EPA-600/2-76-093a
May 1976

Environmental Protection Technology Series

ENVIRONMENTAL ASSESSMENT SAMPLING AND ANALYTICAL STRATEGY PROGRAM

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into five series. These five broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The five series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment, and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

EPA REVIEW NOTICE

This report has been reviewed by the U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policy of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

EPA-600/2-76-093a
May 1976

ENVIRONMENTAL ASSESSMENT SAMPLING AND ANALYTICAL STRATEGY PROGRAM

by

J. Vlahakis and H. Abelson

The Mitre Corporation
Westgate Research Park
McLean, Virginia 22101

Contract No. 68-02-1859, Task 6
ROAP No. 21ADD-BG
Program Element No. 1AB013

EPA Project Officer: Robert M. Statnick

Industrial Environmental Research Laboratory
Office of Energy, Minerals, and Industry
Research Triangle Park, NC 27711

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, DC 20460

ACKNOWLEDGMENTS

The extensive contributions to this project of Mr. James Dorsey, Process Measurements Branch Head, and Dr. Robert Statnick, Project Officer, are gratefully acknowledged.

MITRE personnel, Mr. George Erskine, Associate Department Head, also assisted in various phases of this program. His efforts are appreciated.

This study was performed under Contract Number 68-02-1859 for the Process Measurements Branch, Industrial Environmental Research Laboratory, Environmental Protection Agency, Research Triangle Park, North Carolina.

CONTENTS

FIGURES

TABLES

SECTION I
SUMMARY AND CONCLUSIONS

An environmental assessment costing methodology has been developed for industrial processes at various phases of development. Sampling and analytical strategies were developed as an integral part of this methodology.

The environmental assessment strategies developed in this study provide a mechanism for determining industry, process, and stream priorities on the basis of a staged sampling and analysis technique. This technique employs a screening phase (Level 1) to characterize influent and effluent streams of a process, and enables one to plan additional investigations. Level 2 then provides for a quantitative representation of potentially hazardous substances in those streams prioritized by Level 1.

This procedure provides the mechanism for estimating assessment program implementation costs and provides a format for estimating costs for budgetary planning purposes.

Assessment costs for a process at a specific phase of development were shown to depend heavily on stream mix and complexity of the sampling and analysis employed.

The output from an assessment program is required for control technology development as well as for health effects studies and monitoring studies. The environmental assessment output will be of interest to many industry and government organizations.

Some future efforts might be directed toward refining sampling and analysis costing assumptions.

SECTION II

THE ROLE OF ENVIRONMENTAL ASSESSMENT

An environmental assessment program encompasses a complete characterization (physical, chemical, biological) of a system's influent and waste streams as well as an analysis of incremental loading of pollutants to the environment. This analysis includes determining the potential impact of effluents on human health and ecological systems.

The overall goal of an assessment program is to evaluate both the environmental acceptability of a system or process and also the need for further control of waste streams.

Figure 1 shows the relationship between environmental assessment and other environmental R&D programs of interest to EPA such as control technology development.

The level of environmental assessment is dependent upon the phase of evolutionary development of a process. It is recognized that a complete characterization of a system is most desirable while the process configuration is still developing. This allows for relative ease in process changes and development lead time for control technology should environmental factors warrant such actions. However, the expenditure of a relatively large fraction of the environmental assessment resources in early process development stages is unjustified due to low probability of eventual commercial success. Table 1 shows the characteristics of each process phase as a function of process evolution.

The purpose of this report is to develop an "information-effective" environmental assessment methodology applicable to processes at any phase of development and a sampling and analytical strategy which supports this methodology.

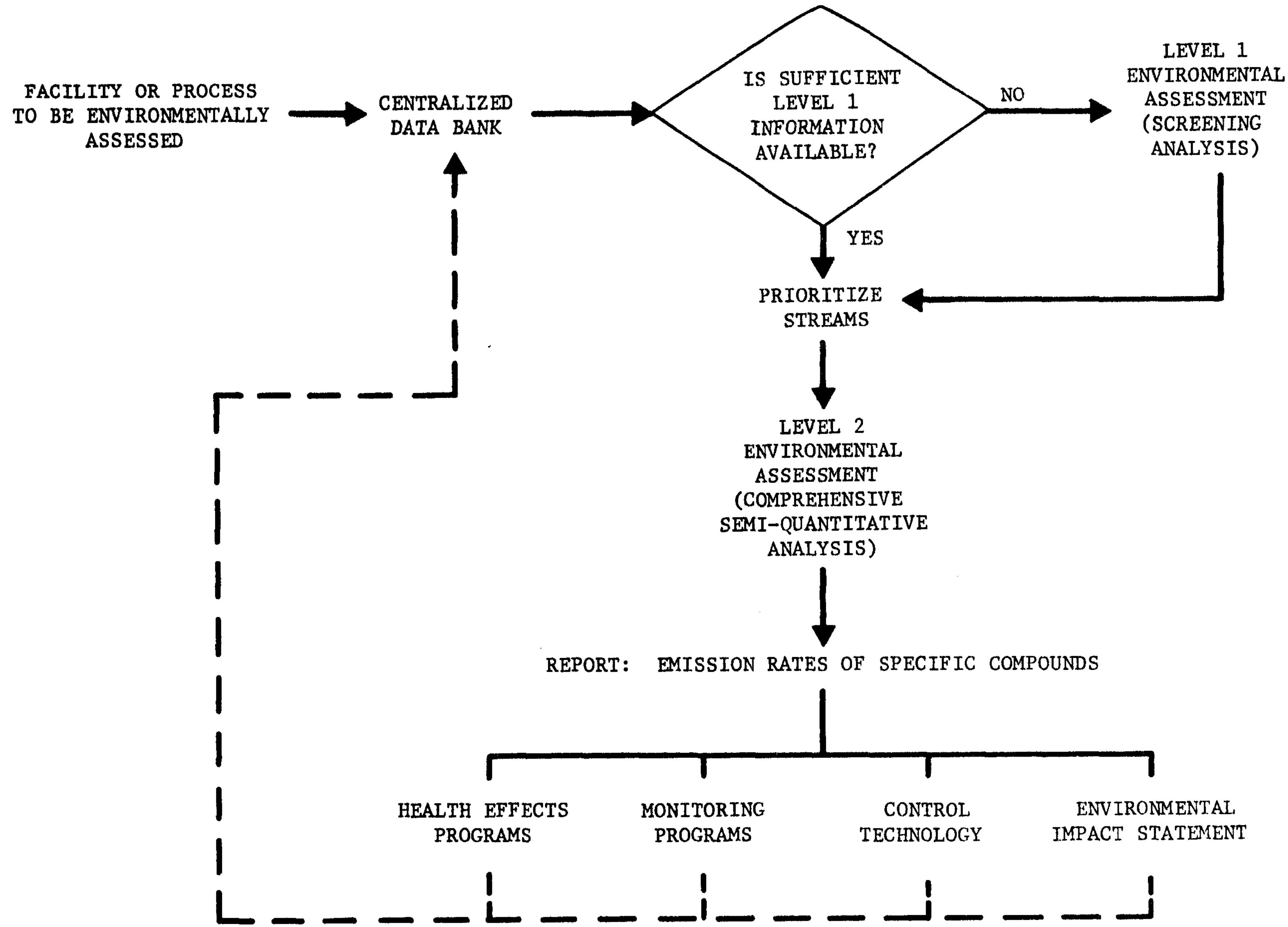


FIGURE 1
THE RELATIONSHIP BETWEEN ENVIRONMENTAL ASSESSMENT AND OTHER ENVIRONMENTAL PROGRAMS

TABLE 1. PHASES OF PROCESS EVOLUTION AND THEIR CHARACTERISTICS

Process Phase	Process Characteristics
Research	Use of pure (idealized) feeds. Exploratory operation solely of key components of process configuration. Extremely low probability of successful commercialization. Nominal instrumentation to provide key process and product characteristics. Intermittent operational mode.
Development	Larger scale, more complete process configuration than in research phase. More representative feedstocks. Fair probability of eventual success. Instrumentation of feed, product, and by-product streams. Semi-continuous operational mode dependent on requisite process changes.
Demonstration	Complete process configuration. Representative feedstocks. Excellent probability of technical success. Complete waste stream measurements. Process measurements for quality control and process stability. Operational mode consistent with obtaining economic quantities of products.

TABLE 1. PHASES OF PROCESS EVOLUTION AND THEIR CHARACTERISTICS (Concluded)

Process Phase	Process Characteristics
Commercial-Scale	As in demonstration phase, but with potential further process improvements. Routine waste and process stream monitoring.
Existing Commercial	Full-scale production units with optimum process configurations (possibly in various locations).

SECTION III

OBJECTIVES OF ENVIRONMENTAL ASSESSMENT SAMPLING AND ANALYTICAL STRATEGY PROGRAM

The objectives of the environmental assessment sampling and analytical strategy program emphasize three points. First, sampling and analytical schemes were developed for assessment programs in general. Secondly, in order to structure a mechanism for recommending assessment program implementation costs, sampling and analysis costing procedures were demonstrated as a function of process development phase. This provides a format for estimating costs for budgetary planning purposes. Thirdly, a sampling and analysis program should yield industry, process, and process stream priorities which leads to an "information-effective" assessment.

Those elements to be stressed in determining the proper allocation of limited resources for assessment involve the following considerations. The output from such a program must identify the requirements for control technology development. This output would provide data such as volume flow rates and pollutant concentrations. Also, the program output should provide for both chemical characterization and biological screening of industrial streams in order to assess pollutant impact on human health. A comprehensive assessment will include the general structure for evaluating and ranking the toxic pollutants emanating from significant industrial sources.

SECTION IV
DEFINITION OF SAMPLING AND ANALYSIS LEVELS

Staged sampling and analysis techniques are employed according to a three-level hierarchy. (The rationale for a phased approach as well as full descriptions of Levels 1 and 2 are presented in the following sections.)

Level 1 is a survey phase which identifies the pollution potential of all process streams in a qualitative manner through chemical and biological testing. No special sampling considerations are required. Level 1 output provides the data to prioritize components and streams for further consideration in subsequent studies at Level 2.

Level 2 is characterized by quantitative representation of potentially hazardous substances in streams (as determined by Level 1). Level 2 output yields the information necessary to undertake requisite control technology and health effects studies.

Level 3 extends the elements of Level 2 and adds procedures to identify the pollutant potential of streams as a function of process variables leading to representative yearly emission factors of specific compounds. It is understood that Level 3 is highly process-specific and is excluded from this study effort.

SECTION V
RATIONALE FOR PHASED APPROACH

The total cost in performing an environmental assessment is highly dependent on the specific process under study and on the stream and component prioritization accomplished upon the completion of Level 1.

A phased sampling and analysis approach will yield an overall "information-effective" assessment program. A Level 1 characterization of all inlet and outlet streams is required not only to determine the presence of unanticipated pollutant classes, but also to subsequently plan a cost-effective sampling and analysis program for future work at Level 2. The output of Level 1 is used to prioritize streams and components for further assessment study. This phased approach allows one to determine the relative priority to be placed on each stream and class of components by screening at Level 1 such that reasonable resource allocation might be made. A Level 1 assessment program is able to provide information which will significantly increase the validity of any future sampling and analysis work.

By providing toxicity and mutagenicity data, the Level 1 program allows the creation of stream priorities on a relative potential health effects basis and may also determine the most probable class of materials causing the effect. Information is thus provided on potential control technology requirements. Level 1 information cannot determine specific compounds in question and thus cannot define secondary pollutants. Long-term health effects cannot be assessed because only acute data is furnished from the bioassay tests.

Level 2 defines stream pollutants such that requisite control technology studies and health effects studies can be initiated. Level 2 also defines effluent streams such that atmospheric transformation and potential secondary formations of pollutants might be predicted more accurately than with Level 1 data. Level 2 determines specific compounds and their concentrations in a more quantitative manner than the previous level. Bioassay work is expanded to include carcinogenicity testing as well as dose-response cytotoxicity measurements and more extensive mutagenic work.

SECTION VI

GENERAL PROPERTIES OF LEVEL 1

The results of this survey phase are used to establish industry, process, and stream priorities. All pollutants in all input and effluent streams will have an opportunity for detection at this level.

In general, the properties of Level 1 are given below. The basic analytical scheme for this level is illustrated in Figures 2 and 3.

1.0 A reasonably characteristic sample is obtained.

2.0 There are no planned replications of sampling and analysis.

3.0 The sample is taken from a conveniently available process stream location consistent with the above considerations.

4.0 There is a general physical characterization of solids.

5.0 Fractions of organics are identified.

6.0 Elements are identified.

7.0 Bioassay analyses include cytotoxicity and mutagenicity tests.

8.0 Steady state measurements at one process operating condition are taken.

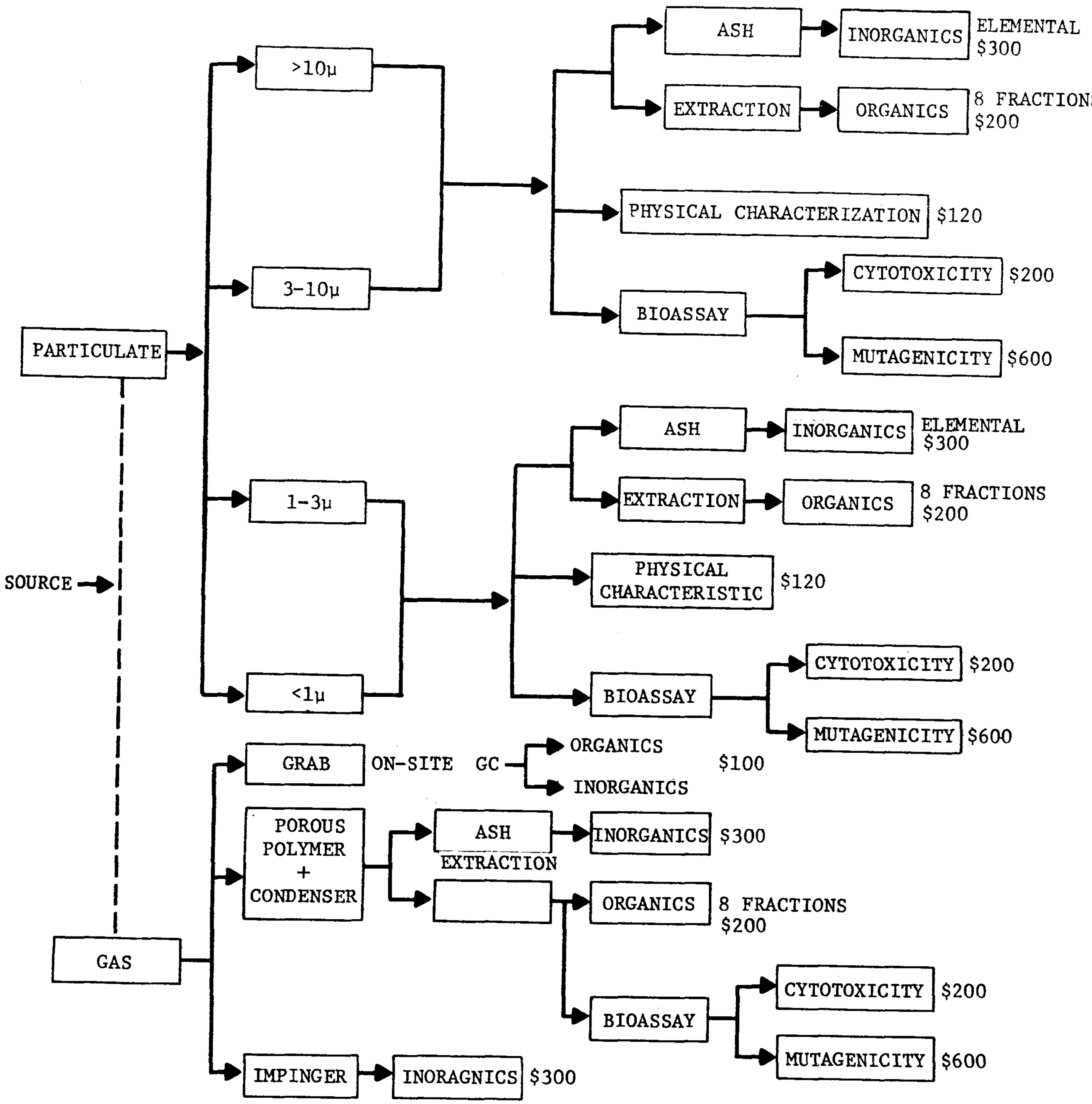


FIGURE 2
BASIC ANALYTICAL SCHEME FOR LEVEL 1 (PARTICULATES AND GASES)

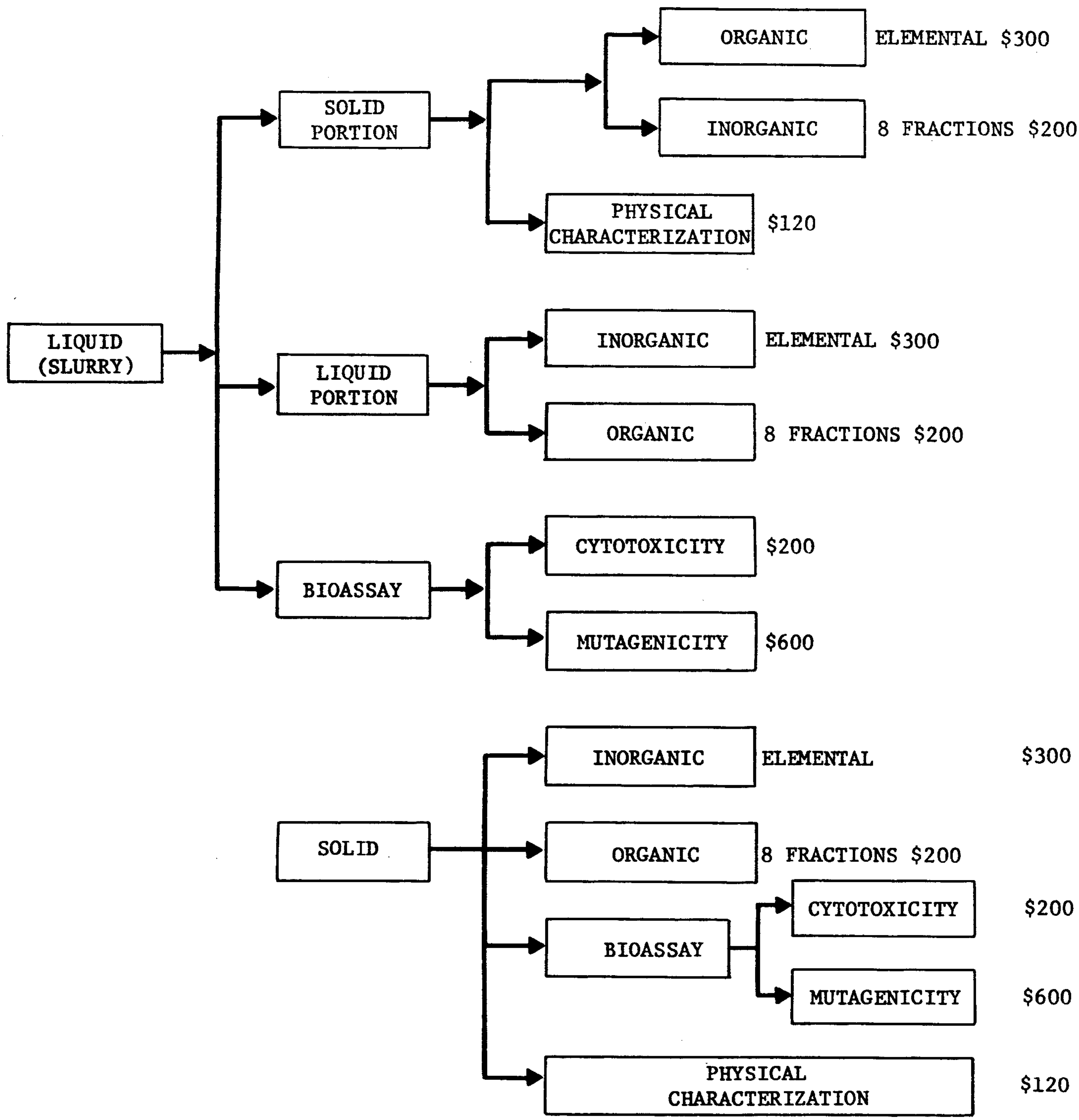


FIGURE 3
BASIC ANALYTICAL SCHEME FOR LEVEL 1 (LIQUID AND SOLID)

SECTION VII

GENERAL PROPERTIES OF LEVEL 2

The results of this phase are used to yield detailed information in order to establish control technology requirements (both in terms of priorities and applicability of various techniques).

The properties of Level 2 are given below. The basic analytical scheme for this level is shown in Figures 4 through 7.

1.0 A representative sample is obtained (involves use of sequential samplers, traversing, etc.).

2.0 Sampling procedures are optimized and samples taken at average operating conditions (use of sampling train for specific components).

3.0 Physical characterization of solids is undertaken.

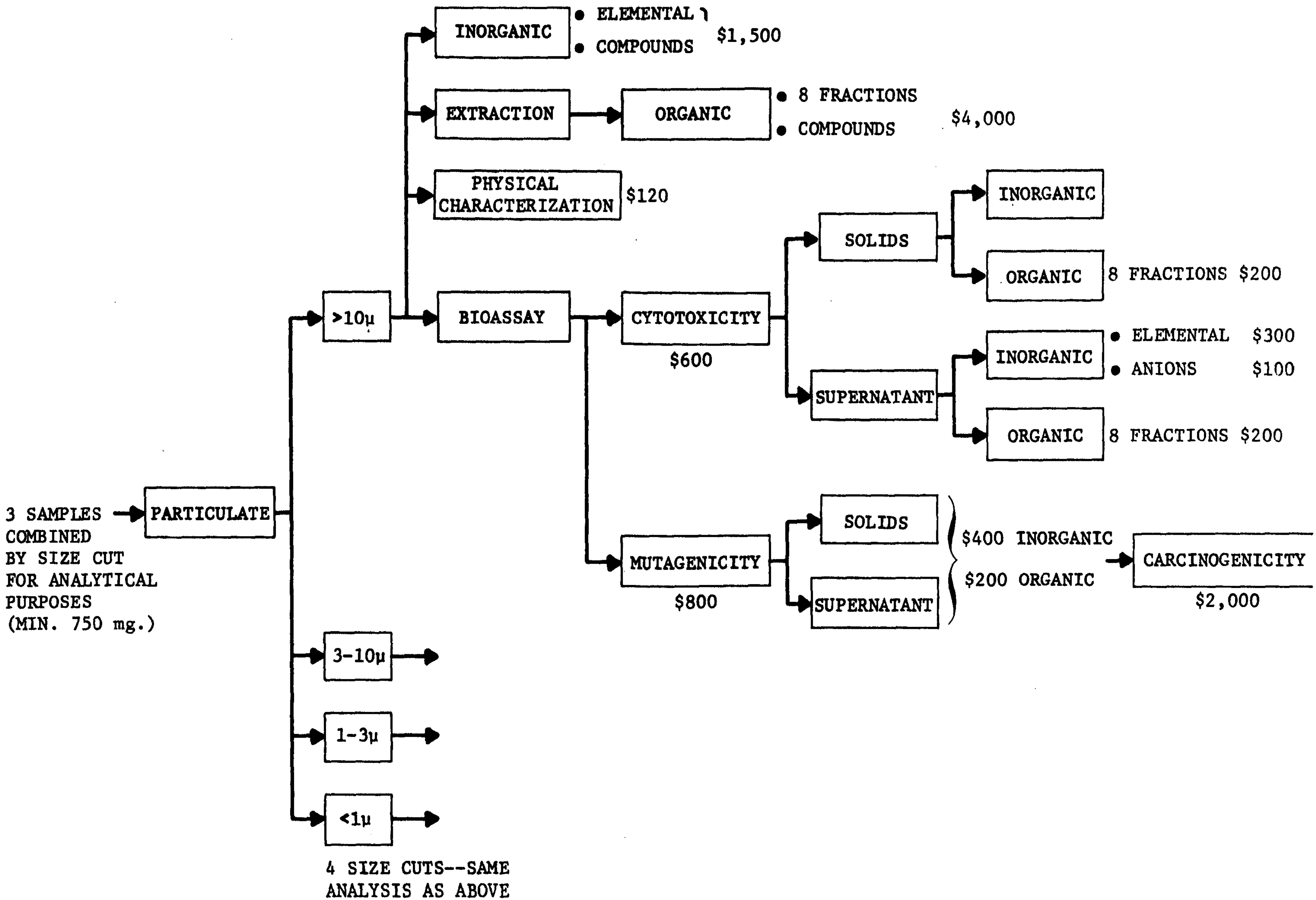
4.0 Identification of specific compounds is undertaken.

5.0 Bioassay analyses include mutagenicity, cytotoxicity, and carcinogenicity tests.

6.0 Bioassay work includes auxiliary chemical analysis on solid/supernatant fractions of biologically active sample.

7.0 Bioassay dose response data are generated.

8.0 Replication in sampling and analysis is done.


3 SAMPLES
COMBINED
BY SIZE CUT
FOR ANALYTICAL
PURPOSES
(MIN. 750 mg.)
PARTICULATE
>10μ
3-10μ
1-3μ
<1μ
4 SIZE CUTS--SAME
ANALYSIS AS ABOVE
INORGANIC
● ELEMENTAL
● COMPOUNDS
$1,500
EXTRACTION
ORGANIC
● 8 FRACTIONS
● COMPOUNDS
$4,000
PHYSICAL
CHARACTERIZATION
$120
BIOASSAY
CYTOTOXICITY
$600
SOLIDS
INORGANIC
ORGANIC
8 FRACTIONS $200
SUPERNATANT
INORGANIC
● ELEMENTAL $300
● ANIONS $100
ORGANIC
8 FRACTIONS $200
MUTAGENICITY
$800
SOLIDS
SUPERNATANT
$400 INORGANIC
$200 ORGANIC
CARCINOGENICITY
$2,000

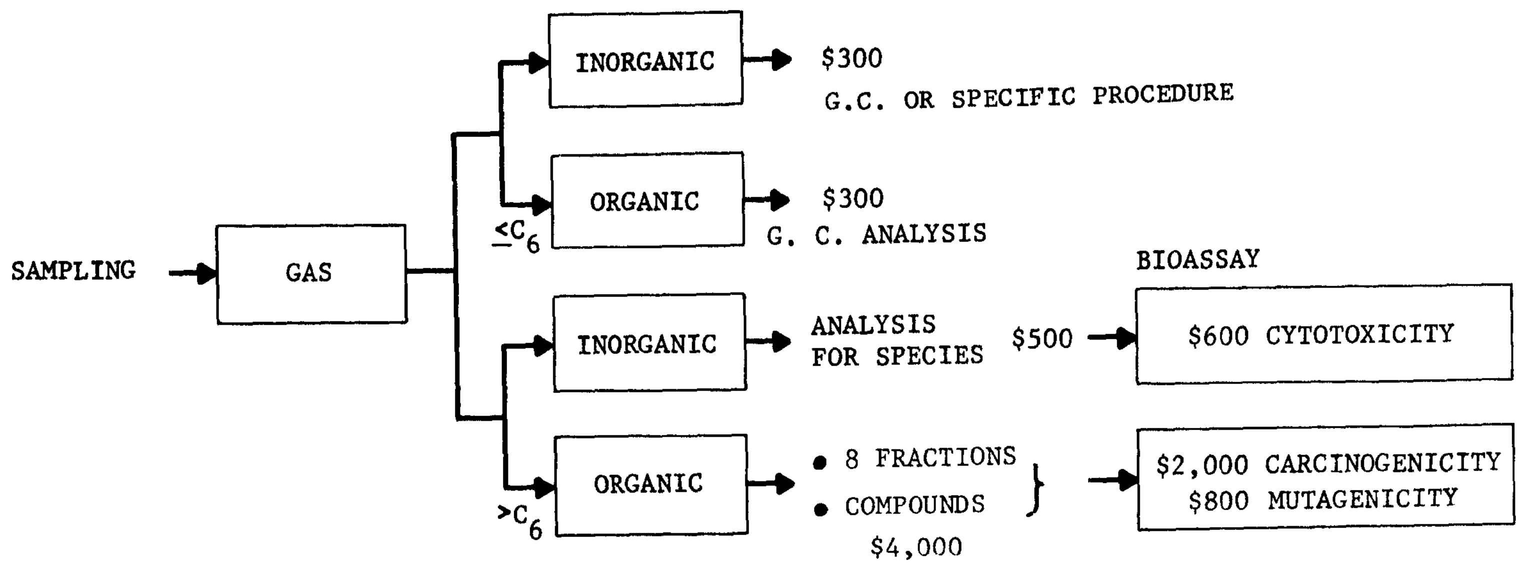


FIGURE 5

BASIC ANALYTICAL SCHEME FOR LEVEL 2
(GASES)

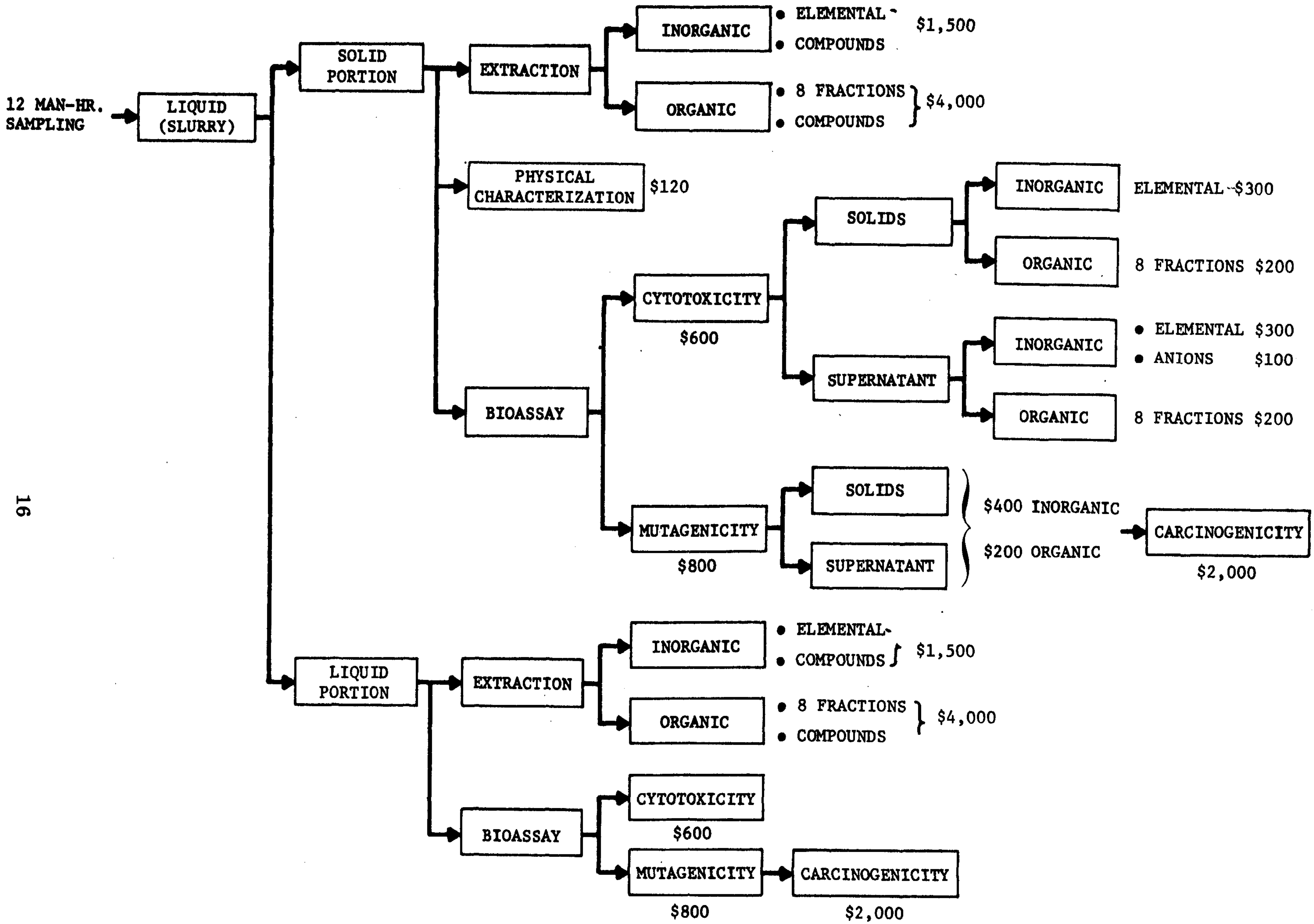


FIGURE 6

BASIC ANALYTICAL SCHEME FOR LEVEL 2
(LIQUID)

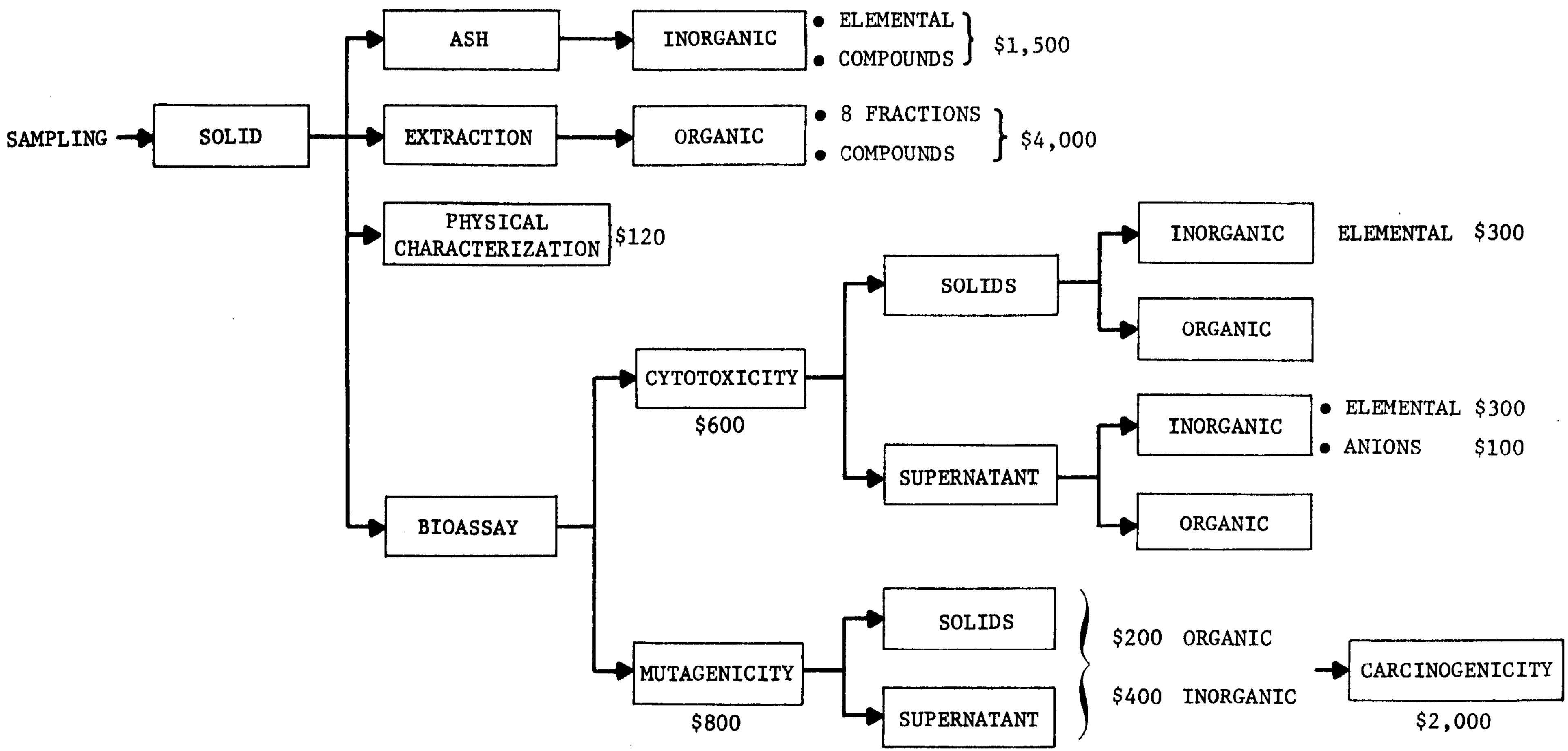


FIGURE 7

BASIC ANALYTICAL SCHEME FOR LEVEL 2
(SOLIDS)

SECTION VIII
COSTING ASSUMPTIONS

SITE PREPARATION

Level 1

It is assumed that sampling access is available at a convenient stream location. No capital costs are included--all required sampling and analytical equipment is assumed to be available. An overall charge of $250 per stream is assessed to account for nominal site preparation.

Level 2

At this level, cost of site preparation is a function of stream type. The following prices have been assumed:

Particulate	25K
Gas	8K
Liquid	2.5K
Solid	10K

Level 2 site preparation charges are higher than those at Level 1 due to the added costs of installing generally more sophisticated sampling equipment in an optimum location. Level 2 costs may involve such items as cutting ports for optimum traversing, installation of mechanical samplers for solids, and use of fluid stream samplers, for example.

TRAVEL

Level 1

This level assumes a three-man team is sent to collect samples.

1.0 Airfare equals $300 per person.

2.0 Travel time includes 16 hours round-trip per person at $32/man-hour.

3.0 Total travel expense = $2,436.

4.0 Equipment preparation and shipping charges = $200.

TOTAL = $2,636

Level 2

Assumes a six-man crew with travel charges analogous to those above.

Total travel expense = $4,872

Equipment preparation and freight charges = $1,000

TOTAL = $5,872

SAMPLE ACQUISITION

Sample acquisition time per stream has been estimated as a function of stream type and is given below. The reported figures include equipment preparation at the site, equipment operation, disassembly, and cleanup time. Level 2 values include an allowance for sample replication time.

For example, the total man-hours for Level 2 particulate acquisition include a two-man team working four days for each process operating condition. One sample per day is collected for three days and combined by size cut for subsequent analysis. The fourth day is allowed for disassembly and cleanup of the particulate sampling train.

Liquid, solid, and ducted gas samples are estimated to require one and one-half man days at Level 2. At Level 1, however, these samples are taken without replication or compositing and require only one or two man-hours.

	Man-hrs/Stream	
Stream Type	Level 1	Level 2
Gas (ducted)	2	12
Gas (unducted)	10	10
Liquid	1	12
Solid	1	12
Particulate	12	64
Fugitive Dust	15	15

ANALYTICAL CHARGES

All samples or fractions are split into inorganic and organic phases. Basic analytical work is carried out according to the schemes shown previously under Level 1 and Level 2 descriptions.

Level 1

At Level 1, the inorganic analysis is done by Spark Source Mass Spectrometry scanning of 70 elements. $300

Particulate size fractions are combined into $>3\mu$ and $<3\mu$ fractions. Each resulting fraction is analyzed according to Figure 2.

Organic samples are first physically separated into eight organic fractions by liquid chromatography and then subjected to infrared an analysis. $200

Organic fractions are separated by liquid chromatography on the basis of polarity. These fractions might include, in order of increasing polarity, aliphatics, 1-2 ring aromatics, 3-7 ring POM's, esters, aldehydes, ketones, alcohols, and acids.

In addition, the gas sample is analyzed by on-site gas chromatography. The inorganic gas (COS, H_2S, PH_3, AsH_3) cost is $100, and the organic gas ($\leq C_6$) cost is also $100.

Since both inorganic and organic analyses are performed on all streams at Level 1, the analytical costs, as shown below, are dependent only on stream type and number of streams.

Stream Type	Level 1 Analysis Cost per Stream* (10^3 Dollars)
Particulate	4.84
Gas	1.9
Liquid	2.72
Solid	1.52

A standard water analysis package totaling $350 is included in the liquid charges.

Level 2

Inorganic analyses are specific both for elements and for compounds ($1,500). Analyses used to characterize inorganics at this level will include X-ray diffraction, electron microscopy, differential scanning calorimetry, and ESCA, for example. The inorganic gas fraction is analyzed by gas chromatograph ($300).

Organic analyses entail separation into as many as 50 fractions and determinations of specific compounds within each fraction by suitable techniques (e.g., $4,000, based on 8 fractions at $500/fraction). Separation is achieved by high performance liquid chromatography.

For gas samples, the high molecular weight fraction is analyzed for organics as above ($4,000), and the low molecular weight ($\leq C_6$) organic analysis is by gas chromatograph ($300).

*Revised analytical costing data has been acquired subsequent to the completion of this document and is shown in Figure 2 and 3. Values presented in this table reflect earlier costing data.

BIOASSAY CHARGES

Level 1

Two cellular *in vitro* bioassays will be used in the Level 1 protocol to assess the biological activity of various process or effluent samples. The advantages of cellular bioassay include its relatively low cost and short experimentation time; hence, its appeal for rapid evaluation of numerous, potentially hazardous compounds.

The rabbit alveolar macrophage (RAM) cytotoxicity bioassay and mutagencity screening using three bacterial strains (*salmonella typhimurium*) can be used to predict the acute toxicity and mutagenic behavior of the samples. Determination of acute toxicity of a given sample at a specified concentration using the RAM procedure costs roughly $200 per sample. The mutagenic bioassay, using only one solvent vehicle, costs about $600 per sample tested. The total cost incurred in evaluating a given process stream is a function of the number of pollutant samples selected for study.

Ducted gas, liquid, or solid samples are subjected to the pair of bioassay procedures. Particulate material is grouped into two categories based on particle aerodynamic diameter (>3μ and <3μ), and subjected to the bioassays.

Fugitive emissions are also screened with the two bioassay procedures. Samples collected by the three downwind samplers are combined and the integrated sample subjected to the bioassays. Material collected in the upwind and portable sampling units are also individually screened.

Level 2

The initial screening tests in Level 1 will be used to identify the potential environmental hazards of pollutant or process streams through examination of their physical and chemical characteristics as well as their biological activity. Those streams identified as hazardous will be subjected to the more intensive testing procedures of Level 2.

The RAM cytotoxicity bioassay is also used in Level 2 to assess the acute toxicity of a particular sample. In Level 2, however, several exposure levels will be tested rather than one, and a dose-response relationship established between exposure level of the sample to the macrophage cells and the resultant cytotoxicity. The mutagenic bioassay will also be conducted, but using three solvent vehicles instead of one. In addition, the carcinogenic potential of the priority streams will be determined. Due to the more intensive effort, unit costs are as follows: $600 per sample for cytotoxicity evaluation, and $800 per sample for mutagenic evaluation. The carcinogenicity tests required classical, whole animal tests, and cost about $2,000 per sample tested.

DATA REDUCTION AND RECORDING

Level 1

The sampling and analysis report will require 40 man hours of senior professional time to prepare, equal to $1,500. Computing time includes an additional $1,000. The report includes the cost of relating data and writing. Total cost is estimated at $2,500.

Level 2

The report costs are similar to those of Level 1. The report includes a listing of the analytical results and a delineation of mass emission rates. Total cost is estimated at $3000.

ASSESSMENT COST AS A FUNCTION OF PROCESS CONDITION

At Level 2, it is assumed that two process operating conditions are adequate to define the range of waste stream emission rates and compositions. The costs for generating data at the second process condition are estimated to be identical to those for the first process condition. The only difference is the elimination of site preparation and travel charges for the second process condition, as seen below. Also, no Level 1 charges and no fugitive charges have been costed into the second process condition.

TABLE 2. MATRIX OF LEVEL 2 CHARGES

Costing Factor	First Process Condition	Second Process Condition
Site Preparation	X	-
Travel	X	-
Sample Acquisition	X	X
Analytical Charges	X	X
Bioassay Charges	X	X
Data Reduction and Recording	X	X

PROCESS DATA ACQUISITION

It is recognized that at each sampling and analysis level, acquisition of process data is an integral part of the assessment program. This effort is minimal at Level 1 but consistent with developing an understanding of the process operation. Operator log sheets should be maintained and volumetric flow data as well as production and consumption rates for the process should be monitored at Level 1. Level 2 efforts are more extensive and entail a detailed knowledge of pollutant concentrations and volume flow rates as a function of operating modes, fuel types, and other process conditions.

These considerations have not been charged into the costing schemes at either level.

SECTION IX

STREAM AND COMPONENT PRIORITIZATION

Prioritization of whole streams or stream components for future consideration in an assessment program is based on the Level 1 tests. The applicable outputs from Level 1 establish the decision critiera for stream prioritization and include:

a) Contents of organic fractions
b) Identification of elements
c) Physical characterization
d) Mutagenicity testing - bioassay
e) Cytotoxicity testing - bioassay
f) Concentration (lower limit of detection)
g) Mass emission rate.

In an actual assessment program for a specific process, one can price those factors determining the overall performance cost by eliminating entire streams and eliminating chemical classes based on Level 1 tests.

However, for the purpose of this study, one must make some assumptions about what could be learned from Level 1 and then develop possible component prioritization categories which will reduce analytical costs based on those assumptions. Those general decisions which one might make concerning sampling and analysis of a process or process stream include:

a) Assume no inorganics
b) Assume no organics
c) Assume only 50 percent of organic fractions present
d) Assume no inorganics and only 50 percent organic fractions present.

The application of the above constraints to inlet and outlet streams of a process yield the ability to estimate variations in assessment costs due to analytical testing. These classifications represent illustrations of chemical class rejection in lieu of actual data and are not meant to be applied universally. A balance was necessarily drawn between making realistic assumptions and readily calculable values. For specific situations many other cases could be costed in a similar fashion using the general cost flow diagrams (Figures 2 through 7).

For the examples shown later in this report, the following definitions apply to the component-rejection classifications.

a) Complete Analysis - assumes complete inorganic, organic, and bioassay work is carried out on a given stream

b) Assume No Inorganics - no inorganic analysis performed; complete organic and bioassay work is carried out on given stream (e.g., stream treated as if consisting entirely of organics)

c) Assume No Organics - analogous to above statement

d) Assume Only 50 Percent of Organic Classes - complete inorganic and bioassay work is carried out on given stream; only 50 percent of the organic classes are analyzed

e) Assume No Inorganics and 50 Percent Organic Classes - same as d) except no inorganic analysis is performed.

By applying the assumptions given within each component-rejection classification to the Level 2 analytical schemes shown in Figures 4 through 7, one can easily develop costs associated with stream type. These costs appear in Table 3.

Also, the unit analytical costs can be combined with site preparation, sampling, and other charges to yield total unit cost per stream data which are dependent on stream type and degree of analysis.

The variations in performance cost of an environmental assessment are dependent on the degree of stream and component elmination as well as stream type. The sums of each group of solid, liquid, gas, and particulate streams comprise the "stream mix" of a process. For a specific

Table 3. LEVEL 2 ANALYSIS COSTS *

Stream Characterization†	Level 2 Analysis Costs (10^3 Dollars)				
	Complete Analysis	Assume no Inorganics	Assume no Organics	Assume only 50% of Organic Classes	Assume no Inorganics and 50% of Organic Classes
Particulate/Organic	51.2	29.6	--	43.2	21.6
Particulate/Inorganic	51.2	--	21.6	43.2	--
Gas/Organic	8.5	7.1	--	6.5	4.95
Gas/Inorganic	8.5	--	1.4	6.5	--
Liquid/Organic	21.7	14.2	--	17.7	11.2
Liquid/Inorganic	21.7	--	7.5	17.7	--
Solid/Organic	12.8	7.4	--	10.8	5.4
Solid/Inorganic	12.8	--	5.4	10.8	--

*Revised analytical costing data has been acquired subsequent to the completion of this document and is shown in Figures 4 through 7. Values presented in this table reflect earlier costing data.

†The organic/inorganic designation used here (and in subsequent tables) implies that a stream is primarily organic or inorganic.

process, one could estimate assessment costs on the basis of stream mix and an assumed degree of analysis. In this manner, a range of assessment costs can be developed. For the same total number of streams and degree of analysis, a higher proportion of particulate streams would result in greater overall cost of assessment. Alternatively, a larger proportion of gaseous streams leads to a lower assessment cost, other factors being equal.

SECTION X

ENVIRONMENTAL ASSESSMENT STRATEGIES

Table 4 indicates an overall sampling and analysis strategy for environmental assessment at each phase of process development. In developing this set of strategies, a balance is drawn between complete characterization of the system at a very early phase, and the expenditure of a large fraction of assessment resources at a phase with low probability of commercial success.

At the research phase, almost no funds are expended. At the development and demonstration phases, Level 1 is used to define the assessment effort for a more detailed Level 2 analysis. The demonstration phase includes fugitive emission analysis. A limited Level 2 assessment of several influent and effluent streams of environmental interest is carried out at the commercial-scale phase where prior assessment results can be utilized. The strategy for the existing commercial phase consists of a Level 1 analysis of all influent and effluent streams, and a subsequent Level 2 analysis of streams prioritized on the basis of Level 1 output. Fugitive analysis work is also necessary since no previous environmental studies have been assumed at this phase.

TABLE 4

ENVIRONMENTAL ASSESSMENT SAMPLING AND ANALYSIS STRATEGIES
AS A FUNCTION OF PROCESS PHASE

Process Phase	Process Characteristics	Sampling and Analysis - Level 1	Sampling and Analysis - Level 2
Research	• Use of pure (idealized) feeds • Exploratory operation solely of key components of process configuration • Extremely low probability of successful commercialization • Nominal instrumentation to provide key process and product characteristics • Intermittent operational mode	← General Observation, Low Level Testing →	
Development	• Larger scale, more complete process configuration than in research phase • More representative feedstocks • Fair probability of eventual success • Instrumentation of feed, product, and by-product streams • Semi-continuous operational mode dependent on requisite process changes	• All system influents and effluents • All pollutant classes screened	• Prioritized system influents and effluents (based on Level 1 pilot output) • Prioritized pollutant classes/species (based on Level 1 pilot output)
Demonstration	• Complete process configuration • Representative feedstocks • Excellent probability of commercial success • Process measurements for quality control and process stability • Operational mode consistent with obtaining economic quantities of products	• All system influents and effluents • All pollutant classes screened	• Prioritized system influents and effluents (based on Level 1 demo. output) • Fugitive emission analysis • Prioritized pollutant classes/species (based on Level 1 demo. output)
Commercial-Scale	• Same configuration as in demonstration phase, but with potential further process improvements • Routine waste and process stream monitoring	• No Level 1 S&A	• Monitoring of a few streams of key environmental interest (selection based on Level 2 demo. output) • Species of key environmental interest (selection based on Level 2 demo. output)
Existing Commercial	• Full-scale production units with optimum process configurations (possibly in various locations)	• All system influents and effluents • All pollutant classes screened	• Prioritized system influents and effluents (based on Level 1 output) • Fugitive emission analysis • Prioritized pollutant classes/species (based on Level 1 output)

SECTION XI

LURGI GASIFICATION PROCESS EXAMPLE

To demonstrate the application of the previously developed costing procedures to an actual process evolutionary cycle, the Lurgi coal gasification process will be used as an example. In Figures 8 through 10, flow diagrams of the Lurgi process are shown at several phases of process evolution.

Process measurements in the research phase (Figure 8) are limited to characterization of the coal feed and product gas streams of the gasifier with very nominal attention given to environmental assessment. The development phase (Figure 9) includes a more complete process configuration with an additional three by-product streams and one residual stream to be analyzed. For the demonstration phase (Figure 10), in accordance with the measurement strategy developed earlier, a complete characterization of all influent and effluent streams of importance including fugitive emissions is called for. The process flow diagrams for the commercial-scale phase and the existing commercial unit are identical to the demonstration phase flow sheet. The degree of stream characterization required for the existing commercial unit and the demonstration unit is similar, but is significantly reduced for the commercial-scale unit, as indicated in Figure 10.

Tables 5 through 7 show an itemization of Level 1 and Level 2 costs as well as the total environmental assessment cost for each phase of the Lurgi process evolution. For the research phase, it has been assumed that the cost of environmental assessment-related process measurements is insignificant and thus will not be considered further. Streams considered for each phase correspond to those indicated on the process flow sheets (Figures 8 through 10) and are characterized both by stream type (e.g., gas, liquid, etc.) and whether they are primarily organic or inorganic.

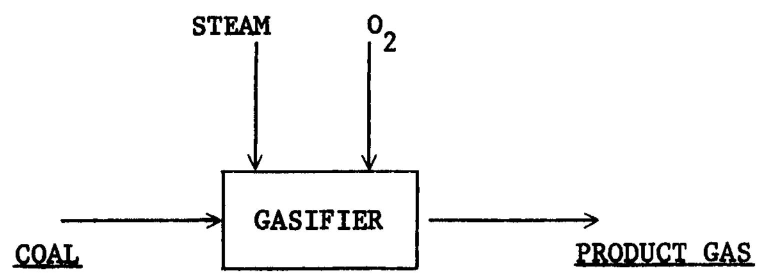


FIGURE 8

PROCESS FLOW DIAGRAM*--LURGI GASIFICATION RESEARCH PHASE

Streams to be analyzed are underlined.

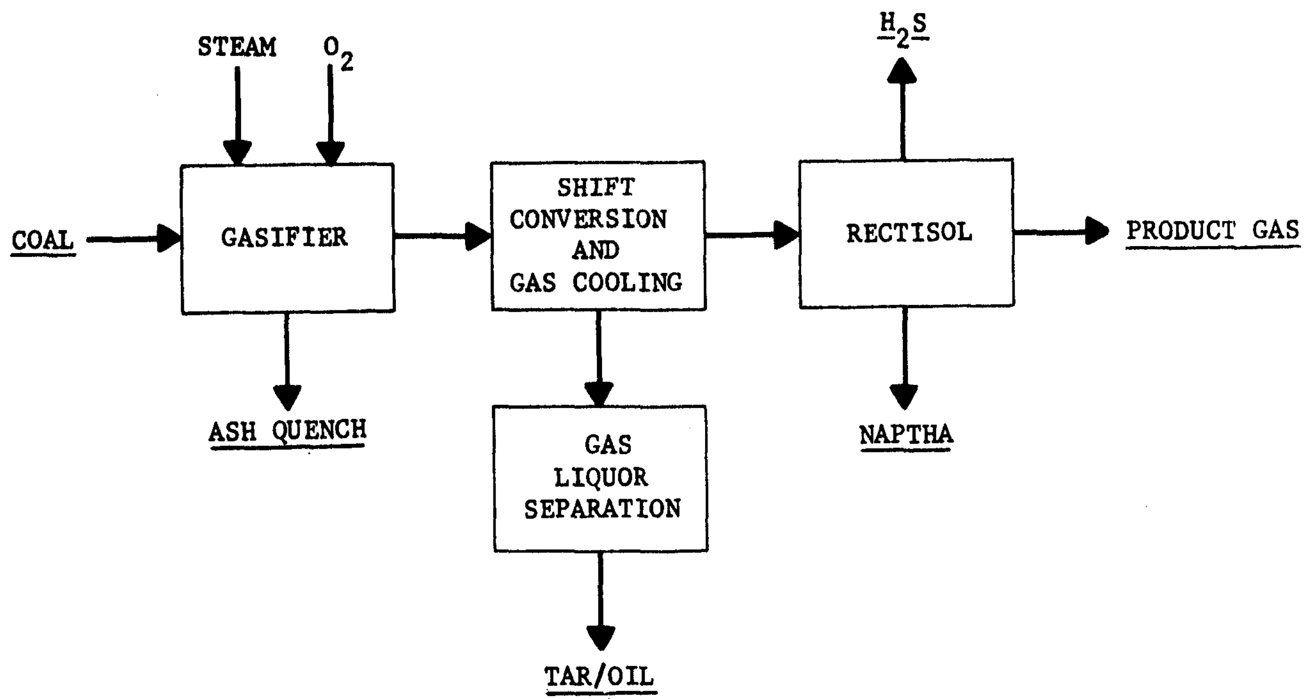


FIGURE 9
PROCESS FLOW DIAGRAM*—LURGI GASIFICATION DEVELOPMENT PHASE

*Streams to be analyzed are underlined

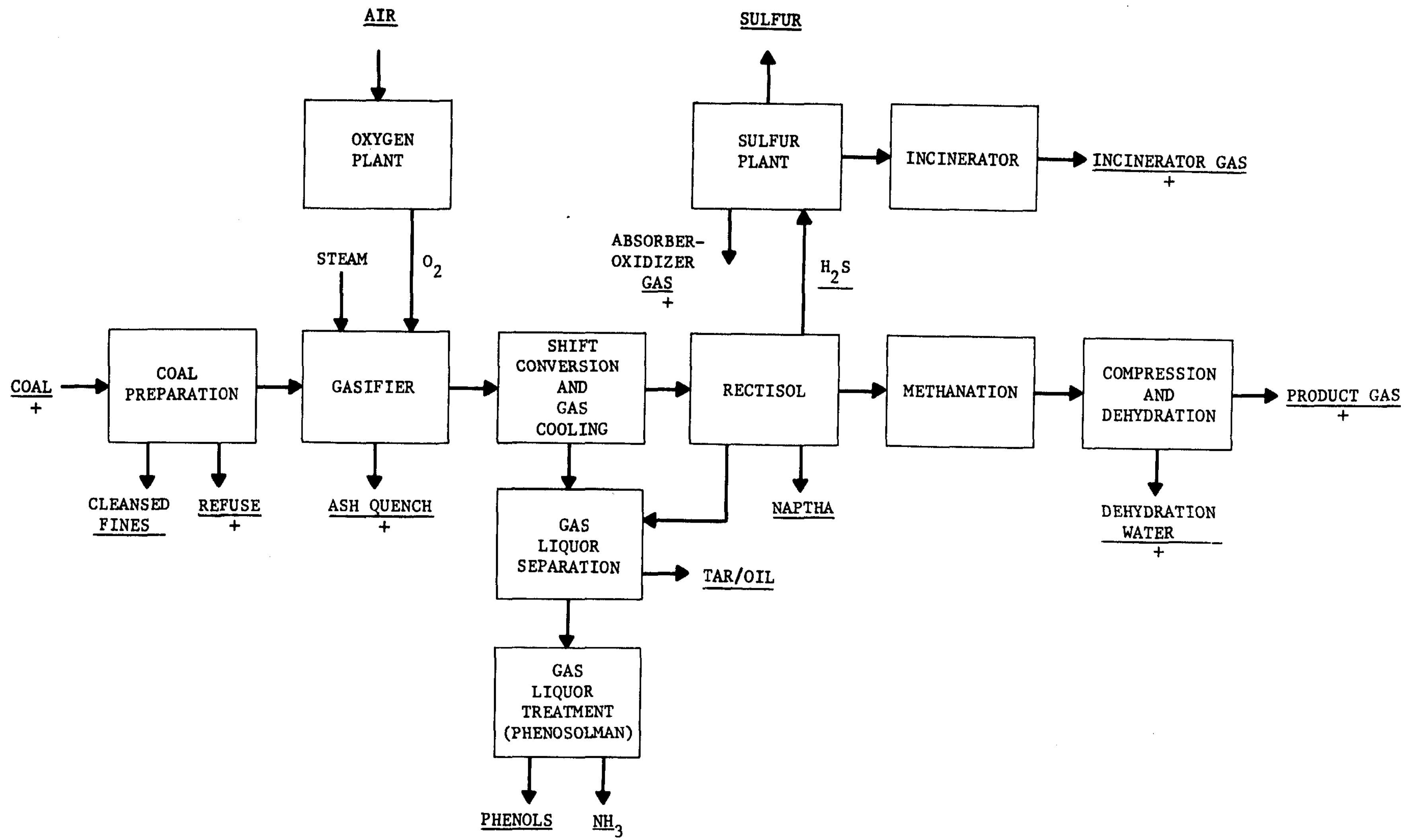


FIGURE 10
PROCESS FLOW DIAGRAM*—LURGI GASIFICATION DEMONSTRATION AND COMMERCIAL-SCALE PHASES

*Streams to be analyzed in demonstration phase and on existing commercial unit are underlined

Plus marks denote streams analyzed in commercial-scale phase

Table 5. ENVIRONMENTAL ASSESSMENT COSTS--LURGI GASIFICATION

PHASE: DEVELOPMENT

STREAM		LEVEL 1 COSTS* (10^3 DOLLARS)			LEVEL 2 COSTS (10^3 DOLLARS)		
DESIGNATION	CHARACTERIZATION	ANALYSIS	SITE PREPARATION	SAMPLING	ANALYSIS**	SITE PREPARATION†	SAMPLING††
Product Gas	Gas/Organic	1.9	0.25	0.064	8.5	8.0	0.384
	Particulate/ Organic	4.84	0.25	0.384	51.2	25.0	2.048
Coal Feed	Solid/Organic	1.52	0.25	0.032	12.8	10.0	0.384
Ash Quench	Liquid/Inorganic	2.72	0.25	0.032	21.7	2.5	0.384
Naptha	Liquid/Organic	2.72	0.25	0.032	21.7	2.5	0.384
H_2S	Gas/Inorganic	1.9	0.25	0.064	8.5	8.0	0.384
Tar/Oil	Liquid/Organic	2.72	0.25	0.032	21.7	2.5	0.384
	SUMS	18.32	1.75	0.640	146.1	58.5	4.352

Level 1:

Sum above costs = 20.7
Level 1 fixed costs = 5.0

Total Level 1 costs → $25.7K

Level 2:

Sum above costs = 209
Level 2 fixed costs (first process point) = 9.0
Level 2 fixed costs (second process point) = 3.0

Total Level 2 costs (first process point) → $209 + 9 = $218K
Total Level 2 costs (second process point) → (209 - 58.5) + 3 = $153.5K

Total cost for development phase → 218.0 + 153.5 + 25.7 = $397.2K

*No Level 1 costs incurred for second process point
**Complete analysis cost (includes all inorganic, organic, and bioassay work)--same for both process points
†No site preparation charges for second process point
††Sampling charges same for both process points

Footnotes applicable to Tables 5, 6, and 7

Table 6. ENVIRONMENTAL ASSESSMENT COSTS--LURGI GASIFICATION

PHASE: DEMONSTRATION†

STREAM		LEVEL 1 COSTS (10^3 DOLLARS)			LEVEL 2 COSTS (10^3 DOLLARS)		
DESIGNATION	CHARACTERIZATION	ANALYSIS	SITE PREPARATION	SAMPLING	ANALYSIS*	SITE PREPARATION	SAMPLING
Product Gas	Gas/Organic	1.9	0.25	0.064	8.5	8.0	0.384
Coal Feed	Solid/Organic	1.52	0.25	0.032	12.8	10.0	0.384
Ash Quench	Liquid/Inorganic	2.72	0.25	0.032	21.7	2.5	0.384
Naptha	Liquid/Organic	2.72	0.25	0.032	21.7	2.5	0.384
H_2S	Gas/Inorganic	1.9	0.25	0.064	8.5	8.0	0.384
Tar/Oil	Liquid/Organic	2.72	0.25	0.032	21.7	2.5	0.384
Phenol	Liquid/Organic	2.72	0.25	0.032	21.7	2.5	0.384
NH_3	Liquid/Inorganic	2.72	0.25	0.032	21.7	2.5	0.384
Air	Gas/Inorganic	1.9	0.25	0.064	8.5	8.0	0.384
Cleaned Fines	Solid/Organic	1.52	0.25	0.032	12.8	10.0	0.384
Refuse	Solid/Organic	1.52	0.25	0.032	12.8	10.0	0.384
Dehydration Water	Liquid/Inorganic	2.72	0.25	0.032	21.7	2.5	0.384
Raw Water‡	Liquid/Inorganic	0.35	0.25	0.032	21.7	2.5	0.384
Sulfur	Solid/Inorganic	1.52	0.25	0.032	12.8	10.0	0.384
Absorber--Oxidizer Gas	Gas/Organic Particulate/Organic	1.9 4.84	0.25 0.25	0.064 0.384	8.5 51.2	8.0 25.0	0.384 2.048
Incinerator Gas	Gas/Inorganic Particulate/Inorganic	1.9 4.84	0.25 0.25	0.064 0.384	8.5 51.2	8.0 25.0	0.384 2.048
	SUMS	41.93	4.0	1.44	348.0	147.5	10.24
		Sum above costs = 47.38 Level 1 fixed costs = 5.0			Sum above costs = 505.7 Level 2 fixed costs (first process point) = 9.0 Level 2 fixed costs (second process point) = 3.0		

Total Level 1 costs → \$52.38K

Total Level 2 costs (first process point) →\$505.7 + 9 = \$514.7K

Total Level 2 costs (second process point) → (505.7 - 147.5) + 3 = \$361.2K

Fugitive analysis cost = \$252K

Total Cost for demonstration phase → 514.7 + 361.2 + 52.38 + 252 = \$1,180.28K

†Matrix for existing commercial unit is identical except for the addition of particulate testing for the product gas stream (\$83.5K first process point; \$53.25K second process point)

*Complete analysis cost (includes all inorganic, organic, and bioassay work)--same for both process points

‡Raw water used at various points in process

Table 7. ENVIRONMENTAL ASSESSMENT COSTS--LURGI GASIFICATION

PHASE: COMMERCIAL-SCALE

STREAM		LEVEL 1* COSTS (10^3 DOLLARS)			LEVEL 2 COSTS (10^3 DOLLARS)		
DESIGNATION	CHARACTERIZATION	ANALYSIS	SITE PREPARATION	SAMPLING	ANALYSIS†	SITE PREPARATION	SAMPLING
Product Gas	Gas/Organic				8.5 A	8.0	0.384
Coal Feed	Solid/Organic				12.8 A	10.0	0.384
Ash Quench	Liquid/Inorganic				7.5 B	2.5	0.384
Refuse	Solid/Organic				10.8 C	10.0	0.384
Absorber--Oxidizer Gas	Gas/Organic				4.95 D	8.0	0.384
Dehydration Water	Liquid/Inorganic				17.7 C	2.5	0.384
Incinerator Gas	Gas/Inorganic				1.4 B	8.0	0.384
	SUMS				63.65	49.0	2.69

Sum above costs = 115.3
Level 2 fixed costs (first process point) = 9.0
Level 2 fixed costs (second process point) = 3.0

Total Level 1 costs → 0

Total Level 2 costs (first process point) → \$124.3K

Total Level 2 costs (second process point) → (115.3 - 49.0) + 3 = \$69.3K

Total cost for commercial-scale phase → 124.3 + 69.3 = \$193.6K

*Level 1 analysis is carried out in the demonstration study

†Letter following cost designates assumption made regarding simplification of analysis--costs are same for both process points

A = complete analysis cost
B = assume no organics
C = assume only 50% of organic classes
D = assume no inorganics and 50% of organic classes

Level 1 and Level 2 costs are comprised of site preparation, sampling, analysis, and fixed costs. Fixed costs, totaling approximately $5K and $9K for the respective levels, are discussed on pages 17 through 25 and include the following: travel, equipment preparation and freight charges, data reduction and recording. Site preparation costs, discussed on page 18, are fixed at $250 per stream for Level 1 but become a function of stream type for Level 2, ranging from $2.5K for a liquid stream to $25K for a particulate stream. The costs of sample acquisition, discussed on page 20, vary with stream type and are different for Levels 1 and 2. By assuming a cost of $32 per man hour, the sampling costs expressed in man-hours on page 20 have been converted to dollar values. The Level 1 analysis costs presented on page 21 have been used for the Lurgi example. In Table 8, Level 2 analysis costs for each stream in the commercialized Lurgi process are presented for a series of previously discussed cases reflecting various simplications in analysis. The cost figures have been extracted from the Level 2 analysis cost matrix (Table 3).

The costs associated with the second process point of Level 2 have also been indicated in Tables 5 through 7 and were determined from the chart given on Table 2. Note that all Level 1 costs and Level 2 site preparation and travel costs are not incurred for the second process point.

In an actual environmental assessment program, the type of Level 2 analysis to be performed on a given stream would be influenced by the results of a prior Level 1 analysis. However, since the Lurgi process is being used here to illustrate the application of costing procedures developed earlier, and because no Level 1 measurement data is actually available, certain assumptions were necessarily made regarding the type of Level 2 analysis to be performed in each phase. These assumptions with their associated analysis costs correspond to the items presented

Table 8. LEVEL 2 ANALYSIS COSTS--LURGI GASIFICATION*

Stream		Level 2 Analysis Costs (10^3 Dollars)				
Designation	Characterization	Complete Analysis	Assume no Inorganics	Assume no Organics	Assume only 50% of Organic Classes	Assume no Inorganics and 50% of Organic Classes
Product Gas	Gas/Organic	8.5	7.1	--	6.5	4.95
	Particulate/Organic	51.2	29.6	--	43.2	21.6
Coal Feed	Solid/Organic	12.8	7.4	--	10.8	5.4
Ash Quench	Liquid/Inorganic	21.7	---	7.5	17.7	---
Naptha	Liquid/Organic	21.7	14.2	--	17.7	10.2
H_2S	Gas/Inorganic	8.5	---	1.4	6.5	---
Tar/Oil	Liquid/Organic	21.7	14.2	--	17.7	10.2
Phenol	Liquid/Organic	21.7	14.2	--	17.7	10.2
NH_3	Liquid/Inorganic	21.7	---	7.5	17.7	---
Air	Gas/Inorganic	8.5	---	1.4	6.5	---
Cleaned Fines	Solid/Organic	12.8	7.4	--	10.8	5.4
Refuse	Solid/Organic	12.8	7.4	--	10.8	5.4
Dehydration Water	Liquid/Inorganic	21.7	---	7.5	17.7	---
Raw Water	Liquid/Inorganic	12.8	---	7.5	17.7	---
Sulfur	Solid/Inorganic	12.8	---	5.4	10.8	---
Absorber-Oxidizer Gas	Gas/Organic	8.5	7.1	---	6.5	4.95
	Particulate/Organic	51.2	29.6	---	43.2	21.6
Incinerator Gas	Gas/Inorganic	8.5	---	1.4	6.5	---
	Particulate/Inorganic	51.2	---	21.6	43.2	---

* All measured streams in existing commercial unit have been listed.

in Table 8 and have been appropriately indicated by footnotes in the Level 2 analysis cost columns of Tables 5 through 7. It is evident that the total Level 2 costs for the development and demonstration phases exceed the corresponding Level 1 costs by an order of magnitude. It should also be noted that for purposes of example, an arbitrary but reasonable selection was made of streams to be considered in the development and commercial-scale phases. The fugitive analysis cost, incurred only at the demonstration phase, is based on up-wind/downwind monitoring for the coal handling operation (see Table 9).

The cost of process measurements as a function of the phase of Lurgi process evolution is summarized graphically in Figure 11. Of a cumulative assessment cost of $1,771K, the percentages attributable to the research, development, demonstration, and commercial-scale phases are respectively, 0, 22.4, 66.6, and 11.

It has been assumed so far, that environmental assessment has been initiated at the research phase and has progressed in parallel with process evolution through the commercial-scale phase. It is entirely conceivable that environmental assessment may be initiated at some later phase. Figure 12 depicts how this situation would affect cumulative assessment cost for the Lurgi process. Also shown is the resulting cost for initiating environmental assessment on an existing commercial unit. Performance of an environmental assessment during the research and development phases (cost $397K) results in a 29 percent increase over the cumulative assessment cost incurred when EA is initiated at the demonstration phase. By allowing environmental assessment to progress in parallel with process development, a minimum-risk, information-effective assessment program is obtained. Lead time is also provided for control technology development, if warranted.

Table 9. FUGITIVE EMISSION SAMPLING AND ANALYSIS COSTS

	SAMPLING STRATEGY		
	Quasi-Stack	Roof Monitor	Up-Wind/ Downwind
No. of Samples (± factor of 2)	4	7	15
Cost/Sample	6K	8K	12K
Sampling Costs	24K	56K	180K
Analyses Done at Level 1			
No. of Inorganic Tests	16	28	60
Costs	4.8K	8.4K	18K
No. of Organic Tests	16	28	60
Costs	3.2K	5.6K	12K
No. of Bioassay Tests	8	14	30
Costs	11.2K	19.6K	42K
TOTAL COST	43.2K	89.6K	252K

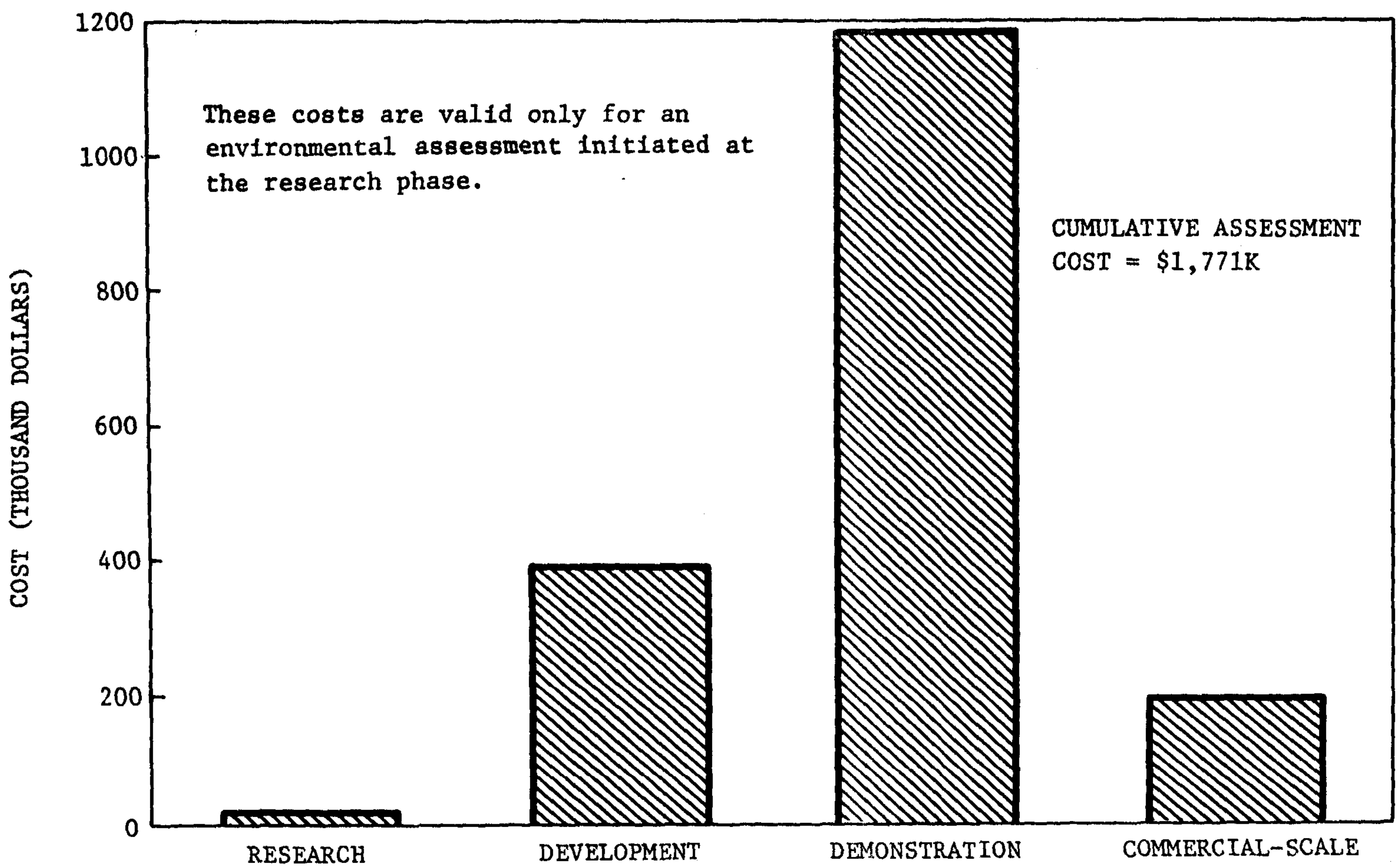
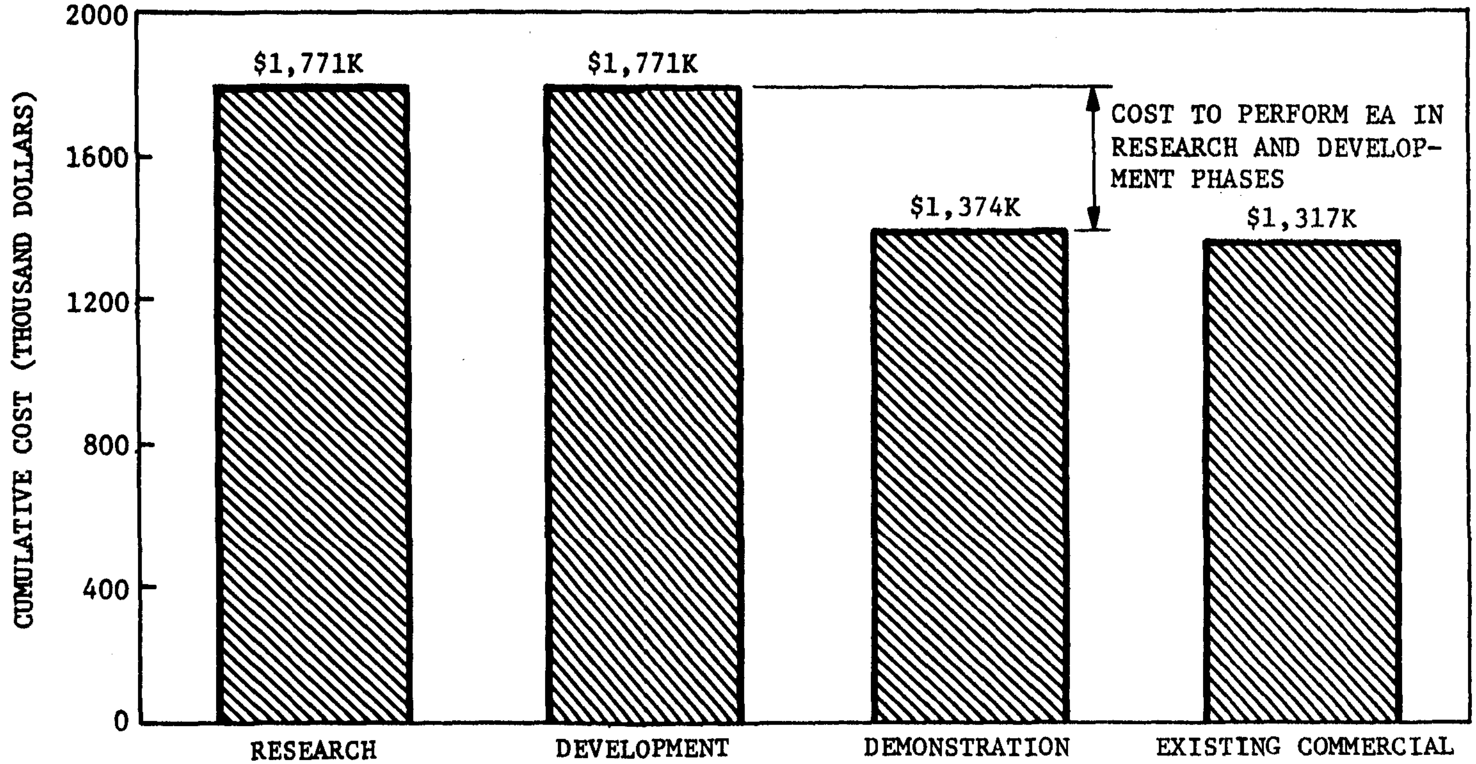


FIGURE 11
ENVIRONMENTAL ASSESSMENT COST VS. PHASE OF PROCESS EVOLUTION
FOR LURGI GASIFICATION



Environmental assessment initiated at the research phase allows for appropriate control technology development lead time.

Environmental assessment commencing at the existing commercial phase would result in an environmentally unsound facility with no control technology available for years.

FIGURE 12
CUMULATIVE ASSESSMENT COST VS. ASSESSMENT ENTRY-LEVEL PHASE FOR LURGI GASIFICATION

SECTION XII

EFFECT OF PROCESS TYPE ON ASSESSMENT COSTS

In addition to the Lurgi gasification process, eleven other processes representing four major areas of current interest to EPA have been investigated in an effort to determine the variation of environmental assessment costs with process type. The major areas and processes considered are as follows:

A. Synthetic Fuels
   1. Koppers-Totzek
   2. Lurgi
   3. Synthoil
   4. Toscoal

B. Primary Metals
   1. Aluminum
   2. Copper
   3. Steel

C. Stationary Combustion
   1. Power Plant
   2. Municipal Incinerator

D. Flue Gas Desulfurization
   1. Magnesium Slurry Scrubbing
   2. Wellman-Lord
   3. Lime-Limestone Scrubbing

The costs of environmental assessment were determined for each process by employing the previously developed costing strategies. The results are summarized in tabular form in Table 10 and displayed in Figure 13 as a function of the number of streams measured. To examine the variability of assessment cost with the degree of Level 2 analysis, two sets of costs are shown, each corresponding to the type of Level 2 analysis indicated. The processes belonging to the primary metals and stationary combustion groups, as well as the Lurgi process, presently exist

Table 10. ENVIRONMENTAL ASSESSMENT COSTS FOR SELECTED PROCESSES

Class/Process	Level 1 Cost (10^3 Dollars)	Total Cost* (10^3 Dollars) Excluding Fugitives/Including Fugitives: Including Complete Analysis at Level 2	Total Cost* (10^3 Dollars) Excluding Fugitives/Including Fugitives: Sampling and Analysis Cost as per Assumed Stream Composition	Fugitive Analysis Cost (10^3 Dollars)
Synthetic Fuels				
Koppers-Totzek	43.0	337/632	237/532	295.2
Lurgi	49.2	1093/1345	627/879	252
Synthoil	53.0	734/986	528/780	252
Toscoal	36.8	410/662	298/550	252
Primary Metals				
Aluminum	90.2	1356/1446	840/930	89.6
Copper	59.0	933/1185	505/752	252
Steel	130.7	788/2522	526/2260	1734.4
Stationary Combustion				
Power Plant	33.9	352/604	284/536	252
Municipal Incinerator	37.0	401/653	387/639	252
Flue Gas Desulfurization				
Magnesium Slurry Scrubbing	47.9	565/565	423/423	---
Wellman-Lord	32.7	483/483	289/289	---
Lime-Limestone Scrubbing	41.6	531/783	371/623	252

*Includes Level 1 costs

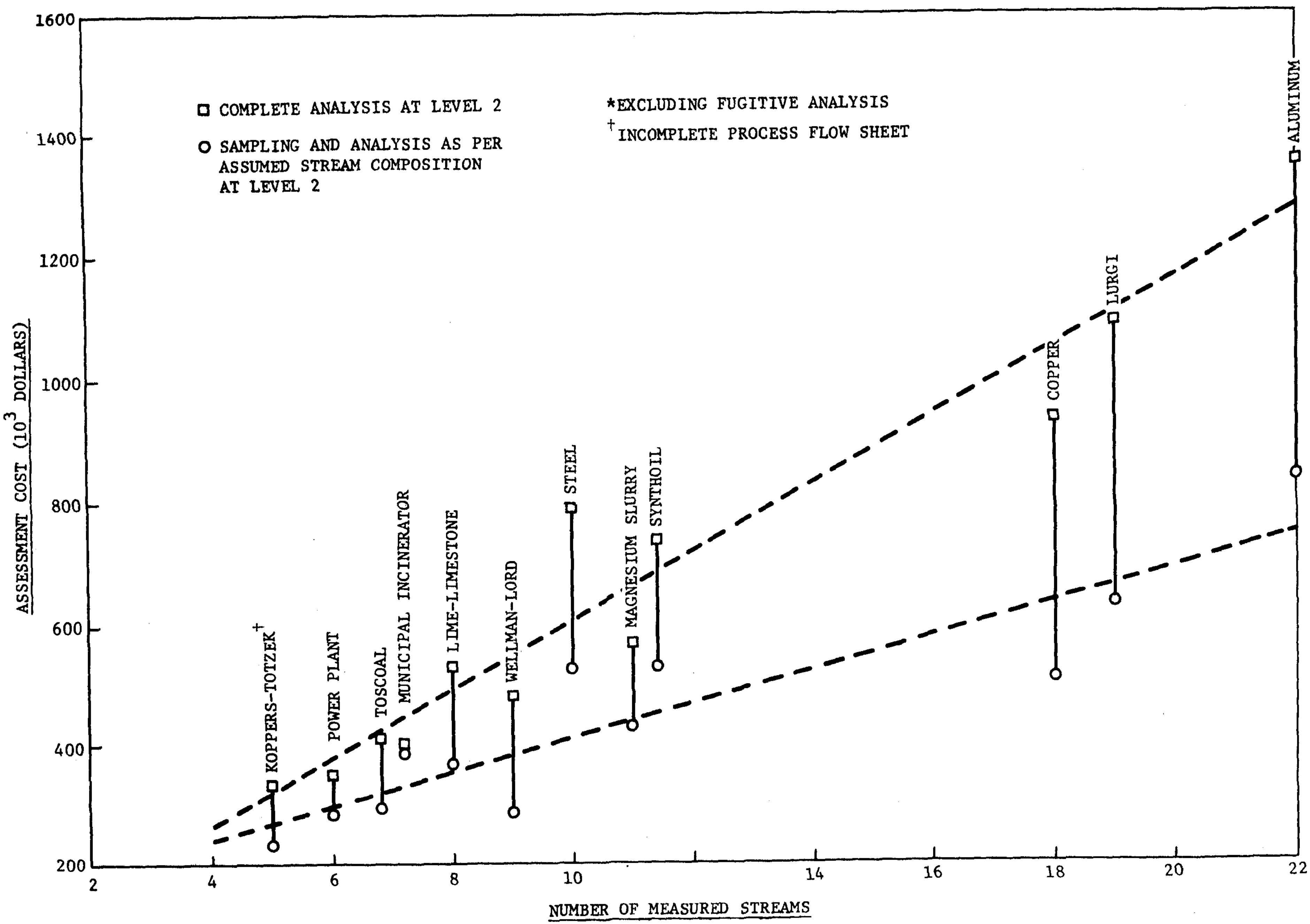


FIGURE 13
ENVIRONMENTAL ASSESSMENT COST* FOR SELECTED PROCESSES VS. NUMBER OF MEASURED STREAMS

at the commercial stage and were costed accordingly. To date, none of the remaining processes in the flue gas desulfurization and synthetic fuels groups have progressed beyond the demonstration phase. Assessment costs for these processes were based on flow diagrams reflecting the most current phase of process evolution. Since the flow diagrams available for a given process were found to vary, an attempt was made to select a representative case for each process under consideration.

As anticipated, costs of environmental assessment are observed in Figure 13 to generally increase with the number of measured streams. The dashed lines shown in Figure 13 represent least square fits for the upper and lower sets of points. Another factor expected to influence assessment cost is stream mix, due to the variation of site preparation, sampling, and analysis cost with stream type. Table 11 shows the total number of measured streams and the stream mix for each of the processes being considered.

Table 11. REPRESENTATIVE STREAM MIX FOR SELECTED PROCESSES

Class/Process	Total Number of Measured Streams	Number of Particulate Streams Measured/ Percentage of Total	Number of Liquid Streams Measured/ Percentage of Total	Number of Solid Streams Measured/ Percentage of Total	Number of Gas Streams Measured/ Percentage of Total
Synthetic Fuels					
Koppers-Totzek	5	1 (20)	2 (40)	1 (20)	1 (20)
Lurgi	19	3 (16)	7 (37)	4 (21)	5 (26)
Synthoil	11	3 (27)	3 (27)	2 (18)	3 (27)
Toscoal	7	1 (14)	3 (43)	2 (29)	1 (14)
Primary Metals					
Aluminum	22	5 (23)	6 (27)	6 (27)	5 (23)
Copper	18	2 (11)	7 (39)	6 (33)	3 (17)
Steel	10	3 (30)	3 (30)	2 (20)	2 (20)
Stationary Combustion					
Power Plant	6	1 (17)	1 (17)	3 (50)	1 (17)
Municipal Incinerator	7	1 (14)	2 (29)	3 (43)	1 (14)
Flue Gas Desulfurization					
Magnesium Slurry Scrubbing	11	3 (27)	3 (27)	2 (18)	3 (27)
Wellman-Lord	9	2 (22)	1 (11)	3 (33)	3 (33)
Lime-Limestone Scrubbing	8	2 (25)	3 (38)	1 (13)	2 (25)
		Avg. % = 20.5	Avg. % = 30.5	Avg. % = 27	Avg. % = 22

Figure 14 shows the variation of assessment costs with stream mix and number of streams measured. Costs include site preparation, sampling, analysis, and fixed costs for Levels 1 and 2 but exclude fugitive analysis costs. Complete analysis at Level 2 has been assumed. The costs on a per stream basis (not including fixed costs) vary with stream type as follows:

Particulate	- 83.55K	includes complete analysis of Level 2
Liquid	- 27.48K	
Solid	- 24.88K	
Gas	- 18.81K	

The lines marked "particulate streams only" and "gas streams only" in Figure 14 represent the upper and lower bounds, respectively, of assessment costs for the particular degree of Level 2 analysis assumed. (Similar curves may, of course, be generated for other degrees of Level 2 analysis.) The assessment cost for any process, regardless of stream mix, must lie in the region bounded by these lines. To illustrate this, assessment costs for six commercial processes reflecting different stream mixes have been plotted on the diagram. These costs have been taken from Table 10 for the case of complete analysis at Level 2. The dashed line in Figure 14 represents assessment costs for an average stream mix, synthesized from average values of stream mix percentages given in Table 10 for the twelve processes under consideration. This stream mix consists of:

Particulates	- 20.5%
Liquid	- 30.5%
Solid	- 27.0%
Gas	- 22.0%

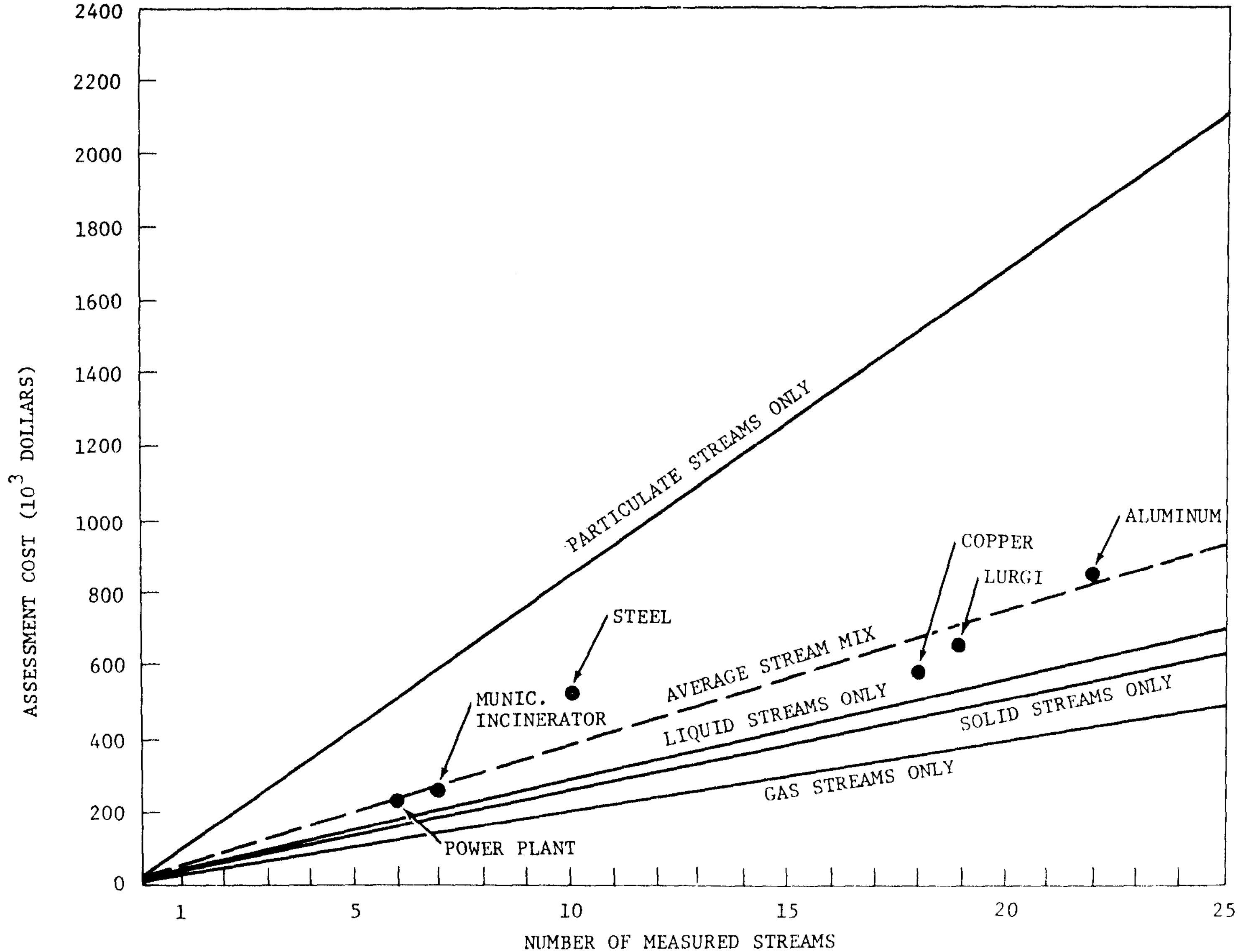


FIGURE 14
EFFECT OF STREAM MIX ON ENVIRONMENTAL ASSESSMENT COSTS*

*EXCLUDES FUGITIVE ANALYSIS AND SECOND PROCESS POINT AT LEVEL 2

It is evident from Figure 14 that the upper and lower bounds represented by the "particulate only" and "gases only" lines encompass a cost range too broad to be used even for gross predictions of assessment costs. The "average stream mix" line could, however, provide a first estimate of assessment costs, provided it was established that this stream mix was representative of many other process classes. Future efforts should be directed to this area of generalized cost prediction.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-76-093a	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Environmental Assessment Sampling and Analytical Strategy Program		5. REPORT DATE May 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) J.. Vlahakis and H. Abelson		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS The Mitre Corporation Westgate Research Park McLean, Virginia 22101		10. PROGRAM ELEMENT NO. 1AB013; ROAP 21ADD-BG 11. CONTRACT/GRANT NO. 68-02-1859, Task 6
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Task Final; 11/75-1/76 14. SPONSORING AGENCY CODE EPA-ORD

15. SUPPLEMENTARY NOTES Project officer for this report is Robert M. Statnick, Mail Drop 62, Ext 2557.

16. ABSTRACT The report describes a costing methodology for environmental assessment that has been generated for industrial processes at various phases of development. The demonstrated environmental assessment strategies provide a framework for determining industry, process, and stream priorities on the basis of a staged sampling and analysis technique. A Level-1 screening phase characterizes the pollutant potential of influent and effluent streams of a process. Level-2 sampling and analysis provides for a quantitative representation of potentially hazardous substances in those streams identified for further investigation by Level 1. The procedure provides a mechanism for recommending assessment program implementation costs as well as for estimating costs for budgetary planning purposes.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Cost Estimates Industrial Processes Sampling Analyzing	Air Pollution Control Stationary Sources Environmental Assessment Analytical Strategy	13B 05A,14A 13H 14B

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 60
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)