GZA
GeoEnvironmental, Inc.

Engineers and
Scientists

March 21, 2006
File No. 32795.08

Terry Simpson
Division of Water Resources
Rhode Island Department of Environmental Management
235 Promenade Street
Providence, Rhode Island 02908

140 Broadway
Providence
Rhode Island
02903
401-421-4140
Fax: 401-751-8613
www.gza.com

Re: Hydrogeologic Study
Charbert Facility
Alton, Rhode Island

Dear Terry:

This report presents the results of a focused hydrogeologic study performed by GZA GeoEnvironmental, Inc. (GZA) for Charbert, a division of NFA Corporation located in Alton, Rhode Island. The purpose of the study was to evaluate the suitability of on-site soils for infiltration of treated process wastewater.

Please do not hesitate to call us if you have any questions.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Anthony B. Urbano, P.E.
Senior Project Manager

Michael A. Powers, P.E.
Senior Principal

Edward A. Summerly, P.G.
Associate Principal

cc: Michael Healy, Charbert

J:\ENV\32795-08.abu\Hydrogeo Study\32795-08covlet.doc

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.'d)

FIGURES

APPENDICES

J:\ENV\32795-08.abu\Hydrogeo Study\32795-08 TOC.doc

1.00 INTRODUCTION

This report presents the results of a focused hydrogeologic study performed by GZA GeoEnvironmental Inc. (GZA) for Charbert, A Division of NFA Corporation located in Alton, Rhode Island. The purpose of the study was to evaluate the suitability of on-site soils for infiltration of treated process wastewater. The study area was the southern portion of the Charbert facility in the proximity of existing lagoons 1, 2, and 3. The study area is bounded by the Wood River to the west and south and by the Pawcatuck River to the east. A Locus Plan is provided as Figure 1. The average daily process wastewater flow is expected to be 210,000 gallons per day (gpd) and the peak daily wastewater flow is expected to be 300,000 gpd. The findings of this report are subject to the limitations described in Appendix A.

Our scope of work included:

- the performance of seven (7) test pit explorations;
- the installation of ten (10) groundwater monitoring wells;
- the collection of water level measurements;
- the performance of a laboratory hydraulic conductivity test;
- the performance of a 35 day duration field hydraulic load test to evaluate the transmissivity and storage coefficient of the aquifer;
- an evaluation of the maximum mound of the groundwater table beneath the treated wastewater infiltration areas using an analytical solution developed by Hantush; and
- preparation of this geohydrologic report.

1.10 BACKGROUND INFORMATION

The existing wastewater lagoons 1, 2, and 3 are currently leaching between 150,000 and 200,000 gallons of wastewater per day. These lagoons have been operating for over 30 years. The leaching rate does vary in response to seasonal groundwater elevations in the area adjacent to the existing lagoons. The leaching rate of the lagoons is higher during periods of lower groundwater elevations such as occur during the summer. The leaching rate is also impacted by the precipitation of particulates. These particulates settle to the bottom and sides of the lagoons and reduce the leaching rate. The lagoons are periodically resurfaced to remove the particulates that plug up the soil pores and reduce the leaching rate.

2.00 SUBSURFACE EXPLORATIONS

The following sections describe the test pit explorations, test borings, monitoring well installations, and the laboratory hydraulic conductivity testing performed in the proposed wastewater disposal areas.

2.10 TEST PIT EXPLORATIONS

Seven test pits (designated ATP-1 to ATP-7) were excavated on April 6, 2005 by Sposato & Sons. These explorations were observed and logged by GZA. The test pit explorations were performed to depths ranging from 7 to 16 feet below grade. The location of test pits ATP-1 to ATP-5, and ATP-7 are depicted on Figure 2. Test pit ATP-6 was excavated on property owned by Charbert approximately 0.5 miles east of the study area. Test pit logs are provided in Appendix B.

2.20 TEST BORINGS AND MONITORING WELLS

Ten test borings (designated GZ-9 to GZ-18) with groundwater monitoring wells were installed by New Hampshire Test Boring using hollow stem auger and drive and wash drilling techniques. Test borings/wells GZ-9 and GZ-10 were installed between April 11 and 13, 2005 and test borings/wells GZ-11 to GZ-18 were installed between July 11 and 14, 2005. The borings were performed to depths ranging from 15 to 45 feet below grade. Split-spoon soil samples were collected at approximately 5 foot intervals. Five feet of bedrock was cored at the bottom of borings GZ-11 and GZ-13 using an NX-type rock core barrel. The test boring/well logs prepared by GZA are provided in Appendix C and the locations are shown on Figure 2.

The monitoring wells were comprised of 5 to 15 foot sections of 2-inch diameter, slotted (0.010-inch), PVC well screen and solid 2-inch diameter PVC riser pipe to ground surface. The annular space around the well screen was backfilled with filter sand and a 1-foot thick bentonite seal was placed above the filter sand. The top of the well was completed with a 5-foot long, locking, protective steel casing that was cemented in place.

2.30 LABORATORY HYDRAULIC CONDUCTIVITY TESTS

A soil sample collected from test pit exploration ATP-2 at a depth of 6 feet was sent to GZA's laboratory located in Hopkinton, Massachusetts for constant head, fixed ring, reconstituted permeability testing. A gradation analysis of the soil sample indicated the sample was a medium to fine sand with trace amounts of silt. The soil sample was reconstituted in the laboratory to the density measured in the field using a Troxler field density device. The test results, provided in Appendix D, indicate the hydraulic conductivitiy(K) of the soil sample was 71 feet per day.

3.00 FIELD HYDRAULIC LOAD TEST

GZA performed a field hydraulic load test to the south of lagoon 3. The purpose of the load test was to evaluate the aquifer characteristics (i.e., transmissivity and storage coefficient) at the study area. The aquifer characteristics were subsequently used to estimate the maximum height of the "groundwater mound" beneath the proposed wastewater infiltration areas. The groundwater mound calculations were used to estimate the capacity of the subsurface soils to accept the planned wastewater discharge.

3.10 FIELD HYDRAULIC LOAD TEST PROCEDURE

A thirty five (35) day duration field hydraulic load test began on July 19, 2005 and ended on August 23, 2005. The test involved pumping water into the ground in the load test areas and measuring the water level response in nearby monitoring wells. Immediately following the load test a 36 day recovery test was performed until September 28, 2005.

The field hydraulic load test was performed as follows: unsuitable soils (topsoil/subsoil/ and fine grained shallow soils) were removed from a main 50-by 50-foot load test area and from nine (9) smaller 20-by 20-foot load test areas. See Figure 2 for the location of the load test areas. The water source for the load test was the Wood River. A centrifugal pump was used to transfer water from the Wood River to the test areas. The water was distributed over the test area using a network of 4-inch diameter perforated plastic pipes that were placed on the ground surface within the test areas. The flow rate was measured in the main test area using a 55-gallon drum with a stop watch and was measured in the smaller test areas using a 5-gallon bucket with a stop watch. A gate valve was used to regulate the flow in the main test area and constant-flow dole valves were used to regulate the flow in the smaller test areas.

Groundwater monitoring wells were installed around the load test areas. These wells were used to record the groundwater mound with respect to time. Continuous water levels were recorded electronically at wells GZ-9, GZ-13, and GZ-15 to GZ-18 using pressure transducers and data loggers. Water levels in the surrounding monitoring wells located within a 200 foot radius of the load test were recorded manually with an electronic water level meter.

Water was only applied to the main 50-by 50-foot test area during the first 7 days of the load test. The flow rate applied to the main test area during this 7 day period was approximately 75 gallons per minute (gpm) which is 43 gallons per day (gpd) per square foot or 108,000 gpd. Note that there was some variation in the flow rate over time. Table 1 summarizes the flow rate applied to each of the test areas over time. The graphs presented in Appendix E depict the fluctuation of the flow rate versus time.

During the second week of the load test the flow rate was applied to both the main 50-by 50-foot test area as well as the smaller test area labeled Pit 4 (see Figure 2 for locations). The flow rate applied to the main test area during this 7 day period was approximately 68 gallons per minute (gpm) and the flow rate applied to Pit 4 was 14 gpm (i.e., total flow of approximately 118,000 gpd). Refer to the graphs in Appendix E to observe the fluctuation of the flow rate versus time.

During the third, fourth, and fifth weeks of the load test the flow rate was applied to the main test area, as wells as, Pits 2 through Pit 9. The average combined flow rate to the test areas during the third, fourth, and fifth weeks of the hydraulic load test was approximately 140 gpm (201,600 gpd). Note that there were variations in the flow rate over time due to plugging of the dole valves and other factors. The flow rate data is summarized in Table 1 and the graphs of the flow rate data are provided in Appendix E.

Note that during the hydraulic load test, the existing lagoons 1, 2 and 3 were receiving their average daily flow of approximately 210,000 gpd.

Rainfall data collected at Charbert during the load test and recovery test is summarized in Table 2. The data indicates that the rainfall during the load test was below average and that the rainfall during the recovery test was similar to average monthly rainfall rates.

3.20 FIELD HYDRAULIC LOAD TEST RESULTS

The static groundwater levels recorded in the monitoring wells prior to the start of the load test on July 19, 2005 are summarized on Table 3. The shallow static water level in the area of the load test varied from 7.9 feet below grade at well GZ-17 to 16.1 feet below grade at well GZ-13. The static groundwater contours are depicted on Figure 2. The contour plan indicates that the groundwater flow in the area of the load tests is predominantly to the southwest towards the Wood River. The static hydraulic gradient in this area is approximately 0.05 feet per foot.

Table 3 also summarizes the water level data after one week of the hydraulic load test (7/26/05), after two weeks of the hydraulic load test (8/2/05), at the end of the hydraulic load test (8/23/05), and at the end of the 36 day recovery test (9/28/05). The height of the groundwater mound for these dates is also summarized in Table 3. The groundwater mound at the end of the load test generally varied from 2.9 feet at well GZ-5 to 9.2 feet at well GZ-18. The groundwater contours at the end of the hydraulic load test (8/23/05) are depicted on Figure 3. This contour plan reveals that the groundwater elevations in the area of the hydraulic load test generally varied from elevation 58 to 61 feet at the end of the test (which is only slightly below existing ground surface).

The groundwater mound in the monitoring wells with the pressure transducers and data loggers (GZ-9, GZ-13, and GZ-15 to GZ-18) are presented on the graphs provided in Appendix F. Note that the data loggers were programmed to stop collecting data after two weeks into the recovery test.

The manually collected water level readings in the 11 monitoring wells located within a 200 foot radius of the load test areas; and, the flow rate measurements for each of the load test areas are presented in Appendix G. Note that Appendix G also includes the manual water level readings recorded at Lagoon 3, wetland stakes WLS-1 and WLS-2 (located to the southwest of the load test) and background well RIZ-18 (located 1,500 feet north of the load test area).

The water level in background well RIZ-18 was dropping at a rate of approximately 0.03 feet per day during the first week of the hydraulic load test and at a rate of approximately 0.02 feet per day for the 35 day duration of the load test. The water levels recorded in the wells with the data loggers four days prior to the hydraulic load test revealed that: (1) the water level in wells GZ-9, GZ-13, and GZ-15 were dropping at a rate of approximately 0.05 feet per day; (2) the water level in wells GZ-16 and GZ-18 were dropping at a rate of approximately 0.07 feet per day; and (3) the water level in well GZ-17 was dropping at a rate of 0.12 feet per day. These data indicate that the seasonal water table was dropping during the load test. Consequently, the operational groundwater mound (under similar loading rates) will be somewhat greater than the values observed during the test when the seasonal water table is rising (versus falling). However, as noted earlier, Lagoons 1 through 3 were receiving an average flow of 210,000 gpd, which may off-set the impact of declining seasonal water levels.

At the end of the hydraulic load test GZA personnel observed the slopes adjacent to the nearby wetlands for evidence of groundwater seepage breaks above the wetlands elevation. No seepage breaks were observed.

The water level data collected from monitoring wells GZ-9, GZ-13, and GZ-15 to GZ-18 were used to evaluate the properties of the aquifer. We evaluated the aquifer properties using both the Cooper-Jacob and the Theis methods of analysis with the assistance of the AQTESOLV for Windows (Version 3.50) computer software program. Because of the large number of load test areas and the variability in the flow rate data, we only used the data for the first 2 weeks of the test in the AQTESOLV evaluation. That is, we used the data when the flow was only to the main 50-by 50-foot test area and Pit 4. Note that because the water table was dropping during the test, a manual correction to the last data point is hand drawn on the AQTESOLV solution. The AQTESOLV results are provided in Appendix H.

The AQTESOLV results are summarized in Table 4. Note that the aquifer thickness was smaller at the beginning of the test and was larger at the end of the test (because the groundwater mound increased the saturated thickness of the shallow sandy aquifer). Consequently, the transmissivity at the early portion of the test was less than the transmissivity at the end of the test. The AQTESOLV results were evaluated for both the initial portion of the test and the later portion of the test. The transmissivity at the early portion of the test was approximately 300 feet squared per day and the transmissivity at the late portion of the test was approximately 700 feet squared per day. The aquifer storage coefficient was approximately 0.10. We believe the transmissivity at the later portion of the test is more representative of anticipated operating conditions.

4.00 SUBSURFACE CONDITIONS

The following sections describe the subsurface conditions in proximity of Lagoons 1, 2, and 3.

4.10 SOIL CONDITIONS

The subsurface conditions were generally comprised of 2 to 4 feet of silty topsoil and subsoil underlain by clean (relatively silt-free) sands with occasional gravelly seams to a depth of 12 to 17 feet below grade. The sandy deposits were underlain by a 5 to 15 foot thick stratum of predominantly silty fine sand. A discontinuous sand zone up to 9 feet thick was encountered in some of the borings beneath the silty sand strata. Glacial till (a dense well graded mixture of silt, sands, cobbles) and bedrock was encountered at depths ranging from 23 to 37 feet below grade.

The top elevation of the silty sand strata was generally encountered at elevation 45 feet to the south of the lagoons. The top of the silty sand strata rose to elevation 49 feet at boring GZ-11 (the southernmost exploration) and dropped to elevation 37 feet at boring GZ-10 located to the west of Lagoon 2. Note that at some of the explorations (such as TP-1, TP-3, and TP-7) the upper sandy soil zone was intermixed with a silty sand stratum.

4.20 BEDROCK

Five foot long bedrock core samples were collected from borings GZ-11 and GZ-13. The top of the bedrock was encountered 23 feet below grade at GZ-11 and the top of the bedrock was encountered 40 feet below grade at GZ-13. The bedrock was a very hard, slightly to moderately weathered, moderately to extremely fractured granite.

4.30 GROUNDWATER CONDITIONS

The static groundwater levels were recorded in the monitoring wells prior to the start of the load test on July 19, 2005. The shallow water levels in the area of the load test varied from 7.9 feet below grade at well GZ-17 to 16.1 feet below grade at well GZ-13. Downward vertical gradients were observed at well couplets GZ-13/GZ-14 and couplet GZ-5/GP-21. The groundwater contour plan for the shallow groundwater levels is depicted on Figure 2. The contour plan indicates that the groundwater flow in the area of the load tests was predominantly to the southwest towards the Wood River with a hydraulic gradient of approximately 0.05 feet per foot. The groundwater flow direction in the area of lagoons 1, 2, and 3 is predominantly to the west and east. The hydraulic gradient in the immediate proximity of the lagoons is very steep (approximately 0.5 feet per foot). The hydraulic gradient decreases to approximately 0.03 feet per foot to the west of the lagoons.

The groundwater contours at the end of the hydraulic load test (8/23/05) are depicted on Figure 3. This contour plan reveals that the groundwater elevations in the area of the hydraulic load test generally varied from elevation 58 to 61 feet (which is only slightly below existing ground surface). The groundwater mound at the end of the load test generally varied from 2.9 feet at well GZ-5 to 9.2 feet at well GZ-18. The flow rate to the load test area was: (1) approximately 108,000 gallons per day (gpd) during the first week of the load test; (2) approximately 118,000 gpd during the second week of the load test; and (3) approximately 201,600 gpd during the third, fourth, and fifth weeks of the hydraulic load test.

4.40 AQUIFER CONDITIONS

As stated in Sections 2.30 and 3.20 of this report, the transmissivity at the early portion of the hydraulic load test was approximately 300 feet squared per day and the transmissivity at the late portion of the hydraulic load test was approximately 700 feet squared per day. The saturated thickness of the upper clean sands in the aquifer at the end of the load test averaged 12 feet. This indicates an average hydraulic conductivity of approximately 60 feet per day. The aquifer storage coefficient was approximately 0.10. We believe the transmissivity at the later portion of the test is more representative of anticipated operating conditions. The hydraulic conductivitiy of the laboratory tested soil sample was 71 feet per day.

5.00 GEOHYDROLOGIC EVALUATION

GZA performed a field hydraulic load test to evaluate the aquifer characteristics (i.e., transmissivity and storage coefficient) in the area of the existing lagoons. The aquifer characteristics were subsequently used to estimate the maximum height of the "groundwater mound" beneath the proposed wastewater infiltration areas. The groundwater mound calculations were then used to estimate the capacity of the subsurface soils to accept the wastewater discharge from the proposed wastewater treatment plant.

The largest groundwater mound will occur at the center of the wastewater infiltration bed and the groundwater mound will become smaller with increased distance from the center. The height of groundwater mounding will depend on the soil transmissivity, storage coefficient, time of stabilization, leaching bed dimensions, and wastewater application rate.

An analytical computer program that uses Hantush's Solution to Glover's Equation was used to estimate the height of the groundwater mound beneath the proposed wastewater disposal areas. A transmissivity of 700 feet squared per day and a storage coefficient of 0.10 were used in the simulations. The estimated time to stabilization (the time at which the groundwater mound ceased to grow) was conservatively chosen to be 90 days. We have assumed that open sand beds, typically referred to as Rapid Infiltration Beds or RIBS, will be utilized for the wastewater disposal areas. We propose to use a wastewater application rate of 5.0 gallons per day per square foot of RIB. We note that during the load test the wastewater application rate generally ranged from 43 to 54 gallons per day per square foot of bottom infiltration area.

Simulations were performed to evaluate capacity of the subsurface soils to accept the wastewater discharge from the proposed wastewater treatment plant without the groundwater mound rising above the finish grade elevation of the RIBs.

Our evaluation identified three areas for the proposed discharge of the wastewater. Area 1 is located to the south of the lagoons, Area 2 is located to the west of the lagoons, and Area 3 is located to the east of the lagoons. We recommend installing a 300 foot long by 80 foot wide RIB at Area 1, a 600 foot long by 40 foot wide RIB at Area 2, and a 250 foot long by 50 foot wide RIB at Area 3. Refer to Figure 4 for the proposed locations of the RIB.

Our groundwater mounding calculations, which are provided in Appendix I, indicate that a flow rate of 120,000 gallons per day (gpd) will result in a maximum groundwater mound of 10.5 feet beneath the center of Area 1, a flow rate of 120,000 gpd will result in a maximum groundwater mound of 8.5 feet beneath the center of Area 2, and a flow rate of 60,000 gpd will result in a maximum groundwater mound of 5.9 feet beneath the center of Area 3.

The groundwater table beneath Area 1 varied from elevation 45 to 50 feet on July 19, 2005. Water level readings collected from well GZ-9 revealed that the water table in the spring time (April 13, 2005) is approximately 1 foot higher than the July 2005 reading (see boring log GZ-9 in Appendix C). Consequently, the mounded seasonal high water table would be expected to range from elevation 56.5 feet to elevation 61.5 feet beneath Area 1. Therefore, the top elevation of the RIB at Area 1 should be at elevation 62.0 feet.

The groundwater table beneath Area 2 was at approximate elevation 45 feet on July 19, 2005. Water level readings collected from well GZ-10 revealed the water table in the spring time (May 25, 2005) is approximately 2 feet higher than the July 2005 readings (see boring log GZ-10 in Appendix C). Consequently, the mounded seasonal high water table would be expected to be at elevation 55.5 feet beneath Area 2. Given the fact that the aquifer data collected from the south of the lagoons was used in this evaluation, we would recommend that the RIB at Area 2 be installed at elevation 57.0 feet.

The groundwater table beneath Area 3 was approximately at elevation 51 feet on April 6, 2005. Consequently, the mounded seasonal high water table would be expected to be at elevation 56.9 feet beneath Area 3. Given the fact that the aquifer data collected from the south of the lagoons was used in this evaluation, we would recommend that the RIB at Area 3 be installed at elevation 62.0 feet. Note that we have assumed that the temporary holding pond located in Area 3 will be backfilled with sand to original grades prior to the installation of the RIB in this area.

6.00 FINDINGS

The following summarizes our major findings of the geohydrologic study.

- The areas surrounding the existing lagoons are suitable for the infiltration of the design flow rate of 300,000 gpd from the wastewater treatment plant.

- The discharge should be sent to three separate areas (designates Areas 1, 2, and 3) and should be applied at a rate of approximately 5 gallons per day per square foot of infiltration area. Note that the exact locations of the RIBs may change slightly based on observations encountered during construction.

- Area 1 is located south of the lagoons and is capable of handling a discharge of 120,000 gpd of treated process wastewater. Area 1 should be 300 feet long, 80 feet wide and installed at the approximate location shown on Figure 4. The top of the sand bed should be at elevation 62.0 feet.

- Area 2 is located west of the lagoons and is capable of handling a discharge of 120,000 gpd of treated process wastewater. Area 2 should be 600 feet long, 40 feet wide and installed at the approximate location shown on Figure 4. The top of the sand bed should be at elevation 57.0 feet.

- Area 3 is located east of the lagoons and is capable of handling a discharge of 60,000 gpd of treated process wastewater. Area 3 should be 250 feet long, 50 feet wide and installed at the approximate location shown on Figure 4. The top of the sand bed should be at elevation 62.0 feet.

- Unsuitable soil consisting of topsoil, subsoil, and silty fine grained soil should be removed from the wastewater disposal areas. The soil should be replaced with clean medium to fine sand (or coarser material) up to the design elevation of the RIBs.

- Periodic maintenance of the RIBs may be required to remove silty build-up at the surface of the RIBs.

- We recommend that Lagoon 3 be cleaned and maintained for backup and additional infiltration capacity.

- Our estimates are based on testing in the vicinity of Area 1 and our analysis was in some ways conservative. Aquifer properties vary spacially and the actual capacity of the soils may be higher or lower than estimated in some areas. We, therefore, recommend that flows be measured, and monitoring wells installed to measure the actual depth to groundwater. In this way, flows can be adjusted to optimize the discharge of water to the RIBs.

J:\ENV\32795-08.abu\Hydrogeo Study\32795-08 rep.doc