material at each of the various depths, the texture, structure, and consistence of the soil material within each of the horizons (Appendix C – Soil Descriptions). The soils present were well drained with the exception of one area that contained Rains soil that was poorly drained.

A composite sample of the top 0-12 inches of soil representing the sprayable areas was collected and analyzed for nutrient composition (Table 7 – Soil Analysis). From these data, it is evident that the soils representing this site are quite low in nutrients such as potassium (K), calcium (Ca), and magnesium (Mg), and phosphorus (P). This conclusion is based on the potential crop response to particular nutrients if fertilizer is applied to the site. The pH is a little low as well as the base saturation (BS%). Optimum growing conditions for topsoil require a BS% of 60-80% of the cation exchange capacity (CEC). Addition of treated wastewater to this site will ultimately improve soil fertility and consequently the growing conditions and productivity of this site. However, additional fertilizer is recommended to maintain agricultural crops on this tract.

Table 8: Summary of Average Soil Fertility at the Proposed Bolton Jones Tract 1 Reclaimed Wastewater Receiver Site Johnston County, NC

Depth	pH	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	CEC [1]	BS% [2]
0-6 in.	4.3	8.4	23.5	137.8	25.8	5.3	17.0
6-12 in.	4.8	0.5	17.6	45.6	9.2	1.9	16.0

[1] 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.
[2] Base saturation – defined as the percentage of the CEC occupied by base cations

1.2c Wetlands, Streams, and Groundwater Wells

According to regulations (Section.0200 – Waste not discharged to surface waters) concerning reclaimed water systems using treated municipal effluent, irrigation spray shall not influence within 25 feet of surface waters not classified SA (shellfish waters), including jurisdictional wetlands. Under the same regulations, wastewater shall not influence areas within 100 feet of a water supply well and within 10 feet of nonpotable wells.

A field investigation was conducted to locate wetlands, streams, and drainage ways that need to be buffered by a 25 foot no spray zone (Appendix A – Site Investigation Map). This property revealed two areas requiring buffers. The stream dividing the properties is located > 25 feet from the spray influence edge. The ephemeral ditch/wetland contained within the field closest to S.R. 1341 will require a 25 foot buffer from the edge of the spray influence.

Approximately < 5% of this property acreage is wetlands, streams, and floodplains. No water supply wells and nonpotable wells were located on the property (Appendix A – Site Investigation Map).

All areas that had potential for spray influences were located, flagged, and mapped using GIS (Appendix A – Site Investigation Map).

2.0C Hydrology

2.1c Wastewater Characterization

The water proposed for this reuse system has undergone treatment via an activated sludge process which includes secondary treatment clarifiers to remove suspended solids from the liquid to improve the secondary effluent disinfection process and ultra violet disinfection to eliminate pathogens and other organisms. Overall, the treated wastewater has concentrations of nutrients, including nitrogen and phosphorus, which would not cause adverse environmental effects when land applied (Table 8).

Table 9: Wastewater Analysis (mg/L) at the Johnston County Wastewater Treatment Plant (August, 1999)

TSS	BOD	DO [1.]	$N\text{-}NH_3$ [2.]	Total P [3.]	Total N [4.]
6.0	3.0	5.49	.38	.58	6.6

1.] Dissolved oxygen
2.] Ammonia nitrogen
3.] Total inorganic and organic phosphorus
4.] Total inorganic and organic nitrogen

2.2c 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)

An SAR in excess of 10 is considered as an irrigation hazard and system operators must take special precautions to monitor salt levels of sodium in both irrigation water and soil. An SAR in excess of 7.5 is considered a mild irrigation hazard and 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 should be implemented.

The SAR of the Johnston County treated municipal wastewater is approximately **5.9**, which does not indicate a risk of developing soil infiltration problems and nutrient imbalances. However, levels of sodium in the wastewater and soil should be closely monitored. Actual sodium levels applied at the County landfill may vary. Additional sampling and monitoring of Na, Ca, and Mg in both wastewater and soils is recommended to ensure optimal performance of the proposed irrigation system. Periodic application of gypsum may be required as a corrective measure if the SAR is consistently above 10 Irrigation wastewater should have SAR values ≤ 10 to avoid potential salting problems in the soil.

2.3c 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 (North Carolina Agronomic Division – Soil Testing Indices)

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 manganese (Mn) & Mg deficiencies in plants. Ca/Mn and Ca/Mg ratios should be kept in balance. The average ESP for the soils at the Bolton Jones Tract 1 is < 1.0 %. Therefore there is no risk of infiltration and nutrient imbalance problems resulting from existing exchangeable sodium ions in the soil.

2.4c Wastewater Remediation

Treated municipal wastewater 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).

2.5c Water Budget

A water budget for the landfill properties was calculated using methods established by EPA, 1981 and long term weather data as well as the simulation model DRAINMOD (Skaggs, 1978). A detailed hydrologic analysis can be found in Appendix D.

2.6c Hydraulic Loading/Liquid Loadings

Following a detailed hydrologic analysis, hydraulic loadings have been calculated for the landfill and adjoining properties (Table 3). These areas are designated as BJT1F1 and BJT1F2. An executive summary along with a detailed hydrologic report describing hydraulic loadings, irrigation scheduling, and related information can be found in Appendix D.

3.0C Environmental Effects

There are no adverse environmental effects from the implementation of this reuse system. The water used is very high quality and meets regulated levels of TSS, BOD, and other nutrients as well as federal shellfish coliform limits required for point source discharges. The use of this wastewater will ultimately increase soil fertility and productivity of the agricultural fields and will enhance adjacent wetlands and low lying areas with increased base flow. There will be no impacts to groundwater supplies or surface water supplies. The addition of water and nutrients to the site may indirectly benefit wildlife through increased biological activity in adjacent wetlands and low lying areas as well as fringe areas.

Bolton Jones Properties Tract 2

1.0D Site Description

The proposed wastewater reuse irrigation system site is located west of S.R 1341, southwest of the city of Smithfield in Johnston County, North Carolina and is located in the Upper Coastal Plain physiographic province (Figure 1). The project area consists of one moderately sloping agricultural field adjacent to regenerating upland and bottomland forest. The soils present at the site are mapped as Varina, Goldsboro, and Rion in the upland areas and Bibb and Pantego in the lowland areas and stream divides. Vegetation consists of seasonal vegetation on the cropland with adjacent regenerating upland and bottomland hardwood/pine forest. Surrounding properties have similar site characteristics.

1.1d Soil Analysis

The soils present on this property were investigated and verified with the USDA soil survey for Johnston County. A series of augerings were completed across the landscape to characterize the soils according to depth of horizons, the color of the soil material at each of the various depths, the texture, structure, and consistence of the soil material within each of the horizons (Appendix C – Soil Descriptions). Soils present were well drained with the exception of one area that was poorly drained.

A composite sample of the top 8-12 inches of soil representing the sprayable areas was collected and analyzed for nutrient composition (Table 9 – Soil Analysis). From these data, it is evident that the soils representing this site are somewhat low in nutrients. The pH is also low as well as the base saturation (BS%) and cation exchange capacity (CEC). The addition of treated wastewater to this site will ultimately improve soil fertility and consequently the growing conditions and productivity of this site.

From these data, it is evident that the soils representing this site are quite low in nutrients such as potassium (K), calcium (Ca), and magnesium (Mg). This conclusion is based on the potential crop response to particular nutrients if fertilizer is applied to the site. The pH is adequate for plant growth and the base saturation (BS%) is a little low. Optimum growing conditions for topsoil require a BS% of 60-80% of the cation exchange capacity (CEC). Addition of treated wastewater to this site will ultimately improve soil fertility and consequently the growing conditions and productivity of this site.

Table 10: Summary of Average Soil Fertility at the Proposed Bolton Jones Tract 2 Reclaimed Wastewater Receiver Site Johnston County, NC							
Depth	pH	Phosphorus (ppm)	Potassium (ppm)	Calcium (ppm)	Magnesium (ppm)	CEC [1]	BS% [2]
0-6 in.	5.0	72.0	66.0	141.4	17.3	3.2	36.3
6-12 in.	5.4	27.6	76.7	156.3	44.4	2.5	48.5

[1] 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.
[2] Base saturation – defined as the percentage of the CEC occupied by base cations

1.2d Wetlands, Streams, and Groundwater Wells

According to regulations (Section.0200 – Waste not discharged to surface waters) concerning reclaimed water systems using treated municipal effluent, irrigation spray shall not influence within 25 feet of surface waters not classified SA (shellfish waters), including jurisdictional wetlands. Under the same regulations, wastewater shall not influence areas within 100 feet of a water supply well and within 10 feet of nonpotable wells.

A field investigation was conducted to locate wetlands, streams, and drainage ways that need to be buffered by a 25 foot no spray zone (Appendix A – Site Investigation Map). This property revealed no areas requiring buffers within the confines of the agricultural field. No water supply wells and nonpotable wells were located on the property (Appendix A – Site Investigation Map).

2.0D Hydrology

2.1d Wastewater Characterization

The water proposed for this reuse system has undergone treatment via an activated sludge process which includes secondary treatment clarifiers to remove suspended solids from the liquid to improve the secondary effluent disinfection process and ultra violet disinfection to eliminate pathogens and other organisms. Overall, the treated wastewater has concentrations of nutrients, including nitrogen and phosphorus, which would not cause adverse environmental effects when land applied (Table 10).

Table 11: Wastewater Analysis (mg/L) at the Johnston County Wastewater Treatment Plant (August, 1999)

TSS	BOD	DO [1.]	$N\text{-}NH_3$ [2.]	Total P [3.]	Total N [4.]
6.0	3.0	5.49	.38	.58	6.6

1.] Dissolved oxygen
2.] Ammonia nitrogen
3.] Total inorganic and organic phosphorus

4.] Total inorganic and organic nitrogen

2.2d 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:

$SAR = Na/(Ca/2 + Mg/2)^{1/2}$ (units in meq/L)

An SAR in excess of 10 is considered as an irrigation hazard and system operators must take special precautions to monitor salt levels of sodium in both irrigation water and soil. An SAR in excess of 7.5 is considered a mild irrigation hazard and 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 should be implemented.

The SAR of the Johnston County treated municipal wastewater is approximately **5.9**, which does not indicate a risk of developing soil infiltration problems and nutrient imbalances. However, levels of sodium in the wastewater and soil should be closely monitored. Actual sodium levels applied at the County landfill may vary. Additional sampling and monitoring of Na, Ca, and Mg in both wastewater and soils is recommended to ensure optimal performance of the proposed irrigation system. Periodic application of gypsum may be required as a corrective measure if the SAR is consistently above 10 Irrigation wastewater should have SAR values ≤ 10 to avoid potential salting problems in the soil.

2.3d 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 (North Carolina Agronomic Division – Soil Testing Indices)

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 manganese (Mn) & Mg deficiencies in plants. Ca/Mn and Ca/Mg ratios should be kept in balance. The average ESP for the soils at the Bolton Jones Tract 2 is < 1.0 %. Therefore there is no risk of infiltration and nutrient imbalance problems resulting from existing exchangeable sodium ions in the soil.

2.4d Wastewater Remediation

Treated municipal wastewater 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).

2.5d Water Budget

A water budget for the landfill properties was calculated using methods established by EPA, 1981 and long term weather data as well as the simulation model DRAINMOD (Skaggs, 1978). A detailed hydrologic analysis can be found in Appendix D.

2.6d Hydraulic Loading/Liquid Loadings

Following a detailed hydrologic analysis, hydraulic loadings have been calculated for the landfill and adjoining properties (Table 3). This area is designated as BJT2F1. An executive summary along with a detailed hydrologic report describing hydraulic loadings, irrigation scheduling, and related information can be found in Appendix D.

3.0D Environmental Effects

There are no adverse environmental effects from the implementation of this reuse system. The water used is very high quality and meets regulated levels of TSS, BOD, and other nutrients as well as federal shellfish coliform limits required for point source discharges. The use of this wastewater will ultimately increase soil fertility and productivity of the agricultural field and will enhance adjacent wetlands and low lying areas with increased base flow. There will be no impacts to groundwater supplies or surface water supplies. The addition of water and nutrients to the site may indirectly benefit wildlife through increased biological activity in adjacent wetlands and low lying areas as well as fringe areas.

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APPENDIX

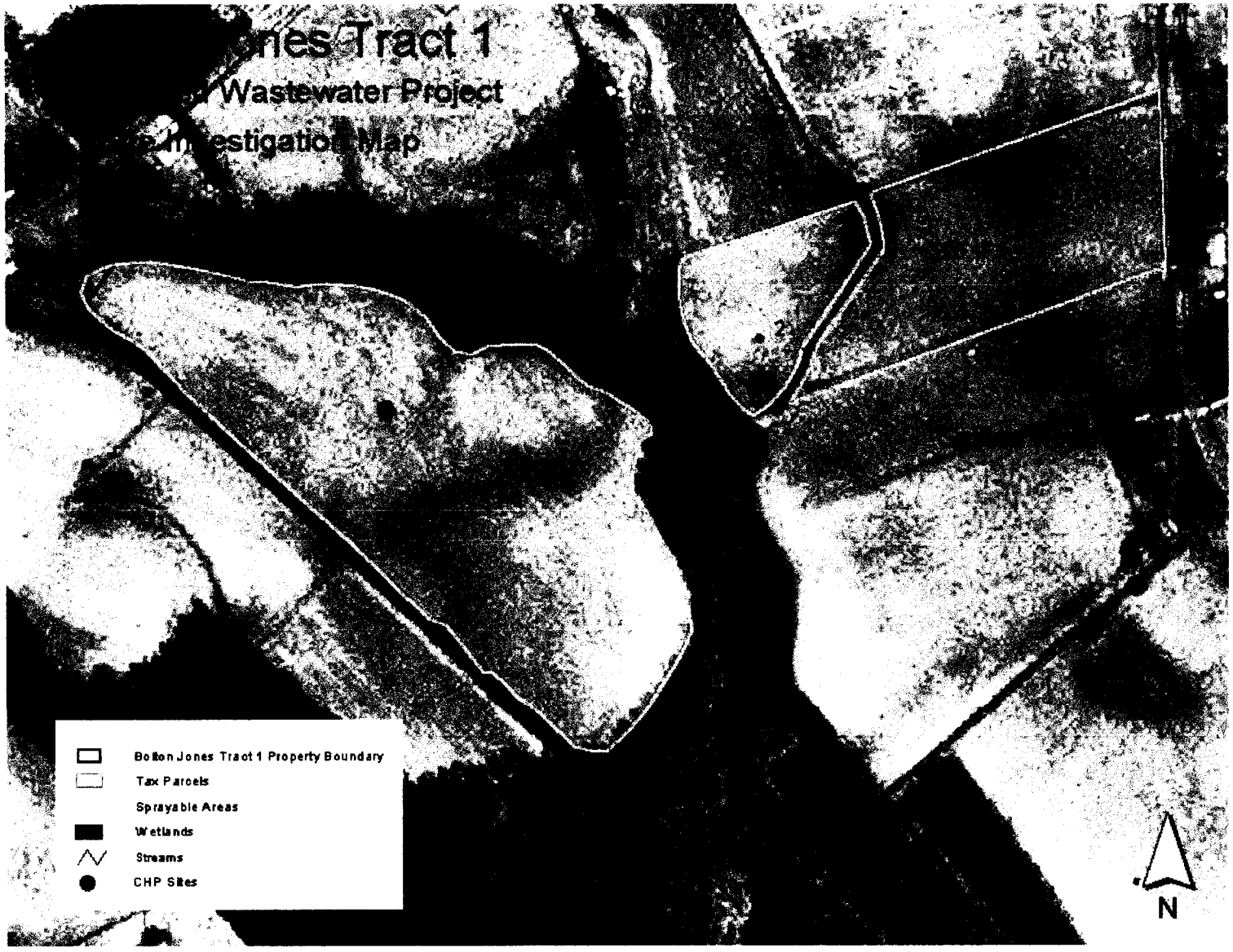
APPENDIX A

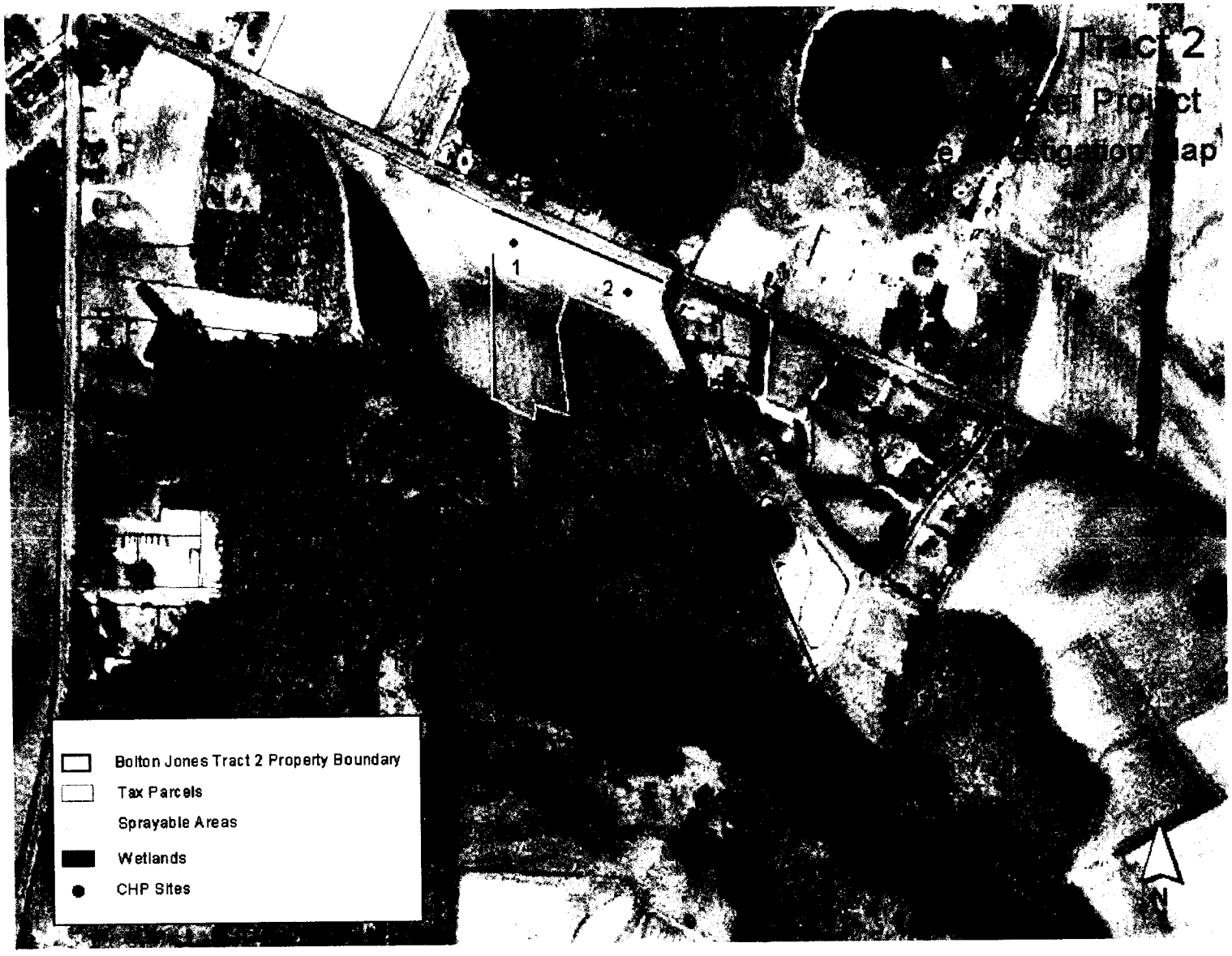
Site Investigation Maps

*GIS data provided by the Johnston County GIS Department and NCCGIA (2000)

Landfill Property
Tax Parcels
Sprayable Areas
Wetlands
Streams
Leachate Pond
CHP Sites

Golf Course Property Boundary
Tax Parcels
Streams
Wetlands
CHP Sites
Water Supply Wells
1
2
4
5
7

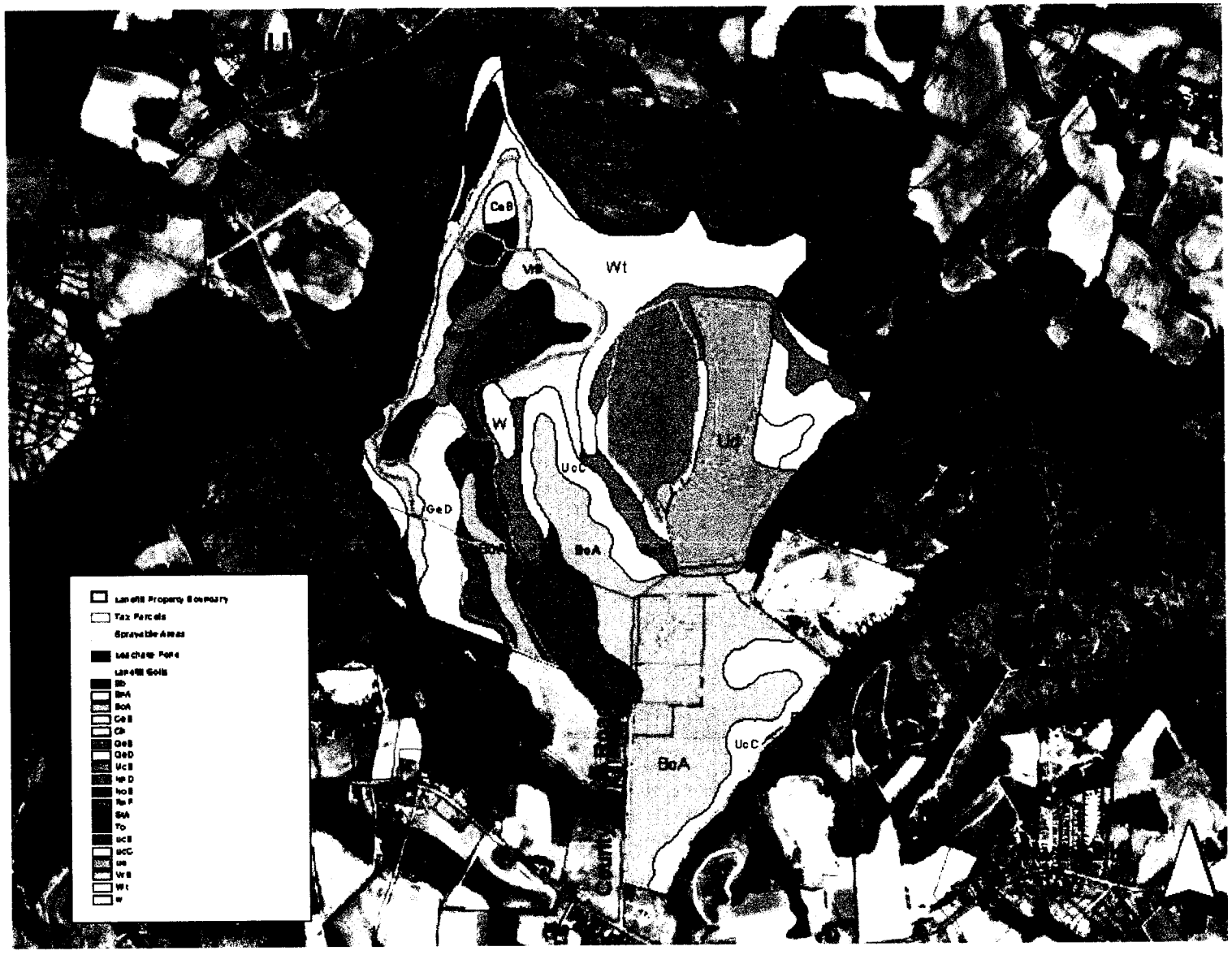

Bolton Jones Tract 1
Wastewater Project
Investigation Map
Bolton Jones Tract 1 Property Boundary
Tax Parcels
Sprayable Areas
Wetlands
Streams
CHP Sites
N


Tract 2
1
2
Bolton Jones Tract 2 Property Boundary
Tax Parcels
Sprayable Areas
Wetlands
CHP Sites
N

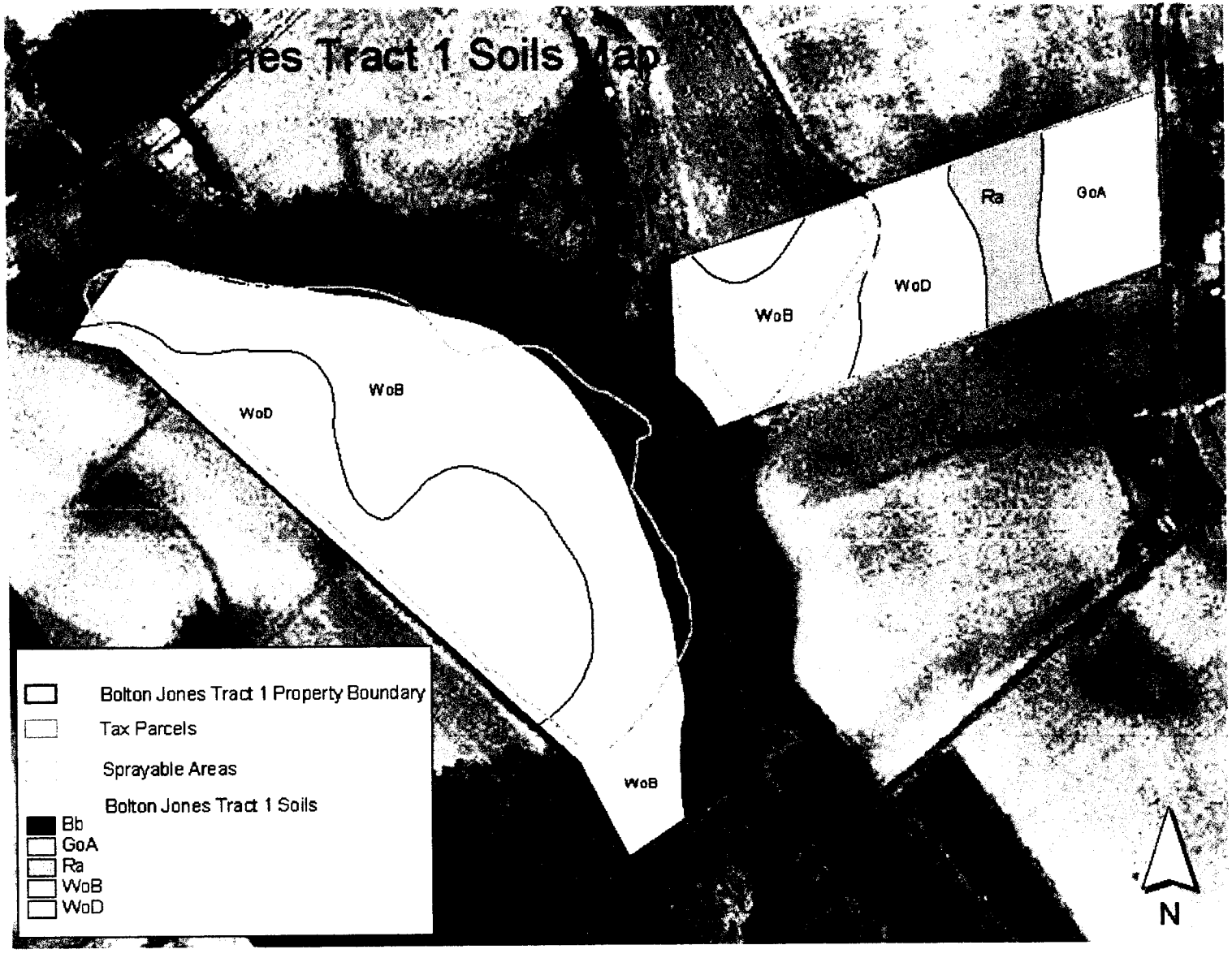
APPENDIX B

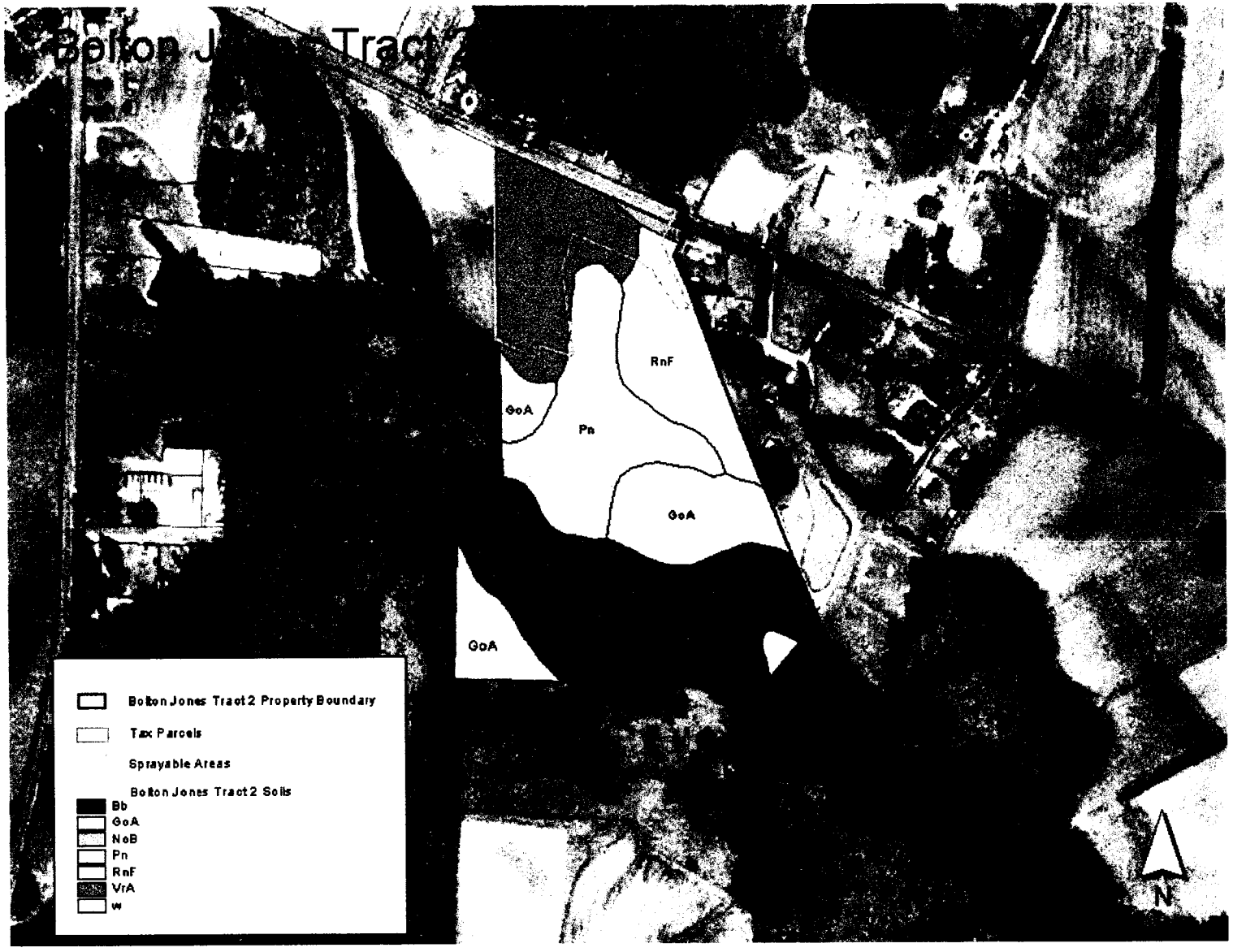
Soils Maps

*GIS data provided by the Johnston County GIS Department and NCCGIA (2000)


CaB
WB
Wt
W
UcC
GeD
BoA
BoA
UcC
Landfill Property Boundary
Tax Parcels
Sprayable Areas
Leachate Point
Landfill Soils

FaA
NoB
GoA
GoA
GoA
Golf Course Property Boundary
Tax Parcels
Golf Course Soils


nes Tract 1 Soils Map
WoB
WoD
Ra
GoA
WoB
WoD
WoB
Bolton Jones Tract 1 Property Boundary
Tax Parcels
Sprayable Areas
Bolton Jones Tract 1 Soils
Bb
GoA
Ra
WoB
WoD
N


Bolton Jones Tract 2 Property Boundary
Tax Parcels
Sprayable Areas
Bolton Jones Tract 2 Soils
Bb
GoA
NoB
Pn
RnF
VrA
W
RnF
GoA
Pn
GoA
GoA
N

APPENDIX C

Soils Descriptions

Bolton Jones Tract 1

Johnston County - Profile 1- #1 Ag Field

Ap 0-9 inches; dark grayish brown (10YR 4/2) sand, friable, subangular blocky structure.

Bt1 9-14 inches; yellowish brown (10YR 5/6) sandy clay loam, friable, subangular blocky structure.

Bt2 14-21 inches; strong brown (7.5YR 5/6) sandy clay with common distinct yellowish red (5YR 5/8) concentrations; firm, subangular blocky structure.

Bt3 21-29 strong brown (7.5YR 5/6) sandy clay loam with common distinct yellowish red (5YR 5/8) concentrations; firm, subangular blocky structure.

BC 29-40 strong brown (7.5YR 5/6) sandy clay loam with common distinct yellowish brown (10YR 5/6) concentrations; friable, subangular blocky structure.

CB 40-46+ inches; strong brown (7.5YR 5/6) sandy clay loam with common distinct red (10R 4/6) concentrations; friable, subangular blocky structure.

Soil Series: Wedowee (WoB, WoD)
Landscape: Piedmont
Landform: Ridge
Landform Position: Summit, side slope
Parent Material: Residuum
Drainage Class: Well
Mineralogy: Kaolinitic
Particle Size Class: clayey
Temperature Regime: thermic
Subgroup Classification: Typic Kanhapludult
Slope: 2 %
Examination Method: auger boring
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

SIMILAR PROFILES: Ag field #1 – rear; (2)

Bolton Jones Tract 2

Johnston County - Profile 3 – Ag Field #2

Ap 0-9 inches; very dark grayish brown (10YR 3/2) sandy loam, friable, granular structure.

E 9-16 inches; pale brown (10YR 6/3) sandy loam, friable, subangular blocky structure.

Bt1 16-23 inches; light yellowish brown (10YR 6/4) sandy loam, friable, subangular blocky structure.

Bt2 23-30 inches; yellowish brown (10YR 5/6) sandy clay firm, subangular blocky structure.

Bt3 30-38 strong brown (7.5YR 5/6) sandy clay loam with common distinct yellowish red (5YR 5/8) concentrations; firm, subangular blocky structure.

Btv1 38-46+ strong brown (7.5YR 5/6) sandy clay loam, firm, subangular blocky structure; approximately 30% plintite.

Soil Series: Varina (VrA)
Landscape: Coastal Plain
Landform: Marine Terrace
Parent Material: Marine Sediments
Drainage Class: Well
Particle Size Class: clayey
Mineralogy: Kaolinitic
Temperature Regime: thermic
Subgroup Classification: Plinthic paleudults
Slope: 3%
Examination Method: auger boring
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

SIMILAR PROFILES: Back side Ag field #2; (5)

Johnston County - Profile 4 – Drainage Swale Ag Field #2

Ap 0-11 inches; very dark gray (10YR 3/1) sandy loam, friable granular structure.

AE 11-20 inches; very dark gray (10YR 3/1) sandy loam, friable subangular structure.

Btg1 20-27 inches; grayish brown (10YR 5/2) fine sandy loam, friable subangular structure.

Btg2 27-36+ inches; brown (7.5YR 4/3) sandy loam, friable subangular structure.

Soil Series: Pantego (Pn)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Very poorly
Particle Size Class: Fine loamy
Temperature Regime: thermic
Subgroup Classification: Umbric paleaquult
Slope: 0%
Examination Method: auger boring
Depth to Water: 2 inches
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County - Profile 6 – Upper End Ag. Field #2

Ap 0-10 inches; dark grayish brown (2.5YR 4/2) sandy loam, friable granular structure.

Bt1 10-21 inches; yellowish brown (10YR 5/6) sandy clay loam, firm subangular blocky structure.

BC 21-31 inches; yellowish brown (10YR 5/6) sandy clay loam, friable subangular blocky structure.

CB 31-40+ inches; brown (10YR 5/3) sandy loam with common distinct yellowish brown (10YR 5/6) and common prominent yellowish red (5YR 5/6) concentrations, friable subangular structure.

Soil Series: Rion (RnF)
Landscape: Piedmont
Landform: Ridge
Landform Position: Summit, side slope
Parent Material: Residuum
Drainage Class: Well
Particle Size Class: Fine loamy
Mineralogy: Mixed
Temperature Regime: thermic
Subgroup Classification: Typic hapludult
Slope: 2 %
Examination Method: auger boring
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County Landfill

Johnston County - Profile 7 – NC Forestry Tract

Ap 0-8 inches; dark gray (10YR 4/1) sandy loam; friable, granular structure.

E 8-12 inches; light yellowish brown (2.5Y 6/3) sandy loam; friable, subangular blocky structure.

Bt1 12-17 inches; light yellowish brown (2.5Y 6/3) sandy loam; friable, subangular blocky structure.

Bt2 17-26 inches; light yellowish brown (10YR 6/4) sandy clay loam; firm, subangular blocky structure.

Bt3 26-35 inches; brownish yellow (10YR 6/6) sandy clay loam with common faint light yellowish brown (10YR 6/4) depletions; firm, subangular blocky structure.

Bt4 35-44+ inches; light yellowish brown (10YR 6/4) sandy clay loam with common distinct yellowish brown (10YR 5/8) concentrations, firm, subangular blocky structure.

Soil Series: Wagram (WaB)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Well
Particle Size Class: Loamy
Temperature Regime: thermic
Mineralogy: siliceous
Subgroup Classification: Arenic Kandiudult
Slope: 2%
Examination Method: auger boring
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

SIMILAR PROFILES: Upper portion of loblolly/slash pine tract; (7, 14)

Johnston County - Profile 8 – NC Forestry Tract

Ap 0-11 inches; olive brown (2.5Y 4/3) sandy loam; friable, subangular blocky structure.

E 11-24 inches; light yellowish brown (2.5Y 6/3) sandy loam; friable, subangular blocky structure.

Bt1 24-39 inches; light yellowish brown (2.5Y 6/4) sandy loam; friable, subangular blocky structure.

Bt2 39-44+ inches; olive yellowish (2.5Y 6/6) sandy loam with common faint light yellowish brown depletions; friable, subangular blocky structure.

Soil Series: Bonneau (BoA)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Somewhat Excessively to Well
Particle Size Class: Loamy
Temperature Regime: thermic
Mineralogy: siliceous
Subgroup Classification: Arenic Paleudult
Examination Method: auger boring
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

SIMILAR PROFILES: Upper portion of loblolly/slash pine tract; (9, 10)

Johnston County - Profile 12 – Northeast Borrow Pit Wall

Ap 0-9 inches; dark grayish brown (2.5Y 4/2) loamy sand, very friable, granular structure.

E 9-26 inches; yellowish brown (10YR 5/6) loamy sand, very friable, granular structure.

Bt 26-66 inches; reddish yellow (7.5YR 6/6) loamy sand, very friable, subangular blocky structure.

Bv 66-72+ inches; reddish yellow (7.5YR 6/6) loamy sand, friable, subangular blocky structure; approximately 35% plinthite.

Soil Series: Varina (VrA)
Landscape: Coastal Plain
Landform: Marine Terrace
Parent Material: Marine Sediments
Drainage Class: Well
Particle Size Class: clayey
Mineralogy: Kaolinitic
Temperature Regime: thermic
Subgroup Classification: Plinthic paleudults
Examination Method: auger boring and cut bank
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County - Profile 13 – Loblolly tract – NE Corner Borrow Pit

A 0-12 inches; light yellowish brown (2.5YR 6/3) sandy loam, very friable, subangular blocky structure.

Bw1 12-20 inches; light yellowish brown (2.5YR 6/4) sandy loam, very friable, subangular blocky structure.

Bw2 20-28 inches; light yellowish brown (2.5YR 6/4) gravelly sandy loam, very friable, subangular blocky structure.

2C 28-72+ inches; multicolored saprolite that crushes to silty clay, massive, common sand lenses throughout.

Soil Series: Cowarts Variant (CoB)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Moderately Well to Somewhat Poorly
Particle Size Class: Fine Loamy
Temperature Regime: thermic
Mineralogy: siliceous
Subgroup Classification: Typic Kanhapludult
Examination Method: auger boring
Date: August 5, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County Golf & Country Club

Johnston County Country Club - Profile 1- Driving Range

A 0-2 inches; grayish brown (10YR 5/2) loamy sand, very friable, granular structure.

EB 2-14 inches; light yellowish brown (10YR 6/4) sandy loam, friable, subangular blocky structure.

Bt1 14-21 inches; strong brown (7.5YR 5/6) sandy clay loam; friable, subangular blocky structure.

Bt2 21-26 inches; strong brown (7.5YR 5/6) clay loam with common distinct light olive brown (2.5Y 5/6) depletions; friable, subangular blocky structure.

BC 26-35 strong brown (7.5YR 5/6) sandy clay loam with common distinct light olive brown (2.5Y 5/6) and common distinct gray (7.5YR 6/1) depletions; firm, subangular blocky structure.

CB 35-44+ inches; strong brown (7.5YR 5/6) sandy clay loam with common distinct light olive brown (2.5Y 5/6) and common distinct gray (7.5YR 6/1) depletions; friable, subangular blocky structure.

Soil Series: State (StA)
Landscape: Coastal Plain
Landform: Stream terrace, Marine terrace
Parent Material: Alluvial, fluvial sediments, Marine sediments
Drainage Class: Well
Particle Size Class: Fine loamy
Temperature Regime: thermic
Mineralogy: mixed
Subgroup Classification: Typic Hapludult
Slope: 4 %
Examination Method: auger boring
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

SIMILAR PROFILES: Fairway #1; Tee Box # 1; (P10, P11)

Johnston County Country Club - Profile 2 – Southside Fairway #18

A 0-2 inches; very dark grayish brown (10YR 3/2) sandy loam, friable granular structure.

EB 2-7 inches; yellowish brown (10YR 5/6) sandy loam, friable subangular blocky structure.

2C1 7-18 inches; very pale brown (10YR 7/3) silt with many distinct brownish yellow (10YR 5/6) concentrations; friable, angular blocky structure.

2C2 18-44+ inches; very pale brown (10YR 7/3) silt with many distinct brownish yellow (10YR 5/6) and few prominent yellowish red (5YR 5/8) concentrations; friable, angular blocky structure.

Soil Series: Nason Variant (NnB)
Landscape: Piedmont
Landform: Ridge
Landform Position: Summit, side slope
Parent Material: Residuum
Drainage Class: Well
Particle Size Class: Clayey
Mineralogy: Mixed
Temperature Regime: thermic
Subgroup Classification: Typic hapludult
Slope: 2 %
Examination Method: auger boring
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County Country Club - Profile 3 – Tee Box #9

AE 0-11 inches; very dark gray (10YR 3/1) sandy loam, friable subangular blocky structure.

Btg1 11-22 inches; very dark gray (2.5Y 3/1) sandy loam, friable subangular blocky structure.

Btg2 22-36+ inches; dark gray (2.5Y 4/1) sandy clay loam, friable subangular structure.

Soil Series: Pantego (Pn)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Very poorly
Particle Size Class: Fine loamy
Temperature Regime: thermic
Subgroup Classification: Umbric paleaquult
Slope: 0%
Examination Method: auger boring
Depth to Water: 2 inches
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County Country Club - Profile 4 – Sideslope #11

A 0 to 4 inches; brown (10YR 5/3) loamy sand; very friable, subangular blocky structure.

AE 4-11 inches; light yellowish brown (2.5Y 6/4) loamy sand; very friable, subangular blocky structure.

E1 11-20 inches; pale yellow (2.5Y 7/3) loamy sand; very friable, subangular blocky structure.

E2 20-31 inches; pale yellow (2.5Y 7/4) loamy sand; very friable, subangular blocky structure.

Bt1 31-40 inches; pale yellow (2.5Y 7/4) sandy loam; friable, subangular blocky structure.

Bt2 40-46+ inches; reddish yellow (7.5YR 6/6) sandy loam with few distinct yellowish red concentrations (5YR 5/6); friable, subangular blocky structure.

Soil Series: Blanton (BnA)
Landscape: Coastal Plain
Landform: Marine terrace, Stream terrace (NONE or RARE)
Parent Material: Marine sediments
Drainage Class: Somewhat Excessive to Moderately Well
Particle Size Class: Loamy
Temperature Regime: thermic
Subgroup Classification: Grossarenic Paleudult
Examination Method: auger boring
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood.

SIMILAR PROFILES: Tee Box #12;(6)

Johnston County Country Club - Profile 5 – Maintenance Shack

A 0 to 4 inches; very dark brown (10YR 3/1) loamy sand; very friable, granular structure.

E 4-13 inches; yellowish brown (10YR 5/4) loamy sand; very friable, subangular blocky structure.

Bt1 13-18 inches; strong brown (7.5YR 5/6) sandy clay loam; firm, subangular blocky structure.

Bt2 18-36 inches; strong brown (7.5YR 5/6) sandy clay with common faint brown (7.5YR 5/4) depletions; firm, subangular blocky structure.

Bt3 40-46+ inches; brown (7.5YR 5/4) sandy clay loam with many red (2.5YR 5/8) concentrations; friable, subangular blocky structure.

Soil Series: Norfolk (NoA)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Well
Particle Size Class: Fine loamy
Temperature Regime: thermic
Subgroup Classification: Typic Kandiudult
Examination Method: auger boring
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

SIMILAR PROFILES: Ladies Tee Box #5; (8)

Johnston County Country Club - Profile 7 – Tee Box #7

A 0 to 2 inches; very dark grayish brown (10YR 3/2) sandy loam; friable, granular structure.

EB 2-7 inches; yellowish brown (10YR 5/4) sandy loam; friable, granular structure.

Bt1 7-13 inches; strong brown (7.5YR 5/8) sandy loam; friable, subangular blocky structure.

Bt2 13-30 inches; yellowish red (5YR 5/8) sandy loam; firm in place, friable out, subangular blocky structure.

Bt3 30-40+ inches; red (2.5YR 5/8) sandy loam; firm in place, friable out, subangular blocky structure.

Soil Series: Faceville Variant (FaA)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Well
Particle Size Class: Clayey
Mineralogy: Kaolinitic
Temperature Regime: thermic
Subgroup Classification: Typic Kandiudult
Examination Method: auger boring
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

Johnston County Country Club - Profile 9 – Fairway #2

A 0 to 6 inches; olive brown (2.5Y 4/3) sandy loam; very friable granular structure.

E 6-17 inches; light yellowish brown (2.5Y 6/3) sandy loam; very friable, subangular blocky structure.

Bt1 17-26 inches; light yellowish brown (2.5Y 6/3) gravelly sandy loam; very friable, subangular blocky structure.

Bt2 26-38+ inches; brownish yellow (10YR 6/6) loam with many distinct very pale brown (10YR 7/3) depletions; very friable, subangular blocky structure.

Soil Series: Goldsboro (GoA)
Landscape: Coastal Plain
Landform: Marine terrace
Parent Material: Marine sediments
Drainage Class: Moderately Well
Particle Size Class: Fine-loamy
Mineralogy: Siliceous
Temperature Regime: thermic
Subgroup Classification: Aquic Paleudult
Examination Method: auger boring
Date: August 19, 2000
Weather: Partly sunny
Investigators: Dave Meyer and Michael Wood

APPENDIX D

Hydrological Report

- Dr. Robert Evans -
Biological and Agricultural Engineering Department
N.C. State University

Hydrologic Wastewater Reuse Irrigation Analysis for Johnston County

Phase I

Robert O. Evans, PhD, PE
Biological and Agricultural Engineering
North Carolina State University

December 4, 2000

Executive Summary

The amount of treated wastewater that can be applied to a field depends on many factors including hydraulic properties of the soil, groundwater flow processes, amount of soil cover, slope, antecedent moisture at the onset of wastewater application, evapotranspiration, rainfall, and rate of irrigation application. Irrigation system design and development of an effective irrigation plan need to consider these hydrologic factors on a field by field, crop by crop basis.

A detailed hydrologic analysis, based on a continuous long-term water balance was conducted using the water management simulation model DRAINMOD (Skaggs, 1978) for the fields identified to receive treated wastewater during Phase I of the Johnston County Wastewater Reuse Project. The simulation inputs were either measured *in situ*; determined from the Johnston county soil survey report (NRCS, 1994); or calibrated by comparing several output hydrologic parameters to published values (water table depth (Daniels et al., 1987), soil color (Vepraskas et al. (2000), and seepage rates established by EPA (1981) or estimated by USGS (Heath, 1980). The hydrologic analysis was performed for the Johnston County Golf Course, Johnston county landfill and neighboring lands owned by Johnston county, and two nearby privately owned farms. Hydrologic parameters evaluated included short and long term irrigation rates and annual amounts, surface runoff, drainage, vertical and lateral seepage. Applications rates were determined that satisfy runoff and percolation constraints established by EPA and also maintain suitable root zone aeration for crop growth.

Irrigation amounts were determined and are reported in Table ES.1 for a range of climatic conditions including wet, average, and dry year rainfall amounts. It is recommended that the irrigation system(s) should be designed with the capacity to apply no less than the annual reuse volume associated with the 20 percentile annual rainfall. That is, the irrigation system should have the capacity to apply the design annual irrigation amount during a dry year (irrigation requirements would be satisfied 4 out of 5 years). This is the design criteria normally utilized for agricultural applications. It is further recommended that the irrigation permit capacity for each site (annual basis) be based on the driest year of record. Since this will be a conjunctive use permit, it should not be necessary to satisfy EPA dedicated site design criteria based on the wet year rainfall amount (10 year recurrence interval). Monthly irrigation amounts are given for each field and cropping scenario in the Tables 8-16.

Table ES.1 Recommended design and permitted annual irrigation amounts.

Field	Vegation	Irrigation Window	Driest YR Permit Amount	10 %tile	20 %tile Minimum Design Amount	Average (2 RYI)	80 %tile (5 YRI)	90 %tile (10 YRI)	Wettest (46 YRI)
			All values in centimeters per year						
LF1	Trees	A1S30	**77.5**	68.0	**64.3**	53.6	43.5	41.6	35.9
		J1D31	**90.7**	81.3	**77.5**	66.3	56.7	52.9	49.1
LF2	BG/nos	A1S30	**76.9**	69.3	**66.8**	58.2	51.7	49.1	39.1
	BG/wos	F1D15	**97.0**	93.2	**85.7**	74.7	66.8	60.5	56.7
	Trees	A1S30	**88.8**	79.4	**73.7**	63.8	54.8	52.9	41.6
	Trees	J1D31	**109.6**	98.3	**92.6**	80.3	69.9	68.0	60.5
LF3	Trees	A1S30	**64.3**	54.8	**49.1**	41.6	34.0	30.2	24.6
Borrow Pit	Trees	J1D31	**73.7**	66.2	**58.6**	49.1	41.6	37.8	32.1
LF4	Trees	A1S30	**77.5**	71.8	**64.3**	55.9	47.3	45.4	35.9
	Trees	J1D31	**92.6**	85.1	**79.4**	69.4	60.5	54.8	51.0
LF cap 1	mixed grass	A1S30	**36.5**	29.0	**26.5**	17.8	10.1	7.6	5.0
LF cap 3	mixed grass	A1S30	**35.3**	27.7	**26.5**	17.2	11.3	7.6	6.3
LF cap 4	mixed grass	A1S30	**36.5**	30.2	**26.5**	18.0	10.1	7.6	5.0
JCCC	BG	A1S30	**69.3**	64.8	**60.3**	54.4	47.7	46.7	39.2
	BG/wos	F1D15	**88.2**	82.8	**81.5**	69.2	62.6	57.6	56.3
	Greens	J1D31	**105.3**	103.5	**102.0**	99.1	97.2	96.6	94.2
BJT1F1	Corn	J1A31	**35.3**	27.7	**20.2**	15.1	8.8	6.3	2.5
	Soybean	J1O15	**30.2**	21.4	**18.9**	11.5	5.0	2.5	0.0
	Corn/Wheat	J1D15	**32.8**	26.5	**21.4**	14.0	6.3	3.8	1.3
	Wheat/Soy	F1O15	**40.3**	30.2	**26.5**	18.1	11.3	10.1	2.5
BJT1F2	Corn	J1A31	**37.8**	32.8	**26.5**	19.5	12.6	10.1	2.5
	Soybean	J1O15	**37.8**	27.7	**25.2**	16.4	10.1	5.0	2.5
	Corn/Wheat	J1D15	**46.6**	36.5	**35.2**	24.5	17.6	13.9	2.5
	Wheat/Soy	F1O15	**42.8**	35.3	**31.5**	19.9	10.1	6.3	1.3
BJT2F1	Corn	J1A31	**42.8**	37.8	**31.5**	23.3	16.4	13.9	2.5
	Soybean	J1O15	**37.8**	60.2	**27.7**	18.1	12.6	7.6	1.3
	Corn/Wheat	J1D15	**52.9**	44.1	**40.3**	29.8	22.7	18.9	3.9
	Wheat/Soy	F1O15	**49.1**	42.8	**35.3**	24.1	15.1	12.6	5.0

BG/nos = bermudagrass with no overseed, BG/wos = bermudagrass with winter overseed
A1S30 = irrigation window beginning April 1 and ending September 30.

Hydrologic Wastewater Reuse Irrigation Analysis for Johnston County

Phase I

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The amount of treated wastewater that can be applied to a field depends on many factors including hydraulic properties of the soil, groundwater flow processes, amount of soil cover, slope, antecedent moisture at the onset of wastewater application, evapotranspiration, rainfall, and rate of irrigation application. Irrigation system design and development of an effective irrigation plan need to consider these hydrologic factors on a field by field, crop by crop basis.

Introduction

EPA (1981) has recommended procedures for the hydrologic evaluation and design of land based municipal wastewater treatment systems. Procedures relevant to wastewater reuse through spray irrigation are covered in Chapter 4 of the EPA Process Design Manual (EPA, 1981). The EPA recommended procedures relevant to the hydrologic analysis presented herein are described in Section 4.5 "Loading rates and land area requirements" of the EPA design manual. EPA recommendations for determining hydraulic loading rates are based on conducting a monthly water balance for the land application site, considering three major components of the hydrologic cyclic - precipitation, evapotranspiration, and percolation. The basic water balance equation is

$$L_w = ET - P_r + P_w$$

Where L_w is the hydraulic loading rate, Et is evapotranspiration rate, Pr is precipitation rate, and Pw is the percolation rate.

NOAA precipitation records are available for more than 100 locations across North Carolina. Long term potential evapotranspiration (PET) estimates are also available. These have been obtained by either direct measurements of pan evaporation; simple empirical mathematical equations such as those developed by Thornthwaite (1948), Blaney Criddle (1950), Hargreaves-Samani (1982, 1985); or complex methods based on physical processes such as Penman-Monteith (1964). Estimates of deep percolation are more difficult to obtain and are influenced by soil hydraulic properties, presence and location of restrictive horizons, hydraulic gradients, and regional groundwater sources and sinks. EPA recommends estimating the percolation rate as 4 to 10 percent of the permeability of the most restrictive soil horizon.

Many land application systems have been permitted where the design hydraulic loading rate was determined using long term average weather records. Unfortunately, precipitation is rarely average. It varies from day to day and from year to year. As a result, application amounts based on long term monthly average rainfall may exceed the soil's storage and infiltration capacity during wetter than average periods resulting in direct runoff or excessive seepage. To account for periods with above average rainfall, EPA recommends using a 10 year recurrence interval value for the design precipitation rate.

In recent years, simulation models have been developed that allow simultaneous consideration of many hydraulic and hydrologic factors that affect water storage and movement in soil. These simulation models can be used to evaluate extreme weather patterns and determine not only average irrigation amounts but also the frequency and duration of periods when conditions are too wet to allow irrigation.

A detailed hydrologic analysis, based on a continuous long-term water balance was conducted using a simulation modeling approach for the fields identified to receive treated wastewater during Phase I of the Johnston County Wastewater Reuse Project. The hydrologic analysis was performed for the Johnston County Golf Course, Johnston county land fill and neighboring lands owned by Johnston county, and two nearby privately owned farms. Hydrologic parameters evaluated included short and long term irrigation rates and amounts, surface runoff, drainage, and seepage. Application rates were determined that satisfy runoff and percolation constraints established by EPA but also maintain suitable root zone aeration for crop growth.

Background

The water management simulation model DRAINMOD (Skaggs, 1978) is a computer program which can be used to predict or simulate the hydrology of a site based on hour-by-hour, day-by-day long term historical climate data. In DRAINMOD, the water table position and soil water regime above it is tracked in response to rainfall, evapotranspiration, given intensities of surface and subsurface drainage, seepage, and sprinkler irrigation. The sprinkler irrigation component was developed so that it can be used to simulate land application of a given amount of wastewater on a preset frequency with each irrigation dependent on soil water and weather conditions at the scheduled time of application. The model was developed for use in relatively flat soils with a shallow water table and has been extensively tested against field data collected under this condition.

Application of DRAINMOD to Well Drained Soil Conditions

DRAINMOD has also been tested with satisfactory results in arid regions of the U.S. under "well drained" soil conditions with high rates of irrigations. Large amounts of irrigation on well drained soils often lead to shallow water table conditions. Daniels et al (1987) reported monthly water table depths based on field measurements for several soils throughout eastern North Carolina. Their data were collected for soil types ranging from poorly drained to excessively drained. They reported values for several sites mapped as Norfolk. The Norfolk series is widespread in Johnston county; and, hydraulically represents the middle of the range of soil drainage classes found in the proposed land application area. Daniels applied statistical procedures to relate water table depth to extremes in monthly precipitation. Using rainfall records near the sites where Daniels obtained field data for the well drained Norfolk series, DRAINMOD simulations were run and compared to the results reported by Daniels (Evans, unpublished results). DRAINMOD input parameters for the Norfolk series were obtained from published soil survey reports. Seepage parameters were adjusted to obtain the best fit of the observed data. These comparisons are shown in Figure 1. There is good agreement between the observed and predicted monthly water table depths for a "wet", "dry" and "average" rainfall year. Note that both observed and predicted water table depths ranged from near the soil surface, a wet

condition, to more than 2 meters deep, a well drained condition.

Application of the DRAINMOD model to well drained soils extends the model's use beyond those conditions for which it has been extensively field tested. However, by exercising careful attention to input parameters as demonstrated in the Norfolk example, especially parameters used to predict vertical and lateral groundwater seepage, the model can be used to simulate the hydrology of well drained soils and is particularly useful for evaluating wastewater irrigation.

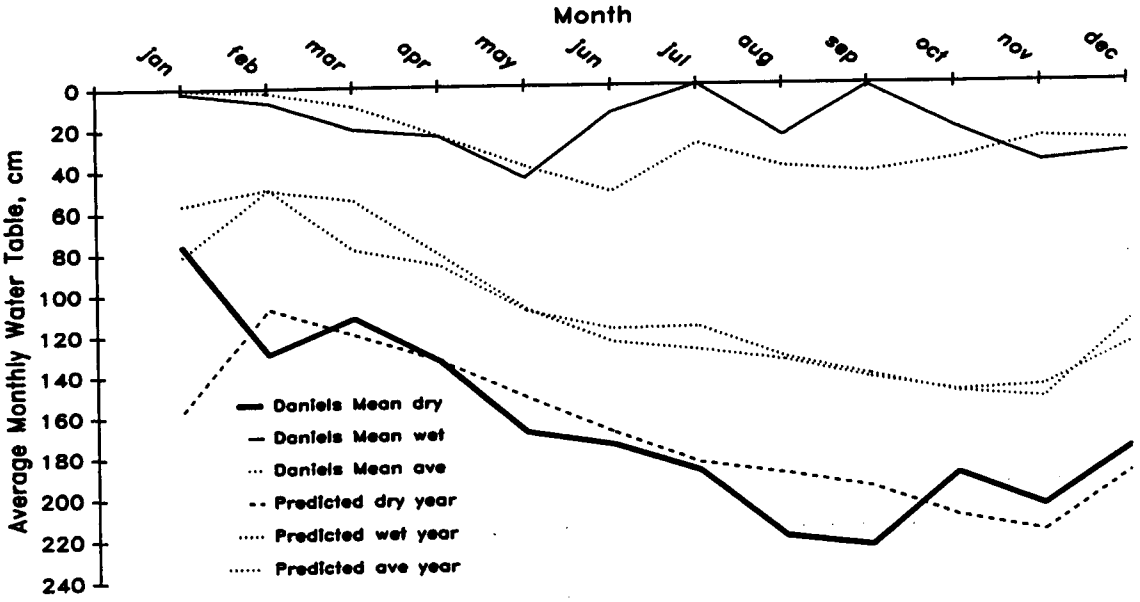

Figure 1 Comparison between observed water table depths for Norfolk series and values simulated with DRAINMOD. Observed values from Daniels et al., 1987.

Soils and Drainage Class

Soils are mapped and grouped into drainage classes often based on indirect measures of wetness, most notably the presence of 2 chroma gray mottles. For Coastal Plain mineral soils, a well drained designation indicates no evidence of 2 chroma mottles within 36 inches of the soil surface. In the moderately well drained class, gray mottles are found between 18 and 36 inches from the surface, and in somewhat poorly drained, 2 chroma mottles first appear between 10 and 18 inches. Most of the soils identified to receive reuse water in Phase I are classified in the Johnston County Soil Survey as well drained. This is further verified by the absence of 2 chroma mottles within 36 inches of the soil surface in the soil descriptions given Appendix B.

Vepraskas et al. (1997-2000, unpublished data) have conducted field studies to correlate the occurrence of gray mottles with the duration and frequency of soil saturation. Soils included in their study range from poorly drained to moderately well drained. They have observed strong correlation between the occurrence of gray mottles (2 or 3 chroma) and saturation duration in excess of 21 consecutive days occurring at least once during the year in at least 50 percent of years. Where gray mottles were present, they observed the soil to become saturated at the mottled depth for at least 21 consecutive days every other year on average. In other words, if gray mottles

were absent at a given depth, a water table was rarely present for 21or more consecutive days. More frequent periods of saturation or saturation of longer duration was correlated to a larger proportion of the soil matrix having a gray color.

The above observations provide a procedure based on fundamental soil morphology for verifying hydrologic simulation models. For example, DRAINMOD predicts the water table depth on a day to day basis, so it is relatively easy to compute the saturation duration and frequency from the water table predictions. Figure 2 summarizes the number of times saturation occurred for 21 days or longer at a depth of 36 inches for a 46 year simulation. The water table was higher than 36 inches for 21 consecutive days during 18 of the 46 years. Thus, this site did not satisfy the water table frequency criteria (> 50% of years) identified by Vepraskas at the 36 inch depth, and therefore, the hydrologic results suggest a well drained soil analogous to the absence of gray mottles within 36 inches when using soil morphology criteria.

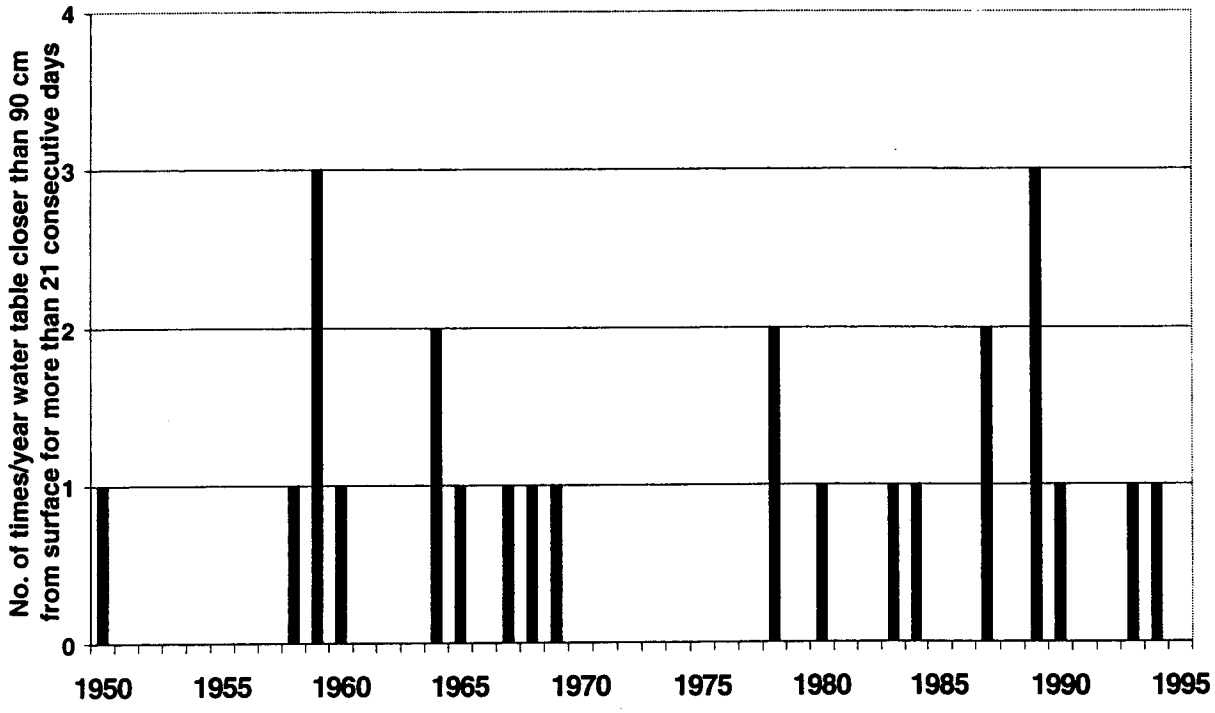

Figure 2 Annual frequency of the water table encroaching within 36 inches (90 cm) of the soil surface for 21 or more consecutive days. 18 of 46 years is less than 50 percent of the time.

Surface Runoff and Seepage

Rainfall exceeds evaporation by 12 to 15 inches in eastern North Carolina; yet, surface runoff from deep, well drained coastal plain soils with sandy loam surface textures is small. Thus, for a soil to be classified as well drained, internal drainage processes must be adequate to remove the excess water in a timely manner (within 21 days at a given depth) so that the soil does not remain saturated long enough for gray mottles to form. Internal drainage processes are either vertical seepage to confined groundwater or lateral seepage towards natural streams. DRAINMOD can simulate both vertical and lateral seepage, however, the required inputs are difficult to measure *in situ*. The U.S. Geological Survey (Heath 1980) estimates that the recharge rate to confined aquifers in the upper coastal plain (Johnston county area) varies from 250,000 gpd/mi^2 to 1,000,000 gpd/mi^2. The lower range equates to 0.014 inch/day or 13 centimeters per year. Jackson et al (1973) observed that 20 to 40 percent of precipitation on coastal plain soils returns to streams with up to 80 percent of flow being lateral flow. Applying these results, the ratio of vertical to lateral seepage should be in the range of 1:2 to 1:4. Since the total nitrogen concentration of the Johnston county treated wastewater (Table 2 soils report) is below the 10 mg/L groundwater standard, so the exact proportion of vertical to lateral seepage is not critical to the irrigation analysis.

Together, the above theoretical relationships provide a methodology for calibrating DRAINMOD to predict the relative flow components of moderately well and well drained soils. The calibration procedures are described in more detail later.

Methodology

Soils

Important soil properties required as input for the simulation analysis include saturated hydraulic conductivity, soil water release curves, and depth to restrictive horizons. In general, hydraulic conductivity values used in the simulation analysis were obtained from the Johnston county soil survey for the soils series identified in the soil maps in Appendix B. The lower end of the range reported in the soil survey was used and depth ranges and corresponding low range values are summarized in Hydrology Appendix Tables HA.1a, HA.1b, and HA.1c, for the Johnston County Golf Course, Landfill, and Bolton tracts, respectively. The hydraulic conductivity of the most restrictive horizon was determined *in situ* using the Constant Head Permeameter Procedure for the Golf Course by Frederick et al. (site analysis report). These values were not used in the simulations directly, but provided an independent check of the vertical and lateral seepage rates determined from calibration (see model calibration procedure). In addition, hydraulic conductivity was determined by the auger hole method (vanBeers, 1970) for 10 locations at the golf course and 4 locations at the Bolton tracts, Table HA.2. The range of values determined by the auger hole compare well to the range of values reported in the soil survey (Table HA.1). Hydraulic conductivity for the disturbed landfill caps was determined in the lab using a constant head procedure for 15 cores. These values are given in Table HA.3.

Hydraulic conductivity often varies by more than an order of magnitude for measurements made within a few feet of each other. Bentley et al (1987) found that water table depth in drainage studies was best correlated to arithmetic average conductivity rather than more conservative

values such as the lowest value measured, the low quarter percentile, or geometric mean. An arithmetic average conductivity was computed for each field from soil survey values based on the predominant soil type(s) identified by Frederick et al.

Skaggs, (1986) reported soil water characteristic values for approximately 20 soils in eastern North Carolina including four series mapped on the proposed spray fields, (well drained Wagram, moderately well drained Goldsboro, poorly drained Rains, and very poorly drained Pantego). Soil water release curves are correlated to soil texture. Soil types in the proposed spray field were matched by texture (B_t) and drainage class to the soil types reported by Skaggs. Soil water release curves for the disturbed landfill cap were determined in the laboratory using the pressure plate method (Hillel, 1980), and are shown in Table HA.4.

Weather

Weather records including hourly rainfall and daily maximum and minimum temperature from which evapotranspiration (ET) is computed for Wilson, NC were used. The 46 year precipitation record for the period 1950 to 1995 is summarized in Table 1 along with the probability of occurrence of the annual amounts shown. Long term average monthly precipitation for Wilson, Table 2, are very similar to records for Smithfield. DRAINMOD requires hourly precipitation values which were not available for the Smithfield record. Potential evapotranspiration is computed in DRAINMOD using the Thornthwaite method.

Calibration Procedure

Soil hydraulic property inputs were selected as described in the soils section. Except where drain tubing was know to exist such as on the golf course greens, drainage system parameters were selected that resulted in insignificant conventional subsurface drainage, i.e., very shallow drains (usually less than 12 inches deep) at wide spacings. Actual distances were determined from aerial photographs. Likewise, the lateral distance from the spray field to the nearest natural stream was determined from aerial photos and input as the distance from the spray field to a remote sink for lateral flow computations.

The depth of the soil profile was assumed to be 4 meters and the restrictive horizon at the base of the soil assumed to be 5 meters thick. The hydraulic head in the underlying confined aquifer was assumed to be at the top of the restrictive layer. Since most of the spray fields are located on interstream divides, it is highly unlikely that the piezometric head in the aquifer extends above the top of the restrictive horizon. An initial simulation was run assuming mature forest. (Vegetation rooting depth affects simulated ET during dry periods so mature forest results in the highest simulated ET and lowest percolation).

An initial value for vertical conductivity through the restrictive horizon was selected so that annual vertical seepage would be in the range estimated by USGS for the given landscape position. The hydraulic conductivity value for the lateral seepage component was initially estimated to be the same as the deepest value reported in the soil survey. The calibration objective was to converge on a value for vertical and lateral seepage that:

Table 1. Annual precipitation Wilson, NC 1950-1995		
YEAR	RAIN (centimeters)	percentile
1981	76.45	2.17
1985	79.48	4.35
1951	82.37	6.52
1970	88.16	8.70
1954	88.21	10.87
1990	91.80	13.04
1988	92.48	15.22
1976	93.32	17.39
1994	94.28	19.57
1965	95.45	21.74
1980	96.77	23.91
1986	97.21	26.09
1950	101.80	28.26
1955	103.00	30.43
1969	104.83	32.61
1961	105.44	34.78
1973	106.17	36.96
1987	108.46	39.13
1963	109.68	41.30
1968	109.83	43.48
1993	112.29	45.65
1974	113.03	47.83
1953	113.16	50.00
1962	113.26	52.17
1957	114.17	54.35
1995	115.11	56.52
1956	116.89	58.70
1971	117.88	60.87
1952	118.26	63.04
1966	118.54	65.22
1977	120.65	67.39
1978	120.65	69.57
1972	121.74	71.74
1983	121.79	73.91
1960	124.41	76.09
1991	125.35	78.26
1958	125.81	80.43
1982	129.84	82.61
1967	131.11	84.78
1984	131.78	86.96
1992	131.78	89.13
1979	133.35	91.30
1975	133.65	93.48
1964	146.13	95.65
1959	155.30	97.83
1989	156.06	100.00
Average	112.76	

Table 2. Long term monthly average precipitation for Wilson, N.C. 1950-1995.

	mean	10 YRI wet	5 YRI Dry
Jan	9.10	10.78	7.62
Feb	8.70	10.30	7.28
Mar	10.10	11.96	8.46
Apr	7.60	9.00	6.36
May	9.20	10.90	7.70
Jun	10.50	12.43	8.79
Jul	13.70	16.22	11.47
Aug	12.60	14.92	10.55
Sep	9.20	10.90	7.70
Oct	6.90	8.17	5.78
Nov	7.00	8.29	5.86
Dec	8.00	9.47	6.70
Total	112.60	133.35	94.28

1) satisfy the saturation duration criteria proposed by Vepraskas for the given soil drainage class. i.e, If the soil was classified as well drained, then no gray mottles would be expected in the upper 36 inches of the profile. Thus, the model criteria would be that the water table could not be within 36 inches (90 cm) for more than 23 out of 46 years. For a moderately well drained soil, saturation for 21 or more days would be expected for more than 23 out of 46 years at a depth between 18 and 36 inches. The actual depth was determined on a case by case basis from the shallowest occurrence of gray mottles in the soil descriptions.

2) do not exceed seepage estimates as reported by USGS for vertical recharge or by Jackson for the ratio of vertical to lateral seepage.

3) Total annual percolation (combination of vertical and lateral seepage) should be less than 4 percent of the permeability of the most restrictive horizon as computed by the procedure recommended by EPA (1981).

The vertical and lateral seepage input values were fined tuned until all three of the above criteria were achieved. For comparison, percolation estimates based on the EPA 1981 procedure are summarized in Appendix HA.5a-12a for a wet year (10 YRI, year recurrence interval rainfall), and Appendix HA.5b-12b for a dry year, 20 percent probability rainfall. Low end percolation estimates were computed for each field using both the constant head permeameter measurements where available and the lowest conductivity value reported in the soil survey for the identified "dominate soil" in the field.

Calibration Results

Fields evaluated in the Phase I analysis are divided into eleven irrigation management zones consistent with irrigation priority areas recommended by Frederick et al. and based on soil type and hydraulic features. The management zones are summarized in Table 3. Calibration criteria and results are shown in Table 4. Field F1 is well drained, and no gray mottles were observed during soils descriptions within 36 inches of the soil surface. The saturation criteria requires that the water table be no closer than 36 inches from the soil surface for more than 21 consecutive days in less than 50 percent of years (<23 years). Twenty two of 46 years just satisfies condition 1. The resulting seepage estimates were 7.9 cm (3.1 inch) vertical and 20.6 cm (8.1 inch) lateral. The simulated vertical seepage of 7.9 cm is below the low-end range estimated by USGS; and, vertical seepage is about 38 percent of lateral seepage so condition 2 is satisfied. Total seepage is considerably less than the EPA estimated percolation value shown in Appendix Table HA.5 so condition 3 is satisfied. Both the saturation and seepage criteria obtained in this simulation represent bias towards the "wetter end" which leads to a conservative estimate from the standpoint of scheduling wastewater application. In other words, the site likely has higher seepage rates than computed in the simulation. Higher seepage rates would allow for higher irrigation amounts. Selecting conservative seepage rates results in conservative estimates of irrigation amounts.

Annual water balance results for the calibrated seepage inputs are summarized for each field in Appendix Tables HA.13 to HA.20. Note that the total seepage (last column in Tables HA.13-HA.20) is lower for all fields except the Johnston County Golf club than the percolation values (Tables HA.5a-HA.12b) computed by the EPA method using either the CHP value or soil survey value for the most restrictive horizon. Again, these results suggest conservative estimates were used to simulate seepage. For the golf course, simulated seepage is lower than the annual percolation (Table HA.9a) computed using the soil survey value but is higher than the percolation estimates based on the *in situ* CHP test. The CHP values for the golf course seem low for the predominate soil textures at this site. The CHP method tends to underestimate conductivity when the measurements are made in the presence of a water table. Water tables were elevated in early August following several days of rainfall.

Table 3. Field designations for Phase I hydrologic analysis.

Property	field designation	relative location	predominate soil types in zone	Simulated drainage class	Vegetation
Landfill	F1	NC forest service building	BoA, UcC	well drained	forest
	F2	yard waste site	BoA, RnF, UcB	well drained	forest, bermudagrass
	F3	borrow pit	GeD, NoB	moderately well drained	forest
	F4	surrounding leachate pond	CeB, McB, NoB, NnB, RnF, UcB	well drained	forest
	Cap1		disturbed (fill)	altered/liner	bermudagrass
	Cap3		disturbed (fill)	altered/liner	bermudagrass
	Cap4		disturbed (fill)	altered/liner	bermudagrass
Johnston County Golf Club	Fairways/ roughs/tees		GoA, FaA, UcC, StA, NnB, NoB, WaB	moderately well drained	bermudagrass
	Greens		disturbed	underdrained	bermudagrass
Bolton Jones	T1F1	road	WoB, Ra, GoA	poorly drained	grain crops
	T1F2	across stream	WoB, WoD	well drained	grain crops
	T2F1	road	VrA	well drained	grain crops

Table 4. Calibration criteria used to establish annual baseline seepage rates.

Property	field designation	Simulated drainage class	Critical depth to gray mottles	Target 21 day criteria at critical depth	Simulated 21 day criteria at critical depth	Average Annual Vertical Seepage (centimeters)	Average Annual Lateral Seepage (centimeters)
Landfill	F1	well drained	>=36 inches	<23 of 46 years	22 of 46	7.9	20.6
	F2	well drained	>=36 inches	<23 of 46 years	19 of 46	14.2	28.3
	F3	moderately well drained	18 inches	>35 of 46 years	36 of 46 46 of 46	9.4 7.4	9.4 7.4
	F4	well drained	>=36 inches	<23 or 46 years	20 of 46	11.1	18.8
	Cap1	altered/liner	NA	NA			
	Cap3	altered/liner	NA	NA			
	Cap4	altered/liner	NA	NA			
Johnston County Golf Club	Fairways/ roughs/tees	moderately well drained	21 inches	>24 of 46 years	25 of 46	8.9	20.3
	Greens	underdrained	NA	NA			
Bolton Jones	T1F1	poorly drained	10-18 inches	>24 of 46 years	36 of 46	5.3	7.1
	T1F2	well drained	>=36 inches	<23 of 46 years	20 of 46	5.7	17.5
	T2F1	well drained	>=36 inches	<23 of 46 years	22 of 46	7.0	21.3

Irrigation

The combination of input parameters determined from calibration using the procedures and criteria discussed above were assumed to represent the natural drainage process for a given field. Vegetation was then modified where appropriate and allowable irrigation amounts determined to satisfy agronomic and hydraulic loading constraints.

In DRAINMOD, irrigation is scheduled at a user set interval and amount when user defined soil storage criteria are satisfied. In other words, if the soil-water storage (water free pore space) on a given day is 3 cm and the preset minimum storage to schedule irrigation is 4 cm, then irrigation will be postponed for that day. The threshold soil-water storage volume is normally set to be equal to the irrigation amount plus a predetermined minimum volume corresponding to a maximum permissible water table depth. For example, if the soil-water storage required prior to applying 1/4 inch is 2 cm, then to irrigate 3/4 inch, the threshold storage would be increased to 3.3 cm. Irrigation can also be canceled if rainfall exceeds a user prescribed amount. Irrigation can be scheduled to occur daily, every other day, every third day, etc or at any regular interval prescribed by the user. Non irrigation days represent rest periods that allow the root zone to re-aerate.

From an agronomic standpoint, irrigation should be scheduled frequent enough to replace plant available water removed by ET. The plant available water holding capacity of the sandy textured soils in the proposed spray fields is about 3/4 of an inch per foot of root zone depth. Application amounts in excess of 3/4 inch will leach below the root zone. Summertime PET is about 1/4 inch per day, thus to use irrigation water effectively in these sandy textured soils and supply water requirements of crops during dry periods, irrigation should be scheduled to replace 3/4 inches every three days in the absence of rainfall. This can be accomplished by applying 1/8 inch twice per day, 1/4 inch daily, ½ inch every other day, or 3/4 inch every third day. Smaller application amounts require more frequent irrigations. Smaller application amounts also result in larger annual irrigation amounts which is desirable from a water disposal standpoint. This relationship is shown for field F1 in Figure 3 and 4.

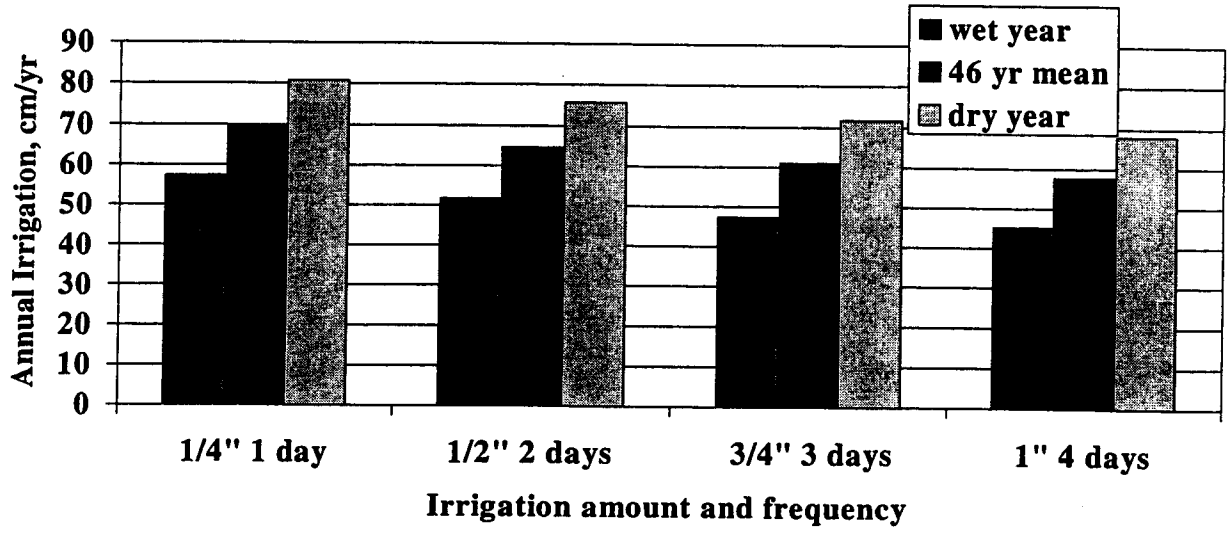

Figure 1 Influence of application amount and scheduling strategy on annual irrigation amount.

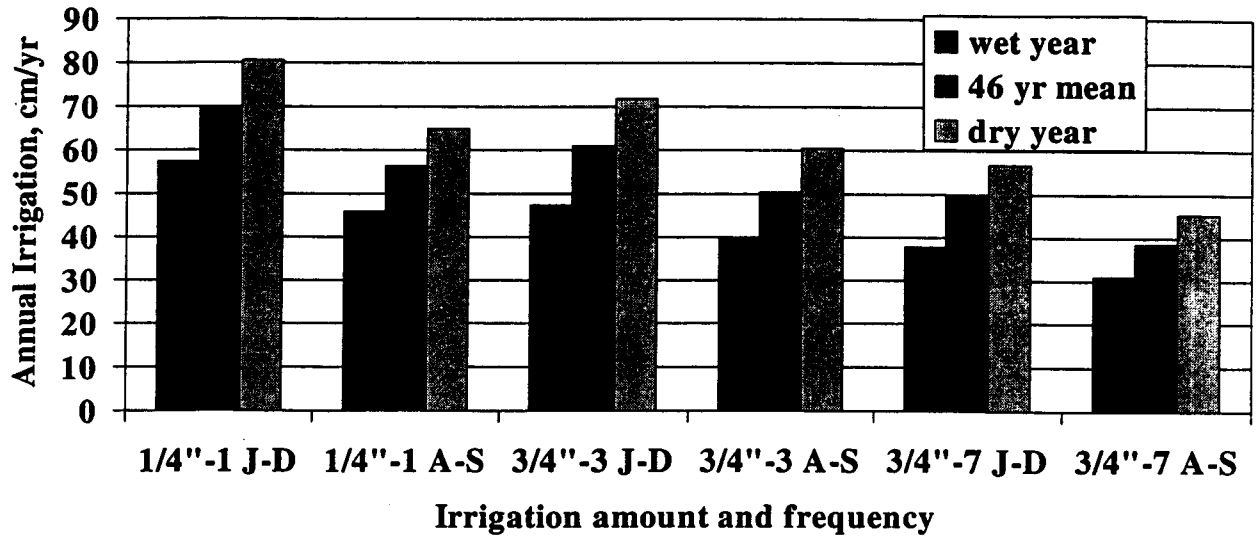

Figure 2 Influence of application amount and scheduling strategy on annual irrigation amount.

Note that as the irrigation schedule changes from a daily application of 1/4 inch to 3/4 inch every third day, the annual irrigation amount decreases by about 13 percent (from 70.1 cm/yr to 61.1 cm/yr). Note also that most irrigation occurs during the growing season even through irrigation was scheduled year round in Figure 4. Increasing the irrigation window from the six month growing season to the entire year only increased the allowable irrigation amount by about 10 percent. For a conjunctive use permit, the additional irrigation during the non growing season is not critical to the total annual application amount. However, in the absence of a discharge permit, a few small irrigations during the winter months can be critical for proper management of the lagoon stage.

In Figures 5 and 6, note that larger, less frequent irrigations allow rest time for the root zone to re-aerate and establish better agronomic moisture conditions for plant growth. The water table may encroach into the root zone even under "well drained" conditions without irrigation (blue line) during wet periods such as during the winter of 1993. Note also that small frequent irrigations (red line) resulted in more frequent periods of the water table encroaching into the root zone (assumed to be about 18 inches (45 cm) deep) during the growing season. Note also the effect of deficit irrigation scheduling, i.e., the case of applying only 3/4 inch every 7 days. The deficit irrigation scheduling strategy results in a drier site, especially during the growing season, but summertime crop PET requirements cannot always be satisfied. Considering all these factors, an irrigation strategy of applying 3/4 of an inch every third day (provided the minimum soil-water storage and rainfall criteria are both satisfied) appears to be the best scheduling strategy for forestry and agricultural crops.

Irrigation was scheduled so that the water table would not encroach into the root zone (rise closer than 18 inches from the soil surface) during or immediately following any irrigation event.

Irrigation was canceled on any day rainfall exceeded a threshold value of 0.2 inches. Irrigation rates and amounts were set so that no surface runoff would result directly from irrigation. Of course, irrigation reduces soil water storage such that the probability of rainfall induced runoff from rainfall events immediately following an irrigation event will be increased. The small spikes (rises in the water table) seen Figures 5 and 6 are the result of scheduled irrigation. Note that these small spikes do not normally encroach into the root zone. The larger spikes that extend to or near the soil surface result from rainfall following irrigation events. Some of these rainfall events may result in surface runoff.

EPA design procedures recommend determining irrigation amounts based on 90 percentile rainfall. Ninety percentile rainfall means a wet year that would occur one year in ten on average referred to as a 10 year recurrence interval rainfall year (10 YRI). The 10 YRI approach is required to determine the land area required to accommodate the waste stream for a non discharge system during a wet year. It is also used to size the storage pond to handle the waste stream during extended periods that are too wet to irrigate. The 10 YRI design irrigation amount is not adequate to satisfy crop water requirements during dry years. Agronomic design criteria are based on satisfying crop water requirements at least 4 years in 5 which is the 20 percentile rainfall. Annual irrigation amounts are presented in the next section for each management zone based on average conditions (long term mean), agronomic conditions (20 percentile rainfall) and EPA criteria, 10 YRI rainfall.

Irrigation Design Loading Rates

In determining irrigation rates, considerable hydrologic simulation analysis were performed and evaluated. Only samples of the hydrologic results along with summaries are presented in this report. Additional results on a field by field basis are available on request.

Annual irrigation amounts for average, wet and dry years are summarized in Table 5. The values shown in Tables 6 and 7 represent the design long term hydrologic performance of each sites. The average annual water balance are summarized in Table 6 for the landfill site and Table 7 for the Johnston county golf course and Bolton Jones tracts.

Johnston County Landfill

Results for the landfill site are presented as 7 management zones; 3 undisturbed fields, F1, F2, and F4, the borrow pit, F3, and 3 landfill caps, 1/2, 3 and 4. Fields 1, 2 and 4 are priority 1 areas for irrigation, field 3 is a priority 3, and the landfill caps are priority 2. For the forested tracts, irrigation results are presented based on two scheduling strategies: applying water year round provided threshold scheduling criteria were satisfied, and applying only during a six month growing season, taken to be April 1 to September 30.

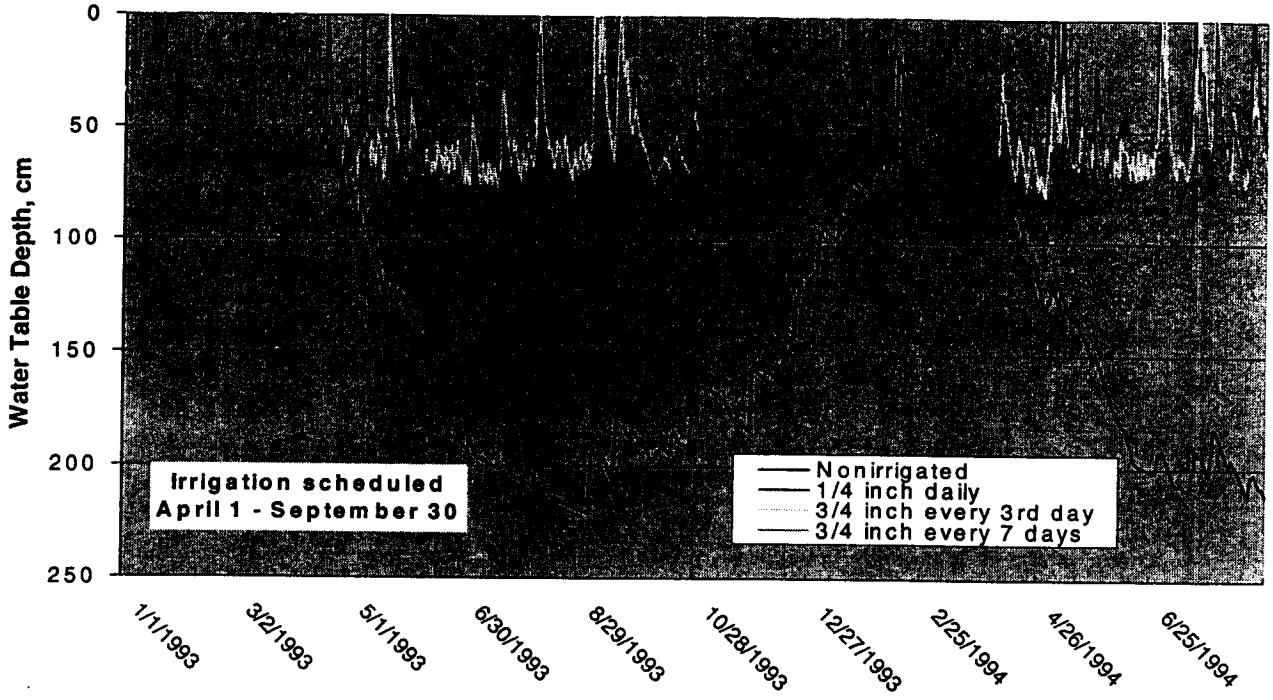

Figure 5. Influence of irrigation on water table depth. Irrigation scheduled scheduled only during the growing season, April 1 to September 30, whenever water free pore space staisfied minimum threshold values.

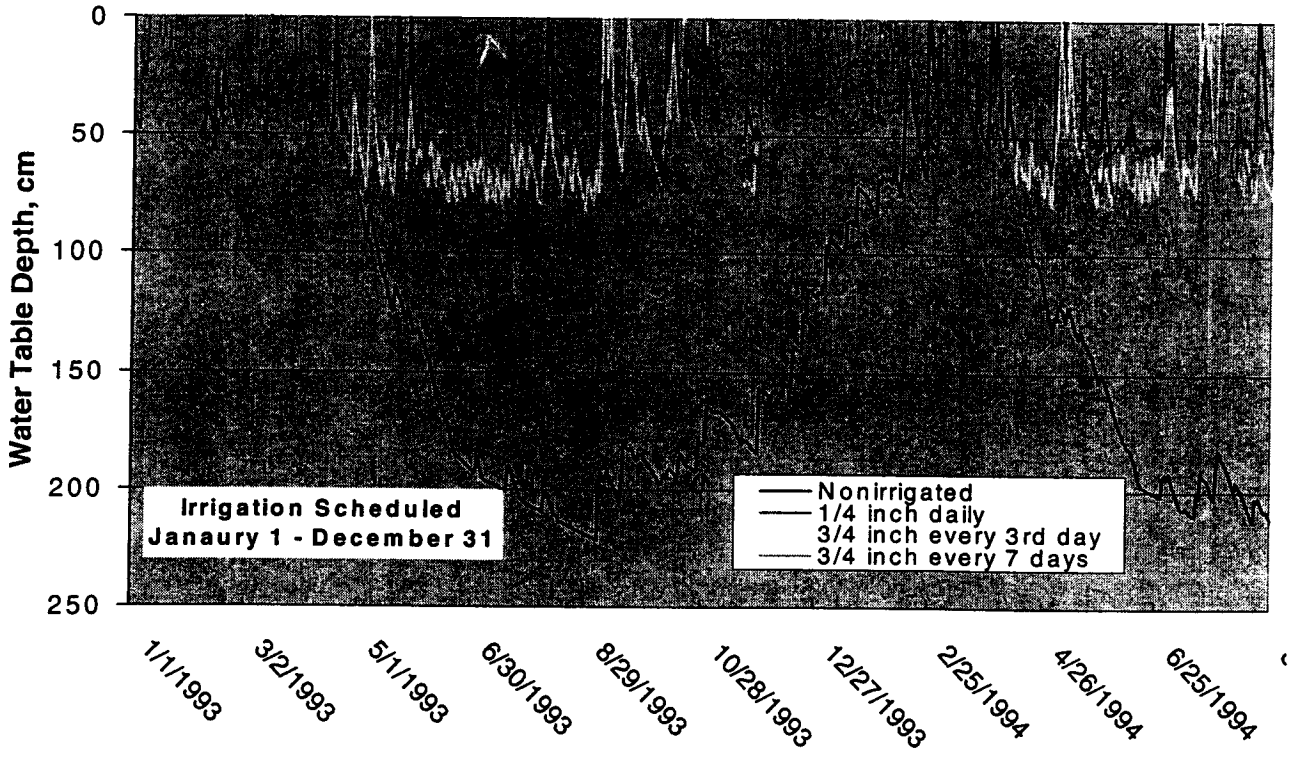

Figure 6. Influence of irrigation on water table depth. Irrigation scheduled January through December whenever water free pore space satisfied minimum threshold values.

In a wet year (10 year recurrence interval rainfall), about 45 cm (18 inches) of irrigation can be applied during the growing season to landfill sites F1 (41.6 cm), F2 (52.9 cm) and F4 (45.4 cm). The long term average is 54 cm on field 1, 64 cm on field 2 and 56 cm on field 4. In a dry year, up to 64, 79 and 72 cm could be applied to fields 1, 2 and 4, resp. Increasing the irrigation season to year round irrigation increased the application amount by about 20 percent on average for each field with most of the additional irrigation occurring in the fall months.

The application amounts for Field F3 (recent borrow pit) are considerably lower with only 30 cm (12 inches) being applied in a wet year with a long term average or 42 cm. To achieve even this low loading rate on Field F3 will require considerable site preparation (smoothing, chiseling, etc). It was assumed that 60 cm of top soil have been removed on this site so surface runoff is a concern. Even through irrigation can be scheduled to eliminate runoff, rainfall induced runoff will be high, simulated to be in excess of 40 cm annually on average. Considering the lower application rates on Field F3 together with the preparation costs, it will be considerable more expensive per unit application of water to irrigate this field.

Monthly irrigation amounts for the landfill sites are summarized in Tables 8-11. While applying wastewater year round increases the total annual application amount, year round application results in slightly lower application amounts during the growing season, particularly during the first two months of the growing season, Figure 7. Also, application amounts during the winter months is relatively low. Non irrigation in February and March leads to development of a soil-water deficit which can be replaced during the first two months of irrigation during the growing season. After the deficit is replaced, irrigation amounts throughout the remainder of the growing season are the same. Even irrigation in the fall with no irrigation between January to March has a slight carry over into April and May by keeping soil moisture higher thus requiring slightly less

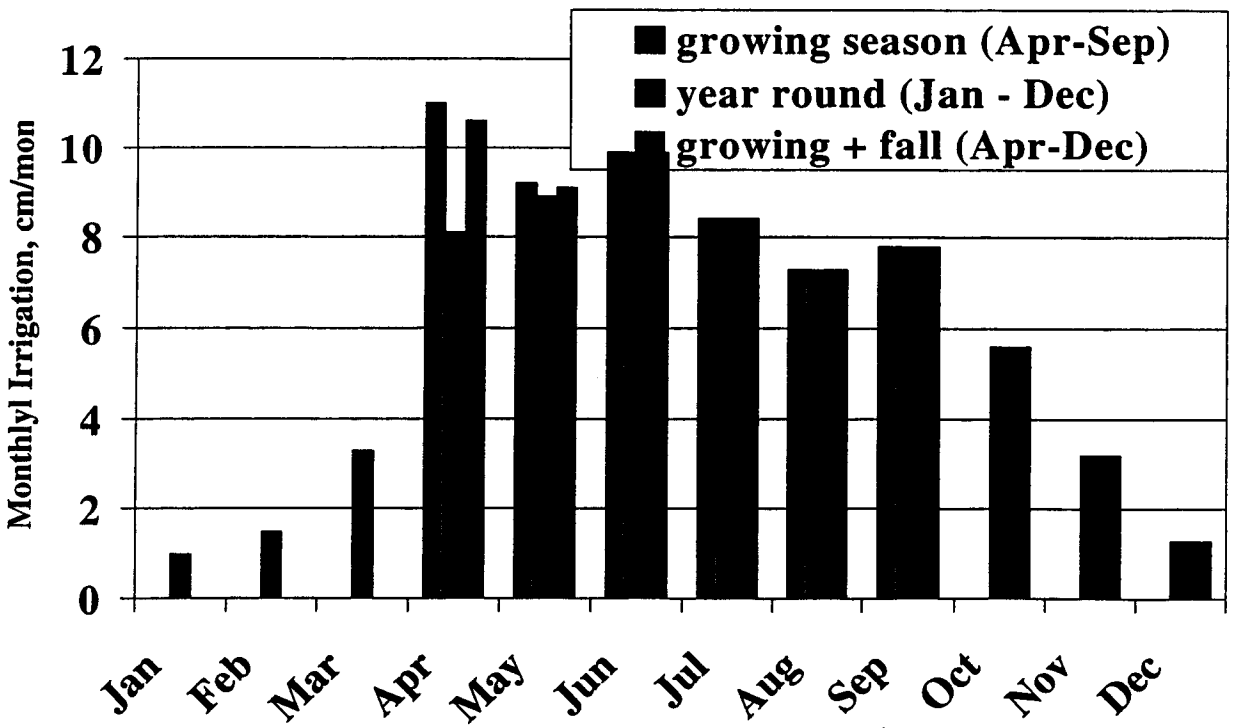

Figure 5 Effect of starting month of irrigation on total annual application.

irrigation at the start of the growing season. Thus, if the objective is to apply as much irrigation as possible to eliminate discharges during the growing season, the irrigation should only be applied during the growing season. If the objective is to eliminate as much discharge as possible on an annual basis, then the irrigation window should be expanded to include most of the year. Due to the shallower profile (assumed to be 75 cm (30 inches)), the irrigation schedule for the landfill caps was set to satisfy only agronomic requirements for maintenance of grass type vegetation. Irrigation was scheduled to apply no more than ½ inch every three days only during the growing season. It was assumed that the cap liner was impermeable although the liner on cap 3 has a design permeability of 10^{-9} cm/sec which will accommodate up to 2 inches of vertical seepage annually. The surface is also graded to encourage surface runoff which is reflected by the relatively high amounts of runoff (25 % of rainfall even with no irrigation) shown in Table 6. Water movement within the landfill cap is predominately precipitation/ET driven with very little drainage and no seepage. The annual agronomic irrigation amounts are about 18 cm/yr (7 inches) with a low of 7.6 cm (3 inches) in a wet year and about 30 cm (12 in) in a dry year. Monthly extremes are shown in Table 12.

Johnston County Golf Course

Irrigation for the Johnston County Golf Course was scheduled according to agronomic guidelines described by the superintendent. Irrigation is applied to the fairways and roughs on a daily basis during the growing season April through September for bermudagrass with no winter overseed. The system is designed to operate daily for 15 minutes per set. The newly designed sprinkler system has a design precipitation rate of 0.713 in/hour which if operated for 15 minutes per day results in a daily application of 0.178 in/day (0.45 cm/day). Irrigation is normally scheduled any day that the rainfall is less than 0.3 inches and normally resumes the next day except when the rainfall amount exceeds ½ inch in which case irrigation to the fairways resumes the second day after rainfall.

The sprinkler system for the greens has a design precipitation rate of 1.06 in/hr when operated half circle. The run time for the greens is 12 minutes per day which results in a daily application of 0.12 in/day (0.3 cm/day). The greens are irrigated daily year round. Irrigation is canceled only in the event of rainfall in excess of 0.2 inches.

As seen in Table 5, the annual irrigation amount to the fairways is 47 cm (18.5 inches) during a wet year, 54 cm (21.4 inches) on average, and 65 cm (25.6 inches) in a dry year. Utilization of a winter overseed would extend the irrigation window from February to December 15 which would increase the annual irrigation amounts to 58, 69 and 83 cm during wet, average and dry years, resp. Irrigation requirements of the greens.

Monthly irrigation amounts for the golf course are provided in Table 13 and range from as little as 5 cm (2 inch) during a wet month up to 12.6 cm (5 inch) during a dry month. Average values are just under 10 cm (4 inch) per month or about an inch per week.

Bolton Jones Tracts.

Annual irrigation amounts for the Bolton Jones tracts are shown in Table 6. Cropping scenarios

considered included corn, soybean, and corn/wheat/soybean in a two year rotation. Cotton was not evaluated but would result in irrigation requirements very similar in amount and schedule to full season soybean. Corn is normally planted in mid April and irrigation commences in mid to late May, concluding in August. Full season soybean are planted in May and Irrigation begins in June, ending in early October. Wheat is planted in November which allows for a couple of fall irrigations and has it's highest water demand in April, but because ET is still relatively low, not much irrigation is required. Soybean planted behind wheat are typically planted in June with irrigation beginning in July and concluding in October.

Tract 1 field 1 was simulated as a poorly drained Rains soil. Even through the Rains occupies a relatively small area of the field, the location of the Rains soil being in the center of the field poses management constraints if it becomes too wet and thus cannot be ignored. The rains being poorly drained does not normally require much irrigation. Irrigation amounts for corn are only 6.3 cm (2.5 inches) and soybean is only 2.5 cm (1 inch) in a typical wet year. The long term average is 15 cm (6 inch) and 11.5 cm (4.5 inch) for corn and full season soybean, resp. In a dry year, these amounts increase to 28 cm (11 inch) and 21 cm (9 inch) for corn and soybean, resp. Adding wheat to the crop mix increased the irrigation amount by about 1 inch.

Both tract 1 field 2 and tract 2 field 1 are predominately well drained soil. The annual irrigation amounts increased from 10 cm (4 inch) during a wet year to about 8 inches for corn and 6 inches for soybean on average. In a dry year, irrigation requirements were 13 inches for corn and 11 inches for soybean. Again, the addition of wheat to the crop mix increased the annual irrigation amount by an inch on average. Irrigation requirements on tract 2 field 1, a more sandy tract, are about 2 inches higher than tract 1 field 2 in all categories. The mean was 9.5 and 7 inches for corn and soybean, resp. in an average year and about 15 inches in a dry year.

Monthly irrigation amounts for each crop and field are shown in Tables 14-16. Monthly irrigation varies from none in wet months to about 5 inch/month in a dry month. The typical seasonal variation is shown in Figure 8 for Tract 1 Field 2.

The overall irrigation amounts and ranges from wet to dry years are very consistent with Natural Resources Conservation and Cooperative Extension Service recommendations for these soils and crop types. General observations have been 8 inches/year on average for grain crops with 12 inches required to satisfy a 5 year recurrence interval drought. These results further validate the methodology used to calibrate the model for these well drained soils.

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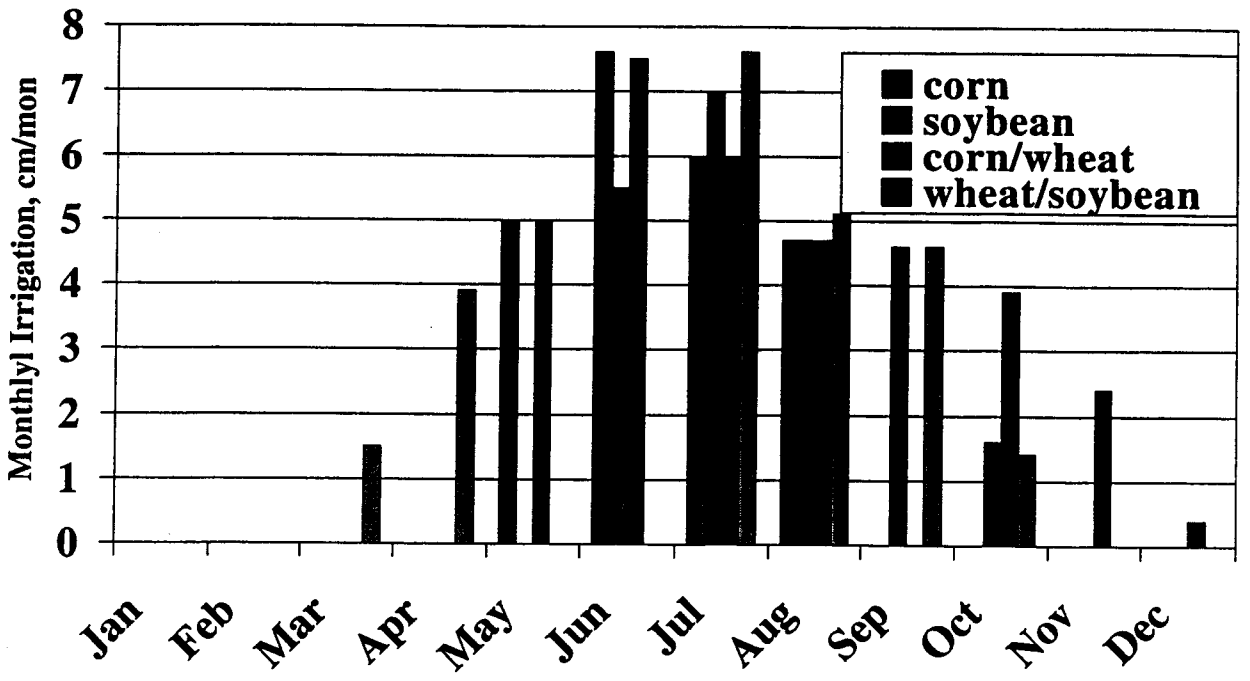

Figure 6 Seasonal irrigation amount on traditional agricultural crops.

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Table 5. Irrigation application amounts as influenced by rainfall probabilities and cropping scenarios. (Centimeters)

			High	10 %tile	20 %tile	Mean	80 %tile	90 %tile	Low
			Driest YR			(2 RYI)	(5 YRI)	(10 YRI)	Wettest YR
LF1	Trees	NOI	-	-	-	-	-	-	-
		A1S30	77.5	68	64.3	53.6	43.5	41.6	35.9
		J1D31	90.7	81.3	77.5	66.3	56.7	52.9	49.1
LF2	BG	NOI	-	-	-	-	-	-	-
	BG/Wos	A1S30	76.9	69.3	66.8	58.2	51.7	49.1	39.1
	BG/wos	F1D15	97	93.2	85.7	74.7	66.8	60.5	56.7
	Trees	A1S30	88.8	79.4	73.7	63.8	54.8	52.9	41.6
	Trees	J1D31	109.6	98.3	92.6	80.3	69.9	68	60.5
LF3	Trees	NOI	-	-	-	-	-	-	-
Borrow	Trees	NOI	-	-	-	-	-	-	-
	Trees	A1S30	64.3	54.8	49.1	41.6	34	30.2	24.6
	Trees	J1D31	73.7	66.2	58.6	49.1	41.6	37.8	32.1
LF4	Trees	NOI	-	-	-	-	-	-	-
	Trees	A1S30	77.5	71.8	64.3	55.9	47.3	45.4	35.9
	Trees	J1D31	92.6	85.1	79.4	69.4	60.5	54.8	51
JCCC	BG	NOI	-	-	-	-	-	-	-
	BG	A1S30	69.3	64.8	60.3	54.4	47.7	46.7	39.2
	BG/wos	F1D15	88.2	82.8	81.5	69.2	62.6	57.6	56.3
	Greens	J1D31	105.3	103.5	102	99.1	97.2	96.6	94.2
BJT1F1	Trees	NOI	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-
	Corn	J1A31	35.3	27.7	20.2	15.1	8.8	6.3	2.5
	Soybean	J1O15	30.2	21.4	18.9	11.5	5	2.5	0
	Corn/Wheat	J1D15	40.3	30.2	26.5	18.1	11.3	10.1	2.5
	Wheat/Soy	F1O15	32.8	26.5	21.4	14.0	6.3	3.8	1.3
BJT1F2	Trees	NOI	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-
	Corn	J1A31	37.8	32.8	26.5	19.5	12.6	10.1	2.5
	Soybean	J1O15	37.8	27.7	25.2	16.4	10.1	5	2.5
	Corn/Wheat	J1D15	46.6	36.5	35.2	24.5	17.6	13.9	2.5
	Wheat/Soy	F1O15	42.8	35.3	31.5	19.9	10.1	6.3	1.3
BJT2F1	Trees	NOI	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-
	Corn	J1A31	42.8	37.8	31.5	23.3	16.4	13.9	2.5
	Soybean	J1O15	37.8	60.2	27.7	18.1	12.6	7.6	1.3
	Corn/Wheat	J1D15	52.9	44.1	40.3	29.8	22.7	18.9	3.9
	Wheat/Soy	F1O15	49.1	42.8	35.3	24.1	15.1	12.6	5

Table 5. Cont. Irrigation application amounts as influenced by rainfall probabilities and cropping scenarios.

	High	10 %tile	20 %tile	Mean	80 %tile	90 %tile	Low
	Driest Yr			(2 RYI)	(5 YRI)	(10 YRI)	Wettest YR
LF cap1	36.5	29.0	26.5	17.8	10.1	7.6	5.0
LF cap3	35.3	27.7	26.5	17.2	11.3	7.6	6.3
LF cap4	36.5	30.2	26.5	18.0	10.1	7.6	5.0

Table 6. Annual water balance for 7 landfill irrigation management zones. (All values are in centimeters).

			rainfall	irrigation	infiltration	ET	Drainage	Runoff	Vertical seepage	Horizontal seepage
LF1	Trees	NOI	112.8	0.0	110.9	81.9	1.1	1.9	7.9	20.6
	Trees	A1S30	112.8	53.6	144.6	94.1	9.2	21.8	12.0	29.5
	Trees	J1D31	112.8	66.3	151.3	94.2	13.6	27.8	12.6	30.9
LF2	BG	NOI	112.8	0.0	110.8	68.6	0.2	1.9	14.2	28.3
	Bg/nos	A1S30	112.8	58.2	150.9	94.1	1.8	20.1	19.8	35.5
	BG/wos	F1D15	112.8	74.7	156.8	94.2	3.2	30.6	21.6	38.0
	Trees	A1S30	112.8	63.8	152.2	94.1	2.1	24.3	20.2	36.1
	Trees	J1D31	112.8	80.3	158.2	94.2	3.7	34.9	21.9	38.4
LF3	Trees	NOI	112.8	0.0	101.1	81.7	0.8	11.7	9.4	9.4
Borrow	Trees	NOI	112.8	0.0	97.8	82.4	0.8	15.0	7.4	7.4
	Trees	A1S30	112.8	41.6	114.2	94.1	1.6	40.2	9.5	9.2
	Trees	J1D31	112.8	49.1	115.4	94.2	1.9	46.5	9.9	9.5
LF4	Trees	NOI	112.8	0.0	111.0	81.4	0.3	1.8	11.1	18.8
	Trees	A1S30	112.8	55.9	141.1	94.1	2.7	27.5	18.2	26.4
	Trees	J1D31	112.8	69.4	145.4	94.2	4.3	36.8	19.2	27.6
LFCap1&2	BG	NOI	112.8	0.0	80.0	78.3	1.7	32.8	-	-
		A1S30	112.8	17.8	90.9	89.0	1.9	39.6	-	-
LFCap 3	BG	NOI	112.8	0.0	83.9	77.5	1.3	28.9	5.2	-
		A1S30	112.8	17.2	96.3	88.1	1.5	34.6	6.6	-
LFCap 4	BG	NOI	112.8	0.0	79.6	78.8	0.9	33.1	-	-
		A1S30	112.8	18.0	90.4	89.4	1.0	40.5	-	-

Table 7. Annual water balance for Johnston county golf course and Bolton Jones tracts. (Centimeters)

JCCC	BG	NOI	112.8	0.0	104.2	74.0	1.3	8.6	8.9	20.3
	BG	A1S30	112.8	54.4	134.0	92.4	3.7	33.2	11.9	26.2
	BG/wos	F1D15	112.8	69.3	139.7	94.2	5.3	42.3	12.6	27.7
	Greens	J1D31	112.8	83.2	182.3	94.2	52.3	13.7	11.2	24.6
BJT1F1	Trees	NOI	112.8	0.0	100.0	85.8	2.1	12.8	5.3	7.1
	Corn	NOI	112.8	0.0	93.9	77.7	3.0	18.9	5.8	7.6
	Soybean	NOI	112.8	0.0	92.5	76.1	3.1	20.3	5.8	7.6
	Corn	J1A31	112.8	15.1	103.6	86.1	3.6	24.3	6.0	8.0
	Soybean	J1O15	112.8	11.5	100.3	82.6	3.7	25.2	6.1	8.0
	Corn/Wheat	J1D15	112.8	18.1	105.5	87.7	3.8	25.4	6.1	8.0
	Wheat/Soy	F1O15	112.8	14.0	101.4	83.7	3.7	25.3	6.1	8.0
BJT1F2	Trees	NOI	112.8	0.0	109.5	86.7	0.3	3.2	5.7	17.5
	Corn	NOI	112.8	0.0	101.2	72.6	0.1	11.5	7.6	21.1
	Soybean	NOI	112.8	0.0	100.9	72.5	0.1	11.9	7.5	21.0
	Corn	J1A31	112.8	19.5	113.9	83.1	0.2	18.4	8.3	22.5
	Soybean	J1O15	112.8	18.8	112.1	81.1	0.2	19.5	8.3	22.5
	Corn/Wheat	J1D15	112.8	24.6	116.6	85.1	0.2	20.7	8.5	22.9
	Wheat/Soy	F1O15	112.8	20.0	113.1	82.1	0.2	19.6	8.4	22.7
BJT2F1	Trees	NOI	112.8	0.0	110.0	81.8	0.4	2.8	7.0	21.3
	Corn	NOI	112.8	0.0	107.1	73.7	0.9	5.7	8.6	24.3
	Soybean	NOI	112.8	0.0	106.4	73.0	1.0	6.3	8.5	24.2
	Corn	J1A31	112.8	23.3	123.7	86.0	1.6	12.4	9.7	26.6
	Soybean	J1O15	112.8	23.3	122.5	84.1	2.0	13.6	9.8	26.8
	Corn/Wheat	J1D15	112.8	29.8	127.6	88.1	2.3	15.0	10.1	27.3
	Wheat/Soy	F1O15	112.8	24.1	123.0	84.4	1.9	13.8	9.9	27.0

Table 8. Monthly irrigation amounts for Landfill field site F1 (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
LF1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	5.7	5.7	5.7	3.8	3.8	5.7	-	-	-	30.4
	Trees	J1D31	0	0	0	3.8	5.7	5.7	3.8	3.8	5.7	3.8	1.9	0	34.2
Monthly irrigation based on long term average rainfall															
LF1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	11	9.2	9.9	8.4	7.3	7.8	-	-	-	53.6
	Trees	J1D31	1	1.5	3.3	8.1	8.9	9.9	8.4	7.3	7.8	5.6	3.2	1.3	66.3
Monthly irrigation based on 20 percentile rainfall (dry year)															
LF1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	18.9	13.2	13.2	11.3	11.3	9.4	-	-	-	77.3
	Trees	J1D31	1.9	3.8	5.7	11.3	11.3	13.2	11.3	11.3	9.4	7.6	3.8	3.8	94.4

Table 9. Monthly irrigation amounts for Landfill field site F2 (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
LF2	BG	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bg/nos	A1S30	-	-	-	6.3	6.3	7.6	6.3	5	6.3	-	-	-	37.8
	BG/wos	F1D15	-	1.3	1.3	5	5	7.6	6.3	3.8	6.3	3.8	1.3	0	41.7
	Trees	A1S30	-	-	-	7.6	7.6	7.6	5.7	3.8	5.7	-	-	-	38
	Trees	J1D31	0	0	1.9	5.7	5.7	7.6	5.7	3.8	5.7	3.8	1.9	0	41.8
Monthly irrigation based on long term average rainfall															
LF2	BG	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bg/nos	A1S30	-	-	-	10.3	10.8	10.4	9.4	8.4	8.4	-	-	-	57.7
	BG/wos	F1D15	-	3.5	4.3	8.3	9.4	10	9.5	8.1	9.1	6.9	4.4	1.2	74.7
	Trees	A1S30	-	-	-	13.3	11.5	11.2	10.1	8.7	9	-	-	-	63.8
	Trees	J1D31	1.8	2.2	4.5	9.5	10.4	11.1	10.1	8.7	9.1	6.7	4.1	2.2	80.4
Monthly irrigation based on 20 percentile rainfall (dry year)															
LF2	BG	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Bg/nos	A1S30	-	-	-	12.6	13.9	12.6	12.6	12.6	11.3	-	-	-	75.6
	BG/wos	F1D15	-	7.6	6.3	11.3	12.6	12.6	12.6	11.3	11.3	8.8	6.3	2.5	103.2
	Trees	A1S30	-	-	-	18.9	15.1	15.1	13.2	11.3	11.3	-	-	-	84.9
	Trees	J1D31	3.8	3.8	2.6	13.2	13.2	15.1	13.2	11.3	11.3	9.4	5.7	5.7	108.3

Table 10. Monthly irrigation amounts for Landfill field site F3 (priority 3 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
LF3	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	3.8	3.8	3.8	3.8	1.9	3.8	-	-	-	20.9
	Trees	J1D31	0	0	0	3.8	3.8	3.8	3.8	1.9	3.8	1.9	0	0	22.8
Monthly irrigation based on long term average rainfall															
LF3	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	8	7.1	8	7	5.7	5.9	-	-	-	41.7
	Trees	J1D31	0.2	0.6	2.3	6.5	7.1	7.9	7	5.7	5.9	3.9	1.6	0.5	49.2
Monthly irrigation based on 20 percentile rainfall (dry year)															
LF3	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	13.2	9.4	11.3	9.4	9.4	9.4	-	-	-	62.1
	Trees	J1D31	0	1.9	3.8	9.4	9.4	11.3	9.4	9.4	9.4	5.7	3.8	1.9	75.4

Table 11. Monthly irrigation amounts for Landfill field site F4 (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
LF4	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	5.7	5.7	5.7	3.8	3.8	5.7	-	-	-	30.4
	Trees	J1D31	0	0	0	3.8	5.7	5.7	3.8	3.8	5.7	3.8	1.9	0	34.2
Monthly irrigation based on long term average rainfall															
LF4	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30				11.4	9.8	10.1	8.9	7.6	8.1				55.9
	Trees	J1D31	1.2	1.6	3.6	8.4	9.1	10.1	8.9	7.6	8.1	6	3.3	1.5	69.4
Monthly irrigation based on 20 percentile rainfall (dry year)															
LF4	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Trees	A1S30	-	-	-	18.9	13.2	13.2	13.2	11.3	11.3	-	-	-	81.1
	Trees	J1D31	1.9	3.8	5.7	11.3	11.3	13.2	13.2	11.3	11.3	7.6	5.7	3.8	100.1

Table 12 Monthly irrigation amounts for Landfill caps 1, 3 and 4 (priority 2 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
LFcap1	90 %tile	A1S30	-	-	-	0	0	0	0	0	0	-	-	-	0
BG/nos	mean		-	-	-	0.2	2.8	4.9	3.9	3.1	3.0	-	-	-	17.9
	20 %tile	A1S30	-	-	-	0	5.0	8.8	6.3	6.3	5.0	-	-	-	31.4
Monthly irrigation based on long term average rainfall															
LFcap3	90 %tile	NOI	-	-	-	0	0	1.3	0	0	0	-	-	-	1.3
BG/nos	mean	A1S30	-	-	-	0	2.2	4.9	3.8	3.1	3.1	-	-	-	17.1
	20 %tile	A1S30	-	-	-	0	3.8	8.8	7.6	5.0	5.0	-	-	-	30.2
Monthly irrigation based on 20 percentile rainfall (dry year)															
LFcap4	90 %tile	A1S30	-	-	-	0	0	1.3	0	0	0	-	-	-	1.3
BG/nos	mean	A1S30	-	-	-	0.2	2.9	5.0	3.9	3.1	3.0	-	-	-	18.1
	20 %tile	A1S30	-	-	-	0	5.0	8.8	6.3	6.3	5.0	-	-	-	31.4

Table 13. Monthly irrigation amounts for Johnston County Golf club (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
JCCC	For	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	BG/nos	A1S30	-	-	-	5.4	6.3	7.2	6.7	4.5	5.8	-	-	-	35.9
	BG/wos	F1D15	-	0.9	1.8	5.4	5.8	7.2	6.7	4.5	5.8	3.6	1.8	-	43.5
	Greens	J1D31	2.4	4.4	5.8	8.1	8.1	8.1	7.8	7.5	7.8	7.8	5.0	2.6	75.4
Monthly irrigation based on long term average rainfall															
JCCC	For	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	BG/nos	A1S30	-	-	-	9.6	9.3	9.7	9.1	8.4	8.3	-	-	-	54.4
	BG/wos	F1D15	-	2.7	4.2	8.1	9.1	9.7	9.1	8.4	8.4	6.0	3.5	-	69.2
	Greens	J1D31	2.8	5.0	6.8	8.5	8.9	8.6	8.7	8.5	8.4	8.6	5.6	2.8	83.2
Monthly irrigation based on 20 percentile rainfall (dry year)															
JCCC	For	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	BG/nos	A1S30	-	-	-	12.6	12.1	12.1	11.7	11.2	10.3	-	-	-	70
	BG/wos	F1D15	-	5.4	5.8	10.3	11.7	12.6	11.7	11.2	10.3	7.6	4.9	-	91.5
	Greens	J1D31	3.1	5.6	7.5	9	9.3	9	9.3	9.3	9	9.3	6.0	3.1	89.5

Table 14.Monthly irrigation amounts for the Bolton Jones Agricultural T1F1 (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
BJT1F1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	0	0	0	0	-	-	-	-	0
	Soybean	J1O15	-	-	-	-	-	0	0	0	0	0	-	-	0
	Corn/Wheat	J1D15	-	-	-	-	0	0	0	0	-	0	0	0	0
	Wheat/Soy	F1O15	-	0	0	0	-	-	0	0	0	0	-	-	0
Monthly irrigation based on long term average rainfall															
BJT1F1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	2.3	5.2	4.1	3.5	-	-	-	-	15.1
	Soybean	J1O15	-	-	-	-		1.8	3.6	3.2	3.1	0.9	-	-	12.6
	Corn/Wheat	J1D15	-	-	-	-	2.3	5.2	4.1	3.5	-	2.1	0.8	0.1	18.1
	Wheat/Soy	F1O15	-	-	0.5	2.3	-	-	3.8	3.4	3.1	0.8	-	-	13.9
Monthly irrigation based on 20 percentile rainfall (dry year)															
BJT1F1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	5	10.1	7.6	7.6	-	-	-	-	30.3
	Soybean	J1O15	-	-	-	-		3.8	6.3	7.6	6.3	2.5	-	-	26.5
	Corn/Wheat	J1D15	-	-	-	-	5	10.1	7.6	7.6	-	5	2.5	0	37.8
	Wheat/Soy	F1O15	-	0	0	5	-	-	7.6	7.6	5	1.3	-	-	26.5

Table 15.Monthly irrigation amounts for the Bolton Jones Agricultural T1F2 (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
BJT1F2	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	0	1.3	1.3	0	-	-	-	-	2.6
	Soybean	J1O15	-	-	-	-	-	0	0	0	0	0	-	-	0
	Corn/Wheat	J1D15	-	-	-	-	0	1.3	1.3	0	-	0	0	0	2.6
	Wheat/Soy	F1O15	-	0	0	0	-	-	0	0	0	0	-	-	0
Monthly irrigation based on long term average rainfall															
BJT1F2	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	3.2	6.5	5.4	4.4	-	-	-	-	19.5
	Soybean	J1O15	-	-	-	-		3.7	5.1	4.3	4.2	1.5	-	-	18.8
	Corn/Wheat	J1D15	-	-	-	-	3.2	6.5	5.3	4.4	-	3.3	1.8	0.2	24.7
	Wheat/Soy	F1O15	-	0	1.0	3.4	-	-	5.6	4.6	4	1.4	-	-	20
Monthly irrigation based on 20 percentile rainfall (dry year)															
BJT1F2	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	6.3	11.3	8.8	8.8	-	-	-	-	35.2
	Soybean	J1O15	-	-	-	-		7.6	8.8	8.8	7.6	3.8	-	-	36.6
	Corn/Wheat	J1D15	-	-	-	-	6.3	11.3	8.8	8.8	-	6.3	3.8	0	45.3
	Wheat/Soy	F1O15	-	0	1.3	6.3	-	-	10.1	8.8	7.6	3.8	-	-	37.9

Table 16.Monthly irrigation amounts for the Bolton Jones Agricultural T2F1 (priority 1 irrigation area). (Centimeters)

			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Monthly irrigation based on 90 percentile rainfall (wet year)															
BJT2F1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	1.3	2.5	1.3	0	-	-	-	-	5.1
	Soybean	J1O15	-	-	-	-	-	0	2.5	0	1.3	0	-	-	3.8
	Corn/Wheat	J1D15	-	-	-	-	1.3	2.5	1.3	0	-	0	0	0	5.1
	Wheat/Soy	F1O15	-	0	0	0	-	-	0	2.5	0	1.3	-	-	3.8
Monthly irrigation based on long term average rainfall															
BJT2F1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	5	7.6	6	4.7	-	-	-	-	23.3
	Soybean	J1O15	-	-	-	-		5.5	7	4.7	4.6	1.6	-	-	23.4
	Corn/Wheat	J1D15	-	-	-	-	5	7.5	6	4.7	-	3.9	2.4	0.4	29.9
	Wheat/Soy	F1O15	-	0	1.5	3.9	-	-	7.6	5.1	4.6	1.4	-	-	24.1
Monthly irrigation based on 20 percentile rainfall (dry year)															
BJT2F1	Trees	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Soybean	NOI	-	-	-	-	-	-	-	-	-	-	-	-	-
	Corn	J1A31	-	-	-	-	7.6	12.8	10.1	8.8	-	-	-	-	39.3
	Soybean	J1O15	-	-	-	-		7.6	12.6	8.8	8.8	3.8	-	-	41.6
	Corn/Wheat	J1D15	-	-	-	-	7.6	12.8	10.1	8.8	-	6.3	3.8	1.3	50.7
	Wheat/Soy	F1O15	-	0	3.8	7.6	-	-	12.6	10.1	8.8	2.5	-	-	45.4

Table HA.1a. Soil properties for the Johnston County Golf Club as taken from the Johnston County soil survey.

Golf Course							Values from soil survey					
							lower	upper		lower	lower	upper
							range	range		range	range	range
Symbol	Soil Type	surface	Bt	Taxonomic class	drainage	depth	Ks	Ks	depth	Ks	Ke	Ke
		texture	Family		class	inch	in/hr	in/hr	cm	cm/hr	cm/hr	cm/hr
CoB	Cowarts	LS	fine loamy	Typic Kanhapludults	WD	6	2.00	6.00	15.24	5.08		
						34	0.20	2.00	86.36	0.51	0.73	2.17
						69	0.06	0.60	175.26	0.15		
FaA	Faceville	SL	clayey	Typic Kandiudults	WD	13	6.00	20.00	33.02	15.24		
						65	0.60	2.00	165.1	1.52	4.27	19.69
GoA	Goldsboro	SL	fine loamy	Aquic Paleudults	MWD	8	2.00	6.00	20.32	5.08		
						26	0.60	2.00	66.04	1.52	1.96	3.69
						65	0.60	2.00	165.1	1.52		
NnB	Nason	SiL	clayey	Typic Hapludults	WD	4	0.60	2.00	10.16	1.52		
						45	0.60	2.00	114.3	1.52	1.52	3.42
						56	0.60	2.00	142.24	1.52		
NoB	Norfolk	SL	fine loamy	Typic Paleudults	WD	14	6.00	20.00	35.56	15.24		
						38	0.60	2.00	96.52	1.52	4.27	14.82
						70	0.60	2.00	177.8	1.52		
Pn	Pantego	L	fine loamy	Typic Unbraquults	VPD	26	2.00	6.00	66.04	5.08		
						72	0.60	2.00	182.88	1.52	2.81	12.40
Bb	Bibb	SL	coarse loamy	Typic Fluvaquents	PD	23	0.60	2.00	58.42	1.52		
						60	0.60	2.00	152.4	1.52	1.52	5.77
StA	State	LS	fine loamy	Typic Hapuldults	WD	9	0.60	6.00	22.86	1.52		
						32	0.60	2.00	81.28	1.52	3.18	6.28

						60	2.00	2.00	152.4	5.08		
UcC	Uchee	LCS	loamy	Arenic Kandiudults	WD	30	6.00	20.00	76.2	15.24		
						53	0.20	0.60	134.62	0.51	7.87	40.44
						60	0.20	2.00	152.4	0.51		
WaB	Wagram	LS	loamy	Arenic Kandiudults	WD	28	6.00	20.00	71.12	15.24		
						80	0.60	2.00	203.2	1.52	6.32	32.26

Table HA.2a. Soil properties for the Johnston County Landfill area (undisturbed) as taken from the Johnston County soil survey.

						Values from soil survey						
Landfill area										lower	lower	upper
							lower	upper			range	range
Symbol	Soil Type	surface	Bt	Order	drain	depth	Ks	Ks	depth	Kx	Ke	Ke
		texture	Family		class	inch	in/hr	in/hr	cm	cm/hr	cm/hr	cm/hr
Bb	Bibb	SL	coarse loamy	Typic Fluvaquents	PD	23	0.60	2.00	58.42	1.52		
						60	0.60	2.00	152.4	1.52	1.52	5.77
BoA	Bonneau	S	loamy	Arenic paleudults	WD	28	6.00	20.00	71.12	15.24		
						53	0.60	2.00	134.62	1.52	6.93	31.23
						71	0.60	2.00	180.34	1.52		
BnA	Blanton	S	loamy	Grossarenic	MWD	52	6.00	20.00	132.08	15.24		
				Paludults		97	0.20	2.00	246.38	0.51	8.41	46.85
CeB	Cecil	L	clayey	Typic Kanhapludults	WD	9	2.00	6.00	22.86	5.08		
						72	0.60	2.00	182.88	1.52	1.97	6.74
GeB/D	Gilead	SL	clayey	Aquic Hapludults	MWD	5	2.00	6.00	12.7	5.08		
						9	0.60	2.00	22.86	1.52	1.03	10.40
						29	0.06	6.00	73.66	0.15		
						38	0.20	0.60	96.52	0.51		
McB	Marboro	L	clayey	Typic Paleudults	WD	13	2.00	6.00	33.02	5.08		
						45	0.60	2.00	114.3	1.52	2.05	4.77
						88	0.60	2.00	223.52	1.52		
NnD	Nason	SiL	clayey	Typic Hapludults	WD	7	0.60	2.00	17.78	1.52		
						24	0.60	2.00	60.96	1.52	1.52	2.79
						45	0.60	2.00	114.3	1.52		
						>45	0.00	0.06				
NoB	Norfolk	SL	fine loamy	Typic Paleudults	WD	14	6.00	20.00	35.56	15.24		
						38	0.60	2.00	96.52	1.52	4.27	14.82

						70	0.60	2.00	177.8	1.52		
RnF	Rion	SL	fine loamy	Typic Hapludults	WD	8	2.00	6.00	20.32	5.08		
						32	0.60	2.00	81.28	1.52	3.66	6.62
						60	2.00	6.00	152.4	5.08		
StA	State	LS	fine loamy	Typic Hapuldults	WD	9	0.60	6.00	22.86	1.52		
						32	0.60	2.00	81.28	1.52	3.18	6.28
						60	2.00	2.00	152.4	5.08		
UcB	Uchee	LCS	loamy	Arenic Kandiudults	WD	30	6.00	20.00	76.2	15.24		
						41	0.20	0.60	104.14	0.51	7.87	36.44
						60	0.20	2.00	152.4	0.51		
UcC	Uchee	LCS	loamy	Arenic Kandiudults	WD	30	6.00	20.00	76.2	15.24		
						53	0.20	0.60	134.62	0.51	7.87	40.44
						60	0.20	2.00	152.4	0.51		
VrB	Varina	LS	clayey	Plinthic Paleudults	WD	13	6.00	20.00	33.02	15.24		
						41	0.60	2.00	104.14	1.52	3.76	15.03
						65	0.06	0.20	165.1	0.15		
Wt	Wehadkee	L	fine loamy	Typic fluvaquents	PD	7	2.00	6.00	17.78	5.08		
						63	-	-	160.02	#VALUE !		

Table HA.3a. Soil properties for the Bolton Jones tracts as taken from the Johnston County soil survey.

Bolton Tracts						Values from soil survey						
										lower	lower	upper
							lower	upper		range	range	range
Symbol	Soil Type	surface	Bt	Order	drain	depth	Ks	Ks	depth	Kx	Ke	Ke
		texture	Family		class	inch	in/hr	in/hr	cm	cm/hr	cm/hr	cm/hr
Tract 1												
GoA	Goldsboro	SL	fine loamy	Aquic Paleudults	MWD	8	2.00	6.00	20.32	5.08		
						26	0.60	2.00	66.04	1.52	1.96	3.69
						65	0.60	2.00	165.1	1.52		
Ra	Rains	SL	fine loamy	Typic Paleaquults	PD	5	2.00	6.00	12.7	5.08		
						44	0.60	2.00	111.76	1.52	1.73	5.88
						62	0.60	2.00	157.48	1.52		
						88	0.60	2.00	223.52	1.52		
WoB / D	Wedowee	SL	clayey	Typic Kanhapludults	WD	9	2.00	6.00	22.86	5.08		
						15	0.60	2.00	38.1	1.52	2.06	13.55
						32	0.60	2.00	81.28	1.52		
						60	0.60	2.00	152.4	1.52		
Tract 2												
VrA	Varina	LS	loamy	Plinthic Paleudults	WD	14	6.00	20.00	35.56	15.24		
						38	0.60	2.00	96.52	1.52	2.62	9.21
						99	0.06	2.00	251.46	0.15		

Table HA.2 Saturated hydraulic conductivity values as determined by the auger hole procedure for the Johnston county golf club and Bolton Jones tracts.

Hole #	gc1	gc2	gc3	gc4	gc5	gc6	gc7	gc8	gc9	gc10	b1	b2	b3	b4
Water table depth (WT)	21.0	18.0	16.0	0.0	5.0	8.0	46.0	34.0	0.0	10.0	15.0	15.0	20.0	silted in
Depth of hole (dep)	89.0	95.0	104.0	85.0	99.0	87.0	129.0	116.0	85.0	69.0	85.0	107.0	67.0	no reading
Diameter of hole (Dia)	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	-
First Reading after bailing (FR)	59.0	49.0	59.0	33.0	60.0	58.0	92.0	81.5	47.0	50.0	47.0	80.0	42.0	-
Hydraulic Head H = (dep-wt))	68.0	77.0	88.0	85.0	94.0	79.0	83.0	82.0	85.0	59.0	70.0	92.0	47.0	-
Initial Drawdown Yo = (FR-WT)	38.0	31.0	43.0	33.0	55.0	50.0	46.0	47.5	47.0	40.0	32.0	65.0	22.0	-
Delta Yo max = (Yo/4)	9.5	7.8	10.8	8.3	13.8	12.5	11.5	11.9	11.8	10.0	8.0	16.3	5.5	-
Last allow value LAV (FR-Yo/4)	49.5	41.3	48.3	24.8	46.3	45.5	80.5	69.6	35.3	40.0	39.0	63.8	36.5	-
Last value used (Y) (<=LAV)	49.5	40.5	47.0	24.0	48.0	45.5	80.0	70.0	31.0	39.0	39.3	64.0	36.5	-
time of last value (t)	135.0	30.0	30.0	20.0	120.0	90.0	150.0	180.0	20.0	20.0	40.0	70.0	60.0	-
delta y = (FR-Y)	9.5	8.5	12.0	9.0	12.0	12.5	12.0	11.5	16.0	11.0	7.8	16.0	5.5	-
Y average = (Yo - del y/2)	33.3	26.8	37.0	28.5	49.0	43.8	40.0	41.8	39.0	34.5	28.1	57.0	19.3	-
X = (Dia/10)	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	-
H' = (H/X)	59.1	67.0	76.5	73.9	81.7	68.7	72.2	71.3	73.9	51.3	60.9	80.0	40.9	-
Y' = (Yave/X)	28.9	23.3	32.2	24.8	42.6	38.0	34.8	36.3	33.9	30.0	24.5	49.6	16.7	-
S either =0 or > H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	>H/2	-
C (read from chart for H', Y', S)	16.0	16.5	12.0	14.0	9.0	11.2	11.5	11.5	12.0	17.5	17.0	8.5	30.0	-
K (m/d) = C*delta y / t	1.1	4.7	4.8	6.3	0.9	1.6	0.9	0.7	9.6	9.6	3.3	1.9	2.8	-
K (cm/hour)	4.7	19.5	20.0	26.3	3.8	6.5	3.8	3.1	40.0	40.1	13.7	8.1	11.5	-
K (inch/hour)	1.8	7.7	7.9	10.3	1.5	2.6	1.5	1.2	15.7	15.8	5.4	3.2	4.5	-

Table HA.3. Saturated hydraulic conductivity for the landfill caps as determined by the constant head permeameter in the lab.

core #	run 1	run 2	run 3	run 4	average		location	mean
	cm/sec	cm/sec	cm/sec	cm/sec	cm/sec	cm/hr		cm/hr
1144	0.00460	0.00514	0.00471	0.00449	0.00473	17.04510	4 top	
1021	0.00235	0.00300	0.00342	0.00310	0.00297	10.68930	4 top	
1126	0.00171	0.00128	0.00128	0.00107	0.00134	4.81500	4 top	10.8
1017	0.00899	0.00877	0.00835	0.00770	0.00845	30.43080	4 side	
1119	0.03379	0.03567	0.03379	0.03292	0.03404	122.55182	4 side	76.5
1044	0.00599	0.00578	0.00471	0.00407	0.00514	18.48960	3 top	
1069	0.00621	0.00642	0.00706	0.00877	0.00712	25.61580	3 top	
1147	0.00091	0.00107	0.00102	0.00150	0.00112	4.04460	3 top	16.1
1149	0.01198	0.01220	0.01220	0.01412	0.01263	45.45360	3 side	
1154	0.00621	0.00599	0.00428	0.00364	0.00503	18.10440	3 side	31.8
1016	0.00034	0.00048	0.00111	0.00107	0.00075	2.69961	1 top	
1092	0.00198	0.00203	0.00257	0.00337	0.00249	8.95590	1 top	
1004	0.01006	0.00984	0.00963	0.00813	0.00942	33.89760	1 top	15.2
1081	0.00428	0.00396	0.00310	0.00268	0.00350	12.61530	1 side	
1024	0.00114	0.00048	0.00021	0.00018	0.00050	1.81365	1 side	7.2

Table HA.4. Soil water characteristic values for the disturbed landfill caps as determined by the pressure plate method.

		Saturated												
		0.000	-3.75	-5.75	-8.75	-14	-34	-64	-104	-204	-404	-604	-5000	-15000
cap 1 top	1092	0.370	0.367	0.367	0.365	0.340	0.256	0.188	0.168	0.141	0.133	0.130	0.059	0.037
cap 1 top	1004	0.363	0.360	0.360	0.353	0.341	0.256	0.173	0.152	0.133	0.124	0.122	0.059	0.033
cap 1 side	1081	0.419	0.412	0.412	0.410	0.382	0.320	0.265	0.258	0.258	0.258	0.258	0.050	0.032
	mean 3	0.384	0.380	0.380	0.376	0.354	0.277	0.209	0.193	0.177	0.172	0.170	0.056	0.034
	mean top	0.367	0.364	0.364	0.359	0.341	0.256	0.181	0.160	0.137	0.128	0.126	0.059	0.035
cap 3 top	1147	0.286	0.284	0.284	0.284	0.284	0.216	0.183	0.169	0.168	0.167	0.167	0.060	0.034
cap 3 top	1069	0.403	0.400	0.400	0.397	0.353	0.255	0.191	0.168	0.153	0.148	0.147	0.069	0.055
cap 3 side	1149	0.416	0.402	0.402	0.388	0.359	0.277	0.214	0.194	0.176	0.168	0.163	0.065	0.051
	mean 3	0.368	0.362	0.362	0.357	0.332	0.250	0.196	0.177	0.166	0.161	0.159	0.065	0.046
	mean top	0.344	0.342	0.342	0.341	0.319	0.236	0.187	0.168	0.160	0.158	0.157	0.065	0.044
cap 4 top	1144	0.385	0.381	0.381	0.378	0.365	0.329	0.298	0.283	0.278	0.274	0.274	0.101	0.078
cap 4 top	1126	0.384	0.377	0.375	0.367	0.361	0.307	0.268	0.259	0.248	0.248	0.248	0.054	0.035
cap 4 side	1017	0.472	0.452	0.452	0.444	0.435	0.401	0.381	0.377	0.376	0.373	0.372	0.086	0.066
	mean 3	0.414	0.403	0.403	0.396	0.387	0.346	0.316	0.306	0.301	0.298	0.298	0.080	0.060
	mean top	0.384	0.379	0.378	0.373	0.363	0.318	0.283	0.271	0.263	0.261	0.261	0.077	0.056

Table HA.5a. Percolation and allowable irrigation rates during a wet year (10 YRI) for landfill field 1 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 1				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	16.74	8.16	15.18	6.60
Feb	10.30	3.30	-7.00	15.12	8.12	13.71	6.71
Mar	11.96	6.70	-5.26	16.74	11.48	15.18	9.92
Apr	9.00	10.60	1.60	16.20	17.80	14.69	16.29
May	10.90	12.30	1.40	16.74	18.14	15.18	16.58
Jun	12.43	13.50	1.07	16.20	17.27	14.69	15.75
Jul	16.22	13.40	-2.82	16.74	13.92	15.18	12.35
Aug	14.92	11.60	-3.32	16.74	13.42	15.18	11.86
Sep	10.90	9.30	-1.60	16.20	14.60	14.69	13.09
Oct	8.17	5.90	-2.27	16.74	14.47	15.18	12.91
Nov	8.29	3.40	-4.89	16.20	11.31	14.69	9.80
Dec	9.47	2.00	-7.47	16.74	9.27	15.18	7.70
total	133.35	94.20	-39.15	197.10	157.95	178.70	139.55

Table HA.5b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for landfill field 1 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 1				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	16.74	11.32	15.18	9.76
Feb	7.28	3.30	-3.98	15.12	11.14	13.71	9.73
Mar	8.46	6.70	-1.76	16.74	14.98	15.18	13.42
Apr	6.36	10.60	4.24	16.20	20.44	14.69	18.93
May	7.70	12.30	4.60	16.74	21.34	15.18	19.78
Jun	8.79	13.50	.4.71	16.20	20.91	14.69	19.40
Jul	11.47	13.40	1.93	16.74	18.67	15.18	17.11
Aug	10.55	11.60	1.05	16.74	17.79	15.18	16.23
Sep	7.70	9.30	1.60	16.20	17.80	14.69	16.29
Oct	5.78	5.90	0.12	16.74	16.86	15.18	15.30
Nov	5.86	3.40	-2.46	16.20	13.74	14.69	12.23
Dec	6.70	2.00	-4.70	16.74	12.04	15.18	10.48
Year	94.27	94.20	-0.07	197.10	197.03	178.70	178.63

Table HA.6a. Percolation and allowable irrigation rates during a wet year (10 YRI) for landfill field 2 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 2				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	16.74	8.16	15.18	6.60
Feb	10.30	3.30	-7.00	15.12	8.12	13.71	6.71
Mar	11.96	6.70	-5.26	16.74	11.48	15.18	9.92
Apr	9.00	10.60	1.60	16.20	17.80	14.69	16.29
May	10.90	12.30	1.40	16.74	18.14	15.18	16.58
Jun	12.43	13.50	1.07	16.20	17.27	14.69	15.75
Jul	16.22	13.40	-2.82	16.74	13.92	15.18	12.35
Aug	14.92	11.60	-3.32	16.74	13.42	15.18	11.86
Sep	10.90	9.30	-1.60	16.20	14.60	14.69	13.09
Oct	8.17	5.90	-2.27	16.74	14.47	15.18	12.91
Nov	8.29	3.40	-4.89	16.20	11.31	14.69	9.80
Dec	9.47	2.00	-7.47	16.74	9.27	15.18	7.70
total	133.35	94.20	-39.15	197.10	157.95	178.70	139.55

Table HA.6b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for landfill field 2 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 2				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	16.74	11.32	15.18	9.76
Feb	7.28	3.30	-3.98	15.12	11.14	13.71	9.73
Mar	8.46	6.70	-1.76	16.74	14.98	15.18	13.42
Apr	6.36	10.60	4.24	16.20	20.44	14.69	18.93
May	7.70	12.30	4.60	16.74	21.34	15.18	19.78
Jun	8.79	13.50	4.71	16.20	20.91	14.69	19.40
Jul	11.47	13.40	1.93	16.74	18.67	15.18	17.11
Aug	10.55	11.60	1.05	16.74	17.79	15.18	16.23
Sep	7.70	9.30	1.60	16.20	17.80	14.69	16.29
Oct	5.78	5.90	0.12	16.74	16.86	15.18	15.30
Nov	5.86	3.40	-2.46	16.20	13.74	14.69	12.23
Dec	6.70	2.00	-4.70	16.74	12.04	15.18	10.48
Year	94.27	94.20	-0.07	197.10	197.03	178.70	178.63

Table HA.7a. Percolation and allowable irrigation rates during a wet year (10 YRI) for landfill field 3 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 3				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	16.74	8.16	4.46	0.00
Feb	10.30	3.30	-7.00	15.12	8.12	4.03	0.00
Mar	11.96	6.70	-5.26	16.74	11.48	4.46	0.00
Apr	9.00	10.60	1.60	16.20	17.80	4.32	5.92
May	10.90	12.30	1.40	16.74	18.14	4.46	5.87
Jun	12.43	13.50	1.07	16.20	17.27	4.32	5.39
Jul	16.22	13.40	-2.82	16.74	13.92	4.46	1.64
Aug	14.92	11.60	-3.32	16.74	13.42	4.46	1.14
Sep	10.90	9.30	-1.60	16.20	14.60	4.32	2.72
Oct	8.17	5.90	-2.27	16.74	14.47	4.46	2.19
Nov	8.29	3.40	-4.89	16.20	11.31	4.32	0.00
Dec	9.47	2.00	-7.47	16.74	9.27	4.46	0.00
total	133.35	94.20	-39.15	197.10	157.95	52.56	24.87

Table HA.7b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for landfill field 3 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 3				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	16.74	11.32	4.46	0.00
Feb	7.28	3.30	-3.98	15.12	11.14	4.03	0.05
Mar	8.46	6.70	-1.76	16.74	14.98	4.46	2.70
Apr	6.36	10.60	4.24	16.20	20.44	4.32	8.56
May	7.70	12.30	4.60	16.74	21.34	4.46	9.06
Jun	8.79	13.50	4.71	16.20	20.91	4.32	9.03
Jul	11.47	13.40	1.93	16.74	18.67	4.46	6.39
Aug	10.55	11.60	1.05	16.74	17.79	4.46	5.51
Sep	7.70	9.30	1.60	16.20	17.80	4.32	5.92
Oct	5.78	5.90	0.12	16.74	16.86	4.46	4.58
Nov	5.86	3.40	-2.46	16.20	13.74	4.32	1.86
Dec	6.70	2.00	-4.70	16.74	12.04	4.46	0.00
Year	94.27	94.20	-0.07	197.10	197.03	52.56	53.68

Table HA.8a. Percolation and allowable irrigation rates during a wet year (10 YRI) for landfill field 4 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 4				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	16.74	8.16	15.18	6.60
Feb	10.30	3.30	-7.00	15.12	8.12	13.71	6.71
Mar	11.96	6.70	-5.26	16.74	11.48	15.18	9.92
Apr	9.00	10.60	1.60	16.20	17.80	14.69	16.29
May	10.90	12.30	1.40	16.74	18.14	15.18	16.58
Jun	12.43	13.50	1.07	16.20	17.27	14.69	15.75
Jul	16.22	13.40	-2.82	16.74	13.92	15.18	12.35
Aug	14.92	11.60	-3.32	16.74	13.42	15.18	11.86
Sep	10.90	9.30	-1.60	16.20	14.60	14.69	13.09
Oct	8.17	5.90	-2.27	16.74	14.47	15.18	12.91
Nov	8.29	3.40	-4.89	16.20	11.31	14.69	9.80
Dec	9.47	2.00	-7.47	16.74	9.27	15.18	7.70
total	133.35	94.20	-39.15	197.10	157.95	178.70	139.55

Table HA.8b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for landfill field 4 based on the 1981 EPA procedure. (Centimeters)

Landfill, field 4				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	16.74	11.32	15.18	9.76
Feb	7.28	3.30	-3.98	15.12	11.14	13.71	9.73
Mar	8.46	6.70	-1.76	16.74	14.98	15.18	13.42
Apr	6.36	10.60	4.24	16.20	20.44	14.69	18.93
May	7.70	12.30	4.60	16.74	21.34	15.18	19.78
Jun	8.79	13.50	4.71	16.20	20.91	14.69	19.40
Jul	11.47	13.40	1.93	16.74	18.67	15.18	17.11
Aug	10.55	11.60	1.05	16.74	17.79	15.18	16.23
Sep	7.70	9.30	1.60	16.20	17.80	14.69	16.29
Oct	5.78	5.90	0.12	16.74	16.86	15.18	15.30
Nov	5.86	3.40	-2.46	16.20	13.74	14.69	12.23
Dec	6.70	2.00	-4.70	16.74	12.04	15.18	10.48
Year	94.27	94.20	-0.07	197.10	197.03	178.70	178.63

Table HA.9a. Percolation and allowable irrigation rates during a wet year (10 YRI) for Johnston county golf course based on the 1981 EPA procedure. (Centimeters)

Golf course				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	1.87	0.00	15.18	6.60
Feb	10.30	3.30	-7.00	1.69	0.00	13.71	6.71
Mar	11.96	6.70	-5.26	1.87	0.00	15.18	9.92
Apr	9.00	10.60	1.60	1.81	3.41	14.69	16.29
May	10.90	12.30	1.40	1.87	3.28	15.18	16.58
Jun	12.43	13.50	1.07	1.81	2.88	14.69	15.75
Jul	16.22	13.40	-2.82	1.87	0.00	15.18	12.35
Aug	14.92	11.60	-3.32	1.87	0.00	15.18	11.86
Sep	10.90	9.30	-1.60	1.81	0.22	14.69	13.09
Oct	8.17	5.90	-2.27	1.87	0.00	15.18	12.91
Nov	8.29	3.40	-4.89	1.81	0.00	14.69	9.80
Dec	9.47	2.00	-7.47	1.87	0.00	15.18	7.70
total	133.35	94.20	-39.15	22.05	9.78	178.70	139.55

Table HA.9b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for Johnston county golf course based on the 1981 EPA procedure. (Centimeters)

Golf course				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	1.87	0.00	15.18	9.76
Feb	7.28	3.30	-3.98	1.69	0.00	13.71	9.73
Mar	8.46	6.70	-1.76	1.87	0.00	15.18	13.42
Apr	6.36	10.60	4.24	1.81	6.05	14.69	18.93
May	7.70	12.30	4.60	1.87	6.47	15.18	19.78
Jun	8.79	13.50	4.71	1.81	6.52	14.69	19.40
Jul	11.47	13.40	1.93	1.87	0.00	15.18	17.11
Aug	10.55	11.60	1.05	1.87	0.00	15.18	16.23
Sep	7.70	9.30	1.60	1.81	3.41	14.69	16.29
Oct	5.78	5.90	0.12	1.87	0.00	15.18	15.30
Nov	5.86	3.40	-2.46	1.81	0.00	14.69	12.23
Dec	6.70	2.00	-4.70	1.87	0.00	15.18	10.48
Year	94.27	94.20	-0.07	22.05	22.46	178.70	178.63

Table HA.10a. Percolation and allowable irrigation rates during a wet year (10 YRI) for Bolton Jones Tract 1, Field 1 based on the 1981 EPA procedure. (Centimeters)

Bolton Jones Tract 1 Field 1				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	6.89	0.00	44.94	36.36
Feb	10.30	3.30	-7.00	6.23	0.00	40.59	33.59
Mar	11.96	6.70	-5.26	6.89	1.63	44.94	39.68
Apr	9.00	10.60	1.60	6.67	8.27	43.49	45.09
May	10.90	12.30	1.40	6.89	8.30	44.94	46.34
Jun	12.43	13.50	1.07	6.67	7.74	43.49	44.55
Jul	16.22	13.40	-2.82	6.89	4.07	44.94	42.11
Aug	14.92	11.60	-3.32	6.89	3.57	44.94	41.62
Sep	10.90	9.30	-1.60	6.67	5.08	43.49	41.89
Oct	8.17	5.90	-2.27	6.89	4.62	44.94	42.67
Nov	8.29	3.40	-4.89	6.67	1.78	43.49	38.60
Dec	9.47	2.00	-7.47	6.89	0.00	44.94	37.46
total	133.35	94.20	-39.15	81.18	45.06	529.10	489.95

Table HA.10b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for Bolton Jones Tract 1 Field 1 based on the 1981 EPA procedure. (Centimeters)

Bolton Jones Tract 1 Field 1				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	6.89	0.00	44.94	39.52
Feb	7.28	3.30	-3.98	6.23	0.00	40.59	36.61
Mar	8.46	6.70	-1.76	6.89	5.13	44.94	43.18
Apr	6.36	10.60	4.24	6.67	10.91	43.49	47.73
May	7.70	12.30	4.60	6.89	11.49	44.94	49.54
Jun	8.79	13.50	4.71	6.67	11.38	43.49	48.20
Jul	11.47	13.40	1.93	6.89	8.82	44.94	46.87
Aug	10.55	11.60	1.05	6.89	7.94	44.94	45.99
Sep	7.70	9.30	1.60	6.67	8.27	43.49	45.09
Oct	5.78	5.90	0.12	6.89	7.01	44.94	45.06
Nov	5.86	3.40	-2.46	6.67	4.21	43.49	41.03
Dec	6.70	2.00	-4.70	6.89	0.00	44.94	40.24
Year	94.27	94.20	-0.07	81.18	75.19	529.10	529.03

Table HA.11a. Percolation and allowable irrigation rates during a wet year (10 YRI) for Bolton Jones Tract 1 Field 2 based on the 1981 EPA procedure. (Centimeters)

Bolton Jones Tract 1 Field 2				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	9.80	1.22	15.18	6.60
Feb	10.30	3.30	-7.00	8.85	1.84	13.71	6.71
Mar	11.96	6.70	-5.26	9.80	4.53	15.18	9.92
Apr	9.00	10.60	1.60	9.48	11.08	14.69	16.29
May	10.90	12.30	1.40	9.80	11.20	15.18	16.58
Jun	12.43	13.50	1.07	9.48	10.55	14.69	15.75
Jul	16.22	13.40	-2.82	9.80	6.97	15.18	12.35
Aug	14.92	11.60	-3.32	9.80	6.47	15.18	11.86
Sep	10.90	9.30	-1.60	9.48	7.88	14.69	13.09
Oct	8.17	5.90	-2.27	9.80	7.52	15.18	12.91
Nov	8.29	3.40	-4.89	9.48	4.59	14.69	9.80
Dec	9.47	2.00	-7.47	9.80	2.32	15.18	7.70
total	133.35	94.20	-39.15	115.34	76.19	178.70	139.55

Table HA.11b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for Bolton Jones Tract 1 Field 2 based on the 1981 EPA procedure. (Centimeters)

Bolton Jones Tract 1 Field 2				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	9.80	4.38	15.18	9.76
Feb	7.28	3.30	-3.98	8.85	4.87	13.71	9.73
Mar	8.46	6.70	-1.76	9.80	8.04	15.18	13.42
Apr	6.36	10.60	4.24	9.48	13.72	14.69	18.93
May	7.70	12.30	4.60	9.80	14.40	15.18	19.78
Jun	8.79	13.50	4.71	9.48	14.19	14.69	19.40
Jul	11.47	13.40	1.93	9.80	11.73	15.18	17.11
Aug	10.55	11.60	1.05	9.80	10.85	15.18	16.23
Sep	7.70	9.30	1.60	9.48	11.08	14.69	16.29
Oct	5.78	5.90	0.12	9.80	9.92	15.18	15.30
Nov	5.86	3.40	-2.46	9.48	7.02	14.69	12.23
Dec	6.70	2.00	-4.70	9.80	5.10	15.18	10.48
Year	94.27	94.20	-0.07	115.34	115.27	178.70	178.63

Table HA.12a. Percolation and allowable irrigation rates during a wet year (10 YRI) for Bolton Jones Tract 2 Field 1 based on the 1981 EPA procedure. (Centimeters)

Bolton Jones Tract 2 Field 1				Estimated	Permissible	Estimated	Permissible
	10 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	wet year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	10.78	2.20	-8.58	11.04	2.46	4.46	0.00
Feb	10.30	3.30	-7.00	9.97	2.96	4.03	0.00
Mar	11.96	6.70	-5.26	11.04	5.77	4.46	0.00
Apr	9.00	10.60	1.60	10.68	12.28	4.32	5.92
May	10.90	12.30	1.40	11.04	12.44	4.46	5.87
Jun	12.43	13.50	1.07	10.68	11.75	4.32	5.39
Jul	16.22	13.40	-2.82	11.04	8.21	4.46	1.64
Aug	14.92	11.60	-3.32	11.04	7.71	4.46	1.14
Sep	10.90	9.30	-1.60	10.68	9.08	4.32	2.72
Oct	8.17	5.90	-2.27	11.04	8.76	4.46	2.19
Nov	8.29	3.40	-4.89	10.68	5.79	4.32	0.00
Dec	9.47	2.00	-7.47	11.04	3.56	4.46	0.00
total	133.35	94.20	-39.15	129.94	90.79	52.56	24.87

Table HA.12b. Percolation and allowable irrigation rates during a dry year (20 percentile rainfall) for Bolton Jones Tract 2 Field 1 based on the 1981 EPA procedure. (Centimeters)

Bolton Jones Tract 2 Field 1				Estimated	Permissible	Estimated	Permissible
	5 YRI rainfall	PET	net ET	percolation	Loading EPA	percolation	Loading EPA
	dry year			in situ CHP	in situ CHP	soil survey	soil survey
Jan	7.62	2.20	-5.42	11.04	5.62	4.46	0.00
Feb	7.28	3.30	-3.98	9.97	5.99	4.03	0.05
Mar	8.46	6.70	-1.76	11.04	9.28	4.46	2.70
Apr	6.36	10.60	4.24	10.68	14.92	4.32	8.56
May	7.70	12.30	4.60	11.04	15.64	4.46	9.06
Jun	8.79	13.50	4.71	10.68	15.39	4.32	9.03
Jul	11.47	13.40	1.93	11.04	12.97	4.46	6.39
Aug	10.55	11.60	1.05	11.04	12.09	4.46	5.51
Sep	7.70	9.30	1.60	10.68	12.28	4.32	5.92
Oct	5.78	5.90	0.12	11.04	11.16	4.46	4.58
Nov	5.86	3.40	-2.46	10.68	8.22	4.32	1.86
Dec	6.70	2.00	-4.70	11.04	6.34	4.46	0.00
Year	94.27	94.20	-0.07	129.94	129.87	52.56	53.68

Table HA.13. Baseline annual water balance for landfill field 1. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	101.8	97.6	0	0	8.1	20.9	29
1951	82.4	82.4	81.5	0	0	2.3	10.7	13
1952	118.3	118.3	77.7	0	0	5.6	16.1	21.7
1953	113.2	113.2	87.9	0	0	6.9	18.4	25.3
1954	88.2	88.2	66.6	0	0	7.2	19.1	26.3
1955	103	103	81.1	0	0	5.6	16.1	21.7
1956	116.9	116.9	78.2	0	0	7.9	20.4	28.2
1957	114.2	114.2	82.1	0	0	7.6	19.9	27.5
1958	125.8	122.2	87	4.1	3.6	9.8	24.6	38.5
1959	155.3	143.9	91.4	4.7	11.4	10.8	26.7	42.1
1960	124.4	116.3	83.8	6.6	8.1	10.4	25.9	42.9
1961	105.4	105.4	81.4	0	0	8.9	22.6	31.5
1962	113.3	113.3	82.8	0	0	7.8	20.3	28.1
1963	109.7	109.7	80	0	0	7.8	20.2	28
1964	146.1	130.6	79.5	1.8	15.6	9.8	24.6	36.2
1965	95.5	94.7	84.9	2.6	0.8	9.7	24.2	36.5
1966	118.5	118.5	84	0	0.1	7.8	20.2	28.1
1967	131.1	128.3	76.2	0.6	2.8	8.7	22.2	31.5
1968	109.8	106.6	82.2	2.6	3.3	9.3	23.3	35.1
1969	104.8	104.5	81.7	0.4	0.3	8.5	21.7	30.6
1970	88.2	88.2	69.9	0	0	6.8	18.2	25
1971	117.9	117.9	86.9	0	0	7.7	20.1	27.8
1972	121.7	121.7	87.2	0	0	6.7	18.1	24.8
1973	106.2	106.2	88.5	0	0	6.8	18.4	25.2
1974	113	113	92.8	0	0	5.8	16.4	22.2
1975	133.7	133.7	93.2	0	0	9	22.7	31.6
1976	93.3	93.3	71.6	0	0	6.9	18.6	25.6
1977	120.7	120.1	82.5	0	0.5	8.3	21.2	29.5
1978	120.7	117	87.4	3.4	3.7	9.5	24	36.9
1979	133.4	133.3	88	0	0	10.1	25	35.2
1980	96.8	94.1	68.9	3.1	2.7	8.9	22.7	34.7
1981	76.5	76.5	62.9	0	0	5.6	16	21.6
1982	129.8	129.8	91.6	0	0	8.1	20.7	28.8
1983	121.8	117	75.4	4	4.8	9.4	23.6	37
1984	131.8	124.3	90.6	5.4	7.5	10.6	26.3	42.4
1985	79.5	79.5	66.9	0	0	6.2	17.3	23.5
1986	97.2	97.2	73.7	0	0	3.5	12.5	16
1987	108.5	102.2	71.4	2.4	6.2	8.5	21.8	32.6
1988	92.5	92.5	72.5	0	0	6.1	16.9	22.9
1989	156.1	152.3	91.2	1.7	3.8	9.9	24.8	36.4
1990	91.8	91.8	89.1	0	0	7.4	19.5	26.9
1991	125.4	125.4	95.6	0	0	6.8	18.2	25
1992	131.8	131.8	81.7	0.1	0	8.2	21	29.3
1993	112.3	103.4	69.8	7.8	8.9	9.6	24.1	41.5
1994	94.3	90.8	85.3	1.4	3.5	8.2	21.3	30.9
1995	115.1	115.1	83.6	0	0	6.8	18.2	25
AVG	112.8	110.9	81.9	1.1	1.9	7.9	20.6	29.6

Table HA.14. Baseline annual water balance for landfill field 2. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	101.8	78.3	0.0	0.0	15.2	29.4	44.6
1951	82.4	82.4	64.7	0.0	0.0	7.3	20.1	27.4
1952	118.3	118.3	67.4	0.0	0.0	12.1	25.5	37.6
1953	113.2	111.6	66.3	0.0	1.6	14.2	28.0	42.2
1954	88.2	88.2	57.3	0.0	0.0	13.0	26.8	39.8
1955	103.0	103.0	66.7	0.0	0.0	10.5	23.7	34.2
1956	116.9	116.9	64.5	0.0	0.0	14.8	28.9	43.7
1957	114.2	114.2	70.8	0.0	0.0	13.4	27.1	40.6
1958	125.8	124.4	78.2	0.6	1.5	16.6	31.2	48.4
1959	155.3	141.2	83.1	1.0	14.1	17.9	32.9	51.7
1960	124.4	118.9	74.2	1.2	5.5	18.2	33.4	52.8
1961	105.4	105.4	66.8	0.0	0.0	14.8	28.9	43.8
1962	113.3	113.3	67.9	0.0	0.0	14.2	28.1	42.3
1963	109.7	109.7	67.4	0.0	0.0	14.0	27.8	41.8
1964	146.1	131.7	69.8	0.3	14.4	16.7	31.3	48.3
1965	95.5	94.5	67.5	0.2	1.0	16.8	31.6	48.6
1966	118.5	117.7	67.5	0.0	0.8	14.7	28.6	43.3
1967	131.1	124.1	62.9	0.5	7.0	16.5	31.0	47.9
1968	109.8	108.3	66.1	0.2	1.5	17.0	31.7	48.9
1969	104.8	104.8	70.5	0.0	0.0	14.7	28.7	43.3
1970	88.2	88.2	59.1	0.0	0.0	11.1	24.4	35.5
1971	117.9	117.9	68.6	0.0	0.0	14.2	28.0	42.2
1972	121.7	121.7	72.5	0.0	0.0	13.7	27.5	41.2
1973	106.2	106.2	73.7	0.0	0.0	12.7	26.4	39.0
1974	113.0	113.0	76.0	0.0	0.0	13.0	26.5	39.5
1975	133.7	132.5	77.4	0.1	1.1	16.3	30.7	47.0
1976	93.3	93.3	54.8	0.0	0.0	14.1	28.0	42.2
1977	120.7	119.3	66.9	0.0	1.4	15.3	29.5	44.9
1978	120.7	116.9	76.7	0.8	3.8	16.6	31.3	48.6
1979	133.4	132.8	78.2	0.0	0.5	16.8	31.4	48.2
1980	96.8	96.8	62.0	0.0	0.0	14.8	28.9	43.7
1981	76.5	76.5	52.6	0.0	0.0	7.9	20.9	28.7
1982	129.8	129.0	75.1	0.0	0.8	14.7	28.6	43.3
1983	121.8	117.1	67.6	0.8	4.7	15.9	30.4	47.1
1984	131.8	123.3	77.6	1.4	8.5	18.2	33.3	53.0
1985	79.5	79.5	56.3	0.0	0.0	10.2	23.5	33.7
1986	97.2	97.0	62.3	0.0	0.3	6.8	19.7	26.5
1987	108.5	103.2	63.9	0.5	5.3	14.1	28.2	42.8
1988	92.5	92.5	57.7	0.0	0.0	11.6	24.9	36.6
1989	156.1	150.0	80.3	0.3	6.1	17.4	32.3	49.9
1990	91.8	91.8	73.2	0.0	0.0	12.9	26.5	39.4
1991	125.4	125.4	71.8	0.0	0.0	14.3	28.3	42.6
1992	131.8	131.8	71.3	0.0	0.0	15.9	30.2	46.1
1993	112.3	103.0	63.5	2.1	9.3	16.4	31.0	49.5
1994	94.3	94.3	71.7	0.1	0.0	13.9	27.9	41.8
1995	115.1	115.1	66.2	0.0	0.0	13.5	27.2	40.7
AVG	112.8	110.8	68.6	0.2	1.9	14.2	28.3	42.7

Table HA.15. Baseline annual water balance for landfill field 3. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	101.8	96.1	0.0	0.0	8.6	8.8	17.4
1951	82.4	82.4	80.2	0.0	0.0	4.7	6.3	11.0
1952	118.3	118.2	81.3	0.1	0.0	8.4	8.7	17.1
1953	113.2	107.9	92.3	0.4	5.2	9.6	9.5	19.5
1954	88.2	80.2	68.4	0.2	8.1	8.3	8.6	17.2
1955	103.0	100.1	80.0	0.1	2.9	8.0	8.4	16.5
1956	116.9	109.0	81.0	0.6	7.9	11.3	10.7	22.5
1957	114.2	104.3	82.4	0.8	9.4	9.3	9.3	19.3
1958	125.8	105.7	85.3	1.4	20.7	10.7	10.2	22.3
1959	155.3	115.1	88.8	1.8	40.2	11.9	11.2	24.9
1960	124.4	101.7	82.4	1.6	22.7	11.1	10.5	23.2
1961	105.4	97.0	81.2	0.9	8.5	9.9	9.7	20.5
1962	113.3	107.2	81.8	0.7	6.0	9.6	9.5	19.8
1963	109.7	102.7	81.1	1.1	7.0	9.8	9.6	20.4
1964	146.1	102.4	77.2	1.7	43.4	10.8	10.4	22.9
1965	95.5	84.7	82.4	1.1	11.0	10.2	9.9	21.1
1966	118.5	112.4	86.7	0.2	6.2	9.1	9.1	18.4
1967	131.1	110.6	78.5	0.7	19.6	10.2	9.9	20.7
1968	109.8	103.8	83.4	0.7	7.0	10.5	10.1	21.3
1969	104.8	93.3	78.5	1.0	11.6	9.6	9.5	20.2
1970	88.2	84.7	72.5	0.5	3.5	8.8	8.9	18.2
1971	117.9	108.7	86.5	0.6	9.2	9.5	9.4	19.5
1972	121.7	117.2	87.9	0.1	3.6	10.0	9.7	19.8
1973	106.2	96.0	86.8	0.8	11.2	7.8	8.3	16.8
1974	113.0	113.0	95.0	0.0	0.0	8.0	8.4	16.4
1975	133.7	115.8	92.5	1.0	17.9	10.3	10.0	21.3
1976	93.3	86.9	71.0	0.2	6.4	7.7	8.2	16.2
1977	120.7	104.3	79.5	0.9	15.5	9.9	9.7	20.5
1978	120.7	101.1	85.8	1.9	20.4	9.9	9.7	21.5
1979	133.4	116.9	88.0	1.3	16.4	11.4	10.7	23.4
1980	96.8	83.5	66.7	1.6	13.3	9.5	9.4	20.5
1981	76.5	76.5	62.6	0.0	0.0	8.0	8.4	16.3
1982	129.8	119.7	91.4	1.2	10.2	10.7	10.2	22.1
1983	121.8	95.9	73.3	1.7	25.9	10.4	10.1	22.1
1984	131.8	100.8	89.7	1.8	31.0	11.1	10.6	23.5
1985	79.5	79.5	68.2	0.0	0.0	7.2	7.9	15.1
1986	97.2	96.3	71.8	0.0	0.9	6.0	7.1	13.1
1987	108.5	80.9	69.3	1.2	27.6	9.2	9.3	19.8
1988	92.5	92.5	72.4	0.0	0.0	8.3	8.6	16.9
1989	156.1	125.6	91.2	1.7	30.2	11.9	11.1	24.7
1990	91.8	90.8	87.7	0.2	1.2	7.9	8.4	16.5
1991	125.4	124.7	97.3	0.1	0.6	9.4	9.3	18.8
1992	131.8	112.6	83.9	1.7	18.6	11.3	10.7	23.8
1993	112.3	89.9	67.6	2.0	22.1	10.3	10.0	22.2
1994	94.3	80.6	83.4	1.5	14.7	8.8	9.0	19.3
1995	115.1	115.1	88.3	0.1	0.0	8.7	8.9	17.7
AVG	112.7	101.08	81.7	0.8	11.7	9.4	9.4	19.6

Table HA.16. Baseline annual water balance for landfill field 4. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	101.8	97.5	0.0	0.0	11.7	19.4	31.0
1951	82.4	82.4	81.5	0.0	0.0	2.4	10.1	12.5
1952	118.3	118.3	77.6	0.0	0.0	7.5	15.3	22.8
1953	113.2	113.2	87.5	0.0	0.0	9.3	16.9	26.2
1954	88.2	88.2	65.6	0.0	0.0	9.7	17.3	27.0
1955	103.0	103.0	81.1	0.0	0.0	7.2	15.0	22.2
1956	116.9	116.9	78.1	0.0	0.0	10.6	18.2	28.8
1957	114.2	114.2	80.9	0.0	0.0	10.3	17.9	28.2
1958	125.8	122.7	87.0	0.9	3.1	14.4	22.2	37.5
1959	155.3	143.8	91.5	1.2	11.5	16.0	23.9	41.0
1960	124.4	113.3	83.7	2.2	11.1	15.5	23.4	41.2
1961	105.4	105.4	80.9	0.0	0.0	12.6	20.3	32.9
1962	113.3	113.3	81.0	0.0	0.0	11.0	18.5	29.5
1963	109.7	109.7	79.3	0.0	0.0	10.9	18.5	29.4
1964	146.1	132.2	77.8	0.4	13.9	14.2	22.0	36.6
1965	95.5	94.1	84.2	1.2	1.3	14.4	22.2	37.9
1966	118.5	118.5	83.6	0.0	0.0	11.1	18.7	29.8
1967	131.1	130.9	75.9	0.1	0.3	12.4	20.1	32.7
1968	109.8	105.4	81.8	0.5	4.4	13.6	21.3	35.4
1969	104.8	104.8	80.7	0.0	0.0	12.2	19.8	32.1
1970	88.2	88.2	69.5	0.0	0.0	9.2	16.9	26.1
1971	117.9	117.9	85.5	0.0	0.0	10.8	18.3	29.1
1972	121.7	121.7	87.1	0.0	0.0	8.8	16.5	25.3
1973	106.2	106.2	86.3	0.0	0.0	9.4	17.1	26.5
1974	113.0	113.0	92.7	0.0	0.0	7.5	15.3	22.8
1975	133.7	133.7	91.4	0.0	0.0	12.6	20.2	32.8
1976	93.3	93.3	70.3	0.0	0.0	9.7	17.4	27.1
1977	120.7	120.2	81.2	0.0	0.4	11.7	19.3	31.0
1978	120.7	117.6	87.3	0.8	3.0	14.1	21.9	36.7
1979	133.4	133.4	87.3	0.0	0.0	14.4	22.1	36.5
1980	96.8	94.1	68.8	0.6	2.7	13.0	20.8	34.4
1981	76.5	76.5	62.7	0.0	0.0	7.3	15.2	22.5
1982	129.8	129.8	91.6	0.0	0.0	11.1	18.7	29.8
1983	121.8	118.3	75.3	1.2	3.5	13.7	21.5	36.3
1984	131.8	122.6	90.4	1.5	9.2	15.7	23.7	40.9
1985	79.5	79.5	66.4	0.0	0.0	8.6	16.3	24.9
1986	97.2	97.2	73.7	0.0	0.0	4.0	12.3	16.3
1987	108.5	103.9	71.4	0.6	4.6	12.4	20.1	33.1
1988	92.5	92.5	72.5	0.0	0.0	8.1	15.9	24.0
1989	156.1	154.1	91.2	0.2	2.0	14.2	22.0	36.4
1990	91.8	91.8	88.8	0.0	0.0	10.5	18.2	28.6
1991	125.4	125.4	95.5	0.0	0.0	9.2	16.8	26.0
1992	131.8	131.8	81.4	0.0	0.0	11.1	18.7	29.8
1993	112.3	102.2	69.8	2.4	10.1	14.2	22.1	38.7
1994	94.3	92.0	85.2	0.4	2.3	11.9	19.7	32.1
1995	115.1	115.1	83.4	0.0	0.0	9.4	17.1	26.5
AVG	112.8	111.0	81.4	0.3	1.8	11.1	18.8	30.2

Table HA.17. Baseline annual water balance for Johnston county golf course. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	100.7	84.0	0.0	1.1	8.6	19.6	28.2
1951	82.4	82.4	69.3	0.0	0.0	5.4	13.9	19.3
1952	118.3	115.1	75.2	0.5	3.2	8.1	18.6	27.2
1953	113.2	105.8	76.9	0.3	7.4	8.9	20.1	29.3
1954	88.2	81.0	61.3	0.4	7.2	7.8	18.2	26.4
1955	103.0	102.0	74.2	0.1	1.0	7.5	17.5	25.1
1956	116.9	112.6	73.4	0.8	4.3	10.2	22.7	33.7
1957	114.2	111.4	77.1	1.1	2.8	8.6	19.6	29.3
1958	125.8	110.4	80.2	2.7	15.5	9.8	21.9	34.5
1959	155.3	125.7	84.5	2.8	29.7	11.0	24.3	38.2
1960	124.4	108.3	76.6	3.3	16.2	10.6	23.5	37.4
1961	105.4	102.2	75.0	0.6	3.2	9.0	20.5	30.1
1962	113.3	111.3	76.7	1.0	1.9	9.1	20.5	30.6
1963	109.7	107.4	73.7	1.0	2.3	9.4	21.1	31.5
1964	146.1	112.5	73.0	3.3	33.6	10.1	22.6	36.0
1965	95.5	86.0	69.1	2.1	9.5	9.8	22.0	33.9
1966	118.5	110.8	73.3	0.5	7.8	9.0	20.2	29.7
1967	131.1	112.6	68.6	1.7	18.5	10.1	22.3	34.0
1968	109.8	103.5	74.1	1.3	6.3	10.1	22.3	33.7
1969	104.8	98.9	74.5	1.3	6.0	8.7	19.9	29.9
1970	88.2	87.9	67.0	0.0	0.3	7.7	17.9	25.6
1971	117.9	112.0	78.9	0.6	5.9	8.8	19.9	29.2
1972	121.7	121.4	81.3	0.0	0.1	9.1	20.4	29.5
1973	106.2	97.7	76.8	1.5	8.7	7.8	18.4	27.7
1974	113.0	109.7	84.2	0.3	3.4	8.2	18.8	27.3
1975	133.7	120.1	83.7	1.5	13.6	9.7	21.8	33.0
1976	93.3	88.5	60.1	0.5	4.8	8.4	19.3	28.2
1977	120.7	109.6	72.7	1.4	11.1	9.5	21.4	32.2
1978	120.7	104.2	77.6	2.9	16.4	9.5	21.5	34.0
1979	133.4	121.8	83.3	1.2	11.5	10.5	23.2	35.0
1980	96.8	90.1	63.5	2.1	6.6	8.8	20.1	31.0
1981	76.5	76.5	55.8	0.0	0.0	6.5	15.8	22.3
1982	129.8	123.6	83.9	1.6	6.3	9.8	22.0	33.4
1983	121.8	103.9	68.3	3.0	17.9	9.5	21.4	33.8
1984	131.8	106.3	79.9	3.5	25.5	10.4	23.1	37.0
1985	79.5	79.5	60.7	0.0	0.0	6.7	16.3	23.0
1986	97.2	95.5	65.9	0.0	1.7	5.5	14.2	19.6
1987	108.5	86.9	63.2	2.4	21.6	8.5	19.6	30.4
1988	92.5	92.5	63.5	0.0	0.0	8.3	18.9	27.1
1989	156.1	136.5	88.4	2.6	19.6	11.1	24.4	38.0
1990	91.8	91.7	78.2	0.2	0.1	8.0	18.5	26.8
1991	125.4	119.6	81.1	0.8	5.8	9.3	20.8	30.8
1992	131.8	122.1	79.4	2.0	9.7	10.6	23.5	36.0
1993	112.3	97.4	64.7	2.9	14.9	9.4	21.2	33.5
1994	94.3	85.1	73.5	2.7	9.2	8.4	19.5	30.5
1995	115.1	112.4	76.7	0.4	2.7	8.8	19.9	29.1
AVG	112.8	104.2	74.0	1.3	8.6	8.9	20.3	30.5

Table HA.18. Baseline annual water balance for Bolton Jones Tract 1 Field 1.(Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	100.8	100.0	0.0	1.1	5.2	6.8	12.0
1951	82.4	82.3	83.6	0.0	0.1	3.6	5.1	8.7
1952	118.3	118.3	85.5	0.0	0.0	4.9	6.5	11.4
1953	113.2	105.0	97.1	1.5	8.1	5.4	7.1	13.9
1954	88.2	80.5	72.8	0.7	7.7	4.9	6.6	12.2
1955	103.0	101.0	83.5	0.2	2.1	4.8	6.4	11.3
1956	116.9	106.6	85.3	2.1	10.3	6.0	7.9	16.0
1957	114.2	103.7	87.3	2.7	10.4	5.3	7.0	15.0
1958	125.8	103.7	87.0	3.5	22.2	5.9	7.7	17.1
1959	155.3	113.0	92.9	5.9	42.3	6.3	8.2	20.4
1960	124.4	101.8	87.3	2.9	22.7	6.0	7.9	16.7
1961	105.4	94.1	86.3	2.9	11.4	5.6	7.4	15.9
1962	113.3	107.4	87.8	2.1	5.9	5.2	6.9	14.3
1963	109.7	103.5	85.7	2.3	6.2	5.4	7.1	14.7
1964	146.1	101.6	81.4	4.3	44.5	5.8	7.7	17.8
1965	95.5	84.7	90.3	2.7	10.7	5.6	7.4	15.6
1966	118.5	110.7	86.7	0.4	7.9	5.3	7.0	12.7
1967	131.1	109.4	83.3	2.8	21.3	5.7	7.5	16.1
1968	109.8	100.6	88.3	1.9	9.7	5.6	7.4	15.0
1969	104.8	94.0	84.6	2.7	10.9	5.3	7.0	15.0
1970	88.2	84.0	76.7	1.3	4.1	5.0	6.7	13.0
1971	117.9	107.7	90.8	1.6	10.1	5.3	7.0	13.8
1972	121.7	113.7	88.0	1.3	7.5	5.9	7.7	14.9
1973	106.2	95.6	91.6	2.2	11.1	4.6	6.3	13.1
1974	113.0	113.0	98.1	0.0	0.0	4.8	6.5	11.3
1975	133.7	111.8	96.7	2.6	21.9	5.6	7.4	15.6
1976	93.3	87.8	75.5	0.5	5.5	4.7	6.3	11.5
1977	120.7	103.0	83.4	2.1	17.4	5.3	7.1	14.4
1978	120.7	99.4	89.1	4.4	21.5	5.6	7.4	17.3
1979	133.4	115.3	91.3	3.6	18.1	6.1	8.0	17.7
1980	96.8	82.0	71.3	3.3	14.7	5.3	7.0	15.6
1981	76.5	76.5	69.6	0.0	0.0	4.7	6.3	11.0
1982	129.8	117.7	91.6	2.6	12.0	5.9	7.8	16.3
1983	121.8	93.0	76.8	5.1	29.0	5.6	7.4	18.2
1984	131.8	99.9	91.7	4.4	31.9	6.0	7.8	18.2
1985	79.5	78.8	73.4	0.3	0.7	4.6	6.2	11.0
1986	97.2	94.7	78.7	0.0	2.5	3.8	5.3	9.0
1987	108.5	84.5	73.8	3.1	23.9	5.2	6.9	15.2
1988	92.5	92.5	77.1	0.0	0.0	4.9	6.5	11.3
1989	156.1	121.3	91.2	5.0	34.8	6.2	8.2	19.4
1990	91.8	90.3	92.8	0.5	1.5	4.8	6.5	11.8
1991	125.4	125.4	101.8	0.0	0.0	5.4	7.1	12.5
1992	131.8	106.6	84.3	4.7	25.1	6.1	8.0	18.8
1993	112.3	89.7	72.3	4.5	22.2	5.6	7.4	17.4
1994	94.3	78.9	88.0	2.6	15.9	5.1	6.8	14.5
1995	115.1	115.1	93.4	0.1	0.0	5.0	6.7	11.7
AVG	112.8	100.0	85.8	2.1	12.8	5.3	7.1	14.5

Table HA.19. Baseline annual water balance for Bolton Jones Tract 1 field 2. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	101.6	100.0	0.0	0.2	6.5	18.9	25.4
1951	82.4	82.2	86.5	0.0	0.2	2.9	12.7	15.6
1952	118.3	118.3	84.7	0.0	0.0	3.2	13.1	16.4
1953	113.2	110.9	97.9	0.0	2.2	3.8	14.0	17.8
1954	88.2	88.2	71.9	0.0	0.0	4.0	14.3	18.3
1955	103.0	102.5	87.6	0.0	0.5	2.7	12.4	15.1
1956	116.9	116.9	85.1	0.0	0.0	4.1	14.7	18.8
1957	114.2	114.2	87.3	0.0	0.0	4.8	15.8	20.6
1958	125.8	121.4	87.0	0.7	4.4	7.3	20.6	28.6
1959	155.3	135.5	94.2	1.9	19.8	8.5	22.9	33.2
1960	124.4	108.2	89.7	2.0	16.2	7.7	21.3	31.0
1961	105.4	105.4	88.0	0.0	0.0	6.8	19.6	26.5
1962	113.3	113.3	87.9	0.0	0.0	5.6	17.3	22.9
1963	109.7	109.7	85.8	0.0	0.0	5.4	16.8	22.2
1964	146.1	130.3	83.6	0.5	15.8	7.3	20.5	28.3
1965	95.5	91.3	91.1	1.1	4.2	7.5	21.0	29.6
1966	118.5	116.8	86.7	0.0	1.8	5.8	17.6	23.3
1967	131.1	130.8	82.8	0.2	0.0	6.2	18.5	24.9
1968	109.8	103.8	89.9	1.0	6.4	7.1	20.1	28.2
1969	104.8	104.8	86.5	0.0	0.0	6.3	18.5	24.8
1970	88.2	88.2	76.3	0.0	0.0	5.0	16.2	21.3
1971	117.9	117.2	91.9	0.0	0.7	5.2	16.6	21.8
1972	121.7	121.7	88.0	0.0	0.0	4.7	15.6	20.3
1973	106.2	106.2	93.0	0.0	0.0	5.5	17.1	22.6
1974	113.0	113.0	98.1	0.0	0.0	4.2	14.7	18.9
1975	133.7	132.3	97.0	0.0	1.4	6.4	18.8	25.2
1976	93.3	93.3	75.8	0.0	0.0	5.2	16.5	21.7
1977	120.7	117.3	85.0	0.0	3.3	5.9	17.8	23.7
1978	120.7	114.3	89.1	0.8	6.3	7.3	20.6	28.8
1979	133.4	129.5	91.3	0.3	3.9	7.6	21.1	28.9
1980	96.8	89.8	74.0	0.8	6.9	6.8	19.7	27.3
1981	76.5	76.5	70.4	0.0	0.0	4.1	14.6	18.8
1982	129.8	128.0	91.6	0.0	1.8	5.3	16.6	21.9
1983	121.8	112.7	80.4	1.1	9.1	7.1	20.2	28.5
1984	131.8	119.3	91.7	1.4	12.5	8.1	22.2	31.7
1985	79.5	79.5	73.7	0.0	0.0	5.3	16.6	21.9
1986	97.2	94.5	79.0	0.0	2.7	2.8	12.5	15.3
1987	108.5	106.9	76.2	0.3	1.5	6.2	18.4	24.8
1988	92.5	92.5	79.5	0.0	0.0	4.3	14.9	19.2
1989	156.1	151.0	91.2	0.9	5.1	7.1	20.2	28.2
1990	91.8	91.1	94.5	0.2	0.7	6.0	18.1	24.2
1991	125.4	125.4	101.8	0.0	0.0	4.6	15.3	19.9
1992	131.8	131.8	84.3	0.0	0.0	5.8	17.6	23.3
1993	112.3	95.6	75.5	2.2	16.7	7.2	20.4	29.8
1994	94.3	90.3	90.1	0.5	4.0	6.4	18.9	25.8
1995	115.1	115.1	93.4	0.0	0.0	4.5	15.2	19.7
AVG	112.8	109.5	86.7	0.3	3.2	5.7	17.5	23.6

Table HA.20. Baseline annual water balance for Bolton Jones tract 2 field 1. (Centimeters)

YEAR	RAINFALL	INFILTRATION	ET	DRAINAGE	RUNOFF	VERTSP	LATSP	DRN+SP
1950	101.8	101.8	97.6	0.0	0.0	7.3	21.9	29.2
1951	82.4	82.4	81.5	0.0	0.0	1.8	12.4	14.2
1952	118.3	118.3	77.7	0.0	0.0	4.7	17.1	21.8
1953	113.2	112.9	87.7	0.0	0.3	5.9	19.2	25.2
1954	88.2	88.2	66.2	0.0	0.0	6.3	19.9	26.2
1955	103.0	103.0	81.1	0.0	0.0	4.8	17.3	22.1
1956	116.9	116.9	78.2	0.0	0.0	6.9	21.0	27.8
1957	114.2	114.2	81.9	0.0	0.0	6.8	20.8	27.5
1958	125.8	119.2	87.0	1.4	6.6	8.8	24.8	35.0
1959	155.3	140.1	91.4	1.9	15.3	9.7	26.6	38.2
1960	124.4	111.7	83.9	2.7	12.7	9.4	26.0	38.0
1961	105.4	105.4	81.6	0.0	0.0	8.1	23.4	31.5
1962	113.3	113.3	82.8	0.0	0.0	7.0	21.3	28.3
1963	109.7	109.7	80.0	0.0	0.0	7.0	21.1	28.1
1964	146.1	128.9	79.2	0.8	17.2	8.8	24.8	34.4
1965	95.5	92.8	85.1	1.2	2.7	8.7	24.6	34.5
1966	118.5	118.0	83.9	0.0	0.6	7.0	21.1	28.1
1967	131.1	128.1	76.2	0.2	3.0	7.8	22.8	30.7
1968	109.8	104.9	82.3	1.3	4.9	8.4	23.8	33.5
1969	104.8	103.8	81.7	0.1	1.0	7.6	22.5	30.2
1970	88.2	88.2	69.9	0.0	0.0	6.0	19.4	25.5
1971	117.9	117.9	86.8	0.0	0.0	6.9	20.9	27.8
1972	121.7	121.7	87.2	0.0	0.0	5.9	19.2	25.1
1973	106.2	106.2	88.1	0.0	0.0	6.0	19.5	25.5
1974	113.0	113.0	92.8	0.0	0.0	5.0	17.6	22.6
1975	133.7	133.2	92.8	0.0	0.5	7.9	23.0	30.9
1976	93.3	93.3	71.4	0.0	0.0	6.2	19.8	25.9
1977	120.7	119.6	81.8	0.0	1.0	7.4	21.9	29.3
1978	120.7	114.6	87.4	1.4	6.1	8.6	24.4	34.3
1979	133.4	132.8	88.1	0.0	0.5	9.1	25.3	34.4
1980	96.8	91.2	68.9	1.0	5.6	8.0	23.3	32.3
1981	76.5	76.5	62.9	0.0	0.0	4.8	17.4	22.3
1982	129.8	129.3	91.6	0.0	0.5	7.1	21.3	28.3
1983	121.8	114.2	75.2	1.4	7.6	8.4	23.9	33.6
1984	131.8	119.8	90.7	2.1	12.0	9.5	26.2	37.9
1985	79.5	79.5	66.9	0.0	0.0	5.5	18.6	24.1
1986	97.2	97.1	73.7	0.0	0.1	2.7	14.0	16.7
1987	108.5	101.5	71.5	0.7	7.0	7.5	22.4	30.6
1988	92.5	92.5	72.5	0.0	0.0	5.3	18.2	23.4
1989	156.1	151.3	91.2	0.7	4.7	8.8	24.8	34.3
1990	91.8	91.8	89.3	0.1	0.0	6.6	20.7	27.5
1991	125.4	125.4	95.5	0.0	0.0	6.0	19.3	25.3
1992	131.8	131.8	81.6	0.0	0.0	7.2	21.6	28.9
1993	112.3	98.0	69.9	2.9	14.3	8.6	24.4	35.9
1994	94.3	89.9	85.5	0.6	4.4	7.4	22.1	30.0
1995	115.1	115.1	83.5	0.0	0.0	6.0	19.4	25.4
AVG	112.8	110.0	81.8	0.4	2.8	7.0	21.3	28.7

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

August 10, 2001

Mrs. Joan Smyth, P.G.
G.N. Richardson & Associates
425 N. Boylan Avenue
Raleigh, N.C. 27603

RE: Hydrogeologic Review Of The Response To Comments For The Design Hydrogeologic Report, Johnston Co. MSWLF Phase 4A
Permit No. 51-~~02~~ 51-03

Dear Mrs. Smyth,

This letter provides comments from the hydrogeologic review of the above referenced document. There are a still a few items that need additional clarification. Please respond to the following questions and comments:

Figure 10 indicates the drainage feature located between PZ-9 and PZ-10 is a flowing stream. Figure 11 indicates this same drainage feature, located further downstream between PZ-10 and MW-8, is not a flowing stream. Please reconcile this inconsistency. It would appear that under seasonal high conditions the lower section of this drainage feature could be a flowing stream. Are there plans to provide a french drain in this area to control water during seasonal high conditions?

Figure 16: The data in Table 2 as plotted on Figure 16 is inconsistent with the ground-water contours in the vicinity of wells MW-7, MW-9D, and CDLMW-5.

Table 2: The Top of Casing Elevation on the revised Borehole Log for MW-8D is inconsistent with the data on Table 2.

Table 3: The % Passing #4 for PZ-1 appears to be incorrect. The values for % Passing for one PZ-5 sample appear to be mismatched and the values for the second sample are missing. The values for % Passing # 200 appear to be switched for PZ-6s and PZ-6d.

Table 5: It is still not clear how the Effective Porosity Values were determined. What is the basis for distinguishing between the 0.20 and 0.17 values being assigned. I do not see any pattern between the values and the soil descriptions. Normally, site specific values for total porosity and effective porosity are provided where possible. Are any such values available? Typically soil grain size analyses along with the Fetter Textual Classification Triangle are used to approximate effective porosity values based on site specific tests.

Table 5a: Based on the diagrams some of the paired wells do not appear to be located close enough together to be true well nests. If the paired wells are more than about ten feet from each other it is difficult to make an accurate evaluation of vertical gradients. The Ground Surface Elevations for MW-13 and MW-13d are significantly different.

Table 6: The Conductivity Values do not appear to be accurate for wells MW-5, MW-8, MW-4d, and MW-9d.

Apx. F: The Ground Surface Elevation and Top of Casing Elevation for Revised Borehole Log MW-8D are inconsistent with other references in the Report.

Will settlement due to soft soils significantly affect the four foot vertical separation?

Water Quality Monitoring Plan:

Pg. 2 Provide reference to monitoring of the leachate lagoon. An additional monitoring well is needed at the mouth of the drainage feature downgradient of Phase 4A.

Pg. 3 The reference to the figure for well locations should be to Figure 7 rather than Figure 1.

Pg. 5 For well purging three to five well volumes is the minimum purging amount. Five well volumes is not a maximum. In some cases more that five well volumes is needed to reduce turbidity and obtain stabilized field parameter measurements.

Pg. 5 Provide more detail on stabilization of field parameters for determining adequate well purging.

Pgs. 6 & 9 It is not clear what type of equipment is being referred to in the discussion of equipment decontamination. Sampling and purging equipment may require different decontamination than equipment used to measure well depths or field testing parameters. Stainless steel and Teflon require different decontamination procedures.

Pgs. 9 & 10 Discussion for NAPLs is not necessary, as this is not usually necessary for routine detection monitoring.

Pg. 22 The final sentence should be deleted. The assessment monitoring schedule should be included in the Assessment Work Plan to be approved by the Solid Waste Section.

When all revisions have been made, they will need to be integrated into the Permit To Construct Application so there will be one complete and accurate document to be stamped as part of the approved permit. Please provide the information and revisions as referenced above. If you or representatives of G. N. Richardson or Johnston County have any questions regarding this letter, you may contact me at (919) 733-0692 extension 258.

Sincerely,

Bobby Lutfy

Bobby Lutfy
Hydrogeologist
Solid Waste Section

cc: Jim Coffey, Solid Waste Section
Ed Mussler, Solid Waste Section
Robert Hearn, Solid Waste Section

Office of
County Commissioners
(919) 989-5100
FAX (919) 989-5179

Joyce H. Ennis, Clerk

Johnston County
POST OFFICE BOX 1049
SMITHFIELD, N. C. 27577

James H. Langdon, Jr., Chm.
Cookie Pope, V-Chm.
Thomas M. Moore
Allen L. Mims, Jr.
Wade M. Stewart
Fred Smith
W. Ray Woodall

Minutes of the Johnston County Board of Commissioners
August 6, 2001

CERTIFIED COPY OF MINUTES

Public Hearing 10:15 a.m. - Expansion of County Landfill - New Subtitle D Cell
Advertised: July 6, 2001 in The Smithfield Hearld

The Chairman opened the public hearing and invited public comment on the proposed expansion of the County landfill to include a new Subtitle D Cell and remediation improvements.

Haywood Phthisic, Director of Operations, showed a map of the existing landfill. He noted this project includes a new cell that will be located between cells 3 and 4, which have been capped and closed for several years. The project also will provide remediation of the closed cells. This expansion is expected to provide space for the County until approximately 2012.

Deirdre Jersey from the Cleveland area asked about the overall lifespan of the existing landfill, and if there are plans to use the methane gas generated. Mr. Phthisic responded the County is considering uses of the methane gas, and the projected life of the existing facility is between 35 and 40 years.

There being no further comments, the Chairman closed the public hearing.

I hereby certify that this is a true and accurate copy which appears on record in the Minute Book of the Johnston County Board of Commissioners, Johnston County, N.C.
In Book 22, Page 645
Witness my hand and seal this the 14th day of August 2001.
Joyce H. Ennis
Joyce H. Ennis, Clerk
Johnston County Board of Commissioners

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

August 3, 2001

51-03

Kenneth Pohlig, Ph.D., P.E.
Environmental Engineer
Design Management Unit
Division of Water Quality
Construction Grants and Loans
1633 Mail Service Center
Raleigh, N.C. 27699-1633

RE: Proposed spray irrigation of reclaimed wastewater at the Johnston County Landfill (Permit #51-02)

Dear Ken,

Thanks for the opportunity to meet with you earlier this week to discuss the proposed spray irrigation at the Johnston County MSW Landfill. While the Report provided regarding the "Proposed Johnston County Landfill Reclaimed Effluent Irrigation System" seemed to address issues associated with spray irrigation in an agricultural setting, the Report did not address some of the special issues unique to landfill sites. As Hydrogeologist for the Solid Waste Section, I have a couple of concerns with the proposed irrigation of reclaimed wastewater at the Johnston County Landfill Facility.

The initial concern would be the possibility of introducing additional contaminants into the ground and surface waters at the site. Although the report seems to indicate that this possibility would be minimal, there is still a certain amount of liability associated with the introduction of another source of potential contamination at the landfill facility. This could complicate the ability to monitor the landfill activities effectively.

If any irrigation is allowed, Johnston County would have to be aware that additional liability and expense could be incurred due to the need for increased ground-water monitoring, water quality assessment, and possible corrective action. For example, because it would be difficult to determine the source of contamination found in a monitoring well for the Phase 5 lined landfill unit, assessment monitoring could be triggered.

Another concern is how the increase in water infiltration at the site would affect the hydrology. The landfill units have been sited and designed based on a good understanding of the existing hydrogeology that is present at the site. Increasing infiltration would raise the water table and could change ground-water flow patterns at the site in ways that are difficult to predict.

The Solid Waste Management Rules require that landfills be designed and operated so as to maintain a minimum of four feet of vertical separation from the waste (or bottom of the liner system) to the seasonal high water table. The increase in infiltration would raise the water table, resulting in a loss of useable air space in future landfill cells. Of even greater concern would be the raising of the water table into waste in the existing unlined landfill units. Current water table data at the facility indicates that the minimum four foot separation required as an operational requirement is marginal under existing natural conditions. Any increase in the water table level could cause the unlined landfill units to be out of compliance with this rule.

Creating a situation where the water table is rising and falling within the bottom of the waste will result in an increase in the release of contaminants to ground water. It could also cause problems with differential settlement and structural stability. Since additional landfill development is planned between landfill Phases 3 and 4, these could be serious problems.

Due to the reasons stated above, there is concern about any irrigation within or upgradient of the landfill facility. There are serious concerns about the impact of additional infiltration on existing landfill units. Therefore, any significant increase in infiltration should be limited to areas that are hydrologically isolated from existing landfill units.

While it may be possible to allow some spray irrigation at agronomic rates (no net increase in infiltration), this would only be possible in limited areas that would not interfere with the construction, operation, or monitoring of waste management activities at the facility. Low volume irrigation for dust suppression on roads should not be a problem if done properly.

Some of the proposed irrigation is incompatible with present plans for future development of the site. For example, there are immediate plans to build the Phase 4A Landfill unit between existing Phases 3 and 4 and up the side slopes for these landfill units.

To summarize, because of the introduction of an additional potential source of contamination *and* because of the increase in infiltration and the unpredictable effects this could have on the hydrology, the Solid Waste Section has concerns about the proposed spray irrigation of reclaimed wastewater at the Johnston County Landfill site. A detailed hydrologic study using an appropriate model would be necessary to begin to understand the possible effects of increased infiltration on the water table and groundwater flow patterns due to spray irrigating on or immediately upgradient of the existing or possible future landfill units.

Ed Mussler, Environmental Engineer with the Solid Waste Section, may also have some additional comments from an engineering perspective. If so, these will be provided in a separate letter.

I hope this information will be useful to you as you evaluate the proposed spray irrigation system for the Johnston County Landfill Facility. If you have any questions regarding this letter, please contact me at (919) 733-0692, extension 258.

Sincerely,

Bobby Lutfy

Bobby Lutfy
Hydrogeologist
Solid Waste Section

cc: Jim Coffey
Ed Mussler
Mark Poindexter

Michael F. Easley, Governor
William G. Ross Jr., Secretary
North Carolina Department of Environment and Natural Resources

Gregory J. Thorpe, Ph.D.
Acting Director
Division of Water Quality

August 1, 2001

Rick J. Hester, County Manager
Johnston County
Post Office Box 1048
Smithfield, North Carolina 27577

51-03

SUBJECT: Johnston County
Coordination Meeting
Wastewater Reuse and
Wastewater Treatment Expansion
Project Number CS370560-07 &
Project Number CS370560-08

Dear Mr. Hester:

This letter is to follow up and summarize a meeting held in our office on July 24, 2001 to discuss the subject projects. A list of attendees is attached for your information and files. Johnston County has submitted plans and specifications for eleven different components of your proposed wastewater construction project. Another set of plans and specifications is anticipated in August to address expansion of the Johnston County Regional Wastewater Treatment Facility. The twelve projects are summarized in Table 1. Supporting documents that have been received are shown in Table 2.

During our meeting, schedules for review and approval of the projects were discussed. The Design Management Unit will provide review comments on items 1 through 5 and item 9, as identified in Table 1, by August 24, 2001. Assuming the consultants can provide thorough and complete responses to all of our review comments by September 24, 2001, we anticipate the permits and approvals for those projects could be completed by October 24, 2001. Within 60 days of receipt of final plans and specifications for the Wastewater Treatment Plant Expansion, the Design Management Unit will provide review comments on items 6 through 8, and 10 through 12, as identified in Table 1. It is anticipated that these items could be permitted and approved in the month of February, 2002, depending on the status of the issuance of the NPDES Permit.

The Division of Waste Management has provided us with verbal comments on the proposed landfill irrigation plan. While they have not completed their review of the hydrogeologic report, it appears that the Division has concerns regarding potential hydrologic impacts associated with irrigation on the landfill property. Construction Grants & Loans has indicated that prior to approval of plans and specifications and permitting of any facilities at the landfill, the Division of Waste Management must agree with any portion of the project that is to occur within the boundaries of the landfill site. Construction Grants and Loans will continue to coordinate the review of the proposed reuse system with the Division of Waste Management.

Table 3 outlines the permit applications that have been received, and the permit applications that need to be submitted. All item numbers in this table correspond to the item numbers in Table 1. From Table 3, it can be determined that four permits need to be issued for Project Number CS370560-07. We have received three of these applications. A single application, Form PSFMGSA 10/99, should be completed and returned to our office to address items 3 and 4. For your convenience, a copy of Form PSFMGSA 10/99 is attached. This application should be supported with the $400 permit application fee. These applications need to be received before we can provide a complete review and obtain the review of our Raleigh Regional Office.

For Project Number CS370560-08, it appears that three permits and one Authorization to Construct will be required. None of the applications have been received for these permits. An application, Form PSFMGSA 10/99, should be completed and returned to our office to address item 7. This application should be supported with the $400 permit application fee. A letter from the County should be provided to request a Non Discharge Minor Permit to address item 8. This letter should be supported with design calculations, a residuals management plan, and the $675 permit application fee. A single application, Form PSFMGSA 10/99, should be completed and returned to our office to address items 10 and 11. This application should be supported with the $400 permit application fee. A letter from the County requesting Authorization to Construct modifications to the Johnston County Regional Wastewater Treatment Facility should also be provided. This letter requires no fee; however, it should be supported with design calculations. It appears that no permit or permit fee will be required for item 6.

The Construction Grants and Loans Section appreciates the time that your staff and consulting engineer took with us on July 24, 2001 to discuss the proposed Johnston County

wastewater project. Should you have questions regarding these matters, please give me a call at (919)715-6203.

Sincerely,

Cecil G. Madden, Jr., P.E., Supervisor
Design Management Unit
Construction Grants & Loans Section

CGM:dr
Attachments

cc: Timothy G. Broome, P.E.
Haywood Phthisic
Amanda Bader, P.E.
Raleigh Regional Office, Water Quality Section
Ed Mussler, Division of Waste Management
Bob Lufty, Division of Waste Management
Jim Struve, P.E.
Amy Simes., P.E.
Daniel Blaisdell, P.E.
Cecil G. Madden, Jr., P.E.
Robert P. Teulings, Ph.D.
Kenneth O. Pohlig, Ph.D., P.E.
David Goodrich, NPDES, Water Quality Section
SRF, 560-07
SRF, 560-08

TABLE 1
PLANS & SPECIFICATIONS
JOHNSTON COUNTY SRF PROJECT
PROJECT NO's. CS370560-07 & CS370560-08

Item No.	Project Plans & Specifications	AE	Date Received	Status	Loan Number
1.	Phase I Water Reuse Facilities - Reuse water Distribution System \ 8-inch WAS Line (Contract 1C)	Hazen & Sawyer	11-13-00	Under Review	Two
2.	Phase I Water Reuse Facilities - Ground Storage Tank and Pump Station (Contracts 1A and 1B)	Hazen & Sawyer	11-20-00	Under Review	Two
3.	Reclaimed Water Elevated Storage Tank	Johnston County	12-19-01	Under Review	Two
4.	McGees Crossroads & Cleveland Area Transmission Facilities with PS	Johnston County	04-16-01	Under Review	Two
5.	Golf Course Irrigation (Non Eligible)	STI Design	04-18-01	Under Review	(Two)
6.	Buffalo Creek Sewer Rehab.	Johnston County	05-17-01	Under Review	Three
7.	Neuse River Parallel Force Main	Johnston County	06-08-01	Under Review	Three
8.	2001 Wastewater System Improvements - Wastewater Solids Dewatering Facilities	Johnston County	06-08-01	Under Review	Three
9.	Landfill Reclaimed Effluent Irrigation System (Portions Eligible)	Johnston County	06-28-01	Under Review	(Two)
10.	Cleveland Area Diversion Force Main	Johnston County	07-10-01	Under Review	Three

TABLE 1 CONTINUED
PLANS & SPECIFICATIONS
JOHNSTON COUNTY SRF PROJECT
PROJECT NO's. CS370560-07 & CS370560-08

Item No.	Project Plans & Specifications	AE	Date Received	Status	Loan Number
11.	Cleveland Area Diversion Facilities: Equalization Basin and Pump Station	McKim & Creed	07-10-01	Under Review	Three
12.	WWTP Expansion Design	Hazen & Sawyer	Targeted 08-17-01	Awaiting Document	Three

Table 2
SUPPORTING DOCUMENTS
JOHNSTON COUNTY SRF PROJECT
PROJECT NO's. CS370560-07 & CS370560-08

Item Nos.	Supporting Documents	A/E	Date Received	Status	Loan Number
2.	Design Calculations for Reuse Water Ground Storage Tank and Pump Station	Hazen & Sawyer	11-20-00	Under Review	Two
5. 9.	Soil/Site Evaluation Report for Reuse Water Irrigation at Land Fill & Golf Course	Triangle Group	01-11-01	Under Review	Two
8.	Design Calculations for Wastewater Solids Dewatering Facility	Johnston Co.	06-27-01	Under Review	Three
9.	Basis of Design & Guide Specifications for Proposed Johnston Co Landfill Reclaimed Water Irrigation System	Johnston Co.	06-28-01	Under Review	None

TABLE 3
WATER QUALITY PERMITS NEEDED FOR
JOHNSTON COUNTY SRF PROJECT
PROJECT NO's. CS370560-07 & CS370560-08

Item Nos.	Individual Permit Descriptions	A/E	Water Quality Application No.	Status	Fee Req.	Date Received
1. 2.	Phase I Water Reuse Facilities - Reuse water Distribution System \ 8-inch WAS Line (Contract 1C) Ground Storage Tank and Pump Station (Contracts 1A and 1B)	Hazen & Sawyer	WQ0019632	Under Review	$400	02-02-01
3. 4.	Reclaimed Water Elevated Storage Tank McGees Crossroads & Cleveland Area	Johnston County	None Received	Waiting on App.	$400	
5.	Golf Course Irrigation	STI Design	WQ0019908	Under Review	$1,090	04-18-01
6.	Buffalo Creek Sewer Rehab.	Johnston County	None Required	Under Review	$0	
7.	Neuse River Parallel Force Main	Johnston County	None Received	Waiting on App.	$400	
8.	2001 Wastewater System Improvements - Wastewater Solids Dewatering Facilities	Johnston County	None Received	Waiting on App.	$675	
9.	Landfill Reclaimed Effluent Irrigation System	Johnston County	WQ0019631	Under Review	$1090	02-12-01
10. 11.	Transmission Facilities with PS Cleveland Area Diversion Facilities: Equalization Basin and Pump Station	Johnston County McKim & Creed	None Received	Waiting on App.	$400	

TABLE 3 CONTINUED
WATER QUALITY PERMITS NEEDED FOR
JOHNSTON COUNTY SRF PROJECT
PROJECT NO's. CS370560-07 & CS370560-08

Item Nos.	Individual Permit Descriptions	A/E	Water Quality Application No.	Status	Fee Req.	Date Received
12.	WWTP Expansion Design	Hazen & Sawyer	Authorization to Construct and NPDES Needed	Waiting on Request	$0 for A to C	

CONSTRUCTION GRANTS AND LOANS SECTION

CONFERENCE LOG

RECIPIENT: Johnston County *PROJECT NO.* SRF 560-07

PURPOSE OF MEETING: Project status discussion

ATTENDANCE LIST
(PLEASE PRINT)

	NAME	PHONE	AFFILIATION
1)	Bob Tenlings	919-715-6210	CG&L
2)	Jim Strunk	(704) 357-3150	Hazen & Sawyer
3)	Dan Blaisdell	(919) 715-6211	CG+L
4)	Haywood Phthisic	(919) 989.5075	Johnston County
5)	Tim Broome	919.989.5075	" "
6)	Amanda Bader	919.989.5075	Johnston County
7)	Amy Sykes	919-715-6217	CG&L
8)	Carl Madden	919-715-6203	CG&L
9)	Ken Pohlig	919-715-6221	CG&L
10)	Ed Mussler	733-6652 x343	DWM.
11)			
12)			
13)			
14)			

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Interim Director

July 26, 2001

MEMORANDUM

To: Ed Mussler

From: Bobby Lutfy BL

RE: Johnston County MSW Landfill Expansion 51-03
Piezometer Abandonment

I have reviewed the Grading Plan for the Johnston County Landfill Phase 4A expansion. It appears that the four foot separation requirement is satisfied with this design. Therefore, Piezometers PZ-5, 5D, 6, 7, 8, 9, and 9D may be abandoned if necessary. The piezometers must be properly abandoned according to the Rules for permanent well abandonment, 15A NCAC 2C .0113(a)(2).

I am still reviewing the Design Hydrogeologic Report and hope to complete my review within the next couple of weeks. A meeting has been scheduled for next Monday with Ken Pohlig of the Division of Water Quality to discuss the proposed Reuse Irrigation System at the site.

CC: Jim Coffey

1646 Mail Service Center, Raleigh, North Carolina 27699-1646
Phone: 919-733-0692 \ FAX: 919-733-4810 \ Internet: www.enr.state.nc.us/

AN EQUAL OPPORTUNITY \ AFFIRMATIVE ACTION EMPLOYER – 50% RECYCLED / 10% POST CONSUMER PAPER

Subject: Johnston County
Date: Tue, 24 Jul 2001 11:04:30 -0400
From: Bobby Lutfy <bobby.lutfy@ncmail.net>
To: ED MUSSLER <ED.MUSSLER@ncmail.net>

57-03

Ed,
As we have discussed in the past, I am basically against any spray irrigation at the landfill site. The past, present, and future permitting at the site is based upon a certain understanding of the hydrology that exists at the site. Irrigation could raise water tables, change ground-water flow patterns, etc. Irrigation could change the hydrology, chemistry, etc. in ways that are difficult to predict. Therefore, I am really not in favor of any irrigation in areas of past, present, or possible future landfill development. If any irrigation is allowed, it should be kept to a minimum and managed very carefully in order to minimize impact. Any ground or surface water contamination resulting from the irrigation would be the liability of the County. It could trigger expensive assessment monitoring and corrective action that may not otherwise be required.
-Bobby

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services

July 18, 2001

Mr. Bobby Lutfy
NCDENR
Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

RE: **Response to Comments**
Proposed Johnston County Landfill
Smithfield, North Carolina

Dear Mr. Lutfy:

G. N. Richardson and Associates, Inc. (GNRA) has received your comments of June 15, 2001 regarding the Permit to Construct Application for the proposed Phase 4a at the above referenced site. This letter is sent to respond to those comments. Additionally, the following attachments are included as revisions to the original submittal:

- Revised Text;
- A revised **Figure 2** -Site Vicinity Map with 2-mile Radius;
- A revised **Figure 7** - Boring/well Location Map;
- A revised **Figure 8** - Bedrock Surface Map;
- Revised **Figures 10, 11, and 12** - Geologic Cross-Sections;
- Revised **Figures 15 and 16** - Ground Water Potentiometric Surface Maps
- The Army Corps. Of Engineers Permit for the Phase 4a area;
- Revised Slug Test Analysis for wells MW-4d and MW-5;
- Revised **Tables 1, 2, 3, 5, and 6**;
- Revised Boring Logs for **Appendix F**;
- A revised Geotechnical Report for **Appendix G**;
- A Water Quality Monitoring Plan for the site for **Appendix J**;
- **Figure 17** depicting basegrade separation from bedrock and ground water; and
- Most recent geophysical study for diabase dikes.

For ease in review, your comments are outlined below in italics with our responses below them.

Comment #1
Page 2 - It is not clear in the Regional Characterization Study if there are any "surface water intakes" in the study area, or if the public water supply "service area" includes the entire study area. Rule .1618 (c)(1)(C).

Response
There are no surface water intakes within the 2-mile radius of the site. The public water supply

service area does not include the entire area. There are roads on which public water has not been supplied at this time, however, the system is planned for expansion in this area.

Comment #2
Page 2 - It is not clear in the Local Characterization Study: (A) if there are any on-site easements, (B) what the zoning classifications are, (C) the location of private residences and schools, (D) the location of commercial and industrial buildings, and (E) the location of historic sites. Rule .1618 (c)(2).

Response
There are no on-site easements. The zoning classification for the entire local characterization area is AR which means it is zoned for agricultural and residential use. There are no schools within the 2000 foot radius. The private residences are shown as small squares on Figure 2, and there are no commercial or industrial buildings or any historic sites in this area.

Comment #3
Page 4 - A Water Quality Monitoring Plan needs to be provided that provides discussion about the adequacy of the existing monitoring system to provide effective monitoring for this area, including Phases 3, 4, and especially 4a. Are additional ground water or surface water monitoring locations needed? Will it be necessary to alter or relocate any of the existing monitoring wells to construct and effectively monitor Phase 4a?

Response
A Water Quality Monitoring Plan for the site is included with this submittal. No additional ground water or surface water points will be needed to monitor Phase 4A. The primary monitoring mechanism for Phase 4A will be the double liner system in which we can monitor the leakance rate above the lower liner. Additionally there are wells in the immediate vicinity that will serve to identify any significant changes in ground water quality. It will not be necessary to alter or relocate any of the existing monitoring well with the exception of MW-8 which has been dry during recent sampling events. This well will be replaced with a well out of the construction area.

Comment #4
Page 4 - Has the approval from the Army Corps. Of Engineers been obtained for the wetlands between Phases 3 and 4?

Response
Yes, a copy of the Nationwide Permit 26 is included in this submittal for inclusion in Appendix B. The County will pay the required amount to the wetland restoration fund a minimum of 30 days prior to impacting any wetland area.

Comment #5
Page 7 - Please explain and clarify the statement made at the bottom of Page 7 that: " The contact between the Middendorf Formation and metamorphic rocks of the Carolina Slate Belt is generally found in boreholes and outcrops at elevations of 165 - 175 feet".

Response
This statement is erroneous and has been removed from the text.

Comment #6
It is my understanding that additional geophysical mapping of dikes was to be done. What are the results of this study?

Response
The additional geophysical mapping has been completed and the results are included with this submittal for your review. This study indicated the presence of three small diabase dikes located in the floodplain in the area of Phase 3. This study indicated these dikes are approximately 5 feet thick and range in depth from 10 feet to 16 feet below grade. Further study of this area and ground water monitoring well installation are proposed to investigate any influence the dikes may have on ground water flow.

Comment #7
Figure 7 - One of the figures needs to show the location of the monitoring wells for the Phase 5 area and the leachate pond.

Response
Figure 7 has been revised with this information and is included for your review.

Comment #8
Figure 8 - Much of the data used to generate the Bedrock Contour Map is inconsistent with the boring logs. Data for borings MW-6, MW-7, PZ-1, T-5, T-6, and T-7 appears to be in error. Is there any data from the Phase 5 area that could supplement the limited data presented?

Response
A revised Figure 8 is included for your review. This figure incorporates data from the Phase 5 permit application which contains additional rock coring data.

Comment #9
Figures 10, 11, 12 - If the Bedrock data is that used for Figure 8, then some of the data is in error. It appears that the well stick-up is plotted for some wells but not others. Some of the well data seems to be plotted up to two or three feet off, based on the boring logs. This makes it difficult to interpret the elevations for PWR, rock, water, etc.

Response
These figures have been revised and are included with this submittal for your review.

Comment #10
Figure 15 - The water table elevation data from Table 2 differs slightly from that on Figure 15 for MW-7 and differs significantly for MW-12b. The water table contours could be adjusted slightly in several locations to better reflect the data. (Especially note the vicinity of MW-8).

Response
This figure and table have been revised and are included for your review.

Comment #11
Figure 16 - There appears to be a number of discrepancies between the data in Table 2 and the data plotted for Figure 16. The data and contouring in the vicinity of PZ-10 is of special concern.

Response
This figure has been revised and is included for your review.

Comment #12
Table 1 - The TOC elevation for MW-5 is inconsistent with the Table in Appendix E. For several of the wells with the MW designation, the ground elevation, top of screen elevation, and bottom elevation values seem to be inconsistent with the boring logs.

Response
A revised Table 1 and revised boring logs are included for your review.

Comment #13
Table 3 - Some of the data in Table 3 is inconsistent with the data in Appendix G. (Note the LL and PI values for PZ-5s and PZ-7). Some of the sieve data is also difficult to match. For some piezometers there appears to be more than one set of data and some of the values differ.

Response
A review of the geotechnical lab report included in Appendix G indicated a typographical error for part of the data for PZ-7. This has been corrected an a new page from the geotechnical report is included for inclusion in Appendix G. Discrepancies between conflicting data for PZ-5s were due to two types of soils encountered in the shelby tube sample. In this instance, both soil types were tested. In general, the data from the differing soil types are not significantly different from each other and both sets of data fall in the CL,OL category.

Comment #14
Table 5 - It is not stated what the units are for the K values. I assume they are ft/day since this is used for Velocity. However, I can not correlate the data in Table 5 with the data in Appendix H. What is the source of the I and n values?

Response
Table 5 has been revised and is included for your review. This revision includes adding information on the sources of the values for I and n.

Comment #15
Table 5 - For vertical gradients, typically the value is calculated by dividing the difference in the water table elevations for the two wells by the difference in the mid-points of the screen intervals. (For the shallow well the mid-point of only the saturated portion of the screen interval is used.) Also comparisons need to be made over time to determine if there are seasonal variations in vertical gradients.

Response
Table 5 and the vertical gradient calculations have been revised and are included for your review. Additional analysis of vertical gradients has been included to allow for comparison of data over time.

Comment #16
Table 6 - The K values in Table 6 do not appear to be consistent with the values in Appendix H. How was aquifer thickness determined? Why is aquifer thickness data provided? How were Total porosity and Effective Porosity values determined? Clay-silts would have different hydraulic characteristics than Sand-silts and should be evaluated as a separate hydrogeologic unit.

Response
Table 6 has been revised and is included for your review. The lithologic listing for each boring is simply a characterization of the more predominant sample type collected. In each of these borings clayey silts are interfingered with sandy-silts and silty sands and silty clays. Therefore, due to the variation in the unconfined aquifer, this is considered one hydrologic unit which exhibits the same basic characteristics which are quite different from the bedrock aquifer (listed as Unit 2).

Comment #17
Appendix F - The blow counts are very low at several of the boring locations. Will this affect soil stability? Has any further evaluation been done for the soils in the wetlands area between Phases 3 and 4 regarding soil stability or foundational analyses? Will some of the soils need to be undercut and backfilled?

Response
GNRA evaluated slope stability and settlement in light of the low blow counts seen in several of the borings. In conducting stability and settlement analyses, GNRA conservatively used lower bound values both for shear strength (cohesion = 150 psf and phi = 25 degrees) and elastic modulus of the underlying subgrade soils. GNRA also anticipates a significant amount of overexcavation and backfill of soils between Phases 3 and 4 including organic (i.e. wetlands) soils. Note also that most of the soils having low blow counts are layers which contain a

significant amount of sand. Elastic settlement of these layers (and, thus, an increase in shear strength) will occur very quickly as the landfill is loaded. Please refer to Attachment G (Slope Stability and Piggyback Liner Evaluation) of the Permit to Construct Application for further information.

Comment #18
Appendix G - As previously stated, I am having a little difficulty matching some of the soils analyses data with that in the Tables.

Response
Table 3 has been revised to more accurately reflect the geotechnical lab report.

Comment #19
Appendix H - Also the slope lines on some of the hydraulic conductivity charts are questionable. (Example MW-4d).

Response
The hydraulic conductivity charts for wells MW-4d and MW-5 have been revised and are included for your review.

Comment #20
Appendix I - Have the results of the additional Dike Studies been completed?

Response
Yes, the report outlining the results of the dike study and proposed additional work is included for your review.

Comment #21
It would help to have a Table (and Drawings) that provide information on the vertical separation: including boring locations, ground surface elevations, base grade elevations, seasonal high water table elevations, and top of bedrock elevations.

Response
A Figure 17 has been created to convey the requested information.

Comment #22
A certification is needed for the proper abandonment of the piezometers. Rule .1623 (b) (2) (I).

Response
The text has been modified to include this certification in **Section 4.1**.

We hope this response letter answers your questions satisfactorily. If you have any further questions, please contact us at your earliest convenience.

Sincerely,
G. N. Richardson and Associates, Inc.

Joan A. Smyth

Joan A. Smyth, P.G.
Project Hydrogeologist

for

Pieter K. Scheer, P.E.
Project Engineer

cc: Tim Broome - Johnston Co.
Haywood Phthisic - Johnston Co.

FACT SHEET
PERMIT NUMBER: 51-03

FACILITY: Johnston County Landfill
COUNTY: Johnston
CITY: Smithfield, North Carolina

OWNER: Johnston County
PO Box 2263
Smithfield, NC 27577

OPERATOR: SAME

Description

A draft Solid Waste Permit, Part 1: Permit to Construct, has been prepared by the Division of Solid Waste Management for the construction and operation of Phase 4A at the Johnston County Landfill, a municipal solid waste landfill facility (MSWLF). The division has determined that the proposed facility plan, engineering plan, construction quality assurance plan, operation plan, closure and post-closure plan and the water quality monitoring plan, as identified in the application, satisfy the requirements and intent of the North Carolina Solid Waste Management Rules, codified as 15A NCAC 13B .1600.

The Johnston County Landfill is owned and operated by Johnston County. The facility is located on NCSR 1503, west of Smithfield, Johnston County, NC. The county currently has two permitted facilities at the location, Permits 51-01 and 51-02. These two facilities are being combined into a single new permit, number 51-03. The combined facility encompasses approximately 500 acres. Phase 4A is being built between Phases 3 and 4 at the landfill. These two phases were unlined disposal units and have ceased accepting waste. Phase 4A will be a lined disposal unit and will "piggy-back" between phases 3 and 4. This permit approves the facility plan and construction and operation of cell 1 of Phase 4A. Cells 2 and 3 of the phase will be permitted and constructed in the future. Phase 4A will add approximately eleven years to the remaining fifteen years of life of the facility . If waste receipts do not reach the permitted levels, the project could last longer.

The MSWLF is permitted to dispose of household, industrial and commercial solid waste. Hazardous or other banned wastes such as yard waste and white goods are not approved for disposal. Separate areas are provided for the management of construction and demolition debris, yard waste, white goods and scrap tires. A convenience center is also provided for the public. The facility will accept waste from Johnston County. The facility will have a total net permitted capacity of approximately 5,660,000 cubic yards. Phase 4A adds approximately 2,155,000 net cubic yards of disposal capacity to the currently permitted capacity of the facility. Johnston County is a rapidly growing county and adds population constantly. Based on historic numbers and population increases, the permitted disposal rate will be approximately 104,000 tons per year based on 312 operating days per year. The

amount of waste disposed of will increase with the population growth of the county and the rate numbers provided are for information purposes. If the population of the county does not increase as currently projected, then the disposal rates will decrease proportionally.

Permit Structure

The permit is divided into sections. Part 1 is the Permit to Construct and Part 2 in the Permit to Operate.

Public Comment Period

North Carolina Solid Waste Management Rules require that the public be given a 45-day period to comment on the draft permit. This 45-day period will begin on February 11, 2002. The draft permit is available for review by appointment from 9 AM to 4 PM, Monday-Friday, at the Division of Waste Management, 401 Oberlin Road, Raleigh, NC. All data submitted by the applicant is available as part of the administrative record. Persons wishing to comment on either this permit or the proposed permit conditions should submit their comments in writing by 5 PM, March 27, 2002. Comments should be sent to the address shown below and include the permit number. All comments received within the 45-day period will be considered in making the final determinations regarding the permit. A final permit decision and responses to comments will be prepared soon after the conclusion of the comment period.

Division Contact

Comments and requests for more information should be sent to:

Mr. Edward Mussler, P.E.
North Carolina Solid Waste Section
1646 Mail Service Center
Raleigh, North Carolina 27699-1646
(919) 733-0692 ext 343
FAX (919) 733-4810
e-mail- ed.mussler@ncmail.net

Public Hearing Notice

The North Carolina Solid Waste Management Rules provide for a public hearing. A public hearing on the draft permit has not been scheduled for this permit. Any person interested in a public hearing should notify the division contact. If sufficient interest exists, then a public hearing will be scheduled and the public given a minimum of fifteen days advance notice.

NOTIFICATION

Persons who want to receive notice of the final permit decision should register with the division contact.

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
William L. Meyer, Director

June 15, 2001

Mrs. Joan Smyth, P.G.
G.N. Richardson & Associates
425 N. Boylan Avenue
Raleigh, N.C. 27603

RE: Hydrogeologic Review Of The Design Hydrogeologic Report, Johnston County MSWLF Phase 4A Expansion, Permit No. 51-~~02~~ 51-03

Dear Mrs. Smyth,

This letter provides comments from the hydrogeologic review of the above referenced document. There are a few items that need additional clarification. Please respond to the following questions and comments:

Pg 2 It is not clear in the Regional Characterization Study if there are any "surface water intakes" in the study area, or if the public water supply "service area" includes the entire study area. Rule .1618(c)(1)(C).

Pg 2 It is not clear in the Local Characterization Study: (A) if there are any on-site easements, (B) what the zoning classifications are, (C) the location of private residences and schools, (D) the location of commercial and industrial buildings, and (F) the location of historic sites. Rule .1618 (c)(2).

Pg 4 A Water Quality Monitoring Plan needs to be provided that provides discussion about the adequacy of the existing monitoring system to provide effective monitoring for this area, including Phases 3, 4, and especially 4A. Are additional ground-water or surface water monitoring locations needed? Will it be necessary to alter or relocate any of the existing monitoring wells to construct and effectively monitor Phase 4A?

Pg 4 Has the approval from the Army Corps. Of Engineers been obtained for the wetlands between Phases 3 and 4?

Pg 7 Please explain and clarify the statement made at the bottom of page 7 that: "The contact between the Middendorf Formation and metamorphic rocks of the Carolina Slate Belt is generally found in boreholes and outcrops at elevations of 165 - 175 feet".

Pg 8 It is my understanding that additional geophysical mapping of dikes was to be done. What are the results of this study?

Fig 7 One of the figures needs to show the location of the monitoring wells for the Phase 5 area and the leachate pond.

Fig 8 Much of the data used to generate the Bedrock Contour Map is inconsistent with the boring logs. Data for borings MW-6, MW-7, PZ-1, T-5, T-6, and T-7 appears to be in error. Is there any data from the Phase 5 area that could supplement the limited data presented?

Figs 10, 11, 12 If the Bedrock data is that used for Fig 8, then some of the data is in error. It appears that the well stick-up is plotted for some wells but not others. Some of the well data seems to be plotted up to two or three feet off, based on the boring logs. This makes it difficult to interpret the elevations for PWR, rock, water, etc.

Fig 15 The Water Table Elevation Data from Table 2 differs slightly from that on Figure 15 for MW-7 and differs significantly for MW-12b. The water table contours could be adjusted slightly in several locations to better reflect the data. (Especially note the vicinity of MW-8.)

Fig 16 There appear to be a number of discrepancies between the data in Table 2 and the data plotted for Figure 16. The data and contouring in the vicinity of PZ-10 is of special concern.

Table 1 The TOC Elevation for MW-5 is inconsistent with the Table in Appendix E. For several of the wells with the MW designation, the Ground Elevation, Top Of Screen Elevation, and Bottom Elevation values seem inconsistent with the Boring Logs.

Table 3 Some of the data in Table 3 is inconsistent with the data in Appendix G. (Note the LL and PI values for PZ-5s and PZ-7.) Some of the sieve data is also difficult to match. For some piezometers there appears to be more than one set of data and some of the values differ.

Table 5 It is not stated what the units are for the K values. I assume they are ft/day since this is used for Velocity. However I can not correlate the data in Table 5 with the data in Appendix H. What is the source of the I and n values?

Table 5 For vertical gradients, typically the value is calculated by dividing the difference in the water table elevations for the two wells by the difference in the mid-points of the screen intervals. (For the shallow well the mid-point of only the saturated portion of the screen interval is used.) Also comparisons need to be made over time to determine if there are seasonal variations in vertical gradients.

Table 6 The K values in Table 6 do not appear to be consistent with the values in Appendix H. How was Aquifer Thickness determined? Why is Aquifer Thickness data provided? How were Total Porosity and Effective Porosity values determined? Clay-Silts would have different hydraulic characteristics than Sand-Silts and should be evaluated as a separate hydrogeologic unit.

Appendix F The blow counts are very low at several of the boring locations. Will this affect soil stability? Has any further evaluation been done for the soils in the wetlands area between Phases 3 and 4 regarding soil stability or foundational analyses? Will some of the soils need to be undercut and backfilled?

Appendix G As previously stated, I am having a little difficulty matching some of the soils analyses data with that in the Tables.

Appendix H Also the slope lines on some of the hydraulic conductivity charts are questionable. (Example: MW-4d)

Appendix I Have the results of the additional Dike Studies been completed?

The focus of the Design Hydrogeologic Study is to develop a good understanding of the hydrogeology in order to determine adequate vertical separation buffers and design an effective water quality monitoring system.

It would help to have a Table (and Drawings) that provide information on the vertical separation: including boring locations, ground surface elevations, base grade elevations, seasonal high water table elevations, and top of bedrock elevations.

Since some of the existing monitoring wells have been dry for some sampling events, and since a new landfill area is proposed in the drainage between Phases 3 and 4, further evaluation of the adequacy of the existing monitoring system is needed.

A certification is needed for the proper abandonment of the piezometers. Rule .1623(b)(2)(I).

Please provide the additional information and revisions as outlined above. If you or representatives of G. N. Richardson or Johnston County have any questions regarding this letter, you may contact me at (919) 733-0692 extension 258.

Sincerely,

Bobby Lutfy
Hydrogeologist
Solid Waste Section

cc: Jim Coffey, Solid Waste Section
Ed Mussler, Solid Waste Section
Robert Hearn, Solid Waste Section

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
William L. Meyer, Director

June 15, 2001

Mr. Rick J. Hester
County Manager
Johnston County
PO Box 1049
Smithfield, NC 27577

51-03

Re: Permitting for Johnston County Landfill, Cell 4A and C&D, Permits 5101 and 5102

Dear Mr. Hester:

The Solid Waste Section (Section) of the Division of Waste Management is in receipt of your letter of June 11, 2001. Johnston County has two municipal solid waste landfill facility (MSWLF) permits, 5101 and 5102. The first is for the original, unlined landfill and current C&D operations and the second is for the currently active lined landfill unit, Cell 5.

The County's request for a permit to construct Cell 4A is unique in North Carolina. As such there has been extensive review of the regulatory and policy implications of such an approach. Section Staff have evaluated the proposal and worked with your consultant, G. N. Richardson & Associates, to formulate an approach to this proposed project. All involved are confident that there are no technical obstacles to the plan.

The proposal does, however, have requirements that are procedural in nature. You have a current permit, 5102, for a lined MSWLF. Continued operation and construction at this facility would be under the auspices of the Solid Waste Management Rules 15A NCAC 13B .1600. The proposed development of Cell 4A qualifies facility permit 5101 as a new facility, under the requirements of Rule .1603(a)(1)(E), a substantial change to the waste stream defined in the effective permit.

As a result, the requirements for a new facility (see Rule .1617) must be met by the County. This requires a Site Study. The technical requirements of the site study have largely been met by the county, during previous permitting actions. The Section will let the County know of any minor additions that may need to be updated. The County will need to meet the requirements of Rule .1618 (c)(5), Local government approvals for municipal solid waste landfills. At this time it is also recommended that the county merge the two permitted properties into one facility. Section staff will be available to work closely with your consultant and staff to ensure that the proper steps are presented to your commissioners for action.

While the county fulfills its legal obligation under Rule .1618 (c)(5), Section staff will be evaluating the current application with respect to the technical aspects, to ensure that sufficient time will be available for construction of a new cell.

Johnston County has also approached the Section about expanding C&D operations over the closed portion of Cells 1 and 2 at facility 5101. Cells 1 and 2 at this facility ceased accepting waste prior to October 9, 1993, and were closed with a two foot dirt cover. They were not subject to regulation under Subtitle D and the new state landfill rules. Unlined landfill units which accepted waste after October 9, 1993 are subject to the federal Subtitle D rules as well as the current Section .1600 rules of the state. The more stringent rules require minimum specification closure caps, as well as upgraded groundwater monitoring wells and financial assurance for closure and post-closure costs. The Section has considered and approved some placement of C&D materials on these units which fall under the .1600 rules. Currently the cutoff date for this activity is January 1, 2003.

The Section has not permitted expansion or placement of C& D on top of old MSW units, which are not subject to the new rules. The subject is on our list of objectives to study this year. Working in conjunction with the local SWANA group, we will be evaluating the current practice and its effects on groundwater, as well as whether the practice should be expanded or stopped all together, and if it should, or could legally, be expanded to non-1600 rule MSW units.

Consequently the county and its consultant should make other arrangements for future C&D disposal capacity. It is unlikely that the Section can complete its review in time for Johnston County to make appropriate plans. The Section Staff will work closely with county staff and your consultant to evaluate your options.

If you have any further questions, please do not hesitate to contact me. Specific questions about permitting and the current status of the permit application can be directed by your staff or consultant to Ed Mussler , the permitting engineer.

Sincerely,

James C Coffey

James C. Coffey
Acting Section Chief
Solid Waste Section

cc; Ed Mussler, DWM
Mark Fry, DWM
Pieter Scheer, GNRA

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services

TRANSMITTAL FORM

If enclosures are not as noted or
if you require additional information,
please notify us immediately

January 31, 2001

Mr. Ed Mussler, P.E.
NC DENR Division of Waste Management
401 Oberlin Road, Suite 150
Raleigh, NC 27605
(919) 733-0692

SUBJECT: **Johnston County Landfill - Revised Operations Manual**

GNRA PROJECT NO: **JOHNSTON-9**

We are sending you the following items:

COPIES	ITEM	DESCRIPTION
1	Letter	Draft Response to Comments Letter
1	Manual	Revised Operations Manual

These are transmitted as checked below:

[X] **For Information**
[ ] As Requested
[ ] For Review and Comments
[ ] For Revision
[ ] For Approval
[ ] Approved
[ ] Approved as Noted
[ ] Approved as Noted-Revise and Resubmit
[ ] Not Approved-Revise and Resubmit
[ ] For Record and File
[ ] Submittal
[ ] For Recording

REMARKS: Ed: Please review the attached draft letter and revised ops. manual and let me know if you have any further comments. We are only waiting on the legal description and the current allowable discharge to the WWTP.

cc:

Pieter K. Scheer, P.E.

425 N. BOYLAN AVENUE • RALEIGH, NORTH CAROLINA 27603 • TEL. 919-828-0577 • FAX. 919-828-3899

NCDA Agronomic Division 4300 Reedy Creek Road Raleigh, NC 27607-6465 (919) 733-2655 Report No: 34048

Soil Test Report

Grower: York, Kenneth
12 Woodsdale Drive
Smithfield, NC 27577

Copies to:

Farm:

4/30/01 SERVING N.C. CITIZENS FOR OVER 50 YEARS Johnston County

Agronomist Comments: C -- 12, $

Field Information		Applied Lime			Recommendations										
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P2O5	K2O	Mg	Cu	Zn	B	Mn	See Note
KCY01	No Crop				1st Crop: Berm Hay/Pas,E	.5T	60-80	0	0	0	0	0		0	12
					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO3-N	NH4-N	Na
MIN	0.22	1.26	4.9	88.0	0.6	5.7	199	89	62.0	17.0	112	77		277	277	146	214				0.0

Field Information		Applied Lime			Recommendations										
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P2O5	K2O	Mg	Cu	Zn	B	Mn	See Note
KCY02	No Crop				1st Crop: Berm Hay/Pas,E	.5T	60-80	0	50-70	0	0	0		0	12
					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO3-N	NH4-N	Na
MIN	0.46	1.48	4.0	85.0	0.6	6.0	468	37	62.0	17.0	132	89		470	470	277	62				0.0

Field Information		Applied Lime			Recommendations										
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P2O5	K2O	Mg	Cu	Zn	B	Mn	See Note
* KCY03	No Crop				1st Crop: Berm Hay/Pas,E	.7T	60-80	0	90-110	$	0	0		0	12
FIELD 4					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO3-N	NH4-N	Na
MIN	0.36	1.38	5.3	85.0	0.8	5.6	715	21	75.0	8.0	106	73		484	484	438	71				0.1

Field Information		Applied Lime			Recommendations										
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P2O5	K2O	Mg	Cu	Zn	B	Mn	See Note
KCY04	No Crop				1st Crop: Clover L/Gr,E	.6T	10-30	90-110	170-190	$	0	0		0	12
					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO3-N	NH4-N	Na
MIN	0.04	1.31	1.7	65.0	0.6	5.1	54	25	44.0	11.0	31	28		75	75	52	127				0.0

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY05	No Crop				1st Crop: Clover L/Gr,E	1.1T	10-30	240-260	170-190	0	0	$		0	12
FIELD 3					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.0	1.21	2.6	54.0	1.2	4.6	1	23	26.0	22.0	47	38		19	19	82	193				0.0

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY06	No Crop				1st Crop: Clover L/Gr,E	1.8T	10-30	240-260	140-160	0	0	$		0	12
FIELD 10					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.0	0.99	3.8	50.0	1.9	4.9	0	33	9.0	37.0	426	265		12	12	64	121				0.2

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY07	No Crop				1st Crop: Clover L/Gr,E	.8T	10-30	240-260	200-220	$	$	$		0	12
FIELD 9					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.0	1.18	1.5	40.0	0.9	4.9	0	13	19.0	15.0	40	33		11	11	14	177				0.1

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY08	No Crop				1st Crop: Clover L/Gr,E	.6T	10-30	240-260	220-240	$	$	$		$	12
1Ac FIELD 8					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.0	1.11	0.9	33.0	0.6	4.8	0	5	20.0	10.0	6	13		8	8	8	86				0.0

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY09	No Crop				1st Crop: Berm Hay/Pas,E	0	60-80	0-20	10-30	0	0	0		0	12
					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.18	1.32	3.8	92.0	0.3	6.2	76	67	59.0	23.0	42	39		89	89	47	59				0.0

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY10	No Crop				1st Crop: Berm Hay/Pas,E	0	60-80	0	50-70	0	0	0		0	12
LARGE PORTION FIELD 2					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.32	1.44	2.5	92.0	0.2	6.4	182	37	65.0	20.0	56	45		108	108	52	25				0.0

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
KCY11	No Crop				1st Crop: Berm Hay/Pas,E	.4T	60-80	0	90-110	0	0	0		0	12
PORTION FIELD 2					2nd Crop:										

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-AI (1)	Mn-AI (2)	Zn-I	Zn-AI	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.44	1.33	3.2	84.0	0.5	6.1	99	20	59.0	22.0	36	31		73	73	40	31				0.0

NCDA Agronomic Division 4300 Reedy Creek Road Raleigh, NC 27607-6465 (919) 733-2655 Report No: 07489

Soil Test Report

Grower: York, Kenneth
12 Woodsdale Drive
Smithfield, NC 27577

Copies to: County Extension Director

Farm:

10/16/02 SERVING N.C. CITIZENS FOR OVER 50 YEARS Johnston County

Agronomist Comments:

C -- 12, $

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
01	No Crop				1st Crop: Berm Hay/Pas,E	1.1T	60-80	0	10-30	0	0	0		0	12
FIELD 3					2nd Crop: Berm Hay/Pas,M	0	180-220	0	70-90	0	0	0		0	12

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-Al (1)	Mn-Al (2)	Zn-I	Zn-Al	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.32	1.30	7.2	81.0	1.4	6.1	406	63	62.0	14.0	158	104	104	471	471	256	38				0.1

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
02	Hardwood,M				1st Crop: Berm Hay/Pas,E	2.8T	60-80	70-90	50-70	$	0	0		0	12
WOODED PORTION FIELD 2					2nd Crop: Berm Hay/Pas,M	0	180-220	60-80	130-150	$	0	0		0	12

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-Al (1)	Mn-Al (2)	Zn-I	Zn-Al	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.32	1.25	5.2	42.0	3.0	5.0	27	40	29.0	8.0	90	63	63	264	264	63	35				0.1

Field Information		Applied Lime			Recommendations									
Sample No.	Last Crop	Mo	Yr	T/A	Crop or Year	Lime	N	P_2O_5	K_2O	Mg	Cu	Zn	B	Mn	See Note
03	Hardwood,M				1st Crop: Berm Hay/Pas,E	1.9T	60-80	80-100	90-110	$	0	0		0	12
WOODED PORTION FIELD 3					2nd Crop: Berm Hay/Pas,M	0	180-220	70-90	180-200	$	0	0		0	12

Test Results																				
Soil Class	HM%	W/V	CEC	BS%	Ac	pH	P-I	K-I	Ca%	Mg%	Mn-I	Mn-Al (1)	Mn-Al (2)	Zn-I	Zn-Al	Cu-I	S-I	SS-I	NO_3-N	NH_4-N	Na
MIN	0.36	1.38	2.9	31.0	2.0	4.9	23	19	21.0	6.0	27	26	26	64	64	86	61				0.1

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
Dexter R. Matthews, Director

January 15, 2002

MEMORANDUM

To: Ed Mussler

From: Bobby Lutfy BL

51-03

RE: Johnston County - Phase 4A Design Hydrogeologic Report

The Johnston County Phase 4A Design Hydrogeologic Report has been reviewed and has undergone several revisions. With the most recent revisions of January 9, 2002, this report now meets the requirements of Rule .1623(b).

A replacement monitoring well, MW-8a, and a new monitoring well, MW-17, are to be installed to upgrade the ground-water monitoring system for Phase 4A. Well MW-17 is to be installed in the middle of the drainage feature immediately downgradient of Phase 4A. An additional surface water sampling location is to be added to the water quality monitoring system, SWPT-3. The leachate collection system *and* the leachate detection system are both also to be sampled semi-annually for the Appendix 1 list of constituents.

CC: Jim Coffey