REPORT ON CONDUCTING PILOT SCALE TREATABILITY STUDIES FOR THE EVERGLADES STORMWATER PROGRAM (ESP) URBAN AND TRIBUTARY BASINS PROGRAM

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BACKGROUND AND INTRODUCTION

Under a previous contract to the South Florida Water Management District (SFWMD), HSA Engineers and Scientists (HSA), a member of the CRA Family of Companies, conducted pilot study investigations in the EAA on Post Stormwater Treatment Area (STA) and Post Best Management Practices (BMP) surface waters. HSA conducted these investigations under the District Contract number C-E10650, Chemical Treatment and Solids Separation Project (CTSS). These pilot study investigations used water treatment processes to assess their effectiveness at removing Total P on Post-STA and Post-BMP surface waters. Field investigations employed the use of pilot units housed in two tractor-trailers each containing flow meters, chemical feed systems, flash mix and flocculation tanks, flocculation mixers and inclined plate settlers/clarifiers. Using this pilot equipment, Total P was reduced to less than 10 parts per billion (ppb) as phosphorus consistently over a three week period of continuous testing on both Post-STA and Post-BMP EAA surface waters.

CTSS field trials in the EAA were completed at the end of 1999 and the tractor-trailer pilot facilities became available for use at other testing locations. In order to assess the effectiveness of chemical treatment processes on the Everglades Stormwater Program Urban Basins, HSA (under contract to the District), moved one of the two portable pilot facilities to the Wellington/Acme Improvement District Pump Station G94D (also known as Pump Station number 2). The pilot unit was then operated both during periods of active pumping and during quiescent periods in order to determine the amount of phosphorus reduction achievable with chemical treatment on Wellington Basin B storm water runoff.

With an historical average discharge value of 187 parts per billion (ppb) of Total P, the Wellington Pump Station 2 has generated the highest average concentration for all of the urban basins, making it a good candidate for initial urban pilot testing for phosphorus reduction.

TESTING PROGRAM

HSA moved and installed the pilot unit test facility to the Wellington Pump Station number 2 during the August and September, 2000 time period and urban storm water testing was conducted during a total of six independent events. Four of these events were during time periods of active pumping while the remaining two were during times that no pumping was occurring.

During the pilot testing, samples were collected periodically (*e.g.*, every 2 to 4 hours). Influent, effluent and solids samples were collected and analyzed for soluble reactive, total dissolved and Total P forms. Additional samples were collected on a less frequent basis for more complete nutrient, and heavy metal characterization.

Specific testing protocols evaluated during the program included:

- Testing of ferric chloride, acid alum and aluminum chloride plus an anionic polymer to aid with the settling of the generated solids;
- Initial jar testing on representative storm water samples to obtain a better idea of effective chemical dosing and flocculation/settling times for these urban waters;
- Varying the clarifier overflow rates;
- Determining solids production rates;
- TCLP characterization of Solids; and,
- Determination of coagulant dose required and experimental conditions required to reduce Total P to less than 10 ppb.

<u>PILOT TESTING RESULTS</u>

Jar testing was conducted on representative storm water samples collected from Wellington Pump Station number 2 during active pumping. Both aluminum chloride and ferric chloride coagulants were evaluated and testing variables included coagulant type, coagulant dose, and settling time. The lowest settled Total P results were obtained using ferric chloride at a dose of 38 mg/L (as iron) coupled with a settling time of 40 minutes. These conditions yielded a Total P value of 12 ppb in the settled water. Using a concentration of 18 mg/L of aluminum chloride (as aluminum) and a settling time of 40 minutes produced a settled Total P of 13 ppb. Jar testing results suggested that using either aluminum chloride or ferric chloride would produce low Total P results when added in the indicated amounts. These jar test results were used to develop pilot unit conditions to be employed during storm water testing.

For all testing trials, a constant coagulation retention time of 1.7 minutes was maintained and a flocculation total hydraulic retention time of 33 minutes was used. In addition, the feed flow rate to the pilot unit was maintained at a constant 12 gpm for all trials.

Run numbers 1 and 2 used higher clarifier loading rates of 0.21 to 0.28 gallons per minute per square foot (gpm/ft^2) of projected plate area and the lowest Total P concentration achieved during these trials was 24 ppb. When using the clarifier overflow rate of 0.14 gpm/ft^2, Total P results of less than 10 ppb were achieved. In run number 4, when feeding a concentration of 47 mg/L of ferric chloride (as Fe), and using a clarifier overflow rate of 0.14 gpm/ft^2, the Total P concentration was equal to 7 ppb in the clarified effluent. Using aluminum chloride in run number 5 at a concentration of 12 mg/L (as Al) yielded an effluent Total P of 6 ppb. Run number 5 was also completed using a clarifier overflow rate of 0.14 gpm/ft^2.

Run number 3 was conducted using acid alum as the coagulant. Acid alum contains aluminum sulfate in a sulfuric acid solution. It was hypothesized that acid alum would produce low Total P results while using lower aluminum dosages. During run number 3, acid alum was titrated into the pilot unit to achieve a steady state pH range of between 5.5 to 6.0. The corresponding concentration of aluminum added at to achieve this pH range was equal to 7 mg/L as aluminum. An average of 17 ppb of Total P was obtained during this test suggesting that acid alum alone will not produce an effluent of 10 ppb or less of Total P.

SFWMD Low Level Mercury Results

Representatives from SFWMD collected feed and filtrate samples for trace level mercury analysis during the October 30, 2000 pilot unit testing. The average total mercury concentration of the feed sample was equal to 1.31 nanograms/L. Unfiltered total mercury was reduced approximately 28 percent with the effluent total mercury concentration equal to 0.94 nanograms/L. Filtered total mercury was reduced approximately 98 percent. Mercury removed by the CTSS pilot unit is accumulated in the clarifier underdrain solids. The concentration of total mercury in the concentrated solids from the CTSS treatment system was equal to 35.7 nanograms/lL.

Bioassay and Algal Growth Potential (AGP) Results

Bioassay and AGP analyses were performed by the FDEP Biology Section on CTSS treatment technology influent and effluent water samples collected October 30, 2000. Specific tests completed included:

- Algal Growth Potential (AGP) using USEPA guidelines (EPA-600/9-78-018);
- Seven-day chronic estimator (screening) tests using the bannerfin shiner (*Cyprinella leedsi*) test;
- Seven-day chronic estimator (screening) tests using the water flea (*Ceriodaphnia dubia*) test; and

- A 96-hour growth test using the unicellular green alga (*Selenastrum capricornutum*) test.

Tests were performed following USEPA guidelines, but substituting *C. leedsi* for the fathead minnow, *Pimephales promelas* (EPA/600/4-91/002). This substitution was made at the request of the FDEP and the Everglades Technical Advisory Committee (ETAC) in order to include a Florida indigenous species in the testing protocols. There was no significant impact identified from the bioassay sampling completed during testing that could be attributed to the CTSS treatment system. The influent sample collected for the AGP test yielded a concentration of 0.81 mg dry weight per liter. The pilot unit effluent sample recorded a much lower value of 0.129 mg dry weight per liter.

Additional Water Quality Results

Extensive water quality testing was conducted on pilot unit influent and effluent samples during each of the six experimental runs. During tests using the coagulant ferric chloride, analytes showing no significant difference between the pilot unit influent and effluent include:

Ammonia Nitrogen	Calcium	Chromium
Lead	Magnesium	Nitrate
Potassium	Silica	Selenium
Sodium	Zinc	

Iron increased from an average of 0.55 mg/L in the feed to the pilot unit to 1.7 mg/L in the pilot unit effluent. This increase is due to the addition of unreacted ferric ions to the effluent stream. The chloride concentration increased to an average of 97 mg/L in the pilot unit effluent from a feed concentration of 35 mg/L. This increase is attributed to the chloride contained in the ferric chloride coagulant.

Alkalinity, pH, organic carbon, color and turbidity were all reduced from the feed water concentrations due to the acidic nature of the ferric salts being added and also due to the precipitation and coagulation reactions occurring within the pilot testing facility.

During tests using the coagulant aluminum chloride, analytes showing no significant difference between the pilot unit influent and effluent include:

Ammonia Nitrogen	Calcium	Chromium
Lead	Magnesium	Nitrate
Potassium	Silica	Selenium
Sodium	Zinc	

Aluminum increased from an average of 0.59 mg/L in the feed to the pilot unit to 1.2 mg/L in the pilot unit effluent. This increase is due to the addition of unreacted aluminum ions to the effluent stream. The chloride concentration increased to an average of 71 mg/L in the pilot unit effluent from a feed concentration of 40 mg/L. This increase is attributed to the chloride contained in the aluminum chloride coagulant.

Alkalinity, pH, organic carbon, color, iron and turbidity were all reduced due to the acidic nature of the aluminum salts being added and also due to the precipitation and coagulation reactions occurring within the pilot testing facility.

CONCEPTUAL DESIGN AND PRELIMINARY COST ESTIMATE FOR A FULL-SCALE CTSS APPLICATION

Flow data used in developing facility conceptual designs was obtained from historical information for Wellington Pump Stations 1 and 2 for the time period of August 31, 1998 through August 31, 2000. The combined mean flow for Pump Stations 1 and 2 during this 2-year period equals 110.6 million gallons per day (average flow for days of pumping, only). The mean flow plus two standard deviations (274.4 million gallons per day) was used as the maximum flow considered in the hydraulic analysis. The average Total P concentration used in developing the design criteria was based upon historical data provided by the District. The average Total P concentration used for Pump Station 1 was equal to 144 ppb of Total P and for Pump Station 2 equivalent to 187 ppb.

The full - scale facility was designed to achieve a flow weighted average effluent Total P concentration of 10 ppb with 0 percent flow diversion. The design criteria was established by optimizing the size of the water treatment plant required to treat incoming storm waters compared to the size of a flow equalization basin (FEB) that would store high volumes of waters resulting from short duration, high intensity rainfall events. The waters stored in the FEB would be treated by the plant during the subsequent hours and days following a storm event. Using a fill and draw hydraulic model to evaluate various plant versus FEB sizes, the optimum plant was determined to be 125 million gallons per day of treatment capacity coupled with a 200-acre flow equalization basin.

In the full scale system, urban storm waters, after flow splitting, would be pumped into parallel concrete basin coagulators where aluminum chloride will be fed at an average dose of 12 mg/L as Al. Coagulated water would flow into parallel concrete flocculation basin where an anionic polymer would be fed into the system at an average dose of 0.5 mg/L. The water would then be clarified in parallel concrete basins equipped with lamella plate settlers. The effluent pumping station would be used to discharge the treated water into the conservation area. Anticipated blended effluent Total P concentration would be equal to 10 ppb.

Residual solids would be discharged to an onsite storage lagoon, with a hydraulic detention time of 3 days. Supernatant overflow from the solids storage area would be returned to the FEB for treatment. Settled solids in the lagoon would be pumped to a dedicated land application facility. The estimated required area for this dedicated solids disposal area is equal to 72 acres and is based upon an annual solids loading rate of 28 tons of dry solids per acre per year (USEPA, 1996). The solids production rate used for these calculations was based upon actual solids generated by the pilot unit which was equivalent to 375 pounds of dry solids produced (using aluminum chloride as the coagulant) per million gallons of treated water.

The 200 acre FEB would be operated using a maximum water height of 4.5-feet, allowing for 4 feet of water storage (0.5 feet to 4.5 feet). The treatment plant would operate at a peak hydraulic capacity of 50 percent greater than its average daily design flow rate when the water level within the equalization basin reached 3.5 feet.

COST ESTIMATES FOR FULL-SCALE IMPLEMENTATION

SFWMD provided unit costs for selected capital, operation and maintenance (O&M), replacement, and salvage items. Additional cost estimate data were developed from equipment supplier quotations and prior engineering experience. The Brown and Caldwell report entitled “The Basis for Cost Estimates of Full-Scale Alternative Treatment (Supplemental) Technology Facilities” (August 1999), prepared by Brown and Caldwell for SFWMD, was also used to source various unit costs and was referenced where applicable.

Including the cost of the land, the estimated installed capital cost of the full-scale 125 mgd facility is equal to slightly less than $46 million dollars. Estimated total annual operating and maintenance costs including all labor to operate the facility and all required chemicals and supplies is equal to approximately $2 million per year.

Fifty (50) year present worth costs were calculated using a net discount rate of 4 percent. The total lump sum 50-year present worth cost (capital and O&M) of the 125 mgd facility is equal to $100,121,311.

CONCLUSIONS AND RECOMMENDATIONS

Study Conclusions

Based upon the results of the pilot investigations conducted at the Wellington Pump Station number 2, a treated effluent containing 10 ppb of Total P can be produced using chemical treatment process equipment and either aluminum chloride or ferric chloride as the coagulants.

- The installed cost of a 125 mgd full - scale system capable of treating the combined storm water flows from Wellington Pump Stations 1 and 2 is equal to $46 million dollars. Total estimated annual operating costs for this full scale is equal to slightly less than $2 million.

- Total land requirements for the full scale system are equal to 277 acres and includes allotments for the flow equalization basin, residual solids management and the treatment facility itself.

Study Recommendations

- Additional investigations should be conducted on assessing potential beneficial reuse of residual solids generated during the treatment process. Potential reuse scenarios that should be piloted include:

  - Solids recycling so that they may be reused as the chemical coagulant in the treatment process; and,

  - Application to agricultural lands to evaluate their ability to trap total phosphorus in the soil column.

- In order to determine the long - term viability of the chemical treatment process and assess its ability to consistently reduce total phosphorus to 10 ppb in treated storm water effluents, a larger prototype facility should be constructed and tested continuously for a six to nine month period. This prototype facility should be able to treat 100,000 gallons per day or more of representative urban storm waters.

1.0 BACKGROUND AND INTRODUCTION

The South Florida Water Management District (SFWMD) established the Everglades Stormwater Program (ESP) after the legislature passed the Everglades Forever Act of 1994 to help protect Florida's Everglades. The ESP includes two main components: the Everglades Agricultural Area (EAA) Phosphorus Reduction Program, and the Urban and Tributary Basins Program. By the end of the year 2003, water quality improvement plans will be submitted to the Florida Department of Environmental Protection (FDEP) which detail the required basin specific regulatory programs and describe the water quality treatment systems needed to adequately safeguard the quantity and quality of water being discharged into the Everglades Ecosystem. The water quality improvement plans will detail the results of the experimental testing found to be effective in reducing total phosphorus (and other constituents) and will describe the full scale systems proposed for development.

HSA Engineers and Scientists (HSA), a member of the CRA Family of Companies, conducted pilot study investigations in the EAA on Post-Stormwater Treatment Area (STA) and Post Best Management Practices (BMP) surface waters. HSA conducted these investigations under SFWMD Contract number C-E10650, Chemical Treatment and Solids Separation Project (CTSS). These pilot study investigations used water treatment processes to assess their effectiveness at removing total phosphorus (Total P) on Post-STA and Post-BMP surface waters. Field investigations employed the use of pilot units housed in two tractor-trailers each containing flow meters, chemical feed systems, flash mix and flocculation tanks, flocculation mixers and inclined plate settlers/clarifiers. Using this pilot equipment, Total P was reduced to less than 10 micrograms per liter (g/L) as phosphorus consistently over a three week period of continuous testing on both Post-STA and Post-BMP EAA surface waters.

CTSS field trials in the EAA were completed at the end of 1999 and the tractor-trailer pilot facilities became available for use at other testing locations. In order to assess the effectiveness of chemical treatment processes on the ESP Urban Basins, HSA (under contract to SFWMD) moved one of the two portable pilot facilities to the Wellington/Acme Improvement District Pump Station G94D (also known as Pump Station number 2). The location of this Pump Station is shown on **Figure 1**. **Figure 2** provides photographs of the treatment trailer after it was installed near the Pump Station. The pilot unit was then operated both during periods of active pumping and during quiescent periods in order to determine the amount of phosphorus reduction achievable with chemical treatment on Wellington Basin B storm water runoff.

Selection of the Acme Pump Station number 2 as the initial location for urban testing was based, in part, on historical water quality data obtained from the eight urban/coastal tributary basins within the ESP. A listing of these eight basins including average Total P discharge concentrations available at that time (May 1, 1998 to April 30, 1999) is provided below:

Basin	Average Total P (ppb)
Wellington/ACME Improvement District	
Pump Station 1DS	144
Pump Station G94D (Pump Station 2)	187
Boynton Farms (Palm Beach County)	N/A
North Springs Improvement (Broward County)	18
North New River (Broward County)	N/A
C-11 West (Broward County – S9)	19
C-111 (Miami-Dade)	7-12
L-28 (Hendry, Collier and Broward)	55
Feeder Canal (Hendry)	76

Since the Wellington Pump Station number 2 surface waters have produced among the highest average concentrations for the listed urban basins, it was considered a good candidate location for initial urban testing as it would appear to represent the "worst case" scenario in terms of assessing P removal effectiveness.

2.0 TESTING PROGRAM

HSA moved and installed the pilot unit test facility at the Wellington Pump Station number 2 during the August and September 2000, time period. The location of Pump Station number 2 within the Wellington Drainage Basin is shown in **Figure 1**. **Figure 2** provides a photograph of the CTSS pilot unit positioned next to the pump station. **Figure 3** provides an aerial view of the trailer next to Pump Station number 2.

The intake hose for the feed flow to the pilot unit was suspended from a steel cable that was strung across the upstream feed canal. The hose was positioned in the center of the canal and approximately 30 feet upstream of the pump structure. The hose was submersed approximately 2 feet below the canal water level. The feed water was delivered to the chemical treatment trailer by means of a centrifugal pump positioned under the treatment trailer and connected by a two–inch suction line to the intake structure. **Figures 4a and 4b** provide photographs of the intake structure positioned upstream of the pump structure.

Urban stormwater testing was conducted during a total of six independent events. Four of these events were during time periods of active pumping while the remaining two were during times that no pumping was occurring. It was requested that some testing be completed on the canal waters when there was no pumping in order to assess the ability of the treatment system to remove phosphorus during low flow, stagnant canal conditions.

As shown schematically in **Figure 5**, feed water first enters the CTSS pilot unit in the coagulation tank. Chemical coagulant is added to this 20-gallon tank to destabilize suspended solids and colloidal matter. Dispersion of these process chemicals is achieved by a mechanical mixer located in the coagulation tank. From the coagulation tank, the water flows into the first of two identical flocculation tanks equipped with variable speed mechanical mixers. The relatively low energy input provides ideal conditions for the formation of larger size floc. This process further augmented by the dosage of a coagulant aid (polymer) into either of the flocculation cells. The hydraulic detention time in each flocculator tank is roughly 17 minutes at the typical feed flow rate of 12 gpm. The mechanical mixer speed in the first flocculation tank is maintained a rate of 10 revolutions per minute (RPM) and the second flocculation tank mixer is operated at 5 RPM.

The separation of fully formed flocs takes place in the downstream clarifier unit. The 6-square foot plan area clarifier is equipped with 28 inclined settling plates with a total projected surface area of 28 ft^2. Each plate was one-foot deep by two-feet wide and inclined 60 degrees from vertical. Clarifier surface loading rates were investigated in the range of 0.14 gpm / sq.ft. to 0.28 gpm / sq.ft. The clarified water exits the unit through a collector trough or weir. Underdrain residual solids from the clarifier are periodically discharged to the residual solids holding tank / pond.

During the pilot testing, samples were collected periodically (*e.g.*, every 2 to 4 hours). Influent, effluent and solids samples were collected and analyzed for soluble reactive, total dissolved and Total P forms. Additional samples were collected on a less frequent basis for more complete nutrient, and heavy metal characterization.

Specific testing protocols evaluated during the program included:

- Testing of ferric chloride, acid alum and aluminum chloride, plus an anionic polymer to aid with the settling of the generated solids;
- Initial jar testing on representative storm water samples to obtain a better idea of effective chemical dosing and flocculation / settling times for these urban waters;
- Varying the clarifier overflow rates;
- Determining solids production rates;
- TCLP characterization of solids; and,
- Determination of coagulant dose required and experimental conditions required to reduce Total P to less than 10 ppb.

3.0 PILOT TESTING RESULTS

3.1 Jar Test Results

Table 1 and **Table 2** provide the results of the jar testing conducted at the onset of the project. Jar testing was conducted on representative storm water samples collected from Wellington Pump Station number 2 during active pumping. **Appendix A** to the report provides a copy of the complete jar testing protocol used for these experiments. Both aluminum chloride and ferric chloride coagulants were evaluated and testing variables included coagulant type, coagulant dose, and settling time. As shown in **Table 1**, the lowest settled Total P results were obtained using ferric chloride at a dose of 38 mg/L (as iron) coupled with a settling time of 40 minutes. These conditions yielded a Total P value of 12 ppb in the settled water. Using a concentration of 18 mg/L of aluminum chloride (as aluminum) and a settling time of 40 minutes produced a settled Total P of 13 ppb. Jar testing results suggested that using either aluminum chloride or ferric chloride would produce low Total P results when added in the indicated amounts. These jar test experimental conditions were used to develop pilot unit conditions to be employed during storm water testing.

3.2 Pilot Testing Phosphorus Response To Experimental Variables

Table 3 provides a summary of the pilot unit testing dates, experimental test conditions used during each trial, and resulting Total P responses. For all testing trials, a constant coagulation retention time of 1.7 minutes was maintained and a flocculation total hydraulic retention time of 33 minutes was used.

Run numbers 1 and 2 used higher clarifier loading rates (0.21 to 0.28 gpm/square foot of projected area) and the lowest Total P concentration achieved during these trials was 24 ppb. When the clarifier overflow rate of 0.14 gpm/square foot of projected area was used, Total P results of less than 10 ppb were achieved. In run number 4, when feeding a concentration of 47 mg/L of ferric chloride (as Fe), and using a clarifier overflow rate of 0.14, the Total P concentration was equal to 7 ppb in the clarified effluent. Using aluminum chloride in run number 5 at a concentration of 12 mg/L (as Al) yielded an effluent Total P of 6 ppb. As indicated in **Table 3**, run number 5 was also completed using a clarifier overflow rate of 0.14 gpm.

Run number 3 was conducted using acid alum as the coagulant. Acid alum contains aluminum sulfate in a sulfuric acid solution. It was hypothesized that acid alum would produce low Total P results while using lower aluminum dosages. During run number 3, acid alum was titrated into the pilot unit to achieve a steady state pH range of between 5.5 to 6.0. The corresponding concentration of aluminum added to achieve this pH range was equal to 7 mg/L as aluminum. An average effluent concentration of 17 ppb of Total P was obtained during this test suggesting that acid alum alone will not produce an effluent of 10 ppb or less of Total P.

3.3 SFWMD Low Level Mercury Results

Representatives from SFWMD collected feed and filtrate samples for trace level mercury analysis during the October 30, 2000, pilot unit testing. Analyses were performed for filtered and total methyl mercury and filtered and total mercury on representative grab samples of feed and filtrate samples. Total mercury and methyl mercury analyses were also collected and analyzed on the clarifier underdrain solids.

The average total mercury concentration of the feed sample was equal to 1.31 nanograms/L (*see* **Table 3**). Unfiltered total mercury was reduced approximately 28 percent with the effluent total mercury concentration equal to 0.94 nanograms/L. Filtered total mercury was reduced approximately 98 percent. Mercury removed by the CTSS pilot unit is accumulated in the clarifier underdrain solids. The concentration of total mercury in the concentrated solids from the CTSS treatment system was equal to 35.7 nanograms/L.

3.4 Bioassay and Algal Growth Potential (AGP) Results

Bioassay and AGP analyses were performed by the FDEP Biology Section on CTSS treatment technology water samples collected October 30. 2000. Summary results for the bioassay and AGP analyses are provided in **Appendix B**. Tests were performed following USEPA guidelines, but substituting *C. leedsi* for the fathead minnow, *Pimephales promelas* (EPA/600/4-91/002). Algal Growth Potential (AGP) tests were performed on the influent and were conducted following USEPA guidelines (EPA-600/9-78-018). Specific tests conducted included the following:

- Seven-day chronic estimator (screening) tests using the bannerfin shiner (*Cyprinella leedsi*) test;
- Seven-day chronic estimator (screening) tests using the water flea (*Ceriodaphnia dubia*) test; and
- A 96-hour growth test using the unicellular green alga (*Selenastrum capricornutum*) test.

Tests were performed following USEPA guidelines, but substituting *C. leedsi* for the fathead minnow, *Pimephales promelas* (EPA/600/4-91/002). Algal Growth Potential (AGP) tests were performed on the influent and were conducted following USEPA guidelines (EPA-600/9-78-018).

Feed and filtrate samples were collected simultaneously to determine if any observed effects were the result of the feed waters or from the CTSS treatment process. There was no significant impact identified from the bioassay sampling completed during testing that could be attributed to the CTSS treatment system. The influent sample collected for the AGP test yielded a concentration of 0.81 mg dry weight per liter. The pilot unit effluent sample recorded a much lower value of 0.13 mg dry weight per liter.

3.5 Additional Water Quality Results

Extensive water quality testing was conducted on pilot unit influent and effluent samples during each of the six experimental runs. **Table 4** provides the results of these water quality analyses on tests conducted while using ferric chloride as the coagulant. Of the parameters tested, those showing no significant difference in **Table 4** between the pilot unit influent and effluent include:

Ammonia Nitrogen	Calcium	Chromium
Lead	Magnesium	Nitrate
Potassium	Silica	Selenium
Sodium	Zinc	

Iron increased from an average of 0.55 mg/L in the feed to the pilot unit to 1.7 mg/L in the pilot unit effluent. This increase is due to the addition of unreacted ferric ions in the effluent stream. The chloride concentration increased to an average of 97 mg/L in the pilot unit effluent from a feed concentration of 35 mg/L. This increase is attributed to the chloride contained in the ferric chloride coagulant.

Alkalinity, pH, organic carbon, color and turbidity were all reduced from the feed water concentrations due to the acidic nature of the ferric salts being added and also due to the precipitation and coagulation reactions occurring within the pilot testing facility.

Table 5 provides the results of these water quality analyses on tests conducted while using aluminum-based coagulants. Of the parameters tested, those showing no significant difference in **Table 5** between the pilot unit influent and effluent include:

Ammonia Nitrogen	Calcium	Chromium
Lead	Magnesium	Nitrate
Potassium	Silica	Selenium
Sodium	Zinc	

Aluminum increased from an average of 0.59 mg/L in the feed to the pilot unit to 1.2 mg/L in the pilot unit effluent. This increase is due to the addition of unreacted aluminum ions in the effluent stream. The chloride concentration increased to an average of 71 mg/L in the pilot unit effluent from a feed concentration of 40 mg/L. This increase is attributed to the chloride contained in the aluminum chloride coagulant.

Alkalinity, pH, organic carbon, color, iron and turbidity were all reduced due to the acidic nature of the aluminum salts being added and also due to the precipitation and coagulation reactions occurring within the pilot testing facility.

3.6 Residual Solids Characterization

On January 8, and February 22, 2001, representative samples of the clarifier underdrain solids were collected and submitted to the FDEP Laboratory in Tallahassee for full toxicity characteristic leachate procedure (TCLP) analyses. The results of the samples collected are provided in **Table 6**. As shown in **Table 6**, all of the analytical results on the residual solids were well below respective allowed limits for TCLP parameters and, by definition, the CTSS residual solids are non-hazardous. Off-site disposal of these solids is scheduled with a licensed waste disposal contractor.

4.0 CONCEPTUAL DESIGN AND PRELIMINARY COST ESTIMATE FOR A FULL-SCALE CTSS APPLICATION

4.1 Development of Hydraulic and Total Phosphorus Design Criteria

Flow data used in developing facility conceptual designs was obtained from historical information for Wellington Pump Station numbers 1 and 2 for the time period of August 31, 1998, through August 31, 2000. The combined mean flow for Pump Stations 1 and 2 during this two-year period equals 110.6 million gallons per day (mgd) (average flow for days of pumping only). The mean flow plus two standard deviations (274.4 mgd) was used as the maximum flow considered in the hydraulic analysis. Out of a total 732 days of record, Wellington Pump Station number 1 pumped a total of 186 days and Wellington Pump Station number 2 recorded a total of 195 days of actual pumping. The average Total P concentration used in developing the design criteria was based upon historical data provided by the District. The average Total P concentration used for Pump Station number 1 was equal to 144 ppb of Total P and for Pump Station number 2 equivalent to 187 ppb.

4.2 Development of Conceptual Designs for Full-Scale Treatment Facilities

The full-scale facility was designed to achieve a flow weighted average effluent Total P concentration of 10 ppb with 0 percent flow diversion. This approach resulted in full-scale treatment scenario shown in **Table 7**. The design criteria was established by optimizing the size of the water treatment plant required to treat incoming storm waters compared to the size of a flow equalization basin (FEB) that would store high volumes of waters resulting from short duration, high intensity rainfall events. The waters stored in the FEB would be treated by the plant during the subsequent hours and days following a storm event. Using a fill and draw hydraulic model to evaluate various plant versus FEB sizes, the optimum plant was determined to be 125 mgd of treatment capacity coupled with a 200-acre FEB. Assumptions used in developing the treatment system are summarized below.

- Rainfall and evapotranspiration from FEB were not considered.

- Total P removal within the FEB is 20 percent.

- The full-scale CTSS system will be able to operate at a peak hydraulic capacity of 50 percent greater than its average daily design flow rate for limited time periods.

- The CTSS technology coupled with aluminum chloride addition will produce an average clarified effluent Total P concentration of at least 0.006 mg/L as P. This concentration was obtained in the clarifier effluent concentrations during the urban testing.

- Raw untreated water would be blended with the CTSS effluent to achieve the respective target discharge concentration of 0.01 mg/L.

- The full-scale treatment scenario was based on a scale-up of the CTSS urban pilot data.

The conceptual design for the resulting 125 mgd full-scale facility is illustrated in **Figure 6**.

Urban storm waters after flow splitting would be pumped into parallel concrete basin coagulators where aluminum chloride will be fed at an average dose of 12 mg/L as Al. Coagulated water would flow into parallel concrete flocculation basin where an anionic polymer would be fed into the system at an average dose of 0.5 mg/L. The water would then be clarified in parallel concrete basins equipped with lamella plate settlers. The effluent pumping station would be used to discharge the treated water into the conservation area.

As shown in **Figure 7**, residual solids would be discharged to an onsite storage lagoon, with a hydraulic detention time of 3 days. Supernatant overflow from the solids storage area would be returned to the FEB for treatment. Settled solids in the lagoon would be pumped to a dedicated land application facility. The estimated required area for this dedicated solids disposal area is equal to 72 acres and is based upon an annual solids loading rate of 28 tons of dry solids per acre per year (USEPA, 1996). The solids production rate used for these calculations was based upon actual solids generated by the pilot unit and was equivalent to 375 pounds of solids (with aluminum chloride as the coagulant) per million gallons of treated water.

The 200-acre FEB would be operated using a maximum water height of 4.5 feet, allowing for 4 feet of water storage (0.5 feet to 4.5 feet). The treatment plant would operate at a peak hydraulic capacity of 50 percent greater than its average daily design flow rate when the water level within the equalization basin reached 3.5 feet.

4.3 Cost Estimates for Full-Scale Implementation

SFWMD provided unit costs for selected capital, operation and maintenance (O&M), replacement, and salvage items. The cost estimate data were developed from equipment supplier quotations and prior engineering experience. **Note that all operation and maintenance costs are based on the number of actual operation days and the actual volume of treated water, and are not based upon 365-days per year operation.** "The Basis for Cost Estimates of Full-Scale Alternative Treatment (Supplemental) Technology Facilities" (August 1999), prepared by Brown and Caldwell (B&C) for SFWMD, was also used to source various unit costs and is referenced where appropriate.

The full-scale facility treatment costs are provided in **Table 7**. Further details on the development of costs for the major categories identified in the detailed cost estimate tables follow.

Capital Costs

- ***Equipment, Tankage, and Piping***

The equipment, tankage, and piping cost includes capital costs associated with concrete tanks (coagulators, flocculators, and clarifiers), lamella clarifier plates, mechanical equipment (mixers and solids collectors), treatment plant piping, and excavation.

Tanks - A typical treatment plant will consist of 4 square coagulators, 4 rectangular flocculators, and 4 rectangular clarifiers.

The tanks are concrete with 12-foot sidewalls, 18-inch thick base, and 12-inch thick walls.

Clarifier Plates – The required clarifier projected plate area was calculated using a hydraulic loading rate of 0.14 gpm/ft^2 and an entrance adjustment factor of 0.8. The number of plate packs required was calculated based on a projected area of 2090 ft^2 for each plate pack. Then the clarifier plate cost was determined using a unit cost of $25,000 per pack (Parkson Corporation)

Mechanical Equipment – The coagulator mechanical equipment capital costs were estimated using $889 per million gallons of average daily design flow. The flocculator mechanical equipment was estimated based on $2,100 per million gallon of average daily design flow. The clarifier scraper costs were estimated using a unit cost of $33 per square foot of clarifier basin (Parkson Corporation).

Piping – The piping costs were calculated based on typical unit costs ($ per linear feet of piping) to purchase and install treatment plant piping.

- ***Residuals Management***

PEER/B&C (August 1996) estimated a base construction cost for residual solids treatment and disposal facilities of $20,000 per mgd of average daily design flow. This cost was developed assuming residual solids thickening in settling ponds followed by underground injection on an adjacent dedicated land disposal site.

- ***Chemical Feed System***

HSA estimated a capital cost for the chemical feed system of 2.5 percent of the treatment plant equipment, tankage, and piping costs. This cost includes aboveground storage tanks, spill containment, pumps, and piping.

- ***Instrumentation and Electrical***

HSA estimated a capital cost for the treatment plant instrumentation and electrical of 15 percent of the treatment plant equipment, tankage, and piping costs.

- ***Power Distribution***

SFWMD provided a unit cost for the electrical power distribution to the treatment plant of $80,000 per mile.

- ***Civil Work***

One water control structure will be installed in the CTSS influent/discharge canal. This structure will control the amount of untreated water to be blended with the CTSS effluent water, prior to discharge to the conservation area. SFWMD provided a unit cost of $300,000 for a gated water control structure.

- ***Pumping Stations***

SFWMD provided unit construction costs for pumping stations based upon the pump capacity (cfs).

- ***Land***

Land acquisition costs were calculated at a price of $25,000 per acre (HSA). An additional 10 percent more land was allowed for easements, right-of-ways, and buffers (B&C, August 1996).

Operating Costs

- ***Labor***

Labor costs were estimated assuming a projected staffing plan for 24-hour per day operation and a unit cost of $30 per hour (includes fringe benefits) per employee.

- ***Maintenance***

Mechanical - SFWMD provided unit costs for maintenance of selected mechanical items. Operating costs were calculated using these unit costs for pumping stations (influent, effluent, and seepage) and for the treatment plant building / support facilities.

Levees - Levee operating costs were calculated for the levees surrounding the FEB cell using the SFWMD-provided unit cost for levee maintenance ($1,500 / mile / year).

- ***Chemicals***

Chemical costs were estimated based on the pilot studies chemical dosage. Nominal chemical dosages of aluminum chloride (12 mg / L as Al) were used to calculate chemical costs.

- ***Energy***

Electricity - Electrical consumption was estimated based on the estimated treatment plant power consumption and a unit cost of $0.08 per kwh (SFWMD).

Fuel Consumption – The pumping stations included in the full-scale facility conceptual design would be diesel power. SFWMD provided a unit rate of 0.55 gallons of diesel fuel consumed per acre-foot of water pumped. Using a unit rate of $0.90 per gallon of diesel fuel, the annual fuel consumption was calculated based on the total volume of water pumped by the pumping stations.

- ***Residual Solids Treatment and Disposal***

The cost of operating and maintaining the residual solids treatment and disposal equipment were estimated based on $1,200 per mgd of nominal treatment plant size (B&C, August 1996).

Demolition/Replacement Costs

- *Demolition Costs*

  Demolition costs were estimated at 20 percent of the treatment plant and pumping station's construction costs (B&C, August 1996).

- *Replacement Costs*

  The following replacement costs items were considered (B&C, August 1999):

  - FEB pump stations - 25 percent of costs replaced once at 25 years;
  - Treatment plant pumping stations - 50 percent of costs replaced once at 25 years;
  - Chemical feed systems - 60 percent of costs replaced every 10 years; and
  - Treatment plant equipment - 25 percent of plant cost replaced at 20th and 40th years.

Salvage Costs

Salvage estimates were prepared considering both salvage value and salvage costs (B&C, August 1996). These costs include restoration costs, and land value. It was assumed that the land purchased for residuals solids disposal was dedicated and no land value or restoration costs were assigned (B&C, August 1996).

Lump Sum Items

- *Telemetry* – SFWMD provided a lump sum telemetry cost of $100,000.

- *Sampling and Monitoring* - It was assumed that sampling and monitoring of the treatment plant would cost approximately $500,000 per year (SFWMD).

- *Treatment Plant Building/Support Facilities* - was estimated at a lump sum of $500,000.

4.4 Present Worth Analysis and Economic Analysis

Fifty (50) year present worth costs were calculated using a net discount rate of 4 percent and are provided in **Table 7**. The total lump sum 50-year present worth cost (capital and O&M) of the 125 mgd facility is equal to $100,121,311.

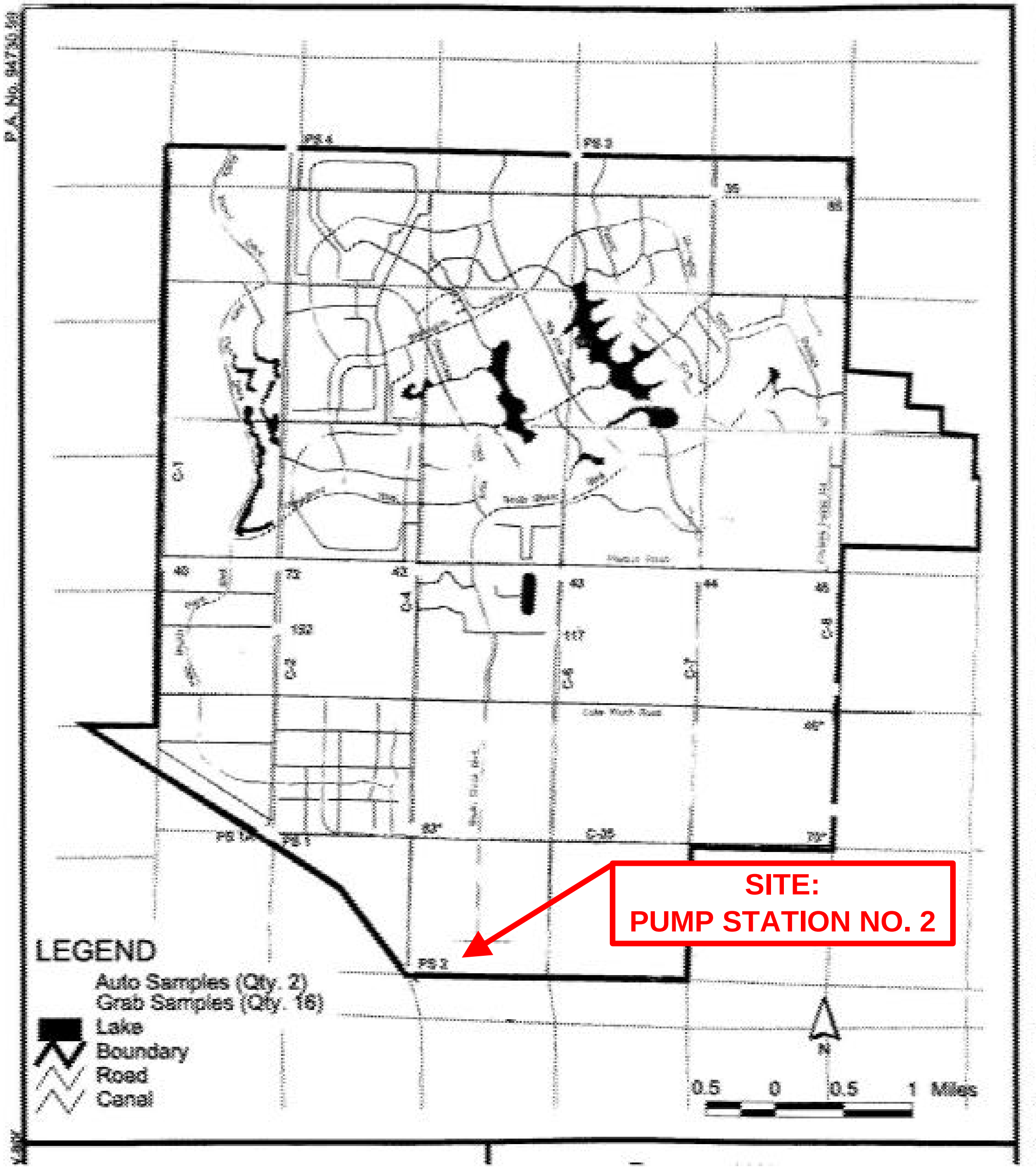

FIGURE 1.

Village of Wellington
DRAINAGE BOUNDARIES

8005.3731.01 **May-01**

FIGURE 2.

CTSS TREATMENT TRAILER
at Wellington Pump Station No. 2

8005.3731.01 May-01

FIGURE 3.

CTSS TREATMENT TRAILER
at Wellington Pump Station No. 2 (aerial)

8005.3731.01 May-01

FIGURES 4a and 4b.
PILOT UNIT INTAKE STRUCTURE IN UPSTREAM CANAL

8005.3731.01 ***May-01***

FIGURE 7.
CONCEPTUAL DESIGN SCHEMATIC

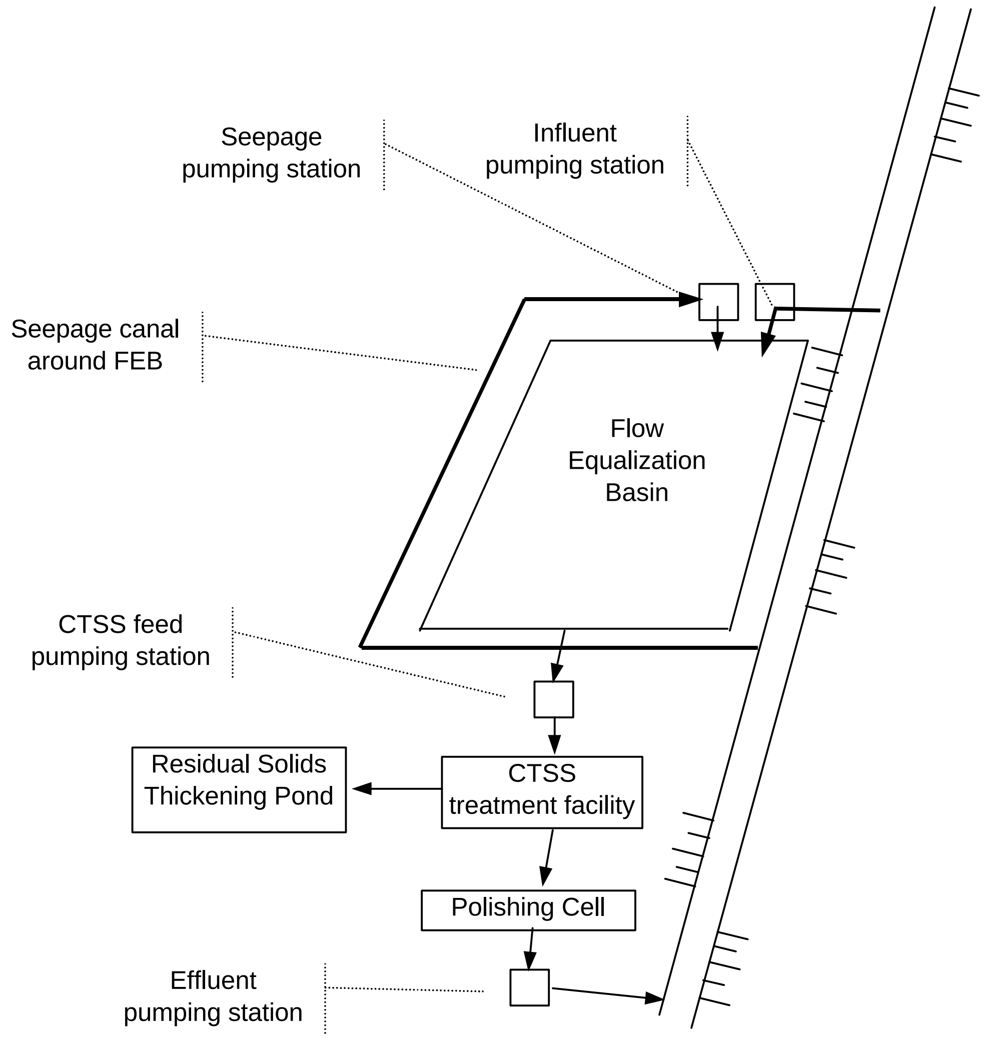

TABLE 1.
JAR TESTING RESULTS

JAR TEST NUMBER: **1**

GENERAL CONDITIONS: **Factorial Design Matrix**

SOURCE WATER: **Canal Water, Pumps Operating**

SPECIFIC CONDITIONS:

	JAR					
	1	**2**	**3**	**4**	**5**	**6 (DI)**
Coagulant:	**AlCl**	**$FeCl_3$**	**AlCl**	**$FeCl_3$**	**AlCl**	**---**
Dose (mg/L as Fe):	**9**	**19**	**18**	**38**	**18**	**---**
Polymer (mg/l):	**0**	**0**	**0**	**0**	**0**	**0**
Flash Mix Time (seconds):	**45**	**45**	**45**	**45**	**45**	**45**
Flocculation time (minutes):	**10**	**10**	**10**	**10**	**10**	**10**
Settling Time (minutes):	**40**	**40**	**40**	**40**	**40**	**40**
Final pH:	**6.72**	**6.31**	**6.16**	**6.17**	**6.24**	**3.84**
Observations:						

TEST RESULTS:

Total Phosphorus (mg/L as P):	**0.022**	**0.037**	**0.013**	**0.012**	**14.0**	**<0.004**
Total Dissolved Phosphorus (mg/L as P):	**0.009**	**0.009**	**0.006**	**0.006**	**0.006**	**<0.004**
Soluble Reactive Phosphorus (mg/L as P):	**<0.004**	**0.005**	**<0.004**	**<0.004**	**<0.004**	**<0.004**

NOTES:

1) Raw water initial pH = 7.76 ; Total P = 0.105 mg/L ; Total Dissolved P = 0.037 mg/L; Soluble Reactive P = 0.023 mg/L
2) Flocculation RPM Speed = 10 ; Coagulation RPM Speed = 250

Sample date is 23 Oct 00

TABLE 2.
JAR TESTING RESULTS

JAR TEST NUMBER: **1**

GENERAL CONDITIONS: **Factorial Design Matrix**

SOURCE WATER: **Canal Water, Pumps Operating**

SPECIFIC CONDITIONS:

	JAR					
	1	**2**	**3**	**4**	**5**	**6 (DI)**
Coagulant:	**AlCl**	**$FeCl_3$**	**AlCl**	**$FeCl_3$**	**AlCl**	**---**
Dose (mg/L as Fe):	**9**	**19**	**18**	**38**	**18**	**---**
Polymer (mg/l):	**0**	**0**	**0**	**0**	**0**	**0**
Flash Mix Time (seconds):	**45**	**45**	**45**	**45**	**45**	**45**
Flocculation time (minutes):	**10**	**10**	**10**	**10**	**10**	**10**
Settling Time (minutes):	**20**	**20**	**20**	**20**	**20**	**20**
Final pH:	**6.72**	**6.31**	**6.16**	**6.17**	**6.24**	**3.84**
Observations:						

TEST RESULTS:

Total Phosphorus (mg/L as P):	**0.034**	**0.028**	**0.019**	**0.022**	**0.014**	**<0.004**

NOTES: **1) Raw water initial pH = 7.76; Total P = 0.105 mg/L ; Total Dissolved P = 0.037 mg/L; Soluble Reactive P = 0.023 mg/L**
2) Flocculation RPM Speed = 10 ; Coagulation RPM Speed = 250

Sample date was 23 Oct 00

TABLE 3.
URBAN STORMWATER TESTING PROGRAM
CTSS - WELLINGTON
(PROJECT# C-11901)

Run No.	Date	Pumping	Throughput (gallons)	Coagulant Type	Coagulant Dose (mg/L as metal)	Clarifier Loading Rate (gpm/ft2)	Influent concentration (mg/L) TP	Influent TDP	Influent SRP	Equilibrium Average Effluent concentration (mg/L) TP	Effluent TDP	Effluent SRP	Solids concentration (mg/L) TP	Solids TDP	Solids SRP
1	9/20/00	Yes	4383	Ferric Chloride	38	0.28	0.127	0.059	0.015	0.024	0.022	0.004	2.14	0.545	0.166
2	9/21/00	No	2667	Ferric Chloride	28	0.21	0.094	0.191	0.008	0.035	0.013	<0.004	0.845	0.291	0.107
3	10/4 - 10/5	Yes	10469	Acid alum	7	0.14	0.318	0.26	0.211	0.017	0.006	<0.004	2.85	0.293	0.223
4	10/5/00	Yes	3433	Ferric Chloride	47	0.14	0.24	0.186	0.155	0.007	0.006	<0.004	2.33	0.014	0.006
5	10/6/00	Yes	2593	Aluminum chloride	12	0.14	0.224	0.154	0.124	0.006	0.009	<0.004	2.25	0.038	0.013
6	10/30/00	No	3973	Aluminum chloride	16	0.14	0.064	0.03	0.006	0.025	0.019	<0.004	0.8	0.105	0.004
6	10/30/00	No	**Biotoxicity Testing**		**No adverse effects observed**										

Mercury Testing

Run No.	Feed THg UF	Feed MeHg UF	Feed THg F	Feed MeHg F	Filtrate THg UF	Filtrate MeHg UF	Filtrate THg F	Filtrate MeHg F	Solids THg UF	Solids MeHg UF
6	1.31	0.289	22.0	0.171	0.940	0.140	0.550	0.089	35.7	1.135

Percent Removal THg UF	MeHg UF	THg F	MeHg F
28%	52%	98%	48%

Notes: 1. All units in nanograms/liter (ng/L)
2. THg UF = total mercury unfiltered; MeHg UF = methyl mercury unfiltered; THg F = total mercury filtered; MeHg F = methyl mercury filtered

TABLE 4.
RESULTS OF WATER QUALITY PARAMETERS
USING IRON COAGULANTS (RUN NOS. 1, 2, AND 4)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Alkalinity (as $CaCO_3$), mg/L (MDL = 0.5 mg/L)			
Mean	165	97	75
Max	196	136	124
Min	120	30.0	20
N	3	4	3
S.D	40	48	52
Aluminum, ug/L (MDL = 2.5 ug/L)			
Mean	433	10	9610
Max	765	18	18800
Min	172	2.5	4510
N	3	4	3
S.D	303	6	7975
Ammonia Nitrogen (as N), mg/L (MDL = 0.004 mg/L)			
Mean	0.165	0.204	0.606
Max	0.238	0.263	1.170
Min	0.060	0.161	0.290
N	3	4	3
S.D	0.093	0.049	0.490
Calcium, mg/L (MDL = 0.02 mg/L)			
Mean	83	82	106
Max	86	83	108
Min	81	80	104
N	2	3	2
S.D	4	1	3
Chloride, mg/L (MDL = 0.3 ug/L)			
Mean	35	97	94
Max	43	106	106
Min	25	93	84
N	3	4	3
S.D	10	6.0	11
Chromium, ug/L (MDL = 0.5 ug/L)			
Mean	1.2	0.95	187
Max	1.4	1.4	256
Min	1.0	0.50	120
N	3	4	3
S.D	0.21	0.52	68
Color, CPU (MDL = 5.0 CPU)			
Mean	203	51	9833
Max	360	75	12500
Min	100	20	7000
N	3	4	3
S.D	138	26	2754

TABLE 4.
RESULTS OF WATER QUALITY PARAMETERS
USING IRON COAGULANTS (RUN NOS. 1, 2, AND 4)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Copper, ug/L (MDL = 1.0 ug/L)			
Mean	5.4	3.5	144
Max	8.2	4.0	221
Min	2.7	2.4	74
N	3	4	3
S.D	2.8	0.8	74
Iron, ug/L (MDL = 4.0 ug/L)			
Mean	555	1730	456667
Max	648	2530	617000
Min	486	1020	297000
N	3	4	3
S.D	84	792	160001
Lead, ug/L (MDL = 3.0 ug/L)			
Mean	3.0	2.6	39
Max	3.0	3.0	46
Min	3.0	1.5	30
N	3	4	3
S.D	0.00	0.75	8
Magnesium, mg/L (MDL = 0.01 mg/L)			
Mean	4.6	4.7	5.2
Max	5.7	5.5	6.4
Min	3.5	3.4	4.1
N	3	4	3
S.D	1.1	1.0	1.1
Nitrate Nitrogen (as N), mg/L (MDL = 0.004 mg/L)			
Mean	0.103	0.090	0.081
Max	0.163	0.143	0.216
Min	0.062	0.067	0.004
N	3	4	3
S.D	0.053	0.036	0.117
Potassium, mg/L (MDL = 0.04 mg/L)			
Mean	5.9	6.0	6.3
Max	6.1	6.1	6.7
Min	5.7	5.7	6.0
N	3	4	3
S.D	0.20	0.21	0.36
Reactive Silica, mg/L (MDL = 0.2 ug/L)			
Mean	8.2	8.2	7.3
Max	8.9	8.7	9.4
Min	7.6	7.6	3.2
N	3	3	3
S.D	0.67	0.6	3.5

TABLE 4.
RESULTS OF WATER QUALITY PARAMETERS
USING IRON COAGULANTS (RUN NOS. 1, 2, AND 4)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Selenium, ug/L (MDL = 0.1 ug/L)			
Mean	1.9	1.8	16
Max	2.5	2.0	20
Min	1.0	1.0	7.4
N	3	4	3
S.D	0.78	0.50	7.3
Sodium, mg/L (MDL = 0.1 mg/L)			
Mean	22	24	21
Max	29	29	28
Min	15	15	13
N	3	4	3
S.D	7.0	6.4	7.7
Sulfate, mg/L (MDL = 2.0 mg/L)			
Mean	24	20	21
Max	30	23	24
Min	18	16	17
N	3	3	3
S.D	5.8	4	4
Total Dissolved Solids (TDS), mg/L (MDL = 3.0 mg/L)			
Mean	289	323	304
Max	317	376	380
Min	242	234	260
N	3	4	3
S.D	41	62	66
Total Kjeldahl Nitrogen (TKN), mg/L (MDL = 0.1 mg/L)			
Mean	1.6	0.9	4.4
Max	1.9	1.1	8.3
Min	1.5	0.6	1.8
N	3	4	3
S.D	0.25	0.19	3.4
Total Organic Carbon (TOC), mg/L (MDL = 2.0 mg/L)			
Mean	25	12	273
Max	29	15	350
Min	18	7.0	210
N	3	4	3
S.D	6.1	3.8	71

TABLE 4.
RESULTS OF WATER QUALITY PARAMETERS
USING IRON COAGULANTS (RUN NOS. 1, 2, AND 4)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Total Solids, mg/L (MDL = 3.0 mg/L)			
Mean	281	311	1363
Max	334	361	1560
Min	224	202	1060
N	3	4	3
S.D	55	75	267
Total Suspended Solids (TSS), mg/L (MDL = 2.0 mg/L)			
Mean	14	8	1261
Max	22	12	1750
Min	8.0	4.0	772
N	3	4	3
S.D	7.2	4.1	489
Turbidity, ntu (MDL = 0.1 ntu)			
Mean	6.3	1.6	276
Max	10	1.9	700
Min	4.4	1.1	38
N	3	4	3
S.D	3.2	0.33	368
Zinc, mg/L (MDL = 2.0 mg/L)			
Mean	7	7	107
Max	10	12	118
Min	5.4	4.3	88
N	3	4	3
S.D	2	3	17

TABLE 5.
RESULTS OF WATER QUALITY PARAMETERS
USING ALUMINUM COAGULANTS (RUN NOS. 3, 5, AND 6)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Alkalinity (as $CaCO_3$), mg/L (MDL = 0.5 mg/L)			
Mean	138	102	65
Max	210	144	136
Min	100	60.0	10
N	4	2	3
S.D	49	59	64
Aluminum, ug/L (MDL = 2.5 ug/L)			
Mean	593	1245	172667
Max	1470	1912	216000
Min	162	632.0	110000
N	4	3	3
S.D	593	642	55582
Ammonia Nitrogen (as N), mg/L (MDL = 0.004 mg/L)			
Mean	0.172	0.203	0.243
Max	0.256	0.385	0.372
Min	0.003	0.003	0.094
N	4	3	3
S.D	0.116	0.192	0.140
Calcium, mg/L (MDL = 0.02 mg/L)			
Mean	78	77	94
Max	78	77	94
Min	78	77	94
N	1	1	1
S.D	---	---	---
Chloride, mg/L (MDL = 0.3 ug/L)			
Mean	40	71	83
Max	74	130	146
Min	23	22	22
N	4	3	3
S.D	23	55	62
Chromium, ug/L (MDL = 0.5 ug/L)			
Mean	1.0	0.60	65
Max	2.0	0.8	158
Min	0.50	0.50	7.3
N	4	3	3
S.D	0.67	0.17	82
Color, CPU (MDL = 5.0 CPU)			
Mean	139	18	2668
Max	180	25	5000
Min	100	10	5
N	4	2	3
S.D	34	11	2514

TABLE 5.
RESULTS OF WATER QUALITY PARAMETERS
USING ALUMINUM COAGULANTS (RUN NOS. 3, 5, AND 6)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Copper, ug/L (MDL = 1.0 ug/L)			
Mean	6.0	1.3	80
Max	7.1	1.9	102
Min	5.1	0.70	58
N	3	2	2
S.D	1.0	0.85	31
Iron, ug/L (MDL = 4.0 ug/L)			
Mean	539	194	18620
Max	586	324	39500
Min	412	69	7970
N	4	3	3
S.D	85	127	18084
Lead, ug/L (MDL = 3.0 ug/L)			
Mean	2.7	3.0	15
Max	3.0	3.0	30
Min	1.8	3.0	6.2
N	4	3	3
S.D	0.60	0.00	13
Magnesium, mg/L (MDL = 0.01 mg/L)			
Mean	6.1	7.0	7.2
Max	14.0	14.2	14.3
Min	3.2	3.1	3.4
N	4	3	3
S.D	5.27	6.2	6.1
Nitrate Nitrogen (as N), mg/L (MDL = 0.004 mg/L)			
Mean	0.113	0.136	0.029
Max	0.216	0.251	0.077
Min	0.008	0.013	0.004
N	4	3	3
S.D	0.086	0.119	0.041
Potassium, mg/L (MDL = 0.04 mg/L)			
Mean	6.1	6.3	6.7
Max	7.8	7.9	8.2
Min	5.5	5.4	5.9
N	4	3	3
S.D	1.1	1.4	1.3
Reactive Silica, mg/L (MDL = 0.2 ug/L)			
Mean	9.2	7.8	5.4
Max	14	12	6.7
Min	6.7	3.9	3.5
N	4	2	3
S.D	3.2	5.5	1.7

TABLE 5.
RESULTS OF WATER QUALITY PARAMETERS
USING ALUMINUM COAGULANTS (RUN NOS. 3, 5, AND 6)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Selenium, ug/L (MDL = 0.1 ug/L)			
Mean	2.2	2.0	4
Max	2.6	2.0	6
Min	2.0	2.0	2.0
N	4	3	3
S.D	0.30	0.0	1.9
Sodium, mg/L (MDL = 0.1 mg/L)			
Mean	24	27	27
Max	51	52	51
Min	14	14	14
N	4	3	3
S.D	17.79	21.07	21.02
Sulfate, mg/L (MDL = 2.0 mg/L)			
Mean	20	90	57
Max	36	146	143
Min	7.0	35	10
N	4	2	3
S.D	12	79	75
Total Dissolved Solids (TDS), mg/L (MDL = 3.0 mg/L)			
Mean	329	363	339
Max	497	478	463
Min	239	248	260
N	3	2	5
S.D	146	163	84
Total Kjeldahl Nitrogen (TKN), mg/L (MDL = 0.1 mg/L)			
Mean	1.5	0.8	10
Max	2.0	1.1	16
Min	1.3	0.59	5.9
N	4	3	3
S.D	0.32	0.27	5.2
Total Organic Carbon (TOC), mg/L (MDL = 2.0 mg/L)			
Mean	22	10	227
Max	29	17	250
Min	18	5.0	200
N	4	3	3
S.D	5.1	6.1	25

TABLE 5.
RESULTS OF WATER QUALITY PARAMETERS
USING ALUMINUM COAGULANTS (RUN NOS. 3, 5, AND 6)
PUMP STATION G-94D

Parameter	Influent	Effluent	Residual Solids
Total Solids, mg/L (MDL = 3.0 mg/L)			
Mean	293	312	1323
Max	454	482	1440
Min	232	190	1210
N	4	3	3
S.D	108	152	115
Total Suspended Solids (TSS), mg/L (MDL = 2.0 mg/L)			
Mean	8	5	1277
Max	11	10	1460
Min	2.0	2.0	1180
N	4	3	3
S.D	3.9	4.6	159
Turbidity, ntu (MDL = 0.1 ntu)			
Mean	6.2	3.5	643
Max	9	5.8	750
Min	3.6	1.9	550
N	4	3	3
S.D	2.0	2.0	101
Zinc, mg/L (MDL = 2.0 mg/L)			
Mean	35	26	111
Max	60	39	143
Min	9.8	2.5	77
N	4	3	3
S.D	21	20	33

TABLE 6.
TOXICITY CHARACTERISTIC LEACHING PROCEDURE

TCLP Analysis - The Toxicity Characteristic Leaching Procedure (TCLP) is used to characterize wastes as hazardous or non-hazardous based on the Toxicity Characteristic Rule published in the Federal Register (40CFR 261.24) in 1990. The rule lists 39 toxic substances and maximum concentrations for each.

The table below lists the federal limits for the Toxicity Rule and the results of samples collected on January 8, 2001 and February 22, 2001 from the Wellington Pump Station No.2 test Site. The samples were composites of aliquots collected from the iron and aluminum residual solids holding tanks.

PARAMETERS	EPA METHOD REFERENCE	FEDERAL LIMITS (mg/L)	Sampling Date	Results (mg/L)	REPORTING LIMIT (mg/L)
Metals (mg/L):					
Arsenic	6010	5.0	February 22, 2001	<0.1	0.1
Barium	6010	100.0	February 22, 2001	0.27*	
Cadmium	6010	1.0	February 22, 2001	<0.0075	0.0075
Chromium	6010	5.0	February 22, 2001	<0.030	0.03
Lead	6010	5.0	February 22, 2001	<0.080	0.08
Mercury	245.1	0.2	February 22, 2001	<0.0010	0.001
Selenium	6010	1.0	February 22, 2001	<0.20	0.2
Silver	6010	5.0	February 22, 2001	0.0017**	
Volatiles (mg/L):					
Benzene	8260	0.5	February 22, 2001	<0.0005	0.0005
Carbon tetrachloride	8260	0.5	February 22, 2001	<0.0002	0.0002
Chlorobenzene	8260	100.0	February 22, 2001	<0.0002	0.0002
Chloroform	8260	6.0	February 22, 2001	<0.0002	0.0002
1,2-Dichloroethane	8260	0.5	February 22, 2001	<0.0002	0.0002
1,1-Dichloroethylene	8260	0.7	February 22, 2001	<0.0002	0.0002
Methyl ethyl ketone	8260	200.0	February 22, 2001	n/a	
Tetrachloroethylene	8260	0.7	February 22, 2001	n/a	
Trichloroethylene	8260	0.5	February 22, 2001	<0.0002	0.0002
Vinyl chloride	8260	0.2	February 22, 2001	<0.0005	0.0005
Semivolatiles (mg/L):					
o-Cresol	625/8270 mod.	200.00	January 8, 2001	<0.004	0.004
m, p-Cresols	625/8270 mod.	200.00	January 8, 2001	<0.004	0.004
1,4-Dichlorobenzene	625/8270 mod.	7.5	January 8, 2001	<0.002	0.002
2,4-Dinitrotoluene	625/8270 mod.	0.13	January 8, 2001	<0.002	0.002
Hexachlorobenzene	625/8270 mod.	0.130	January 8, 2001	<0.002	0.002
Hexachlorobutadiene	625/8270 mod.	0.5	January 8, 2001	<0.006	0.006
Hexachloroethane	625/8270 mod.	3.0	January 8, 2001	<0.006	0.006
Nitrobenzene	625/8270 mod.	2.0	January 8, 2001	<0.004	0.004
Pentachlorophenol	625/8270 mod.	100.0	January 8, 2001	<0.006	0.006
Pyridine	625/8270 mod.	5.0	January 8, 2001	<0.008	0.008
2,4,5-Trichlorophenol	625/8270 mod.	400.0	January 8, 2001	<0.002	0.002
2,4,6-Trichlorophenol	625/8270 mod.	2.0	January 8, 2001	<0.002	0.002
Pesticides (mg/L):					
Chlordane	8080	0.030	January 8, 2001	<0.0002	0.0002
Lindane	8080	0.4	January 8, 2001	<0.00001	0.00001
Methoxychlor	8080	10.0	January 8, 2001	<0.00005	0.00005
Toxaphene	8080	0.5	January 8, 2001	<0.00075	0.00075
Endrin	8080	0.02	January 8, 2001	<0.00005	0.0005
Heptachlor	8080	0.008	January 8, 2001	<0.00001	0.00001
Herbicides (mg/L):					
2,4-D	1311	10.0	January 8, 2001	<0.002	0.002
2,4,5-TP (Silvex)	1311	1.0	January 8, 2001	<0.002	0.002

*Notes: * Reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.*

*** Reported value is the mean of two or more determinations and is an estimated value.*

TABLE 7.
STSOC UNIT COST SUMMARY
125 MGD CTSS

	Item/Task	Unit	Unit cost	Quantity	Total	Comments/Explanation
1	**Capital Cost**					
1.1.1	Equipment, tankage, and piping[1]		L.S.		$ 13,374,970	
1.1.2	Residuals management	$/mgal avg.daily design flow	$ 20,000	125	$ 2,500,000	B&C Desktop, 1988
1.1.3	Chemical feed system		L.S.		$ 334,374	2.5% of equipment cost includes AST, pumps, piping
1.2	Freight		L.S.		$ -	
1.3	Installation		L.S.		$ -	
1.4	Instrumentation and Electrical		L.S.		$ 2,006,245	15% of equipment cost
1.5	Electrical power distribution	$/mile	$ 80,000	0.5	$ 40,000	
1.6	Civil Work- water control structures					
1.6.1	84" culvert open	per structure	$ 20,000	$ -	$ -	
1.6.2	84" culvert with gate	per structure	$ 35,000	$ -	$ -	
1.6.3	With gates	per structure	$ 300,000	1	$ 300,000	
1.6.4	Without gates	per structure	$ 150,000	$ -	$ -	
1.7.1	Canals (digging - no blasting)					
1.7.1.1	Canals - deep excavation	$/cubic yard	$ 3.50	$ -	$ -	
1.7.1.2	Canals - shallow excavation	$/cubic yard	$ 2.50	10952	$ 27,380	Perimeter seepage canal
1.7.2	Canals (including blasting)					
1.7.2.1	Canals - deep excavation	$/cubic yard	$ 4.50	$ -	$ -	
1.7.2.2	Canals - shallow excavation	$/cubic yard	$ 3.50	$ -	$ -	
1.8.1	Levees (no blasting)					
1.8.1.1	Internal- 7' (4.5' SWD)	$/mile	$ 390,000	$ -	$ -	
1.8.1.3	External- 8' (4.5' SWD)	$/mile	$ 485,000	1.25	$ 606,250	
1.8.1.4	External- 9' (4.5' SWD)	$/mile	$ 562,000	$ -	$ -	
1.8.1.5	External-10' (4.5' SWD)	$/mile	$ 703,000	$ -		
1.9.1	Pumping stations - influent					
1.9.1.1	FEB Influent pumping station	$/cfs	$ 7,500	425	$ 3,187,500	275 MGD
1.9.1.2	CTSS Influent pumping station	$/cfs	$ 9,900	195	$ 1,930,500	125 MGD
1.9.2	Pumping stations - effluent					
1.9.1.2	Effluent pumping station	$/cfs	$ 7,500	425	$ 3,187,500	275 MGD
1.9.3	Pumping stations - seepage					
1.9.3.1	0-40 cfs	$/cfs	$ 7,600	$ -	$ -	
1.9.3.2	41-60 cfs	$/cfs	$ 9,500	$ -	$ -	
1.9.3.3	60-500 cfs	$/cfs	$ 9,900	70	$ 693,000	
1.1	Interior land preparation					
1.10.1	Disking	$/acre	$ 60		$ -	
Subtotal					$ 28,187,719	
Construction contingencies					$ 5,637,544	20% of capital costs
Subtotal, construction costs					$ 33,825,263	
Engineering and Design costs					$ 5,073,790	15% of construction costs
1.11	Land					

TABLE 7.
STSOC UNIT COST SUMMARY
125 MGD CTSS

	Item/Task	Unit	Unit cost	Quantity	Total	Comments/Explanation
1.11.1	Equalization basin	$acre	$ 25,000	200	$ 5,000,000	
1.11.2	Treatment, solids thickening, buffer cell	$/acre	$ 25,000	5	$ 125,000	
1.11.3	Residuals management	$/acre	$ 25,000	72	$ 1,800,000	28.4 dry tons solids/acre/yr
1.12	6" gravel access roads (12 ft wide road)	$/linear ft	$ 150		$ -	
TOTAL CAPITAL COSTS					$ 45,824,053	
PRESENT WORTH - CAPITAL COST					$ 45,824,053	
2	**OPERATING COSTS (per year)**					
2.1	Labor	hr	$ 30	18720	$ 561,600	
2.1.1	Engine operator/Maintenance mechanic	each	$ 50,000			
2.1.2	Lead operator	each	$ 60,000			
2.2.1.1	Mechanical maintenance (lubrication, spare parts, etc.)- 500- 3,000 cfs pumps	per unit	$ 23,000		$ -	
2.2.1.2	Mechanical maintenance- 0-500 cfs pumps	per unit	$ 10,000	4	$ 40,000	
2.2.2	Maintenance (water control structures)	each	$ 12,000	1	$ 12,000	
2.2.3	Maintenance (building)	per unit	$ 12,000	1	$ 12,000	
2.2.4	Maintenance - levees	$/mile	$ 1,500	1.25	$ 1,875	
2.2.5	Maintenance (vegetation control)	$/acre	$ 22		$ -	
2.2.6					$ -	
2.2.7					$ -	
2.2.8	Maintenance- residual solids treatment	$/mgal avg.daily design flow	$ 1,200	125	$ 150,000	B&C Desktop, 1988
2.3	chemicals					
2.3.1	Aluminum chloride	Dry ton	$ 160	2700	$ 432,000	
2.3.2	PAC	lb	$ 0.20		$ -	
2.3.3	Ferric chloride	$/mgal treated	$ 86		$ -	
2.3.4	Ferric sulfate	lb	$ 0.40		$ -	
2.3.5	Lime				$ -	
2.3.6	Polymer	$/mgal treated	$ 8	10822	$ 90,255	$4,000/ton
2.3.7	Others				$ -	
2.4	Solids disposal	Tons	$ 50		$ -	
2.5	Energy				$ -	
2.5.1	Electricity	kwh	$ 0.08	1320460	$ 105,637	
2.5.2	Fuel consumption	acre-feet	$ 0.50	101800	$ 50,900	0.55 gal/acre-foot @ $0.9/gallon
2.6	Sampling and monitoring	yr			$ 500,000	
TOTAL OPERATING COSTS					$ 1,956,267	
PRESENT WORTH - OPERATING COSTS					$ 42,059,747	
3	**Demolition/Replacement Costs**					
3.1	Demolition costs	Lump sum			$ 4,474,694	20% of treatment plant/pumping stations capital
3.2	Restoration of levees	$/yard	$ 3	10952	$ 32,856	
3.3	Restoration of FEBs		$ -		$ -	
3.4	Clearing and grubbing		$ -		$ -	
	Light folliage	$/acre	$ 300	200	$ 60,000	
	Forest/heavy brushes	$/acre	$ 1,500			
3.5	Replacement items					

TABLE 7.
STSOC UNIT COST SUMMARY
125 MGD CTSS

	Item/Task	Unit	Unit cost	Quantity	Total	Comments/Explanation
3.5.1	Seepage pumping stations	Lump sum			$ 346,500	50% of cost replaced once at 25 years
3.5.2	FEB/CTSS pumping stations	Lump sum			$ 4,152,750	50% of cost replaced once at 25 years
3.5.3	Chemical feed system	Lump sum			$ 200,625	60% of cost replaced every 10 years
3.5.4	Treatment plant equipment	Lump sum			$ 3,343,742	25% of plant cost replaced at 20th and 40th year
TOTAL DEMOLITION/REPLACEMENT COSTS					$ 12,611,167	
PRESENT WORTH - DEMOLITION/REPLACEMENT COSTS					$ 12,611,167	
4	**Salvage Cost**					
4.1	Salvage Cost	$acre	$ 25,000	277	$ (6,925,000)	STA, FEB, and treatment plant land
TOTAL SALVAGE COSTS					$ (6,925,000)	
PRESENT WORTH - SALVAGE COSTS					$ (973,655)	
5	**Lump Sum/ Contingency Items**					
5.1	Telemetry	Lump sum			$ 100,000	SFWMD
5.1.1	Pump Stations	$/unit	$ 50,000		$ -	accounted for
5.1.2	Water Control Structures	$unit	$ 25,000		$ -	accounted for
5.2	FPL Improvements	Lump sum	$ -		$ -	accounted for
5.3	Treatment plant building/ support facilities	Lump sum	$ -		$ 500,000	10,000 S.F building with equipment
TOTAL LUMP SUM ITEMS					$ 600,000	

50-YEAR PRESENT WORTH

CAPITAL COST	$ 45,824,053
OPERATING COST	$ 42,059,747
DEMOLITION/REPLACEMENT COST	$ 12,611,167
SALVAGE COST	$ (973,655)
LUMP SUM COST	$ 600,000
TOTAL	$ 100,121,311
$/MILLION GALLONS TREATED	185.03
$/POUND P REMOVED	134.18

Note:

[1] Equipment, tankage, and piping = Capital costs asssociated with concrete tanks (coagulators, flocculators, and clarifiers), clarifier plates, mechanical equipment (mixers and scrapers), treatment plant piping, and excavation.

APPENDIX A

Proposal for Jar Testing
Pilot Scale Treatability Studies
for the Everglades Stormwater Program

INTRODUCTION

The South Florida Water Management District (SFWMD) initiated the Everglades Stormwater Program (ESP) after the legislature enacted the Everglades Forever Act (EFA) in 1994. The two major issues of ESP were (1) Everglades agricultural area (EAA) phosphorus reduction, and (2) the management of urban and tributary basins.

In 1999, SFWMD contracted HSA Engineers & Scientists (HSA) to conduct a pilot scale testing program on two distinct water sources within the EAA. The objective of the program was the assessment of feasible chemical treatment technologies, which could reduce total phosphorus (TP) concentration below 10 μg/l. The concentration of raw water TP varied from 15 μg/l up to 250 μg/l. The research project concluded that under certain settings of the operational variables the objective could be met.

The SFWMD has identified two additional urban pumping stations for pilot scale investigations. These stations are (1) G-94D, and (2) S-9. The initial jar test is to investigate chemically assisted settling characteristics of water supplied from pumping station G-94D. EAA surface waters typically contain elevated levels of color, dissolved organic carbon, and phosphorus. Surface waters generally contain lower color in urban basins than the EAA waters. Since color content can increase chemical dosing (*i.e.*, more coagulant required to remove the higher color), a lower color content in the urban waters could potentially result in less chemicals needed to achieve a 10 μg/l TP level. Since color and the efficiency of phosphorus removal of the same source often correlate, an effective removal of TP is expected. The average TP concentration at the Wellington G-94D pumping station was 187 μg/l during a twelve months period from May 1, 1998.

Defining optimum coagulation-flocculation conditions can be time consuming and expensive in actual or even pilot scale treatment facilities. Therefore, HSA recommends conducting a series of jar tests to provide baseline information in an expeditious and cost-effective manner.

OBJECTIVES AND BENEFITS

The overall objective of the jar-testing program is to investigate different physico-chemical experimental conditions and their effect on TP reduction.

The major benefit of the jar-testing program will be the development of baseline knowledge of the expected impact of the introduction of treatment chemicals on water quality. The outcome of the proposed jar-testing program will be used as a starting point for pilot studies planned under this scope of work.

DESCRIPTION OF PROPOSED TESTING

HSA will collect representative water samples at the G-94D pumping station site upon a storm event. After a minimum of two-hour pumping, the sample will be collected from the pump discharge line. After delivering the raw surface water samples to SFWMD laboratories, the jar testing will commence as expeditiously as possible or practical. The G-94D sampling location is shown in **Figure 1**.

A standard Phipps and Bird six-place gang stirrer will be used for the investigation. The unit is supplied with six square plexiglas jars with a liquid volume of 2 liters each. In addition to the easy insertion of a sample tap, the square shape Gator jar setup helps dampen rotational velocity while their plexiglas walls offer sufficient thermal insulation, thus minimizing temperature change during testing.

EXPERIMENTAL APPROACH

Sorting out the few significant variables that most significantly effect TP removal can be time consuming and expensive, unless a logical basis is found which minimizes the necessary effort and maximizes the probability that important variables will be identified and their effects estimated. The techniques used to achieve these objectives are those of experimental design. A factorial-type experiment is proposed to identify important variables. By systematically altering the variables from one experiment to the next, the experimental design method will give good estimates of the effects of variables. It will also give additional, important information, which the classical method of altering only one variable at a time cannot.

For each water source, HSA suggests to investigate a total of four operational variables in the jar test program. The proposed variables are (1) coagulant type, (2) coagulant dosage concentration, (3) flocculation time, and (4) settling time. The major system response is TP concentration. Additional response parameters including (1) pH, (2) turbidity, (3) apparent color, (4) total dissolved phosphorus (TDP), (5) soluble reactive phosphorus (SRP), (6) total suspended solids (TSS), (7) hardness, (8) alkalinity, (9) aluminum, and (10) iron will also be monitored and recorded.

HSA recommends to investigate the identified four variables at two design levels. Both the proposed design factors and design levels are identified for a single water source in **Table 1**. The proposed quantitative levels of settling time are 20 and 40 minutes.

Table 1: 2^3 Factorial Design Matrix for a Single Water Source

Segment	Experiment	Variables: Coagulant Type - alum + ferric-chloride	Variables: Coagulant Dosage Concentration* - 1 mew + 2 mew	Variables: Flocculation Time - 20 minutes** + 40 minutes***
1	1	-	-	-
	2	+	-	-
	3	-	+	-
	4	+	+	-
	duplicate #1	+	+	-
	control #1			
2	5	-	-	+
	6	+	-	+
	7	-	+	+
	8	+	+	+
	duplicate #2	+	+	+
	control #2			

Notes: * *1 mew Al = 9 mg/L as Al*
1 mew Fe = 19 mg/L as Fe
** *10 minute @ 40 RPM followed by additional 10 minutes @ 20 RPM*
**** *20 minute @ 40 RPM followed by additional 20 minutes @ 20 RPM*
mew = milli equivalent weight

JAR TESTING PROTOCOL

Major steps of a jar-testing program are summarized below. For detailed outline see APHA, AWWA, and WEF (1992) Standard Methods for the Examination of Water and Wastewater, 18^{th} Edition. The proposed analytical plan is summarized in **Table 2**.

- Fill 2 liter raw water samples into each jar;
- Initiate rapid mixing at 250 rpm;
- Inject the identified concentration of coagulant into the jars expeditiously and continue mixing at 250 rpm for an additional 45 seconds;
- After 45 seconds of rapid mixing, reduce the agitation intensity to 40 rpm for a duration of 10 or 20 minutes as identified in **Table 2**;
- Reduce the agitation intensity to 20 rpm for a duration of 10 or 20 minutes as identified in **Table 2**;
- Introduce 0.3 mg/L coagulant aid (A-130) into the jars expeditiously shortly after reducing agitation speed to 20 rpm;
- Stop agitation, remove mixing blades from all jars and allow flocs to settle;
- Take supernatant samples after 20 minutes and 40 minutes of the commencement of quiescent settling; and
- Identify and submit samples to SFWMD personnel for analysis.

Table 2: Proposed Jar Test Analytical Plan

Analyzed Parameter	Water Source		
	Raw Water	Water after 20 Minutes of Settling	Water after 40 Minutes of Settling
PH	●	●	●
Turbidity	●	●	●
Apparent color	●		●
TP	●	●	●
TDP	●		●
SRP	●		●
TSS	●		●
Hardness	●		●
Alkalinity	●		●
Total organic carbon	●		●
Aluminum	●		●
Iron	●		●
Calcium	●		●
Magnesium	●		●

SCHEDULE AND PERSONNEL

The sampling and subsequent jar testing of the surface waters will take place shortly after a storm event. HSA qualified personnel will conduct the collection, delivery, and jar testing of surface waters, as well as the evaluation of the laboratory data. SFWMD will arrange for analysis of the submitted samples for the suggested parameters in **Table 2**. Prior to jar testing, the required amounts of samples for each analysis should be determined. Arrangements for appropriate bottles will also be made with the contract laboratory identified by SFWMD.

HSA will prepare and submit a draft report on the jar testing results within two weeks of obtaining the laboratory analytical data from SFWMD.

Biological Analysis Report

SFWMD-2000-10-31-01

Florida Department of Environmental Protection
Central Laboratory
2600 Blair Stone Road
Tallahassee, FL 32399-2400
CompQAP# 870688G

Event Description: Toxicity Testing - Influent and Effluent

Request ID: RQ-2000-10-30-29

Customer: SFWMD

Project ID: SOLID-SEP

Job: TLH-2000-10-31-31 Group: AGP/LN
Job: TLH-2000-10-31-32 Group: Toxicology

Send Reports to
South Florida Water Management District
SFWMD
8894 Belvedere Rd.
West Palm Beach, FL 33411
Attn: Patrick Martin

For additional information please contact
Steven H. Wolfe - Administrator
Robert Buda - Bench Biology
Joy Jackson - Invertebrate Zoology
J. Marshall Faircloth - Aquatic Toxicology
Elizabeth Miller - Algal Biology
Melva Campos - Microbiology
Suncom 277-2245 Phone (850) 487-2245

Certified by:

Report Printed Date: Dec 20, 2000

Date:

Abbreviations and data remark codes

A - Value reported is the mean of two or more determinations
B - Results based on colony counts outside the acceptable range.
I -The reported value is between the laboratory method detection limit and the laboratory practical quantitaticn limit.
J - Estimated value
K - Actual value is known to be less than value given
I - Actual value is known to be greater than value given
N - Presumptive evidence of presence of material.
O - Sampled, but analysis lost or not performed.
Q - Sample held beyond normal holding time.
T - Value reported is less than the criterion of detection.
U - Material was analyzed for but not detected; The value reported is the minimum detection limit.
V - Analyte was detected in both sample and method blank.
Y - The laboratory analysis was from an unpreserved or improperly preserved sample. The data may not be accurate.
Z - Colonies were too numerous to count (TNTC).

Results for NELAP accredited tests contained in this report meet the requirements specified for the National Environmental Laboratory Accreditation Program.

APPENDIX B (page 1)

Sample Location: CTSS URBAN WELLINGTON
Field ID: EFFLUENT
Collection Date/Time: 10/30/2000 5:00 PM

Matrix: W-EFFLUENT

Lab ID	Storet Code	Component	Result	Code	Units
491695					

Test: Potential algal growth determination. (EPA 600/9-78-018 (mod.))

Comments: The AGP value is from day 14 of the test.

Lab ID	Storet Code	Component	Result	Code	Units
491695	85209	Algal Growth Potential	0.129	I	mg DryWtL

Lab ID	Storet Code	Component	Result	Code	Units
491697					

Test: Chronic toxicity test, screen, FW--freshwater fish. (EPA 600/4-89/001, Method 1000)

Comments: Average w eight in the 100% effluent sample was 0.340 mg per larvae. Average weight in the control was 0.455 mg per larve.

Lab ID	Storet Code	Component	Result	Code	Units
491697		Bioassay-Chronic-Scrn-FW-Fish, NOEC	100	K	NOEC

Test: Chronic toxicity test, screen, FW--water flea. (EPA 600/4-89/001, Method 1002.0)

Comments: Average reproduction in the 100% effluent sample was 23.9 neonates per adult. Average reproduction in the control was 21.5 neonates per adult.

Lab ID	Storet Code	Component	Result	Code	Units
491697		Bioassay -Chronic-Scrn-FW-C.dubia, NOEC	100	L	NOEC

Sample Location: CTSS URBAN WELLINGTON
Field ID: INFLUENT
Collection Date/Time: 10/30/2000 5:00 PM

Matrix: W-INFLUENT

Lab ID	Storet Code	Component	Result	Code	Units
491694					

Test: **Potential algal growth determination. (EPA 600/9-78-018 (mod.))**

Comments:
The AGP value is from day 14 of the test.

Lab ID	Storet Code	Component	Result	Code	Units
491694	85209	Algal Growth Potential	0.810		mg DryWtL

Lab ID	Storet Code	Component	Result	Code	Units
491696					

Test: Chronic toxicity test, screen, FW--freshwater fish. (EPA 600/4-89/001, Method 1000)

Comments:
Average weight in the 100% influent sample was 0.417 mg per larvae. Average weight in the control was 0.455 mg per larve.

Lab ID	Storet Code	Component	Result	Code	Units
491696		Bioassay-Chronic-Scrn-FW-Fish, NOEC	100	L	NOEC

Test: Chronic toxicity test, screen, FW--water flea. (EPA 600/4-89/001, Method 1002.0)

Comments:
Average reproduction in the 100% influent sample was 28.1 neonates per adult. Average reproduction in the control was 25.3 neonates per adult.

Bioassay-Chronic-Scrn-FW-C.dubia, NOEC	100	L	NOEC

Biological Analysis Report

SFWMD-2000-11-02-01

Florida Department of Environmental Protection
Central Laboratory
2600 Blair Stone Road
Tallahassee, FL 32399-2400
CompQAP# 8706886

Event Description: Toxicity Testing - Influent and Effluent

Request ID: RQ-2000-10-30-29

Customer: SFWMD

Project ID: SOLID-SEP

Job: TLH-2000-11-02-26

Group: Toxicology

Send Reports to
South Florida Water Management District
SFWMD
3301 Gun Club Road
West Palm Beach, FL 33411
Attn: Patrick Martin

For additional information please contact
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Steven H. Wolfe
David Whiting
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Melva Campos
Suncom 277-2245 Phone (850) 487-2245

Certified by:

Date:

Report Printed Date: Nov 21, 2000

Abbreviations and data remark codes

A - Value reported is the mean of two or more determinations
B - Results based on colony counts outside the acceptable range.
I -The reported value is between the laboratory method detection limit and the laboratory practical quantitaticn limit.
J - Estimated value
K - Actual value is known to be less than value given
I - Actual value is known to be greater than value given
N - Presumptive evidence of presence of material.
O - Sampled, but analysis lost or not performed.
Q - Sample held beyond normal holding time.
T - Value reported is less than the criterion of detection.
U - Material was analyzed for but not detected; The value reported is the minimum detection limit.
V - Analyte was detected in both sample and method blank.
Y - The laboratory analysis was from an unpreserved or improperly preserved sample. The data may not be accurate.
Z - Colonies were too numerous to count (TNTC).

Results for NELAP accredited tests contained in this report meet the requirements specified for the National Environmental Laboratory Accreditation Program.

Sample Location: CTSS URBAN WELLINGTON
Field ID: EFFLUENT
Collection Date/Time: 10/30/2000 5:00 PM

Matrix: W-EFFLUENT

Lab ID: **492141**	**Storet Code**	**Component**	**Result**	**Code**	**Units**
Test: Chronic toxicity test, screen, FW—freshwater alga (EPA 600/4-91/002					
		Bioassay -Chronic-Screen-FW-Algae, NOEC	100	L	NOEC

*** Analysis exceeds holding time ***

Comments:
Reproduction in the effluent sample was significantly greater than reproduction in the controls.

Sample Location: CTSS URBAN WELLINGTON
Field ID: INFLUENT
Collection Date/Time: 10/30/2000 5:00 PM

Matrix: W-INFLUENT

Lab ID: **492140**	**Storet Code**	**Component**	**Result**	**Code**	**Units**
Test: Chronic toxicity test, screen, FW—freshwatr alga (EPA 600/4-91/002					
		Bioassay-Chronic-Screen-FW-Algae, NOEC	100	L	NOEC

*** Analysis exceeds holding time ***

Comments:
Reproduction in the influent sample was significantly greater than reproduction in the controls.