A PLAN DESIGNED TO PREPARE FOR THE CONSEQUENCES OF FUELS CONVERSION ON AIR QUALITY IN HARRIS COUNTY, TEXAS

Harris County Pollution Control Department
Toxcon Engineering Company

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INTRODUCTION

SCOPE OF PROJECT

The Harris County Pollution Control Department obtained federal grant funds in the amount of $27,248 to finance a planning project designed to prepare for the consequences of new or expanded energy facilities in Harris County. In kind matching funds of $6,812 were provided through our operating budget. Particular emphasis was given to the impact of fuels conversion on air quality. We set out to:

1. Compile a list of energy consuming sources constructed or expanded after July 26, 1976.
2. Assemble available air quality data thereby establishing a data base for total suspended particulate (TSP), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2).
3. Make a proposal for a sampling program to measure the impact on air quality of these new and expanded sources.
4. Make a proposal for sampling equipment to carry out the sampling program including design criteria and operating personnel.
5. Make a data collection proposal which would include laboratory support and data processing.
6. Make a proposal for analyzing and evaluating the data with the objective of coordinating energy management to minimize the effect on air quality of increased energy usage.

We believe we have accomplished these objectives and have delineated them in the report which follows. In addition to the stated objectives we also investigated and included in this report information about energy sources outside the County which impact us; and by questionnaire we obtained an SO_2 emissions inventory. Not originally planned or scheduled are seven maps accompanying this report. They visually depict data which otherwise is less easily comprehended.

ENERGY CONSUMING SOURCES: A DEFINITION

The list of energy consuming sources is extensive. In the broadest sense, these sources include everything from lawnmowers to atomic powered electric generating plants.

For practical purposes it was necessary to limit the kinds of energy consuming sources to be considered. The primary criteria relied upon involved atmospheric emissions. Only those energy consuming sources which would emit significant quantities of pollutants into the atmosphere were investigated. If the construction, modification, or expansion of an energy consuming source required a Texas Air Control Board (TACB) construction permit, then it was included in the study. As a result of this decision, the study primarily focused upon petroleum refineries, petrochemical plants, chemical plants, and fossil fuel fired electric generating plants. These kinds of facilities represent the dominant industrial activity in Harris County.

GEOGRAPHICAL AREA OF CONSIDERATION

The most important concern of this study involved past, present, and future air quality over Harris County. Given the nature of our atmosphere, it is clear that activities in adjacent counties are an important factor in future air pollution problems. With the appropriate wind direction, SO_2 emitted from a boiler stack in Texas City on one day may be breathed by a shopper in downtown Houston the next day. Energy consuming sources in Galveston, Chambers, Montgomery, Ft. Bend, and eastern Brazoria counties were therefore also considered.

Major energy consuming sources in western Brazoria County (i.e., those located near Freeport and Sweeny) could have conceivably been included in this study. However, given the prevailing wind direction, proximity of sources, and historical air emissions data, it was concluded that atmospheric emissions from these sources would probably have only a minor impact on air quality over Harris County.

TIME FRAME

This study came about as a result of funds made available by the Coastal Energy Impact Program. The Coastal Energy Impact Program was created by the 1976 amendments to the Coastal Zone Management Act of 1972. These amendments were signed into law on July 26, 1976.

The purpose of the grant under which this study was conducted was to consider the impact on air quality of certain activities commencing after July 26, 1976. The activities of interest were the construction, modification, and expansion of energy consuming sources. As many energy consuming sources were built, modified, or constructed in and around Harris County in the years prior to the grant date, the decision was made to expand the time frame of the study as much as possible.

TACB records were the key source of information with respect to new energy consuming sources. Construction permits for most new air pollutant emitting industrial facilities were required in Texas after March 5, 1972. As important information was readily available only from that date forward, March 5, 1972 marked the beginning date of the study.

The time frame of the study ends on June 30, 1979.

AIR EMISSIONS

The term "energy consuming sources" covers a tremendous range of devices, equipment, and operations. As noted above, the thrust of this work was to focus on only a portion of the possible sources that might have been considered. Atmospheric emissions were of primary concern.

Generally, atmospheric emissions arise from energy consuming sources as a result of the combustion of fossil fuels. When fuels such as natural gas, fuel oil, coal, and gasoline are burned, a variety of gaseous and solid pollutants are created. Among these pollutants are total suspended particulates (TSP), NO_2, SO_2, carbon monoxide, and hydrocarbons.

In and around Harris County, significant quantities of four of the above mentioned pollutants are emitted from both stationary and mobile sources (i.e., cars and trucks). The energy consuming sources of interest in this study are all stationary in nature. The impact of the emission from stationary sources of four of the five important air pollutants would be impossible to distinguish from similar emissions from mobile sources. It was therefore decided to concentrate primarily on SO_2 as the air pollutant of interest. Given the fact that gasoline and diesel fuel contain small amounts of sulfur, some SO_2 is emitted as the result of the operation of motor vehicles. However, the quantity of SO_2 emitted from mobile sources is inconsequential when compared with the amount of SO_2 emitted from stationary facilities.

The best indicator of the air quality impact of new, modified, and expanded energy consuming sources is ambient air SO_2 concentrations. Much work was done compiling an inventory of past, present, and predicted SO_2 emissions. Air quality data reflecting past ambient air concentrations of SO_2 was gathered. A sampling system capable of monitoring future ambient air SO_2, NO_2, and TSP concentrations is described in the following pages. Similar efforts could be (and sometimes were) expended to generate information related to other major pollutants. None of the others, however, can be directly related to increased activity associated with energy consuming sources. SO_2 is therefore the primary concern of this report.

ENERGY CONSUMING SOURCES

THE KINDS OF SOURCES

The dominant industrial activity in and around Harris County is related to the refining of petroleum and the subsequent conversion of the refined components into petrochemicals and derivative products. There are nine oil refineries located within fifty miles of Houston. These refineries supply large quantities of gasoline and fuel oil for direct consumption. In addition, they provide raw materials for a network of petrochemical and chemical plants. There are at least one hundred of the latter kind of facilities located in the counties of interest.

Power for these industrial facilities is generally provided in one of two ways. Either electricity is imported from fossil fuel fired electric generating plants located around the area, or fossil fuels are combusted in boilers and heaters situated within plant boundaries.

If power is generated within a plant by utilizing a boiler, the procedure involves burning a fossil fuel in a confined space and transferring the heat thus released through a metal surface to a supply of water. As the water absorbs heat, it boils and is converted to high pressure steam. The steam is in turn used to provide heat in a variety of unit operations.

If heaters are employed for energy utilization, the operation is quite similar. In a process heater, fossil fuels are again combusted in a confined space. The heat of combustion is transferred through a metal surface to a process fluid (as opposed to water). The process fluid is thus heated to the desired temperature for subsequent reaction, distillation, or similar purpose.

Significant amounts of electricity are also utilized in industrial facilities in and around Harris County. For the most part, this electricity is purchased and imported from power plants in the area. At present, there are ten large fossil fuel fired electric generating plants operating within the study area.

The generation of electricity in a fossil fuel fired plant is a relatively simple process. The procedure is based upon producing steam in large boilers. Fossil fuel is combusted in a confined space, heat is transferred through a metal surface to a supply of water, and steam is created. The steam is used to drive a turbine which generates the desired electricity. Occasionally the process is more complex. Newer facilities may include combined cycle processes in which initial combustion takes place in a gas turbine.

All of the above mentioned processes have at least one factor in common. Each requires the combustion of a fossil fuel with the subsequent release of pollutants into the atmosphere. If the sulfur content of the fossil fuel utilized is low (as with natural gas), then the resultant SO_2 emissions will be low. If the sulfur content of the fossil fuel is significant (as with fuel oil and coal), then SO_2 emissions will be relatively large.

In the early 1970's, fossil fuel fired combustion units accounted for about 60% of all SO_2 emissions from stationary sources in Harris County (1).

Plants which produce sulfuric acid are also important with respect to atmospheric SO_2 emissions. In general terms, sulfuric acid is produced by the reaction of sulfur trioxide and water. Sulfur trioxide is obtained by the catalytic conversion of SO_2. The SO_2 utilized in sulfuric acid production is normally obtained by burning elemental sulfur or spent sulfuric acid sludges. In the process, not all SO_2 generated is converted to sulfur trioxide. That portion not converted is normally vented to the atmosphere.

In 1973, sulfuric acid plants accounted for about 35% of all SO_2 emissions from stationary sources in Harris County (1).

There are numerous minor stationary sources of atmospheric SO_2 emissions in and around Harris County. Industrial, municipal, and commercial incinerators emit small quantities of the gas when sulfur bearing waste materials are burned. Chemical plants which operate sulfonation reactions typically emit SO_2 into the atmosphere. Generally however, these kinds of sources make a small contribution when compared with SO_2 emissions that arise from fossil fuel combustion and sulfuric acid manufacture.

NEW, MODIFIED, AND EXPANDED ENERGY CONSUMING SOURCES

Historically, most fossil fuel fired energy generating activity in and around Harris County was based on pipeline quality natural gas. Natural gas has a very low sulfur content. As a result, SO_2 emissions from boilers and fired heaters tended to be small.*

The "energy crisis" changed the pattern of energy consumption at industrial facilities in the study area. A number of factors including an apparent shortage of natural gas, the Arab oil embargo of 1973, and Docket 600 of the Railroad Commission of Texas (this regulation required the eventual curtailment of the use of natural gas in utility boilers) catalyzed the search for alternate means of generating steam and electricity.

As a result of the search for alternate ways to generate power, many industrial operators applied to the TACB for permission to modify existing boilers and heaters for the purpose of combusting fuel oil and coal. Additionally, in the past four or five years, most new refining, petrochemical, and chemical facilities have been permitted and built with the capability of firing fuel oil as well as natural gas. Between 3/5/72 and 6/30/79, the TACB approved permits for the construction, modification, and expansion of hundreds of energy consuming sources. The SO_2 emissions allowed by these permits totals more than 488,000 annual tons from industrial facilities located in the study area.

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*An exception to this statement is those boilers and heaters fired with "refinery gas". Refinery gas is a by-product of petroleum refining operations consisting of hydrogen, methane, heavier aliphatic hydrocarbons, and hydrogen sulfide. If the refinery gas in question was derived from sour crude oil, then its hydrogen sulfide content might be substantial. When combusted, hydrogen sulfide is converted to SO_2. Therefore, significant quantities of SO_2 were probably emitted from some boilers and heaters fired with gaseous fuel.

Approximately 291,000 annual tons were permitted from energy consuming sources built, modified, or expanded between 7/26/76 and 6/30/79. As a means of comparison, in 1972, actual SO_2 emissions from all stationary sources in the study area were estimated to be 162,000 annual tons (1).

Table I is a compilation of total permitted SO_2 emissions as a function of time for the period 3/5/72 to 6/30/79. Clearly, the amount of SO_2 that may legally be emitted from new, modified, and expanded sources has increased tremendously over the last seven years.

TABLE I

SO_2 EMISSIONS PERMITTED FROM FACILITIES IN THE STUDY AREA

A YEARLY COMPILATION

Year	Total SO_2 Emissions Permitted During The Year (Tons)
1972	6,380
1973	34,900
1974	119,000
1975	65,000
1976	151,000
1977	96,400
1978	11,800
1979	2,400

NOTE: The value for 1979 is accurate through 6/30/79.

Table II is a list of all energy consuming sources built, modified, or expanded between 7/26/76 and 6/30/79. To be included in this table, the new facility had to have received a TACB construction permit dated after 6/25/75*; it had to be part of a facility with total permitted SO_2 emissions greater than 100 tons per year; and it had to be located within the study area.

Table III depicts permitted SO_2 emissions by county for all facilities in the study area built, modified, or expanded between 7/26/76 and 6/30/79. As the table illustrates, the facilities listed in Table II may emit approximately 291,000 tons per year of SO_2. Harris County facilities account for about 38% of that total.

Table IV is a compilation of all SO_2 emissions permitted in the study area between 3/5/72 and 6/30/79. Again, Harris County sources account for the largest share of the permitted emissions.

The Appendix contains a list of all TACB construction permits which allow SO_2 emissions from facilities built, modified, or expanded in the study area between 3/5/72 and 6/30/79.

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* TACB construction permits are valid for one year from the date of issue. For purposes of this study, all facilities permitted after 7/25/75 were assumed to be built, modified, or expanded after 7/26/76.

TABLE II

ENERGY CONSUMING SOURCES BUILT, MODIFIED, OR CONSTRUCTED

BETWEEN 7/26/76 AND 6/30/79

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
Air Products - Channelview	7033	H_2/CO Plant	298
Air Products - La Porte	771B	Process Heater	311
Air Products - La Porte	4803	Steam Boiler	55
Amerada-Hess	6526	Steam Boiler Conversion	162
American Hoechst	5252	Process Heater	12
American Hoechst	5252A	Steam Boiler	1,010
American Hoechst	5252B	Steam Boiler	1,010
American Hoechst	5252C	Steam Boiler	1,010
American Hoechst	5252D	Process Heater	254
American Hoechst	5252E	Steam Superheater	675
Amoco - Chocolate Bayou	4483	Process Heater	14
Amoco - Texas City	3362	Steam Generator	2,270
Amoco - Texas City	3363	Steam Generator	2,430
Amoco - Texas City	3364	Steam Generator	2,960
Amoco - Texas City	4903	Process Heater	123
Anheuser Busch	5351	Boiler Conversion	867
Anheuser Busch	7079	Boiler	298
ARCO - Channelview	6386	Poly-MDI Unit	385

Table II - continued

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
ARCO - Deer Park	3908	Boiler	837
ARCO Refinery	6065	Process Heater	5
Berwind Railway	5609	Flare	3,640
Big Three	2627A	Boiler Conversion	613
Big Three	4957	Boiler Conversion	2,540
Big Three	4960	Boiler Conversion	845
Big Three	4961	Boiler Conversion	3,780
Big Three	4964	Boiler Conversion	2,280
Cameron Iron	4813	Boiler Conversion	561
Champion Paper	6002	Recovery Boiler Conversion	1,040
Champion Paper	6003	Marine Boilers Conversion	1,240
Charter International Oil	2507	Sulfur Recovery Unit	2,250
Charter International Oil	2508	Sourwater Stripper	1,730
Cities Service	3956A	Process Heater	110
Columbian Carbon	3601	Process Heater/Boiler	153
Crown Central Petroleum	5953	Process Heaters	53
Crown Central Petroleum	6059	Sulfur Recovery Unit	14
Diamond Shamrock - Deer Park	1522	Boiler Conversion	1,360
Diamond Shamrock - Deer Park	4528A	Boiler Conversion	753
Diamond Shamrock - Deer Park	5128A	Boiler Conversion	950
Diamond Shamrock - Deer Park	5240	Boiler Conversion	1,680

Table II - continued

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
Diamond Shamrock - Greens Bayou	4893	Boiler Process Heater	244
Diamond Shamrock - Independence	3855	VC Plant	2,220
DuPont	2621A	Steam Generator	1,070
DuPont	4019	Steam Generator	2,160
DuPont	5034	Process Heater	22
DuPont	5034A	Process Heater	35
Duval Corporation	3735	Boilers	420
Eddy Refining	3697	Steam Generators	136
Eddy Refining	4709	Fired Heater	29
Eddy Refining	5211	Fired Heater	29
Ethyl	3962	Process Heater	98
Ethyl	4551	Process Heater	66
Exxon Chemical - Baytown	3452	Olefins Plant	14
Exxon Chemical - Baytown	3871	Steam Generator	5,620
Exxon Chemical - Baytown	4600	Process Heater	53
Exxon Chemical - Baytown	5019	Process Heater	1,180
Exxon Chemical - Baytown	5121	Process Heater	368
Exxon Chemical - Baytown	5259	Process Heater	850
Exxon Chemical - Baytown	5555	Process Heater	850
Exxon Chemical - Mont Belvieu	4831	Process Heater	380
Exxon Refinery	4973	Gas Turbine	390
Exxon Refinery	5330	Process Heater	385

Table II - continued

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
GAF	6918	Boiler Conversion	946
Georgia Pacific	4825	Process Heater	368
Gulf Chem. & Met.	5094	Tin Smelting Plant	447
Gulf Coast Portland Cement	5100	Cement Kiln Conversion	2,720
Houston Fuel Oil	5783	Terminal	201
H. L. & P. - Bertron	4484	Boiler	24
H. L. & P. - Bertron	4485	Boiler	24
H. L. & P. - Cedar Bayou	1532	Boiler Conversion	46,700
H. L. & P. - Parish	2348A	Steam Generator	33,800
H. L. & P. - Parish	2349A	Steam Generator	33,800
H. L. & P. - Parish	5530	Boiler	30,100
ICI - United States	3619	Process Heater	118
ICI - United States	4717	Process Heater	1
ICI - United States	4719	Reactor	11
Ideal Cement	5321A	Cement Kiln Conversion	2,860
Koppers	5359	Process Heater	28
Koppers	6467	Process Heater	84
Koppers	7443	Process Heater	5
Lubrizol - Deer Park	4688	Steam Generator Conversion	657

Table II - continued

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
Marathon Oil	6756	Process Heater	269
Maxwell House	5341	Boiler	451
Maxwell House	5500	Process Heater	872
Mobay	5030	Boiler Conversion	2,730
Mobay	6177	Steam Boiler	1,160
Monsanto - Chocolate Bayou	4634	Process Heater	6,560
Monsanto - Chocolate Bayou	5084	Process Heater	31
Monsanto - Chocolate Bayou	5336	Boiler Conversion	5,260
Monsanto - Chocolate Bayou	5336A	Waste Heat Boiler	2,100
Monsanto - Texas City	5260	Boiler Conversion	6,640
Oxirane - Channelview	3286A	Boiler	2,510
Oxirane - Channelview	3286B	Boiler	2,510
Oxirane - Channelview	3286C	Boiler	2,510
Paktank - Deer Park	4872	Boiler Conversion	106
Paktank - Deer Park	5313	Boilers	160
Pennwalt	3917	Process Heater	1,920
Rexene	4157	Process Heater	346
Rohm & Haas	4276	Process Heater	16

Table II - continued

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
Shell	3199	Boiler	3,600
Shell	3200	Boiler	3,570
Shell	3201	Boiler	3,570
Shell	3202	Process Heater	14,600
Shell	4596	Incinerator	13
Shell	6713	Pyrolysis Furnace	79
Stauffer - Houston	4802	Process Heater	5,100
Syngas	4773	Process Heater	854
Tenneco	4545	Steam Generator	898
Texas City Refining	2940	Sour Water Stripper	823
Texas City Refining	4393	Process Heater	806
Texas City Refining	4499	Sulfur Plant	52
Texas City Refining	4797	Process Heater	57
Texas Industries	4534A	Fuel Conversion - Coal	2,100
Union Carbide - Deer Park	4861	Boiler Conversion	40
Union Carbide - Deer Park	4862	Plant Heater	193
Union Carbide - Deer Park	4863	Boiler	164
Union Carbide - Deer Park	4864	Plant Heater	248
Union Carbide - Texas City	2958A	Boiler	5,260
United Salt	5935	Boiler	188
Upjohn	1483A	Steam Generator	1,330
Upjohn	4221	Steam Generator	530

Table II - continued

Facility	Construction Permit Number	Kind of Source	Permitted SO_2 Emission Rate (Tons/Year)
USI - Chemicals	5226	Steam Boiler	561
Witco Chemical	3874	Steam Generator	66

TABLE III

PERMITTED SO_2 EMISSIONS FROM FACILITIES CONSTRUCTED BETWEEN 7/26/76 AND 6/30/79

County	Permitted SO_2 Emissions (Tons/Year)	Number of Permits	Number of Facilities
Harris	102,000	92	44
Fort Bend	100,000	5	3
Chambers	51,200	5	4
Galveston	22,300	14	8
Brazoria	14,000	5	2
Montgomery	150	1	1
	289,650	122	62

TABLE IV

PERMITTED SO_2 EMISSIONS FROM FACILITIES CONSTRUCTED BETWEEN 3/5/72 AND 6/30/79

County	Permitted SO_2 Emissions (Tons/Year)	Number of Permits	Number of Facilities
Harris	264,000	205	59
Fort Bend	100,000	5	3
Galveston	58,200	38	9
Chambers	51,200	5	4
Brazoria	14,500	11	2
Montgomery	150	1	1
	488,050	265	78

ACTUAL SO_2 EMISSIONS

As the preceding section of this report illustrates, the amount of SO_2 that may be emitted into the atmosphere over Harris County has increased significantly in the last seven years. If actual 1972 SO_2 emissions were added to SO_2 emissions permitted subsequent to 1972, 648,000 tons of SO_2 could have been emitted into the atmosphere during 1979.

The amount of SO_2 that is actually emitted into the atmosphere was unknown prior to this study. The TACB compiled an inventory of atmospheric emissions originating at industrial sources in 1972, 1973, and 1975. An emissions inventory has not been compiled since 1975.

As a part of this study, an effort was made to define atmospheric SO_2 emissions for the period after 1975. A questionnaire was devised and sent to the operators of seventy-eight major industrial facilities. Information related to SO_2 emissions from permitted facilities, SO_2 emissions from facilities built before the permit system was implemented, fuel oil usage, and coal usage for the years 1976, 1977, 1978, and 1979 was solicited (a sample questionnaire is included in the Appendix).

The cooperation received from industrial operators with respect to the questionnaire was generally good. Responses were received from seventy-four percent of the facilities questioned.

Questionnaire responses yielded interesting and useful data on fuel use patterns and SO_2 emissions data. Table V contains information about 1976, 1977, and 1978 fuel use patterns in the study area. Based on the responses received, fuel oil usage increased by more than a factor of four during the three year period. Coal usage increased by more than thirty times over the same period. Clearly however, both fuel oil and coal usage remains small compared with total fossil fuel requirements.

TABLE V

FUEL USE PATTERNS IN STUDY AREA

1976 - 1978

Year	Fuel Oil Consumed (1,000's of Tons)	Coal Consumed (1,000's of Tons)
1976	500	19
1977	1,900	22
1978	2,300	640

NOTE: This table is based on data received from fifty-eight facilities.

Table VI contains a compilation of data regarding actual SO_2 emissions from permitted sources in the study area. As the table indicates, SO_2 emissions from new, modified, and expanded energy consuming sources has increased over the years. In 1978, SO_2 emissions from these sources were more than 39,000 tons. The indicated increase in actual emissions is surprisingly small. As noted in Table IV, SO_2 emissions from permitted facilities could legally be as much as 488,000 tons per year. In 1978, actual SO_2 emissions from all permitted facilities were apparently less than 10% of that value.

TABLE VI

ACTUAL SO_2 EMISSIONS FROM PERMITTED SOURCES

1976 - 1978

Year	SO_2 Emissions From Facilities Permitted Between 3/5/72 & 7/25/75 (Tons)	SO_2 Emissions From Facilities Permitted Between 7/26/75 & 6/30/79 (Tons)
1976	9,250	4.5
1977	22,000	4,410
1978	24,200	14,800

NOTE: This table is based on data received from fifty-eight facilities. See the Appendix for a compilation of SO_2 emissions from individual facilities.

In an effort to better illustrate the possible influence of SO_2 emissions on Harris County, several figures have been prepared. Figure I is a map which depicts permitted SO_2 emissions for energy consuming sources built, modified, and expanded between 3/5/72 and 6/30/79. Figure II is a map which depicts permitted SO_2 emissions from energy consuming sources built, modified, and expanded between 7/26/76 and 6/30/79. Figure III is a map which depicts actual SO_2 emissions for the year 1978 from those energy consuming sources permitted after 7/25/75.

These maps clearly indicate three important points:

1. SO_2 emission sources are concentrated along the Houston Ship Channel.

2. The whole of Harris County is subject to atmospheric SO_2 exposure.
3. The amount of SO_2 which is actually emitted is small compared with the amount that can be legally emitted.

AIR QUALITY DATA BASE

BACKGROUND

In Harris County, routine ambient air sampling is conducted by the City of Houston Bureau of Air Quality Control (the City) and the Texas Air Control Board (TACB). Each agency maintains a sampling network designed primarily to monitor the "criteria pollutants" designated by the U. S. Environmental Protection Agency (EPA). The data collected by these networks is summarized and published annually by the TACB. Additionally, the City publishes quarterly reports indicating ambient air concentrations detected by the instruments in their network. The contents of these reports constitute the available air quality data base for Harris County. See the Appendix for a list of air quality data reports.

During 1978, there were forty-three sites in Harris County at which the City or the TACB collected non-continuous air quality data. Once every six days, equipment at these sites is actuated to collect a twenty-four hour composite ambient air sample. Each of the sites is equipped with a high volume air sampler used to monitor TSP concentrations. Thirty-eight of the sites are also equipped with diffusion bubbler equipment designed to detect ambient air concentrations of SO_2, NO_2, and other gaseous pollutants.

At the non-continuous sites, SO_2 is detected by the West-Gaeke method.* NO_2 is detected by the Christie method. These and

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*In 1978 the TACB abandoned the West-Gaeke method of SO_2 detection in favor of a method involving absorption in a carbonate solution followed by analysis based on ion chromatography.

other air quality analysis methods are discussed in more detail in the next section of this report.

Between them, the City and the TACB also maintain nine sites at which continuous ambient air sampling equipment is operated. The City is responsible for six of these locations. One of their sites is equipped with a continuous SO_2 analyzer; two are equipped with NO_2 analyzers. The TACB operates three continuous monitoring sites (the third one became operational in December, 1978). All three TACB sites have the capability of monitoring SO_2 and NO_2.

At the continuous sites, SO_2 analysis is done by a gas chromatograph equipped with a flame photometric detector. Continuous NO_2 analysis is accomplished by chemiluminescence.

COMMENTS ON THE DATA

The TACB and the City participate in a joint ambient air data quality assurance program. The TACB has reported that during 1978, 95% of the analysis of particulate matter samples performed by air pollution agencies around the state were accurate to within ±20% (2). This value is believed to represent the precision of the particulate matter analytical method.

The precision of data reported for gaseous air pollutants is probably not as good. The non-continuous methods of detecting gaseous air pollutants depend on absorbing gases in liquid chemicals. These chemicals must be prepared in laboratories and transported to the monitoring site where they will be used. Once the pollutants of interest are absorbed, the liquids are returned to the lab where detection is done by wet chemical methods. Final results are subject to errors introduced by initial preparation of chemicals, analytical procedures, as well as interaction of bubbler liquids with factors in the surrounding environment (heat effects and interference by other atmospheric constituents are both important considerations).

Ambient air quality data is reported on several time bases. Most continuous data is reported as an hourly average. Non-continuous data is normally reported as a twenty-four hour average value. Depending on the pollutant in question, three hour and eight hour averages may also be of importance. Annual averages are often reported for the criteria pollutants. These averages are computed values. They may be derived from hourly averages if based on continuous data, or from twenty-four hour composites if based on non-continuous data.

The data base reported in this study is limited to annual averages. The choice to consider only annual averages was made primarily on the basis of simplicity and brevity. Air quality reports listed in the Appendix contain hundreds of pages of information related to data reported as hourly, three hour, eight hour, and daily averages.

In principle, an annual average pollutant concentration can be derived from either continuous or non-continuous data. In practice, the continuous monitors located in Harris County have not met EPA's criteria for calculating annual averages.

The annual means reported herein are therefore all based on non-continuous data.

Table VII is a compilation of primary ambient air quality standards for SO_2, NO_2, and TSP. Each value shown is an annual average. By definition, a primary standard represents the maximum pollutant concentration acceptable in terms of the protection of human health. The table is included as a means of illustrating the significance of Harris County air pollution concentrations as measured during the past six years.

TABLE VII

PRIMARY AMBIENT AIR QUALITY STANDARDS

FOR THREE CRITERIA AIR POLLUTANTS

Air Pollutant	Primary Ambient Air Quality Standard (Annual Average)
Sulfur dioxide	80 $\mu g/m^3$
Nitrogen dioxide	100 $\mu g/m^3$
Particulate matter	75 $\mu g/m^3$

NOTE: SO_2 and NO_2 standards are arithmetic means; the particulate matter standard is a geometric mean.

SULFUR DIOXIDE DATA

Figure IV is a map which summarizes ambient air SO_2 data for non-continuous monitors. The values shown on the map represent annual arithmetic means for the years 1973 through 1978. The data is depicted on the map at the location of the sampling site where the individual values which comprise the average were actually monitored. Each sampling site is identified by its agency code number. It should be noted that some of the values indicated on the map do not meet the EPA minimum criteria for calculating annual means.

As the map indicates, the primary ambient air quality standard for SO_2 has never been exceeded. However, it is clear that SO_2 concentrations are higher at sites closer to the Houston Ship Channel than at other places in the County. This is to be expected, as most large SO_2 sources are located along the Ship Channel. Table VIII compares SO_2 concentrations at fourteen Ship Channel sites with SO_2 concentrations at twenty-two other sites in the County.

TABLE VIII

A COMPARISON OF ANNUAL AVERAGE SO_2 CONCENTRATIONS AT SHIP CHANNEL SITES AND OTHER COUNTY SITES

Year	SO_2 Concentrations at Ship Channel Sites ($\mu g/m^3$)	SO_2 Concentrations at Other County Sites ($\mu g/m^3$)
1973	18	4
1974	17	4
1975	9	4
1976	7	2
1977	8	3
1978	8	6

The reported SO_2 data has other interesting aspects. A review of the data reported at TACB sites in 1978 indicates a significant increase which is probably related to a change in analytical method.

In 1978, the TACB abandoned the West-Gaeke method of analysis for SO_2. This change was made because of negative interference believed to be a result of heat effects at the sampling site. The current analytical method is less subject to variation due to temperature fluctuation.

Data reported from City sites in 1978 do not reflect an increase in SO_2 ambient air concentrations. The City still uses the West-Gaeke method of analysis; therefore most of the TACB data and all of the City data may be conservative with respect to actual SO_2 ambient air concentrations.

As Table VIII indicates, there was an apparent decrease in ambient air SO_2 concentrations between 1974 and 1975 as measured at Ship Channel sites.

Perhaps the most significant aspect of the data is that SO_2 concentrations are relatively low, and they have not increased significantly since 1973.

NITROGEN DIOXIDE DATA

Figure V is a map which summarizes ambient air NO_2 data. The values shown on the map represent annual arithmetic means for the years 1973 through 1978. The data is depicted on the map at the location of the sampling site where the individual values which comprise the average are actually monitored. Each sampling site is identified by its agency code number. It should be noted that some of the values indicated on the map do not meet the EPA minimum criteria for calculating annual means.

As the map indicates, NO_2 ambient air concentrations are significant when compared with the primary ambient air quality standard. In fact, in 1973, annual averages at several sites actually exceeded the primary standard.

Since 1973, the ambient air concentration of NO_2 appears to have decreased somewhat.

If the NO_2 data is grouped in a particular way, a trend is apparent as shown in Table IX. For a given year,

1) average the NO_2 data reported at all sites in the County,
2) average the NO_2 data reported at only those sites located inside Loop 610, and
3) average the NO_2 data reported at only those sites located in or near downtown Houston.

When this is done, it can be seen that in every year the ambient air NO_2 concentrations decrease as the distance from the inner city increases. This suggests that NO_2 concentrations are more dependent on mobile sources of air emissions than on industrial sources.

TABLE IX

ANNUAL AVERAGE NO_2 CONCENTRATIONS AS A FUNCTION OF DISTANCE FROM THE INNER CITY

Year	NO_2 Concentration in or near Downtown Houston ($\mu g/m^3$)	NO_2 Concentration Inside Loop 610 ($\mu g/m^3$)	NO_2 Concentration Countywide ($\mu g/m^3$)
1973	142	116	86
1974	91	81	65
1975	89	69	56
1976	83	59	48
1977	79	63	52
1978	81	63	56

TOTAL SUSPENDED PARTICULATE

Figure VI is a map which summarizes ambient air TSP data. The values shown on the map represent annual geometric means for the years 1973 through 1978. The data is depicted on the map at the location of the sampling site where the individual values which comprise the average are actually monitored. Each sampling site is identified by its agency code number. It should be noted that some of the values indicated on the map do not meet the EPA minimum criteria for calculating annual means.

Ambient air concentrations of TSP represent a significant problem. During the six year period studied, the primary standard for TSP was equaled or exceeded a total of seventy-five times at twenty-three sites.

There is no apparent single cause to explain the multiple standard violations. The City and the TACB have stated that most TSP problems are the result of fugitive dust emissions related to traffic, materials handling, and construction activities (3). Particulate emissions from industrial activity also contribute. Should energy use patterns change to increased reliance on fuel oil and coal, this air pollution problem may become worse.

Table X includes data which indicates the highest annual average TSP concentration that was recorded at selected sampling sites between 1973 and 1978. The sites included in the table are those at which at least one violation of the primary standard has been observed.

TABLE X

MAXIMUM ANNUAL AVERAGE TOTAL SUSPENDED PARTICULATE CONCENTRATIONS AT SOME HARRIS COUNTY SAMPLING SITES: 1973-1978

Sampling Site Designation	Year in Which Maximum Value Was Observed	Maximum Annual Geometric Mean TSP Concentration ($\mu g/m^3$)
Cams 1	1973	103
Bayway	1976	83
Park	1974	82
H-12	1978	75
H-13	1974	76

TABLE X - continued

Sampling Site Designation	Year in Which Maximum Value Was Observed	Maximum Annual Geometric Mean TSP Concentration (μg/m^3)
H-15	1978	102
H-18	1973	102
DP-22	1976	101
H-23	1977	89
DP-1	1974	81
H-21	1973	79
H-17	1975	90
P-2	1973	85
H-04	1978	91
T-5	1978	157
H-19	1978	123
T-25	1978	88
H-14	1978	95
H-02	1975	104
H-05	1973	103
H-01	1975	97
T-19	1977	76
H-09	1977	78

AMBIENT AIR MONITORING
EQUIPMENT EVALUATION
AND SITE LOCATION

INTRODUCTION

The change in energy use patterns which is expected to take place in Harris and surrounding counties may tend to elevate ambient air concentrations of SO_2, NO_2, and TSP. Existing ambient air quality data has been summarized in the preceding section of this report.

The purpose of the following paragraphs is to develop the background for a sampling network sufficient to provide accurate and timely data related to changes in ambient air concentrations of SO_2, NO_2, and TSP for all of Harris County. Available analytical methods are discussed. An evaluation of monitoring instruments which might be utilized in a sampling network is presented. And finally, a proposal for a comprehensive ambient air monitoring network is delineated.

AVAILABLE ANALYTICAL METHODS

There are four EPA approved methods for the determination of sulfur dioxide. The Pararosaniline or modified West-Gaeke procedure is the EPA reference method. In this analytical method, SO_2 is absorbed in a solution of potassium tetrachloromercurate. A red-violet color is developed at a later time by the addition of reagents. The color intensity developed is a function of the concentration of absorbed SO_2 and is measured using a spectrophotometer or colorimeter. The SO_2 tetrachloromercurate complex formed during the absorption is thermally unstable; an SO_2 loss of 1% -

3% per day has been noted. At high ambient temperatures the loss rate is much higher; therefore, the sooner the analysis can be done the more accurate the determination can be. There is evidence that the SO_2 tetrachloromercurate complex is photo-reactive; wrapping the impingers with aluminum foil provides some protection. The absorber efficiency is influenced by collection rate as well as temperature during and after sample collection. Reducing the temperature of the potassium tetrachloromercurate absorber solution also reduces the absorber efficiency.

This analytical method requires extensive laboratory wet chemistry in the preparation of reagents - some of which must be prepared daily due to their degradability. The few advantages of this method of analysis for SO_2 include a relatively small capital investment and a high degree of portability for the actual sample device. This method at best shows only the average SO_2 concentration from time start to time stop. The method does not indicate highs and lows, nor will it reveal trends over short periods of time.

There are two automated analytical systems for SO_2 that utilize the pararosaniline method. These are the Atmosphere - Technicon I and the Atmosphere - Technicon II. Both automated systems were developed by the EPA. These systems require the same wet chemistry as the manual pararosaniline method for the determination of SO_2. The samples must likewise be taken with an impinger system and then are introduced into the automatic analysis system. These systems were not evaluated in detail.

The next EPA method for the detection of SO_2 in the atmosphere is coulometric. In this method, a gas stream is continuously bubbled through a solution of potassium bromide and sulfuric acid contained in a reaction cell. The SO_2 is trapped by reacting it with electrolytically generated bromine. The bromine concentration is automatically maintained at a constant value by means of sensing electrodes which match the rate of bromine generation to the quantity of SO_2 reacted. The bromine generating current is monitored and varies proportionally to the amount of SO_2 present in the sample. Philips Electronic Industries is the source for two of the three coulometric instruments designated as equivalent methods by the EPA. These are the Philips PW 9755 and the Philips PW 9700; both instruments are manufactured in Holland and have the highest initial capital cost of any EPA SO_2 designated system available. The third coulometric type instrument is manufactured by Asarco Incorporated. These instruments were not available for evaluation. Apparently they are no longer sold in the United States.

The next method for the detection of SO_2 in the atmosphere utilizes the flame photometric detection method (FPD). The operating principle of the FPD utilizes the photometric detection of the 394 nanometer spectral band emitted by sulfur containing compounds in a hydrogen rich flame. There are four FPD instruments recognized by the EPA as equivalent methods for the detection of SO_2 in the atmosphere. These four instruments are discussed in detail under the next heading in this section.

The next type of instrument designated by the EPA as an equivalent method in the analysis of atmospheric SO_2 is pulsed ultraviolet fluorescence. The principle on which this instrument is based is: pulsed ultraviolet light passes through a narrow bandpass filter to a measurement chamber where it excites SO_2 molecules. As these molecules return to their ground state they fluoresce. The intensity of the fluorescence is linearly proportional to the concentration of SO_2 molecules in the sample. The fluoresced light then passes through a second filter to illuminate the sensitive surface of a photomultiplier tube. Electronic amplification of the output of the photomultiplier tube provides a meter reading and an electronic analog signal for recorder output. There are at least three commercially available SO_2 analyzers based on this principle.

There are two EPA approved methods for the determination of NO_2. The sodium arsenite or modified Christie method is the EPA reference method. Utilizing this method, NO_2 is absorbed in a sodium arsenite solution to form sodium nitrite. The concentration of nitrite ions is measured after the addition of reagents which develop a color. The intensity of the color is proportional to the concentration of nitrite ions present and is measured using a spectrophotometer or colorimeter.

There are few interferences with this test. Nitric oxide (NO) does not appear to interfere to any significant extent. SO_2 interferes slightly to the extent that 100 $\mu g/m^3 SO_2$ gives a negative response equivalent to 3 $\mu g/m^3 NO_2$.

This method requires extensive laboratory wet chemistry in the preparation of reagents - some of which must be prepared daily due to their degradability. The few advantages to this method of analysis of NO_2 include a relatively small capital investment and a high degree of portability for the actual sample device. This method only shows the average NO_2 concentration; it does not indicate highs or lows.

There is one automated method which utilizes the sodium arsenite wet chemistry. It is the Technicon II automated analysis system. This system requires the same reagents and laboratory backup except that the impinged samples are introduced into the Technicon II for automatic titration and analysis.

There is a single instrumental method for the analysis of oxides of nitrogen in the ambient air. The method is chemiluminescence. It is based on the principle that NO reacts with ozone (O_3) to produce electrically excited NO_2 and oxygen. Following the NO - O_3 reaction, the electrically charged NO_2 molecules revert to a normal energy state thereby emitting photons that produce a light emission directly proportional to the NO concentration in the ambient air sample. To determine NO_x (NO + NO_2) concentration, the sample is first routed through a converter where the NO_2 is converted to NO and is then routed to a reaction chamber for analysis. NO_2 concentrations are determined by an electronic subtraction circuit that automatically calculates the difference for a direct NO_2 output.

The only EPA designated method available for determining the ambient air concentration of TSP is the high volume method. In this method, a measured amount of ambient air is passed through a pre-weighed, non-hygroscopic filter paper. The filter is removed from the sampler and returned to a laboratory where it is held at 50% relative humidity for twenty-four hours. The filter is then weighed to determine particulate weight. Knowing particulate weight and flow rate of air through the filter, it is possible to calculate the ambient air TSP concentration.

INSTRUMENT EVALUATION

As a part of this project, an instrument evaluation was performed. The purpose of the evaluation was to review the performance characteristics of a number of ambient air monitoring devices. This review provided information about the possible suitability of various instruments as components in an ambient air sampling system. Of particular importance was the need to determine if the instruments available were capable of reliably detecting SO_2 and NO_2 in ppb ranges of 0 - 50. Additionally, an effort was made to determine if the several instruments tested would perform satisfactorily under simulated monitoring conditions.

The instrument evaluations were done under "hands-on" conditions in most cases; i.e., the instruments considered were operated and observed in the Harris County Pollution Control Department laboratory. Operation of the instruments was evaluated in actual sampling modes. Zero and span were checked on initial start-up and after twenty-four hours of continuous operation. Instrument drift and electrical noise were observed. In short, a concerted effort was made to verify that a particular instrument had the capability of reliably and accurately detecting the air pollutant of interest.

The course of the evaluation generally followed procedures outlined in references (4) and (5). The evaluation results are discussed below. Recommendations concerning the best choice of instruments to continuously monitor ambient air SO_2 and NO_2 are presented.

SO_2 ANALYZERS - FPD

Four SO_2 analyzers which utilize the FPD method of detection were evaluated.

MELOY SA 285E

The first instrument evaluated was the Meloy Laboratories SA 285E Sulfur Analyzer. This was the only instrument evaluated which is EPA certified at the expanded scale, low-level of detectability, 0.05 ppm or 50 ppb full scale. This capability made the instrument extremely interesting since baseline SO_2 values are expected to be 10-30 ppb. The instrument responded excellently in the zero and span modes and had very little drift. The only difficulty encountered involved flame-out problems. The instrument does have automatic hydrogen shut-off due to flame-out or loss of power and there is a flame-out indicator with automatic electronic re-ignition.

The Meloy SA 285E had the following favorable Points:

1. Excellent operating characteristics.
2. Stable sample air flow of 200 ml/minute.
3. Excellent zero and span adjustability and reproducibility.
4. Optional remote zero and span availability.
5. Optional timed zero and span availability.
6. Excellent linearity through the four ranges.
7. Insensitive to vibration.
8. Can be rack or shock mounted.
9. Insensitive to temperature fluctuations.
10. Broad operating ambient temperature range: 10° - 40° C.
11. Insensitive to electrical noise.
12. Components are accessible for maintenance and troubleshooting.
13. Built in troubleshooting aids.
14. Circuit boards are interchangeable with those of the Meloy NA 530R NO_2 analyzer.
15. In-house repairability is excellent.
16. Parts availability is good.
17. Training school is offered.
18. Capability of remote diagnoses of some malfunctions.

19. Required preventive maintenance is low.
20. Manual is well reproduced and illustrated.
21. Manual troubleshooting section is thorough.
22. Low operating range: 0 - 50 ppb.
23. Low signal lag time: 10 seconds maximum.
24. Low rise or fall time: 2 minutes maximum.
25. Low detectable limit: 2 ppb.

The Meloy SA 285E had the following unfavorable points:

1. Requires hydrogen.
2. Exhibited flame-out problems.
3. Has relatively high interferent levels; 20 ppb each interferent (maximum) and 60 ppb total interferent (maximum).

MELOY SA 185-2A

The Meloy SA 185-2A is also EPA designated, but not in the low ranges of the SA 285E. This instrument is very similar to the SA 285E and was not evaluated further.

MONITOR LABS MODEL 8450

The Monitor Labs Model 8450 Sulfur Monitor is also based on FPD. This instrument makes claims of performance equal to or better than the Meloy SA 285E. This instrument was not available for evaluation.

BENDIX MODEL 8303

The Bendix Corporation Model 8303 Sulfur Analyzer is an FPD instrument. This instrument was not made available for evaluation, but was demonstrated by a vendor. The instrument measures SO_2, H_2S, and total sulfur.

The Bendix 8303 had the following favorable points:

1. Low signal lag time; 18 seconds in SO_2 mode.
2. Low response time: 30 seconds maximum.
3. Low rise and fall time: 25 seconds maximum.
4. Low zero and span drift; less than 2% for three days.
5. Broad operating ambient temperature range: 5° - 40° C.
6. Independent range, span and zero controls for each component (hydrogen sulfide, sulfur dioxide, and total sulfur).
7. Linear output.
8. Good zero/span adjustability.
9. Good linearity between ranges.
10. Insensitive to vibration.
11. Insensitive to electrical noise.
12. Trouble shooting aids and diagnostics.

The Bendix 8303 had the following unfavorable points:

1. Requires hydrogen.
2. Has relatively high interferent level: 30 ppb.
3. High minimum detectable sensitivity: 5 ppb.
4. High linearity requirement: 10 ppb.
5. Temperature sensitive.

SO_2 ANALYZERS - PULSE FLUORESCENCE

Three pulsed fluorescence type SO_2 monitoring instruments were evaluated. Some important characteristics of each are listed below.

THERMO ELECTRON CORP. MODEL 43

The Thermo Electron Corporation Model 43 is a true pulsed fluorescence type instrument. The UV lamp is actually switched on and off at 4 microsecond intervals rather than being mechanically chopped.

The Thermo Electron 43 had the following favorable points:

1. Good zero and span adjustability.
2. Remote zero and span control availability.
3. No need for support gases or reagents.

4. Good instrument linearity between scales.
5. Insensitive to vibration.
6. Insensitive to temperature changes.
7. Insensitive to electrical noise.
8. Excellent component accessibility.
9. Built-in troubleshooting aids.
10. Circuit boards interchangeable with TECO 14 B/E or D/E.
11. Excellent in-house repairability.
12. Good parts availability.
13. Training is offered.
14. Remote diagnostics of some malfunctions available.
15. Low required preventive maintenance.
16. Good operating characteristics.
17. Stable sample air flow.
18. Can be rack or shock mounted.
19. Broad operating ambient temperature range: 5° - 40° C.
20. Manual is well written and reproduced.
21. Low signal lag time: 10 second maximum.
22. Low rise and fall time: 2 minute maximum.
23. Low detectability limit: 2 ppb.
24. Low interference equivalent: 11 ppb.
25. No heated or temperature controlled chambers required.

26. Insensitive to flow variations.

The Thermo Electron 43 had the following unfavorable point:

1. Zero drift excessive: factory specs allow 1% of full scale.

BECKMAN INSTRUMENTS MODEL 953

The Beckman Instruments Model 953 Fluorescent Ambient SO_2 Analyzer is a mechanically chopped UV fluorescence instrument. This instrument did not perform satisfactorily. The rise and fall times were excessive. They often exceeded 15 minutes. The instrument evaluated exhibited a negative drift, and it was hard to maintain zero or span without frequent potentiometer adjustments. The automatic hydrocarbon cutter required a temperature of 400° C. The manual was poorly written and did not include a pictorial or exploded view of the instrument showing component location or breakdown of individual components. This instrument did not perform according to the manufacturer's specifications.

The Beckman 953 had the following favorable points:

1. Remote zero and span control availability.

2. Good linearity when switching ranges.
3. Insensitive to vibration.
4. Insensitive to electrical noise.
5. Good component accessibility.
6. Built in diagnostics.
7. Training is offered.
8. Remote diagnostics capability.
9. No need for support gases or reagents.
10. Rack or shock mounting.
11. Internal zero air scrubber.
12. Flow system integrity gauge.
13. Automatic hydrocarbon cutter.
14. Circuit boards interchangeable with Beckman 952A oxides of nitrogen analyzer.

The Beckman 953 has the following unfavorable points:

1. Poor zero and span adjustability.
2. Poor zero and span reproduceability.
3. Poor parts availability.
4. Requires periodic and frequent preventive maintenance.
5. Manual is poorly written and reproduced.
6. Slow response.
7. Temperature controlled analysis section; 110° F.

8. Thermal automatic hydrocarbon cutter: 400° C.
9. Narrow operating ambient temperature range: 20° - 30° C.

LEAR SIEGLER MODEL SM1000

The Lear Siegler Model SM1000 sulfur dioxide ambient monitor also operates on the pulsed UV, fluorescence principle; however, the instrument utilizes a monochromator with a continuously rotating scanner to modulate the wavelength of fluoresced light as required. The instrument is termed by the manufacturer to be a "second derivative spectroscopy sulfur analyzer." This instrument was not evaluated.

In terms of an extensive ambient air monitoring network, the most effective way to monitor SO_2 concentrations is with a continuously operating instrument. In Harris County, the level of SO_2 concentrations that will have to be measured should range upward from a level of about 13 ppb. The method of SO_2 analysis chosen must be capable of detecting concentrations that small. On the basis of the instrument evaluation conducted as a part of this project, both the Meloy Laboratories SA 285E FPD sulfur analyzer and the Thermo Electron pulsed fluorescence Model 43 sulfur analyzer should provide satisfactory performance. These instruments worked equally well under test conditions.

NO_2 ANALYZERS

There are eight instruments designated by EPA as equivalent methods for the detection of NO_2 in ambient air. Each instrument is based on the principle of chemiluminescence. Five of these instruments were evaluated.

COLUMBIA SCIENTIFIC INDUSTRIES MODEL 1600

The Columbia Scientific Industries Model 1600 oxides of nitrogen analyzer performed flawlessly. The manual adequately shows in drawing layouts the location of components. The instrument has excellent built in diagnostics and the trouble-shooting section is thorough. The instrument had excellent linearity when switched from one range to another.

The CSI Model 1600 NO_2 analyzer had the following favorable points:

1. Excellent sample air flow.
2. Excellent zero and span adjustability.
3. No need for support gases or reagents.
4. Remote zero and span control availability.
5. Excellent operating characteristics.
6. Excellent instrument linearity.
7. Excellent zero and span reproduceability.
8. Insensitive to vibration.
9. Insensitive to electrical noise.
10. Good component accessibility.

11. Excellent built-in diagnostics.

12. Good in-house repairability.

13. Good parts availability.

14. Training is offered.

15. Remote diagnostic capability for some malfunctions.

16. Low required preventive maintenance.

17. Rapid switching of NO and NO_X signals: 8 times/minute.

18. Temperature regulated reaction chamber and PM tube.

19. Built-in push button diagnostic display system.

20. Rack or bench mountable.

21. Filter protected and thermally regulated flow controlling capillaries.

22. Stable over wide ambient temperature range: 10° - 40° C.

23. Low signal noise: 1 ppb.

24. Low detectable limit: 2 ppb.

25. Low total interference equivalent: 10 ppb.

26. Low zero drift: 1 ppb.

27. Low span drift.

28. Low lag time: 8 seconds.

29. Low signal rise/fall time: selectable time constant.

30. High operating humidity range: up to 95%.

The CSI Model 1600 NO_2 had no readily discernible unfavorable points.

BENDIX MODEL 8101-C

The Bendix Model 8101-C oxides of nitrogen analyzer performed satisfactorily and had the following favorable points:

1. Excellent sample air flow.
2. Good zero and span adjustability.
3. Good zero and span reproduceability.
4. Good operating characteristics.
5. Good instrument linearity.
6. Insensitive to vibration.
7. Insensitive to electrical noise.
8. Good component accessibility.
9. Temperature regulated reaction chamber and PM tube.
10. Rack or bench mountable.
11. Stable over wide ambient temperature range: 5° - 40° C.
12. Low signal noise: 2 ppb.
13. Moderately low detectable limit: 5 ppb.
14. Low interference equivalent: 10 ppb.
15. Moderately low zero drift: 5 ppb.

16. Low span drift: 10 ppb.
17. Short time cycle between NO and NO_X: 23 seconds.
18. Remote zero and span capability.

The Bendix Model 8101-C oxides of nitrogen analyzer had a single unfavorable feature. It does not have a system of built-in diagnostics.

MELOY NA 530R

The Meloy NA 530R oxides of nitrogen analyzer performed satisfactorily. This instrument has dual chambers for NO and NO_X; NO_2 is yielded by subtraction of constant signals. This is the only instrument EPA certified in a low expanded range of 0 - 100 ppb full scale. This factor was important since baseline NO_2 values are expected to be 20 - 50 ppb.

The Meloy NA 530R oxides of nitrogen analyzer had the following favorable points:

1. Excellent sample air flow.
2. Good zero and span adjustability.
3. No need for support gases or reagents.
4. Remote zero and span control availability.
5. Timed zero and span availability.
6. Excellent operating characteristics.
7. Good instrument linearity.
8. Good zero and span reproduceability.

9. Insensitive to vibration.
10. Insensitive to electrical noise.
11. Good component accessibility.
12. Excellent built-in diagnostics.
13. Good in-house repairability.
14. Good parts availability.
15. Training is offered.
16. Remote diagnostic capability for some malfunctions.
17. Low required preventive maintenance.
18. Rack or bench mountable.
19. Wide ambient temperature operating range: 10° - 40° C.
20. Moderately low signal noise: 4 ppb.
21. Moderately low detectable limit: 4 ppb.
22. Moderately low total interference equivalent: 15 ppb.
23. Low signal lag time: 5 seconds.
24. High relative humidity range: 0 - 95%.
25. Interchangeability of components with Meloy SA 285.

The Meloy NA 530R has the following unfavorable points:

1. Zero drift relatively large: 7 ppb.
2. Span drift relatively large: 13 ppb.

3. Large rise and fall time on low range: 6 minutes.

THERMO ELECTRON MODEL 14B/E

The Thermo Electron Model 14B/E performed satisfactorily. It had the following favorable characteristics:

1. Excellent sample air flow.
2. Excellent zero and span adjustability.
3. No need for support gases or reagents.
4. Remote zero and span control availability.
5. Excellent operating characteristics.
6. Excellent linearity of ranges.
7. Excellent zero and span reproduceability.
8. Insensitive to vibration.
9. Insensitive to electrical noise.
10. Good component accessibility.
11. Good built-in diagnostics.
12. Good in-house repairability.
13. Good parts availability.
14. Training is offered.
15. Remote diagnostic capability for some malfunctions.
16. Low required preventive maintenance.
17. Fast switching of NO and NO_X signals: 3 times/minute.

18. Temperature regulated PM tube.
19. Rack or bench mountable.
20. Wide ambient temperature operating range: 0° - 40° C.
21. Low signal noise: 1 ppb.
22. Low detectable limit: 2 ppb.
23. Low interference equivalent: 0.5 ppb stated.
24. Low zero drift: 1 ppb.
25. Low span drift: 1%
26. Moderately low rise/fall times: 2 and 2.5 minutes respectively.
27. Moderately low signal lag time: 30 seconds.

The Thermo Electron Model 14B/E had the following unfavorable points:

1. Lack of thermally controlled reaction chamber.
2. Cabinet lacked compactness.

BECKMAN 952A

The Beckman 952A NO_2 analyzer did not perform satisfactorily. The instrument would not span or zero. It was not evaluated extensively for this reason.

Three other NO_2 analyzers are commercially available. They are the Monitor Labs Model 8440E, the Thermo Electron Model 14D/E, and the Bendix Model 8101-B. None of these three instruments were available for evaluation.

Given the need for extensive, accurate monitoring of ambient air NO_2 concentrations, a continuously operating instrument is the best choice of analytical methods. In Harris County NO_2 concentrations as low as 20 ppb will have to be detected. On the basis of the instrument evaluation conducted as a part of this project, at least four instruments are available which would be satisfactory for NO_2 analysis. Those four instruments are the CSI Model 1600, the Bendix Model 8101-C, the Meloy Model NA 530R, and the Thermo Electron Model 14B/E.

INSTRUMENT CALIBRATION

EPA requirements for ambient air monitoring networks address instrument calibration as well as analytical method. As a result, an evaluation of instrument calibration methodology was also undertaken as a part of this project.

EPA requirements for analyzer calibration may be summarized as follows:

1. A zero-span check must be performed once per week.
2. A two point precision check must be performed once every two weeks.
3. A multipoint precision check must be performed at least once each calendar quarter.

The required instrument calibration could be accomplished in one of two ways. Either a multipoint calibrator could be maintained at each site where a continuous SO_2 or NO_2 analyzer is operated, or a single point calibrator could be maintained at each analyzer site with several multipoint calibrators kept at a central location. The multipoint calibrators would then be transported to the analyzers as required.

Given either approach, the specifications of an acceptable single point calibrator should include:

1. At least two ranges: 0 - 100 ppb and 0 - 500 ppb.
2. Stable, precise calibration gases.
3. Minimum maintenance requirements.

The specifications of an acceptable multipoint calibrator should include:

1. At least two ranges: 0 - 100 ppb and 0 - 500 ppb.
2. Stable, precise calibration gases.
3. Minimum maintenance requirements.
4. Short warm-up time.

Permeation tube (PT) type calibrators and gas phase titration (GPT) type calibrators were both considered for use with SO_2 monitoring instruments. A PT type calibrator is more useful with SO_2 than a GPT type. The PT type calibrator is simple to operate and does not require calibration gases. GPT type calibrators can present problems because of the relatively high density of SO_2 and its proclivity to stratify in gas cylinders.

PT type calibrators are available in both single point and multipoint models. They are commercially available from a number of sources. Three commercial models were investigated for possible use with SO_2 analyzers. The calibrators considered were the Metronics Model 230, the TECO Model 143, and the Meloy Labs Model CS-10-2.

Both the Metronics Model 230 and the TECO Model 143 performed satisfactorily. The precision of both models was good over the entire range of operation. The Metronics calibrator had the shorter warm-up time.

The Meloy Labs Model CS-10-2 did not perform well. It required a twenty-four hour warm-up period. It did not yield consistent calibration gases.

With respect to use with NO_2 continuous analyzers, three types of calibrators were considered. The three alternatives were PT type, GPT type, and dilution of bottled gas type calibration.

Due to time constraints, this study did not include an actual field evaluation of NO_2 calibrators. Instead, the experience of others (Dow Chemical, Mobay Chemical, SUMX Corp., Radian Corp. and TACB) was relied upon as a guide. The method often chosen by government agencies for multipoint NO_2 calibration is GPT. These type calibrators tend to yield stable, precise calibration gases. Warm-up times are reasonable. NO_2 PT type calibrators, on the other hand, tend to be very temperature sensitive. They are also reported to have a relatively short life.

The results of this work indicate that SO_2 continuous analyzers can best be served by PT type calibrators. Continuous NO_2

analyzers can best be served by GPT type calibrators. Both requirements can be met with devices easily obtained on the commercial market.

TOTAL SUSPENDED PARTICULATES

No hi-vol air samplers were evaluated. There is little to choose from among the several manufacturers as most equipment is generally satisfactory. Calibration kits are available from hi-vol suppliers.

METEOROLOGICAL EQUIPMENT

With respect to meteorological equipment, it is recommended that wind speed, wind direction, temperature, relative humidity, and rainfall, be measured at each site. Equipment to measure these parameters is readily available. None was evaluated as a part of this study.

PROPOSED AMBIENT AIR MONITORING NETWORK

The existing ambient air sampling network in Harris County can be substantially improved. As noted previously, two government agencies currently operate the existing monitoring sites. Different equipment using different analytical methods is sometimes employed to detect the same air pollutants. Available data is a mixture of continuous and non-continuous values. Both wet chemical and continuous instrumental methods are in use. The existing sampling sites tend to be bunched along either side of the Houston Ship Channel or within the city limits of Houston. Many heavily populated areas of the County are devoid of air quality monitoring sites. Finally, under the present system, the lag time between the day that air quality is actually measured and the day that analytical results are available to those outside the Texas Air Control Board may approach months.

It is almost impossible to predict impending changes in energy use patterns among industrial users in and around Harris County. Clearly, however, if natural gas usage is curtailed in favor of alternate fossil fuels, air quality will probably deteriorate. The potential for substantial air quality deterioration exists because of permitted fuel conversion (6) (7).

It is proposed that the existing ambient air monitoring network in Harris County be substantially upgraded. Needed improvements would be designed to increase the number of sampling sites; modernize and standardize the monitoring equipment; and streamline the data handling, storage and retrieval systems.

The primary improvement in the ambient air monitoring network would involve the addition of ten new fixed sites and two new mobile sites. The twelve new sites would be combined with between five and fifteen existing sites to form a countywide network. The fixed sites would serve to monitor ambient air quality on a coordinated continuous basis. The two mobile monitors would supplement the fixed network by providing the capability to verify abnormal data near a particular fixed site; by collecting supplementary data at "hotspots;" and by allowing the monitoring of particular events like the start-up of a new coal fired electric power generating facility.

Figure VII is a map which illustrates the proposed ambient air monitoring network. Approximate locations of the new sites are shown. The location of all existing monitoring sites in Harris County are also indicated.

It would be desirable for the proposed network to operate under the authority of a single government entity. The operating agency will provide the ambient air data generated to all interested parties on a timely basis. Since it is unlikely that all monitoring sites will be owned and operated by a single government agency, a plan to coordinate activities would be absolutely necessary for maximum effectiveness.

SAMPLING EQUIPMENT

INTRODUCTION

In the preceding section of this report, a recommendation was made for the development of a countywide sampling network. That recommendation would require the development of certain fixed sampling sites supported by mobile monitors. The purpose of the following discussion is to detail the hardware that would be used; to explain probable personnel requirements associated with the sampling network; and to discuss the economic requirements of the system.

FIXED SAMPLING SITES

Ten new fixed sampling sites would be required in the recommended monitoring network. A fixed site would consist of a trailer and the instrumentation needed to analyze ambient air and to transmit analytical results to a central data bank.

The trailer would be located, where possible, on secure public property such as school yards, fire station grounds, police station parking lots, etc. In some cases it might be necessary to lease privately owned land in order to locate a sampling trailer in an appropriate part of the County.

The hardware associated with a fixed site would consist of the following items:

1. A secure shelter (at least 10' x 16') with air conditioning and heating.

2. An Ace Glass sampling manifold with at least 8 ports.
3. A continuous SO_2 analyzer.
4. A continuous NO_2 - NO - NO_x analyzer.
5. Four hi-vol particulate samplers.
6. A multipoint calibrator for NO_2 and SO_2.
7. A data logging system.
8. A cassette tape or floppy disc data storage system.
9. A keyboard printer.
10. A 10 meter meterological tower.
11. Appropriate meterological instruments.
12. Strip chart recorders for all analyzer outputs.
13. An equipment rack for mounting instruments.
14. All required plumbing.
15. A lightning arrester.
16. Storage space for required support and calibration gases.
17. A telephone line.

The estimated personnel requirements for the proposed ten additional sampling sites are three field operators, one instrument technician, and one supervisor. The field operators would be needed to collect keyboard printer sheets and floppy discs from each site, to monitor equipment operation, and to perform routine maintenance on and around the sampling equipment. The field operators would also be needed to perform simple instrument calibrations. The instrument technician would be needed for non-routine analyzer maintenance and repair, to do unusual or difficult calibrations, and to stock and maintain a small instrument repair shop. The supervisor would be responsible for the day to day activities of the field operators and the instrument technician and would also be required to assemble and disseminate periodic reports summarizing ambient air quality at various points in the County. Proper operation of the data handling and storage system would also fall within the responsibility of the supervisor.

MOBILE MONITORS

Two mobile monitors would be used in the recommended network. The primary function of these monitors would be to provide data that could not be obtained with fixed sites. In essence, these mobile facilities would be able to go anywhere in the County that ambient air problems develop.

A mobile monitor would have the same hardware as a fixed sampling site. In addition, a mobile monitor would be housed in a trailer that could be easily transported from place to place. All analyzers and other delicate instruments associated with a mobile monitor would be specially shock mounted. A power generator to allow operation in remote areas would also be provided.

The estimated personnel requirements for the mobile monitors would be two field operators. Their responsibilities would include operating, maintaining and relocating the mobile monitors as required. They would also collect data and perform routine instrument calibrations. Instrument repair at the mobile monitors would be done by the same instrument technician hired to service fixed site instruments. The two field operators would be responsible to the fixed site supervisor.

ECONOMIC CONSIDERATIONS

There are several options available with respect to implementation of the proposed sampling network. The government agency that administers the program could elect to merely receive data generated by a network owned and operated by a private entity (Option I). A second alternative would involve the agency maintaining ownership of all equipment but contracting with a private entity to operate the equipment and generate the required data (Option II). A third alternative would involve the agency owning and operating all sampling equipment (Option III).*

A preliminary estimate of the capital and operating costs associated with each of the above mentioned options has been prepared. It is based upon a network of ten fixed sampling sites, plus two mobile trailers. All indicated costs are believed to be accurate to within ±20%.

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*There are a number of private businesses that are experienced in developing and maintaining ambient air monitoring systems. Beckman Instruments, Radian Corporation, and SUMX Corporation all have experience in projects similar to the undertaking described in these pages.

Table XI contains a detailed estimate of the capital and first year operating costs associated with the ambient air network, if owned and operated by a government entity. The indicated capital cost is $690,000. The purchase of analytical instruments would account for more than one-half of this amount. Operating costs during the first year of the project would total $320,000. Operating costs are expected to escalate to $350,000 and $390,000 during the second and third years of the project respectively.

TABLE XI

FIRST YEAR CAPITAL AND OPERATING COSTS FOR A TEN FIXED SITE AMBIENT AIR SAMPLING NETWORK

(Option III)

Estimated Capital Cost	
Analyzers, calibrators, samplers	$350,000
Data loggers	150,000
Trailers	100,000
Integration of equipment, utilities, etc.	90,000
Estimated Annual Operating Cost	
Personnel	$135,000
Maintenance	100,000
Telephone, supplies, electrical	85,000

Table XII is an illustration of the estimated total costs involved with operating a ten site network under the three different options defined above. Total costs for the first year and first three years of operation are indicated. It should be emphasized that these costs include data handling and storage charges.

Table XIII is a tabulation of the capital and operating costs associated with purchasing the equipment needed to fabricate two mobile monitors. It is estimated that these monitors can be obtained for approximately $75,000 each.

Annual operating costs for the two mobile monitors are estimated to be $125,000 during the first year; $138,000 during the second year; and $151,000 during the third year. The three year cost associated with the two mobile monitors would therefore total $564,000. It is assumed that these monitors would be owned and operated by the government agency.

The total three year monetary requirement for the ten fixed site, two mobile monitor ambient air monitoring system is as follows:

Option I:	$3,200,000
Option II:	$3,100,000
Option III:	$2,300,000

The alternative wherein the government agency owns and operates the entire proposed network appears to be the most cost effective.

TABLE XII

CAPITAL AND OPERATING COSTS FOR A TEN FIXED SITE AMBIENT AIR MONITORING NETWORK

Option*	Monitoring Network Owned By	Monitoring Network Operated By	Capital And Operating Costs For First Year	Capital And Operating Costs For First Three Years
I	Private Entity	Private Entity	$990,000	$2,640,000
II	Government Agency	Private Entity	1,260,000	2,580,000
III	Government Agency	Government Agency	1,010,000	1,750,000

*All options include the cost for a private entity to:

(1) Integrate the equipment into a viable monitoring system.

(2) Check out the system.

(3) Ship the facilities to the government agency.

(4) Train government agency personnel to operate the equipment. (If the private entity is not being retained to operate).

TABLE XIII

CAPITAL AND OPERATING COSTS FOR TWO MOBILE MONITORS

Estimated Capital Cost	
Analyzers, calibrators, samplers	$60,000
Data loggers	24,000
Trailers	30,000
Power generators	10,000
Integration of equipment, utilities, etc.	26,000
Estimated Annual Operating Cost	
Personnel	$80,000
Maintenance	25,000
Telephone, supplies, electrical	20,000

DATA COLLECTION AND HANDLING

INTRODUCTION

An ambient air monitoring network composed of ten fixed sites and two mobile monitors will require an automated data handling system. Over the course of a year, millions of bits of data will be generated. A carefully designed system will have to be provided to collect, store, and utilize this information.

The purpose of this section of the report is threefold. First, the key elements of an appropriate data handling system will be defined. Next, the results of a preliminary review of some commercially available data handling systems will be summarized. Finally, the cost of acquiring an acceptable system will be estimated.

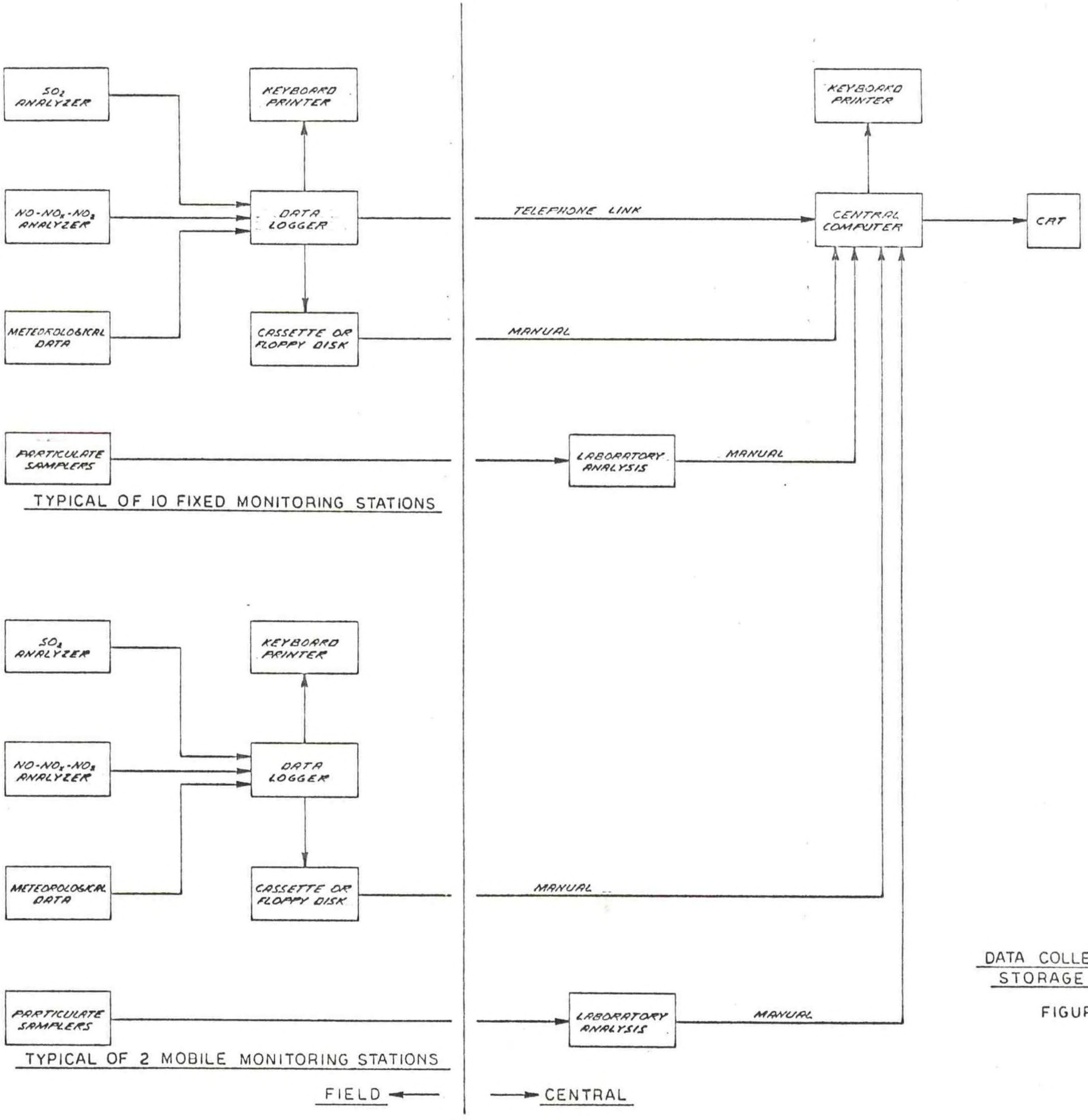
ELEMENTS OF A DATA HANDLING SYSTEM

An effective data handling and storage system should have two primary components. The first component is a data logger. A single data logger would be required at each sampling site in the network. Its key function would be to receive an analog signal from each continuous analyzer and from appropriate meteorological equipment and convert that signal to a form suitable for temporary storage and eventual transfer to the central data storage site. The data logger can store information in the same form that it is received and it can reduce information by integration and averaging. One hour, three hour, daily, and weekly averages are available. The data logger should be designed to output information in a variety of forms. Data can be converted to printed words or numbers through the use of a keyboard printer. The electrical outputs can be converted to magnetic signals and stored on cassette tapes or floppy discs or, the output can take the form of an electrical signal for transmission over telephone lines to a central computer.

A small central computer represents the other primary component in an effective data handling and storage system. The computer would be used to collect incoming data from all sampling sites in the monitoring system. Voice grade telephone lines would provide the primary communication link between central computer and field data loggers. The computer should also accept data in the form of cassette tapes or floppy discs. The computer should have the capability of "calling up" each sampling site and ascertaining the operational status of each monitoring instrument. The computer might also be programmed to initiate automatic calibration procedures at the field sampling sites.

A keyboard printer and a cathode ray tube (CRT) should be provided to supplement the central computer. These auxiliaries would allow system operators to monitor network operations and to extract ambient air data in either printed or display form.

Figure VIII is a schematic of a typical data handling and storage system. It illustrates the relationship between the various components in the system. Note that all TSP data must be hand carried from field to laboratory to central computer.



DATA COLLECTION AND
STORAGE SYSTEM

FIGURE VIII

COMMERCIALLY AVAILABLE DATA HANDLING SYSTEMS

Data handling and storage systems commercially available from three companies were investigated. The purpose of these investigations was to conduct a preliminary review of systems capabilities and to obtain an estimate of the cost to acquire an acceptable system. An effort was not made to exhaustively review every data handling system commercially available. The systems investigated may not be the most effective technically or economically. The thrust of the review was to verify that systems capable of meeting the needs of the recommended network are in fact obtainable. The equipment considered and a brief review of its capabilities is given below.

The SUMX Corporation offers an SX-410 Data Acquisition System used in conjunction with a Data General Nova III mini-computer for data handling purposes. This system was designed specifically for ambient air monitoring applications. It would meet all the requirements of the proposed sampling network.

The Radian Corporation offers a Dart II system used in conjunction with a Unitech Products mini-computer. The Dart II system was designed specifically for ambient air monitoring applications. It would meet all the requirements of the proposed sampling network.

BIF, a unit of General Signal, offers an Accutel system which is composed of data logging equipment used in conjunction with a mini-computer. The BIF system was developed primarily for use in monitoring remote water pumping stations and sewage treatment plants. This system appears to meet all the requirements of the proposed sampling network.

SYSTEM COSTS

It is estimated that a data handling and storage system suitable for use with the proposed ambient air sampling network could be obtained at a cost of from $125,000 - $150,000.

THE CONTINUING EVALUATION OF SO_2 AIR POLLUTION PROBLEMS

MONITOR AND EVALUATE AMBIENT AIR DATA

Information contained in preceding sections of this report illustrates several key points with respect to future SO_2 air pollution problems. The quantity of SO_2 that may legally be emitted into the atmosphere over Harris County is significantly greater in 1979 than it was in 1972. The quantity of SO_2 that is actually emitted into the atmosphere over Harris County is greater in 1979 than in 1972; however measured ambient air SO_2 concentrations do not appear to have changed appreciably in the past few years.

Given the uncertainty in the energy situation, industrial operators will be under continuing pressure to develop and utilize alternate fuels. If natural gas becomes difficult to obtain, increasing amounts of fuel oil and coal will probably be utilized. In this event the gap between the amount of SO_2 that can be emitted and the amount of SO_2 that is emitted will narrow.

Permits to construct new facilities which will emit SO_2 into the atmpshere are still being issued. The conversion of existing facilities to allow the combustion of fuel oil and coal instead of natural gas is also still being permitted. The TACB is presently in the process of adopting a regulation which will allow, on an emergency basis, the use of high sulfur content fuel oil if fuel oil with a low sulfur content is not available. Under these circumstances, the threat exists for SO_2 emissions to increase; therefore the need to monitor atmospheric quality to observe measureable changes is real.

Atmospheric emissions of NO_2 and TSP may also increase if alternate fossil fuels replace natural gas. As Houston's population grows, these pollutants, NO_2 and TSP, will also enter the atmosphere due to factors not related to changes in stationary energy use patterns. The consequences of any increased ambient air concentrations of NO_2 and TSP will none the less be important.

Should atmospheric emissions of SO_2 increase, it will become important to carefully monitor the resultant increases in ambient air concentrations. A sampling network capable of providing comprehensive, timely ambient air data is described in other sections of this report. Deploying and operating this network would provide the basic information needed to make rational decisions regarding increased regulatory control.

MONITOR EMISSION DATA

Until the work described in this report was undertaken, little or no information was available regarding actual SO_2 emissions from industrial facilities located in and around Harris County. The TACB has not compiled an emission inventory since 1975. To obtain information concerning actual SO_2 emissions from new, modified, and expanded sources, a questionnaire was prepared and mailed to potentially major emitters. The responses clearly indicate that some source operators do not understand how much SO_2 they may legally emit from permitted facilities. However, the data obtained gives an insight into actual conditions, allowing a comparison to be made between emissions and ambient air quality and providing a base line by which to judge the effect of increased emissions on air quality as fuel conversion takes place.

In coming years, should SO_2 air pollution problems increase, accurate, up-to-date information related to SO_2 air emissions as well as fuel oil and coal usage will be a key factor in siting new energy consuming sources. A questionnaire similar to the one used in this study should be submitted to major industrial sources each year. If accurately completed, it will provide some very useful information. It would also be helpful if annual TACB emission inventories are compiled. In this way, it may be possible to better understand the complex relationship between actual SO_2 emissions and observed ambient air SO_2 concentrations.

DEVELOP POSSIBLE REMEDIAL ACTIONS

If all of the SO_2 is emitted into the atmosphere that can be legally emitted, it is likely that a serious problem will develop. Two recent studies show that unhealthful ambient air concentrations of SO_2 could occur in Harris County given permitted emissions (6) (7). This situation will be further compounded if more and more SO_2 emissions are permitted. Excessive concentrations of NO_2 and TSP are also likely.

It would therefore seem prudent to prepare for the future by developing a plan to deal with an unacceptable SO_2 air pollution problem. Virtually any plan which effectively controls the ambient air concentration of SO_2 will also have a positive effect on NO_2 and TSP concentrations. There are at least three different approaches that might be taken. A moratorium could be placed on the construction of new industrial sources of SO_2 emissions. If a severe SO_2 air pollution problem develops, then the construction of more SO_2 emitting facilities would only tend to exacerbate the problem. Another approach would be to attempt to reduce SO_2 emissions from existing sources. Control devices might be required on a greater variety of industrial point sources that emit SO_2. The sulfur content of fuel oil and coal to be used for power generation might be further restricted. Or, if the air pollution problem becomes truly severe, the operation of some SO_2 emitting facilities might be curtailed. The third possible approach would involve the management of clean burning fuels. If only a limited amount of low sulfur fuel is available, and if a significant SO_2 air pollution problem is being experienced, then clean burning fuels might be allocated to industrial facilities located in areas of Harris County where the problem is most severe.

The use of fuels should be managed and the emissions therefrom regulated in a manner directly related to the concentration of pollutants in the ambient air, if not, we may one day find the national standards exceeded all over Harris County, Texas.

APPENDIX

TABLE OF CONTENTS

REFERENCES

(1) Records of the Emission Inventory Section, Texas Air Control Board, Austin, Texas.

(2) 1978 Annual Data Summary for Non-continuous Monitoring, Texas Air Control Board, 1978.

(3) Attainment Analysis, Volume I, Causes of Nonattainment, Texas Air Control Board, January, 1977.

(4) "Procedures for Testing Performance Characteristics of Automated Methods," 40 CFR Part 53, Subpart B, pp. 953-976.

(5) "Determination of Sulfur Dioxide Emissions from Stationary Sources by Continuous Monitors," 40 CFR Part 52, Appendix D, pp. 935-941.

(6) Evaluation of the Impact of the Federal Prevention of Significant Deterioration Regulations for Sulfur Dioxide in Houston, Texas, ERT, Inc., April, 1979.

(7) Final Report on the SO_2 Air Quality for Harris, Ft. Bend, and Chambers Counties, Radian Corporation, May 4, 1979.

MASTER LIST OF SOURCES

HARRIS COUNTY SO_2 PROJECT

Facility Number	Facility Name
1	Texas Industries
2	H. L. & P. - Parish
3	Cameron Iron
4	Shell Development
5	H. L. & P. - Wharton
6	United Salt
7	Columbian Carbon
8	Witco Chemical
9	Maxwell House
10	General Portland
11	Eddy Refining
12	Gulf Coast Portland Cement
13	Stauffer - Houston
14	Lone Star Cement
15	Anheuser Busch
16	Petro-Tex
17	Charter International Oil
18	H. L. & P. - Greens Bayou
19	Ideal Cement
20	Monsanto - Chocolate Bayou
21	ARCO Refinery

Master List of Sources - continued

Facility Number	Facility Name
22	GATX - Galena Park
23	Champion Paper
24	Amoco - Chocolate Bayou
25	Amerada Hess
26	Crown Central Petroleum
27	Koppers
28	Pennwalt
29	Air Products - Pasadena
30	Diamond Shamrock - Greens Bayou
31	Ethyl
32	Georgia Pacific
33	Tenneco
34	Berwind Railway
35	Shell
36	Air Products - Channelview
37	Houston Fuel Oil
38	Lubrizol - Deer Park
39	Union Carbide - Deer Park
40	Diamond Shamrock - Deer Park
41	ARCO - Channelview
42	Oxirane - Channelview
43	Southland Paper
44	Rohm & Haas
45	Rollins

Master List of Sources - continued

Facility Number	Facility Name
46	Paktank - Deer Park
47	Diamond Shamrock - Independence
48	ARCO - Deer Park
49	Upjohn
50	Rexene
51	I.C.I. - United States
52	Diamond Shamrock - Battleground
53	U.S.I.
54	Quaker Oats
55	Celanese - Bayport
56	H. L. & P. - Bertron
57	Syngas
58	Air Products - La Porte
59	Big Three
60	DuPont
61	Exxon Chemical - Baytown
62	Exxon Refinery
63	American Hoechst
64	GAF
65	Union Carbide - Texas City
66	Gulf Chem. & Met.
67	H. L. & P. - Robinson
68	Amoco - Texas City
69	Gulf Oil Chemicals

Master List of Sources - continued

Facility Number	Facility Name
70	J. M. Huber
71	H. L. & P. - Cedar Bayou
72	Marathon Oil
73	Texas City Refining
74	Exxon Chemical - Mont Belvieu
75	Cities Service
76	Mobay
77	Monsanto - Texas City
78	Duval Corp.

ACTUAL 1978 SO_2 EMISSIONS FROM PERMITTED FACILITIES

(Questionnaire Values)

Facility Number	SO_2 Emissions From Facilities Permitted Before 7/26/75 (Tons)	SO_2 Emissions From Facilities Permitted After 7/26/75 (Tons)
1	1,520	0
2	0	4,150
3	?	?
4	0	0
5	10	0
6	0	0
7	0	0
8	5	0
9	214	0
10	0	0
11	0	11
12	0	451
13	0	0
14	38	0
15	0	209
16	88	0
17	5,070	1,650
18	0	0
19	0	78
20	?	?
21	1,300	0

Actual 1978 SO_2 Emissions - continued

Facility Number	SO_2 Emissions From Facilities Permitted Before 7/26/75 (Tons)	SO_2 Emissions From Facilities Permitted After 7/26/75 (Tons)
22	?	?
23	475	0
24	?	?
25	0	0
26	0	0
27	0	12
28	0	0
29	0	0
30	0	0
31	348	0
32	?	?
33	0	0
34	?	?
35	1,860	142
36	?	?
37	0	0
38	0	258
39	?	?
40	0	59
41	6,210	0
42	0	3,510
43	612	0

Actual 1978 SO_2 Emissions - continued

Facility Number	SO_2 Emissions From Facilities Permitted Before 7/26/75 (Tons)	SO_2 Emissions From Facilities Permitted After 7/26/75 (Tons)
44	673	0
45	?	?
46	?	?
47	0	0
48	0	20
49	?	?
50	291	103
51	0	148
52	0	0
53	0	0
54	201	0
55	845	0
56	140	0
57	?	?
58	17	1
59	0	1
60	285	55
61	0	3,170
62	137	0
63	?	?
64	0	0
65	?	?

Actual 1978 SO_2 Emissions - continued

Facility Number	SO_2 Emissions From Facilities Permitted Before 7/26/75 (Tons)	SO_2 Emissions From Facilities Permitted After 7/26/75 (Tons)
66	?	?
67	868	0
68	?	?
69	990	0
70	1,980	0
71	0	65
72	?	?
73	?	?
74	0	0
75	0	27
76	0	723
77	0	0
78	0	0

NOTE: Facilities which did not respond to the questionnaire are indicated by a question mark (?).

A LIST OF ALL CONSTRUCTION PERMITS ALLOWING SO_2 EMISSIONS:

3/5/72 TO 6/30/79

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Air Products - Channelview	7033	3/30/79	298
Air Products - La Porte	771A	7/2/75	70
Air Products - La Porte	771B	3/9/77	311
Air Products - La Porte	3402	7/2/75	486
Air Products - La Porte	3403	7/2/75	657
Air Products - La Porte	4803	3/9/77	55
Air Products - La Porte	2022	4/1/74	13
Air Products - Pasadena	912	5/31/73	372
Air Products - Pasadena	1778	2/7/74	324
Air Products - Pasadena	1499	11/27/73	26
Air Products - Pasadena	184	5/23/72	5
Amerada Hess	6526	4/25/79	162
American Hoechst	5252	7/1/77	12
American Hoechst	5252A	7/1/77	1,010
American Hoechst	5252B	7/1/77	1,010
American Hoechst	5252C	7/1/77	1,010
American Hoechst	5252D	7/1/77	254
American Hoechst	5252E	7/1/77	675
Amoco - Chocolate Bayou	101	10/2/72	119
Amoco - Chocolate Bayou	102	10/2/72	119
Amoco - Chocolate Bayou	217	10/2/72	119
Amoco - Chocolate Bayou	2798	11/29/74	72
Amoco - Chocolate Bayou	2798A	11/29/74	72
Amoco - Chocolate Bayou	4483	9/15/76	14
Amoco - Texas City	2103	6/5/74	123
Amoco - Texas City	2315	8/23/74	9
Amoco - Texas City	2384A	7/18/74	889
Amoco - Texas City	2542	10/3/74	2,330
Amoco - Texas City	2610A	11/4/74	62
Amoco - Texas City	2611	10/1/74	32
Amoco - Texas City	2612	10/1/74	11
Amoco - Texas City	2636	10/1/74	21
Amoco - Texas City	2939	4/9/75	2,230
Amoco - Texas City (continued)	3170	4/15/75	13

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Amoco - Texas City (continued)	3362	10/3/75	2,270
Amoco - Texas City	3363	10/3/75	2,430
Amoco - Texas City	3364	10/3/75	2,960
Amoco - Texas City	4903	4/13/77	123
Anheuser Busch	5351	7/5/77	867
Anheuser Busch	7079	3/16/79	298
ARCO - Channelview	2933	2/3/75	7,900
ARCO - Channelview	6386	6/22/79	385
ARCO - Channelview	1768	5/6/74	8,480
ARCO - Deer Park	2558	8/5/74	254
ARCO - Deer Park	3908	3/5/76	837
ARCO Refinery	446	12/27/72	1
ARCO Refinery	1500	10/26/73	350
ARCO Refinery	2149	8/7/74	1,870
ARCO Refinery	2151	8/7/74	315
ARCO Refinery	2152	8/7/74	101
ARCO Refinery	2153	8/7/74	3,540
ARCO Refinery	2166	8/7/74	241
ARCO Refinery	2167	8/7/74	131
ARCO Refinery	6065	5/15/78	5
Berwind Railway	5609	10/25/77	3,640
Big Three	2627A	7/14/78	613
Big Three	4957	4/5/77	2,540
Big Three	4960	4/5/77	845
Big Three	4961	4/5/77	3,780
Big Three	4964	4/5/77	2,280
Cameron Iron	4813	2/3/77	561
Celanese - Bayport	261	9/12/72	48
Celanese - Bayport	264	9/12/72	876
Champion Paper	70	5/3/72	1,150
Champion Paper	6002	2/28/78	1,040
Champion Paper	6003	2/28/78	1,240
Charter International Oil	2498	11/14/74	44
Charter International Oil (continued)	2501	10/9/74	7,030

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Charter International Oil (continued)	2507	12/2/75	2,250
Charter International Oil	2508	12/2/75	1,730
Cities Service	3956A	11/1/78	110
Columbian Carbon	3601	10/3/75	153
Crown Central Petroleum	2871	1/3/75	1,180
Crown Central Petroleum	5953	2/27/78	53
Crown Central Petroleum	6059		14
Diamond Shamrock - Battleground	1911A	9/12/74	1,030
Diamond Shamrock - Battleground	1911B	9/12/74	1,030
Diamond Shamrock - Battleground	1911C	1/6/75	1,030
Diamond Shamrock - Deer Park	1522	11/10/76	1,360
Diamond Shamrock - Deer Park	4528A	9/27/77	753
Diamond Shamrock - Deer Park	5128A	2/28/78	950
Diamond Shamrock - Deer Park	5240	9/27/77	1,680
Diamond Shamrock - Greens Bayou	2299	5/22/74	350
Diamond Shamrock - Greens Bayou	4893	4/12/77	244
Diamond Shamrock - Independence	3855	11/2/76	2,220
DuPont	1529	8/21/73	228
DuPont	1834A	6/20/75	156
DuPont	2621A	5/11/76	1,070
DuPont	3078	4/9/75	88
DuPont	4019	5/11/76	2,160
DuPont	5034	3/30/77	22
DuPont	5034A	4/13/79	35
DuPont	1834	1/29/74	125
DuPont	663	8/21/73	9
Duval Corp.	3735	12/1/75	420
Eddy Refining	3697	10/3/75	136
Eddy Refining	4709	11/22/76	29
Eddy Refining	5211	6/7/77	29
Ethyl	734	7/19/73	2,390
Ethyl	1188	7/19/73	477
Ethyl	1820	2/19/74	1,810
Ethyl	3962	4/1/76	98
Ethyl	4551	10/8/76	66

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Exxon Chemical - Baytown	3162	4/15/75	13
Exxon Chemical - Baytown	3452	12/29/75	14
Exxon Chemical - Baytown	3871	1/27/76	5,620
Exxon Chemical - Baytown	4600	9/30/76	53
Exxon Chemical - Baytown	5019	4/19/77	1,180
Exxon Chemical - Baytown	5121	4/19/77	368
Exxon Chemical - Baytown	5259	6/29/77	850
Exxon Chemical - Baytown	5555	11/28/77	850
Exxon Chemical - Mont Belvieu	4831	2/24/78	380
Exxon Refinery	243	7/5/72	241
Exxon Refinery	244	7/5/72	241
Exxon Refinery	527	3/1/73	710
Exxon Refinery	1632	12/12/73	392
Exxon Refinery	2007	5/22/74	3,980
Exxon Refinery	2070	5/22/74	175
Exxon Refinery	2071	5/22/74	188
Exxon Refinery	2072	5/22/74	394
Exxon Refinery	2185	5/22/74	4,670
Exxon Refinery	2210	5/22/74	6,930
Exxon Refinery	2258	4/12/74	407
Exxon Refinery	2338	5/13/74	1,070
Exxon Refinery	2389	5/22/74	696
Exxon Refinery	2665	10/9/74	1,940
Exxon Refinery	2932	2/10/75	670
Exxon Refinery	4973	3/28/77	390
Exxon Refinery	5330	6/16/77	385
GAF	6918	4/13/79	946
GATX - Galena Park	2443	7/25/74	196
GATX - Galena Park	2444	7/25/74	196
General Portland	2658	11/7/74	2,280
Georgia Pacific	4825	1/18/77	368
Gulf Chem. & Met.	5094	2/28/78	447
Gulf Coast Portland Cement	5100	4/27/77	2,720
Gulf Oil Chemicals	1504	4/1/74	2,280
Gulf Oil Chemicals	2138	4/1/74	5,530
Gulf Oil Chemicals	2139	4/1/74	4,380

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Houston Fuel Oil	5783	2/28/78	201
H. L. & P. - Bertron	1751	12/28/73	3,060
H. L. & P. - Bertron	1752	12/28/73	3,060
H. L. & P. - Bertron	1753	12/18/73	4,100
H. L. & P. - Bertron	1754	12/28/73	4,100
H. L. & P. - Bertron	4484	8/4/76	24
H. L. & P. - Bertron	4485	8/4/76	24
H. L. & P. - Cedar Bayou	1532	8/26/76	46,700
H. L. & P. - Greens Bayou	2894	7/24/75	10,200
H. L. & P. - Parish	2348A	6/17/76	33,800
H. L. & P. - Parish	2349A	6/17/76	33,800
H. L. & P. - Parish	5530	9/19/77	30,100
H. L. & P. - Robinson	2306	6/27/74	23,300
H. L. & P. - Wharton	445	12/7/72	3,050
H. L. & P. - Wharton	2094	3/29/74	11,200
I.C.I. - United States	3619	9/5/75	118
I.C.I. - United States	4717	1/27/77	1
I.C.I. - United States	4919	2/3/77	11
Ideal Cement	5321A	8/9/77	2,860
J. M. Huber	2596	10/9/74	2,570
Koppers	5359	8/17/77	28
Koppers	6467	12/19/78	84
Koppers	7443	6/11/79	5
Lone Star Cement	1765	1/15/74	2,330
Lubrizol - Deer Park	3319	7/3/75	512
Lubrizol - Deer Park	4688	2/10/77	657
Marathon Oil	616	6/13/73	39
Marathon Oil	988	7/9/73	127
Marathon Oil	2084	4/19/74	464
Marathon Oil	6756	3/28/79	269

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Maxwell House	1286	8/17/73	456
Maxwell House	5341	9/2/77	451
Maxwell House	5500	9/2/77	872
Mobay	5030	4/5/77	2,730
Mobay	6177	2/28/78	1,160
Monsanto - Chocolate Bayou	4634	1/26/77	6,560
Monsanto - Chocolate Bayou	5084	4/29/77	31
Monsanto - Chocolate Bayou	5336	9/22/77	5,260
Monsanto - Chocolate Bayou	5336A	9/22/77	2,100
Monsanto - Chocolate Bayou	2271	6/27/74	39
Monsanto - Texas City	1272	1/2/74	845
Monsanto - Texas City	5260	9/2/77	6,640
Oxirane - Channelview	3286A	8/25/75	2,510
Oxirane - Channelview	3286B	8/25/75	2,510
Oxirane - Channelview	3286C	8/25/75	2,510
Paktank - Deer Park	4872	1/27/77	106
Paktank - Deer Park	5313	9/23/77	160
Pennwalt	3917	8/26/76	1,920
Petro-Tex	1341	11/19/73	548
Quaker Oats	3008	2/27/75	1,270
Rexene	3126	4/29/75	368
Rexene	4157	7/28/76	346
Rohm & Haas	751	4/5/73	574
Rohm & Haas	818	6/20/73	9
Rohm & Haas	1257	9/10/73	280
Rohm & Haas	1257A	7/16/75	329
Rohm & Haas	1717	1/17/74	425
Rohm & Haas	1909	1/17/74	442
Rohm & Haas	1910	1/11/74	889
Rohm & Haas	2165	4/1/74	2,020
Rohm & Haas	4276	7/23/76	16
Rollins	679	4/18/73	876

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Shell	920	6/26/73	9,750
Shell	1235	11/19/73	999
Shell	1830	4/3/74	127
Shell	1831	4/3/74	96
Shell	1832	4/3/74	206
Shell	1833	4/3/74	110
Shell	1838	3/12/74	438
Shell	1839	3/12/74	438
Shell	1840	3/12/74	1,840
Shell	1841	3/12/74	1,840
Shell	1842	3/12/74	263
Shell	1843	3/12/74	346
Shell	1844	3/12/74	232
Shell	1845	3/12/74	902
Shell	1846	3/12/74	942
Shell	1847	3/12/74	1,500
Shell	1848	3/12/74	272
Shell	1920	9/25/74	245
Shell	3179	5/28/75	85
Shell	3199	8/15/75	3,600
Shell	3200	8/15/75	3,570
Shell	3201	8/15/75	3,570
Shell	3202	7/23/76	14,600
Shell	3213	5/29/75	198
Shell	3214	5/29/75	1,690
Shell	3215	5/29/75	9
Shell	3216	5/29/75	134
Shell	3219	5/29/75	206
Shell	3333	6/4/75	53
Shell	4596	2/25/77	13
Shell	6713	10/5/78	79
Shell Development	1190	8/14/73	136
Shell Development	1191	8/14/73	136
Southland Paper	190	5/26/72	1,560
Southland Paper	1629	11/2/73	105
Stauffer - Houston	4802	7/27/77	5,100
Syngas	4773	2/18/77	854
Tenneco	2964	7/10/75	1,980
Tenneco	4545	10/14/76	898

Construction Permits - continued

Facility	Construction Permit Number	Permit Issue Date	Permitted SO_2 Emission Rate (Tons/Year)
Texas City Refining	1035	8/18/73	114
Texas City Refining	1122	8/17/73	298
Texas City Refining	1972	2/20/74	72
Texas City Refining	2940	9/5/75	823
Texas City Refining	4393	9/17/76	806
Texas City Refining	4499	9/17/76	52
Texas City Refining	4797	4/12/77	57
Texas Industries	4534A	1/6/77	2,090
Union Carbide - Deer Park	4861	3/15/77	40
Union Carbide - Deer Park	4862	3/15/77	193
Union Carbide - Deer Park	4863	3/15/77	164
Union Carbide - Deer Park	4864	3/15/77	248
Union Carbide - Texas City	1516A	11/29/73	635
Union Carbide - Texas City	1516B	11/29/73	635
Union Carbide - Texas City	1516C	11/29/73	635
Union Carbide - Texas City	1516D	11/29/73	635
Union Carbide - Texas City	2958A	1/4/78	5,260
Union Carbide - Texas City	3052	2/27/75	20
Union Carbide - Texas City	2958	3/18/75	2,520
United Salt	5935	2/3/78	188
Upjohn	1483A	5/4/76	1,330
Upjohn	4221	5/4/76	530
U.S.I. Chemicals	5226	6/1/77	561
Witco Chemical	524	6/5/73	48
Witco Chemical	3874	12/16/75	66

NOTE: To be included in this table, a construction permit had to have been issued between 3/5/72 and 6/30/79. Additionally, the construction permit had to have been issued to a facility with total permitted SO_2 emissions of at least 100 tons per year.

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AMBIENT AIR DATA

ANNUAL ARITHMETIC MEANS BY SITE

SO_2 μg/m^3

T.A.C.B. Sampling Sites:

	CYPRESS 233004	SPRING 233005	CAMS 8 233024	CAMS 1 256034	C.V. 233006
73	2	2			2
74	2	2	2	6	2
75	2	4	2	7	4
76	2	2	2	3	3
77	2	2	3	7	3
78	9	12	10	15	16

	PARK 032002	LA PORTE 313002	COLLEGE 406006	ALIEF 233003
73	6	3	4	2
74	5	4	3	2
75	4	2	2	3
76	3	3	2	2
77	4	2	3	2
78	9	12	13	9

City of Houston Sampling Sites:

	H 11 256045	H 25 256041	H 12 256048	H 13 256046	H 15 256050
73	3		3	5	9
74	2		NR	7	13
75	3		4	3	8
76	2	2	2	2	7
77	4	3	4	2	8
78	6	4	4	3	3

	H 18 233018	H 20 233020	DP 22 137002	H 23 233023	DP 1 137001
73	12	25	58	10	19
74	10	28	74	10	20
75	13	11	22	12	6
76	3	9	17	7	3
77	4	22	10	3	4
78	4	5	12	3	6

SO_2 - continued

	H 21 256028	H 17 256017	P 2 406002	H04 256042	T 5 256035
73	12	17	11	7	
74	3	26	4	4	
75	6	13	3	2	
76	4	14	3	2	16
77	6	8	7	2	19
78	8	9	10	3	4

	H 19 256019	H 14 256049	H02 256002	H06 256006	H05 256043
73	36	6	4	7	4
74	25	3	5	6	5
75	6	2	9	4	4
76	11	3	3	2	3
77	13	3	4	3	5
78	3	4	4	3	4

	H01 256001	T 19 256037	H07 256007	H 10 256010	H08 256044
73	3		6	3	2
74	4		7	3	2
75	10		9	7	3
76	3	4	3	2	2
77	5	6	4	4	2
78	4	4	4	4	3

	H 24 256040	H09 256009
73		5
74		2
75		5
76	3	2
77	3	2
78	3	3

AMBIENT AIR DATA

ANNUAL ARITHMETIC MEANS BY SITE

NO_2 µg/m^3

T.A.C.B. Sampling Sites:

	CYPRESS 233004	SPRING 233005	CAMS 8 233024	CAMS 1 256034	C.V. 233006
73	22	16			19
74	28	33	40	51	21
75	23	33	46	63	39
76	25	31	36	37	34
77	32	41	47	45	45
78	35	38	50	53	43

	PARK 032002	LA PORTE 313002	COLLEGE 406006	ALIEF 233003
73	30	20	18	21
74	32	24	24	30
75	38	21	24	44
76	28	22	27	20
77	26	33	33	36
78	22	37	46	40

City of Houston Sampling Sites:

	H 11 256045	H 25 256041	H 12 256048	H 13 256046	H 15 256050
73	86		100	92	121
74	59		76	66	90
75	48		58	58	76
76	50	66	46	54	60
77	80	64	56	48	54
78	81	68	64	58	67

	H 18 233018	H 20 233020	DP 22 137002	H 23 233023	DP 1 137001
73	93	92	112	86	107
74	74	66	86	66	89
75	52	45	68	50	81
76	30	49	56	44	52
77	49	52	57	29	50
78	55	57	54	42	64

NO$_2$ - continued

	H 21 256028	H 17 256017	P 2 406002	H04 256042	T 5 256035
73	100	114	106	97	
74	80	80	87	73	
75	58	58	74	50	
76	52	55	62	47	64
77	51	61	64	45	64
78	53	59	64	48	71

	H 19 256019	H 14 256049	H02 256002	H06 256006	H05 256043
73	120	104	125	116	99
74	92	77	92	91	76
75	64	57	82	61	59
76	57	48	70	40	41
77	71	55	75	45	41
78	85	51	95	52	35

	H01 256001	T 19 256037	H07 256007	H 10 256010	H08 256044
73	159		92	112	97
74	89		73	67	68
75	96		66	62	67
76	82	96	45	41	44
77	74	87	51	46	60
78	56	91	60	61	58

	H 24 256040	H09 256009
73		100
74		86
75		79
76	55	64
77	54	67
78	37	64

AMBIENT AIR DATA

ANNUAL GEOMETRIC MEANS BY SITE

TSP $\mu g/m^3$

T.A.C.B. Sampling Sites:

CYPRESS 233004		SPRING 233005		CAMS 8 233024		CAMS 1 256034		C.V. 233006	
73	49	73	50	73		73	103	73	62
74	59	74	46	74	61	74	71	74	60
75	62	75	54	75	64	75	82	75	70
76	53	76	51	76	65	76	90	76	74
77	64	77	57	77	74	77	91	77	71
78	61	78	61	78	72	78	99	78	

BAYWAY 032003		PARK 032002		ROSELAND 032001		LA PORTE 313002		COLLEGE 406006	
73	64	73	69	73	41	73	55	73	50
74	65	74	82	74	48	74	47	74	44
75	71	75	64	75	46	75	60	75	49
76	83	76	64	76	52	76	56	76	55
77	74	77	71	77	47	77	60	77	58
78	65	78	64	78	46	78	63	78	60

ALIEF 233003	
73	48
74	51
75	57
76	52
77	60
78	60

City of Houston Sampling Sites:

H 11 256045		H 25 256041		H 12 256048		T 22 256038		H 13 256046	
73	57	73		73	61	73		73	63
74	49	74		74	55	74	55	74	76
75	57	75		75	55	75	63	75	75
76	60	76	46	76	65	76	64	76	69
77	62	77	66	77	75	77	67	77	68
78	67	78	61	78	75	78	67	78	68

TSP - continued

H 15 256050	
73	93
74	78
75	79
76	95
77	102
78	102

H 18 233018	
73	102
74	68
75	65
76	70
77	77
78	101

H 20 233020	
73	62
74	57
75	55
76	61
77	68
78	70

DP 22 137002	
73	61
74	85
75	80
76	101
77	91
78	83

H 23 233023	
73	46
74	56
75	55
76	63
77	89
78	62

DP 1 137001	
73	66
74	81
75	78
76	73
77	74
78	73

H 21 256028	
73	79
74	73
75	66
76	65
77	72
78	70

H 17 256017	
73	83
74	86
75	90
76	79
77	82
78	76

P 2 406002	
73	85
74	83
75	84
76	81
77	78
78	81

H04 256042	
73	49
74	54
75	51
76	57
77	57
78	91

T 5 256035	
73	
74	101
75	--
76	110
77	142
78	157

H 19 256019	
73	105
74	105
75	96
76	92
77	108
78	123

T 25 256039	
73	
74	55
75	65
76	60
77	63
78	88

H 14 256049	
73	88
74	86
75	90
76	86
77	94
78	95

H02 256002	
73	99
74	92
75	104
76	97
77	97
78	95

H06 256006	
73	67
74	59
75	66
76	59
77	68
78	67

H05 256043	
73	103
74	79
75	63
76	66
77	67
78	74

H01 256001	
73	84
74	82
75	97
76	69
77	86
78	80

T 19 256037	
73	
74	70
75	71
76	69
77	76
78	74

H07 256007	
73	59
74	60
75	62
76	53
77	53
78	63

H 10 256010	
73	56
74	56
75	56
76	57
77	61
78	63

H08 256044	
73	48
74	48
75	54
76	55
77	54
78	56

H 24 256040	
73	
74	
75	
76	46
77	61
78	64

H09 256009	
73	68
74	61
75	79
76	68
77	78
78	72

HARRIS COUNTY
POLLUTION CONTROL
DEPARTMENT

A. R. PEIRCE
DIRECTOR

The Harris County Pollution Control Department received through the Coastal Energy Impact Program a federal grant to design a plan to prepare for the consequences of new or expanded energy facilities located in this area. Our plan specifically addresses the impact on air quality of fuels conversion.

At the present time, we are in the process of assembling air quality data to establish a data base for total suspended particulate, sulfur dioxide and nitrogen dioxide. We believe these data will be more meaningful if the quantity of sulfur bearing fuels combusted in Harris County can be determined. Permit information provides a picture of the quantity of sulfur bearing fuels allowed but does not give an indication of how much is being or has been burned. In proceeding with this planning grant, we believe it is necessary to look at the record as accurately as possible and to that end, we are asking for your assistance.

The attached questionnaire goes into some detail but the information will assist us greatly since it is extremely important to correlate the quantity of sulfur bearing fuels burned with actual air quality. We do not have a sulfur dioxide problem at present; perhaps we never will have one. If, however, future monitoring shows an increasing level of sulfur dioxide with an increasing usage of sulfur bearing fuels, we will have a realistic basis on which to predict future ambient air concentrations as the use of sulfur bearing fuels continues to increase. With such factual information control strategies can be better formulated.

Your cooperation in completing the questionnaire and returning it to us by October 15 will be greatly appreciated. If there are any questions, please call.

Very truly yours,

A. R. Peirce
Director

ARP/lb

Attachment

107 NORTH MUNGER • P. O. BOX 6031 • PASADENA, TEXAS 77506 • (713) 221-5224

HARRIS COUNTY POLLUTION CONTROL DEPARTMENT

COASTAL ENERGY IMPACT PROGRAM PLANNING GRANT QUESTIONNAIRE

COMPANY NAME____

LOCATION OR STREET ADDRESS____

FUEL OIL - Please record in the appropriate spaces below the total amount of fuel oil fired in your entire facility and the average weight percent of sulfur in the fuel oil. If exact values are unavailable please estimate and indicate the estimated values with the letter "E" preceding the number.

Year	1976				1977				1978				1979	
Calendar Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2
1000's of tons of fuel oil														
Average weight percent sulfur														

COAL - Please record in the appropriate spaces below the total amount of coal fired in your entire facility by quarter and the average weight percent of sulfur in the coal. If exact values are unavailable please estimate and indicate the estimated values with the letter "E" preceding the number.

Year	1976				1977				1978				1979	
Calendar Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2
1000's of tons of coal														
Average weight percent sulfur														

NON-PERMITTED SULFUR DIOXIDE EMISSIONS - Please record in the appropriate spaces below the actual total sulfur dioxide emissions from all sources at this facility constructed or last modified prior to March 5, 1972. If exact values are unavailable please estimate and indicate the estimated values with the letter "E" preceding the number.

Year	1976				1977				1978				1979	
Calendar Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2
100's of tons of SO_2														

HARRIS COUNTY POLLUTION CONTROL DEPARTMENT
COASTAL ENERGY IMPACT PROGRAM PLANNING GRANT QUESTIONNAIRE

COMPANY NAME____

LOCATION OR STREET ADDRESS____

SULFUR DIOXIDE EMISSIONS - Please list by calendar quarter and T.A.C.B. permit number actual sulfur dioxide emissions in tons for all permitted sources at this facility constructed or modified between March 5, 1972 and July 26, 1976. If exact values are unavailable please estimate and indicate the estimated values with the letter "E" preceding the number.

	TONS OF SULFUR DIOXIDE BY CALENDAR QUARTER															
Year	1976				1977				1978				1979			
Calendar Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2		
Permit Number																

COMPANY NAME______________________________

LOCATION OR STREET ADDRESS______________________________

PERMITTED SULFUR DIOXIDE EMISSIONS - Please list by calendar quarter and T.A.C.B. permit number sulfur dioxide emissions in tons for all permitted sources at this facility constructed or modified after July 26, 1976. If exact values are unavailable please estimate and indicate the estimated values with the letter "E" preceding the number.

	TONS OF SULFUR DIOXIDE BY CALENDAR QUARTER													
Year	1976				1977				1978				1979	
Calendar Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Permit Number														

PREPARED BY____________________

TELEPHONE NUMBER____________________ DATE__________