Final Report

Dare County Regional Water System,
County of Dare, North Carolina.

Water Treatment Plant Improvements.

Arsenic Reduction Project, North Reverse Osmosis Plant,
Kill Devil Hills, North Carolina.

TASK 2 ~ Pilot Plant Test Report

AFFIDAVIT

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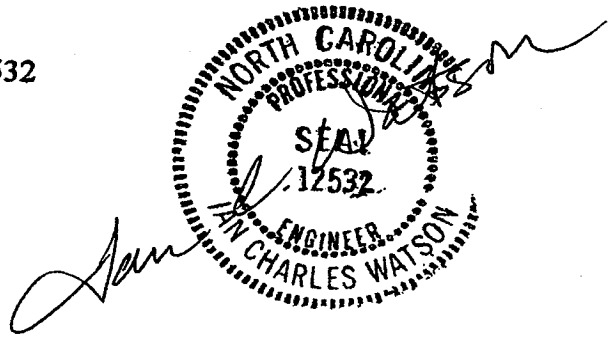

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CHAPTER 1

INTRODUCTION

The North RO plant operated by the Dare County Regional Water System at Kill Devil Hills, North Carolina, is the only water treatment plant in the County system that has an elevated level of arsenic in the raw water source. At the time the plant entered service in August 1989, the Maximum Contaminant Level (MCL) for arsenic in the Federal and State drinking water standards was 50 micrograms/liter (μg/l). The product water produced from the NRO plant was well in compliance with this MCL, with an average value from compliance testing of 15.5 μg/l between 1989 and 2001. During this period of time the average arsenic concentration in the NRO plant feedwater was approximately 60 μg/l. Speciation of the arsenic revealed that two forms are present, As(III) and As(V). Arsenic (V) is very well rejected by the NRO plant's membranes, but As(III) is not. Virtually 100% of the arsenic in the permeate was found to be As(III).

In 2002, the MCL for arsenic in drinking water was lowered from 50 μg/l to 10 μg/l. Public notification of non-compliance was mandated for January of 2002, and full compliance with the MCL is currently scheduled for January 22nd, 2006.

In July of 2002, RosTek Associates, Inc. delivered an initial report on arsenic reduction strategies to the County.[1] This report reviewed the history of arsenic in NRO plant waters; reviewed emerging technologies for arsenic reduction; examined the potential for alternate water sources; provided conceptual costs; and recommended the next step of pilot testing those technologies that best fit the situation at the NRO.

This document reports on the findings of the pilot testing program, during which five strategies were evaluated, provides cost opinions at a higher level of accuracy than Task 1 and provides a road map for moving forward to compliance.

[1] "Arsenic Reduction Project, North Reverse Osmosis Plant. Task 1 – Overview Study". RosTek Associates, Inc. July 2002.

CHAPTER 2

PILOT TEST EQUIPMENT

2.1 The Processes

The Task 1 report identified several processes that appeared to fit the constraints that the configuration and space limitation of the NRO plant impose on the arsenic reduction project. The major constraints are tabulated below:

- The selected process must be compact enough to fit in the limited space available immediately behind the existing plant building and/or in the space immediately north of the building. The later site would require relocation of existing staff and water system vehicle parking. The space requirement assumes the capacity of the arsenic system would ultimately be 8.0 MGD, the current build-out capacity of the NRO membrane treatment plant.

- Given the location of the NRO plant, and the distance to solid waste disposal landfill, it is desirable to select a process with minimum sludge generating capability. A process with zero sludge production would be optimum in this regard.

- Since the existing NRO plant is a membrane water treatment plant, a membrane-based solution would be very desirable, given staff familiarity and expertise with this type of process.

- Since part of the raw water is blended with RO permeate to increase hardness and alkalinity in the finished water for corrosion control reasons, a process suitable for reducing the arsenic in this blend water would provide a "safety margin", in the event the MCL is lowered in the future. If the blend water were not treated, the resulting blend would have an arsenic content of about 8 µg/l, very close to the current MCL. By reducing arsenic in the blend water to 10 µg/l or less, the finished water arsenic will be approximately 5 µg/l.

- If a process which involves solid waste disposal is selected, which would be a once-through adsorption process, of some type, the selected vendor must be prepared to replace the spent adsorption media, and dispose of it on a long term contracted basis, relieving the county of the responsibility and liability.

2.1.1 Raw Water Treatment

The process selected for the treatment of the feedwater for blending purposes was manganese greensand oxidation and filtration. In the literature search in Task 1, it was frequently reported that arsenic can be adsorbed on an iron floc, and removed by filtration. Based on the research, it was clear that As(III) needed to be oxidized to As(V), and a small dose of an iron salt added to adsorb the arsenic. This floc is filtered by the manganese greensand bed, and essentially free from arsenic, can be blended with the RO permeate that has been treated for arsenic removal in a separate process.

During the Task 1 study, the feasibility of treating the whole feedwater flow was examined, and determined not to be feasible, because of equipment size and sludge volume. However, a much smaller system would be needed for treating the blend water.

Full scale feed treatment volume @ build-out @ 75% recovery:	~10.5MGD
Blend water treatment volume @ build-out:	~1.0 MGD

The greensand pilot test equipment was leased from Hungerford & Terry, Inc. The equipment consisted of a 9" diameter fiberglass tank containing the greensand media, and two chemical systems for sodium hypochlorite (bleach) and ferric chloride. Ferric sulphate may also be used, and may be the preferred ferric salt for full scale, since it is somewhat easier to handle, and is less corrosive than ferric chloride. Ferric salt addition was required because the adsorption capacity of the natural iron in the feedwater was insufficient to collect all the arsenic in the water. The bleach system was used to oxidize the natural iron from the ferrous to the ferric state, and to oxidize As(III) to As(V).

2.1.2 Permeate Treatment by Adsorption

Three technologies in this category were tested, and although each uses a proprietary media, the mechanisms are very similar. Each uses a media that utilizes ferric oxide or hydroxide to adsorb the arsenic from the water. One of the attractive characteristics of these processes is that As(III) is effectively removed without the need for oxidation to As(V). In addition because the arsenic-bearing water is RO permeate, it is extremely clean and essentially devoid of any components that would compete for adsorption sites on the media. All three vendors predicted that expected media life would be eighteen months to two years at a flow rate of 5 MGD.

A. US Filter GFH™. This system uses a media called Granular Ferric Hydroxide, which is loaded into vessels very similar in size and shape to the ion exchange vessels at the County's Skyco plant. The pilot equipment was purchased by the County, and is still located at the NRO plant. It

consists of 14 inch diameter fiberglass tank containing about 32" of GFH media. A control head is mounted on top. This device controls the service flow and backwash, and totalizes the volume of water treated.

B. Severn Trent Services Sorb 33™. This system also uses a granular media, but differs from the US Filter process in that the adsorption surfaces are ferric oxide, rather than ferric hydroxide. The media is contained in vessels similar to the Skyco ion exchange vessels. The pilot equipment consisted of a 4 inch diameter clear PVC column, 5 feet tall, equipped with piping and valves, flow and pressure instruments, and filled with the media, Bayoxide® E33. The column operated in the down flow mode, like a conventional filter. Provision was made for a periodic backwash, or "fluffing", of the media bed by directing the feedwater to the bottom of the column to lift the bed for a short period of time. This feature was not used, and given the high physical purity of the permeate, this backwash step would likely be very infrequent in full-scale operation.

C. Water Remediation Technology Z-33™. The third adsorption process differs from the USFilter and Severn Trent processes in the geometry of the beds, and the media itself. The media is a chemically modified zeolite that occurs naturally in the USA. It adsorbs arsenic readily, and like the other two types, when exhausted it is not regenerated, but rather replaced. The full-scale plant differs also in that the media is contained in rather tall slender columns, and the water passes upward through the media. The velocity of the water causes the media to separate slightly, allowing the water to contact the entire surface area available. The pilot plant was leased, and was built into a small closed trailer. Because of the height limitation of the trailer, short columns of 6" clear PVC were used, piped in series to simulate a full height column. Twelve of these columns were installed in the trailer, and samples were taken at the exit of each. Since the bed operates in up-flow mode, backwashing is not required for this process, so there is no liquid waste stream.

2.1.3 Membrane Pilot

A small pilot plant was leased for the membrane test. The feedwater for this unit was permeate from the NRO plant at the rate of 25 gpm. This permeate steam was chemically treated to convert As(III) to As(V) by adding approximately 0.5 mg/l of commercial grade bleach as an oxidant. Because modern RO membrane are sensitive to chlorine, the excess added as beach was quenched with sodium bisulphite so that no chlorine entered the membranes.

The membranes used for this test are called nanofiltration (NF) membranes. NF membranes differ from brackish water RO membranes in two important characteristics when applied in this situation. NF membranes have low rejection

of sodium chloride, the primary constituent of the NRO plant permeate, but good rejection of calcium, magnesium and other divalent and higher irons, such as As(V). NF membranes also operate at much lower pressure than RO membranes to produce the same volume of water.

For this test, the NF pilot plant was set up to operate at a high recovery (90%) and high flux compared to the NRO plant. Since the feedwater was permeate with essentially no fouling potential, an average flux of 20 gfd was selected. The advantage of high flux is the reduction in membrane area needed for the full-scale system.

The recovery was set at 90%, since there is no scaling potential in the NRO permeate.

The pilot plant was equipped with sufficient instrumentation to monitor the operation of the plant. Sampling for arsenic was done not only for the NF permeate, but also for the concentrate, since in full-scale this will be recycled to the NRO plant feedwater, and ultimately be discharged as RO plant concentrate.

CHAPTER 3

PILOT TEST RESULTS

3.1 General Discussion

As discussed earlier, five pilot plants were tested at the NRO plant. One of these, the greensand filter, was originally intended as a treatment for the feedwater to the RO plant. The other four were selected to treat the permeate from the RO plant, reducing the As(III) in the permeate to a level well below the current MCL of 10 µg/l.

All of the tests were successful, measured against the objective of arsenic reduction. The feedwater test reduced the total arsenic in the feedwater from an average over 60 µg/l to less than 15 µg/l. The permeate tests resulted in arsenic reduction from an average of 14.6 µg/l over the test duration to less than 1 µg/l in all samples except one.

As discussed in the Task 1 report, one of the difficulties associated with the lowered arsenic MCL is the variability of analytical results. This has been recognized by USEPA (see Task 1 Report, Chapter 1, page 11), and was experienced to some degree during the pilot test sampling program. To make sure that future analyses performed on the operating system do not cause an MCL violation, an objective was to reduce arsenic to as low a number as possible.

The processes selected for testing on the permeate were done so on the basis of minimizing or eliminating any waste produced on a daily basis. The three adsorption processes use a media that will eventually need to be replaced, and the exhausted media disposed of. Each of the three companies whose process was tested indicated that they would contract with the County to remove and replace their own material.

The greensand filter used for treating the RO feedwater will generate a small amount of sludge. In the Task 1 Report, this was estimated at 80 lbs dry solids per day per million gallons treated. Piloting this process reduced this estimate to about 25 lbs per day per million gallons treated, or about 50 lbs of 50% solids per day per million gallons. This sludge is derived from the filter backwash, which is very dilute, and requires settling and pressing to achieve the 50% dry solids target. Disposal of this sludge will be in a sanitary landfill, while the water from backwashing can be combined with the RO plant concentrate.

The NF option for removing arsenic from the RO permeate will generate no waste, except for the membranes, which are assumed to have a 3-year life. The County experience with RO membranes is 10-year life. However there is some

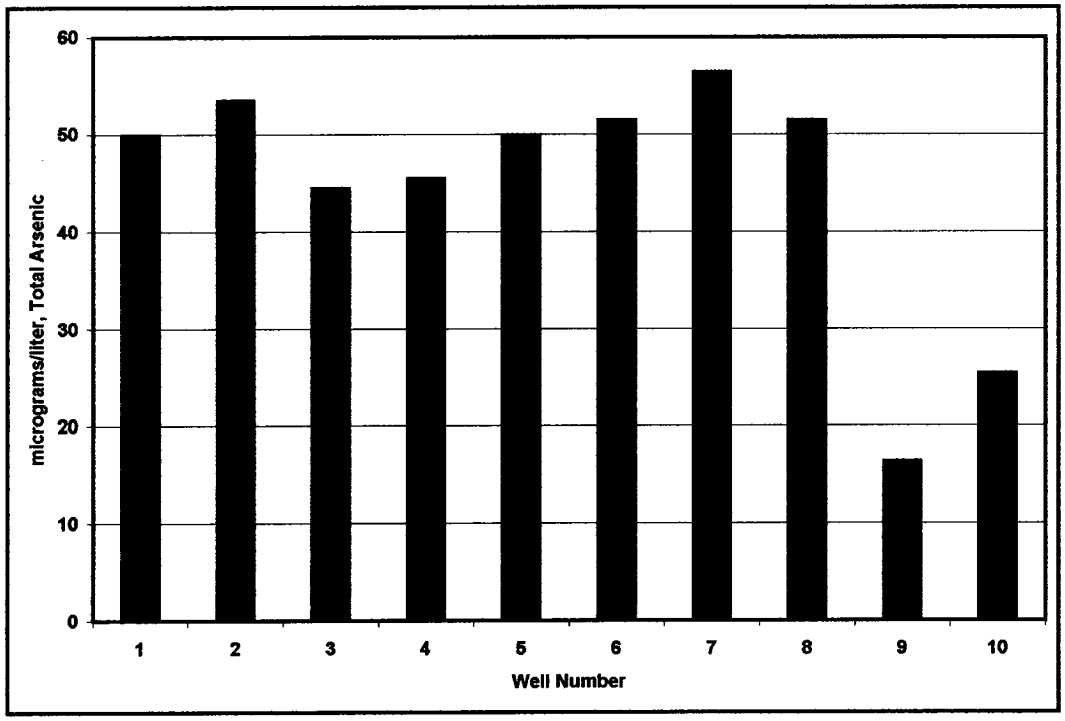
indication (Task 1 literature search) that As(V) may be absorbed in the surface of the membrane, and over time will shed in to the permeate side. Thus a shorter 3-year membrane life was assumed for the NF O&M cost opinion.

The concentrate from the NF can be recycled to the RO plant feedwater, and since the arsenic is in the As(V) form, will not contribute to additional arsenic in the RO plant permeate.

Use of the NF option will however result in two significant changes to the current operation; reduction in NRO plant capacity and extremely high quality permeate.

Increasing the blending ratio could possibly offset these two changes. The current plant operation standard is to blend 10-15% of raw water with the RO permeate, to provide some calcium and alkalinity in the blended water. These two components, together with pH adjustment and the addition of a corrosion inhibitor, make the finished water stable and non-corrosive.

Figure 3-1. Total Concentration of Arsenic in Individual NRO Plant Wells



Increasing the blend ratio will require that the blend water be treated for arsenic removal when the NRO plant is initially modified. Without this treatment, the blend will be limited by the arsenic concentration in the blended water. This blending limit is removed by reducing the arsenic in the raw water. However, the raw water also contains the organic precursors to trihalomethanes (THM), and the

presence of these precursors may limit the blend to something less than is desirable for the purpose of achieving stability.

Figure 3.1 shows the total arsenic concentration in each of the ten feedwater wells. These data are from July of 2002, and are consistent with the similar data reported on the Task 1 Report. The highest value is well #7, at 56.5 µg/l, compared to 55 µg/l for the same well in November of 2001.

3.2 Individual Test Results

3.2.1 Feedwater Treatment

The Hungerford and Terry Manganese Greensand filter was set up to operate with 2.5 mg/l of sodium hypochlorite to oxidize As(III) to As(V), and 2 mg/l of ferric chloride to adsorb the As(V). The raw water contains 0.5 to 0.7 mg/l of iron naturally, and this iron was also oxidized from the ferrous to the ferric (insoluble) state by the sodium hypochlorite. The requirement for iron oxidation is much greater than the hypochlorite required to oxidize the As(III), which explains the need for the relatively large dose of hypochlorite.

Figure 3-2 Influent and Effluent As Concentrations for the Greensand Filter

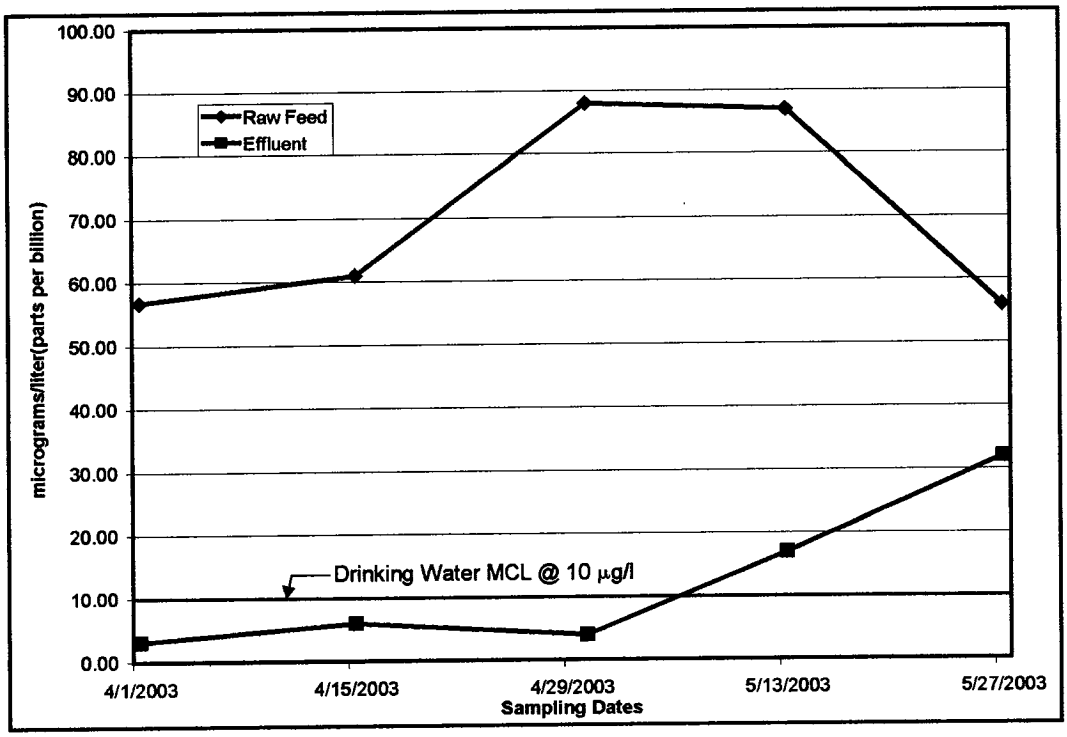


Figure 3.2 shows the total arsenic in the raw water, compared with the total arsenic in the effluent from the test column. Note that two of the feed arsenic concentrations are significantly higher than any one of the individual well

readings, again pointing out the difficulties being encountered in obtaining reliably accurate analyses for arsenic at commercial laboratories. All samples were split and sent to two laboratories, Huffman Laboratories, Inc of Golden, Colorado and Frontier Geosciences, Inc. of Seattle, Washington. This was done with all samples for all the tests. These laboratories were used because they have the capability of speciating As(III) and As(V), a capability that exists in only a very few commercial laboratories.

Based on the reported values, only the test of May 13 appears to be accurate, since the reported values were 87 μg/l and <86 μg/l. The Frontier analysis for April 30 reports 11 μg/l compared with Huffman's report of 88 μg/l.

Examination of Figure 3.2 reveals that the effluent arsenic was increasing toward the end of the test period. This again appears to be a problem with the accuracy of the analyses, since Huffman reported 17 μg/l and 32 μg/l, while Frontier reported 8 μg/l and 2 μg/l for the same sample.

Some difficulties were experienced with regulating the chemicals to the unit. This is typical of small flow pilot plants, since the chemical feed rates are very low, and the chemical metering pumps are operating at the bottom end of the stroke and speed range. (See operators log in Appendix 4).

An attempt was made to quantify the amount of sludge produced by settling and decanting the liquid, and weighing the resultant wet floc. A snapshot between May 15 and May 21st gives a total flow of approximately 13,000 gallons through the filter. After backwashing at 4.5 gpm for 15 minutes, a volume of 67.5 gallons, the settled floc weighted 9 lbs. The most optimistic estimate for the concentration of this floc is estimated to be about 1%. This translates into about 80 lbs of dry solids/1 million gallons of water treated, slightly higher than was previously estimated but still relatively low.

In general, the greensand test generated some useful data, meeting the objective of demonstrating arsenic removal with a relatively low consumption of chemicals. The operators in maintaining the operation of the chemical feed pumps experienced difficulties, but this will not be an issued in full scale.

This is a process that has been in use for many years, and several companies can provide the necessary equipment, providing a competitive environment for bidding during the construction phase. The costs presented in Chapter 4 of this report were obtained from Hungerford & Terry, who supplied the pilot plant equipment.

3.2.2 Adsorption Processes

Because the media that is used in the three adsorption processes removes both As(III) and As(V), no oxidation step converting As(III) to As(V) is required. The RO permeate containing primarily As(III) was fed directly to the three adsorption pilots.

The three processes removed arsenic very effectively. Table 3.1 shows the analytical results from Huffman and Frontier.

Table 3-1 Comparison of Arsenic in Adsorption Unit Effluent

Sample Date (All 2003)	USFilter GFH		Severn Test Sorb 33		WRT 2-3	
	Huffman	Frontier	Huffman	Frontier	Huffman	Frontier
April 11	<0.5	<0.03	<0.5	<0.04	<0.5	<0.04
April 15	<0.5	<0.2	<0.5	<0.2	<0.5	0.24
April 30	<0.5	<0.4	<0.5	<0.4	<0.5	<0.4
May 13	<0.5	<0.57	-	-	<0.5	0.64
May 27	<0.5	<0.14	<0.5	<0.14	<0.5	0.31
Average	<0.5	<0.27	<0.5	<0.20	<0.5	<0.3

Note: all values in µg/l (parts per billion)

It can be seen from Table 3.1 that all the results reported by Huffman are stated as "less than" values, and all are less then 0.5 µg/l compared to the MCL of 10 µg/l. The Frontier results are mixed, with the majority reported as "less than" values, but some reported as actual concentrations. Comparison with Huffman results reveals that all the Frontier results except the WRT sample on May 13, 2003, are lower than Huffman's. It can be assumed from these data that the effluents from the three adsorption processes are essentially free from arsenic.

RO staff was also testing with a portable arsenic analysis kit. Resolution on this kit is limited to 1 µg/l. All results reported by staff coinciding with the Table 3.1 results are 0 µg/l, supporting the essentially "free from arsenic" assumption.

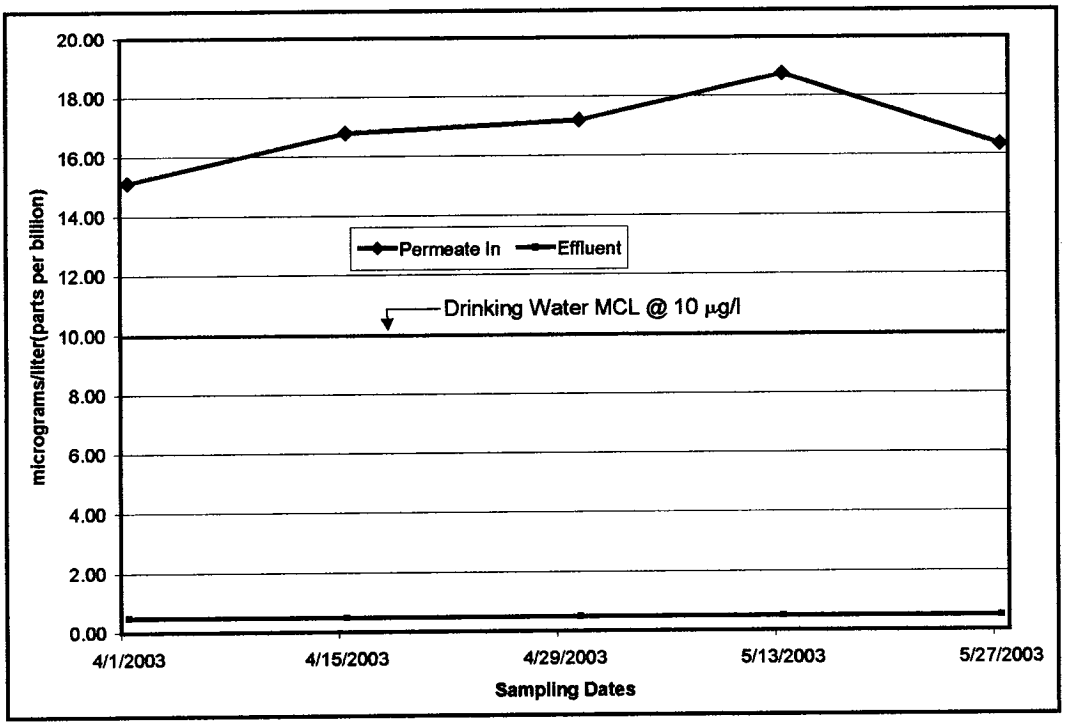
Figure 3.3 shows the comparison of the adsorption test results with the NRO permeate arsenic concentration. The effluent arsenic concentration was kept constant at 0.5 µg/l.

The flow rates for the three columns were different, and are shown in Figure 3.4. From these flow rates, and the test duration, a total volume treated has been calculated:

USFilter 41,806 gallons

Severn Trent	3,506 gallons
WRT	7,693 gallons

Figure 3-3 Influent and Effluent As Concentrations for the Three Adsorption Processes



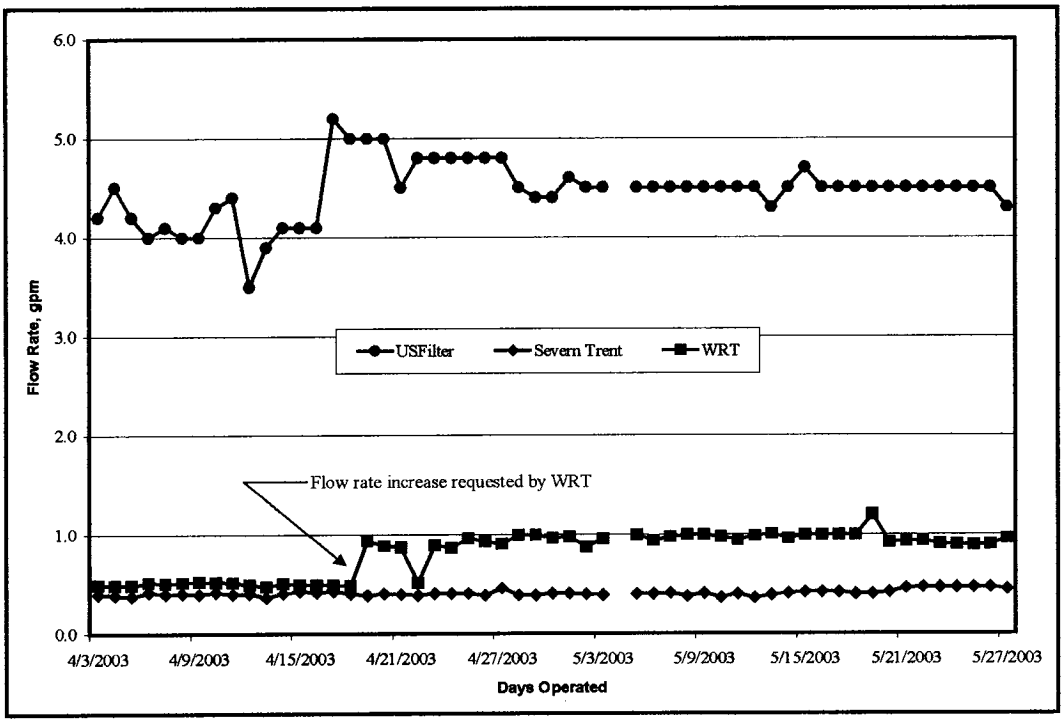
The three suppliers provided the loading rates for the feeds. The rates were:

USFilter	5.62 gpm/ft^2
Severn Trent	4.94 gpm/ft^2
WRT – initial	6.21 gpm/ft^2
- final	11.00 gpm/ft^2

The loading rates determine the bed area that is required for full-scale operation. Adsorption of the arsenic is time-dependent, so increasing the loading rate will also increase the bed depth required, and the hydraulic pressure losses. During plant design, each supplier would be required to develop the optimum configuration for his process, including the total volume of media required.

The two down-flow processes, USFilter and Severn Trent, use a media that has a higher adsorption capacity for arsenic than the up flow WRT process. However, the WRT media is less expensive than the other two types, with the net result being an approximately equal media replacement cost. In the design specifications for this type of system, the requirement for guaranteed operating cost for media would be included as a long-term contractual item with the supplier.

Figure 3.4 Flow Rates through the Adsorption Units.



In the NRO plant operation, the product water is delivered to the ground storage tank without additional pumping. The energy required for the permeate to overcome the static backpressure imposed by the tank's standpipe is provided by the RO feed pumps. Inserting a process between the RO units and the storage tank will increase the permeate backpressure on the RO units. This extra pressure requirement will be delivered by the RO feed pumps. It is therefore important economically to minimize the added RO pressure requirement by optimizing the relationship between loading rates and bed depths for the three adsorption processes. Design decisions such as this will be made during the preliminary design phase for the full-scale plant.

The pilot testing of the three adsorption processes could not, unfortunately, provide an indication of the longevity of the media prior to exhaustion. All three of the suppliers believe that a period of eighteen months to two years is reasonable. Given the purity of the permeate and the absence of competing ions, the media life could be longer than two years, but according to the manufacturers there is no way of predicting this aspect of the process. Given the little that is known, a life of two years is assumed for costing purposes in Chapter 4.

3.2.3 Membrane Option

As discussed in Chapter 2, the membrane option requires that As(III) be oxidized to As(V) for rejection by the membrane. However, because the well water has already been demineralized by the RO membranes at the NRO plant, a membrane with high As(V) rejection capability, but lesser rejection of other ions, was selected. The membrane used was a Dow FilmTec NF-90 nanofiltration (NF) membrane. NF membranes with similar characteristics are also available from other manufacturers, permitting price competition among suppliers.

Calculations made during the Task 1 work had confirmed that a dose of 0.1 mg/l of chlorine would oxidize 20 µg/l of As(III) to As(V), with some excess. From this was derived the dose of 12% sodium hypochlorite required, and therefore the dose of sodium bisulphite needed to quench the excess chlorine remaining. The oxidation reaction is very rapid, and the bisulphite reaction is also very fast. These two reactions take place within 10 feet of each other in pilot scale, which represents a time of about 3 seconds. This is an important consideration for full-scale design, since there will be a relatively short piping run between the RO permeate outlet and the inlet to the boost pump that is needed to drive the NF addition. At this time, it is planned to mount the NF second pass on top of the existing RO units, and the two planned expansion units.

Figure 3.5 Arsenic Concentrations for various NF Sample Points

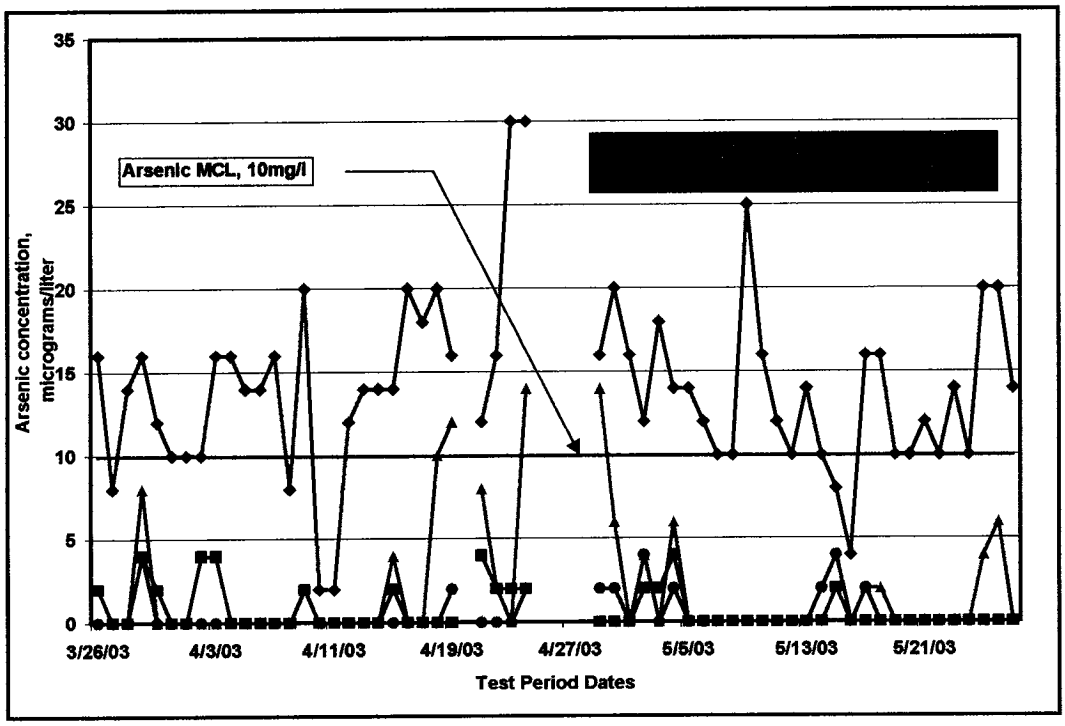
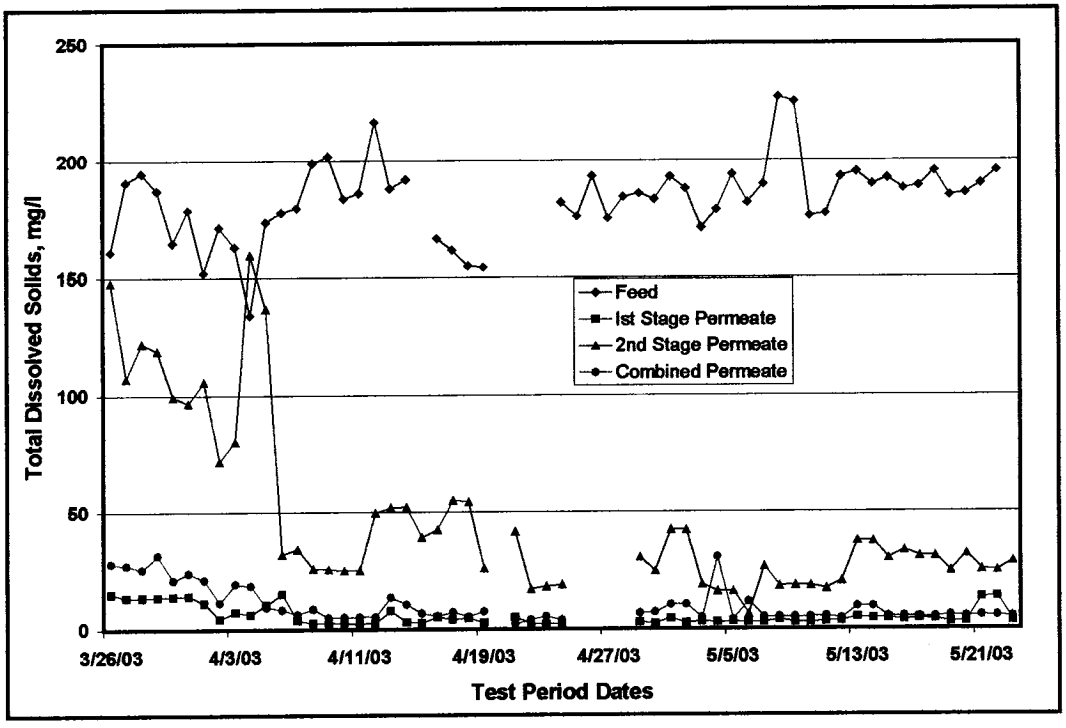


Figure 3.5 shows the arsenic concentrations in the NF feedwater (RO plant permeate), first and second stage and combined permeates, and NF concentrate. The arsenic removal efficiency is very good, almost as consistent as the adsorption processes. However, the NF performance will remain reasonably consistent for a time (assumed to be three years) and then may start to pass As(V) while the adsorption processes will eventually start to "leak" arsenic as their adsorption capability is approached. As discussed earlier, this is expected to be about two years.

Figure 3.6 shows the feedwater and permeate total dissolved solids (TDS). The permeate quality is very important. The permeate will be blended with wellwater to raise the hardness and alkalinity, and the lower the TDS, the higher the blend ratio, resulting in the possibility of a smaller NF system and associated cost savings. The concentrate will be recycled to the RO feedwater. Since the concentrate TDS averaged about 1600 mg/l, compared to the wellwater TDS of about 4300 mg/l, recycling the NF concentrate will reduce the RO feedwater TDS to about 3950 mg/l. This will result in a slightly lower operating pressure, will conserve valuable well water, and allow for the disposal of the arsenic contaminant in the existing concentrate stream. It is estimated that the arsenic concentration in the RO concentrate will increase from about 160μg/l to about 190μg/l

Figure 3.6 NF Feed and Permeate Quality, Total Dissolved Solids.



The pilot NF plant was set up to operate at 90% recovery, at a flux of approximately 20 gfd. The high recovery and flux are possible because the feedwater is permeate, without fouling or scaling potential. In full scale it may be possible to operate at slightly higher recovery (92.5%) and flux (22 gfd). The options for the design of the nanofilter system will be examined during preliminary design, with 90%/20 gfd as the baseline.

The NF feed pressure generally varied between 75 and 100 psig throughout the test. Given the hydraulic differences between a 4" diameter membrane pilot system and an 8" diameter full-scale system, the NF feed pressure will be toward the upper end of this range, say 90-100 psig. This pressure will be provided by a booster pump that will take the RO permeate from each train and deliver it as feedwater to the NF unit mounted above.

Because of the service the NF membranes are performing, there is no reason to expect that membrane life will be any less than the RO plant, where 10 years has been experienced, and is expected for the current membranes. One aspect of the membrane separation process that was not examined was whether or not arsenic was being adsorbed at the membrane surface, and not completely rejected by the membranes. If so, at some point in time the membranes may start to "shed" arsenic into the permeate stream, increasing the concentration and requiring replacement of some, if not all, of the NF membranes.

CHAPTER 4

PLANT MODIFICATIONS

4.1 Blend Water Treatment

The blend water bypassing the RO system in the current NRO facility is located in a trench at the west end of the process room. It is connected to the well water piping after the well water enters the building, but before the addition of acid and scale inhibitor in the pretreatment step. The blend piping is connected to the existing permeate header, and blend water flow is controlled by a modulating valve. The process set point for the valve positioner is the conductivity of the blended water measured as it exits the building to go to storage.

To incorporate an arsenic removal system for the blend water, a treatment facility, consisting of the treatment vessels, piping and valves, and chemical storage and feed equipment would need to be constructed outside the existing building. In addition to the treatment process, a system for backwashing the filters will be required. This system will consist of backwash pumps, air scour blower, backwash holding tank, and sludge handling equipment. Vehicle access must also be available, since trucks will be required to deliver chemicals and load and haul off the iron sludge.

This scope will only be required if NF is implemented for permeate treatment, to maximize the blend ratio of well water to permeate without approaching the arsenic MCL in the finished water.

As designed the build-out capacity of the NRO plant is 8.0 MGD, a portion of which is blended wellwater. The capacity of the blend treatment system really depends on which permeate treatment process is selected. Because the NF option significantly reduces the TDS of the permeate, a greater percentage of the finished water can be bypass wellwater. Preliminary calculations, based on the current wellwater TDS of approximately 4,400 mg/l, yield the following blend treatment capacity would be required, maintaining a 450 mg/l TDS in the blended product.

Adsorption Process Volume of permeate is unchanged, with a TDS of approximately 200 mg/l. When the currently planned RO plant modifications are complete, this TDS will be reduced to about 160 mg/l.

Water produced by RO at buildout @ 160 mg/l = 7.44 MGD
Water bypassed = 0.56 MGD

? 7.53%
3

Assuming 60 µg/l of arsenic in the wellwater, and 2 µg/l in the treated permeate, the combined arsenic in the product water will be 6 µg/l. This is below the target MCL of 10 µg/l.

NF Process – Since part of the RO plant permeate capacity is lost in the NF process as NF concentrate, implementation of the NF option will result in a permeate output of only 6.8 MGD. This will mean that 1.2 MGD of wellwater must be blended to maintain the rated plant capacity, or 15%. Assuming 10 µg/l of arsenic in the treated blend and 4 µg/l in the NF permeate, the combined arsenic in the product water will be 4.9 µg/l. However, at this blend ratio, the blended TDS will exceed the goal of 450 mg/l. To maintain the finished TDS goal, the maximum blend will be about 9.2%, and the combined plant output will be limited to about 7.5 MGD, assuming the current RO operating process conditions.
From the foregoing discussion, it can be concluded that using the adsorption technology will not require blend treatment initially, but it may be required in the future if the arsenic MCL is lowered again. It is thought that the NF process will need the blend treatment system initially, since the arsenic if the permeate shows more variability. As an alternative to treating the blend, a new post treatment system could be installed designed to add calcium hardness to the finished water, and the blend could be discontinued.

4.2 Permeate Treatment

4.2.1 Adsorption Technology

Regardless of which adsorption technology may be implemented, a fairly significant construction project must be undertaken outside the existing NRO process building.

Preliminary proposals from each of the three vendors whose equipment was piloted have been received. Each has slightly different geometry, but basically the equipment consists of large vessels filled with the adsorption media and support material; piping valves and controls; and a building to house the equipment. These preliminary proposals were based on treating 5.0 MGD of permeate with provision for expanding the system to the build-out capacity of 8.0 MGD.

Since the arsenic treatment equipment will be housed in a separate building, certain modifications to the existing RO system piping will be required.

- The existing blend piping will be relocated so that blending will take place downstream of the arsenic treatment process. This relocation will be planned for the possible addition of the blend treatment system in the future.

- The existing product piping from the existing building to the storage tank will have to be replaced with PVC or HDPE material because of the extremely corrosive nature of the permeate. The existing piping is ductile iron.
- The new permeate piping will be directed into the new treatment building with a valved bypass directly to the tank. This is to take advantage of the existing blending connection with Skyco water during the off peak months. Reducing the load on the adsorption media during these months will extend the life of the media, and thus reduce the long term cost of treatment.
- The existing post-treatment chemicals, caustic soda, chlorine, fluoride and corrosion inhibitor, are injected into the product water immediately before the product water piping exits the existing process building. This application point must be relocated to the new piping downstream of the arsenic treatment and the new wellwater blending connection.

The footprint required for the adsorption system rated at 8.0 MGD is approximately 32 ft. wide x 48 ft long. Additional space must be provided for pumps, electrical & control room, and working space for loading and unloading media, and media storage. No staff facilities will be required, and no chemical handling or dispensing facilities are required in this building. An estimate of the overall building footprint is 40 ft wide x 70 ft long, or 2800 ft^2. The clear height in this building will range from approximately 16 ft for the USFilter System to 25 ft for the WRT system.

To fit this building on the existing NRO plant site will require that the space currently available between the process building and the ground storage tank will be fully utilized.

This will place the west building wall very close to the ground storage tank, similar to the situation with the anion exchange building addition at Skyco. Special construction techniques will be required to install foundations without breaching the integrity of the ground storage tank foundation.

To make the necessary piping modifications, the NRO plant must be shut down for several weeks. This should be scheduled for the off peak winter months, when demand is at its lowest point for the year, and the northern Outer Banks can be served from Skyco. This shutdown should take place in the winter of 2004-2005.

At the present, wellwater enters the NRO building, is treated with chemicals for scale control and filtered, and high pressure pumps deliver the water to the inlet to the membranes at about 250 psig. Some untreated wellwater bypasses the RO and is blended with the RO permeate, post-treated, and delivered to ground storage.

Adding the nanofiltration treatment will require the addition of additional membrane assemblies to each RO train, piping modifications to redirect the RO permeate to the NF systems, the addition of a boost pump to increase the

permeate pressure for feeding the NF system, and additional piping to collect the concentrate from each NF system and recycle it to the incoming wellwater. Two chemical systems will also be needed, sodium hypochlorite to oxidize the As(III) to As(V) in the RO permeate, and sodium bisulphite to quench the excess chlorine.

The NF assemblies will contain sixteen pressure vessels for each RO train. The array will be 10:6, and each vessel will contain seven elements. The recovery will be controlled by a modulating concentrate valve, and permeate flow by pump speed. The booster pump will be sized to deliver up to 695 gpm at a pressure of 100 psig. The pump motor will be 50 to 60 horsepower, depending on pump efficiency. The NF controls will be interlocked with the parent RO train, so that the combined operation will be seamless. The chemical feed systems will share common day tanks, but each combined train will operate independently, with two additional chemical feed pumps per train.

The existing post-treatment systems will be retained, but the wellwater blend, treated for arsenic reduction, will be introduced downstream of the post-treatment area.

CHAPTER 5

FULL SCALE COSTS

5.1 Basis of Costs

The cost opinions presented in this chapter are based on a combination of vendor quotes, current industry pricing, and commonly used unit prices for civil works.

Operating costs have been calculated using the pilot test data, and chemical costs currently being charged the Dare County Water System. Two chemicals, ferric chloride and sodium bisulphite, were priced from regional chemical suppliers.

Based on the American Association of Cost Engineers guidelines, the accuracy of the cost opinions presented here for the level of detail available at this stage in the project is in the range of –10% to +30%. Process and civil works construction estimates are adjusted on the following basis:

- Engineering, Administrative and Legal 15%
- Interest during construction (12 month schedule) 5%
- Contingency 15%
- Contractors O/H and Profit 25%

The present worth factor (PWF) for O&M costs is based on a 20 year life, at a discount rate of 6%. The PWF is 11.47.

All estimates are based on a plant capacity of 5.0 MGD, with adsorption process building costs based on 8.0 MGD.

The following flows are assumed for a 5.0 MGD plant production:

- Wellwater feed to RO 6.22 MGD
- Wellwater blend for As treatment 0.46 MGD
- Wellwater blend untreated 0.35 MGD
- Feed to NF per train 1.0 MGD
- NF concentrate recycle 0.5 MGD

5.2 Capital Cost Opinions

The capital cost opinions for the two treatment process options are tabulated below.

A. Nanofiltration Option

Nanofiltration membrane assemblies including vessels, membranes, piping, valves, pumps, electrical and controls, and chemical systems for oxidation and quenching.	$1,152,000
Mn greensand system for treating blend water (based on build-out capacity)	$ 400,000
Construction Cost	$1,552,000
Contingency @ 15%	$ 232,800
Contractors O/H & Profit @ 25%	$ 446,200
Total Construction Cost	**$2,231,000**
6 months Interest during construction @ 5%	$ 55,800
Engineering, Administration and Legal @ 15%	$ 334,650
Total Capital Cost	**$2,621,450**

B. Adsorption Option

Adsorption process addition, including building, yard piping modifications, relocation of post-treatment systems, blend water turnout, process equipment and first media charge	$1,950,000
Contingency @ 15%	$ 292,500
Contractors O/H & Profit @ 25%	$ 560,600
Total Construction Cost	**$2,803,100**
6 months Interest during construction @ 5%	$ 70,100
Engineering, Administration and Legal @ 15%	$ 420,500
Total Capital Cost	**$3,293,700**

5.3 Operating and Maintenance Cost Opinions

A. Nanofiltration Option

All costs shown as costs per year, based on a total annual plant production of 900 MG

1. NF Oxidant, sodium hypochlorite	$ 8,400
2. NF Quench, sodium bisulphite	$16,700
3. NF feed pump power	$51,300
4. Ferric chloride	$2,000
5. Sodium hypochlorite for Mn greensand	$42,000
6. Sludge disposal (assumed non-hazardous)	$5,000
7. Membrane replacement @ 3 years	$131,000
Total annual cost	**$256,400**

B. Adsorption Option

The only two known operating costs are the media removal and replacement cost, and the additional RO feed pump power needed to push the water through the adsorption columns. This backpressure should not exceed 10 psig. No chemical feeds are required.

Media maintenance cost(based on vendor quotes)	$ 108,000
Additional power	$ 1,200
Total annual cost	**$ 109,200**

5.4 Total Cost Summary

Cost Item	NF Option	Adsorption
Capital Cost	$2,621,450	$3,293,700
Discounted 20 year O&M	$2,941,000	$1,238,800
Total present worth	**$5,562,450**	**$4,532,500**

The total present worth of the NF option is reduced by assuming a longer membrane life. If the life is increased to ten years, the current RO experience, then the total present worth cost for the NF option becomes $4,510,500, very comparable to the adsorption option.

CHAPTER 6

IMPLEMENTATION

6.1 Schedule

The modifications to the NRO plant must be fully operational prior to January 1st, 2006, for the County to be sure of meeting the compliance deadline. This means that about 24 months is available for the design, construction and start-up of the arsenic treatment modifications.

In order to meet this schedule, the following milestones must be established and achieved.

January 5, 2004	Start preliminary design and permitting
February 27, 2004	Complete preliminary design and submit permit application.
May 3, 2004	Complete plans and specifications and advertise for bids.
May 29, 2004	Receive bids from Contractors.
June 7, 2004	Recommend award at Commission meeting.
June 21, 2004	Complete contractor paperwork.
June 28, 2004	Issue notice to proceed.
September 2005	Construction substantially complete.
November 2005	Construction complete – modifications in operation.

This schedule presupposes that the conventional design-bid-build approach be taken. However, the County may consider other procurement strategies.

6.2 Procurement Options

It may be possible to shorten the period between initiating design and completing the project by using a procurement strategy other than the conventional design-bid-build approach.

- Pre-bid process equipment and assign contract to General Contractor who is awarded the contract. This can shorten the design period, particularly for the adsorption processes, since the new building can be designed specifically for the process selected. Since the geometries of each of the three are different, a generic building design to accommodate all three would have to be developed for the conventional approach.

- Design-Build. This is currently a very popular approach to public works construction. The supposed benefits to the Owner are shortened schedule and less cost. In fact, unless the design documents are prepared in a high

level of detail, very often the finished product is not the quality expected. During the construction period, when the Owner questions equipment or materials being supplied, the Contractor can be obstinate about the Owner's request, either delaying the project, raising the cost of both. Generally speaking, the advantages of design-build accrue with large projects requiring a long engineering design period, and detailed coordination between designer and Contractor during construction.

- Construction Manager at Risk. This approach was used successfully by the County for the implementation of the new Courthouse. It is a good approach for large projects, provided that the procedures followed permit the Owner and Contractor the opportunity to fully define the scope prior to the actual pricing of the project. By doing the project in phases, the Owner can be satisfied that the quality he seeks is being provided, and the Contractor has the opportunity to make a reasonable profit.

  However, the front end procedures are cumbersome for a small, process oriented project. By the time the County has asked for pre-qualification, received proposals from the pre-qualified firms, the design and pricing have been established, possibly more time will have elapsed than if the conventional approach were used.

- Treatment Purchase Agreement. One of the adsorption process vendors has proposed a "take or pay" contract for providing arsenic treated water to the County on a unit price basis. The County would still be responsible for construction of the building and infrastructure, but the process equipment and media would be purchased and installed by the process vendor, and maintained by him, with media removal and replacement, etc. The County would pay on a unit price basis, with a minimum production agreed to contractually.

  This is a reasonable approach if competitive bids can be taken, and a realistic payment schedule based on the annual monthly demands for water established. It will be a more expensive way of contracting than for the County build and operate, but may be attractive from the point of view of shifting liability to the Contractor. It would appear that the legal questions and negotiations would take some time to answer and complete, and in the long run the County would be paying more for the arsenic treatment than could be justified.

CHAPTER 7

SUMMARY AND RECOMMENDATIONS

7.1 Summary

- It is clear from the results of the pilot testing that the objectives of the test program were met. All of the processes identified in the Task 1 report performed as anticipated, reducing arsenic in the feed water (one process) and permeate (four processes), to predicted concentrations on a consistent basis.
- The ongoing difficulty with repeatable accurate arsenic analysis also was experienced during the pilot test program. Because of the possibility of significant variations by different labs using the same sample, the arsenic plant design should also allow for a comfortable cushion between the arsenic level predicted and the MCL of 10μg/l.
- The cost opinions developed from the pilot plant data confirm the conceptual cost opinions contained in the Task 1 report. The adsorption process equipment costs have been reduced by the vendors. The additional treatment cost attributable to arsenic removal is estimated to be $0.30-$0.35/kgallon produced, based on 900 MG/yr of production.

$109,200 ÷ 900,000 Kgal = $0.1213/Kgal.

7.2 Recommendations

- Based on the time schedule available, it is recommended that a conventional design-bid-build approach be taken. This will provide the County with maximum control over the project.
- Because of the criticality of the compliance deadline, it is recommended that early completion incentives and punitive liquidated damages be included in the contract language.
- Both adsorption and membrane options were efficient at removing the arsenic from the permeate. However, because of the requirement to revise the County's NPDES permit to discharge RO concentrate to the Atlantic Ocean, and the uncertainty of the time required by the State to complete this permit modification, it is recommended that the adsorption process be selected for implementation.
- It is recommended in the interest of time, that proposals be taken from the three adsorption process vendors, and that their contract be assigned to the General Contractor.

APPENDIX A

PILOT TEST PROTOCOL

Final Report

Dare County Water System North RO Plant
Kill Devil Hills, North Carolina

1. General Notes

a. The permeate feeds from all three trains should be open at all times when the trains are in operation. Close the valve on the appropriate train if cleaning.
b. The sampling program log should note which wells are in operation at all times, with dates and times on and off.
c. Special care must be taken with the NF pilot, since this water is being pre-chlorinated and dechlorinated. Frequent chlorine residual measurements must be made, so that the membranes are not damaged by chlorine.
d. Try to take As analysis samples at the same time every day that sampling is done.

2. Feedwater System

This system is intended to convert the As(III) in the raw water to As(V). The effluent from this Hungerford and Terry system will be used in the single element test unit primarily to evaluate the fouling potential of the feedwater after oxidation in the Mn greensand filter. Sampling for this system will be different than for the balance of the units. Test parameters are as follows:

Feedwater to unit: As(V) and As(III)
Effluent from unit: As(V) and As(III). As(III) should be very low, or non-detectable. Also turbidity and SDI should be measured. We will operate this unit without the membrane unit following until suitable water quality is achieved on a repeatable basis.
Some of the arsenic will be adsorbed onto the ferric hydroxide, which will be formed from the iron in the feedwater.
Feed flow rate and inlet and outlet pressure should also be recorded routinely.

3. Other Media systems

The other media systems, USFilter, Severn Trent, and WRT, are all supposed to remove the As(III) from the RO permeate. There is no regeneration involved, since the media is used and then disposed of and replaced with a fresh charge. Therefore the important data to be collected is the rate of decrease of As(III) removal by the media. We have been informed that the media life with permeate as feedwater should be about 2 years. Since we are not running this for 2 years (except possibly the USF unit that is being purchased), it is critical for future decision-making that accurate records of the inlet and outlet arsenic values are kept.
The volume of water passed through each system must be recorded. Since these are pilot units, and small scale, a small error in data will become a big error in full scale.

Each manufacturer will provide individual protocols.

The feedwater sampling can be taken from the common feed header, with individual system samples for each system. The samples can be analyzed for total As only, since we know that it will be As(III), almost 100%. If the raw water feed to the RO is constant, check sampling should be done with the in house kit in between send away sampling. The actual frequency of sampling may change during the test program, as we learn more about these systems. If the raw water source is changed, allow a period of time to elapse (Mr. Oreskovich has, I believe calculated in the past how long it takes water to pass through the RO), a complete set of send away samples should be taken. We will lose accuracy if we calculate the As(III) mass balance with incorrect feedwater data.

4. NF unit

The NF unit represents a potential membrane solution to the As(III) problem. In summary, RO permeate will be treated with NaOCl to oxidize As(III) to As(V). This reaction is virtually instantaneous. Preliminary calculations indicate that 0.1 mg/; of Cl will be needed to oxidize the As(III) to As(V). The residual chlorine must then be "killed" with sodium metabisulphite to prevent damage to the membranes. Consequently, some time will be spent running the pretreatment systems without the NF, to finalize the dosing rates needed for the process.

The feedwater rate to the NF will be 25gpmn, or 36,000 gpd. Therefore the NaOCl dose will be about 0.0013gph. The dose of a 10% sodium metabisulphite solution (made up with arsenic free water) will be about 5 times as much, or about 0.0065gph.

The NF Unit will be setup to run at 90% recovery. Normal RO plant operating data will be accumulated in addition to Arsenic data for feed, concentrate, and permeate. This will be total arsenic since it will be As(V). However, initially some As(III) analysis will be required to verify the efficiency of the oxidation step.

Chlorine is applied as 12% NaOCl solution.

Feed to NF unit	25 gpm	36,000 gpd
Cl required	0.1 mg/l	
Cl Needed (100%)	0.1 mg/l	0.0008 lbs/kgal
Cl Needed (100%)	0.0300 #/day	
12% NaOCl required, 0.99# available Cl/gallon		0.0303 #/day
Density of 12% NaOCl	9.74 #/gal	
Gallons/day of NaOCl		0.0303
Gallons/hour of NaOCl		**0.001263**

HUNGERFORD & TERRY Inc.

CLAYTON, N.J.

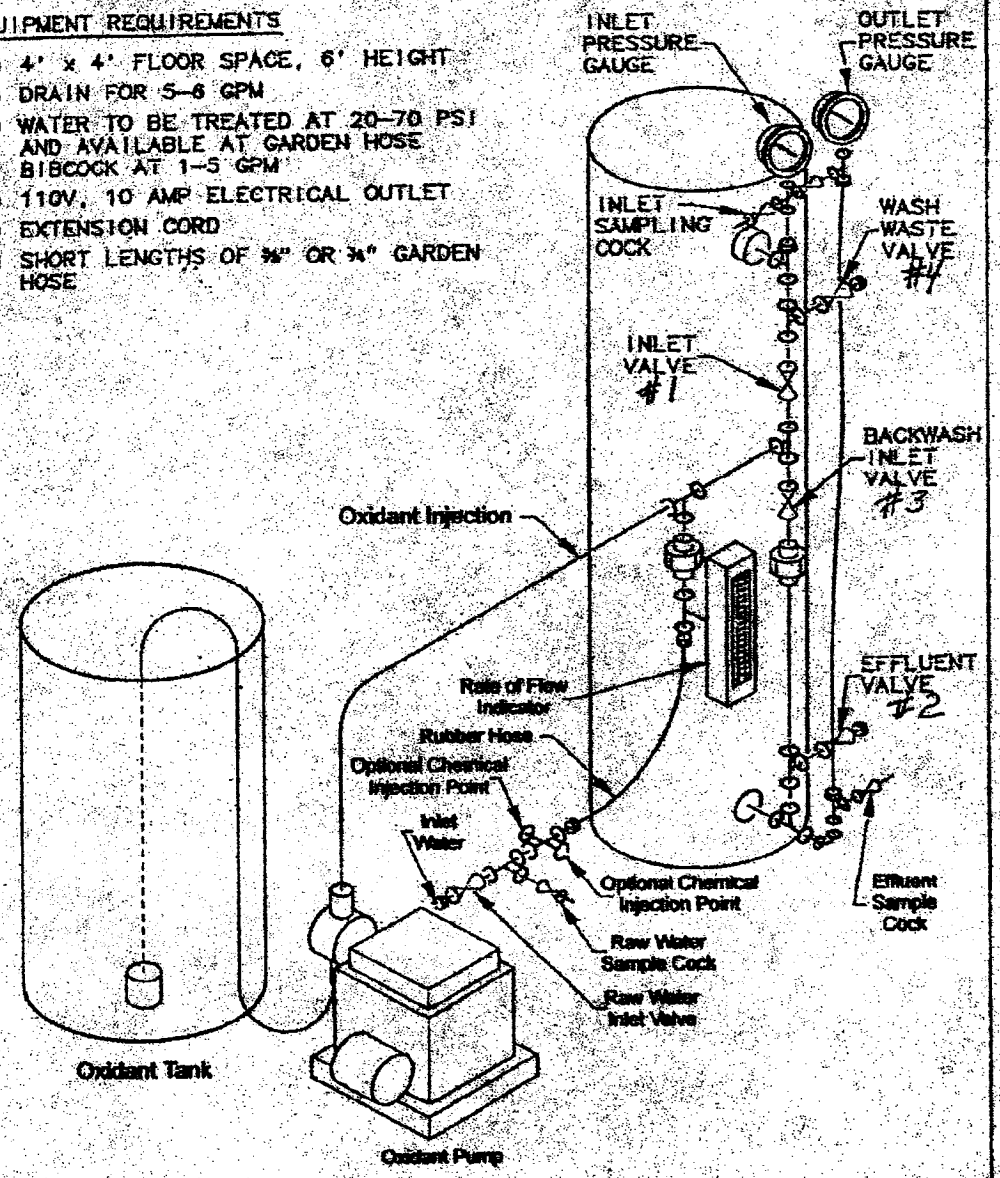
MADE BY RKG
DATE 12/19/91
SCALE NONE
CHECKED
APPROVED

TITLE FERROSAND "CR" PILOT PLANT

FORM NO.

EQUIPMENT REQUIREMENTS

1.) 4' x 4' FLOOR SPACE, 6' HEIGHT
2.) DRAIN FOR 5-6 GPM
3.) WATER TO BE TREATED AT 20-70 PSI AND AVAILABLE AT GARDEN HOSE BIBCOCK AT 1-5 GPM
4.) 110V, 10 AMP ELECTRICAL OUTLET
5.) EXTENSION CORD
6.) SHORT LENGTHS OF ⅝" OR ¾" GARDEN HOSE



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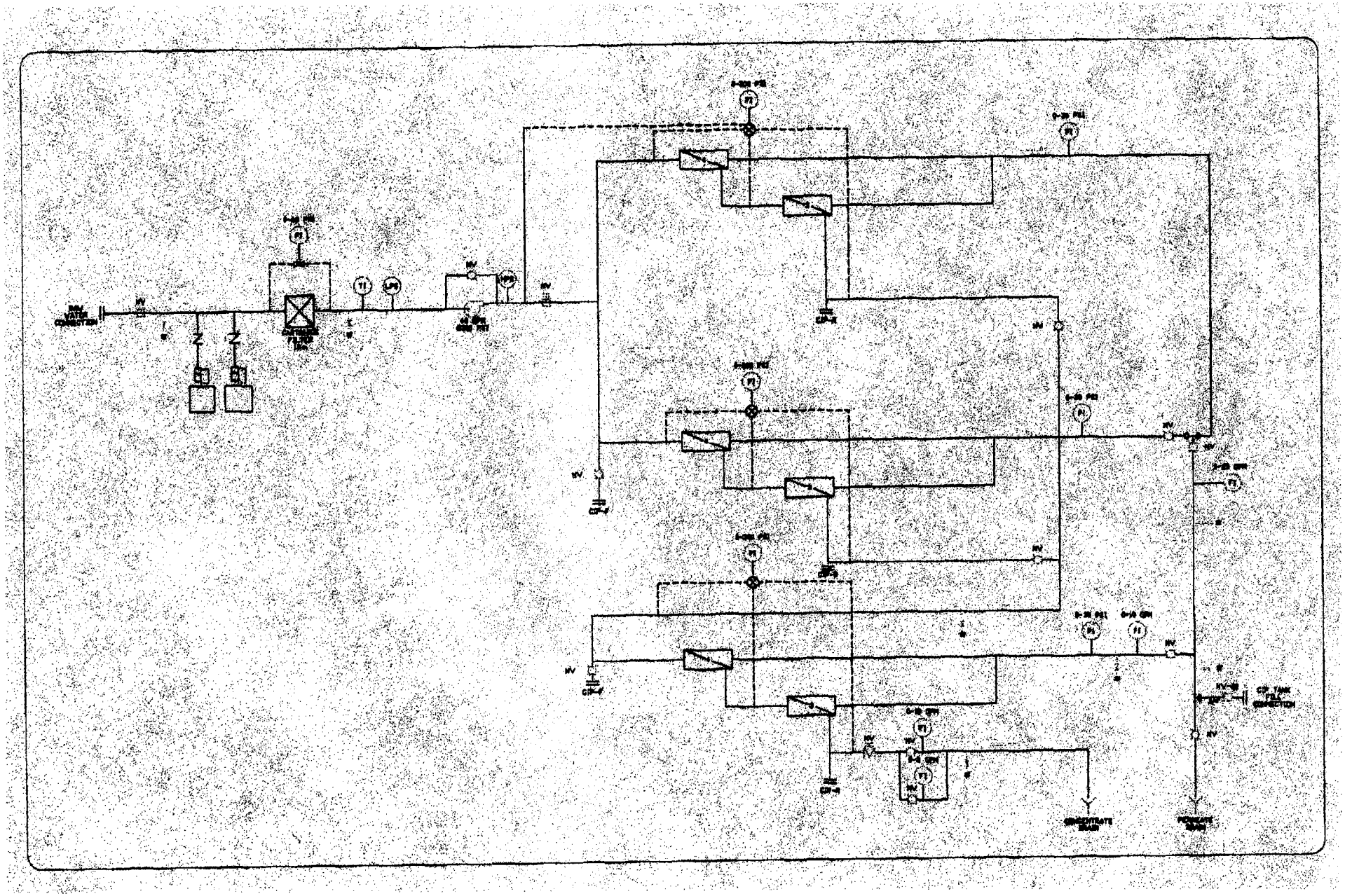
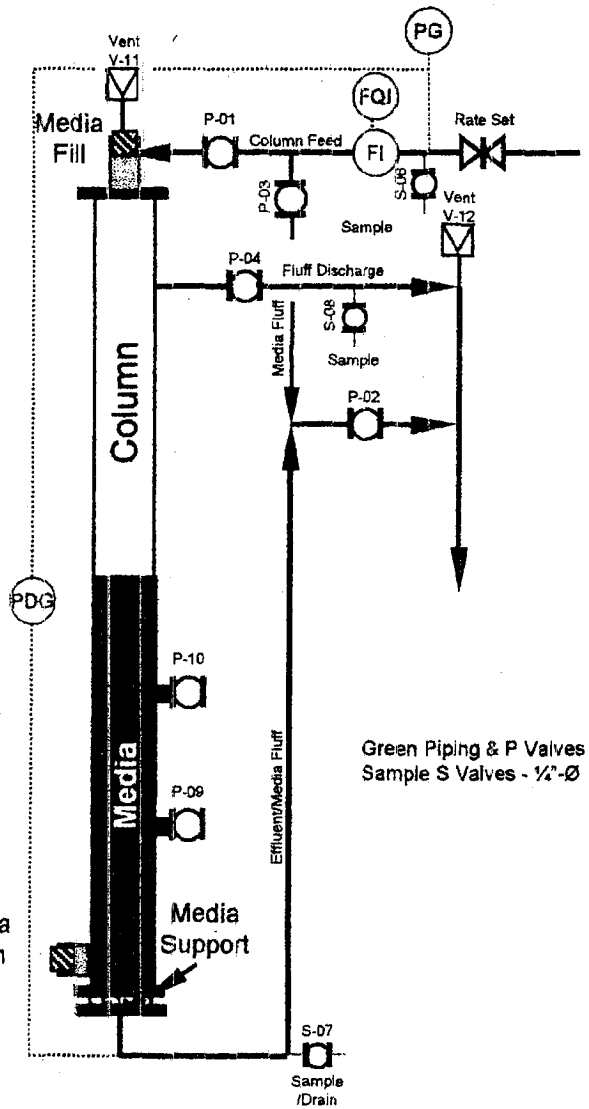
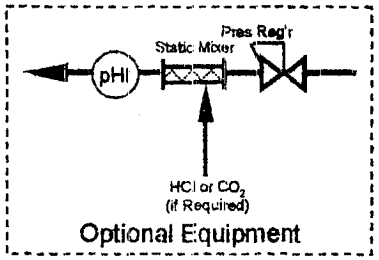


Reiss Environmental Nanofiltration Pilot Plant

SORB 33™ As Removal Pilot Unit





Descriptions

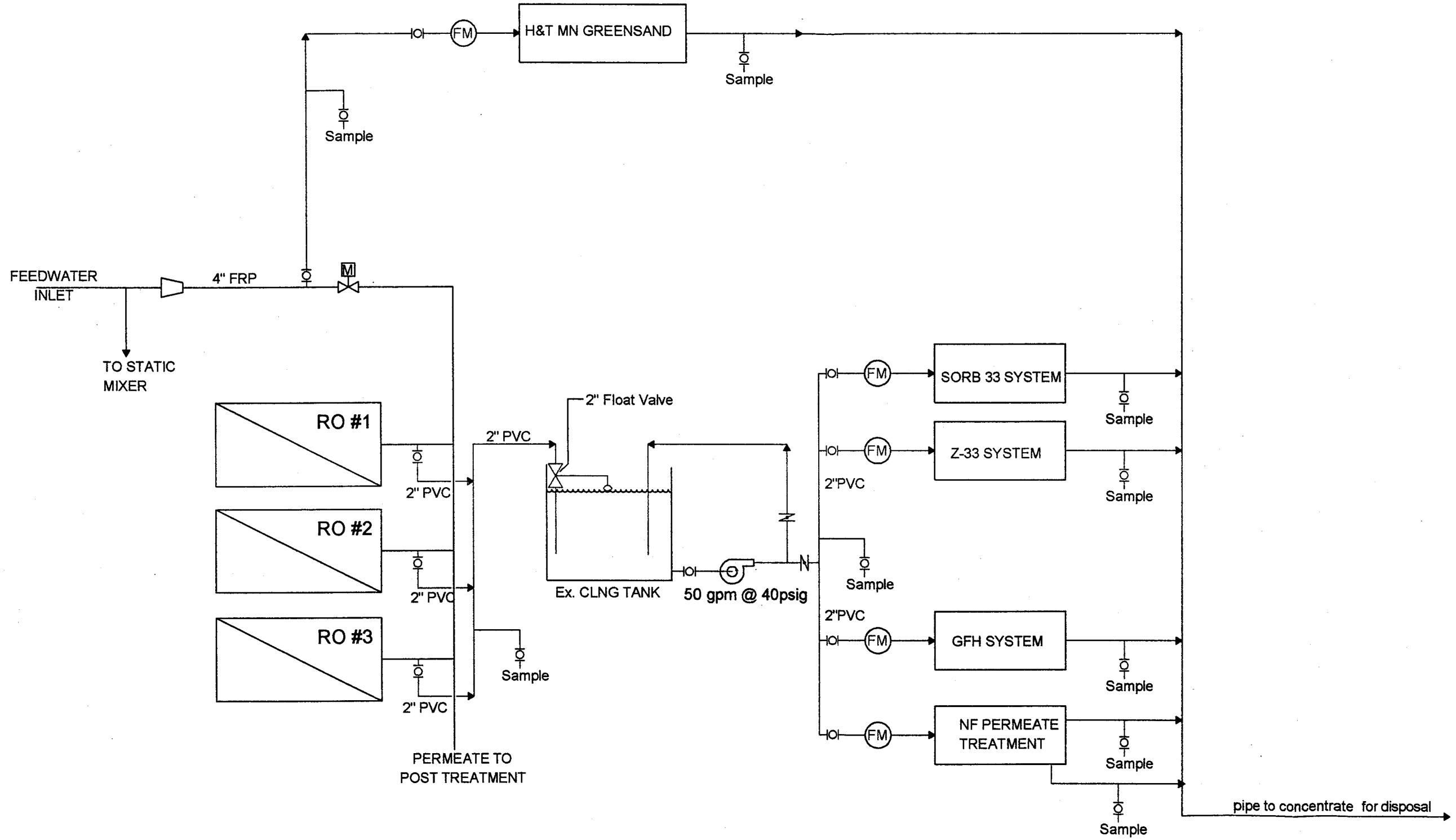
- Rate Set — Diaphragm Valve to Throttle Flow
- FQI — Flow Totalizer
- PG — Pressure Gauge (0-60 PSIG)
- PDG — Pressure Differential Gauge (0-30 PSI)
- pHI — pH Probe
- FI — Flowmeter

Green Piping & P Valves - ¾"-Ø
Sample S Valves - ½"-Ø

P&I Flow Diagram
Figure A
23-Aug-02

SEVERN TRENT SERVICES
Filtration Products

Sorb-Plt-P&ID



DATE: FEBRUARY 20, 2003
DESIGNED: ICW
DRAWN: ICW
CHECKED: ICW
SCALE: nts
FILE NO. 01-018

MARK	DATE	BY	REVISIONS

RosTek Associates, Inc.
P O Box 47567, Tampa, Florida, 33647

NRO ARSENIC PILOT PROGRAM
Dare Regional Water System
600 Mustian Street, Kill Devil Hills, NC, 27948

PILOT PLANTS P & ID

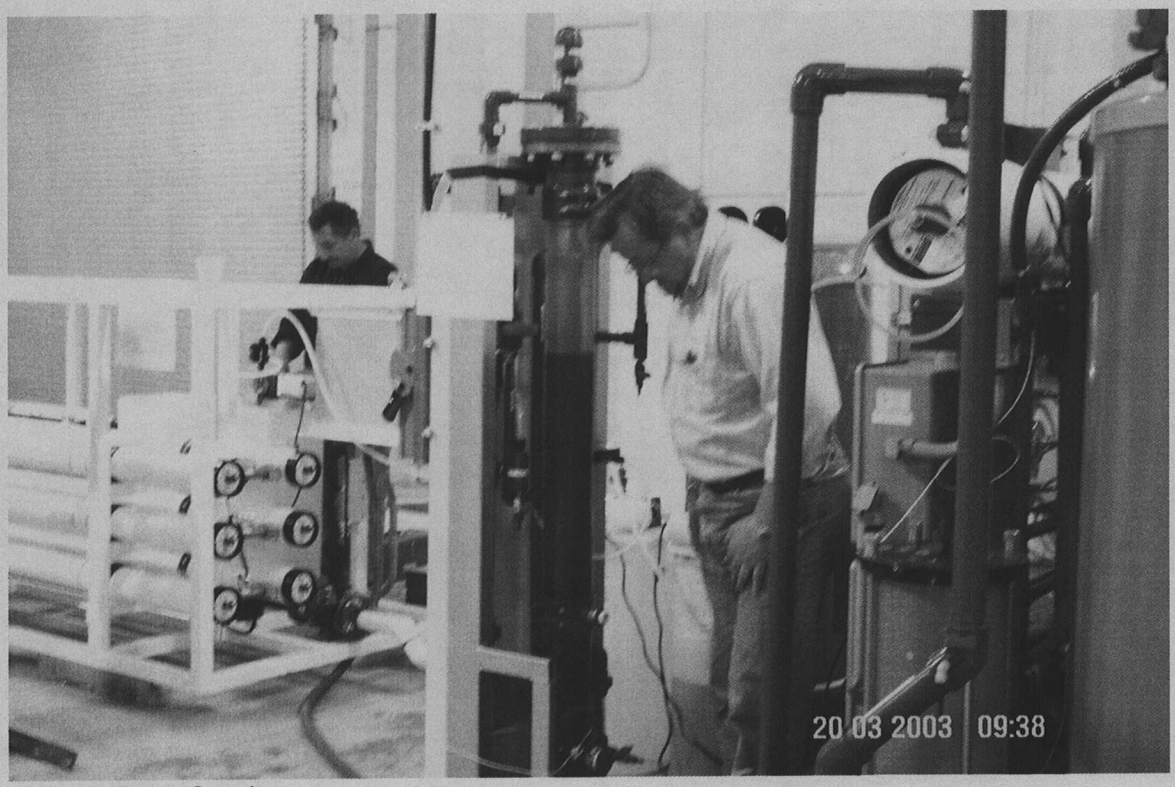
DWG No:
P-1

SHEET NO.
OF

APPENDIX B

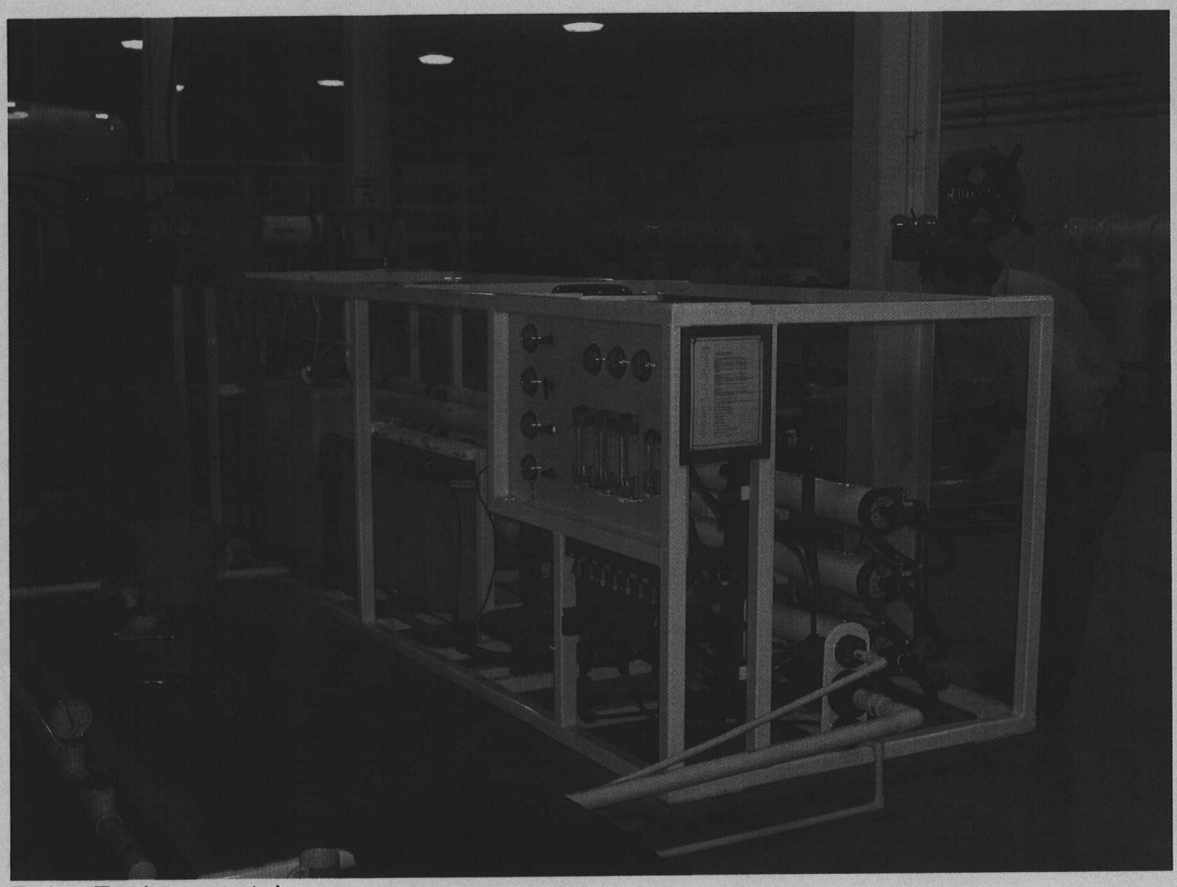
EQUIPMENT PHOTOGRAPHS

Water Remediation Technology

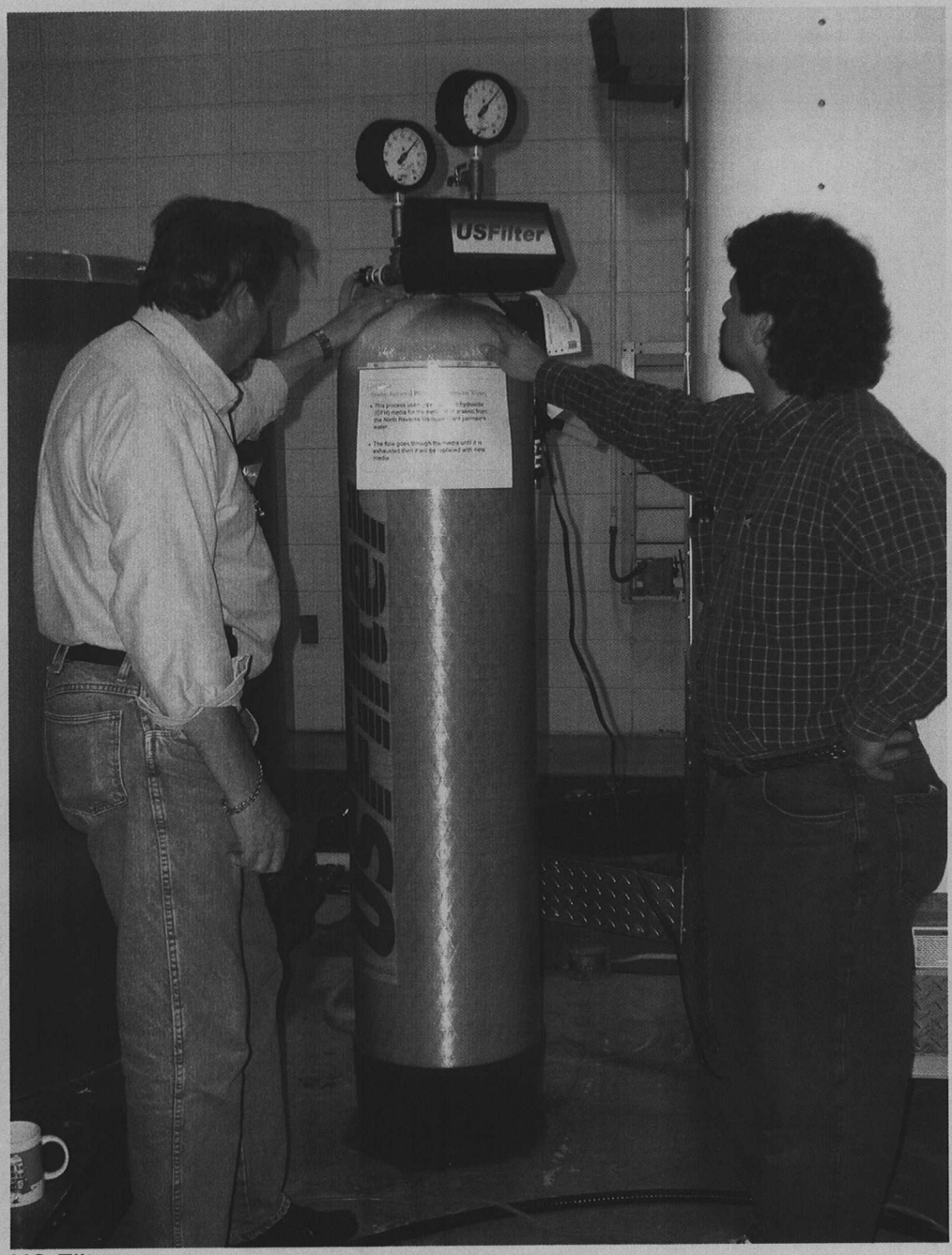


Severn Trent Services

Hungerford & Terry



Reiss Environmental



US Filter

APPENDIX C

ANALYTICAL RESULTS

Total Arsenic Test results on NRO wells

July 23 2002

WELL #	Catawba test kit	HACH test kit	Huffman Lab Split Sample Results		
1	40ppm	25ppm	49	51	50
2	50ppm	25ppm	53	54	53.5
3	30ppm	25ppm	42	49	45.5
4	30ppm	25ppm	44	46	45.5
5	40ppm	25ppm	49	51	50
6	40ppm	25ppm	50	53	51.5
7	40ppm	25ppm	57	56	56.5
8	40ppm	10+ppm	51	52	51.5
9	20ppm	0-2ppm	16	17	16.5
10	30ppm	25ppm	25	26	25.5

Pilot Unit Test Results

North Reverse Osmosis Plant
Pilot Unit Arsenic Results
4/1/2003

	Huffman			Frontier			In House			
	As III ppb	AsV ppb	Total ppb	As III ppb	As V ppb	Total ppb	Total ppb	Min.	Max.	Average
Permeate Feed to Units	9	5	14	11.1	5.14	16.24	10	5	16.24	10.07
WRT Vessel 2	1	1	2	2.12	0.11	2.23	0	0	2.23	1.21
WRT Vessel 4	0	0	<.5	0.54	0.05	0.59	0	0	0.59	0.20
WRT Effluent	0	0	<.5	<.01	0.03	<.04	0	0	0.03	0.01
US Filter Effluent	0	0	<.5	<.01	<.02	<.03	0	0	0	0.00
SevernTrent Effluent	0	0	<.5	<.01	0.03	<.04	0	0	0.03	0.01
Hungerford&Terry Raw Feed	23	33	56	32.4	25.1	57.5	20	20	57.5	35.29
Hungerford&Terry Effluent	<.5	6	6	<.01	0.86	0.86	2	0.86	6	3.14
Reiss First Stage Perm	0	0	<.5	<.01	0.03	0.03	0	0	0.03	0.01
Reiss Second Stage Perm	0	0	<.5	0.04	0.13	0.17	0	0	0.17	0.06
Reiss Combined Perm	0	0	<.5	<.01	<.02	<.03	0	0	0	0.00
Reiss Interstage Conc	2	53	55	<.01	57.2	57.2	40	2	57.2	44.07
Reiss Conc	36	113	149	<.01	110	110	80	36	149	99.67

Pilot Unit Test Results

15-Apr-03

North Reverse Osmosis Plant
Pilot Unit Arsenic Results
4/15/2003

	Huffman			Frontier			In House			
	As III ppb	AsV ppb	Total ppb	As III ppb	As V ppb	Total ppb	Total ppb	Min.	Max.	Average
Permeate Feed to Units	8	6	14	8.38	11.2	19.58	16	6	19.58	11.88
WRT Vessel 2	2	1	2	1.77	0.493	2.263	0	0	2.263	1.36
WRT Vessel 4	0	0	<.5	0.51	0.235	0.745	0	0	0.745	0.25
WRT Effluent	0	0	<.5	<.001	0.235	0.235	0	0	0.235	0.09
US Filter Effluent	0	0	<.5	<.001	<.206	<.206	0	0	0	0.00
SevernTrent Effluent	0	0	<.5	0.015	<.206	<.221	0	0	0.015	0.00
Hungerford&Terry Raw Feed	1	60	61	<.001	6.73	6.73	20	1	61	25.91
Hungerford&Terry Effluent	<.5	8	8	<.001	1.8	1.8	10	1.8	10	5.92
Reiss First Stage Perm	4	0	4	2.75	1.73	4.48	2	0	4.48	2.71
Reiss Second Stage Perm	12	<.5	12	0.816	14.3	15.116	4	0.816	15.116	9.71
Reiss Combined Perm	4	<.5	4	5.8	0.349	6.149	0	0	6.149	3.38
Reiss Interstage Conc	18	37	55	10.3	37.3	47.3	40	10.3	55	34.99
Reiss Conc	116	39	155	11.6	174	185.6	60	11.6	185.6	105.89

Pilot Unit Test Results

North Reverse Osmosis Plant
Pilot Unit Arsenic Results
4/30/2003

	Huffman			Frontier			In House			
	As III ppb	AsV ppb	Total ppb	As III ppb	As V ppb	Total ppb	Total ppb	Min.	Max.	Average
Permeate Feed to Units	5	11	16	4.89	13.5	18.39	14	4.89	18.39	11.83
WRT Vessel 2	1	1	2	1.86	1.05	2.91	0	0	2.91	1.40
WRT Vessel 4	1	<.5	1	0.747	0.571	1.318	0	0	1.318	0.77
WRT Effluent	0	0	<.5	<.003	<.408	<.411	0	0	0	0.00
US Filter Effluent	0	0	<.5	<.003	<.408	<.411	0	0	0	0.00
SevernTrent Effluent	0	0	<.5	<.003	<.408	<.411	0	0	0	0.00
Hungerford&Terry Raw Feed	0.5	88	88	<.015	11	11.015	30	0.5	88	38.09
Hungerford&Terry Effluent	4	<.5	4	<.003	<.408	<.411	2	2	4	3.33
Reiss First Stage Perm	0	0	<.5	<.030	5.03	5.03	0	0	5.03	2.01
Reiss Second Stage Perm	0	0	<.5	0.457	6.89	7.37	6	0	7.37	3.45
Reiss Combined Perm	0	0	<.5	0.096	0.422	0.518	2	0	2	0.51
Reiss Interstage Conc				0.681	57.6	58.281	60	0.681	60	44.14
Reiss Conc	25	119	144	<.180	114	114	80	25	144	99.33

Pilot Unit Test Results

North Reverse Osmosis Plant
Pilot Unit Arsenic Results
5/13/2003

	Huffman			Frontier			In House			
	As III ppb	AsV ppb	Total ppb	As III ppb	As V ppb	Total ppb	Total ppb	Min.	Max.	Average
Permeate Feed to Units	2	11	13	0.792	23.7	24.49	12	0.792	24.49	12.43
WRT Vessel 6	<0.5	<0.5	<0.5	0.075	<0.571	0.645	0	0	0.645	0.24
WRT Vessel 8	<0.5	<0.5	<0.5	0.067	<0.571	0.638	0	0	0.638	0.24
								0	0	
US Filter Effluent	<0.5	<0.5	<0.5	<0.003	<0.571	<0.574	0	0	0	0.00
SevernTrent Effluent							0	0	0	0.00
Hungerford&Terry Raw Feed	<0.5	87	87	<0.450	<85.6	<86.05	30	30	87	68.00
Hungerford&Terry Effluent	1	16	17	<0.030	7.88	7.91	20	1	20	11.63
Reiss First Stage Perm	<0.5	<0.5	<0.5	<0.030	10.7	10.73	0	0	10.73	7.14
Reiss Second Stage Perm	<0.5	<0.5	<0.5	0.082	8.98	9.062	0	0	9.062	4.53
Reiss Combined Perm	<0.5	<0.5	<0.5	<0.060	83.3	83.3	0	0	83.3	55.53
Reiss Interstage Conc	1	41	42	<0.030	34.9	34.9	40	1	42	32.30
Reiss Conc	4	97	101	<0.450	116	116.45	100	4	116.45	89.08

Pilot Unit Test Results

North Reverse Osmosis Plant
Pilot Unit Arsenic Results
5/27/2003

	Huffman			Frontier			In House			
	As III ppb	AsV ppb	Total ppb	As III ppb	As V ppb	Total ppb	Total ppb	Min.	Max.	Average
Permeate Feed to Units	1	15	16	1.03	15.7	16.73	16	1	16.73	11.64
WRT Vessel 6	<0.5	<0.5	<0.5	0.076	0.211	0.287	0	0	0.287	0.14
WRT Vessel 8	<0.5	<0.5	<0.5	0.179	<0.135	0.314	0	0	0.314	0.16
								0	0	
US Filter Effluent	<0.5	<0.5	<0.5	<0.006	<0.135	<0.141	0	0	0	0.00
SevernTrent Effluent	<0.5	<0.5	<0.5	<0.006	<0.135	<0.141	0	0	0	0.00
Hungerford&Terry Raw Feed	13	43	56	14.1	10.2	24.3	20	10.2	56	25.80
Hungerford&Terry Effluent	1	31	32	0.634	1.17	1.804	0	0	32	9.66
Reiss First Stage Perm	<0.5	1	1	<0.030	0.261	0.291	0	0	1	0.51
Reiss Second Stage Perm	1	2	3	2.07	1.53	3.6	0	0	3.6	1.89
Reiss Combined Perm	1	<.05	1	1.2	<0.68	1.88	0	0	1.88	1.02
Reiss Interstage Conc	3	62	65	<0.075	74.6	74.675	60	3	74.675	56.55
Reiss Conc	6	131	137	<0.450	165	165.45	60	6	165.45	110.74

Frontier Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

Frontier Geosciences' Sampling Instructions For Arsenic Speciation by IC-ICP-MS

Method Development Background: Determination of low levels of arsenic with ICP-MS is not an easy task. Formation of the $ArCl^+$ or $CaCl^+$ species in the plasma results in false positives for the monoisotopic arsenic. Correction equations are commonly used but these can get complicated when significant amounts of Se are present. Most chlorine related problems are encountered in the speciation analysis of arsenic when an ICP-MS is used as the detector. Presence of chloride or chlorine-containing species in chromatographic eluants results in increased baseline due to $ArCl^+$, which also means increased detection limits for As species. The worst case scenario is due to excess chlorine containing species (mostly chloride) in the samples. The presence of a false arsenic peak due to ArCl can be identified by monitoring m/z 77. Still, if this false peak co-elutes with any of the As species, quantitation can be very difficult. In an effort to eliminate some of the analytical issues Frontier demonstrate the separation and determination of As(III) (arsenite), As(V) (arsenate), and many other species by ion chromatography-inductively coupled plasma-mass spectrometry (IC-ICP-MS) in various matrices.

Following are sample collection instructions for achieving *in-situ* arsenic speciation concentrations in an aqueous matrix.

- The samples are not to be preserved in the field or in the laboratory as acidification may destroy some arsenic species (e.g. thio-arsenic species).
- Fill the bottles all the way to the top; leave little or no headspace to avoid oxygen exposure. Try to avoid air bubbles in the sample matrix during collection.
- Keep cool (< 4 °C) and dark, ship ***priority overnight*** to Frontier.

It is a ***must*** to notify Frontier of any speciation samples prior to shipping to our laboratory. This information helps us to ensure proper receipt of speciation samples. As an additional quality control measure, please provide a shipment tracking number and we will begin searching for any shipment that was not delivered as scheduled.

Please inform us about the date of sample delivery, carrier and tracking number by sending a short email to Frontier's speciation Project Manager – Misty Kennard: mistyk@Frontiergeosciences.com

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fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com

Frontier
Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

April 25, 2003

Nancy Roop Loomis
Dare County
600 Mustain Street
Kill Devil Hills, NC 27948
Phone: (252) 475-5816
Fax: (252) 441-2239

SUBJECT: Arsenic (III) and (V) Results in Aqueous Samples

Project ID: Arsenic Speciation Monitoring
PO #: 20031687-000

Dear Nancy,

Enclosed are results for arsenic III and V in the aqueous samples collected on April 1, 2003. The samples were received in good condition on April 2, 2003.

Upon arrival at Frontier Geosciences, the samples were unpacked, verified against the chain of custody (COC) and immediately transferred to our laboratory for preservation. The sample cooler temperature at time of receipt was 0.8°C and all samples had minimal headspace.

IC-ICP-MS Analysis for As(III) and (V)

The samples were analyzed by **I**on **C**hromatography coupled with **I**nductively **C**oupled **P**lasma **M**ass **S**pectrometry (IC-ICP-MS). In this procedure, samples are filtered through a 0.2 μm filter and then injected onto an anion-exchange column capable of separating different ionic arsenic species. In this specific batch, the separation was optimized for the determination of As(III) and As(V) and only these species were quantified. Each species that eluted from the column was introduced into the ICP-MS instrument. This procedure results in two different peaks: one for As(III) (at 5.7 min) and one for As(V) (at 11.6 min). The areas under these peaks are used for quantization.

Analytical Comments

There were no significant analytical difficulties experienced. Since the sample matrices submitted were not all considered similar, Frontier performed two sets of QC on samples containing visible differences in matrix composition. All QC is within established control

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www.FrontierGeosciences.com

limits with the following exceptions identified below within each analytical comments summary.

As(III) and As(V) Analysis

There is no certified reference material available for As(III). However, internal standards prepared and tested by Frontier yield recoverable concentrations for As(III). These standards, coupled with ongoing calibration blanks, are analyzed per 20 samples to provide evidence of ongoing system optimization. All of the recoveries show excellent on-going precision at a recovery range of 99.6%-110.0%. There is no certified reference material available for As(III). However, NIST 1643d, a freshwater SRM, shows a consistent As(V) concentration. All of the recoveries show excellent on-going precision at a recovery range of 96.1%-106.0%.

As a method of evaluating sample preparation, a blank is analyzed with each sample batch. The blank recovery showed a less than detect value for both As(III) and As(V). Instrument blanks are also analyzed to evaluate instrument equipment, reagent cleanliness and used to determine the batch specific estimated method detection limit (est.MDL).

Reproducibility is examined by sample replicates prepared and analyzed in the exact same manner as the native. For As(III), all samples results were near (10 times the est.MDL) or below the batch specific MDL. At such low concentrations, analytical variability tends to increase significantly; therefore the percent differences were not calculated. For As(V), the sample *Severn Trent Effluent* showed an elevated relative percent deviation at 40%; where the control limit is at 25%. However, the native and duplicate sample concentrations are at two and three times the est. MDL. Again, these concentrations are too low to consider significant.

Accuracy in sample preparation and identification of matrix issues is often identified through matrix spikes. For As(III), the matrix spike duplicate performed on sample *Reiss Concentrate Stage Perm* showed a slightly elevated recovery at 127.7%; where established control limits are 75-125%. For As(V), the matrix spike duplicate shows an elevated recovery at 175.7%. Since all of the remaining QC (i.e., spikes, reps, standard recoveries and blanks) shows good precision and accuracy, this is perceived as an isolated incident, most likely due to a pipetting error, and no corrective action was taken.

Please feel free to call or contact me if you have any questions regarding this report.

Sincerely,

M. D. Kennard

Misty D. Kennard
Project Manager

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported April 25, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Sample Results

Sample ID	As(III) (ug/L)	As(V) (ug/L)
H&T INF. RAW Raw water	32.4	25.1
H&T EFFLUENT	< 0.01	0.86
FEED TO UNITS Perm Feed to units	11.1	5.14
U.S. FILTER EFF	< 0.01	< 0.02
SEVEREN TRENT EFFLUENT	< 0.01	0.03
WRT VESSEL 2	2.12	0.11
WRT VESSEL 4	0.54	0.05
WRT EFFLUENT	< 0.01	0.03
DIST	< 0.01	1.08
REISS 1ST STAGE PERM	< 0.01	0.03
REISS 2ND STAGE PERM	0.04	0.13
REISS INTER STAGE [redacted] Reiss interstage Conc.	< 0.01	57.2
REISS COMBINED [redacted] PERM	< 0.01	< 0.02
REISS CONCENTRATE [redacted]	< 0.01	110

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported April 25, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Duplicate Report

Analyte (ug/L)	Sample QC'd	Rep. 1	Rep. 2	Mean	RPD
As(V)	Severn Trent Effluent	0.03	0.02	0.03	40.0
As(V)	Reiss Concentrate	109.8	110.6	110.2	0.8
As(III)	Severn Trent Effluent	< 0.01	0.02	NC	NC
As(III)	Reiss Concentrate	< 0.01	< 0.01	< 0.01	NC

NC= not calculated; please refer to narrative

Quality Control Data - Matrix Spike / Matrix Spike Duplicate Report

Analyte (ug/L)	Sample QC'd	Mean	Spike Level	MS	% Rec.	Spike Level	MSD	% Rec.	RPD
As(V)	Severn Trent Effluent	0.03	10.00	8.97	89.5	10.00	9.84	98.2	9.3
As(V)	Reiss Concentrate	110.2	200.0	324.5	107.2	200.0	461.6	175.7*	34.9
As(III)	Severn Trent Effluent	NC	10.00	9.54	95.3	10.00	10.12	101.1	5.9
As(III)	Reiss Concentrate	< 0.01	200.0	213.7	106.9	200.0	255.5	127.7*	17.8

MS = matrix spike

MSD = matrix spike duplicate

RPD = relative percent difference

* = outside of established control limits; please refer to narrative.

Arsenic Speciation Results for Dare County - Nancy Loomis
Arsenic Speciation Monitoring Project

Reported April 25, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Preparation Blank Report

Analyte (ug/L)	IBW1	IBW2	IBW3	Mean	Std Dev	Est. MDL
As(V)	0.02	0.01	0.01	0.01	0.01	0.02
As(III)	0.00	0.00	0.00	0.00	0.00	0.01

IBW = instrument blank water

Est. MDL = estimated method detection limit

Std Dev = Standard deviation

Quality Control Data - Ultra Trace Level Reagent Water Blank Concentration

Analyte (ug/L)	Sample Identity	Obs.Value
As(V)	Blank	0.05
As(III)	Blank	0.00

Quality Control Data - Standard Reference Material Report

Analyte (ug/L)	SRM Identity	Cert. Value	Obs. Value	% Rec.
As(V)	NIST 1643d	56.0	47.6	85.0
AS(III)	Internal Std.	25.0	24.9	99.6

SRM = standard reference material

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 4-1-03 Page: 1 of 2

Client Company: Dare County
Address:

CONTACT: Nancy Roop Loomis
Phone: 252-475-5816 Fax: 252-441-
Email:

Project Name: As Speciation Monitoring
Contract/PO #: 20031687-00

Frontier Project Manager: Misty Kennard
Guaranteed Turnaround Time: 28 DAYS
Confirmation of Sample Arrival at Frontier: ☒ YES ☐ NO
Quality Assurance Level: ☒ Standard ☐ High
Disposal*: ☒ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
*All samples are held for at least 2 months after date of receipt.
Please note that after this time they are disposed of or returned to the client.
Clients may request a longer holding time by writing to the Frontier Project Manager.
**Please discuss this with the Frontier Project Manager.
Carrier Information: FED EX ☐ UPS ☒ Other ☐
Tracking # 1ZX861201417183 23

Engraved Bottle ID	Sample ID	Matrix[1]	# Bottles	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
HCLB-311	H+T Inf. RAW	BW	1	4-1-03 1:15p	NL	None	AsIII + AsV
~~HCLA-031~~	~~H+T EFF.~~	~~FW~~	~~1~~	"			
HCLB-252	H+T EFF	FW	1	4-1-03 1:30pm			
HCLA-032	BIA NIL						
HCLB-323	Fecoto Units	FW	1	4-1-03 1:45p			
HCLB-538	U.S. Filter EFF	FW	1	4-1-03 1:50pm			
HCLB320	Severn Trent EFF	FW	1	4-1-03 2:00p			
HCLB-305	WRT Vessel 2	FW	1	4-1-03 2:10p			
" -317	WRT Vessel 4	FW	1	4-1-03 2:20p			
" -318	WRT EFF	FW	1	4-1-03 2:30p			

Sample Receipt
C.O.C. Seal Intact? ☐ YES ☐ NO ☒ N/A
Cooler Temperature: 0.8 °C
Comments:

VTSR: 10:30

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by: N. Roop Loomis	Relinquished by:	
Print name: Nancy Roop Loomis	Print name:	
Company: Dare County	Company:	
Date: 4-1-03 Time:	Date:	Time:
Received by:	Received by:	
Print name: M. Ollearn	Print name:	
Company: Frontier	Company:	
Date: 4/2/03 Time: 11:00	Date:	Time:

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 4-1-03 Page: 2 of 2

Client Company: Dare County	Frontier Project Manager: Misty Kennard
Address: 600 Mustain Street KDH NC 27948	Guaranteed Turnaround Time: 28 DAYS
CONTACT: NANCY LOOMIS	Confirmation of Sample Arrival at Frontier: ☒ YES ☐ NO
Phone: 252-475-5816 Fax: 252-441-2239	Quality Assurance Level: ☒ Standard ☐ High
Email:	Disposal*: ☒ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
Project Name: As Speciation Monitoring	*All samples are held for at least 2 months after date of receipt. Please note that after this time they are disposed of or returned to the client. Clients may request a longer holding time by writing to the Frontier Project Manager. **Please discuss this with the Frontier Project Manager.
Contract/PO #: 20031687-000	Carrier Information: FED EX ☐ UPS ☒ Other ☐ Tracking #

Engraved Bottle ID	Sample ID	Matrix[1]	# Bottles	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
HCLB-300	DIST	FW	1	4-1-03 9AM	NL	NONE	AsIII AsV
HCLB-349	Reiss 1st Stage Perm	FW	1	4-1-03 2:45pm	↓	↓	
HCLB-341	" 2nd Stage Perm	FW	1	4-1-03 3:00pm			
HCLB-342	" Inter Stage Perm	FW	1	4-1-03 3:05pm			
HCLB-038	" Combined Perm	FW	1	4-1-03 3:10pm			
" -345	" Concentrate	BW	1	4-1-03 3:15pm			

Sample Receipt

C.O.C. Seal Intact? ☐ YES ☐ NO ☐ N/A

Cooler Temperature: °C

Comments:

VTSR:

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by: N Loomis	Relinquished by:
Print name: Nancy Loomis	Print name:
Company: DARE County	Company:
Date: 4-1-03 Time:	Date: Time:
Received by:	Received by:
Print name: M. Ottaker	Print name:
Company: Frontier	Company:
Date: 4/2/03 Time: 11:00	Date: Time:

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Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

May 14, 2003

Nancy Roop Loomis
Dare County
600 Mustain Street
Kill Devil Hills, NC 27948
Phone: (252) 475-5816
Fax: (252) 441-2239

SUBJECT: Arsenic (III) and (V) Results in Aqueous Samples

Project ID: Arsenic Speciation Monitoring
PO #: 20031687-000

Dear Nancy,

Enclosed are results for arsenic III and V in the aqueous samples collected on April 15, 2003. The samples were received in good condition on April 16, 2003.

Upon arrival at Frontier Geosciences, the samples were unpacked, verified against the chain of custody (COC) and immediately transferred to our laboratory for preservation. The sample cooler temperature at time of receipt was 0.3°C and all samples had minimal headspace.

IC-ICP-MS Analysis for As(III) and (V)

The samples were analyzed by Ion Chromatography coupled with Inductively Coupled Plasma Mass Spectrometry (IC-ICP-MS). In this procedure, samples are filtered through a 0.2 µm filter and then injected onto an anion-exchange column capable of separating different ionic arsenic species. In this specific batch, the separation was optimized for the determination of As(III) and As(V) and only these species were quantified. Each species that eluted from the column was introduced into the ICP-MS instrument. This procedure results in two different peaks: one for As(III) (at 5.7 min) and one for As(V) (at 11.6 min). The areas under these peaks are used for quantization.

Analytical Comments

There were no significant analytical difficulties experienced. Since the sample matrices submitted were not all considered similar, Frontier performed two sets of QC on samples containing visible differences in matrix composition. All QC is within established control limits with the following exceptions identified below.

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As(III) and As(V) Analysis

There are no certified reference materials available for As(III) and As(V). However, internal standards prepared and tested by Frontier yield recoverable concentrations for both arsenic species. These standards, coupled with ongoing calibration blanks, are analyzed per 20 samples to provide evidence of ongoing system optimization. All of the recoveries show excellent on-going precision at a recovery ranges well within established control limits (75-125%).

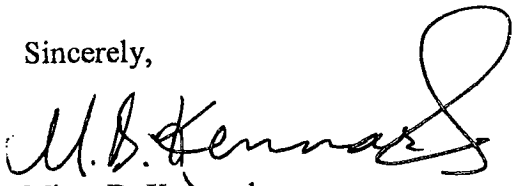
As a method of evaluating sample preparation, a blank is analyzed with each sample batch. The blank recovery showed a less than detect value for both As(III) and As(V). Instrument blanks are also analyzed to evaluate instrument equipment, reagent cleanliness and used to determine the batch specific estimated method detection limit (est.MDL).

Reproducibility is examined by sample replicates prepared and analyzed in the exact same manner as the native. For As(III), all samples results were near (10 times the est.MDL) or below the batch specific MDL. At such low concentrations, analytical variability tends to increase significantly; therefore the percent differences were not calculated. For As(V), the sample *Severn Trent Effluent* showed an elevated relative percent deviation at 35%; where the control limit is at 25%. However, the native and duplicate sample concentrations are at two and three times the est. MDL. Again, these concentrations are too low to consider significant.

Accuracy in sample preparation and identification of matrix issues is often identified through matrix spikes. For As(III), the matrix spike and duplicate performed on sample *Reiss Concentrate Stage Perm* showed a slightly elevated relative percent deviation at 28%; where 25% is acceptable. Since all of the remaining QC (i.e., spikes, reps, standard recoveries and blanks) shows good precision and accuracy, this is perceived as an isolated incident, most likely due to a pipetting error, and no corrective action was taken.

Please feel free to call or contact me if you have any questions regarding this report.

Sincerely,



Misty D. Kennard
Project Manager
Mistyk@frontiergeosciences.com

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported May 14, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Sample Results

Sample ID	As(III) (ug/L)	As(V) (ug/L)
PERM FEED Perm Feed to units	8.38	11.2
U.S. FILTER EFF	< 0.001	< 0.206
SEVEREN TRENT EFFLUENT	0.015	< 0.206
WRT VESSEL 2	1.77	0.493
WRT VESSEL 4	0.510	0.235
WRT EFFLUENT	< 0.001	0.292
REISS 1ST STAGE Reiss 1st stage perm	2.75	1.73
REISS 2ND STAGE Reiss 2nd stage perm	0.816	14.3
REISS INTERSTAGE Reiss interstage Conc	10.3	37.3
REISS COMBINED Reiss Combined perm	5.80	0.349
REISS CONC	11.6	174
H&T INFLUENT Raw Water	< 0.001	6.73
H&T EFF	< 0.001	1.80
BLANK	0.007	< 0.206
KHPS INFL	< 0.001	3.34
KHPS EFFL	< 0.001	4.32

Cl_2 not Feeding on unit

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported May 14, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Duplicate Report

Analyte (ug/L)	Sample QC'd	Rep. 1	Rep. 2	Mean	RPD
As(V)	Severn Trent Effluent	< 0.206	< 0.206	NC	NC
As(V)	Reiss Concentrate	174.2	174.4	174.3	0.1
As(III)	Severn Trent Effluent	0.015	0.010	0.012	35.8*
As(III)	Reiss Concentrate	11.60	10.70	11.15	8.1

NC= not calculated; please refer to narrative

Quality Control Data - Matrix Spike / Matrix Spike Duplicate Report

Analyte (ug/L)	Sample QC'd	Mean	Spike Level	MS	% Rec.	Spike Level	MSD	% Rec.	RPD
As(V)	Severn Trent Effluent	NC	5.000	5.040	101.5	5.000	4.862	97.9	3.6
As(V)	Reiss Concentrate	174.3	1000	1047	87.2	1000	1082	90.8	3.3
As(III)	Severn Trent Effluent	0.012	5.000	5.005	99.9	5.000	4.897	97.7	2.2
As(III)	Reiss Concentrate	11.15	125.0	160.6	119.6	125.0	120.0	87.1	28.9

MS = matrix spike

MSD = matrix spike duplicate

RPD = relative percent difference

* = outside of established control limits; please refer to narrative.

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported May 14, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Preparation Blank Report

Analyte (ug/L)	IBW1	IBW2	IBW3	IBW4	Mean	Std Dev	Est. MDL
As(V)	0.211	0.137	0.215	0.071	0.159	0.068	0.206
As(III)	0.000	0.000	0.000	0.000	0.000	0.000	0.001

IBW = instrument blank water

Est. MDL = estimated method detection limit

Std Dev = Standard deviation

Quality Control Data - Standard Reference Material Report

Analyte (ug/L)	SRM Identity	Cert. Value	Obs. Value	% Rec.
As(V)	Internal Std.	10.00	10.62	106.2
AS(III)	Internal Std.	10.00	10.47	104.7

SRM = standard reference material

Frontier Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

May 28, 2003

Nancy Roop Loomis
Dare County
600 Mustain Street
Kill Devil Hills, NC 27948
Phone: (252) 475-5816
Fax: (252) 441-2239

SUBJECT: Arsenic (III) and (V) Results in Aqueous Samples

Project ID: Arsenic Speciation Monitoring
PO #: 20031687-000

Dear Nancy,

Enclosed are results for arsenic III and V in the aqueous samples collected on April 30, 2003. The samples were received in good condition on May 1, 2003.

Upon arrival at Frontier Geosciences, the samples were unpacked, verified against the chain of custody (COC) and immediately transferred to our laboratory for preservation. The sample cooler temperature at time of receipt was 1.3°C and all samples had minimal headspace.

IC-ICP-MS Analysis for As(III) and (V)

The samples were analyzed by Ion Chromatography coupled with Inductively Coupled Plasma Mass Spectrometry (IC-ICP-MS). In this procedure, samples are filtered through a 0.2 μm filter and then injected onto an anion-exchange column capable of separating different ionic arsenic species. In this specific batch, the separation was optimized for the determination of As(III) and As(V) and only these species were quantified. Each species that eluted from the column was introduced into the ICP-MS instrument. This procedure results in two different peaks: one for As(III) (at 5.7 min) and one for As(V) (at 11.6 min). The areas under these peaks are used for quantization.

Analytical Comments

There were no significant analytical difficulties experienced. All QC is within established control limits with the following exceptions identified below.

206 622 6960
fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com

As(III) and As(V) Analysis

There are no certified reference materials available for As(III) and As(V). However, internal standards prepared and tested by Frontier yield recoverable concentrations for both arsenic species. These standards, coupled with ongoing calibration blanks, are analyzed per 20 samples to provide evidence of ongoing system optimization. All of the recoveries show excellent on-going precision at a recovery ranges well within established control limits (75-125%).

As a method of evaluating sample preparation, a blank is analyzed with each sample batch. The blank recovery showed a less than detect value for both As(III) and As(V). Instrument blanks are also analyzed to evaluate instrument equipment, reagent cleanliness and used to determine the batch specific estimated method detection limit (est.MDL).

Reproducibility is examined by sample replicates prepared and analyzed in the exact same manner as the native. For As(III), all samples results were below the batch specific MDL. At such low concentrations, analytical variability tends to increase significantly; therefore the percent differences were not calculated.

Accuracy in sample preparation and identification of matrix issues is often identified through matrix spikes. All recoveries are within established control limits.

The batch specific estimated MDLs have been determined for each dilution performed. Dilutions performed per sample are identified in the results summary table.

Please feel free to call or contact me if you have any questions regarding this report.

Sincerely,

Misty D. Kennard
Project Manager
Mistyk@frontiergeosciences.com

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported May 28, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Sample Results

Sample ID	Dilution performed	As(III) (ug/L)	As(V) (ug/L)
FEED TO UNITS Perm Feedtounits	10	4.89	13.5
U.S. FILTER EFF	1	< 0.003	< 0.408
SEVEREN TRENT EFFLUENT	1	< 0.003	< 0.408
WRT VESSEL #2	1	1.86	1.05
WRT VESSEL #4	1	0.747	0.571
WRT EFFLUENT	1	< 0.003	< 0.408
REISS 1ST STAGE CONC. Reiss interstage Conc	1	0.681	57.6
REISS 1ST STAGE PERM.	10	< 0.030	5.03
REISS 2ND STAGE PERM.	10	0.457	6.89
REISS COMBINED Reiss Combined Perm	1	0.096	0.422
REISS CONC	20	< 0.180	114
H&T RAW Raw Water	5	< 0.015	11.0
H&T EFF	1	< 0.003	< 0.408
BLANK	1	< 0.003	< 0.408

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported May 28, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Duplicate Report

Analyte (ug/L)	Sample QC'd	Rep. 1	Rep. 2	Mean	RPD
As(V)	Severn Trent Effluent	0.176	0.192	0.184	9.1
As(III)	Severn Trent Effluent	< 0.003	< 0.003	< 0.003	N/C

NC= not calculated; please refer to narrative

Quality Control Data - Matrix Spike / Matrix Spike Duplicate Report

Analyte (ug/L)	Sample QC'd	Mean	Spike Level	MS	% Rec.	Spike Level	MSD	% Rec.	RPD
As(V)	Severn Trent Effluent	0.184	10.00	11.76	115.8	10.00	11.79	116.1	0.3
As(III)	Severn Trent Effluent	< 0.003	10.00	10.23	102.3	10.00	10.46	104.6	2.2

MS = matrix spike

MSD = matrix spike duplicate

RPD = relative percent difference

* = outside of established control limits; please refer to narrative.

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported May 28, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Preparation Blank Report

Analyte (ug/L)	IBW1	IBW2	IBW3	Mean	Std Dev	1x Est. MDL	5x Est. MDL	10x Est. MDL	20x Est. MDL
As(V)	0.861	0.641	0.613	0.705	0.136	0.408	2.04	4.08	24.5
As(III)	0.000	0.000	0.000	0.000	0.001	0.003	0.015	0.030	0.180

IBW = instrument blank water

Est. MDL = estimated method detection limit

Std Dev = Standard deviation

Quality Control Data - Standard Reference Material Report

Analyte (ug/L)	SRM Identity	Cert. Value	Obs. Value	% Rec.
As(V)	Internal Std.	10.00	11.23	112.3
AS(III)	Internal Std.	10.00	11.62	116.2

SRM = standard reference material

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 4-30-03 Page: 1 of 2

Client Company: Dare County	Frontier Project Manager: Misty Kennard
Address: 600 Mustain Street Kill Devil Hills NC 27948	Guaranteed Turnaround Time:
CONTACT: NANCY Roop Loomis	Confirmation of Sample Arrival at Frontier: ☐ YES ☐ NO
Phone: 252-475-5816 Fax: 252-441-2239	Quality Assurance Level: ☐ Standard ☐ High
Email: nancyl@co.dare.nc.us	Disposal*: ☐ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
Project Name: As Speciation Monitoring	*All samples are held for at least 2 months after date of receipt. Please note that after this time they are disposed of or returned to the client. Clients may request a longer holding time by writing to the Frontier Project Manager. **Please discuss this with the Frontier Project Manager.
Contract/PO #: 20031687-00	Carrier Information: FED EX ☒ UPS ☐ Other ☐ Tracking # 1Z X86 112 13 4145 1099

Engraved Lab ID	Sample ID	Matrix[1]	# Bottles	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
HCIB-428	H+T RAW	BW	1	4-30-03 1120A	WL	None	As III + V
HCIB-434	H+T EFF.	FW	1	4-30-03 1118A			
HCIB-422	FEED TO UNITS	FW	1	4-30-03 11AM			
HCIB-244A	US Filter EFF	FW	1	4-30-03 1115A			
HCIB-399	WRT Vessel #2	FW	1	4-30-03 1110AM			
HCI-B455	Severn Trent EFF	FW	1	4-30-03 1106AM			
HCI-B-238A	WRT Vessel #4	FW	1	4-30-03 1112AM			
HCI-B-418	WRT EFF	FW	1	4-30-03 1105AM			
HCC-B-36	Reiss 1st Stage Perm	FW	1	4-30-03 1126AM			
HCI-B-443	Reiss 2nd Stage Perm	FW	1	4-30-03 1128A			

Sample Receipt

C.O.C. Seal Intact? ☐ YES ☐ NO ☒ N/A

Cooler Temperature: 1.3 °C

Comments:

VTSR: 1100

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by:	Relinquished by:
Print name:	Print name:
Company:	Company:
Date: Time:	Date: Time:
Received by: A. Mallek	Received by:
Print name: A. Mallek Colbeck	Print name:
Company: Frontier	Company:
Date: 5.1.03 Time: 1130	Date: Time:

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Environmental Research & Specialty Analytical Laboratory

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(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 4-30-03 Page: 2 of 2

Client Company: Dare County	Frontier Project Manager: Misty Kennard
Address: 600 Mustain Street Kill Devil Hills NC 27948	Guaranteed Turnaround Time:
CONTACT: NANCY Roop Loomis	Confirmation of Sample Arrival at Frontier: ☐ YES ☐ NO
Phone: 252-475-5816 Fax: 252-441-2239	Quality Assurance Level: ☐ Standard ☐ High
Email: nancyl@co.dare.nc.us	Disposal*: ☐ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
Project Name: As Speciation Monitering	*All samples are held for at least 2 months after date of receipt. Please note that after this time they are disposed of or returned to the client. Clients may request a longer holding time by writing to the Frontier Project Manager. **Please discuss this with the Frontier Project Manager.
Contract/PO #: 20031687-00	Carrier Information: FED EX ☐ UPS ☐ Other ☐ Tracking # 1Z X86 112 13 4145 1099

Sample Archive ID	Sample Description	Matrix[1]	# Bottles	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
HCLB-391	Reiss Comb. Perm.	FW	1	4-30-03 1130Am	NLL	None	As3 As5
HCLB-251-A	Reiss Cone	SW	1	4-30-03 1135Am			
HCLB-415	Blank	FW	1	4-30-03 1030Am			
HCLB-336	Reiss ~~Interstage~~ 1st Stage Cone	SW	1	4-30-03 1150Am			

Sample Receipt

C.O.C. Seal Intact? ☐ YES ☐ NO ☐ N/A

Cooler Temperature: 1.3 °C

Comments:

VTSR: 1100

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by:	Relinquished by:
Print name:	Print name:
Company:	Company:
Date: Time:	Date: Time:
Received by: A. Malaket	Received by:
Print name: A. Malaket	Print name:
Company: Frontier	Company:
Date: 5.1.03 Time: 1130	Date: Time:

flec 6-23-03

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Ave N · Seattle WA 98109

June 16, 2003

Nancy Roop Loomis
Dare County
600 Mustain Street
Kill Devil Hills, NC 27948
Phone: (252) 475-5816
Fax: (252) 441-2239

SUBJECT: Arsenic (III) and (V) Results in Aqueous Samples

Project ID: Arsenic Speciation Monitoring
PO #: 20031687-00

Dear Nancy,

Enclosed are results for arsenic III and V in the aqueous samples collected on May 13, 2003. The samples were received in good condition on May 14, 2003.

Upon arrival at Frontier Geosciences, the samples were unpacked, verified against the chain of custody (COC) and immediately transferred to our laboratory for preservation. The sample cooler temperature at time of receipt was –0.5°C and all samples had minimal headspace.

IC-ICP-MS Analysis for As(III) and (V)

The samples were analyzed by Ion Chromatography coupled with Inductively Coupled Plasma Mass Spectrometry (IC-ICP-MS). In this procedure, samples are filtered through a 0.2 μm filter and then injected onto an anion-exchange column capable of separating different ionic arsenic species. In this specific batch, the separation was optimized for the determination of As(III) and As(V) and only these species were quantified. Each species that eluted from the column was introduced into the ICP-MS instrument. This procedure results in two different peaks: one for As(III) (at 5.7 min) and one for As(V) (at 11.6 min). The areas under these peaks are used for quantization.

Analytical Comments

Due to instrumentation issues the samples were re-prepped and re-analyzed on May 15 and 16, 2003. **Since the samples were exposed to O_2 during initial sample preparation performed on 5/14/03 it is perceivable that the arsenic speciation may have been altered (As(III) converted into As(V)).** There were no further significant

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fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com

analytical difficulties experienced. All QC is within established control limits with the following exceptions identified below.

As(III) and As(V) Analysis

There are no certified reference materials available for As(III) and As(V). However, internal standards prepared and tested by Frontier yield recoverable concentrations for both arsenic species. These standards, coupled with ongoing calibration blanks, are analyzed per 20 samples to provide evidence of ongoing system optimization. All of the recoveries show excellent on-going precision at a recovery ranges well within established control limits (75-125%).

As a method of evaluating sample preparation, three filter blanks were analyzed with each sample batch. The filter blank recoveries showed a less than detect value for As(III) and semi-elevated values for As(V). In effort to account for this perceived contamination source, As(V) results were corrected for the mean (0.787 ug/L) of the filter blanks. Instrument blanks are also analyzed to evaluate instrument equipment, reagent cleanliness and used to determine the batch specific estimated method detection limit (est.MDL).

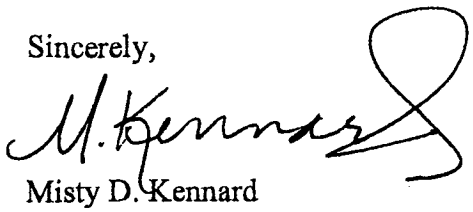
Reproducibility is examined by sample replicates prepared and analyzed in the exact same manner as the native. For As(III), all samples results were below the batch specific MDL. At such low concentrations, analytical variability tends to increase significantly; therefore the percent differences were not calculated.

Accuracy in sample preparation and identification of matrix issues is often evident through matrix spikes recoveries. For the sample H&T Effluent all matrix spike and matrix spike duplicate recoveries are outside established control limits. To investigate these poor recoveries the sample was analyzed at 1x and 10x dilutions in an effort to eliminate matrix issues. Both dilutions showed similar low recoveries. A third analysis was not performed and considered inappropriate due to sample matrix exposure to O_2. This exposure is known to oxidize all As(III) into As(V) hence skewing the results. Regarding poor spike recoveries, it is very likely poor recoveries are resulting from matrix issues that require further investigative analytical chemistry. As an initial measure towards investigative chemistry, matrix spikes and duplicates have been performed on the H&T Effluent sample collected on May 27, 2003. These results will be reported shortly. **Please feel free to contact our Research Scientist, Dr. Hakan Gurleyuk, at (206) 957-1410 for a detailed discussion about these issues.**

The batch specific estimated MDLs have been determined for each dilution performed. Dilutions performed per sample are identified in the results summary table.

Please feel free to call or contact me if you have any questions regarding this report.

Sincerely,



Misty D. Kennard
Project Manager
Mistyk@frontiergeosciences.com

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 16, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Sample Results

Sample ID	Dilution performed	As(III) (ug/L)	As(V) (ug/L)
BLANK	1	< 0.003	<0.571
WRT VESSEL #8	1	0.067	<0.571
WRT VESSEL #6	1	0.075	<0.571
FEED TO UNITS perm Feed	10	0.792	23.7
US FILTER EFF	1	< 0.003	<0.571
H&T EFFLUENT	10	< 0.030	7.88
H&T INFLUENT Raw Water	50	< 0.450	<85.6
1ST STAGE PERM REISS	10	<0.030	10.7
1ST STAGE CONC REISS Interstage Conc	10	<0.030	34.9
COMB. PERM REISS	20	<0.060	83.3
2ND STAGE PERM REISS	10	0.082	8.98
FINAL CONC REISS	50	<0.450	116

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 16, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Duplicate Report

Analyte (ug/L)	Sample QC'd	Rep. 1	Rep. 2	Mean	RPD
As(V)	H&T Effluent	7.880	6.734	7.307	15.7
As(III)	H&T Effluent	< 0.030	< 0.030	< 0.030	NC

NC= not calculated; please refer to narrative

Quality Control Data - Matrix Spike / Matrix Spike Duplicate Report

Analyte (ug/L)	Sample QC'd	Mean	Spike Level	MS	% Rec.	Spike Level	MSD	% Rec.	RPD
As(V)	H&T Effluent	7.307	100.00	76.70	69.4*	100.00	71.22	63.9*	7.4
As(III)	H&T Effluent	< 0.030	100.00	9.10	9.1*	100.00	9.57	9.6*	5.1

MS = matrix spike

MSD = matrix spike duplicate

RPD = relative percent difference

* = outside of established control limits; please refer to narrative.

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 16, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Preparation Blank Report

Analyte (ug/L)	IBW1	IBW2	IBW3	Mean	Std Dev	1x Est. MDL	10x Est. MDL	20x Est. MDL	50x Est. MDL
As(V)	0.316	0.697	0.512	0.508	0.190	0.571	5.71	11.4	85.6
As(III)	0.000	0.000	0.000	0.000	0.001	0.003	0.030	0.060	0.450

IBW = instrument blank water

Est. MDL = estimated method detection limit

Std Dev = Standard deviation

Quality Control Data - Standard Reference Material Report

Analyte (ug/L)	SRM Identity	Cert. Value	Obs. Value	% Rec.
As(V)	Internal Std.	10.00	9.34	93.4
AS(III)	Internal Std.	10.00	11.80	118.0

SRM = standard reference material

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 5-13-03 Page: 1 of 2

Client Company: Dare County	Frontier Project Manager: Misty Kennard
Address: 600 Mustain Street Kill Devil Hills NC 27948	Guaranteed Turnaround Time: 28 DAYS
CONTACT: NANCY Roop Loomis	Confirmation of Sample Arrival at Frontier: ☒ YES ☐ NO
Phone: 252-475-5816 Fax: 252-441-2237	Quality Assurance Level: ☒ Standard ☐ High
Email: nancyl@co.dare.nc.us	Disposal*: ☒ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
Project Name: As Speciation Monitoring	*All samples are held for at least 2 months after date of receipt. Please note that after this time they are disposed of or returned to the client. Clients may request a longer holding time by writing to the Frontier Project Manager. **Please discuss this with the Frontier Project Manager.
Contract/PO #: 20031687-00	Carrier Information: FED EX ☐ UPS ☒ Other ☐ Tracking # 1Z X86 112 01 4103 3572

Frontier Project ID	Sample ID	Matrix[1]	Bottles	Date/Time Sampled	Collected by	Preservation	Analysis Required/Comments
HCl-B-445	Blank		1	5-13-03	NRL	NONE	As3 As5
HCL-B-309	WRT Vessel #8	FW	1	5-13-03 840 AM			
HCL-B-297	WRT Vessel #6	FW	1	5-13-03 8:45 AM			
HCL-B-314	Feed to Units	FW	1	5-13-03 8:50 AM			
HCL-B-295	US Filter EFF	FW	1	5-13-03 900 AM			
HCL-B-316A	H+T EFF	FW	1	5-13-03 915 AM			
HCl B-318A	H+T Inf	BW	1	5-13-03 910 AM			
HCL-A-147	1st Stage Perm Reiss	FW	1	5-13-03 950 AM			
HCL-B-307	1st Stage Conc Reiss	FW	1	5-13-03 955 AM			
HCl-B-254A	Comb. Perm Reis	FW	1	5-13-03 1005 AM			

Shipment Receipt

C.O.C. Seal Intact? ☒ YES ☐ NO ☐ N/A

Cooler Temperature: -0.5 °C

Comments:

VTSR: 1030

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by:	Relinquished by:
Print name:	Print name:
Company:	Company:
Date: Time:	Date: Time:
Received by: Deborah L Cussen	Received by:
Print name: D. Cussen	Print name:
Company: Frontier	Company:
Date: 5-14-03 Time: 1230	Date: Time:

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 5-13-03 Page: 1 of 2

Client Company: Dare County
Address: 600 Mustain Street
Kill Devil Hills NC 27948
CONTACT: NANCY Roop Loomis
Phone: 252-475-5816 Fax: 252-441-2239
Email: nancyl@co.dare.nc.us
Project Name: As Speciation Monitoring
Contract/PO #: 20031687-00

Frontier Project Manager: Misty Kennard
Guaranteed Turnaround Time:
Confirmation of Sample Arrival at Frontier: ☐ YES ☐ NO
Quality Assurance Level: ☐ Standard ☐ High
Disposal*: ☐ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
*All samples are held for at least 2 months after date of receipt.
Please note that after this time they are disposed of or returned to the client.
Clients may request a longer holding time by writing to the Frontier Project Manager.
**Please discuss this with the Frontier Project Manager.
Carrier Information: FED EX ☐ UPS ☒ Other ☐
Tracking # 1ZX86 112 01 4103 3572

Laboratory ID	Sample Description	Matrix[1]	# Bottles	Date/Time Sampled	Analyses Requested		Analysis Priority/Comments
HCL-B-303	2nd Stage Perm Pass	FW	1	5-13-03 1010A	NRL	NONE	AS3 AS5
HCL-B-456	Final Conc Pass	BW	1	5-13-03 1015A			

C.O.C. Seal Intact? ☒ YES ☐ NO ☐ N/A
Cooler Temperature: −0.5 °C
Comments:

VTSR: 1036

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by:	Relinquished by:
Print name:	Print name:
Company:	Company:
Date: Time:	Date: Time:
Received by: Deborah L Cussen	Received by:
Print name: D. Cussen	Print name:
Company: Frontier	Company:
Date: 5-14-03 Time: 1230	Date: Time:

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 23, 2003; Revised 7/1/03

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Sample Results

Sample ID	Dilution performed	As(III) (ug/L)	As(V) (ug/L)
Severn Trent Effluent	2	< 0.006	< 0.135
Perm Feed	10	1.03	15.7
US Filter Eff	2	< 0.006	< 0.135
Reiss 1st Stage Con	25	< 0.075	74.6
Reiss 1st Stage Perm	10	< 0.030	0.261
Reiss 2nd Stage Perm	10	2.07	1.53
Reiss Combine Perm	10	1.20	< 0.68
H&T Effluent	10	0.634	1.17
WRT #8	2	0.179	< 0.135
WRT #6	2	0.076	0.211
Reiss Final Conc	50	< 0.450	165
H&T Influent	50	14.1	10.2
Blank	1	< 0.003	< 0.068

Fax Cover Sheet

To: Nancy Roop Loomis

fax (252) 441-2239 phone: _____

From: Misty Kennard

fax: 206.622.6870 phone: 206.622.6960

Date: 7/1/03

Subject: Revised 5/27/03 results

- NOTICE: This communication may contain privileged or other confidential information. If you have received it in error, please advise the sender by reply and immediately discard the message and any attachments without copying or disclosing the contents. Thank you.

Number of pages including this cover sheet . . .

2

Frontier Geosciences Inc.
Environmental Research Corporation
414 Pontius Avenue North
Seattle, WA 98109
www.FrontierGeosciences.com

Frontier
Geosciences Inc.
Environmental Research & Specialty Analytical Laboratory
414 Pontius Ave N · Seattle WA 98109

June 23, 2003

Nancy Roop Loomis
Dare County
600 Mustain Street
Kill Devil Hills, NC 27948
Phone: (252) 475-5816
Fax: (252) 441-2239

SUBJECT: Arsenic (III) and (V) Results in Aqueous Samples

Project ID: Arsenic Speciation Monitoring
PO #: 20031687-00

Dear Nancy,

Enclosed are results for arsenic III and V in the aqueous samples collected on May 27, 2003. The samples were received in good condition on May 28, 2003.

Upon arrival at Frontier Geosciences, the samples were unpacked, verified against the chain of custody (COC) and immediately transferred to our laboratory for preservation. The sample cooler temperature at time of receipt was 0.5°C and all samples had minimal headspace.

IC-ICP-MS Analysis for As(III) and (V)

The samples were analyzed by **I**on **C**hromatography coupled with **I**nductively **C**oupled **P**lasma **M**ass **S**pectrometry (IC-ICP-MS). In this procedure, samples are filtered through a 0.2 μm filter and then injected onto an anion-exchange column capable of separating different ionic arsenic species. In this specific batch, the separation was optimized for the determination of As(III) and As(V) and only these species were quantified. Each species that eluted from the column was introduced into the ICP-MS instrument. This procedure results in two different peaks: one for As(III) (at 5.7 min) and one for As(V) (at 11.6 min). The areas under these peaks are used for quantization.

Analytical Comments

There were no significant analytical difficulties experienced. All QC is within established control limits with the following exceptions identified below.

206 622 6960
fax 206 622 6870
email: info@Frontier.WA.com
www.FrontierGeosciences.com

As(III) and As(V) Analysis

There are no certified reference materials available for As(III) and As(V). However, internal standards prepared and tested by Frontier yield recoverable concentrations for both arsenic species. These standards, coupled with ongoing calibration blanks, are analyzed per 20 samples to provide evidence of ongoing system optimization. There was one elevated recovery for As(III) at 144%. Additionally, there was evidence of oxidation of the standard from As(III) to As(V). No other recoveries were outside of control limits however, as a corrective action measure, in the future, an additional standard reference material will be analyzed for both As(III) and (V).

As a method of evaluating sample preparation, three preparation blanks were analyzed with each sample batch. These blanks provide evidence of instrument equipment, reagents and sample preparation cleanliness and are used to determine the batch specific estimated method detection limit (est.MDL).

Reproducibility is examined by sample replicates prepared and analyzed in the exact same manner as the native. For As(III), all samples results were below the batch specific MDL. At such low concentrations, analytical variability tends to increase significantly; therefore the percent deviations were not calculated.

Accuracy in sample preparation and identification of matrix issues is often evident through matrix spikes recoveries. As mentioned in the report dated June 16, 2003, sample H&T Effluent matrix spikes and duplicate spikes were performed again to further investigate the poor recovery history of this matrix. Again, the matrix does not hold the known arsenic species very well indicating matrix species conversion. **Please feel free to contact our Research Scientist, Dr. Hakan Gurleyuk, at (206) 957-1410 for a detailed discussion about these issues.**

The batch specific estimated MDLs have been determined for each dilution performed. Dilutions performed per sample are identified in the results summary table.

Please feel free to call or contact me if you have any questions regarding this report.

Sincerely,

Misty D. Kennard
Project Manager
Mistyk@frontiergeosciences.com

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 23, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Sample Results

Sample ID	Dilution performed	As(III) (ug/L)	As(V) (ug/L)
Severn Trent Effluent	2	< 0.006	< 0.135
Perm Feed	10	1.03	15.7
US Filter Eff	2	< 0.006	< 0.135
Reiss 1st Stage Con	25	< 0.075	74.6
Reiss 2nd Stage Perm	10	2.07	1.53
Reiss Combine Perm	10	1.20	< 0.68
H&T Effluent	10	0.634	1.17
WRT #8	2	0.179	< 0.135
WRT #6	2	0.076	0.211
Reiss Final Conc	50	< 0.450	165
H&T Influent	50	14.1	10.2
Blank	1	< 0.003	< 0.068

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 16, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Duplicate Report

Analyte (ug/L)	Sample QC'd	Rep. 1	Rep. 2	Mean	RPD
As(V)	H&T Effluent	1.170	1.008	1.089	14.9
	Severn Trent Effluent	< 0.135	< 0.135	< 0.135	NC
As(III)	H&T Effluent	0.634	0.865	0.750	30.8
	Severn Trent Effluent	< 0.006	< 0.006	< 0.006	NC

NC= not calculated; please refer to narrative

Quality Control Data - Matrix Spike / Matrix Spike Duplicate Report

Analyte (ug/L)	Sample QC'd	Mean	Spike Level	MS	% Rec.	Spike Level	MSD	% Rec.	RPD
As(V)	H&T Effluent	1.089	100.00	68.61	67.5*	100.00	55.35	54.3*	21.4
	Severn Trent Effluent	< 0.135	20.00	22.63	113.3	20.00	24.11	120.7	6.3
As(III)	H&T Effluent	0.750	100.00	37.38	36.6*	100.00	43.02	42.3*	14.0
	Severn Trent Effluent	< 0.006	20.00	15.77	78.9	20.00	17.42	87.1	9.9

MS = matrix spike

MSD = matrix spike duplicate

RPD = relative percent difference

* = outside of established control limits; please refer to narrative.

Arsenic Speciation Results for Dare County - Nancy Loomis

Arsenic Speciation Monitoring Project

Reported June 23, 2003

Frontier Geosciences Inc., 414 Pontius Ave. N, Seattle WA 98109

Quality Control Data - Preparation Blank Report

Analyte (ug/L)	IBW1	IBW2	IBW3	Mean	Std Dev	1x Est. MDL	2x Est. MDL	10x Est. MDL	25x Est. MDL	50x Est. MDL
As(V)	0.107	0.076	0.063	0.082	0.023	0.068	0.135	0.68	1.7	10
As(III)	0.000	0.000	0.000	0.000	0.001	0.003	0.006	0.030	0.075	0.450

IBW = instrument blank water

Est. MDL = estimated method detection limit

Std Dev = Standard deviation

Quality Control Data - Standard Reference Material Report

Analyte (ug/L)	SRM Identity	Cert. Value	Obs. Value	% Rec.
As(V)	Internal Std.	20.00	23.69	118.5
AS(III)	Internal Std.	20.00	28.80	144.0*

SRM = standard reference material

* = outside of established control limits; please refer to narrative.

Deliver to Crystal

900 - 20 min
1:30 min = 1200

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 5-27-03 Page: 1 of 2

Client Company: DARE County
Address: 600 Mustain Street
Kill Devil Hills NC 27948
CONTACT: NANCY RoopLoomis
Phone: 252-475-5816 Fax: 252-441-2237
Email: nancyl@co.dare.nc.us
Project Name: As Speciation Monitoring
Contract/PO #: 20031687-00

Frontier Project Manager: Misty Kennard
Guaranteed Turnaround Time: 28 DAY
Confirmation of Sample Arrival at Frontier: ☒ YES ☐ NO
Quality Assurance Level: ☒ Standard ☐ High
Disposal*: ☒ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
*All samples are held for at least 2 months after date of receipt.
Please note that after this time they are disposed of or returned to the client.
Clients may request a longer holding time by writing to the Frontier Project Manager.
**Please discuss this with the Frontier Project Manager.
Carrier Information: FED EX ☐ UPS ☒ Other ☐
Tracking #

Sample ID	Description	Matrix[1]	# Bottles	Date/Time Sampled	Sampled by	Preservation	Analyses Requested/Comments
HCL-B-302	WRT #8	FW	1	5-27-03 8AM	NRL	NONE	As3 As5
HCL-B-298	WRT #6	FW	1	5-27-03 805A			
HCL-B-369	Perm Feed	FW	1	5-27-03 810AM			
HCL-B-330	U.S. Filter EFF	FW	1	5-27-03 815A			
HCL-B-450	SevernTrent EFF	FW	1	5 27 03 820A			
HCL-B-319	Reiss 1st Stage Perm	FW	1	5-27-03 8:45A			
HCL-B-417	Reiss 2nd Stage Perm	FW	1	5-27-03 850A			
HCL-B-431	Reiss Combine Perm	FW	1	5-27-03 855A			
HCLB-314	H+T EFF	FW	1	5-27-03 905A			
HCL-B-222A	Reiss 1st Stage Conc	BW	1	5-27-03 920A			

C.O.C. Seal Intact? ☐ YES ☐ NO ☒ N/A
Cooler Temperature: 0.5 °C
Comments: ☒ HCL-B-222A
VTSR: 1015

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

UPSTAIRS W/ Crystal

Relinquished by:	Relinquished by:
Print name:	Print name:
Company:	Company:
Date: Time:	Date: Time:
Received by:	Received by:
Print name: Christabel Fowler	Print name:
Company: FGS	Company:
Date: 5/28/3 Time: 1100	Date: Time:

Frontier Geosciences Inc.

Environmental Research & Specialty Analytical Laboratory

414 Pontius Avenue North, Suite B Seattle WA 98109
(206) 622-6960 fax (206) 622-6870 Info@Frontier.WA.com

Chain-of-Custody Record & Laboratory Analysis Request

Date: 5-27-03 Page: 2 of 2

Client Company: Dare County	Frontier Project Manager: Misty Kennard
Address: 600 Mustain Street Kill Devil Hills NC 27948	Guaranteed Turnaround Time: 28 DAY
CONTACT: NANCY Roop Loomis	Confirmation of Sample Arrival at Frontier: ☒ YES ☐ NO
Phone: 252-475-5816 Fax: 252-441-2239	Quality Assurance Level: ☒ Standard ☐ High
Email: nancyl@co.dare.nc.us	Disposal*: ☒ Frontier Dispose ☐ Return to Client ☐ Ship to 3rd Party**
Project Name: As Speciation Monitoring	*All samples are held for at least 2 months after date of receipt. Please note that after this time they are disposed of or returned to the client. Clients may request a longer holding time by writing to the Frontier Project Manager. **Please discuss this with the Frontier Project Manager.
Contract/PO #: 20031687-00	Carrier Information: FED EX ☐ UPS ☒ Other ☐ Tracking # 1ZX861120141571295

Frontier ID	Your Sample ID	Matrix[1]	# Containers	Date/Time Sampled	Relinquished by	Preservation	Analysis Requested/Comments
~~HCL-B-239~~							
HCL-B-239-A	Reiss Final Conc	BW	1	5-27-03 - 825AM	NRL	None	As 5 As 5
HCLP-379	H+TINF	BW	1	5-27-03 930A			
HCL-B-243A	BLANK	FW	1	5-27-03 1:45P			

C.O.C. Seal Intact? ☐ YES ☐ NO ☐ N/A

Cooler Temperature: °C

Comments:

VTSR:

[1]Matrix Codes:
FW = fresh water (salinity < 0.5 ppth)
BW = brackish water
SW = seawater
WW = wastewater
SE = sediment
SO = soil
AT = animal tissue
PT = plant tissue
TR = trap
PP = petroleum product
OT = other

Relinquished by:	Relinquished by:
Print name:	Print name:
Company:	Company:
Date: Time:	Date: Time:
Received by: CF	Received by:
Print name: CHRISTABEL FOWLER	Print name:
Company: FGS	Company:
Date: 5/28/3 Time: 1100	Date: Time:

CUSTOMER #:
07120

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1956
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 4/30/03
LAB# 137203
P.O.
RECD 04/16/03
* * (CONT) * *

ANALYSIS REPORT

NANCY ROOP LOOMIS
DARE COUNTY WATER DEPT.
600 MUSTIAN STREET
KILL DEVIL HIL NC 27948

HUFFMAN SEQUENCE NUMBER 08	REISS 1ST STAGE 4-15-03
HUFFMAN SEQUENCE NUMBER 09	REISS 2ND STAGE PERM 4-15-03
HUFFMAN SEQUENCE NUMBER 10	REISS COMBINED 4-15-03
HUFFMAN SEQUENCE NUMBER 11	REISS INTERSTAGE 4-15-03
HUFFMAN SEQUENCE NUMBER 12	SEVERN TRENT EFF
HUFFMAN SEQUENCE NUMBER 13	U.S. FILTER 4-15-03
HUFFMAN SEQUENCE NUMBER 15	WRT VESSEL 2 4-15-03
HUFFMAN SEQUENCE NUMBER 16	WRT VESSEL 4 4-15-03

"Total" arsenic as reported above is sum of inorganic arsenic species in solution at time of analysis (arsenate + arsenite). Arsenite (As+3) measured on separate sample aliquot, and arsenate (As+5) calculated by difference.

*Arsenate and arsenite speciation analyses not performed since "total" arsenic below limit of detection.

Rec 4-17-03

CUSTOMER #:
07120

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1936
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 4/11/03
LAB# 130603
P.O.
RECD 04/02/03

ANALYSIS REPORT

NANCY ROOP LOOMIS
DARE COUNTY WATER DEPT.
600 MUSTIAN STREET
KILL DEVIL HIL NC 27948

SEQUENCE/ SAMPLE NUMBER	ANALYSIS ARSENIC III----UG/L	ARSENIC V---UG/L	"TOTAL" ARSENIC----UG/L	
01/BLANK	*	*	<0.5	
02/CONC REISS	36.	113.	149.	Reiss Conc
03/DIST	<0.5	5.	5.	
04/FEED TO UNITS	9.	5.	14.	Perm Feed to Units
05/H+T INFLU	23.	33.	56.	RAW Water
06/H+T EFFLUENT	<0.5	6.	6.	
07/1ST STAGE PERM	*	*	<0.5	Reiss 1st stage Perm
08/2ND STAGE PERM	*	*	<0.5	" 2nd " "
09/REISS IN?? STAG	2.	53.	55.	Reiss interstage Conc
10/REISS COMBINED	*	*	<0.5	Reiss Combined Perm
11/U.S. FILTER EFF	*	*	<0.5	
12/SEVERN TRENT EF	*	*	<0.5	
13/WRT EFF	*	*	<0.5	
14/WRT 2	1.	1.	2.	
15/WRT 4	*	*	<0.5	

HUFFMAN SEQUENCE NUMBER 09 REISS IN?? STAGE PERM
HUFFMAN SEQUENCE NUMBER 10 REISS COMBINED PERM
HUFFMAN SEQUENCE NUMBER 12 SEVERN TRENT EFF

"Total" arsenic as reported above is sum of inorganic arsenic species in solution at time of analysis (arsenate + arsenite). Arsenite (As+3) measured on separate sample aliquot, and arsenate (As+5) calculated by difference.

*Arsenate and arsenite speciation analyses not performed since "total" arsenic below limit of detection.

CUSTOMER #:
07120

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1936
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 4/30/03
LAB# 137203
P.O.
RECD 04/16/03

ANALYSIS REPORT

NANCY ROOP LOOMIS
DARE COUNTY WATER DEPT.
600 MUSTIAN STREET
KILL DEVIL HIL NC 27948

SEQUENCE/ SAMPLE NUMBER	ANALYSIS TOTAL ARSENIC---UG/L	ARSENIC+III--UG/L	ARSENIC+V--UG/L	
01/BLANK 4-15-03	<0.5	*	*	
02/H+T INFLUENT 4	61.	1.	60.	Raw water
03/H+T EFF 4-15-03	8.	<0.5	8.	
04/KITTY HAWK INF	3.	<0.5	3.	
05/KITTY HAWK EFF	2.	<0.5	2.	
06/PERM FEED 4-15	14.	8.	6.	Perm Feed to units
07/REISS CONC 4-15	155.	116.	39.	Reiss Conc
08/REISS 1ST STAGE	4.	4.	<0.5	
09/REISS 2ND STAGE	12.	12.	<0.5	
10/REISS COMBINED	4.	4.	<0.5	Reiss Combined perm
11/REISS INTERSTAG	55.	18.	37.	Reiss interstage Conc
12/SEVERN TRENT EF	<0.5	*	*	
13/U.S. FILTER 4-1	<0.5	*	*	Effluent
14/WRT EFF 4-15-03	<0.5	*	*	
15/WRT VESSEL 2 4	2.	2.	<0.5	
16/WRT VESSEL 4 4	<0.5	*	*	

HUFFMAN SEQUENCE NUMBER 02 H+T INFLUENT 4-15-03
HUFFMAN SEQUENCE NUMBER 06 PERM FEED 4-15-03
HUFFMAN SEQUENCE NUMBER 07 REISS CONC 4-15-03

Cl_2 not Feeding on unit

CUSTOMER #:
07120

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1936
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 5/16/03
LAB# 142503
P.O.
RECD 05/01/03

ANALYSIS REPORT

NANCY ROOP LOOMIS
DARE COUNTY WATER DEPT.
600 MUSTIAN STREET
KILL DEVIL HIL NC 27948

rec 5-21-03

SEQUENCE/ SAMPLE NUMBER	ANALYSIS "TOTAL" ARSENIC--UG/L	AS+3-------UG/L	AS+5-------UG/L	
01/BLANK	<0.5	*	*	
02/FEED TO UNITS	16.	5.	11.	Perm Feed to Units
03/H+T RAW	88.	0.5	88.	Influent
04/H+T EFF	4.	<0.5	4.	
05/REISS COMB PERM	<0.5	*	*	Reiss Combined perm
06/REISS CONC	144.	25.	119.	Reiss Conc
07/REISS 1ST STAGE	<0.5	*	*	" 1st stage perm
08/REISS 2ND STAGE	<0.5	*	*	" 2nd stage "
09/SEVERN TRENT EFF	<0.5	*	*	
10/U.S. FILTER	<0.5	*	*	EFFluent
11/WRT EFF	<0.5	*	*	
12/WRT VESSEL 2	2.	1.	1.	
13/WRT VESSEL #4	1.	1.	<0.5	

* Reiss interstage Conc was not tested.

HUFFMAN SEQUENCE NUMBER 07 REISS 1ST STAGE PERM
HUFFMAN SEQUENCE NUMBER 08 REISS 2ND STAGE PERM

"Total" arsenic as reported above is sum of inorganic arsenic species in solution at time of analysis (arsenate + arsenite). Arsenite (As+3) measured on separate sample aliquot, and arsenate (As+5) calculated by difference.

*Arsenate and arsenite speciation analyses not performed since "total" arsenic below limit of detection.

CUSTOMER #:
07120

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1936
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

DATE 5/27/03
LAB# 148503
P.O.
RECD 05/14/03

ANALYSIS REPORT

NANCY ROOP LOOMIS
DARE COUNTY WATER DEPT.
600 MUSTIAN STREET
KILL DEVIL HIL NC 27948

SEQUENCE/ SAMPLE NUMBER	ANALYSIS TOTAL ARSENIC---UG/LI	ARSENIC+III-UG/L	ARSENIC+V--UG/L	
01/BLANK	<0.5	*	*	
02/FEED TO UNITS	13.	2.	11.	Perm to the units
03/H+T INF	87.	<0.5	87.	Raw water
04/H+T EFF	17.	1.	16.	
05/1ST STAGE CONC.	42.	1.	41.	Reiss interstage Conc
06/1ST STAGE PERM.	<0.5	*	*	Reiss 1st stage Perm
07/2ND STAGE PERM.	<0.5	*	*	Reiss 2nd stage Perm
08/COMBINED PERM R	<0.5	*	*	Reiss Combined perm
09/FINAL CONC. REI	101.	4.	97.	Reiss Conc
10/US FILTER EFF	<0.5	*	*	
11/VESSEL #6	<0.5	*	*	wrt Vessel #6
12/WRT VESSEL #8	<0.5	*	*	wrt Vessel #8

HUFFMAN SEQUENCE NUMBER 05 1ST STAGE CONC. REISS
HUFFMAN SEQUENCE NUMBER 06 1ST STAGE PERM. REISS
HUFFMAN SEQUENCE NUMBER 07 2ND STAGE PERM. REISS
HUFFMAN SEQUENCE NUMBER 08 COMBINED PERM REISS
HUFFMAN SEQUENCE NUMBER 09 FINAL CONC. REISS

"Total" arsenic as reported above is sum of inorganic arsenic species in solution at time of analysis (arsenate + arsenite). Arsenite (As+3) measured on separate sample aliquot and arsenate (As+5) calculated by difference.

*Arsenate and arsenite speciation analyses not performed since "total" arsenic below limit of detection.

CUSTOMER #:
07120

DATE 6/19/03
LAB# 153703
P.O.
RECD 05/28/03

HUFFMAN
LABORATORIES, INC.
Quality Analytical Services Since 1936
4630 Indiana Street • Golden, CO 80403
Phone: (303) 278-4455 • FAX: (303) 278-7012

ANALYSIS REPORT

Rec 6-23-03 NRL

NANCY ROOP LOOMIS
DARE COUNTY WATER DEPT.
600 MUSTIAN STREET
KILL DEVIL HIL NC 27948

SEQUENCE/ SAMPLE NUMBER	ANALYSIS TOTAL AS--UG/L	AS + 3-----UG/L	AS + 5-----UG/L	
01/BLANK	<0.5	*	*	
02/H+T INF	56.	13.	43.	Raw Water
03/H+T EFF	32.	1.	31.	
04/PERM FEED	16.	1.	15.	Perm Feed to units
05/REISS 1ST STAGE	65.	3.	62.	Reiss 1st stage perm
06/REISS FINAL CON	137.	6.	131.	Reiss Conc
07/REISS 1ST STAGE	1.	<0.5	1.	Reiss 1st stage perm
08/REISS 2ND STAGE	3.	1.	2.	Reiss 2nd stage perm
09/REISS COMB. PER	1.	1.	<0.5	Reiss Combined perm
10/SEVERN TRENT EF	<0.5	*	*	
11/U.S. FILTER EFF	<0.5	*	*	
12/WRT #6	<0.5	*	*	
13/WRT #8	<0.5	*	*	

HUFFMAN SEQUENCE NUMBER 05 REISS 1ST STAGE CONC.
HUFFMAN SEQUENCE NUMBER 06 REISS FINAL CONC.
HUFFMAN SEQUENCE NUMBER 07 REISS 1ST STAGE PERM.
HUFFMAN SEQUENCE NUMBER 08 REISS 2ND STAGE PERM.
HUFFMAN SEQUENCE NUMBER 09 REISS COMB. PERM.
HUFFMAN SEQUENCE NUMBER 10 SEVERN TRENT EFF

"Total" arsenic as reported above is sum of inorganic arsenic species in solution at time of analysis (arsenate + arsenite). Arsenite (As + 3) measured on separate sample aliquot and arsenate (As+5) calculated by difference.

*Arsenate and arsenite speciation analyses not performed since "total" arsenic below limit of detection.

APPENDIX D

OPERATORS LOG

3.2003

Operators-
use this notebook to make Comments
+ observations of ALL As. Pilot units

Operator's Notebook
for
Agenic Pilot

3-20-03 Wells, 2 - 3 - 6

3-21-03 Wells 2 - 3 - 6

→ Mixed up stock Ferric Chloride + Chlorine Solution for the Hungerford + Terry Pilot

3-22-03 Wells- 2 - 3
Iron + Cl_2 up on Hungerford + Terry - A 150 Increase in effluent By-Pass

3-23-03 Wells 2, 3, 6

3-24-03 Wells 2, 3, 6

3-25-03 Wells 2, 3, 6

3-26-03 Wells 2, 3, 7

3-27 Wells #3 & #10

3-28 Wells 3 & 10
Back Washed Hungerford Terry

3-29-03 Wells 3 & 10
Cl_2 High on Hungerford/Terry Effluent Adjusted down
Cl_2 low on NANO unit adjusted up
Filled Hungerford/Terry Chem. Day tanks.

3-30-3 Wells 3 & 10 PS/DH
- Excessive Cl_2 on Hungerford/Terry Effluent checking it every two hours.
- Filled Hungerford/Terry Day tanks 3pm
- Reiss unit is hard to check for Feed Cl_2 - Art said that you have to check it at the right time to set A good reading. I found that if you put reagent in bottle and Add A couple of Drops of H_2O from Sight At a time you can tell by color change when you will get An Accurate reading.

3-31-03 wells 3 & 10
Found chemicals ~~the~~ not feeding on Hungerford/Terry - reset breaker

3-31-03
3-31-03 Charlie from WRT called, they were pleased with results I faxed to them. He said we only needed to test their Unit once per. week. However NRL, Bob O, Pat I and Ian W. would have to give the OK for that.

Cl_2 - for Hungeford/Terry droppings

3-31-03 PS 2nd shift

- Filled Reiss Sodium Bisulfite Day tank @ 6:45 pm Beg level 6.5 filled to 15
- Filled Hungerford/Terry Cl_2 Day tank, beg level 5 filled to 10, Cl_2 is feeding faster than Iron Solution.

* Tank levels at 7pm 3-31-03 Cl_2 - 10 inchs
Iron - 9.9 inchs

2AM Hungerford/Terry Day Tanks seem to be keeping pace with each other. Cl_2 on Effluent has dropped also.

4-1-03 AB/NW 1st SHIFT
Wells 3+10 ON
Cl2 WAS NORMAL ON Hungerford & Terry This MORNING.
ALL PILOT UNITS RUNNING SMOOTHLY.

4-1-03 Collected As Samples Sent to Huffman Geo Sweet Wells 3, 10

4-1-03 H & T pumps off again at 3:45pm I reset ground fault breaker and pumps came back on.
Please check ground fault and reset it each time you check the Cl2 on the Riese unit.

- Filled Day tanks on Hungerford/Terry unit, Iron to 10 and Cl_2 to 10.5. 8pm

4-2-03

4-2-03 RIESSE UNIT, FOUND ON POST BISSULFATE Cl2 OF .21, NOTICED PUMP WAS AIR LOCK. UN AIRLOCK PUMP GOT IT TO PUMP & Cl2 BACK TO .02. OTHER PILOT UNITS NORMAL. EXCEPT EFF FROM H+T HAD A DISCOLOR TO IT GETTING SAMPLE.

- THE OPM on H+T is .4ppm DH checked it 2 times

SEE NEXT PAGE

4-3-03 If you find a flow that is incorrect on any of the pilot units please adjust it to where it is supposed to be.

If you do not know what valve to adjust for flow control please ASK or READ ↓ THIS

FLOWS →

H & T	1.5 GPM
S & T	0.4 GPM
US filters	5.0 GPM
WRT	~~0.5 GPM~~ → 1.0 4-7-03 LB
Reiss	20 GPM 1st perm.

→ The Reiss unit has several other flows that can be adjusted. NRL or LB will adjust those. Operators just adjust 1st stage perm. flow using the blue handle HPP by-pass valve. 20 GPM

→ H & T flow is adjusted by Hose bib type gate valve at bottom of the unit. Look at plastic flow through type flow meter and adjust to 1.5 GPM

→ S & T flow valve is round knob at bottom left of unit Read digital flow meter on middle left of unit. 0.4 GPM

→ WRT flow valve is at bottom left of trailer by the white bucket, read digital flow meter at same location. 0.50 GPM

→ US filter flow control is by valve that is taped up with electrical tape, time flow meter on in flow to unit with a stop watch; should be 5.0 GPM

[redacted]

4-3-03 Weighed the decanted fluid from Back Washing the H&T unit 27 lbs LB

4-4-03 Charlie from WRT called and requested that we increase the flow on their unit to 1.0 GPM LB turned it up 2PM

4-5-3 Filled Iron Day tank H+T to 8 inch

4-6-3 Filled Cl_2 Day tank H+T to

4-6-03 Cl_2 STO2 Bisulfite = .15. Turned Bisulfite up T638 Reiss → From 60% to [redacted] Air Locked, Bisulfite Pump. Cl_2 = .02 NC

4-7-03 On the Reiss unit please record Hrs from Hrs meter on the control box.

4-7-03 When you sample the H&T unit from the effluent tap please shut off the little valve at the end of the tap so water doesn't drip on the floor all day! Thanks LB

Filled H&T Day Tanks. Cl_2 added 5 gal / FC added 5 gal still big difference between levels, looks like Cl_2 is Feeding at a higher rate AGAIN

4-8 - Filled H/T Cl_2 Day Tank
- Fixed Reiss Cl_2/Sodium Bisulphite feed lines so they stay below fluid level in tank.
- Cl_2 line still leaking, Hose from Pump Head to permeate line is too short.

4-8-3 BACKWASHED/FLUSHED HUNGERFORD + TERRY PILOT UNIT
Reset H2O flow to 1.5 gpm.

4-10-03 Filled Reiss Sodium Bisulfate day tank.

Plant Down @ 9:50pm
Due to Storm
+ Power Outages

4-11-03 Plant start-up ~~9:10 AM~~ 10:30 AM

Started Cleaning pump & opened all valves to Arsenic units & cleaning pump.
Unairlocked Cl2 pump for Reiss unit.

4/12 Added 18 gallons FC TO H+T Arsenic unit.

4/13 Filled H/T Cl2 tank with 5 gals.
4-13-03 FILLED H&T FERRIC CHLORIDE AND Cl2 WITH 5 GALS EACH
4-14-03 Started 3 trains w/ wells 1, 4, 5, 6, 9, 10
4-15-03 Filled Hungerford/Terry Cl2 tank,
RUNNING low on Ferric chloride
- Cl2 pump on Reiss airlocked AGAIN
- Running 3 trains 24 hrs
wells 1, 4, 5, 6, 9, 10
- Collected Samples + Sent to Huffman + GeoScience Frontier - Wells 1, 4, 5, 6, 9, 10

4-16-03 - ALL UNITS WERE FUNCTIONING NORMAL.
- REISS UNIT POST Cl2 WAS AIRLOCKED UNAIR LOCKED. NOW ADDING Cl2.

4-16 Backwash Hungerford & Terry unit for 15 min @ 4gpm ~~—~~ unit is ~~shut~~ down due low Iron chem, Iron chem been here FRIDAY

4-17-03 H+T OFF Line - waiting for Iron

Worked on leak on Riess unit NaCl feed (Replaced feed tube) But it still leaks.

4-20-03 Plant shut down @ 1:30pm - Float in Cleaning tank Blew-off - Trench Flooded

4-21-03 Start up Pilot Units @ 11:30 AM, Wells 2, 8

4-23-03 Replaced pump head on Raiss Unit (Sodium Hypo) ↩↪ Worked on discharge leak on same. Unit not pumping very well!

4-23-03 Filled Ferric Chloride day tank on H & T unit and started it back up

4-03 Shut down Reiss unit - Cl_2 pump will not pump Cl_2. LB called & the company is sending another pump.

4/25/03 7Am. Added 10 gallon H20/Bleach TO H+J. Added 10 gallon ferric clonde TO all

4/26 6Pm Added 10 gallon H20/Bleach TO H+J. WC

4/29 Cl_2 Pump on Reiss unit was installed today. New pump and new check valve.
- Still will not work correctly
- CP/ said that the guys in Ocracoke told him they had to cut the lead section with 30% H_2O to get pump to work. CP Also said A peristolic pump may prove better than the diaphragm type we are using.
- Cl_2 will not feed steady and still air locks often NO matter what you do!

4-30-03 - Diluted NaCl on Reiss unit with 50% water, also moved pump down on the ground so it has a Flooded suction via a siphon, Pump is pumping Much better now, however... if the siphon is broken then the pump quits pumping. Fill the ~~Ac Hypo~~ Cl2 tank with at least 50/50 water/ Cl2. We may even go with 75% water, 25% Cl2 this reduces air in the Cl2 solution, pump needs to run in the 60 to 80% range to get .5 Cl2 with diluted Cl2.

4-28-03 Added 10 gal. Bleach & 10 gal. Iron crap to H & T unit. EB

5-1-03 Added Sodium Hypochlorite & Sodium bisulfite to day tanks on Reiss unit.

5-3-3 Filled Day tanks on H/T Cl_2 to 1/2 Iron to 12
Reiss unit still not feeding Cl_2 correctly
- Reiss unit motor was cycling on and off today had to open valve All the way for motor to stay on.

5-4-3 Reiss unit will not feed Cl_2 more than A few minutes before it Airlocks pump. Serious design flaw present when the operator spends precious hours manipulating equipment to get results.

5-5-03 Reiss Unit Cl_2 pump CANNOT OVER come the BACK PSI. Worked on it until 10:45 am. Replaced pump with the ~~[illegible]~~ ORIGINAL pump and got Cl_2 up.

5-6-03 REISS UNIT Cl_2 check but AIR LOCKED. WATER ~~[illegible]~~ LOCKED. But soon GETS ~~[illegible]~~ LOCKED.

5-7-03 Topped off Sodium Hypochloride from 12.5 to 15.0 and Fill Sodium Bisulfite Tank From 4.5 to 15

5-8-03 Cl_2 pump Airlocks often, Un Airlocked it twice today

5-9-03 Backwashed H&T unit

5/10 10 gallon added to H&T Clz

5-13-03 Turned up psi switch (cut off) on Reiss Unit several times (at least 3) to attemp to keep flows at 20 gpm 1st stage perm, 3.6 GPM 2nd stage perm and 2.65 gpm Conc. flow.
Unable to achieve 20 & 3.6 GPM on Perm as of today 5-13-03

Any equipment that required the maintenance of the Reiss (Clz addition problem) or the H&T (Back wash & Chem. addition) will not be User friendly for NRO operations personel.

The WRT units, the Severn & Trent Unit & The US Filters Unit have required no maintenance, Back Wash or Chem. feed problems

5-15-03 Weighed H&T sludge after decanting 41-23 = (18) LB

Backwashed H&T unit ~~10~~ 14 min. at 4.5 GPM LB

ADDED 10 gal Clz SOLUTION - H&T unit

5-15-03 Increased Speed on H&T ferric feed to try to get it to feed also pumped to Atmosphere psi several times & in effort to get it to feed.

5-20-03 Fred filled Ferric tank on H&T unit.

5-20-03 Filled Sodium Bisulfite tank on Reiss unit.

5-21-03 Weighed sludge on H&T unit 32 - 23 = 9 lbs.

From: "Ian C. Watson, PE" <waterpro@msn.com>
To: "Robert Oreskovich" <BobO@darenc.com>; "Pat Irwin" <pati@darenc.com>; "Nancy Loomis" <nancyl@co.dare.nc.us>
Sent: Tuesday, May 20, 2003 9:52 AM
Subject: Arsenic!

Now that the test has been running for two months, I would like to discontinue the ferric feed to the H&T system, but maintain the hypochlorite feed to convert 111 to V. Nancy, you probably should talk to the guy who set it up to make sure that you have the hypo dose right. Santa Rosa is great. Cheers, Ian.

5-22-03 Back washed H&T unit
Weighed previous sludge

Started H&T back up with Cl2 feed only
Added Cl2 at the new mix ratio of 227ml. Bleach/10gal. H2O

5-26 Full Cl2 10gal H&T

5-27-03 End of Pilot Study

720
1440
2160
2880
12,930

APPENDIX E

OPERATING DATA LOGS

Hungerford & Terry Arsenic Removal Pilot Unit (Raw Water)																	
Date	Time On	Time Off	Operators Initials	Total Hours Operated Previous Day	Meter Reading	Flow (gpm)	Chemical Feed Pumps On or Off	Pressure Influent	Pressure Effluent	Delta P	Influent Arsenic	Influent Iron	Effluent Arsenic	Effluent Iron	Effluent Free Chlorine	Production Wells In Service
3/20/2003			PS/LB	N/A	225	1.5	On	51	50	1	40	2.37	4	0	0.15	2,3,6
3/21/2003			PS/LB	N/A	280	1.2	On	51	50	1	40	2.94	4	0.01	0.3	2,3,6
3/22/2003	8:40 AM	7 PM	MW/LB	10.3	342	1.2	On	51	49	1	50	2.98	20	0.803	1.04	2,3,6
3/23/2003	8:00 AM	Allnight	PS	24	443	1	On	51	49	2	40	2.52	14	0.576	0.64	2,3,6
3/24/2003	7:20 AM	6:45 PM	MW	24	487	1.1	On	51	48	3	40	2.59	20	0.632	0.79	2,3,6
3/25/2003	7:00 AM	9 PM	MW	24	566	1.2	On	51	47	4	40	3.09	21	1.254	0.21	2,3,7
3/26/2003	7:30 AM	6:45 PM	AB	24	669	1.2	On	50.5	45	5	40	1.805	2	0.608	0.25	3,10
3/27/2003	1:40 AM	Allnight	LB	24	789	1	On	47	41	6	50	2.179	2	0.704	0.47	3,10
3/28/2003	7:40 AM	Allnight	FL	24	916	1.2	On	47	40	7	14	4.65	14	1.29	0.35	3,10
3/29/2003	7:00 AM	Allnight	NC/PS	24	1046	1.2	On	49	48	1	14	4.38	8	0.113	3.6	3,10
3/30/2003	6:30 AM	Allnight	DH/PS	24	1124	1.3	On	49	49	0	20	4.72	10	0.04	6.2	3,10
3/30/2003	8:00 AM	Allnight	MW/DH	24	1192	1	On	50	49	1	20	4.59	2	0.126	6.1	3,10
4/1/2003	8:00 AM	Allnight	AB/MW	24	1259	1.2	On	47	45	2	20	3.87	2	0.191	0.19	3,10
4/2/03	8:00 AM	Allnight	Ab	24	1322	0.4	On	47	45	2	20	2.96	2	2.96	0.1	3,10
4/3/2003	8:00 AM	Allnight	FL	24	1394	1.5	On	47	40	6	20	2.89	2	1.8	0.13	8,10
4/4/2003	8:00 AM	Allnight	AB	24	1531	1.5	On	49	39	10	20	3.02	2	2.215	0.15	7,9
4/5/2003	8:00 AM	Allnight	DH/PS	24	1685	1.6	On	45	35	10	20	3.01	2	0.564	0.16	7,9
4/6/2003	8:00 AM	Allnight	DH/PS	24	1824	1.2	On	50	38	12	20	1.275	2	0.683	1.4	7,9
4/7/2003	8:00 AM	Allnight	MW/DH	24	1962	1	On	50	36	14	20	1.65	4	0.17	0.65	7,9
4/8/2003	7:30 AM	Allnight	AB	24	2075	0.9	On	50	34	16	60	1.285	40	10.1	0.3	7,9
4/9/2003	9:00 AM	Allnight	AB	24	2250	1	On	48	47	1	20	2.87	4	0.314	0.39	6,9
4/10/2003	7:45 AM	Allnight	AB	24	2470	1.2	On	48	45	2	20	2.563	4	1.476	0.31	6,9
4/11/2003	6:00 PM	Allnight	AB	24	2490	1.2	On	48	45	2	20	3.21	2	2.01	0.37	3,10
4/12/2003	8:00 AM	Allnight	NC/PS	24	2603	1.2	On	49	44	5	20	1.68	10	5.12	0.22	3,10
4/13/2003	7:30 AM	Allnight	DH/PS	24	2743	1.2	On	48	43	5	60	1.94	20	0.392	0.4	3,10
4/14/2003	8:00 AM	Allnight	CP/MW/DH	24	2890	1.2	On	48	41	7	30	2.55	10	9	0.31	3,10
4/15/2003	8:00 AM	Allnight	AB	24	3141	1.1	On	43	34	9	40	3.778	10	0.381	0.29	1,4,5,6,9,10
4/16/2003			Backwashed	OFF LINE												
4/17/2003																
4/18/2003																
4/19/2003																
4/20/2003																
4/21/2003																
4/22/2003																
4/23/2003																
4/24/2003	8:00 AM		AB		3239	1.1	On	37	37.5	0.5	14	3.75	2	0.205	0.87	2,8
4/25/2003	8:00 AM	Allnight	AB	24	3301	1.1	On	34	32	2	40	0.206	0	3.59	0.86	2,8
4/26/2003	8:00 AM	Allnight	NC	24	3355	1.1	On	40	38	2	30	0.072	0	3.75	0.39	2,4
4/27/2003	9:00 AM	Allnight	DH	24	3404	1.1	On	51	46	5.3	30	0.107	0	4.2	0.41	2,4
4/28/2003	9:00 AM	Allnight	DH	24	3467	1.1	On	52	46	6	40	0.383	0	3.16	0.59	1,2,4
4/29/2003	8:00 AM	Allnight	MW	24	3538	1	On	52	42	10	30	2.19	2	0.335	0.51	1,2,3,4,7,8,9,10
4/30/2003	8:00 AM	Allnight	AB	24	3606	1	On	48	36	12	30	6.11	2	0.686	0.32	1,2,4,7,8,9,10
5/1/2003	10:30 AM	Allnight	CP	24	3676	1	On	48	35	13	40	6.34	4	0.659	0.3	1,2,4,7,8,9,10
5/2/2003	8:00 PM	Allnight	AB	24	3759	1	On	48	34	14	30	6.52	2	0.653	0.25	1,2,4,7,8,9,10
5/3/2003	7:50 AM	Allnight	PS	24	3785	1.2	On	48	32	16+	40	0.236	2	0.809	0.31	2,10
5/4/2003	8:00 AM	Allnight	DH	24	3850.	1.1	On	48	36	12	30	0.036	0	0.642	0.3	2,10
5/5/2003	8:00 AM	Allnight	DH	24	3929	1.1	On	46	32	14	16	0.032	0	0.69	0.3	2,10
5/6/2003	8:00 AM	Allnight	AB	24	3986	1.1	On	46	27	20	12	0.101	0	7.55	0.33	2,10
5/7/2003	9:00 AM	Allnight	AB	24	4058	1.1	on	49	26	23	12	1.85	2	0.053	0.17	2,10
5/8/2003	9:30 AM	3:40 AM	CP	17.8	4120	1.1	On	48	23	25	12	1.952	4	0.552	0.25	3,7,8,9
5/9/2003	8:00 AM		NC	24	4176	1.1	On	42	25	16	40	2.3	4	0.69	0.14	3,7
5/10/2003	8:00 AM	Allnight	PS	24	4308	0.9	On	46	42	4	50	2.01	10	0.701	0.49	1,3,4,5,7,8,,9
5/11/2003	8:00 AM	Allnight	DH	24	4458	1	On	46	41	5	30	0.894	4	0.238	0.32	1,3,4,5,7,8,9
5/12/2003	8:00 AM	Allnight	MW/DH	24	4588	1	On	41	30	3	30	1.046	8	1.016	0.35	1,3,4,5,7,8,9
5/13/2003	8:00 AM	Allnight	MW	24	4760	1.1	On	41	7	7	30	1.085	20	0.999	0.31	7,9,1
5/14/2003	8:00 AM	Allnight	AB	24	4861	1.1	On	47	38	9	20	1.028	2	0.657	0.32	4,9
5/15/2003	8:00 AM	Allnight	FL	24	4960	1	On	42	32	10	20	0.835	16	0.082	0.34	4,5,6,8,9,10
5/16/2003	8:00 AM	Allnight	FL	24	5081	1.1	On	41	40	1	16	2.87	0	0.84	0.41	4,5,6,8,9,10
5/17/2003	8:00 AM	Allnight	NC	24	5194	1.1	On	40	39	1	55	2.8	0	0.91	0.41	4,5,6,8,9,10
5/18/2003	8:00 AM	Allnight	NC	24	5297	1.1	On	40	35	5	40	1.16	20	0.86	0.42	4,5,6,8,9,10
5/19/2003	8:30 AM	Allnight	PS/CP	24	5378	1	On	40	36	4	40	1.82	8	0.903	0.48	4,5,6,8,9,10
5/20/2003	9:00 PM	Allnight	FL	24	5525	1.1	On	40	29	11	20	2.27	0	0.76	0.31	4,5,6,8,9,10
5/21/2003	6:00 PM	Allnight	DH	24	5704	1.1	On	43	33	10	18	1.15	0	0.8	0.59	4,5,6,8,9,10
5/22/2003	7:00 PM	Allnight	DH	24	5841	1	On	42	42	0	16	1.17	0	0.109	0.22	1,4,5,6,9,10
5/23/2003	9:00 AM	Allnight	MW	24	5916	1	On	42	42	0	12	5.14	0	0.086	0.2	1,4,5,6,9,10
5/24/2003	9:00 AM	Allnight	AB	24	6041	1	On	43	42	1	12	5.51	0	0.096	0.3	1,4,5,6,9,10
5/25/2003	9:00 AM	Allnight	NC	24	6156	1	On	42	42	0	45	4.3	0	0.036	0.29	1,4,5,69,10
5/26/2003	10:00 AM	Allnight	PS	24	6285	1	On	43	42	1	30	3.92	0	0.047	0.37	1,4,5,6,9,10
5/27/2003	8:30 AM	Allnight	DH	24	6401	1	On	42	41	1	20		2	0.082	0.012	1,4,5,6,9,10

WRT Arsenic Removal Pilot Unit (Permeate Water)																		
Date	Time	Time	Operators Initials	Total Hours Operated	Meter Reading	Flow (gpm)	Effluent	Effluent	Effluent	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Arsenic	Production Wells	
	On	Off		Previous Day			Arsenic	Turbidity	Iron	Col. 12	Col. 10	Col. 8	Col. 6	Col. 4	Col. 2	Feed	In Service	
3/20/2003	1:35 PM		PS/LB		53	0.5	0	0.22		0	0	0	0	0	2	20	2,3,6	
3/21/2003	1:15 PM	6:50 PM	PS/NC		82	0.49	0	0.07	0.084	0	0	1	2	4	4	20	2,3,6	
3/22/2003	8:50 AM	7 PM	MW	5.5	98	0.49	0	0.2	0.074	0	0	1	1	1	2	20	2,3,6	
3/23/2003	8:00 AM	6:45 PM	PS	10	143	0.52	0	0.06	0.073	0	0	0	0	1	1	20	2,3,6	
3/24/2003	7:20 AM	6:45 PM	MW	10.75	162	0.51	0	0.2	0.093	0	0	0	0	1	1	20	2,3,6	
3/25/2003	7:00 AM	9 PM	MW	11.5	198	0.52	0	0.17	0.14	0	0	0	0	0	1	16	2,3,7	
3/26/2003	7:30 AM	6:45 PM	AB	14	239	0.53	0	0.14	0.118	0	0	0	0	0	0	16	3,10	
3/27/2003	1:40 PM	Allnight	LB	11.25	280	0.525	0	0.13	0.025	0	0	1	1	1	1	8	3,10	
3/28/2003	7:40 AM	Allnight	FL	10.5	331	0.52	0	1.25	0.251	1	1	1	1	1	1	20	3,10	
3/29/2003	7:00 AM	Allnight	NC/PS	24	400	0.5	0	1.53	0.334	0	0	0	0	0	0	16	3,10	
3/30/2003	6:30 AM	Allnight	DH/PS	24	465	0.48	0	1.72	0.425	0	0	0	0	0	0	16	3,10	
3/31/2003	8:00 AM	Allnight	MW/DH	24	535	0.51	0	2.23	0.595	0	0	0	0	0	0	10	3,10	
4/1/2003	8:00 AM	Allnight	AB/MW	24	606	0.5	0	1.91	0.555	0	0	0	0	0	0	10	3,10	
4/2/2003	8:00 AM	Allnight	AB	24	673	0.5	0	1.83	0.621	0	0	0	0	0	0	12	3,10	
4/3/2003	10:30 AM	Allnight	FL	24	750	0.5	0	1.71	0.564	0	0	0	0	0	0	16	8,10	
4/4/2003	7:10 AM	Allnight	AB	24	811	0.49	0	1.8	0.59	0	0	0	0	0	0	16	7,9	
4/5/2003	8:00 AM	Allnight	NC/PS	24	927	0.937	0	0.51	0.02	0	0	0	0	0	0	14	7,9	
4/6/03	8:00 AM	Allnight	DH/PS	24	1050	0.894	0	0.53	0.123	0	0	0	0	0	1	14	7,9	
4/7/2003	8:00 AM	Allnight	MW/DH	24	1178	0.877	0	0.74	0.039	0	0	0	0	0	0	8	7,9	
4/8/2003	7:30 AM	Allnight	MW	24	1310	0.517	0	0.14	0.012	0	0	0	0	1	1	12	7,9	
4/9/2003	9:00 AM	Allnight	AB	24	1440	0.898	0	0.12	0.012	0	0	0	0	1	0	12	6,9	
4/10/2003	7:45 AM	Allnight	AB/CP	24	1560	0.869	0	0.14	0.012	0	0	0	0	0	0	12	6,9	
4/11/2003	6:00 PM	Allnight	AB	24	1607	0.968	0	0.1	0.013	0	0	0	0	0	0	14	3,10	
4/12/2003	8:00 AM	Allnight	NC/PS	24	1688	0.933	0	0.14	0.011	0	0	0	0	0	0	12	3,10	
4/13/2003	7:30 AM	Allnight	DH/PS	24	1818	0.906	0	0.19	0.004	0	0	0	0	0	0	14	3,10	
4/14/2003	8:00 AM	Allnight	CP/DH/MW	24	1938	1	0	0.15	0.007	0	0	0	0	0	0	14	3,10	
4/15/2003	8:00 AM	Allnight	MW	24	2078	1	0	0.11	0.001	0	0	0	0	0	0	16	1,4,5,6,9,10	
4/16/2003	8:00 AM	Allnight	AB	24	2219	0.968	0	0.12	0.015	0	0	0	0	0	0	10	1,4,5,6,9,10	
4/17/2003	8:00 AM	Allnight	FL	24	2350	0.98	0	0.12	0.009	0	0	0	0	0	0	10	1,5,6,7,9,10	
4/18/2003	8:15 AM	Allnight	FL	24	2485	0.877	0	0.12	0.004	0	0	0	0	0	0	10	1,5,6,7,9,10	
4/19/2003	9:00 AM	Allnight	NC	24	2631	0.96	0	0.13	0.001	0	0	0	0	0	0			
4/20/2003	Plant Shutdown																	
4/21/2003	11:00 AM	Allnight	CP/DH/MW	2.6	2786	1	0	0.21	0	0	0	0	0	0	0	14	2,8	
4/22/2003	7:30 AM	Allnight	AB	24	2887	0.941	0	0.07	0.01	0	0	0	0	0	0	12	2,8	
4/23/2003	8:30 AM	Allnight	AB	24	3026	0.98	0	0.08	0.015	0	0	0	0	0	0	12	2,8	
4/24/2003	8:00 AM	Allnight	AB	24	3153	1	0	0.08	0.02	0	0	0	0	0	2	14	2,8	
4/25/2003	8:00 AM	Allnight	AB	24	3291	1	0	0.21	0.02	0	0	0	0	0	4	16	2,8	
4/26/2003	8:00 AM	Allnight	NC/PS	24	3428	0.98	0	0.02	0.02	0	0	0	0	0	4	16	2,4	
4/27/2003	9:00 AM	Allnight	DH/PS	24	3567	0.95	0	0	0.021	0	0	0	0	0	4	14	2,4	
4/28/2003	8:00 AM	Allnight	DH/PS	24	3691	0.99	0	0	0.009	0	0	0	0	0	4	14	1,2,4	
4/29/2003	8:00 AM	Allnight	MW	24	3839	1.007	0	0.06	0.001	0	0	0	0	0	0	16	1,2,6,7,8,9,10	
4/30/2003	8:00 AM	Allnight	AB	24	3971	0.964	0	0.02	0.018	0	0	0	0	0	0	14	1,2,4,7,8,9,10	
5/1/2003	10:30 AM	Allnight	CP	24	4120	1	0	0.07	0.03	0	0	0	0	0	0	14	1,2,4,7,8,9,10	
5/2/2003	8:00 AM	Allnight	AB	24	4316	1	0	0.08	0.022	0	0	0	0	0	0	14	1,2,4,7,8,9,10	
5/3/2003	8:00 AM	Allnight	FL	24	4386	1	0	0.11	0.018	0	0	0	0	0	0	14	2,10	
5/4/2003	8:00 AM	Allnight	DH/PS	24	4452	1	0	0.1	0.011	0	0	0	0	0	0	14	2,10	
5/5/2003	8:00 AM	Allnight	DH/PS	24	4660	1.2	0	0.07	0.032	0	0	0	0	0	0	12	2,10	
5/6/2003	8:00 AM	Allnight	AB	24	4801	0.923	0	0.09	0.001	0	0	0	0	0	0	10	2,10	
5/7/2003	9:00 AM	Allnight	AB	24	4942	0.935	0	0.01	0.008	0	0	0	0	0	0	10	2,10	
5/8/2003	9:30 AM	3:40AM	CP	17.8	5056	0.941	0	0.06	0.007	0	0	0	0	0	0	10	3,7,8,9	
5/9/2003	8:00 AM		NC	24	5176	0.908	0	0.06	0.009	0	0	0	0	0	0	25	3,7	
5/10/2003	8:00 AM	Allnight	PS	24	5530	0.901	0	0.08	0.007	0	0	0	0	0	0	16	1,3,4,5,7,8,9	
5/11/2003	8:00 AM	Allnight	DH/PS	24	5437	0.898	0	0.13	0.013	0	0	0	0	0	0	10	1,3,4,5,7,8,9	
5/12/2003	8:00 AM	Allnight	MW/DH	24	5559	0.905	0	0.11	0.02	0	0	0	0	0	1	12	1,3,4,5,7,8,9	
5/13/2003	8:00 AM	Allnight	MW	24	5728	0.964	0	0.09	0.017	0	0	0	0	0	0	12	1,3,4,5,7,8,9	
5/14/2003	8:00 AM	Allnight	AB	24	5841	1.07	0	0.03	0.1	0	0	0	0	0	0	14	4,9	
5/15/2003	8:00 AM	Allnight	FL	24	5970	0.93	0	0.01	0.008	0	0	0	0	0	0	10	4,5,6,7,9,10	
5/16/2003	8:00 AM	Allnight	FL	24	6118	0.96	0	0.09	0.011	0	0	0	0	0	0	12	4,5,6,8,9,10	
5/17/2003	8:00 AM	Allnight	NC	24	6276	0.96	0	0.09	0.01	0	0	0	0	0	1	16	4,5,6,8,9,10	
5/18/2003	10:00 AM	Allnight	NC	24	6436	0.96	0	0.06	0.02	0	0	0	0	0	1	16	4,5,6,8,910	
5/19/2003	8:30 AM	Allnight	CP/PS	24	6576	1.06	0	0.05	0.008	0	0	0	0	0	0	10	4,5,6,8,9,10	
5/20/2003	9:00 AM	Allnight	FL	24	6759	0.96	0	0.11	0.011	0	0	0	0	0	1	14	4,5,6,8,9,10	
5/21/03	6:00 PM	Allnight	DH/PS	24	6922	1.05	0	0.08	0.006	0	0	0	0	0	0	12	4,6,5,8,9,10	
5/22/2003	7:00 PM	Allnight	DH/PS	24	7072	1.048	0	0.06	0.008	0	0	0	0	0	0	8	1,4,5,6,9,10	
5/23/2003	9:00 AM	Allnight	AB	24	7163	1.041	0	0.07	0.029	0	0	0	0	0	0	12	4,5,6,8,9,10	
5/24/2003	9:00 AM	Allnight	AB	24	7313	1.037	0	0.1	0.031	0	0	0	0	0	0	12	4,5,6,8,9,10	
5/25/2003	9:00 AM	Allnight	NC	24	7453	1.03	0	0.098	0.009	0	0	0	0	0	0	20	1,4,5,6,9,10	
5/26/2003	10:00 AM	Allnight	PS	24	7608	1.026	0	0.04	0.013	0	0	0	0	0	0	20	1,4,5,6,9,10	
5/27/2003	8:30 AM	Allnight	DH/PS	24	7746	1.29	0	0.05	0.037	0	0	0	0	0	0	16	1,4,5,6,9,10	
					7693													

Severn Trent Arsenic Removal Pilot Unit (Permeate Water)													
Date	Time On	Time Off	Operators Initials	Total Hours Operated Previous Day	Meter Reading	Flow (gpm)	Influent Pressure (Header)	Effluent Pressure (Unit Back PSI 10-15psi)	Delta P	Influent Arsenic	Effluent Arsenic	Effluent Iron	Production Wells In Service
3/20/03	1:15 PM		LB/PS		30	0.4	75	11	0.75	20	2		2,3,6
3/21/2003	11:20 AM	6:50 AM	PS		48	0.39	75	12	1	20	2	0	2,3,6
3/22/2003	8:40 AM	7 PM	MW/Lb	7.5	64	0.38	75	12	0.5	20	1	0.012	2,3,6
3/23/2003	7:00 PM	7 PM	PS	10.3	96	0.42	75	14	0.75	20	1	0.025	2,3,6
3/24/2003	7:20 AM	6:45 PM	MW	12	111	0.4	75	13	0.5	20	0	0.022	2,3,6
3/25/2003	7:00 AM	9 PM	MW	11.5	137	0.41	75	14	0.5	16	0	0.013	2,3,7
3/26/2003	7:30 AM	6:45 PM	LB	14	169	0.4	75	14	0.5	16	0	0.01	3,10
3/27/2003	1:30 PM	Allnight	LB	11.25	202	0.42	70	12	0.5	8	1	0.015	3,10
3/28/2003	7:40 AM	Allnight	FL	10.5	243	0.4	70	12	0.5	14	1	0.015	3,10
3/29/2003	7:00 AM	Allnight	NC/PS	24	299	0.41	70	11	0.5	16	0	0	3,10
3/30/2003	6:30 AM	Allnight	DH/PS	24	354	0.37	70	11	0.3	16	0	0	3,10
3/31/2003	8:00 AM	Allnight	MW/DH	24	415	0.41	70	11	0.3	10	0	0.015	3,10
4/1/2003	8:00 AM	Allnight	AB/MW	24	473	0.43	70	11	0.3	10	0	0.005	3,10
4/2/03	8:00 AM	Allnight	AB/MW	24	528	0.42	70	11	0.3	10	0	0.005	3,10
4/3/2003	10:30 AM	Allnight	FL	24	595	0.43	70	11	0.3	16	2	0.022	8,10
4/4/2003	7:00 AM	Allnight	AB/MW	24	641	0.41	70	11	0.3	16	0	0.013	7,9
4/5/2003	8:00 AM	Allnight	NC/PS	24	697	0.39	70	11	0.3	14	0	0.002	7,9
4/6/2003	8:00 AM	Allnight	DH/PS	24	753	0.41	70	11	0.3	14	0	0.008	7,9
4/7/2003	8:00AM	Allnight	MW/DH	24	803	0.4	70	11	0.3	8	0	0.024	7,9
4/8/2003	7:30 AM	Allnight	MW	24	854	0.39	70	11	1	12	2	0.005	7,9
4/9/2003	9:00 AM	Allnight	AB/MW	24	914	0.41	70	11	1	12	0	0.01	6,9
4/10/2003	7:45 AM	Allnight	AB/CP	24	966	0.41	70	11	0.4	10	0	0.007	6,9
4/11/2003	6:00 PM	Allnight	AB	24	977	0.41	70	11	0.4	12	0	0.002	3,10
4/12/2003	8:00 AM	Allnight	NC/PS	24	1023	0.39	70	10	0.75	12	2	0.005	3,10
4/13/2003	7:30 AM	Allnight	DH/PS	24	1061	0.46	70	11	0.75	14	2	0	3,10
4/14/2003	8:00 AM	Allnight	CP/MW/DH	24	1113	0.39	70	11	0.75	12	2	0.001	3,10
4/15/2003	8:00 AM	Allnight	MW	24	1166	0.39	70	10	1	16	0	0.011	1,4,5,6,9,10
4/16/2003	8:00 AM	Allnight	AB	24	1221	0.41	70	11	1	12	0	0.002	1,4,5,6,9,10
4/17/2003	7:45 AM	Allnight	FL	24	1276	0.41	70	11	1	10	0	0	1,5,6,7,9,10
4/18/2003	8:30 AM	Allnight	FL	24	1328	0.4	70	11	0.75	10	0	0.002	1,5,6,7,9,10
4/19/2003	9:00 AM	Allnight	NC	24	1385	0.39	70	11	1	11	1	0.001	1,5,6,7,9,10
4/20/2003	Plant Shutdown												
4/21/2003	11:00 AM	Allnight	CP/MW/DH		1447	0.4	65	11	2	20	0	0	2,8
4/22/2003	7:30 AM	Allnight	AB	24	1486	0.4	65	11	2	12	0	0.015	2,8
4/23/2003	8:30 AM	Allnight	AB	24	1542	0.41	65	11	2	12	0	0.013	2,8
4/24/2003	8:00 AM	Allnight	AB	24	1589	0.38	65	11	2	14	0	0.016	2,8
4/25/2003	8:00 AM	Allnight	AB	24	1640	0.41	65	10	1	16	0	0.022	2,8
4/26/2003	8:00 AM	Allnight	NC	24	1690	0.37	70	10	0.75	16	0	0.021	2,4
4/27/2003	8:00 AM	Allnight	DH/PS	24	1741	0.4	70	10	0.75	14	0	0.013	2,4
4/28/2003	8:00 AM	Allnight	CP/MW/DH	24	1786	0.36	70	10	0.75	14	0	0.004	1,2,4
4/29/2003	8:00 AM	Allnight	MW	24	1838	0.39	70	12	0.75	16	0	0.014	1,2,3,4,7,8,9,10
4/30/2003	8:00 AM	Allnight	AB	24	1894	0.41	70	12	0.75	14	0	0.021	1,2,4,7,8,9,10
5/1/2003	10:30 AM	Allnight	CP	24	1956	0.42	70	12	0.75	14	0	0	1,2,4,7,8,9,10
5/2/2003	8:00 PM	Allnight	AB	24	2036	0.42	70	12	0.75	16	0	0.01	1,2,4,7,8,9,10
5/3/2003	8:00 AM	Allnight	ps	24	2063	0.42	70	14	0.75	16	0	0.005	2,10
5/4/2003	8:00 AM	Allnight	DH/PS	24	2121	0.4	70	14	0.5	14	0	0.009	2,10
5/5/2003	8:00 AM	Allnight	DH/PS	24	2175	0.4	70	14	0.4	12	0	0.007	2,10
5/6/2003	8:00 AM	Allnight	AB	24	2231	0.42	70	12	0.4	12	0	0.007	2,10
5/7/2003	9:00 AM	Allnight	AB	24	2298	0.46	70	12	0.41	10	0	0.008	2,10
5/8/2003	9:30 AM	3.40 AM	CP	17.8	2351	0.47	70	12	0.5	12	0	0.009	3,7,8,9
5/9/2003	8:00 AM		NC	24	2414	0.47	70	12	0.5	20	0	0.009	3,7
5/10/2003	8:00 AM	Allnight	PS	24	2481	0.47	70	12	0.25	16	1	0.008	1,3,4,5,7,8,9
5/11/2003	8:00 AM	Allnight	DH/PS	24	2567	0.47	70	12	0.3	16	0	0.006	1,3,4,5,7,8,9
5/12/2003	12:00 AM	Allnight	MW	24	2610	0.47	70	11	0.7	12	0	0.003	1,3,,4,5,7,8,9
5/13/2003	12:30 PM	Allnight	MW	24	2696	0.45	70	11	0.75	12	0	0.046	3,7,9
5/14/2003	8:00 AM	Allnight	AB	24	2735	0.45	70	11	0.75	12	0	0.039	4,9
5/15/2003	8:00 AM	Allnight	FL	24	2789	0.47	70	11	0.75	10	0	0.021	4,5,6,8,9,10
5/16/2003	8:00 AM	Allnight	FL	24	2852	0.45	70	11	0.75	12	0	0.004	4,5,6,8,9,10
5/17/2003	9:00 AM	Allnight	NC	24	2920	0.45	65	11	0.75	16	0	0.004	4,5,6,8,9,10
5/18/2003	10:00 AM	Allnight	NC	24	2987	0.47	70	11	1	16	0	0.002	4,5,6,8,9,10
5/19/2003	8:30 AM	Allnight	PS/CP	24	3043	0.46	70	12	1	10	0	0.005	4,5,6,8,9,10
5/20/2003	9:00 PM	Allnight	FL	24	3109	0.44	70	12	1	16	0	0.0003	4,5,6,8,9,10
5/21/2003	6:00 PM	Allnight	DH/PS	24	3191	0.48	70	12	1	12	0	0.002	4,5,6,8,9,10
5/22/2003	7:00 PM	Allnight	DH/PS	24	3254	0.48	70	12	1	12	0	0.001	4,5,6,8,9,10
5/23/2003	9:00 AM	Allnight	AB	24	3292	0.45	70	12	1	12	0	0.002	4,5,6,8,9,10
5/24/2003	9:00 AM	Allnight	AB	24	3355	0.45	70	12	1	12	0	0.002	1,4,5,6,9,10
5/25/2003	9:00 AM	Allnight	NC	24	3443	0.45	70	12	1	20	0	0.002	1,4,5,6,9,10
5/26/2003	10:00 AM	Allnight	PS	24	3478	0.46	70	11	0.75	20	0	0.003	1,4,5,6,9,10
5/27/2003	8:30 AM	Allnight	DH/PS	24	3536	0.45	70	11	1	18	0	0.014	1,4,5,6,9,10
					3506								

US Filter Arsenic Removal Pilot Unit (Permeate Water)

Date	Time On	Time Off	Operators Initials	Total Hours Operated Previous Day	Meter Reading	Flow (gpm)	Influent Pressure	Effluent Pressure	Influent Arsenic	Effluent Arsenic	Effluent iron	Production Wells In Service
3/20/2003	1:30 AM		LB/PS		366	4.2	68	66	20	1		2,3,6
3/21/2003	11:20 AM	6:50 AM	PS		570	4.5	68	66	20	1	0	2,3,6
3/22/2003	8:40 AM	7 PM	MW/LB	7.2	770	4.2	67	66	20	1	0	2,3,6
3/23/2003	8:00 AM	6:45 PM	PS	10.3	1144	4.0	68	66	20	1	0	2,3,6
3/24/2003	7:20 AM	6:45 PM	MW	10.75	1303	4.1	68	66	20	0	0.018	2,3,6
3/25/2003	7:00 AM	9 PM	MW	11.5	1603	4.0	68	65	16	0	0.014	2,3,7
3/26/2003	7:30 AM	6:45 PM	AB	14	1953	4.0	68	66	16	0	0.025	3,10
3/27/2003	1:40 PM	Allnight	LB	11.25	2306	4.3	65	63	8	1	0.019	3,10
3/28/2003	7:40 AM	Allnight	FL	24	2806	4.4	65	63	16	1	0.019	3,10
3/29/2003	7:00 AM	Allnight	NC/PS	24	3487	3.5	64	63	16	0	0.023	3,10
3/30/2003	6:30 AM	Allnight	DH/PS	24	4141	3.9	64	63	16	0	0.021	3,10
3/31/2003	8:00 AM	Allnight	MW/DH	24	4864	4.1	66	64	10	0	0.007	3,10
4/1/2003	8:00 AM	Allnight	AB/MW	24	5559	4.1	68	66	10	0	0.005	3,10
4/2/03	8:00 AM	Allnight	AB	24	6208	4.1	68	66	10	0	0.004	3,10
4/3/2003	10:30 AM	Allnight	FL	24	6902	5.2	64	62	16	0	0.13	8,10
4/4/2003	7:00 AM	Allnight	AB	24	7570	5.0	64	62	16	0	0.056	7,9
4/5/2003	8:00 AM	Allnight	DH/PS	24	8275	5.0	64	64	14	0	0.003	7,9
4/6/2003	8:00 AM	Allnight	DH/PS	24	8999	5.0	64	64	12	0	0.012	7,9
4/7/2003	8:00 AM	Allnight	MW/DH	24	9625	4.5	64	63	8	0	0.008	7,9
4/8/2003	7:30 AM	Allnight	AB	24	10292	4.8	64	63	12	0	0.013	7,9
4/9/2003	9:00 AM	Allnight	AB	24	11024	4.8	68	66	12	0	0.009	6,9
4/10/2003	7:45 AM	Allnight	AB	24	11666	4.8	65	63	14	0	0.02	6,9
4/11/2003	6:00 PM	Allnight	AB	24	11935	4.8	65	63	12	0	0.01	10,3
4/12/2003	8:00 AM	Allnight	NC/PS	24	12407	4.8	65	63	12	0	0.02	10,3
4/13/2003	8:00 AM	Allnight	DH/PS	24	13020	4.8	65	63	14	0	0.025	10,3
4/14/2003	8:00 AM	Allnight	CP/MW/DH	24	13689	4.5	68	64	10	0	0.028	10,3
4/15/2003	8:00 AM	Allnight	MW	24	14377	4.4	65	62	12	0	0.017	1,4,5,6,9,10
4/16/2003	8:00 AM	Allnight	AB	24	15068	4.4	65	63	14	0	0.005	1,4,5,6,9,10
4/17/2003	7:45 AM	Allnight	FL	24	15742	4.6	64	63	10	0	0.018	1,5,6,7,9,10
4/18/2003	9:00 AM	Allnight	NC	24	17135	4.5	65	64	16	0	0.12	1,5,6,7,9,10
4/19/2003	9:00 AM	Allnight	NC	24	17135	4.5	65	64	16	0	0.12	1,5,6,7,9,10
4/20/2003	Plant Shutdown											
4/21/2003	11:00 AM	Allnight	CP/MW/DH	2.8	17135	4.5	64	63	12	0	0.08	2,8
4/22/2003	7:30 AM	Allnight	AB	24	18440	4.5	64	63	12	0	0.03	2,8
4/23/2003	8:30 AM	Allnight	Ab	24	19138	4.5	64	63	12	0	0.08	2,8
4/24/2003	8:00 AM	Allnight	AB	24	19757	4.5	65	63	14	0	0.04	2,8
4/25/2003	8:00 AM	Allnight	AB	24	20442	4.5	67	65	16	0	0.04	2,8
4/26/2003	8:00 AM	Allnight	NC	24	21138	4.5	68	66	16	0	0.05	2,4
4/27/2003	9:00 AM	Allnight	DH/PS	24	21867	4.5	68	66	14	0	0.03	2,4
4/28/2003	8:00 AM	Allnight	CP/MW/DH	24	22526	4.5	68	66	16	0	0.04	1,2,4
4/29/2003	8:00 AM	Allnight	MW	24	23242	4.3	67	65	16	0	0.022	1,2,3,4,7,8,9,10
4/30/2003	8:00 AM	Allnight	AB	24	23930	4.5	65	63	14	0	0.023	1,2,4,7,8,9,10
5/1/2003	10:30 AM	Allnight	CP	24	24687	4.7	66	64	16	0	0.03	1,2,4,7,8,9,10
5/2/2003	8:00 PM	Allnight	AB	24	25655	4.5	64	62	14	0	0.021	1,2,4,7,8,9,10
5/3/2003	8:00 AM	Allnight	FL	24	25976	4.5	65	64	16	0	0.024	2,10
5/4/2003	8:00 AM	Allnight	DH/PS	24	26994	4.5	68	64	16	0	0.01	2,10
5/5/2003	8:00 AM	Allnight	DH/PS	24	27652	4.5	68	64	12	0	0.1	2,10
5/6/2003	8:00 AM	Allnight	AB	24	28020	4.5	64	62	12	0	0.02	2,10
5/7/2003	9:00 AM	Allnight	AB	24	28742	4.5	64	62	10	0	0.024	2,10
5/8/2003	9:30 AM	3:40 AM	CP	17.8	29337	4.5	64	62	10	0	0.019	3,7,8,9
5/9/2003	8:00 AM	Allnight	NC	24	29956	4.5	65	62	20	0	0.051	3,7
5/10/2003	8:00 AM	Allnight	PS	24	30643	4.5	64	62	16	1	0.047	1,3,4,5,7,8,9
5/11/2003	8:00 AM	Allnight	DH/PS	24	31346	4.5	63	61	16	0	0.031	1,3,4,5,7,,8,9
5/12/2003	8:00 AM	Allnight	MW/DH	24	31990	4.5	62	60	12	0	0.012	1,3,4,5,7,8,9
5/13/2003	8:00 AM	Allnight	MW	24	32917	4.3	66	64	12	0	0.006	3,7
5/14/2003	8:00 AM	Allnight	AB	24	33364	4.3	63	62	12	0	0.002	4,9
5/15/2003	8:00 AM	Allnight	FL	24	33960	4.2	63	62	16	0	0.033	4,5,6,8,9,10
5/16/2003	8:00 AM	Allnight	FL	24	34641	4.4	63	61	8	0	0.021	4,5,6,8,9,10
5/17/2003	8:00 AM	Allnight	NC	24	35374	4.4	63	61	16	0	0.041	4,5,6,8,9,10
5/18/2003	10:00 AM	Allnight	NC	24	36112	4.4	64	62	16	0	0.042	4,5,6,8,9,10
5/19/2003	8:30 AM	Allnight	PS/CP	24	36746	4.0	64	61	8	0	0.021	4,5,6,8,9,10,
5/20/2003	9:00 PM	Allnight	FL	24	37696	4.0	63	61	10	0	0.019	4,5,6,8,9,10
5/21/2003	6:00 PM	Allnight	DH/PS	24	38355	4.0	64	62	10	0	0.016	4,5,6,8,9,10
5/22/2003	7:00 PM	Allnight	DH/PS	24	39050	4.0	64	62	10	0	0.018	1,4,5,6,9,10
5/23/2003	8:00 AM	Allnight	AB	24	39465	4.0	64	62	12	0	0.001	4,5,6,8,9,10
5/24/2003	9:00 AM	Allnight	AB	24	40160	4.0	64	62	12	0	0.005	1,4,5,6,9,10
5/25/2003	9:00 AM	Allnight	NC	24	40806	4.0	64	62	20	0	0.006	1,4,5,6,9,10
5/26/2003	10:00 AM	Allnight	PS	24	41527	4.0	64	62	20	0	0.018	1,4,5,6,9,10
5/27/2003	8:30 AM	Allnight	DH/PS	24	42172	4.5	64	62	20	0	0.002	1,4,5,6,9,10
				Total treated	41806							

NANOFILTRATION TEST SYSTEM

Date	Time	Operators' Initials	Feed (ST-01) pH	Feed (ST-01) Free Chlorine (0.5 ppm)	Quenched (ST-02) pH	Quenched (ST-02) Free Chlorine (0 ppm)	Feed (ST-02) TDS	Feed (ST-02) Arsenic (V)	1st Stage Permeate (ST-03) TDS	1st Stage Permeate (ST-03) Arsenic (V)	Interstage (ST-04) TDS	Interstage (ST-04) Arsenic (V)	2nd Stage Permeate (ST-06) TDS	2nd Stage Permeate (ST-06) Arsenic (V)	Combined Permeate (ST-05) pH	Combined Permeate (ST-05) TDS	Combined Permeate (ST-05) Arsenic (V)	Concentrate (Final ST-07) pH	Concentrate (Final ST-07) TDS	Concentrate (Final ST-07) Arsenic (V)	Feed Total Gallons	Runtime Hours	Chlorine Dose %	Chlorine Tank Level	Bisulfite Dose %	Bisulfite Tank Level	Temp	Raw PI-01 (1) PSI	Post Cartridge PI-01 (2) PSI	HPP Discharge PI-02 (1) PSI	1st Stage 1st Bank Feed PI-02 (2) PSI	1st Stage 1st Bank Concentrate PI-02 (4) PSI	1st Stage 1st Bank Permeate PI-03 PSI	1st Stage 2nd Bank Feed PI-04 (1) PSI	1st Stage 2nd Bank Concentrate PI-04 (3) PSI	1st Stage 2nd Bank Permeate PI-05 PSI	2nd Stage Feed (PI-06) (1)	2nd Stage Concentrate (PI-06) (3)	2nd Stage Permeate (PI-07)	Production Wells in Service
3/26/2003	3:30 PM	LB	6.45	0.55	8.02	0	185	16	15.1	2	882	90	148	2	4.75	28	0	5.96	1312	80	14600	0	41	14.8	50	13.9	69	64	100	98	66	4	90	65									2,3,6
3/27/2003	3:00 PM	MW	6.91	0.52	6.17	0	150.7	8	13.4	0	600	40	107.2	0	5.75	27.2	0	5.97	1196	80	27600	3	45	14.5	50	13.25	69.1	64	95	96	65	4	83	63	4									2,3,6
3/28/2003	7:40 PM	FL	6.37	0.1	5.61	0	159	14	13.5	0	697	50	122	0	5.36	25.5	0	5.86	1414	80	48700	27	50	14	78	12.25	71.6	64	112	75	4.5	89	66	5									2,3,6
3/29/2003	7:00 AM	NC/PS	8.35	0.14	6.09	0	172	18	13.7	4	713	40	118.8	8	5.8	31.5	4	6.35	1430	80	88400	51	60	13.75	82	10.25	69	64	115	100	77	6	100	75	6									2,3,6
3/30/2003	8:45 AM	DH/PS	6.52	0.42	6.18	0	172	12	13.95	2	738	60	89.3	0	5.25	20.9	0	6.11	1538	80	125000	75	52	13	80	8	68	64	115	100	76	6	100	75	6									2,3,6
3/31/2003	8:00 AM	MW/DH	6.71	0.58	6.13	0	181.1	10	14.3	0	742	40	96.8	0	5.01	23.9	0	5.81	1550	50	169800	99	55	12.75	60	13.75	68	64	110	80	69	5	75	75	6									2,3,7
4/1/2003	8:00 AM	AB/MW	8.58	0.45	5.55	0	191	10	11.2	0	742	40	105.8	0	5.78	21.1	0	5.95	1533	80	206800	123	55	12	80	13.75	68	64	100	80	69	5	75	66	5									3,10
4/2/2003	8:00 AM	AB	6.47	0.4	5.85	0	194.8	10	4.5	4	746	60	72	0	6.1	11.4	0	5.4	1690	100	242900	147	80	11.5	55	12.25	68	64	100	80	60	6	80	61	5									3,10
4/3/2003	11:30 AM	FL	6.39	0.43	5.76	0	187.4	16	7.4	4	748	60	80.4	0	5.2	19.4	0	5.8	1520	80	269000	171	55	10.8	55	10	68	64	110	80	70	6	80	70	4									8,10
4/4/2003	7:10 AM	AB	6.47	0.4	6.45	0	185	16	6.5	0	850	50	160	0	5.39	18.5	0	6.19	1532	80	329400	195	60	10	55	8	68	64	110	80	70	4	80	70	4									7,9
4/5/2003	8:00 AM	NC/PS	6.28	0.4	6.07	0	179	14	10.6	0	721	60	136.9	0	5.61	9.5	0	4.3	1470	80	353800	219	60	8.75	60	6.5	68	65	103	96	70	3	91	71	3									7,9
4/6/2003	8:00 AM	DH/PS	6.15	0.4	6.3	0	152.2	14	15.19	0	804	50	31.9	0	5.87	8.4	0	8.3	1296	80	385400	243	62	9.25	60	8	68	64	120	100	70	4	89	70	4									7,9
4/7/2003	8:00 AM	MW/DH	6.59	0.42	6.13	0	171.7	16	3.8	0	669	40	34.3	0	5.58	6.4	0	6.78	1443	80	427500	267	62	9	59	8	68	64	90	85	70	4	100	70	4									7,9
4/8/2003	7:30 AM	AB	6.15	0.53	6.16	0	193.2	8	2.8	0	582	20	25.9	0	5.93	8.6	0	7.18	1252	80	446200	281	58	8.5	64	6.25	68	64	110	100	80	4	100	78	5									7,9
4/9/2003	9:00 AM	AB	6.61	0.75	8.23	0	134	20	2.9	2	946	50	25.6	2	6.34	5	2	5.78	1414	80	500000	316	85	8.25	45	5.25	69	64	110	100	80	4	100	78	5									7,9
4/10/2003	7:45 AM	AB/CP	5.92	0.5	6.79	0	174	2	2.7	0	980	40	25.2	0	5.57	5.2	0	5.94	1427	80	535700	339.4	43	8	50	4.25	69	64	110	100	69	4	99	78	5									6,9
4/11/2003	6:00 PM	AB	5.99	0.34	5.75	0	178	2	2.5	0	964	50	50	0	5.7	5.3	0	5.89	1435	80	548500	348.7	43	7.75	50	14.5	69	64	110	100	69	4	99	78	5									6,9
4/12/2003	8:00 AM	NC/PS	6.00	0.33	5.85	0	190	12	2.8	0	700	40	40	0	5.8	5.3	0	5.91	1450	75	574700	362.7	55	7.5	50	13.5	68	64	110	100	69	4	100	78	5									6,9
4/13/2003	8:00 AM	DH/PS	5.98	0.52	5.99	0	199	14	7.8	0	880	40	52.1	0	5.8	13.5	0	6.28	2490	80	607900	387.8	56	7.5	50	12.25	68	64	110	100	69	4	100	78	5									6,9
4/14/2003	8:00 AM	CP/DH/MW	5.58	0.5	5.75	0	202	14	3.1	0	851	50	52.4	0	5.09	10.8	0	5.21	2480	80	648600	410.6	50	11	68	8	69	65	110	100	83	4	100	80	5									6,9
4/15/2003	8:00 AM	MW	5.9	0.47	6.09	0	183.8	14	2.9	2	824	40	39.3	4	5.84	6.7	0	6.33	2400	80	715300	448	50	8.5	48	8.25	69	65	110	101	84	4	100	80	5									6,9
4/16/2003	8:00 AM	AB	6.57	0.44	5.26	0	186.2	20	5.2	0	822	60	42.7	0	6.16	6.7	0	6.21	2350	80	715300	480	50	8.5	48	8.25	69	65	110	101	84	4	100	80	5									6,9
4/17/2003	8:00 AM	FL/CP	6.48	0.4	6.94	0	216.5	18	4.2	0	842	60	56.1	0	6.16	7.3	0	6.19	2420	100	749800	493	47	6.25	52	8.5	69	65	110	101	80	4	100	78	3									6,9
4/18/2003	8:15 AM	FL	6.1	0.38	6.24	0	188.1	20	4.8	0	854	60	54.4	10	6.11	6.3	0	6.11	2300	80	784700	502	47	6	50	8.5	68	65	110	100	83	4	100	80	4									6,9
4/19/2003	9:00 AM	NC	6.1	0.5	6.09	0	192	16	2.8	0	700	60	80	12	6.06	7.6	2	6.09	1800	80	830700	531	45	6	50	5.25	68	64	100	90	80	3	100	75	3									1,5,8,7,9,10
4/20/2003	Plant Shutdown																																									
4/21/2003	2:06 AM	CP	6.07	0.81	5.85	0	188.8	12	6.1	4	859	40	65	0	5.9	2	0	5.85	1345	100	866700	569.4	46	5.25	52	5.25	68	64	110	100	80	5	100	78	5									2,8
4/22/2003	7:30 AM	AB	6.01	0.51	5.95	0	161.8	16	2.4	2	698	40	40	0	5.87	4	0	5.81	1241	60	893200	577	50	10	40	9.5	69	65	105	95	75	6	95	75	6									2,8
4/23/2003	8:30 AM	AB	6.68	0.4	6.3	0	165	30	2.1	2	800	40	40	0	6.15	5.3	0	6.84	1285	80	929800	601.8	50	8.75	43	8.25	69	65	110	101	80	5	100	80	5									2,8
4/24/2003	8:00 AM	AB	6.82	0.11	6.33	0	154.5	30	2.2	2	820	40	18.9	14	5.92	3.8	2	5.75	1337	80	962800	623.8	50	9.9	43	6.9	68	64	110	101	81	5	100	80	6									2,8
4/25/2003	Chemical Pump Out of Service																																									
4/26/2003	Chemical Pump Out of Service																																									
4/27/2003	Chemical Pump Out of Service																																									
4/28/2003	7:00 PM	PS	6.34	0.13	5.32	0	182.2	16	2.8	0	790	40	40	0	5.58	6.6	2	6.3	1490	20	9809	635.4	50	8.75	50	8.25	69	64	115	105	80	5	100	80	6	80	75	35	1,2,4,7,8,9,10								
4/29/2003	8:00 AM	AB	6.08	0.49	8.23	0	176.2	20	2.4	0	705	60	60	0	5.8	7.1	2	5.88	1473	80	10015	648	50	9.5	55	5.5	69	64	115	105	84	5	104	82	5	81	74	35	1,2,4,7,8,9,10								
4/30/2003	10:30 AM	CP	5.86	1.86	6.25	0	183.4	16	4.5	0	852	60	80	0	5.71	10.3	0	5.87	1420	40	10337	672	55	8	50	5	68	64	110	105	74	5	99	78	5	79	70	32	1,2,4,7,8,9,10								
5/1/2003	8:00 PM	AB	5.88	0.12	5.45	0	175.4	12	2.5	0	852	60	42.3	4	5.81	10.3	4	5.89	1450	80	10830	709	50	13.5	60	11.25	68	64	110	105	78	5	99	78	5	79	72	32	1,2,4,7,8,9,10								
5/2/2003	7:50 AM	AB	6.01	0.4	5.84	0	184.4	18	3.1	2	869	80	18.9	0	5.98	4.8	0	5.82	1410	80	10894	720	55	6.5	50	6	68	64	105	100	75	4	95	75	5	80	72	32	2,10								
5/3/2003	8:00 AM	DH	6.01	0.26	4.95	0	186	14	2.6	4	589	40	18	0	4.99	30.5	2	6.29	1343	80	11138.5	745.6	70	13.25	50	9.25	65	64	105	100	75	5	95	75	5	80	72	32	2,10								
5/4/2003	8:30 AM	DH	5.83	0.3	7.71	0	193.4	14	3	0	583	60	16	0	4.99	4	0	6.06	1779	80	11758	769	60	13.25	50	7.75	69	65	105	100	75	5	95	75	5	80	72	32	2,10								
5/5/2003	8:00 AM	AB	5.87	0.4	5.4	0	193	12	2.6	0	611	20	6.3	0	5.87	11.5	0	6.01	1828	40	12114	791.6	50	12.5	40	6.5	65	64	105	100	75	5	95	75	5	80	72	32	2,10								
5/6/2003	9:00 AM	AB	6.78	0.25	5.72	0	189	10	2.8	0	737	30	28.6	0	5.81	5	0	5.01	1677	80	12507	817	40	12.5	40	4.75	68	64	105	101	80	5	100	79	5	79	70	32	2,10								
5/7/2003	9:15 AM	CP	6.3	1.05	6.14	0	171.3	10	3.9	0	616	50	18.2	0	5.7	5	0	6.28	1550	80	12823	840	40	14.75	50	14.75	68	64	106	107	105	8	105	80	5	81	71	10	3,7,8,9								
5/8/2003	8:00 AM	NC	6.4	0.3	6.19	0	179	25	2.8	0	658	60	18.4	0	4.9	5.1	0	6.3	1450	100	13180	859	40	14.7	50	12.5	68	64	105	100	80	8	105	77	7.5	77	77	28	3,8								
5/9/2003	8:00 AM	PS	6.01	0.7	5.43	0	194	16	2.7	0	614	60	17.2	0	4.8	5.3	0	5.87	1620	80	13559	884.4	50	13	50	11	68	64	105	100	75	6	95	75	6	81	74	35	1,3,4,5,7,8,9								
5/10/2003	8:00 AM	DH	5.85	0.71	5.8	0	182	12	3.2	0	620	40	20.5	0	5.8	4.4	0	5.97	1561	80	14236.8	932.2	40	12	50	9.5	68	64	105	100	75	6	95	75	6	80	74	35	1,3,4,5,7,8,9								
5/11/2003	8:00 AM	MW/DH	5.83	0.67	5.42	0	189.9	10	3.4	0	690	40	37.8	0	5.93	9.4	0	6.36	1620	100	14670	962.5	35	11	50	6.75	68	64	105	100	75	6	95	75	6	80	74	35	1,3,4,5,7,8,9								
5/12/2003	7:30 AM	MW	6.73	0.47	6.15	0	227	14	4.9	0	904	40	40	0	5.99	9.5	2	6.37	1700	30	14901	977.5	40	11.25	50	8.75	68	64	105	100	75	6	95	75	6	80	74	35	1,3,4,5,7,8,9								
5/13/2003	8:00 AM	AB	6.02	0.56	6.1	0	225	10	4.5	0	900	15	30.1	2	5.37	5.2	4	6.34	1587	30	15220	999.5	40	11	50	8.75	68	64	105	100	75	6	95	75	6	80	74	35	4,9								
5/14/2003	8:00 AM	FL	6.1	0.5	6.3	0	176.3	8	4.5	2	722	30	18	0	5.08	5.4	0	6.45	1588	80	15453	1024.1	40	10.5	60	7	68	64	105	100	75	6	95	75	6	80	74	35	4,5,6,8,9,10								
5/15/2003	8:00 AM	FL	6.08	0.5	5.49	0	177.2	4	3.7	0	735	16	33.3	0	5.08	6.4	0	6.45	1586	80	15453	1024.1	40	10.25	60	7	68	64	105	100	75	6	95	75	6	80	74	35	4,5,6,8,9,10								
5/16/2003	8:00 AM	NC	6.06	0.6	5.89	0	183	16	4.4	0	780	45	31	2	5.85	5	2	6.39	1600	80	16057	1047	40	10.25	50	5.5	68	64	105	100	75	6	95	75	6	80	74	35	4,5,6,8,9,10								
5/17/2003	10:00 AM	NC	6.06	0.6	5.9	0	185	16	4.1	0	780	45	31	2	5.8	5	0	6.42	1600	80	16448	1078	40	10	50	4	68	64	105	100	75	6	95	75	6	80	74	36	4,5,6,8,9,10								
5/18/2003	8:30 AM	PS/CP	6.05	0.4	5.97	0	189.8	10	2.9	0	798	40	24.7	0	5.78	5.7	0	6.21	1710	100	16742	1094.7	50	8.9	50	3	68	64	110	100	80	4	100	80	5	80	74	38	4,5,6,8,9,10								
5/19/2003	9:00 PM	FL	6.05	0.6	5.99	0	192.4	10	3.2	0	774	40	32	0	5.86	5.2	0	6.46	1620	100	1706	1112	40	9.5	50	12.5	68	64	110	100	80	4	100	80	5	80	74	39	4,5,6,8,9,10								
5/20/2003	9:00 PM	DH	5.14	0.59	5.58	0	189	12	13.4	0	787	60	25.4	0	5.84	5.8	0	6.51	1260	80	17658.9	1154	41	8.5	50	10.75	68	64	110	100	80	4	100	80	5	80	74	35	4,5,6,8,9,10								
5/21/2003	7:00 PM	DH	5.2	0.38	5.8	0	189	10	13.7	0	780	60	24.9	0	5.71	6.5	0	5.49	1190	80	18010	1177	40	8.5	50	9.5	68	64	110	100	80	4	100	80	5	80	74	34	4,5,6,8,9,10								
5/22/2003	8:00 AM	MW	5.94	0.6	5.58	0	195.3	14	3.4	0	780	40	28.6	0	5.84	5.2	0	6.21	1677	80	18210	1191	50	8.5	50	9.5	68	64	110	100	80	4	100	80	5	80	74	34	4,5,6,8,9,10								
5/23/2003	9:00 AM	AB	6.01	0.32	5.58	0	195	10	2.5	0	720	30	24.5	0	5.87	5.1	0	6.18	1750	80	18587	1218	50	8.5	50	7.5	68	64	110	100	80	4	100	80	5	80	74	33	4,5,6,8,9,10								
5/24/2003	8:00 AM	NC	5.98	0.39	5.8	0	196	20	2.8	0	820	70	30	4	5.89	5.8	0	6.16	1690	100	18923	1238	50	8.5	50	8	69	65	110	101	80	4	100	80	5	80	74	33	4,5,6,8,9,10								
5/25/2003	8:00 AM	NC	5.98	0.39	5.8	0	196	20	2.8	0	820	70	31	6	5.93	5.8	0	6.17	1710	100	19312	1263.9	50	8.5	50	4.75	68	64	105	100	81	8.5	100	80	9	80	80	70	32	1,4,5,6,8,10								
5/26/2003	10:00 AM	PS	6.01	0.51	5.87	0	190	20	2.7	0	629	70	32.2	0	5.94	5.8	0	5.97	1693	80	19676	1287.8	50	8.5	50	4.75	68	64	105	100	81	8.5	100	80	9	80	80	70	32	1,4,5,6,8,10								
5/27/2003	8:30 AM	DH	6.17	0.41	5.59	0	195.5	14	3.3	0	800	70	68	0	5.84	5.8	0	5.87	1693	80	19676	1287.8	50	8.5	50	3.75	69	64	105	100	84	9	105	80	8	80	75	35	1,4,5,6,8,10								

Arsenic Pilot Units!

11/14/2003