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BUREAU OF AIR REGULATION

June 30, 2004

Mr. David Lloyd
U.S. Environmental Protection Agency, Region IV
61 Forsyth Street, S.E.
Atlanta, Georgia 30303

Via FedEx
Airbill No. 7912 8311 1771

Re: **Tampa Electric Company**
Consent Decree
Civil Action No. 99-2524 CIV-T-23F
Big Bend Station Early NO_x Reduction Results Report

Dear Mr. Lloyd:

On February 23, 2001, Tampa Electric Company (TEC) submitted an Early NO_x Reduction Plan (Plan) detailing projects that would be undertaken at Big Bend Station with the intent of achieving near term NO_x reductions. This Plan is required under Paragraph 35 of the Consent Decree and subsequent amendment dated September 10, 2001 (Amendment). It was approved by the United States Environmental Protection Agency (USEPA) on March 8, 2001. TEC indicated in section 6.0 of the Plan that an Early NO_x Emissions Reduction Update Report (Update Report) would be submitted to the USEPA no later than January 1, 2002. The Update Report detailed the effectiveness of each selected NO_x emission reduction technology and outlined a strategy for implementing additional NO_x emission reduction projects in 2002. The Update report was sent to the USEPA on December 12, 2001. In addition, Paragraph 35 of the Consent Decree and Amendment required TEC to submit a report detailing the results of the Plan and Update Reports. Enclosed is the Early NO_x Reduction Results Report that provides the information discussed above through December 31, 2003. Submission of this report satisfies Paragraph 35 of the Consent Decree and the Amendment.

If you have any questions, please feel free to telephone me at (813) 228-4408.

Sincerely,

Shelly Castro
Engineer, Air Programs
Environmental, Health & Safety

EHS\bmr\SSC197

Enclosure

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Tampa Electric Company

Big Bend Station Units 1 through 3
Early NO_x Reduction Results Report

TAMPA ELECTRIC

July 1, 2004

1.0 Executive Summary

Pursuant to the requirements set forth in the Consent Decree and subsequent amendment dated September 10, 2001 (Amendment), between the United States Environmental Protection Agency (USEPA) and Tampa Electric Company (TEC), TEC has completed several projects through December 31, 2003 with the intent of reducing NO_x emissions from Big Bend Station. The Consent Decree required TEC to employ projects that focused on the reduction of NO_x emissions from Big Bend Station while spending up to $3 million. The Early NO_x Emissions Reduction Projects were originally required to be implemented on or before December 31, 2002. The Amendment to the Consent Decree allowed for any modification of Big Bend Units 3 or 4 to be completed by December 31, 2003. TEC was also required to submit an Early NO_x Emissions Reduction Plan (Plan) to the USEPA on or before December 31, 2001 that described the technologies used in an effort to achieve the desired reductions. This Plan was submitted to USEPA on February 23, 2001 and approved by USEPA on March 8, 2001. The Plan specified that TEC would modify the burners serving Big Bend Unit 1, install a neural network on Big Bend Unit 2, evaluate the impacts of each technology on NO_x emissions and report the results to USEPA by January 1, 2002. In addition, TEC was required to provide details pertaining to future projects that were to be undertaken to reduce NO_x emissions from Big Bend Station as required by Paragraph 35 of the Consent Decree and the Amendment. The Early NO_x Emissions Reduction Update Report (Update Report) which provided the results from the modifications made to Big Bend Units 1 and 2 was submitted to USEPA on December 12, 2001. The Update Report also provided detailed information relevant to the future projects which TEC planned to implement to reduce NO_x emissions from Big Bend Station as required by Paragraph 35 of the Consent Decree and Amendment.

Based upon the performance of the low NO_x burner modifications installed on Big Bend Unit 1, TEC implemented low NO_x burner modifications on Big Bend Units 2 and 3. TEC also installed coal and air flow monitoring and control equipment on Big Bend Unit 1 and the neural network combustion optimization system on Big Bend Unit 2. With these modifications, TEC contributed to the NO_x emission reduction goals of 30%, 30% and 15% below 1998 levels for Big Bend Units 1, 2 and 3, respectively.

Through December 31, 2003 the NO_x emissions from Big Bend Units 1, 2 and 3 have been reduced to approximately 22%, 22%, and 3% below 1998 levels, respectively. Significant NO_x emissions reductions were achieved even though TEC did not meet the goals set forth in the Consent Decree. These reductions were accomplished with the $3 million that was spent on the Early NO_x Reduction Projects considering there were limited commercially demonstrated technologies that reduce NO_x emissions for the Riley Stoker Turbo® wet bottom boilers.

2.0 Introduction

Paragraph 35 of the USEPA Consent Decree required TEC to attempt to reduce NO_x emissions from Big Bend Units 1 through 3, as referenced against 1998 emission levels. Specifically, the emission reduction goals were 30% below 1998 levels for Big Bend Units 1 and 2 and 15% below 1998 levels for Big Bend Unit 3. The baseline emission rates were understood by TEC and USEPA to be as shown in Table 1 below:

Table 1 - Baseline and Goal Summary

Unit	1998 NO_x Emission Rate [lb/MMBtu]	Early NO_x Reduction Plan Emission Rate Goal [lb/MMBtu]
Big Bend Unit 1	0.86	0.60
Big Bend Unit 2	0.86	0.60
Big Bend Unit 3	0.57	0.48

TEC was required to expend up to $3 million on Big Bend Units 1 through 3 in pursuit of this objective. Big Bend Unit 4 may also be identified as a viable candidate for achieving early NO_x emission reductions as indicated in the Amendment. The Consent Decree requires that the methodology to be employed for the NO_x emission reduction strategy be based upon "…commercially available combustion optimization technologies, techniques, systems, or equipment, or combinations thereof."

2.1 Big Bend Station Generating Unit Descriptions

Big Bend Station Units 1 through 3 each utilize Riley Stoker Turbo® wet bottom boilers. TEC owns and operates the only known boilers of this type. Big Bend Unit 1 began commercial operation in October 1970, Big Bend Unit 2 began commercial operation in April 1973 and Big Bend Unit 3 began commercial operation in May 1976. These boilers are different from wall-fired boilers and other firing configurations in that the burners are aligned at a fixed downward angle to maintain high temperatures in the lower furnace to allow the slag to exist in a molten form. This is critical because the slag must be in liquid state in order to flow into a slag tank for collection. Any diversion of heat from this zone could cause the slag to solidify, making the operation of the boiler impossible.

Many of the commercially demonstrated available NO_x emission control technologies that are available for other types of boilers are not suited for application on the Riley Stoker Turbo® wet bottom boiler design due to the slag flow issues noted above. Because of this operational requirement, TEC relied on NO_x emission reduction techniques that did not reduce the lower furnace temperature.

3.0 Alternatives Considered

To satisfy the requirements of the Consent Decree for Early NO_x Reductions, TEC investigated and evaluated numerous NO_x emission control technologies for use on Big Bend Station Units 1 through 3. Due to the limited number of commercially available NO_x emission control technologies applicable for the Riley Stoker Turbo® wet bottom, TEC included emerging technologies and post-combustion NO_x emission reduction technologies as part of the review. The post combustion technologies were limited to selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR). In support of these investigations, TEC's research included:

- Review of public domain literature
- Interviews with operators of the same or similar technologies
- Consultations with independent consulting firms
- Presentations and proposals from system suppliers
- Internal engineering evaluation of the technologies

TEC used the following criteria to establish which technologies would be best suited for application at Big Bend Station:

Ranking of NO_x Potential

Each NO_x emission reduction technology was selected based upon its cost versus NO_x emission reductions potential. Those technologies that had the greatest potential for reducing NO_x emissions when compared to the cost of the technology were deemed to be the most prudent, provided that the requirements of the criteria listed below were satisfied. The Consent Decree specifically stated TEC was to spend up to $3 million.

Operating Risk

Potential adverse impacts of each technology as it related to unit operation were evaluated. This evaluation was primarily focused upon increased safety hazards to personnel and equipment, boiler fouling, the ability to maintain proper temperatures in the lower furnace to allow for slag tapping, waterwall wastage, impacts to the wet flue gas desulfurization system and impacts to the electrostatic precipitators.

Performance Risk

TEC recognized that the vast majority of NO_x emission control systems degrade unit performance to varying degrees. The performance degradation potential for the various NO_x emission reduction technologies was considered. The items considered included: unburned carbon, adverse impacts to the sale of flyash and other byproducts, unit capacity, and net heat rate.

Environmental Risk

The objective of the Early NO_x Reduction Plan was to reduce the NO_x emissions. Each technology was evaluated based upon its potential to emit other undesirable emissions.

Several technologies were evaluated in support of the Early NO_x Reduction Plan. A brief description for each technology is provided below.

Over-fired Air (OFA) Systems– OFA technology diverts some of the combustion air from the burners to air ports above the combustion zone, reducing the oxygen available at the burners. The reduction in oxygen results in a reduction in NO_x formation. The application of this technology to Big Bend Units 1 through 3 was determined to be unacceptable since it would change the temperature profile of the furnace floor. This would have a large negative operational and safety impact by solidifying the slag in the lower furnace causing unit shutdowns.

Selective Catalytic Reduction (SCR) – SCR removes NO_x from the flue gas stream by reacting ammonia and NO_x in the presence of a catalyst, to form molecular nitrogen and water vapor. This method of NO_x control can be extremely effective. This was not considered for the Early NO_x Reduction Plan since the cost of installing and operating this technology is much greater than the $3 million project dollar limit found in the Consent Decree.

Selective Non-Catalytic Reduction (SNCR) - SNCR technology has chemistry similar to SCR, but uses no catalyst and injects ammonia into specific temperature zones within the boiler. Ammonia is reacted with the NO_x present in the furnace to produce molecular nitrogen and water vapor. The cost for the installation and operation of this technology exceeds $3 million.

Burners and Air Staging - Modifying burners and staging localized combustion air can be a cost-effective method of achieving NO_x emission reductions. This technology utilizes a two-fold approach: 1) reduction of peak flame temperatures which lowers thermal NO_x generation; and 2) limiting excess oxygen during the initial stages of the combustion process which reduces fuel NO_x production.

Fuel and Primary Air Monitoring – Obtaining and maintaining fuel balance between the coal nozzles is necessary to help minimize NO_x emissions. Establishing uniform coal flow between the nozzles, control of the localized stoichiometric (fuel to air) ratios during combustion is essential to lower NO_x production. This project provides real-time monitoring of fuel and primary airflow to assist operators in optimizing the combustion process for NO_x control.

Reburning - Reburning reduces NO_x emissions by injecting fuel above the original combustion zone with insufficient combustion air creating a reducing atmosphere. The fuel injected can be natural gas, coal, or another suitable fuel.

When the NO_x from the original combustion zone reaches the reburn zone, the oxygen molecules are stripped from the NO_x and used to complete the combustion in the reburn zone. Reburn can result in adverse operational impacts such as increased levels of unburned carbon in the flyash, and a reduction in lower furnace temperatures. The cost for implementing a reburn system would exceed $3 million.

Neural Network Combustion Optimization Systems - The application of a neural network combustion optimization system (neural network) can be a cost-effective method of reducing NO_x emissions. This technology monitors numerous parameters associated with the combustion process and recommends or automatically adjusts specific parameters to satisfy the NO_x emission reduction objective. The neural network 'learns' over time what conditions produce the lowest NO_x emissions and adjusts the combustion process accordingly. This technology can reduce NO_x emissions while having minimal adverse impacts on operations.

Fuel Switch – NO_x emissions can be reduced through the firing of high moisture, low heat content coals, such as Powder River Basin coal. However, this fuel can cause adverse impacts on associated fuel handling, combustion systems and slagging. For example, high moisture, low heat content fuels tend to be more abrasive than the typical coal fired at Big Bend Station. This causes accelerated degradation in fuel handling systems which, in turn, will increase operational and maintenance expenditures at the plant. In addition, slagging of these fuels tend to become problematic for boilers originally designed for burning bituminous coal. Big Bend Station was designed to accommodate fuels that have a heat content between 10,500 and 12,000 Btu/kwh. These high moisture, low heat content fuels are significantly below this design heat content, which requires more fuel to be fired to generate an equivalent amount of electricity. Due to these potential adverse impacts, TEC determined that switching fuels to reduce NO_x emissions was infeasible.

Water Tempering - Water tempering reduces NO_x emissions by strategically directing a stream of water toward the flame with the goal of reducing the flame temperature. Because NO_x formation is highly dependent on flame temperature, a reduction in flame temperature results in a reduction of NO_x emissions. Implementation of this technology was deemed to be infeasible due to the physical location of the peak flame temperatures relative to the boiler design geometry.

Table 2 summarizes the results of TEC's investigations of the NO_x emission reduction technologies which could be applied to Big Bend Station Units 1 through 3.

Table 2 – Technology Summary

Technology	Cost	$/ton	Operating Risk	Performance Risk	Environmental Risk
Over-fired Air	**High**	**Med**	**High**	**High**	**Low**
SCR	**High**	**High**	**Med**	**Med**	**Med**
SNCR	**High**	**High**	**Med**	**Med**	**Med**
Low NO_x Burners	**Med**	**Med**	**Low**	**Med/Low**	**Low**
Fuel/Primary Air Monitoring	**Med**	**Med/Low**	**Low**	**Low**	**Low**
Reburning	**High**	**Med**	**High**	**Med/Low**	**Low**
Neural Networks	**Med**	**Med/Low**	**Low**	**Low**	**Low**
Fuel Switching	**High**	**Med/Low**	**Med/Low**	**Med/Low**	**Low**
Water Tempering	**Low**	**Low**	**High**	**High**	**Low**

4.0 Implementation Plan

TEC investigated several potential Early NO_x Reduction technologies for implementation at Big Bend Station. TEC selected those technologies with the highest probability for success as measured by the selection criteria that were within the project dollars limitation in the Consent Decree.

4.1 Big Bend Unit 1

TEC selected two technologies for the Early NO_x Reduction targets for this unit. These were low NO_x burners and fuel and primary air monitoring. For the low NO_x burners, TEC contracted a Computational Fluid Dynamic (CFD) modeling firm that successfully modeled other coal-fired steam generators to reduce NO_x emissions. The modeling effort included simulation of the effects of installing local air staging and OFA configurations. The results of the modeling indicated that an advanced coal nozzle design in conjunction with local air staging could reduce NO_x emissions. The OFA modeling results predicted that a drop in temperature at the slag tap location would be approximately 600 degrees Fahrenheit, which would prevent boiler operation. Low NO_x burners were selected because of the operational constraints of the boiler. The low NO_x burners became operational in April 2001 and cost $673,603.

TEC researched the market for systems that could achieve the requirements for fuel and primary air monitoring. This resulted in the selection the Electric Charge Technology (ECT) system which is licensed domestically to Foster Wheeler. This system uses an array of tungsten-carbide probes installed within the fuel pipes to detect small changes in electric charge density. These changes were calibrated against field test results to provide real-time mass flow, velocity and particle sizing. This information allowed the station engineers and operators to optimize fuel and primary air flow to achieve NO_x emission reductions. The system became operational in April 2002 and cost $458,332.

4.2 Big Bend Unit 2

Based upon the results of the low NO_x burner project on Big Bend Unit 1, TEC installed low NO_x burners on Big Bend Unit 2 which incorporated minor design changes from the Big Bend Unit 1 system. The burners became operational in December 2002 and cost $443,903.

In addition to the low NO_x burners, TEC installed a neural network combustion optimization system on Big Bend Unit 2. TEC contracted a consultant to research the market to identify neural network systems, prepare a bid specification and aid in the technical evaluation of the bids. Pegasus Technologies was the selected system supplier for the neural network system. The neural network system was installed in January 2001 and cost $885,077.

4.3 Big Bend Unit 3

Big Bend Unit 3 boiler is slightly different in design than Big Bend Units 1 and 2. CFD modeling was also performed on Big Bend Unit 3 to determine the effects of local air staging using low NO_x burners and OFA systems. Not unlike Big Bend Units 1 and 2, the OFA model predicted unacceptably low temperatures at the slag tap, which would prevent operation of the unit. TEC installed low NO_x burners on Big Bend Unit 3 which became operational April 2002 and cost $550,188.

4.4 Project Dollars

The actual allocation of project dollars for the technologies implemented for the Early NO_x Reduction Plan is shown below in Table 3.

Table 3 – Actual Allocation of Funds

Unit	Dollars
Big Bend Unit 1	**$1,131,935**
Big Bend Unit 2	**$1,328,980**
Big Bend Unit 3	**$550,188**
Total Dollars	**$3,011,103**

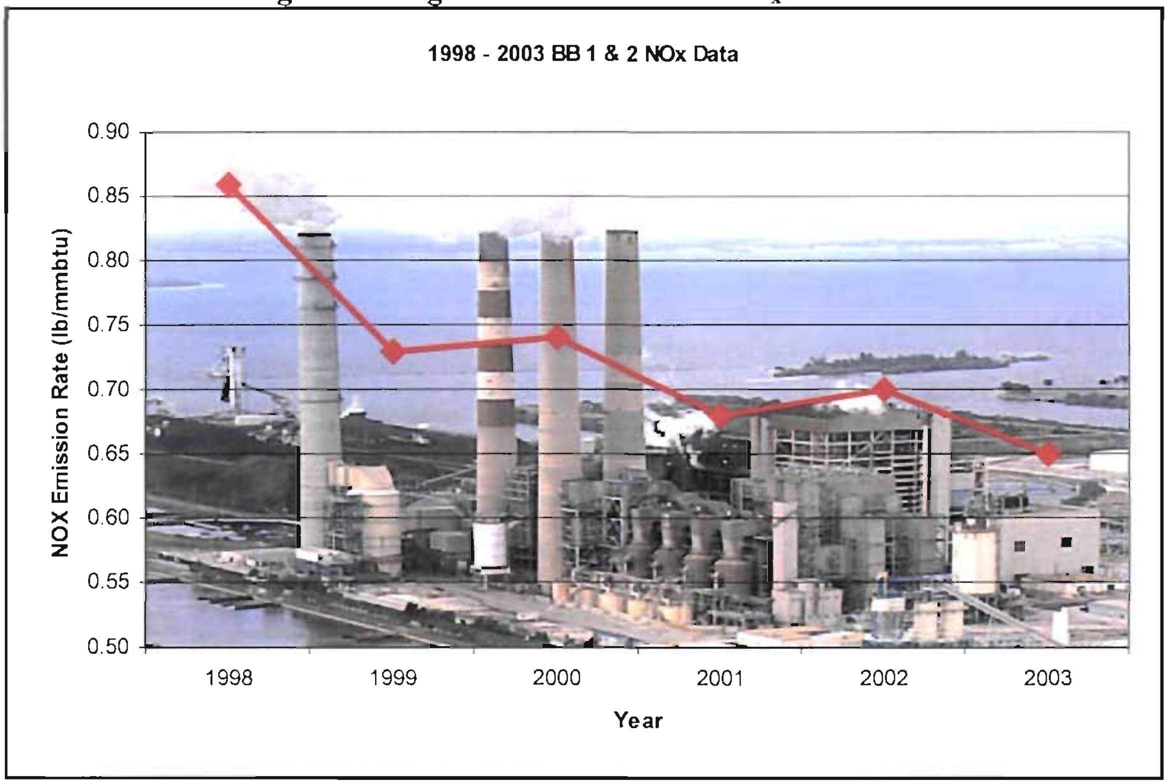
5.0 Results and Costs of Applied Technologies

TEC has satisfied Paragraph 35 of the Consent Decree by spending over $3 million on the Early NO_x Reduction Plan while achieving NO_x emission reductions from each coal fired generating unit at Big Bend Station. Below is a discussion of the results along with the costs of each of the applied technologies.

5.1 Big Bend Unit 1 and 2 NO_x Emissions

TEC's Big Bend Station Units 1 and 2 share a common stack and NO_x analyzer. Therefore, the results obtained from the Early NO_x Reduction Plan are combined for these units. Figure 1 illustrates the results of the Early NO_x Reduction Plan over time. The average emission rate for 2003 from these units was 0.65 lb/mmBTU. This represents an average rate reduction of approximately 22% in NO_x emissions as compared to the 1998 NO_x emission rate.

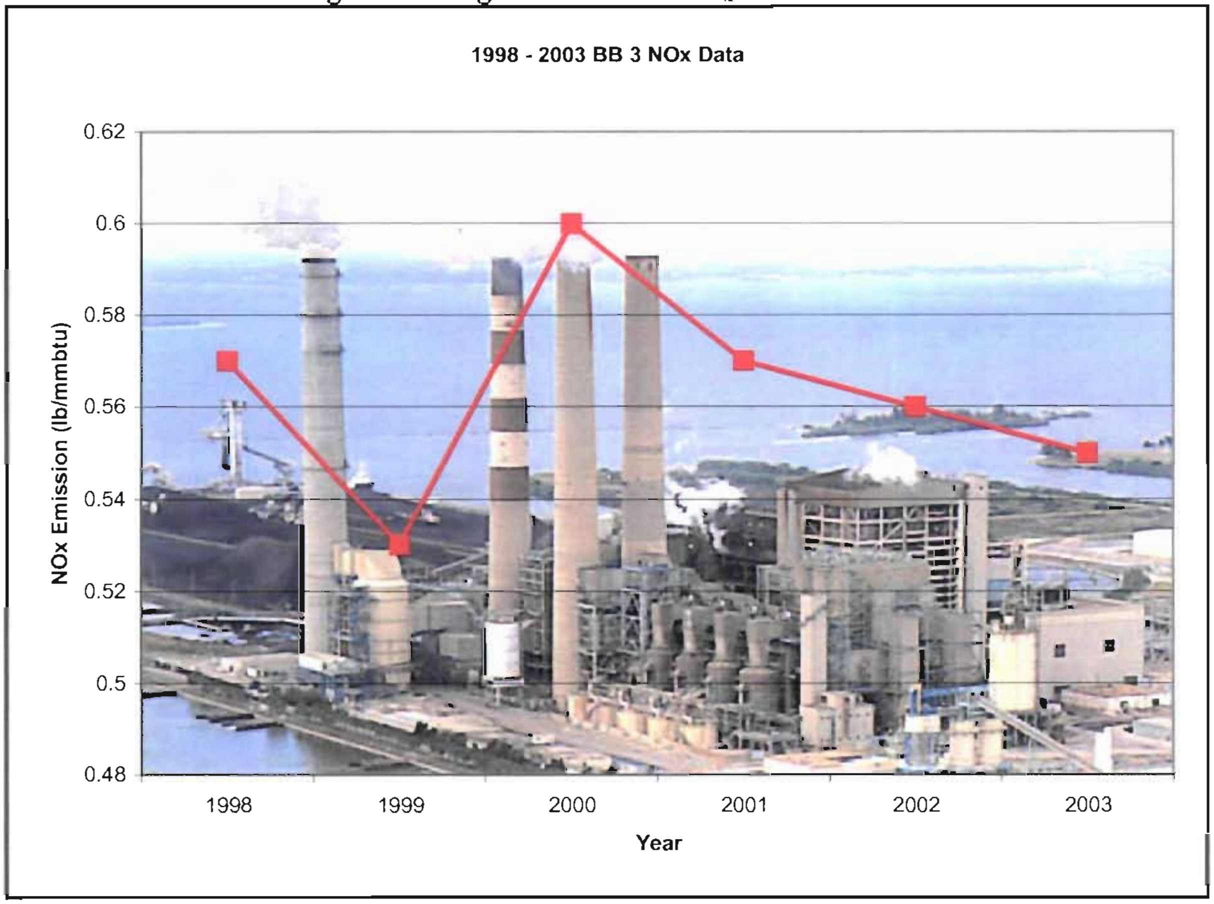
Figure 1 – Big Bend Units 1 and 2 NO_x Emissions



5.2 Big Bend Unit 3 NO_x Emissions

Low NO_x burners were also installed on Big Bend Unit 3. TEC evaluated the impact on Big Bend Unit 3 NO_x emissions through December 31, 2003, and found that there was a decrease in NO_x emissions. Figure 2 illustrates the results of the Early NO_x Reduction Plan over time. The average emission rate for 2003 from this unit was 0.55 lb/mmBTU. This represents an average rate reduction of approximately 3% in NO_x emissions as compared to the 1998 NO_x emission rate.

Figure 2 – Big Bend Unit 3 NO_x Emissions



6.0 Conclusion

The Early NO_x Reduction Plan at Big Bend Station has been successful. Although the goals of 30%, 30%, and 15% below 1998 levels were not met, significant reductions of NO_x emissions were achieved. TEC evaluated NO_x reduction technologies suitable for application on the units at Big Bend Station. TEC elected to install low NO_x burners on Big Bend Units 1 through 3 coal and primary air flow monitoring equipment on Big Bend Unit 1, and a neural network combustion optimization system on Big Bend Unit 2. In addition, TEC identified technologies that will be applied to the units at Big Bend Station as part of the long-term NO_x strategy.

TEC expended over $3 million on the Early NO_x Reduction Plan. Submission of this report satisfies Paragraph 35 of the EPA Consent Decree and the Amendment which requires that TEC to expend up to $3 million and to submit to EPA the results from the Early NO_x Reduction Plan for Big Bend Units 1 through 3.