

ChemScan® UV-6100 Process Analyzer

PROJECT REPORT AND DATA SUMMARY
NITRATE-AMMONIA-PHOSPHATE MONITORING
ACCEPTANCE TEST

CITY OF AUSTIN
SOUTH AUSTIN REGIONAL
BNR PILOT FACILITY

Published By:
Applied Spectrometry Associates, Inc.
W226 N555G Eastmound Drive
Waukesha, WI 53186

August 30, 1996

BACKGROUND

The South Austin Regional Pilot Facility is a 40 MGD wastewater treatment facility designed to pilot test Biological Nutrient Removal (BNR) processes to be employed at Austin and elsewhere in the State of Texas. The facility was designed by CH2M-Hill and is being operated by OMI and City of Austin personnel.

ASA was asked to provide a process analyzer capable of detecting nitrate, ammonia and phosphate in samples from any of eight pilot plant sample points from primary influent to process effluent, as shown in Figure 1.

All sample points have high solids content, which require the use of a dedicated ultrafilter and a gallon permeate accumulator for each sample line. Each sample point has a dedicated sample pump, sized to provide a continuous high volume flow of sample concentrate through the ultrafilter, which is located at a central point close to the analyzer.

A ChemScan UV-6100 Process Analyzer System was configured to perform analysis of nitrate using multiple wavelength UV light absorbance. Ammonia analysis is performed using a (patent pending) method where a chlorine bleach solution and a hydroxide solution are injected into a volume of sample, forming a chloramine which can be analyzed using multiple wavelength UV light absorbance. Phosphate analysis is performed using a (patent pending) method where a pH buffered ferric solution is proportionately consumed by orthophosphate in the sample and is measured using multiple wavelength UV light absorbance.

An external PLC controls the valves for each sample accumulator, opening the valve to the accumulator for each specific sample point in a specified sequence. The sample is pumped through the ChemScan Process Analyzer System to flush any prior sample from supply lines and the flow cell.

The new sample is analyzed for nitrate by the analyzer following the initial flush. A portion of the sample flow is diverted through the Ammonia Sample Conditioning Unit, where the bleach and hydroxide are injected and is given sufficient time to react with the sample, after which the sample is pumped to the ChemScan instrument for analysis of ammonia. The remaining ultrafilter permeate is pumped from the accumulator and diverted through the Phosphate Sample Conditioning System, where the ferric solution is injected, reacted with the sample and pumped to the ChemScan instrument for phosphate analysis.

An external PLC controls the sample selection sequence and accepts a dedicated 4-20 mA output from the ChemScan analyzer for nitrate, ammonia and phosphate in each sample, with the output signals matched to the appropriate sample point. Communication between the ChemScan System and the external PLC prevents initiation of a new test sequence until the previous sequence has been completed.

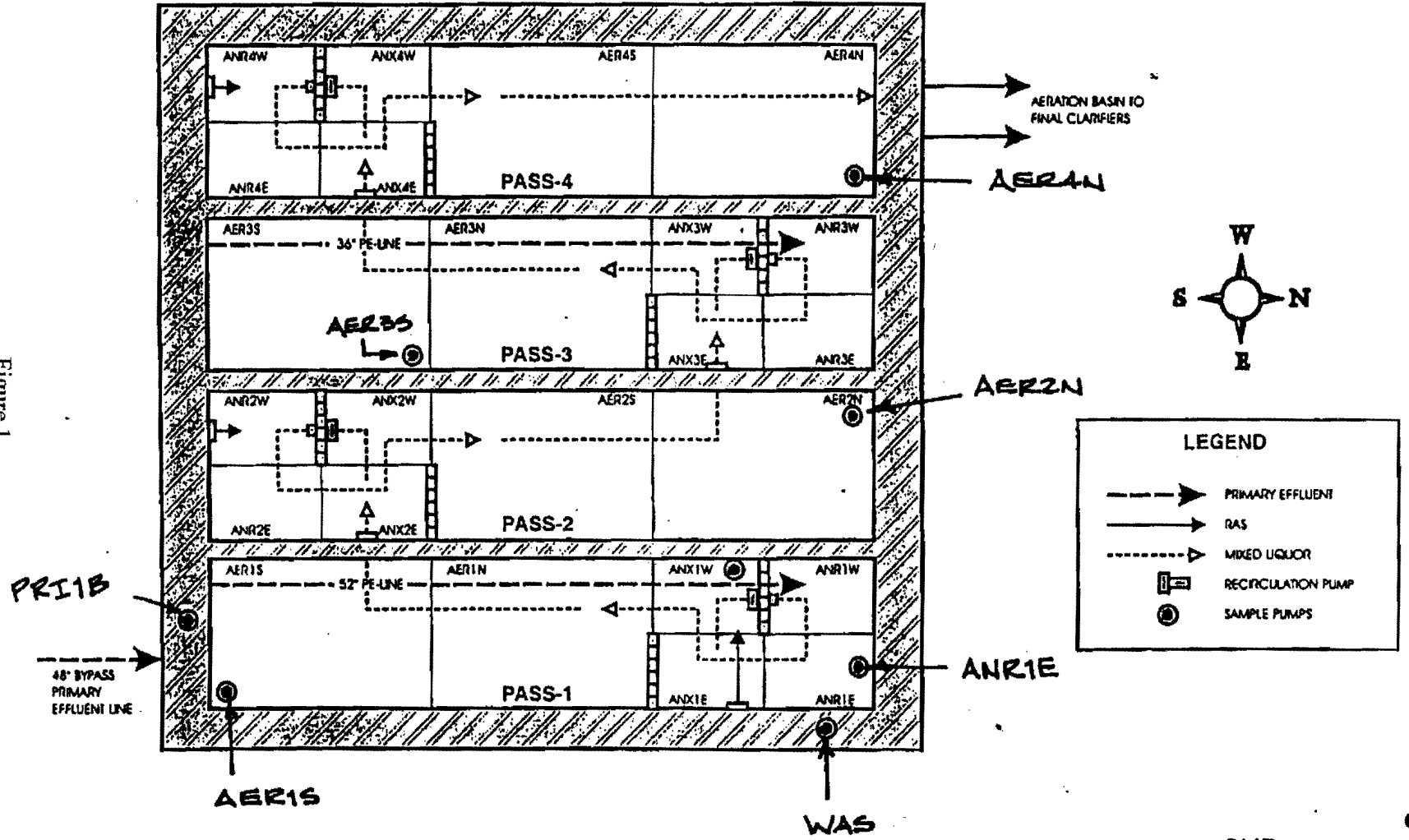
A diagram of ChemScan Process Analyzer system plus ultrafilter and PLC is shown in Figure 2.

SYSTEM PERFORMANCE

ASA and CH2M-Hill collected a substantial volume of information to summarize the startup and calibration results for the ChemScan Process Analyzer and to demonstrate compliance with the specification requirements.

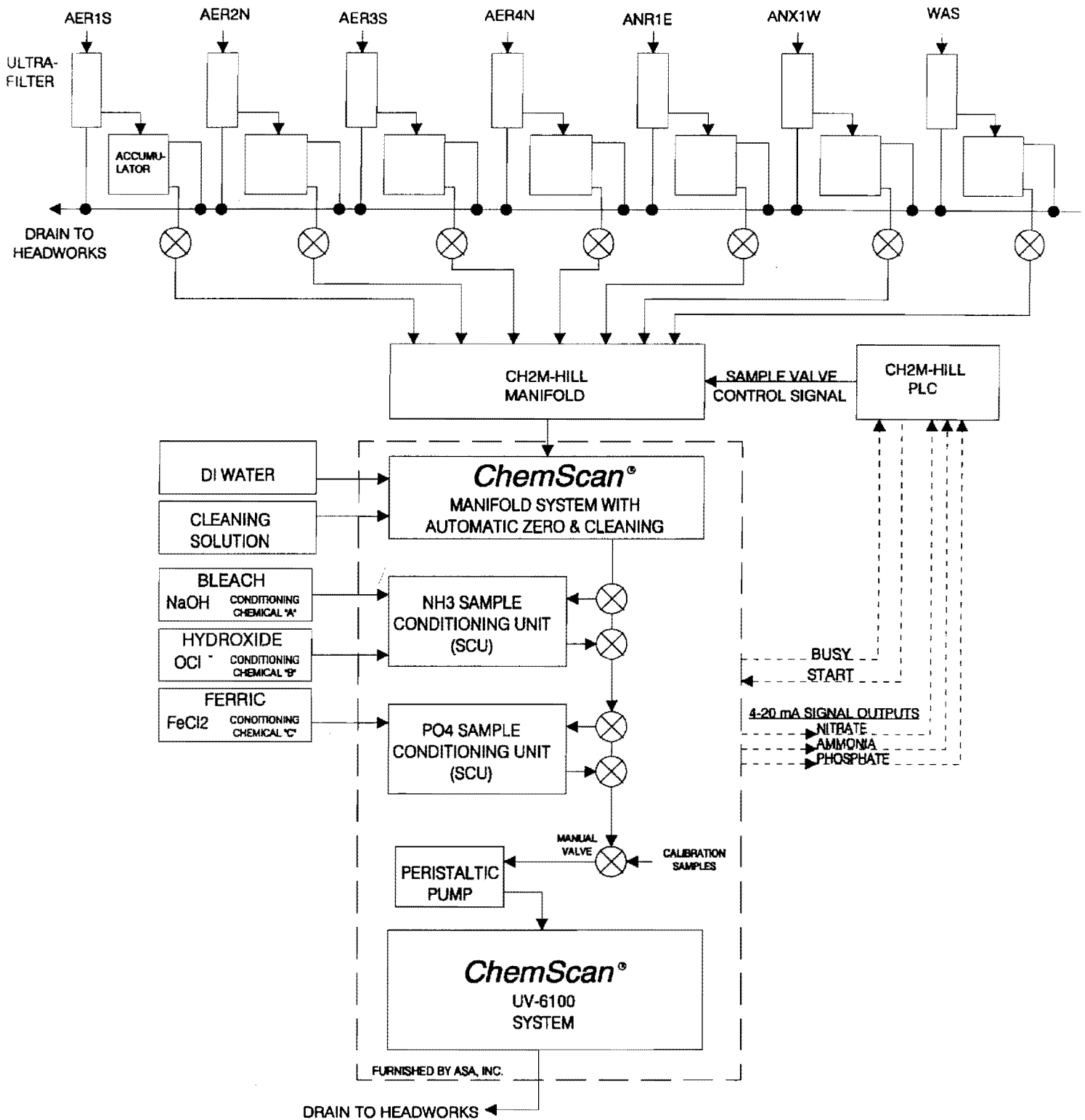
The ChemScan Process Analyzer is an on-line multiple wavelength spectrometry system that uses a site specific detection algorithm for analysis of each parameter of interest. We refer to the creation of these detection algorithms as the "calibration" of the analyzer, which is significantly more elaborate a process than the response adjustment performed for other types of instruments.

Figure 1



BNR
FLOW DIAGRAM





Functional Block Diagram
Denitrification & Phosphate Monitoring System

City of Austin
Regional Pilot Facility
September 1, 1996
Figure 2

ASA, INC.
F# BDAUSTN2
D#BH31P041
REV: 960901

Specification section 11595, paragraph 2.6B defines the detection range and accuracy requirements for each parameter and also defines a method for calculation of average error. The specified range for each parameter is shown below. Also shown is an operating range for each parameter. This is the range actually used as the minimum and maximum values for analog output from the analyzer. The operating range was selected based on observations during the first few months of operation.

	NITRATE NITROGEN	AMMONIA NITROGEN	ORTHO PHOSPHATE
Specification Range	0 - 40 ppm	0 - 40 ppm	0 - 15 ppm
Operating Range	0 - 20 ppm	0 - 15 ppm	0 - 20 ppm

Two methods of calculating errors were used. The first method, average error, is the specified method. This method uses the sum of the arithmetic differences, divided by the number of samples. The second method, absolute error, is a more demanding method. This method uses the sum of the absolute differences, divided by the number of samples. Results for each calibration are shown in Table 1 using both methods. Results are also shown for average error and absolute error as a percentage of the specification range and of the operating range. ASA expects errors of 5% of range or less to be achieved for each parameter.

Table 1
ChemScan vs. Laboratory Analysis Error

	Average Error Method			Absolute Error Method		
	Nitrate	Ammonia	Phosphate	Nitrate	Ammonia	Phosphate
Startup Calibration Error 5/22/96 to 6/12/96	1.75 ppm	0.19 ppm	-0.66 ppm	1.78 ppm	0.56 ppm	1.59 ppm
% of Spec Range	4.4	0.5	-4.4	4.5	1.4	10.6
% of Operating Range	8.7	1.2	-3.3	8.9	3.7	8.0
Initial Site Calibration Error 6/24/96 to 7/23/96	-0.11 ppm	-0.43 ppm	-1.54 ppm	0.60 ppm	0.61 ppm	2.23 ppm
% of Spec Range	-0.3	-1.1	-10.2	1.5	1.5	14.9
% of Operating Range	-0.6	-2.9	-7.7	3.0	4.1	11.2
Adjusted Site Calibration Error 7/24/96 and on	-0.22 ppm	-0.05 ppm	-0.59 ppm	0.40 ppm	0.18 ppm	0.73 ppm
% of Spec Range	-0.5	-0.1	-4.0	1.0	0.4	4.8
% of Operating Range	-1.1	-0.3	-3.0	2.0	1.2	3.6

A calibration for the detection of nitrate-nitrogen, ammonia-nitrogen and orthophosphate (as P) based on pure water standards was installed at the factory. These factory calibrations were operated during an initial site specific calibration file collection period, from May 22 to June 23. During this period, the factory calibration for nitrate exceeded the specified error. This is not unusual because nitrate analysis is performed by ChemScan using primary analysis, a direct measurement of light absorbance which is not assisted by the use of reagents. This method requires site specific samples to provide information sufficient to compensate for background chemistry. The ammonia and phosphate calibrations did meet the specification requirements when average error was used for evaluation, but were above the specified error when absolute error was used for evaluation.

An initial site specific calibration for each parameter was installed on June 24, based on files collected during the prior month. Both average error and absolute error for nitrate analysis was substantially reduced compared to the factory calibration results, although the absolute error was slightly above the specified value. Errors for both ammonia and phosphate were well above the error rates experienced using the factory calibration. This unusual outcome was determined to be the result of condensation of water vapor on one of the flow cell windows and also the result of improperly calibrated reagent injector valves. Both problems were corrected on July 23.

Additional files collected after June 24 were used to produce adjusted calibrations for all parameters, which were installed on July 23. Results, based on 11 samples collected on July 24 and 25 indicate compliance with specification requirements for all parameters, using either the average error method or the absolute error method. Furthermore, error as a percentage of range was under 5% for all parameters when compared to either the specified range or to the operating range.

Comparisons between ChemScan and laboratory values for each parameter are shown on Figures 3, 4 and 5. Closer correlation between these values can be observed as an improved site specific calibration was developed.

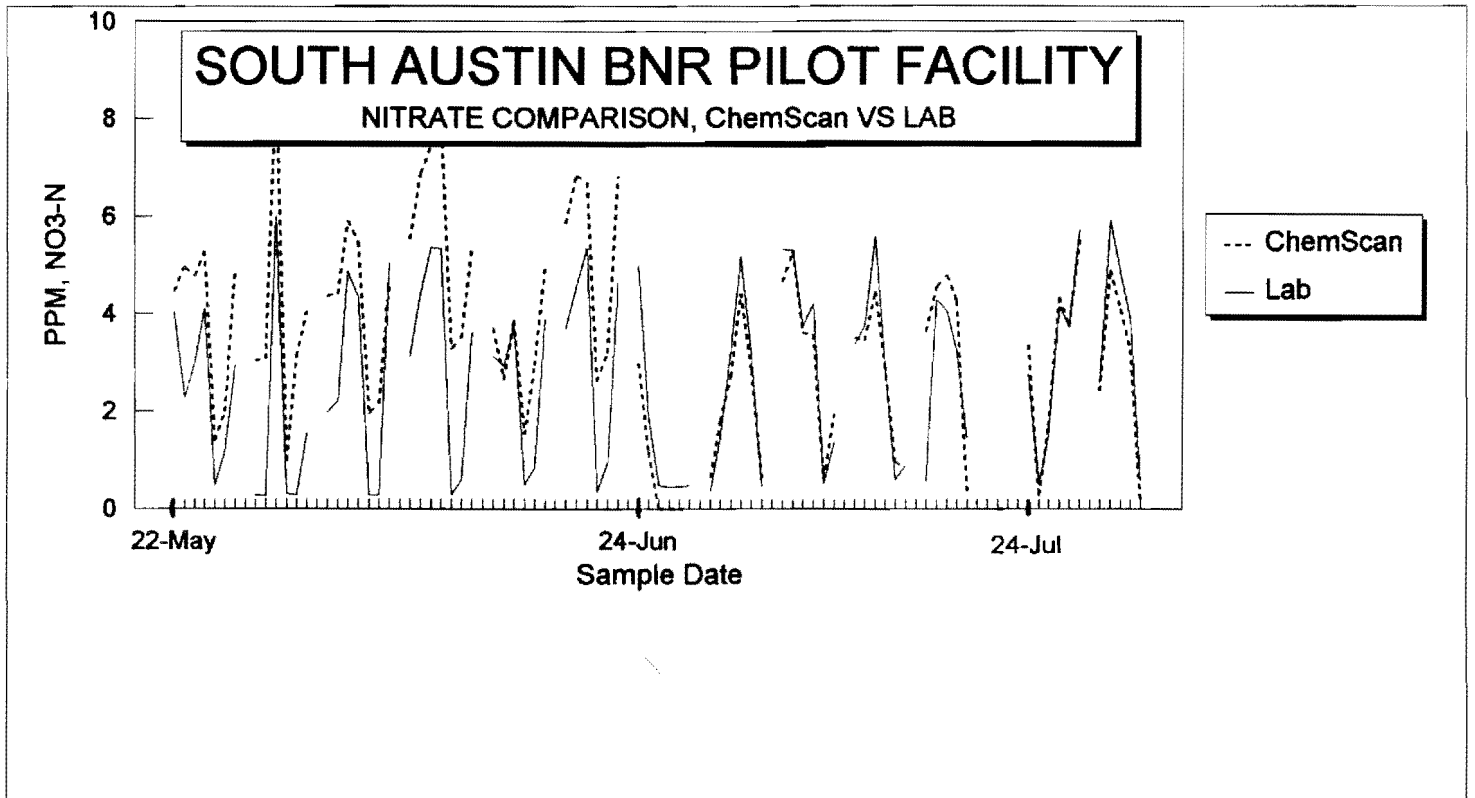


Figure 3

SOUTH AUSTIN BNR PILOT FACILITY

AMMONIA COMPARISON, ChemScan VS LAB

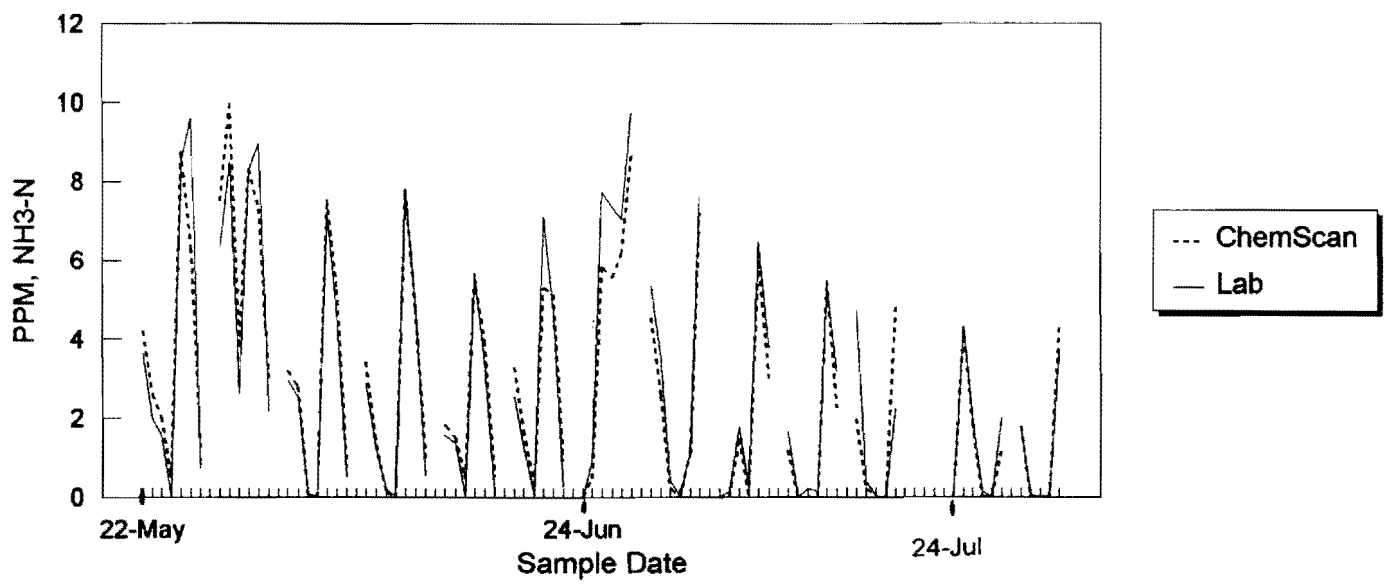


Figure 4

SOUTH AUSTIN BNR PILOT FACILITY

PHOSPHATE COMPARISON, ChemScan VS LAB

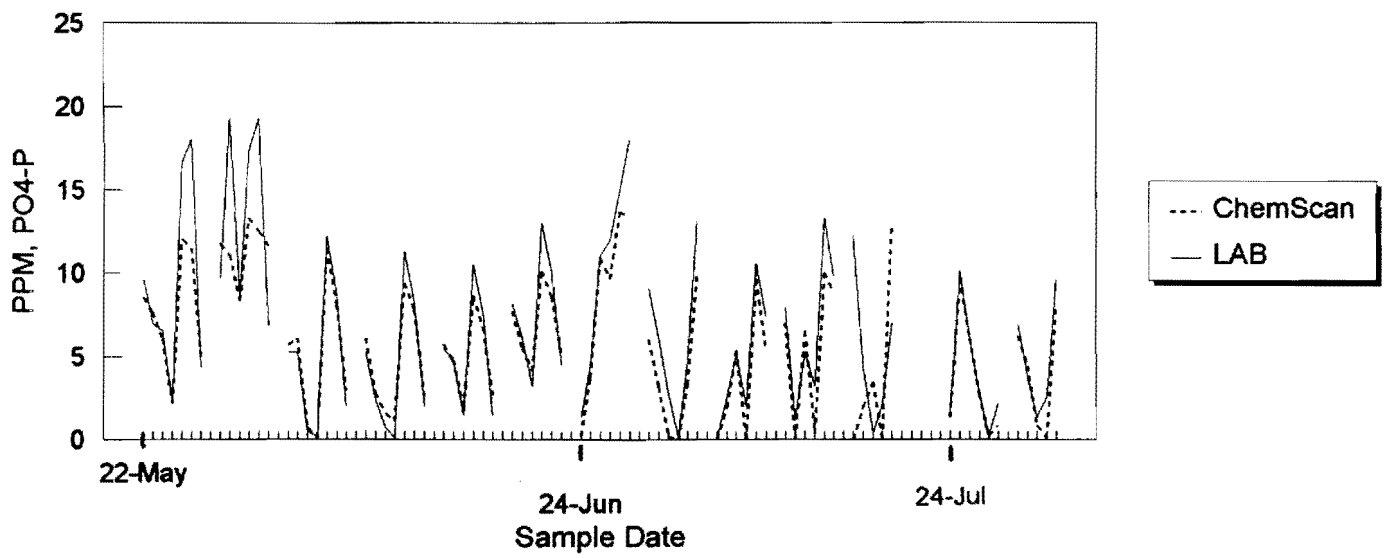


Figure 5