United States
Environmental Protection
Agency

State of Illinois
Environmental Protection
Agency

EPA 905-R-95-003
February 1995
Vol. 1

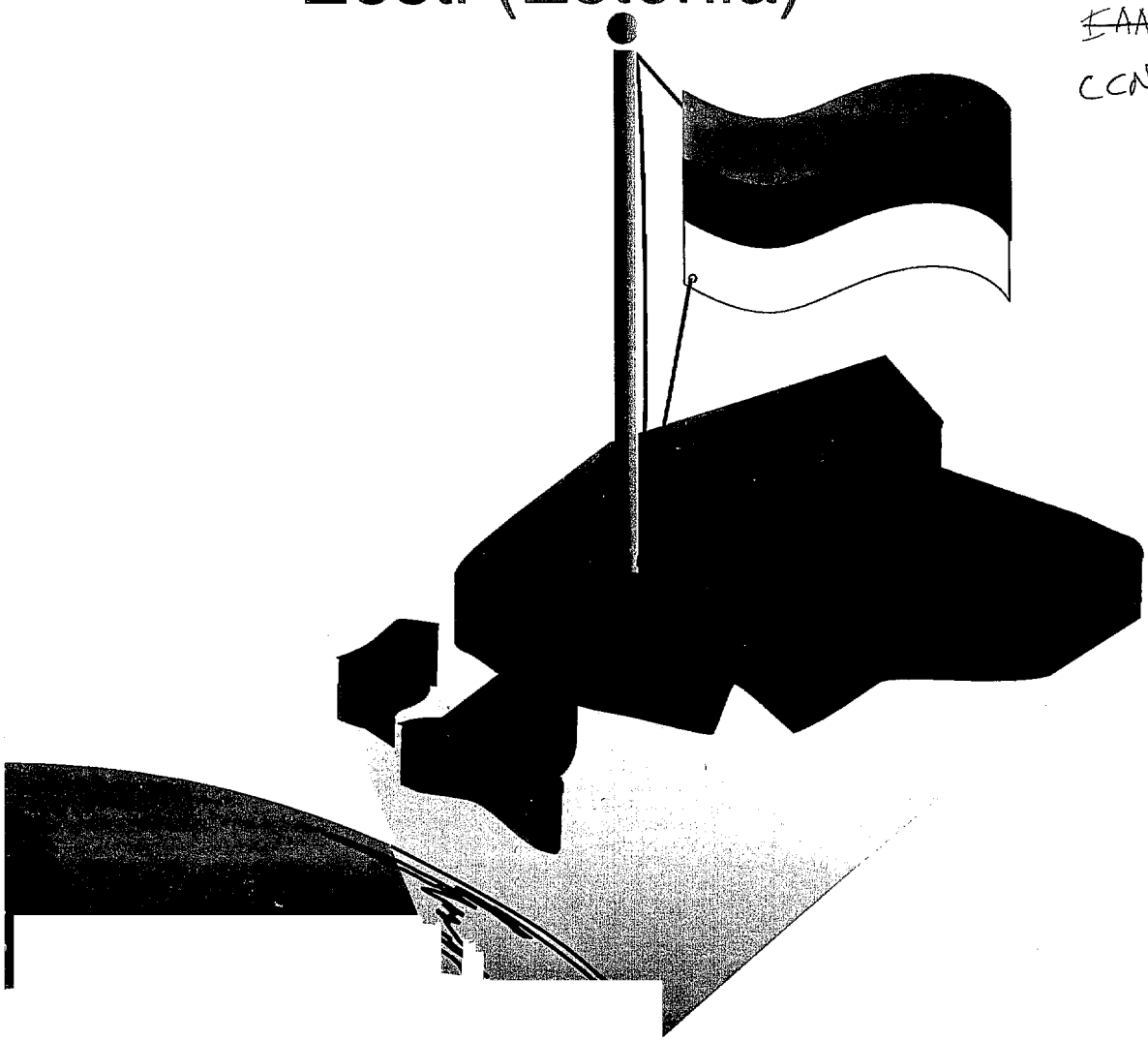
PN-ACB-384 95331

Baltic Republics Environmental Monitoring Review Project

Findings and Recommendations

Eesti (Estonia)

ENI/EEUD/ENR
~~EAA 180-0039~~
CCN-0003-P-EP-4116



NOTICE

This document has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Preface

This project was conducted by USEPA to evaluate the environmental monitoring programs of Estonia, Latvia and Lithuania and provide third party recomendations for their strengthening. The evaluation was performed in response to the concern that the air and water monitoring infrastructures inherited by the new governments were inefficient; failed to provide the information necessary for effective environmental control decisions; that the data provided was both undependable and untimely for effective management of the environment. The project consists of three phases. The first phase, initiated during the previous year, consisted of developing a snapshot of the existing monitoring networks and their supporting objectives. The preliminary analysis of the questionaires and the associated software were presented during the week of September 26, 1994 in Tallinn, Estonia to the senior staff of the Environmental Ministries of each of the three countries. The project objectives were reconfirmed at this workshop and agreement was reached with the Ministries to correct the survey deficiencies by Spring of 1995.

The workshop coincided with the introduction of the start of the second phase of the project which focused on the implementation of the monitoring programs. This visit introduced the Illinois Environmental Protection Agency managment and review staff to the senior staff of the three environmental Ministries. It provided for a joint review and discussion of the priorities of each country's environmental program, and agreement on the specialists needed for the detailed program review during the second site visit.

The second phase site visits to each country were completed during the period of November 9-22, 1994. A team for each respective country worked with appropriate ministry monitoring specialists to complete a detailed evaluation of each country's monitoring program. Each team included at least three people; a laboratory specialist, an air monitoring specialist, and a water monitoring specialist. The team leader served as one of the program specialists. Each team's findings and recommendations are presented in separate report for each country. Issues common to all three countries and recommendations are presented in a separate section. An overall project report executive summary provides a brief review of the findings and recommendations.

The third phase of the project will focus on the implementation of the recommendations. USEPA and IEPA will work with the environmental Ministries of Estonia, Latvia and Lithuania to assist in implementation of the recommendations The need for computerized data management systems by all Ministries was identified as an early priority and fast tracked as a separate sub-project by USEPA Region 5. All activities were coordinated with principle donor agencies active in the three countries.

ACKNOWLEDGMENTS

This report is prepared in connection with a US EPA environmental needs assessment project for the Baltic States, with funding from US AID. Its production represents the combined efforts of representatives from the US EPA, the Illinois Environmental Protection Agency, the Wisconsin Department of Natural Resources, the Bowling Green State University and Eurpopean Union's international program Phare.

An expert team was assembled that visited Estonia from November 9-19, 1994, when it put together the major components of the report. Team members were:

- Dr. Michael Flanagan (Phare representative)
  Irish Environmental Protection Agency

- Mr. James Hughes
  Wisconsin Department of Natural Resources

- Dr. Harold Kibby
  US Environmental Protection Agency

- Dr. Reginald Noble (Team Leader for Estonia)
  Bowling Green State University

- Dr. Ciaran O'Donnell (Phare representative)
  Irish Environmental Protection Agency

The final team report was prepared for publication by Mr. Vacys Saulys of US EPA Region V, Chicago, IL and William H. Busch, Technical Project Coordinator from Illinois EPA, Springfield, IL.

Special thanks are extended to the Phare program for its support which made possible participation by the two Irish experts. Thanks are also extended by the team to its Estonian hosts. Their cooperation, assistance, and hospitality were greatly appreciated.

EXECUTIVE SUMMARY

The report presents the findings and recommendations of multidisciplinary review teams of United States specialists, supplemented in Estonia with European Community PHARE program consultants from the Irish Environmental Protection Agency. While the report is based primarily on the findings of the three project teams that visited Estonia, Latvia and Lithuania during the period of November 9-22, 1994, it also drew upon the results of the questionnaires compiled during the Summer of 1994, some earlier reviews conducted by USEPA Environmental Research Laboratory in Athens, Georgia and previous missions by individual team membersto the Baltic Region. Each team consisted of at least three experts: one for each of the program areas of laboratory operations, air pollution control and water pollution control. The report consists of a section presenting recommendations on issues common to the region followed by a country specific report and supporting appendices.

- **Highly qualified staff:** All three teams found that the monitoring programs in the three countries were served by highly qualified and committed technical staff that worked under severe physical and budgetary constraints.

- **Investments needed:** All three countries face needs for substantial investment in new laboratory equipment, physical plant and sampling apparatus. These investments are needed to supply the monitoring programs with the minimum capability to detect pollutants down to levels consistent with both existing and emerging ambient standards for protection of human health wildlife and aquatic life.

- **Operational budgets:** While new laboratory equipment is critical to improvement of both environmental laboratory capability and capacity, budgeting and purchase practices need to change to ensure adequate maintenance and operating support to dependably exploit the investments.

- **Organizational and procedural changes:** The teams also evaluated organizational relationships and administrative practices in each country against program priorities and regional and international objectives for the control of pollutants. Each country report includes recommended strategies, alternatives for organizational and procedural changes in addition to recommendations for equipment investments. While each country, in particular the environmental ministries, have taken steps to streamline the monitoring, analytical laboratory support and data management systems, additional organizational and procedural changes need to be taken to optimize data collection, analysis and data management.

- **Quality Assurance Management Programs:** Immediate steps should be taken to develop and implement rigorous Data Quality Management Programs to improve both the quality and documentation of precision of the environmental data gathered by the three countries.

- **Regional coordination:** Environmental monitoring, data quality and environmental data base management protocols and standards should be not only be coordinated on a national basis but also internationally on a regional basis to address common airshed and watershed issues. As a minimum, the countries should work together to develop compatible standards and protocols, preferably this work could be done in concert with other members of HELCOM.

Baltic Republics Environmental Monitoring Project

Regional Recommendations

- **Trans-boundary monitoring and data compatibility:**

  Recommendation: All Baltic Sea community countries should begin an initiative to assure that all monitoring protocols and monitoring data format is consistent to assure comparability of data across boundaries. This will help track progress by all countries in the area to implement the objectives of the HELCOM agreement. This is particularly important for accounting for inputs of pollutants to the Baltic Sea and other boundary waters and airsheds between countries. Consideration should be given by each country to provide funding support to form and participate in a technical committee to develop and implement consistent sampling and analytical standards, and data storage and reporting formats between all Baltic Sea countries

- **Laboratory performance standards and certification:**

  Recommendation: Laboratory standards, quality control and quality assurance procedures must be consistent for all Baltic Sea drainage basin countries to assure the ability to share data on environmental impacts in the region as discussed in the recommendation above. It is recommended that funding be provided to start and maintain a regional technical committee of laboratory experts from each of the Baltic Sea countries to begin a project of developing and coordinating laboratory analytical standards and procedures. This committee could be a subcommittee of the regional monitoring committee discussed above. The lab standards committee should meet periodically on an on-going basis to coordinate appropriate standards and laboratory certification procedures for the Baltic region. Rigorous quality assurance management programs should be designed for the monitoring networks and implemented to develop confidence in the national environmental data both internally and internationally.

- **Strategy for monitoring information management and reporting:**

  Recommendation: A monitoring data management and reporting strategy should be developed for each country that assures cost effective integration of monitoring data processing and reporting efforts within each Ministry. This strategy should avoid duplication of effort, and assure consistency of reporting formats and software compatibility. The strategy should set objectives to quickly summarize monitoring data, and present it in an appropriate format to key program managers. The strategy should establish a process to report extreme excursions of parameters above or below predetermined levels immediately to

appropriate Ministry staff for investigation and corrective action. The strategy should present a plan to produce regular monthly exception reports on changing short-term trends as well as annual reports of long-term changes.

- **Special monitoring priorities for protected or special use areas:**

  Recommendation: Each of the Baltic Republics has "protected" or special use areas that deserve special attention to protect public health, existing high-quality areas, sensitive aquifers, or ecologically sensitive areas. It is recommended that high priority be placed on special monitoring for such areas in the strategic plans currently under development. These special monitoring efforts would include complete scans for toxic pollutants for air and water samples at monitoring sites carefully selected to detect threats to such areas. Special sampling studies such as intensive stream basin, lake or beach area studies are also recommended to detect local impacts of pollutants on human health, fish and wildlife resources, and the environment. The budgeting strategy for each Ministry should be include in plans to support an annual program of conducting a number of intensive surveys each year based on a priority system.

- **Multi-country coordination and grouping of purchases of major pieces of equipment:**

  Recommendation: The Environmental Ministries of the Baltic Republics should coordinate purchases of major pieces of laboratory equipment if at all possible. If each can purchase the same make of equipment and purchase orders can be combined for the same types of instruments, not only better prices may be secured, but also manufacturers will be given incentive to set up regional service centers, and provide better training assistance in the region.

- **Adequate, high-quality supplies and reagents, and for laboratory operations:**

  Recommendation: The teams observed problems in laboratory operations due to poor quality reagents and inadequate laboratory supplies and other items such as glassware. It is recommended that each Ministry's budgeting process provide allowance for sufficient funds to provide at least two years supply of high-quality reagents, purge gasses, and other consumable supplies such as glassware for all central and regional office laboratories.

- **Staff training:**

- ***Recommendation:*** Adequate training must be provided for new sample handling and laboratory methods as new methods are implemented and new equipment is acquired. Appropriate budget costs must be planned for this training.

- **Training and support from vendors of new analytical and computer equipment:**
  Adequate staff training must be provided for new sample collection, handling, laboratory methods, quality control, and quality assurance as new methods are implemented and new equipment is acquired. Appropriate budget costs must be planned for this training.

  Recommendation: Vendors of all new major equipment must be required to provide adequate on-site training and maintenance support for at least one year after startup. This cost should be incorporated in new equipment purchase costs. Currently it is not unusual to encounter equipment in disrepair or not used due to lack of adequate training and maintenance support for the technology.

- **Preventative maintenance agreements for major new equipment:**

  Recommendation: A minimum of a two year maintenance and service agreement is recommended for all major new laboratory equipment.

- **Access to INTERNET:**

  Recommendation: Each of the Baltic Republics should improve access to INTERNET to facilitate:
  1.) Sharing of environmental data on a regional basis .
  2.) Access to technical tools and databases in more developed countries.
  3.) Self-help via non-for-profit technical assistance resources on INTERNET.
  Current technical limitations restrict Environmental Ministries primarily to rudimentary e-mail.

- **Global Positioning Satellite receivers:**

  Recommendation: Each of the Baltic Republics should acquire Global Positioning Receivers to accurately verify the locations of all fixed monitoring stations, special survey sampling stations and sources for both GIS mapping and development of spatial data bases to drive modeling and forecasting tools and planning of special surveys.

TABLE OF CONTENTS

Part 1 - Overview 1
Background 1
Monitoring Objectives 2
Monitoring Priorities 3
Organization 4
Figure 1 - Ministry of the Environment 5
Figure 2 6
Figure 3a 7
Figure 3b 8
Figure 4 - Estonian State Monitoring System 9
Part II - Current Status and Recommendations
Air 10
Background 10
Related Activities - Biomonitoring 12
Recommendations 12
Table A1 15
Water 16
Background 16
Surface Water Monitoring 17
Table W1 17
Methodology 18
Laboratory Methods 18
Hydrobiology 19
Table W2 19
Table W3a 20
Table W3b 20
Table W3c 20
Table W4a 21
Table W4b 21
Table 5 22
Drinking Water Monitoring 22
Ground Water Monitoring 22
Table W6a 23
Table W6b 23
Recommendations 23

Information Management 26
Background 26
Recommendations 26
Landscape Monitoring 28
Background 28
Recommendations 28
Estonian Center of Excellence 28
Background 28
Recommendations 29
Part III - Equipment Required 30
Air 30
Water 32
Information Management 34
Landscape Monitoring 34
All Areas 34
Part IV - Equipment Needs Priorities 35
Air 35
Water 36
Information Management 37
Landscape Monitoring 37
All Areas 37

PART I - OVERVIEW

Background

The transition of Estonia from the fragmented character of environmental protection activities of the former Estonian SSR to a centralized national environmental monitoring program is underway. The current project is undertaken in connection with the desire of the international community to see that this transition occurs as rapidly and effectively as possible. Environmental monitoring became a legal responsibility of the Estonian government one year ago (October 1993). At that time the concept of state environmental monitoring was decreed by the Minister of Environment. This decree identified the Estonian Environmental Information Center (EEIC) as having lead responsibility. Provisions were made for creation of a monitoring board which in turn is responsible for electing persons responsible for implementation of monitoring activities. Formal contracts were established with these individuals by the Environmental Information Center. Monitoring activities carried out since October 1993 have been funded from the state budget (6,783,000 Estonian Crowns) and treated as a mandatory obligation. Responsibilities include collecting, processing and preserving monitoring information.

Although cooperation at the state level has only been possible since 1991, joint activities were taking place before that. For example, for over a decade Estonian specialists have been actively participating in the working groups of HELCOM, and have been represented in international organizations and in international meetings worldwide. Working contacts exist between experts and scientific institutes of Estonia and its neighboring countries. In the development of economic measures related to environmental behavior, the Estonian government applies the "Polluter Pays Principle." Since 1991 the country's economy has been influenced by charges for natural resources and pollution taxes which are a considerable financial instrument being channeled through an "Environmental Fund." According to its status, the fund, which is outside state budget, is used for:

- additional financing of national, regional and local environmental programs and measures,
- updating of information system,
- training of staff,
- developing of environmentally friendly technologies and equipment,
- scientific research.

Environmental awareness and nature protection enjoy a long tradition in Estonia, having begun at the state level, almost 700 years ago, in 1297 (Nature Conservation in Estonia, 1994); while the Nature Investigators Society, an academic non-governmental organization, first became active in 1853. Air temperature measurements in Estonia started in 1339 and a continuous air temperature record exists from 1600 (Tarand, 1994); and river flow discharge gauging have been carried out at 77 sites for more than 60 years.

In general, the basic philosophy of the current design of the Estonian monitoring system is well thought out and, when fully implemented, will provide the Estonian government with critical

information on pollution problems in the country. Progress has been rapid on improving on the fragmented character of environmental protection activities of the Soviet era. Addition of new equipment and methodologies has been so rapid that reporting the current status is practically impossible. Even more problematic is the difficulty experienced in trying to compare information during the transition from the Soviet era to the current situation in which information is based upon more modern technologies.

Officials have identified key problems that need to be addressed in tailoring a monitoring program that satisfies their needs. They include:

- intercalibration of laboratory procedures,
- establishing priorities in the field of hazardous waste,
- establishing a suitable database for managing,
- automation of EMEP stations.

Substantial progress has been made in realizing solutions to these problems. For example, responsibility for calibrating methodologies has been assigned as follows: methodology for sewage - the Estonia Environmental Research Laboratory; methodology for surface water - the Tallinn Technical University; and methodology for ground water - the Geology Center. In the future those laboratories that participate in intercalibration practices will be given highest priority when the state awards contracts for analytical services. The EEIC has given laboratory responsibility for the monitoring program to the Estonian Environmental Research Laboratory Ltd. (EERL). Intercalibration activities by the EERL are as follows:

- EMEP precipitation chemistry - Norwegian Institute for Air Research (NILU)
- HELCOM sewage and surface waters intercalibration,
- Interlaboratory Test Comparisons: Nitrogen and Phosphorus (Sewage) - Swedish ITM,
- International Sediment Exchange for Test on Organic Contaminants (SETOC) - Wageningen Agricultural University (the Netherlands),
- International Soil-analytical Exchange (ISE) -Wageningen Agricultural University (the Netherlands), etc.

Recognition of the need to join international monitoring systems has prompted Estonia to introduce integrated monitoring into its program. They started setting up two integrated monitoring stations in 1994 (Saarejarve station and Vilsandi monitoring area). These stations are following the guidelines (Manual for Integrated Monitoring, Helsinki 1993) provided by the United Nations European Economic Committee (UN/ECE ICP/IM).

Descriptions of programs and sub-programs for Estonian environmental monitoring are on record at the Environmental Information Center, which is under the direction of Mr. Leo Saare. The Center has already produced several reports and summary documents including "Estonian Environment 1993," and "Water Pollution and Quality in Estonia." These publications and one entitled "Air Pollution in Estonia, 1985 -1990" (all with English translations) will prove useful to those trying to understand the nature, the extent and the degree to which the state is addressing its environmental problems.

Monitoring Objectives

- Upon arrival of the US expert team in Estonia, monitoring personnel provided the following objectives for the Estonian monitoring program:

- To provide data for determining current state of environment and making available quick updates for short-term reporting

  - This primary objective is shared with the National Board for Health Protection in that the monitoring system will allow the appropriate authorities to issue warnings of threats to human health and to take corrective actions. For example, if there is a major NOx problem that is detected with the monitoring systems, automobile traffic might be restricted in the center of Tallinn.

- To monitor long-term and large-scale trends in the environment and in that way identify problems that require research efforts or direct countermeasures

  - In addition to knowing which problems need further research and corrective action, this objective will allow the government to assess whether their policies to protect the environment are working. For example, if over time there are fewer fish kills from toxic substances or if the health of the forest is improving, then the authorities will know that the long term results of their policies have been successful. Opportunities would be provided for decision makers to assess the potential effects of development; to know the significance of the problem so that corrective action will be taken at the most polluted places and to set priorities to improve the environment, and to take most cost effective actions.

- To keep track on exchange of pollutants with adjacent countries for estimating Estonian role in formation of regional pollution load, carry out comparisons with other countries and compile the national budget of transboundary pollution

  - Even though a monitoring program can keep track of the state of pollution for an area it is important to know whether the source is within your country or whether the pollution is coming from another country. Similarly, responsible governments want to know if they are creating a problem for a neighboring country. International pollution problems can be more difficult to solve, but are just a important as internal problems. International agreements based on historical levels of pollutants. Estonia is cooperating with many countries to reduce SO2 levels. Therefore, exact inventories are critical.

- To develop and continuously improve the system of environmental indicators for generating information from the EMP data

  - One of the most difficult problems facing the scientific community today, not only in Estonia, but also in the rest of the world, is the problem of communicating environmental

problems in terms that are meaningful to decision makers. Development of a meaningful set of indicators may be able to reduce the number of parameters measured with little loss of information. As new indicators are developed, data must be made comparable to existing information.

Monitoring Priorities

Also upon arrival, the expert team was supplied with the following list of priorities. Both a statement of monitoring objectives and priorities had been requested by the team prior to arrival. The priorities were:

- Developing the data communication network and unification of data exchange protocols among institutions implementing monitoring subprograms. *(They noted that access to Internet service, and availability of data communication hardware and software, were necessary)*

- Developing metadatabase of EMP and introducing GIS principles in data management. *(Here it was noted the need for GPS and GIS technology)*

- Intercalibrating the analysis methodology and establishing the lab system for systematic follow ups of the analysis results. *(Here it was noted that these requirements are determined by the Union of Environmental Laboratories)*

- Improving the field sampling techniques and related equipment for minimizing the deterioration and maximizing representativeness of samples. *(It was noted that this too is determined by the Union of Environmental Laboratories)*

- Automation of measurement result transfer from international monitoring stations (e.g. EMEP to supervising institutions. *(Here the need for data loggers and establishment of an on-line communication system was noted.)*

Organization

Organizationally, the Environmental Information Center answers directly to the Minister of the Environment; however, it lies outside the Ministry of Environment. This somewhat confusing arrangement can best be understood by consulting the Estonian Nature Conservation System organizational chart (Figure 1).

Monitoring activities that report to the EEIC are divided into four programs as follows:

Meteorological Monitoring (MMP),
Physical-Chemical Monitoring (PCMP),
Biological Monitoring (BMP), and
Integrated Monitoring (IMP).

These programs are then subdivided into a number of subprograms that are diagrammed in Figures 2, 3a, and 3b and 4. It is then within this framework that the current tasks of the Estonian monitoring program are conducted.

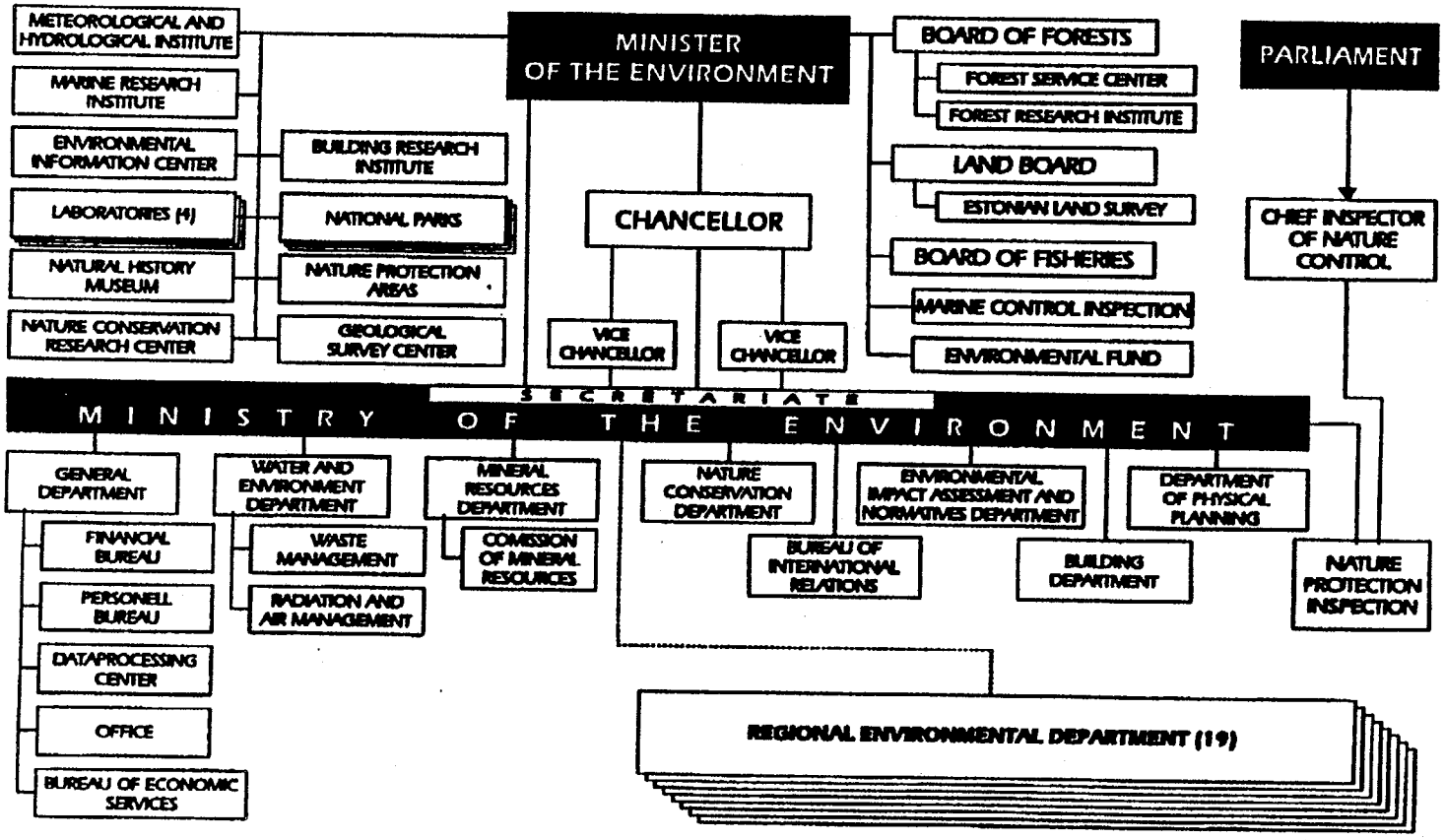


Figure 1

BEST AVAILABLE COPY

Figure 1

Estonian State Monitoring System			
Meteorological Monitoring Program (MMP)	*Physical-Chemical Monitoring Program (PCMP)*	*Biological Monitoring Program (BMP)*	*Integrated Monitoring Program (IMP)*

Subprograms:

• *Meteorological* • *Agrometeorological*	• *Groundwater* • *Surface water* • *Marine water* • *Coastal survey* • *Air, aerosols and precipitation chemistry* • *Radiation* • *Geochemical (soil chemistry)* • *Seismic survey* • *Pollution load control*	• *Forest* • *Marine biota* • *Freshwater biota* • *Species and community composition* • *Aerobiology*	

Figure 2 *Meteorological Monitoring Program (MMP)*

Subprogram	*Responsible institution*	*Stations / Parameters*
Meteorological	*Estonian Meteorological and Hydrological Institute (EMHI)*	*83 stations & samplepoints / max. 24 param.*
Aarometeorological	*EMHI*	*13/max. 24*

Biological Monitoring Program (BMP)

Subprogram	*Responsible institution*	*Stations / Parameters*
Forest monitoring	*Estonian Forest Research Institute (EFI)*	*94 samplepoints / max. 14 param.*
Marine biota: • *Fishes - coastal waters* *- open sea* • *Bottom animals & plants*	*Estonian Marine Research Institute (EMI)*	
Freshwater biota: • *Rivers* • *Lakes - hydrobiology* *- hydrochemistry*	*Estonian Academy of Sciences, Institute of Zoology and Botany, Vôrtsyärve Limnological Station*	• *250 /29* • *31 / ca 30*
Species & community composition: • *Plant communities* • *Plant species comp.* • *Birds* • *Macromammals* • *Micromammals* • *Invertebrates*	*Estonian Nature Conservation and Research Centre (ENCRC)*	• *under elaboration* • *under elaboration* • *UTM-grid /different* • *under elaboration* • *under elaboration* • *different*
Aerobiology	*Estonian Academy of Sciences (EAS)*	*1 station & 30 samplers* *1 param. & 35 objects*

Figure 3a *Integrated Monitoring Program (IMP)*

Monitoring Stations	*Responsible Institution*	*Projects*
Vilsandi Station	*Estonian Central Environmental Research Laboratory (ECERL)*	*16 projects*
Saare Station	*ECERL*	*21 projects*

Figure 3b *Physical-Chemical Monitoring Program (PCMP)*

Subprogram	*Responsible Institution*	*Stations / Parameters*
Groundwater	*Estonian Geological Survey Centre (EGSC)*	*ca 400 / ca 30*
Surface water: • *EMHI* • *Lake Pelpsz* • *Riverine Runoff* *Hydrochemistry of rivers*	*Estonian Environmental Information Centre (EEIC)* • *14/ ca 100* • *EMHI* • *Tallinn Technical University*	 • *74 / ca 5* • *58 /ca 30*
Marine water: • *Eutrofication* • *Harmful substances* • *Radiation*	*EMI* • *EMI* • *EMI* • *EMHI*	 • *63/23* • *ca 15 / ca 20* • *ca 20 / ca 50*
Coastal survey	*EGSC*	*8 / 6*
Air, aerosols and precipitation chemistry • *Bioindication*	*ECERL* • *Tallinn Botanical Garden*	*17/35* • *92 /10*
Radiation	*EMHI*	*19 /3*
Geochemical survey	*EGSC*	*ca 100/ca 80*
Seismic survey	*EGSC*	*2 / 5*
Pollution load control	*ECERL*	*ca 90*

Estonian State Monitoring System

(number of stations)

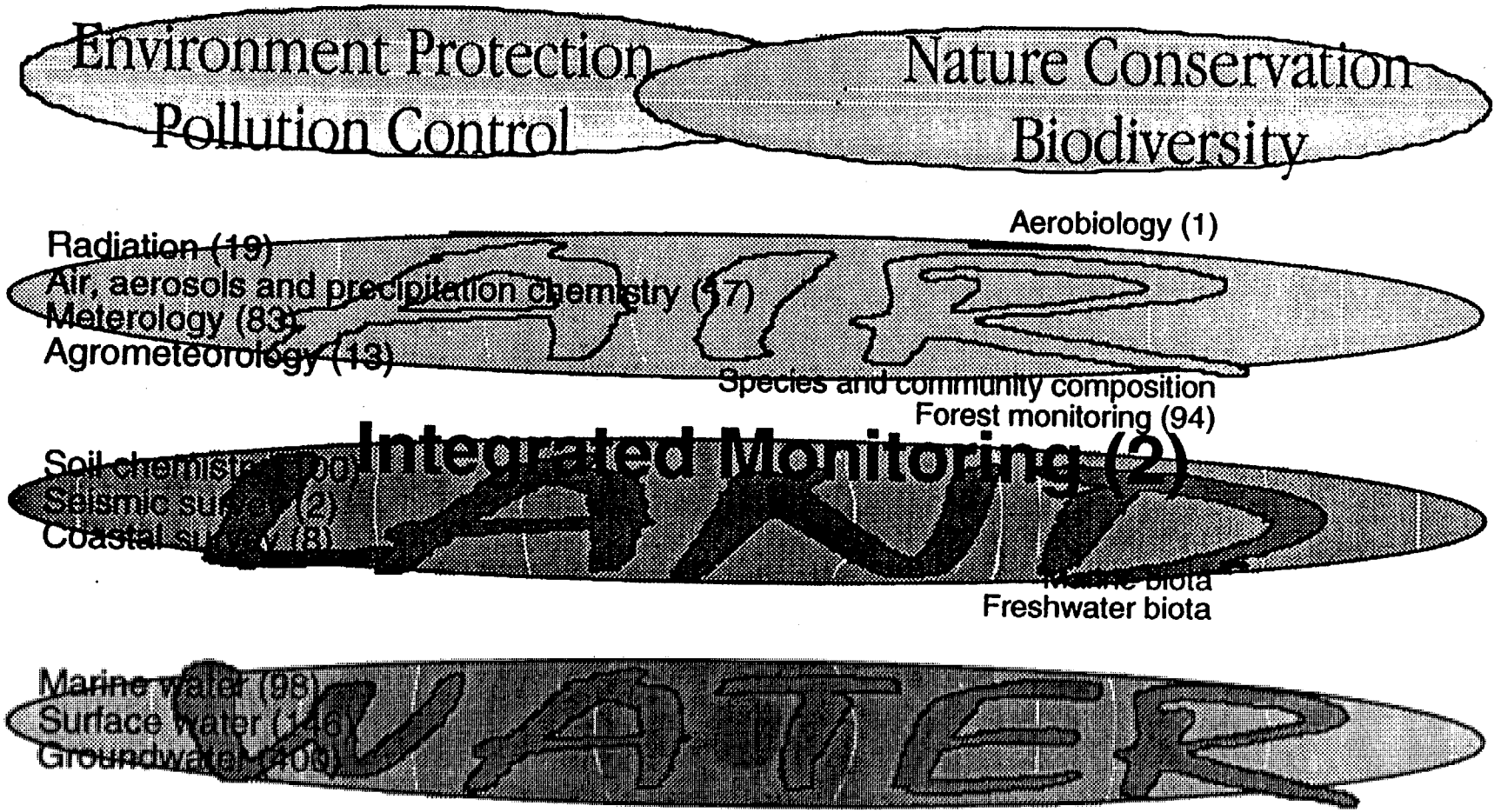


Figure 4

10

PART II - CURRENT STATUS AND RECOMMENDATIONS

Air

Background

The air monitoring network of Estonia was evaluated relative to its ability to provide a balanced coverage of the country. The expense connected with such monitoring programs seldom makes it possible to locate a sufficient number of monitoring stations to provide the data required to completely describe the air quality in an area or region. However, by carefully locating relatively few monitoring stations, adequate air quality data can be collected.

Estonia, because of its low level of industrialization compared to its European neighbors, emits minor amounts of sulfur dioxide and oxides of nitrogen. However, it has some major problem areas. These are primarily connected with industry and electric power generation (the Baltic and Estonian thermal generating stations, the Kunda cement plant and the oil-shale chemical industries in the northeast).

The aforementioned industries contribute more than 80% of the total measured loads of solids and toxic gasses entering the atmosphere over Estonia. Thus, they should be given priority when considering pollution abatement and amelioration. The industries need to be advised on the pertinent advanced technology available to curtail their emissions. Such emissions are known to be capable of causing serious effects on human health, including respiratory and skin diseases. Another pollution source of concern is that of automobile emissions in highly populated areas, especially Tallinn.

Following are observations about these pollution sources:

- Solids which are currently being monitored at three sites adjacent to the Kunda cement plant also contribute to the emission load and represent a potentially significant health hazard.

- The Baltic thermal generating plant is of fundamental concern to community health being situated 3 km southwest of Narva. The effects are magnified by the fact that the prevailing wind blows in a direction from the power plants to Narva. Narva has a stationary sampling site where oxides of sulfur and nitrogen are measured three times daily.

- There is a privately operated OPSIS system located at Kohtla-Jarve to monitor emissions from the oil-shale chemical industries. In addition to sulfur dioxide, this system measures a wide range of emission components including nitrogen dioxide, benzene, formaldehyde, phenols, toluene and styrene.

- Automobiles in Estonia are subject to no exhaust emission regulation. This is compounded by the fact that many of the vehicles are old and either have no emission

controls or they are non-functional (often disabled). Vehicular exhaust emissions are of particular concern in the larger cities particularly in Tallinn and Tartu. Currently, there appears to be insufficient data to estimate, with confidence, vehicular emission loads.

- A significant stationary pollutant source in Tallinn is the Iru thermal plant. There the emissions are of grave concern.

In Estonia the air monitoring network is a mixture of industrial sites and state run sites. When an industry is the obvious emission source, it is required to provide the funding for monitoring equipment. In cases where there is doubt, or the number of sources is large (as in Tallinn) the state has installed permanent monitoring sites. There are 19 state owned monitoring sites. Data from these sites is collected and analyzed by four laboratories. The collection of the samples and the analysis of the data are divided among four main laboratories. All sample results then go to the Estonian Environmental Research Laboratory (EERL) (See Table A1).

Industries are responsible for self monitoring. Industrial methods have not been standardized and consequently the data is of unknown quality. For example, the OPSIS long path measuring device is producing data. Unfortunately, this data is not usable by the Environmental Ministry.

A tour of Tallinn's three monitoring sites was given by Aare Sirendi, chemical engineer at EERL. The following observations were made:

- The Rahu site was observed to be equipped with aspirator type samplers. It was reported that this type of sampler is the norm for state-owned monitoring stations in Estonia. The monitoring staff expressed a distrust of the results obtained from this type of sampler, and indicated their desire to have more current technology.

- Concerns were also expressed with the quality of data obtained from particulate monitors. (These monitors were observed to be the old Soviet-style devices.) For example, particulate weights were coming back as negative when simple visual inspection indicated high levels of particlates. The Kunda cement plant purchased, and now uses, several high volume samplers. The EERL reports that the results with these new samplers are much improved, and wishes to expand use of this technology to other monitoring locations.

- The Majaka site has the only functioning meteorological equipment. Sulfur dioxide is being measured by a state-of-the-art continuous sampler manufactured by Thermo Environmental. Wind speed, wind direction, inside and outside temperature, and SO2 concentration in PPB are continuously updated and presented on a computer screen. Thirty minute averages are calculated and stored. This data is processed by the EERL.

- The Viru site CO, NOx, and SO2 are measured using electronic continuous monitoring analyzers. The data is collected by a data logger and then sent to Helsinki via a cellular phone. This data is processed daily in Finland and then returned to the EEIC. The monitoring specialists were generally pleased with the performance of these new analyzers but expressed concern that there are no repair parts. For example, a drift

problem reported in an SO2 analyzer may be due to a failing catalytic converter. This item must be changed periodically for the analyzer to operate properly. One of the sampling pumps is beginning to fail and will need to be replaced.

- Continuous analyzers require regular calibration checks as well as periodic maintenance and adjustments to confirm and maintain data reliability. The EERL has two Monitor Labs 8500 permeation tube calibrators with accompanying operation and repair manuals for the calibrators and analyzers. The instruments are being checked every two weeks, but, no written documentation was available to review.

- The Estonian thermal generating plant situated to the southwest of Narva has better removal facilities than the Baltic station farther north. It has emission treatment technology capable of removing 60% of the sulfur dioxide load.

Related Activities - Biomonitoring

The long tradition of using biological monitoring in connection with chemical and physical air pollution monitoring in Estonia has led to its gaining international recognition in this arena. Published work in this area goes back in the literature to as early as 1968 (H. Trass).

Currently active Estonian biomonitoring activities of significance that this team is aware of include the following:

- Bioindicational mapping -

  Estonian scientists have successfully used this technique in which they employ lichens, mosses, tree rings and other pollution-sensitive bioindicator species to develop pollution zonation maps. Such techniques can be of great value where employment of traditional monitoring technology may not be possible. In addition, it can serve as a preliminary source of information relative to identification of sites for new monitoring stations, problem areas, "hot spots," etc.

- Forest Monitoring -

  Forest health and condition monitoring via traditional inventory practices has been common in Estonia and throughout the region for decades. Recently more intensive monitoring activities have been introduced. For example, defoliation studies, integrated monitoring atmospheric deposition studies, and forest health monitoring are currently active projects that are generating valuable environmental monitoring data that is relevant to modern air and water monitoring programs.

- Especially worthy of note is the Baltic Forest Health Monitoring Project that Estonia participates in. It is clearly a project in which all the Baltic countries are working closely to meet common objectives. In this project the same techniques are applied, using the same instrumentation and data handling and processing procedures and the same QA plan. Furthermore, they use the same information management scheme which makes for

fully compatible data which is then being assembled and reported on for each country as well as the entire region.

Estonia's cooperation in and support for, biological monitoring activities is commendable and has paid dividends. Currently, these activities are somewhat fragmented and appear to be carried on, for the most part, outside the framework of the country's monitoring program.

Recommendations

Based upon the observation made and information gained in the process of evaluating the current status of Estonia's environmental monitoring program, the expert team offers the following recommendations:

- It is suggested that a continuous monitoring site be retained upwind of the Kunda cement plant and that the emissions be measured during the reconstruction and thereafter as a means of establishing a monitoring record of air quality in this location as industrial activity changes. Ongoing, simultaneous monitoring of precipitation would provide additional analytical support for developing a more reliable record of the long and short-term changes in the adjacent area.

- The major emissions sources are currently being monitored adequately in the northeast, relative to number and location of sites. However, technology upgrading is needed. Tallinn, the main population center however, should have monitoring sites and more monitors. These monitors should be continuous when possible and accessible in real time. This will make it possible to issue a report on the air quality in Tallinn as the conditions are changing.

- Tartu, the second largest population center, is also poorly covered. There should be at least one additional monitoring site in Tartu and instrumentation upgrading.

- In order to characterize transboundary transport and to establish a background baseline for future reference, at least three stations should be added. Estonian specialists have suggested one southern site near Valga, one in the southwest at Saarvejarve, and one in the northeast at Narva. These site locations were selected on the basis of geographic location and on availability of qualified site operators and on locations of existing sites.

- Estonia can be rightfully proud of the leading role it has played in the field of biological monitoring. If it is to continue to enjoy this enviable position, it will be necessary to bring at least some of these projects into the mainstream of its formal monitoring program. There is currently evidence of efforts to try to achieve incorporation of the findings from biomonitoring projects into the databases of the Environmental Information Center. Furthermore, in some cases it is evident that good communications exist between biomonitoring specialists and the Information Center. As Estonian monitoring work expands and develops, steps should be taken to ensure establishment of procedures that include biomonitoring into the formal monitoring program, where appropriate.

- Efforts should also be made to encourage close cooperation between parallel biomonitoring activities, such as the Forest Health Monitoring and the EC Forest Programs, without destroying their autonomy. Actions such as these will lead to realization of greater benefits from these complementary activities ensure a prominent role for Estonia in international monitoring programs and enhance opportunities for continued funding support from international sources.

- In view of existing uncertainties and the fluid condition of the emission picture in Estonia, ability to move monitoring sites is necessary. Mobile trailers or mobile mini labs, that are fully equipped, would best meet this need.

- Replace all existing wet chemistry technology for measuring SO_2, CO, and NO_x, and replace them with modern continuous analyzers.

- At all sites with continuous monitors, the installation of dataloggers and modems will be necessary. The purpose of the datalogger is to store all of the information coming from the continuous analyzers and properly formatting it. For example, it may be decided to calculate and store one hour averages. With this technology such information can be recovered over telecommunication channels or downloaded to a computer when the site operator visits the site.

- Purchase MET equipment for the Vilsandi site to complete the instrumentation package there. Also a data logger should be provided and connected to a telecommunications link to Tallinn. If no land lines are available to this remote island, cellular phones should be employed.

- In all major equipment purchases provisions should be made for five-year maintenance agreements, installation in the lab and pretraining for lab personnel.

- Continue to develop a quality assurance and control plan with central oversight. Prepare a standard operating procedures manual to ensure that everyone is using the same procedures. The QA plan should have provisions for worker training (and retraining) and certification, and for periodic audits by an expert team.

- Do continuous monitor calibrator calibrations at the (EERL) to ensure the quality of calibration transfer standards.

- Formalize a periodic QA review plan to ensure timely revision of QA standards document.

- When industry is required to monitor itself the QA administrator should examine and approve their methods and procedures. The same standards should be required of these labs as are required of state labs.

- Evaluate the operation of the new 24 hour high volume TSP samplers currently in use. If they are doing the job, purchase more to replace the old Soviet samplers that are not performing. If the HiVol samplers are not suitable, make inquiries of outside labs and see what they recommend.

- Buy four sets of MET gear. (Wind speed, wind direction, and temperature) to put at sites where this information is needed.

- Develop an industrial audit system to periodically check that industry is also following standard operating procedure.

- Continue to improve computer modeling to compliment and extend the information provided by air monitoring analyzers.

- Improve the emission inventory accuracy by starting a stack testing program to begin measuring actual pollution levels coming from smoke stacks.

- Establish a continuous monitoring network that is connected to a central location through a telecommunications link in order to provide immediate access to monitoring conditions as necessary, and to automate the collection of data through the use of data loggers and modems.

- Expand atmospheric deposition studies and lichen bioindication work.

- Promote efforts to adopt internationally accepted air monitoring standards. These standards should be adopted in consultation with those countries with whom information sharing is most important to Estonia and its Baltic neighbors.

- Promote and expand practice of sharing air monitoring data on a regional scale. This should be approached on several levels, however, immediate focus should be on the Baltic States, Nordic countries and Belarus, Poland and Russia.

- Expand or develop a system of information management of air monitoring information that effectively reports and communicates the vital information needed for policy makers and their constituents to make informed decisions relative to environmental policy.

Table A1 - Regional Laboratory locations and parameters measured

Lab/site	SO_2	NO_2	CO	TSP	O_3	PPT	WS	WD	AT	T	CH_2O	NO	H_2S	Phenols	NH_3	SO_4
EERL																
Kunda — 1				HV												
Kunda — 2				HV												
Kunda — 3				HV												
EMEP	C				C											
Viru	C	C	C	2 HV												
Rahu																
Maajukal	C						C	C	C	C						
Vilsandi	C	C			C	yes										
VERL																
Ahtme	W	W		FH									W	W	W	
Johvi	W	W									W					
Kivioli	W	W		FH							W		W	W		W
Kohtla — 1	W	W									W	W	W	W	W	
Narva — 1	W	W	B	FH							W					
Narva — 2	W	W	B	FH								W	W			
Narva — 3	W	W	B	FH												W
SEERL																
Tartu	W	W	C													
Tahkuse	W															
Saarjarve						yes										
PERL																
Parnu	W	W	W													

Key to Table:

SO_2	Sulfur Dioxide	WD	Wind Deviation	C	Continuous Analyzer
NO_2	Nitric Oxide	AT	Ambient Temperature	W	Wet Chemistry
CO	Carbon Monoxide	T	Temperature	B	Baloon Sampler
TSP	Total Suspended Particles	CH_2O	Formaldehyde	HV	High Volume Sampling
O_3	Ozone	NO	Nitrous Oxide	FH	Filter Holder (Total Suspended Particle Sampling)
PPT	Precipitation	H_2S	Hydrogen Sulfide	NH_3	Ammonia
WS	Wind Speed	Phenols		SO_4	Sulfate

Water

Background

Water quality in Estonia is well described in the publication "Water Pollution and Quality in Estonia" which was compiled by the Estonian Environmental Information Center and published in Finland by the Environmental Data Center. During the Soviet times the aquatic environment was continually degraded. More recently due to the downturn in the economy and hard work by the Estonians,pollutant loadings have decreased and water quality is improving.

Estonia has many small rivers. The Narva River in the northeast has a mean flow rate of 330 m^3 per second; an order of magnitude greater than all other rivers in Estonia. Many rivers in Estonia have average annual flow rates of less than 10 m^3 per second; in fact most have a flow rate of less than 5 m^3 per second. Consequently the rate of dilution of pollutants is extremely slow. The gradient of most rivers is shallow. The Mustoja, which flows into the Gulf of Finland has the biggest grade (3.5 m/km). It is significant to note that 67% of the river flow goes directly to the Baltic Sea (23% to Gulf of Finland, 44% to the Gulf of Riga). Thirty-three percent of the flow first goes into Lake Peipsi and the Narva River before entering the Gulf of Finland. As pointed out by several people, there is a lack of coordination between flow and chemical measurements. Consequently it is difficult to get precise estimates of loading to the Baltic Sea and Lake Pepsi. There is only a minor flow of water into Latvia and Russia.

The principle sources of pollution to Estonian water bodies are from industrial sources, non-point sources and domestic sewage. Due to the economy, industrial discharges have been significantly reduced, though there are still significant discharges from those industries still in operation. Of particular note is the oil shale industry in the northeast part of the country. In addition, the cement plant east of Tallinn has significant discharges. The use of fertilizer in the agricultural sector has also dropped dramatically. Consequently loading to the rivers from non-point sources has also dropped.

Most cities have combined industrial and domestic sewer systems with the majority of the discharges being inadequately treated. Some cities such as Tartu have no treatment and the discharges go directly to the river. Tartu is presently building a treatment plant with Swiss and German made equipment, so that when the plant comes on line state-of-the-art treatment will occur. Estonians have done a very commendable job of upgrading and improving many treatment plants. Many facilities are still in need of renovation.

The Institute of Zoology and Botany of the Estonian Academy of Sciences has conducted excellent hydrobiological surveys of the Estonian rivers. Sixty-one percent of 394 sections in 152 different rivers showed that 50 percent of these sections were hypereutrophic or eutrophic. This obviously indicates very high nutrient loading to the rivers. The BOD loading to rivers has decreased since the mid-1980's.

Estonia has over 1500 small lakes and reservoirs, most of which are shallow and very susceptible to eutrophication. With poorly treated or untreated sewage and non-point source runoff to rivers,

eutrophication is the most widespread problem facing Estonian lakes. Almost half of the lakes in Estonia are reported to be eutrophic or hypereutrophic. The effect of toxic organics on lakes is unknown. However, with most of the industry in the north and northeastern part of the country most of the toxic problems, if they occur, are expected to be in this region.

Surface Water Monitoring

The water monitoring program is based on the Estonian Environmental Research Laboratory (EERL), three main regional laboratories and Tallinn Technical University Laboratory, which was visited by the team, is better equipped than the regional laboratories and provides backup analysis for the more demanding parameters (such as heavy metals and organics), mainly on contract from the other laboratories.

The Environmental Institute of Tallinn Technical University leads the surface water monitoring system. It operates a sampling and analysis scheme for surface waters at Tallinn and the surrounding area. Samples for which methods or equipment are not available (heavy metals, oils, pesticides etc.) are forwarded to the Central Laboratory (EERL) for analysis.

The Tallinn Technical University group collects data on surface water monitoring from the regional laboratories at Tartu, Parnu and Johvi, and processes it before passing final results on to the Estonian Environmental Information Centre (EEIC). The University group also runs intercalibration exercises twice a year for the regional laboratories as a control on the quality of the data being produced.

The South Eastern Regional laboratory at Tartu is next in size and was also seen by the team, while the two smaller laboratories at Parnu and Johvi were not inspected.

An estimate of the relative size and throughout of samples in the laboratories in the system can be made from the approximate number of samples processed in a year:

Table W1 - Number of Water Samples Analyzed Annually

	Total Number	Surface H_2O	Air	Staff
EERL Tallinn	8,500	700	700	49
Tallinn Tech. Univ.	NA	126	NA	NA
Tartu	2,700	198	700	43
Parnu	1,200	60	400	6
Johvi	2,400	114	2,000	7

The reported numbers of samples at four of the laboratories includes other work, including effluent, soil and sediment analysis as well as the wet chemistry associated with air and precipitation monitoring, while the number for Tallinn Technical University only refers to samples for the surface water monitoring scheme. It does not appear that any background monitoring of surface waters is done by the number of smaller labs in the country which are mainly concerned with local effluent monitoring.

There is a core program of surface water monitoring covering the whole state of Estonia. There are 59 sampling stations in this scheme which are sampled from 6 to 12 times a year. Comparing this with the total number of water samples analyzed in the four laboratories for which figures are available, less than 10% of the throughput is directly due to the surface water monitoring program.

The network of sampling stations in this program is under review at the EEIC. The sampling stations have been chosen using local knowledge of the requirements at each point and form the basis of a working system. It is assumed that locally chosen sampling stations are correctly positioned for the moment, but it is possible that gaps in the data or changing needs may involve moving or adding further stations. All sampling stations are being coded by the EEIC according to several parameters including geographical coordinates and river mile.

Data on surface water from this monitoring program are used for several purposes which are defined as priorities of the Estonian monitoring system.

- Calculation of runoff of pollution loads into the sea or into the major lakes is done using a combination of river quality and flow data. This information is needed for, among other things, the HELCOM agreement. This may entail extra sampling at times of high river flow and combination of sampling with flow measurements to improve load estimation for some rivers and to bring more rivers into the estimation process.

- Reports on the overall state of the environment and changes in the background levels of nutrients and other parameters (such as metals and organics) are based on this data. It is then used for assessment of the effects of both point source and wider pollution.

- The acceptability of surface water streams as abstraction sources for drinking water is based on a range of chemical parameters. Results based upon ongoing analysis of rivers, and determination of compliance with Health Department regulations are in preparation. They will show which rivers can be considered suitable for water supply abstraction as needs arise in the future.

Methodology

Field methodology as described by Estonian experts and observed by team members were as routine and typical of those commonly used in monitoring programs in the US and Western Europe.

- Rivers are sampled by field sampling personnel who take grab samples of water and measure pH and dissolved oxygen on site.

Laboratory Methods

The team visited the Central Laboratory (EERL) and the South Estonian Regional Laboratory at Tartu. These are two of the main laboratories involved in environmental monitoring in Estonia and the comments below are based on these visits.

- Wet chemical methods are used for several parameters using colorimetry. This is labor intensive but is acceptable as long as throughput is adequate for the program and intercalibration results are good. Nutrient analysis could however be improved by the introduction of autoanalysis methodology as mentioned in the recommendations.

- Metal analysis at both the central EERL and Tartu laboratories is done with a modern Varian AA system, but these are only equipped for flame work (none have graphite furnaces).

- Ion chromatography is used to measure trace sulfate levels at the laboratories, both for rain water and air pollution. The instruments are modular in design with conductivity detection using electronic suppression. These are home-assembled from available components.

- Distilled water is deionized in both laboratories in locally made-up systems. These systems work to a certain degree but suffer from the fact that they are not free of metal components, causing difficulties for trace metal analysis.

- Existing GC facilities are a combination of older and modern equipment and are adequate for the monitoring of target compounds. The major problem appears to be oil spill detection and quantification in former military areas.

- High Performance Liquid Chromatography (HPLC) is used at the EERL to analyze for oil products and phenols. A modern HPLC system with UV detection is used for this work; but, it is not equipped with a fluorescence detection.

Hydrobiology

Biological monitoring of lakes is the responsibility of the Vôrtsjärv Limnological Station (hydrobiological sampling) with assistance from the South-Estonian Environmental Protection Laboratory. Two large lakes, (Lake Peipsi, Lake Vortsijarv) and twelve smaller lakes are routinely monitored. (Table W.1) A normal set of parameters is collected at each visit, and routine methods of analysis are used (Table W.2a and W.2b).

The Estonian Institute for Zoology and Botany is responsible for monitoring of streams. There are over 400 stream sites covering all significant Estonian rivers and streams. A selected number of stations are visited every year, with all 400 stations being visited on a rotating basis once every 5 years. The primary purpose of biological monitoring of the rivers is for trophic condition.

Table W2 - Lakes Monitored

Small Lakes	Large Lakes
Soodla reservoir	Peipsi
Viitna Pikkjärv	Vortsijarv
Uljaste	
Äntu Sinijärv	
Saadjärv	
Oisu	
Valguta Mustjärv	
Pühajärv	
Nohipalu Valgejärv	
Nohipalu Mustjärv	
Rôuge Suurjärv	
Väikejärv	

Table W3a - Hydrobiological Monitoring Lake Peipsi

Parameter	Frequency/location
Phytoplankton	4 times/year from 15 stations
Zooplankton	4 times/year from 15 stations
Bacterioplankton	4 times/year from 15 stations
Macrobenthos	once a year from 12 stations
Fish	during ice-free period once a month, total up to to 6 times/year in three regions
Samples are taken four times per year (in February or March; May or June; July or August; and in October) from 15 stations (points).	

Table W3b - Hydrobiological Monitoring Lake Vortsjarv

Parameter	Frequency/location
Phytoplankton	2 times/year (May and July) from the deepest point of the lake from 2-4 layers (horizons)
Zooplankton	12 times/year (from the whole column of water)
Bacterioplankton	12 times/year (from surface and benthos)
Zoobenthos	9 times/year from 2 stations
Samples are taken three times per year (in April, June, August) from 14 stations.	

Table W3c - Hydrobiological Monitoring - Small Lakes

Parameter	Frequency/location
Phytoplankton	2 times/yr (May & July) from the deepest point in lake from 2-4 layers (horizons)
Zooplankton	2 times/yr (May & July) from the deepest point in lake
Bacterioplankton	2 times/yr (May & July) from the deepest point in lake from 2-4 layers (horizons)
Zoobenthos	2 times/yr (May & July) from littoral (near shore)
Macrophytes	from 2 lakes out of 12 each year, covering all lakes with a 6-year cycle
Fish	from 4 lakes out of 12 each year, covering all lakes with a 3-year cycle

Table W4a - Sampling Methods

Parameter	Protocol
Phytoplankton	quantity samples taken with Ruttner batometer quality samples taken with conic silk net (screen No. 77)
Zooplankton	samples taken with Apstein zooplankton silk net (screen No. 49)
Bacterioplankton	samples taken with Frantser batometer
Zoobenthos	samples taken with Borutski or Zobolotski (225 cm^3) benthos scoop (shovel)

Table W4b - Laboratory Methods

Parameter	Protocol
Phytoplankton	species, biomass, chlorophyll a, b, c, and phaeopigments
Zooplankton	taxons, number of individuals, biomass, species variety, Index-E
Microbiology	total count, saprobbacteria, coli-index, BOD_7
Zoobenthos	species variety, dominant species
Fish	species composition, relative abundance of species and biomass, main components of predatory fish feed, growth rate and of roach and perch

Table W5 - River Water Parameters Measured

River width	depth
velocity	discharge
temperature	pH
dissolved oxygen	5 day BOD
Total P	PO_4 - P
Total N	$N0_3$ - N
$N0_2$ - N	NH_4 - N
Trophic Level	Nutrient limiting primary production
sediment type	Chlorophyll in water
Chlorophyll in sediment	Abundance of phytoplankton
Number of algae species	Dominant species
Bacteria general abundance	Saprophytic bacteria abundance
Abundance of saprophytes	Coliform index
Percent coverage by macrophytes	Macrophyte dominant species
Microphytobenthos biomass	Number of fish species
Dominant fish species	

Drinking Water Monitoring

Drinking water monitoring is the responsibility of the National Board for Health Protection. Samples are taken by Health personnel and tested for bacteriological and chemical parameters. All samples are tested by the Bacteriology laboratory while a subset of these are analyzed chemically. Chemical parameters are analyzed at the main laboratory of the National Centre for Health Protection in Tallinn and at a number of smaller laboratories throughout the country. The total number of samples analyzed per annum is in the region of 23,000. About half of these are analyzed for chemical parameters at the main laboratory and the other half at the smaller laboratories situated at local water supply facilities. Only the main laboratory has the equipment to analyze for metals and organics and this laboratory analyses about 50% of the chemical samples.

Most of the drinking water is from ground water sources with the exception of Tallinn and Parnu. In Tallinn slightly less than half of the supply comes from ground water and the remainder comes from Lake Ulemste.

Ground Water Monitoring

Estonia has been divided into 6 regions for the purposes of ground water monitoring. These are Tallinn, Ida-Viru County, Tartu, Pärnu, The Pandivere Heights, The West Estonian Archipelago, plus a partly overlapping regional network. The observation wells of the regional observation network lie in groups or profiles of wells and are scattered over the whole territory of Estonia in different lithological conditions. Monitoring is based on local needs and the proposed use of the water (See Tables W.6a & b for frequency and parameters measured). A substantial proportion of the ground water is used as industrial cooling water.

There is an extensive use of ground water as drinking water in Estonia and some problems exist with the content of natural minerals. Iron and heavy metals occur above current safe standards guidelines in some places, as does fluoride which can reach over 6mg/l in southwestern Estonia.

Table W6a - Observations & Number of Wells by Region

Location	Observed 5-10 times/mo	Observed 1-2 times/yr
Tallinn	113	37
Pandivere Heights	13	61
Ida-Viru County	149	108
Tartu	25	7
Parnu	12	20
West-Estonian Archipelago	12	29
Regional	50	34

Table W6b - Ground Water Parameters Measured

color	transparency	suspended solids	taste
smell	Na	K	NH_4
Ca	Mg	Fe	Cl
SO_4	NO_3	NO_2	CO_2
HCO_3	hardness	pH	SiO_2
oxygen demand	microcomponents	water isotopes	oil products
phenols	total aggressiveness	water flow	water temperature

Recommendations

Based upon the observation made and information gained in the process of evaluating the current status of Estonia's environmental monitoring program, the expert team offers its recommendations. These recommendations are made with the benefit of discussions and consultation with Ministry representatives.

The recommendations are subdivided into areas of QA, Sites, Sampling and Other.

- Quality Assurance

  Continue to expand and improve the QA system in current use. The medium term objective should be laboratory accreditation of at least the EERL to international standards.

  Other improvements to the system include practices such as the duplication of stream sampling on occasions to assess on-site variations while sampling rivers.

  Periodic audits of QA records should be undertaken by an independent body.

  Formal training for staff in QA procedures should be provided where appropriate.

  The continuation of the ongoing participation in international intecalibration tests is recommended.

  Continue or increase use of standard reference materials, particularly for metals and organics analysis.

  Prepare a standardized list of approved methods for Estonia.

  Prepare a quality assurance program document with provision for an annual update.

  The instruments used for field measurement of pH and dissolved oxygen should be pH meter.

  Provide sampling personnel with reliable vehicles in order to ensure that samples get back to the laboratories for analysis on time and without danger of deterioration. This is a quality assurance factor which should not be overlooked.

- Sites

  Continue the ongoing review of monitoring sites and consider the need for relocation of some sites and/or the inclusion of new sites.

  The coding of sites is in progress and additions to this should provide for small movements of sites without confusing the data interpretation process.

  Continue to assess the suitability of the data produced from each site to achieve the stated program objectives.

  Utilize the new equipment to expand the database by increasing the number of sites to improve the database.

- Sampling

  Consider simultaneous water quality sampling and flow measurement to improve the reliability of the calculation of, for example, loads to the Baltic Sea under the HELCOM agreement.

  Develop a national hydrobiological program for lakes based on the excellent stream program that rotates on a five-year cycle to include all lakes.

  Dispersion of wastewater into receiving waters necessitates cross-sectional studies to establish the extent of the mixing zone and ensure that downstream samples are homogeneous and representative of the water body in the adjacent area.

  Where possible samples should be collected upstream from an incoming probable pollutant source to establish a baseline study or changes in quality.

  Rivers should be sampled at points of confluence with their tributaries to ascertain whether chemical or biological changes downstream of the mixing zone are due to the effects of inflowing lithogeneous materials or related to anthropogenic pollution.

  Sampling frequency and location both depend to great extent on the reason or reasons for sampling. Seasonal samples may be sufficient for determining the quality of recreational waters but sampling points should reflect the water quality of the recreational zone in the case of swimming waters and the frequency should be intensified during the swimming period.

It may be necessary to take hourly or composite samples to accurately evaluate varying waste loads or measure the effects of intermittent discharges. Raw waters to be abstracted for drinking or treated drinking waters need to be sampled frequently if they are susceptible to rapid change.

The accurate evaluation of drinking water quality necessitates systematic sampling for a range of physical, chemical and bacteriological characteristics throughout the distribution system and water quality changes need to be monitored to evaluate long- and short-term trends.

The Environmental Information Centre in Tallinn has prepared a comprehensive river water sampling station code that allows sites to be accurately identified in terms of geographical coordinates and the national grid. The code allows samples to be sorted according to river name, sampling station, location and sampling personnel. It has been formulated for the efficient compilation and dissemination of environmental information. This practice should be continued and expanded. For example, GPS technology should be employed to precisely locate the coordinates for monitoring sites.

- Other

  Continue current participation in international ring tests

  Continue or increase use of standard reference materials

  Prepare a standardized list of approved methods for Estonia

  Prepare a quality assurance program document with provision for annual review and updating.

Information Management

Background

The Environmental Information Center has responsibility for management of environmental monitoring data for the Estonian Ministry of Environment. It is staffed with approximately thirty employees. Key staff include Director Leo Saare, and Ott Roots, Monitoring Councilor. Support staff include hardware and software experts and GIS database management specialists. Their GIS system is PC based on 486 computer technology. They also have a digitizer, printers and plotters. The central office is located in cramped offices on the outskirts of Tallinn. It is on a LAN; however, it does not yet have Internet connectivity. In the absence of a workstation data management activities are being carried out on PCs.

Considerable evidence exists suggesting that the center staff is highly competent and very productive. Data received from monitoring stations around the country are being catalogued, archived and organized into interpretative reports and publications. Many of the latter are being

printed in English as well as Estonian which enhances their usefulness regionally and internationally.

Recommendations

Information management is a vital component in any environmental monitoring program. It represents the link between generation of technical data and the presentation of useful information to the client (managers, policy makers and the general public). In order to meets its information management responsibilities, an information management center must have a highly trained staff, suitable hardware and software and adequate physical facilities, including space, hardware and software. Especially important is the ability to communicate electronically over a local area network and over the Internet. Thus it is recommended that the Estonian Environmental Information Center be upgraded in such ways that it can achieve the following goals:

- become a state of the art *ENVIRONMENTAL INFORMATION MANAGEMENT / GIS CENTER* in Estonia;

- achieve an enhanced level of economic and performance efficiency that will permit rapid generation of technically accurate, easily understood information about status and trends in the environment that all citizens are entitled to;

- meet the combined information management needs of the Estonian Ministry of Environment, and other Ministries and organizations (such as the Ministry of health's drinking water monitoring program, Academy of Sciences Institutes, and Universities), as well as numerous externally funded environmental projects;

- serve as an information management center *PROTOTYPE* for the Baltic countries, as well as other NIS neighbors, and, in some cases, provide regional services;

- develop a level of visibility for this center that will lead to supplemental funding from a variety of other sources (short-term and long-term).

In order to achieve the above suggested goals a considerable funding outlay will be required for facility improvements, (or preferably relocation to larger, more modern, central office complex; hardware acquisition), software, and training.

Such a Center should function as a central hub, having provisions to serve a number of PC-based satellite facilities linked to the Center via Internet or the Center's Ethernet LAN. Such links would be local, national and international. The current staff and computer facilities of the EEIC would be utilized and upgraded as necessary. For example, the Center's current PC/ARC Info system would be upgraded to a UNIX workstation platform; additional GIS support hardware and software would be supplied; additional technical and non-technical staff would be added; and

additional space needs would have to be satisfied. Additional hardware and software would be added only when resources (for training, etc.) were demonstrated to be adequate to support them once in place.

The funding required for expanding the existing Estonian Environmental Information Center to the level recommended above should be accomplished via a cooperative effort. This effort can incorporates the combined existing resources (national and international) currently committed to information management with new sources of international support (See appendix) information management center proposal.

Landscape Monitoring

Background

The accelerating increase in changes in practices and policies relative to land use make it imperative that Estonia improve its ability to monitor its landscape. Land reform measures, changes in agriculture and forestry, and the rapid influx of commercial interests from the West, are all contributing to shifts in land use that have potential for major impacts on the human population as well as the natural systems of the country. A landscape monitoring program could utilize a GIS database to integrate existing statistics with aerial photographs, and satellite images. The information generated in such a system could demonstrate graphically historical trends of the last decade (as existing data permit) and well as provide the baseline information for reporting trends in future years.

The EEIC recognizes the importance of landscape monitoring and has already begun limited efforts, utilizing satellite images. Currently, they have insufficient image frames, their GIS hardware and software are insufficient, and they need external experts with whom they can collaborate.

Recommendations

The EEIC needs additional resources, including personnel, hardware, software, aerial and satellite images, and training, in order to develop a meaningful landscape monitoring program. This is a need that they recognize and have supported within the limitations of their resources. Its expansion depends to a large degree on development of Estonia's information management capabilities that are refereed to elsewhere in this report. If those needs are met, the only major additional needs for landscape monitoring would be acquisition of additional imagery and training.

Estonian Center of Excellence

Background

It is the wish of the Estonian Ministry to establish some component of its monitoring program which can enjoy international recognition for its outstanding quality. It is envisioned that Estonia would call upon its most outstanding experts to work cooperatively in forming such a center and that it would offer its services and expertise regionally and internationally. Since Estonia already enjoys an international reputation for its outstanding work in selected areas of biological monitoring, it is no surprise that they would choose biological monitoring as the area of expertise that they would like to elevate to world class quality.

Following is a quote from staff at the EEIC:
"Bioindication is the method of environmental monitoring where Estonia can contribute to international environmental monitoring community. Having the decades of experience in academic research, Estonia is currently adopting the bioindication methodology in the National Environmental Monitoring Program (EMP). The named methods are incorporated in the following subprograms of EMP:

- Air, aerosols and precipitation (lichenoindication);
- Marine biota;
- Lake hydrobiology;
- River hydrobiology;
- Forest monitoring;

Integration, analyses and presentation of the data, collected by listed EMP subprograms is carried out in the geographic information systems (GIS). This allows linking the bioindication data to other themes of environmental data and remotely sensed imagery."

Recommendations

Estonia does clearly have considerable expertise in this arena. If it is truly committed to an international program, there are numerous other specialist in surrounding countries who would likely cherish opportunities to cycle in and out of the center if it offered opportunities for expert collaboration with peers in a highly specialized facility. This combined with the potential for a leadership role in information management system development, where leadership is desperately needed in neighboring countries to the East, could allow Estonia to play a central role in cooperative monitoring efforts in the region. It is conceivable that the Nordic countries would promote and support establishment of a center which could serve their needs also. Such an approach is highly recommended and would be especially effective if neighboring countries would use the same approach (provided they did not duplicate each others efforts). Pursuit of such an approach on a regional basis could contribute immensely to the overall quality of the monitoring efforts, while yielding substantial economic savings.

To accomplish the Estonian goals in this area little additional funding would be required beyond that already being recommended at priority level four in the air and water categories. The goal is

certainly deemed worthy of support; however, it is deemed beyond the scope of the expert team's role to expand further on this interesting idea.

PART III - EQUIPMENT REQUIRED

In order to address the recommendations itemized in previous sections of this report, a major commitment of resources will be necessary. Equipment items needed are itemized and prioritized according to the team's assessment of the degree of need. It is very important to note that concomitant with the equipment purchase, there must be provisions made to provide supplies, maintenance and training.

Also to be addressed are needs for physical facility modifications. These modifications are necessary in order to:

- accommodate special equipment requirements, such as proper ventilation and high purity water;
- satisfy health and safety requirements, such as eye wash stations and emergency showers;
- security measures, such as alarm systems

Air

1. Background Stations (4)
   It is desirable to equip these stations with continuous analyses to measure concentrations of NO_x, SO_x, O_3, and to make basic meteorological measurements. Wind speed and direction indicators incorporated into these stations provide useful information on transport, transfer and fluctuations in air pollution parameters.

2. Urban Stations (4)
   It is desirable to have additional urban monitoring stations which have the capacity to monitor NO_x, SO_x, O_3, NH_4, CO, HF, and basic meteorology parameters in order to have a more complete picture of the pollution problems in these locations.

3. Mobile Station (1)
   A mobile station that can measure NO_x, SO_x, O_3, NH_4, CO, and HF would be valuable for use in locations where there is inadequate information to justify establishing a permanent station. Mobile monitoring capability also permits responses to emergencies and the evaluation of temporary "hot spots."

4. Portable GC for measuring organics (1)
   This instrument is necessary to monitor changes in emissions concentrations of trace organic constituents during technological improvements at industrial sites. This instrument should be fitted with a flame-ionization detector (FID) or a photo-ionization detector (PID).

5. Computer software for modeling (1 set)

Computer models that can be used to predict the effect of point sources on local surroundings are needed. In order to utilize such models; however, information of stack velocity, temperature and emissions are necessary. Thus other items in this list will need to be provided also, if this software is to be useful.

6. Laboratory balances (4)
   A high quality analytical balance is required in each laboratory where weighing of particulate collecting filters takes place.

7. pH meters (4)
   Compilation of accurate records of variations in the acidity and alkalinity of precipitation and wet deposition samples necessitates the availability of a research grade pH meters.

8. Particulate samplers for EMEP (2)
   These inexpensive equipment items are required to satisfy sampling requirements of the two EMEP stations in Estonia.

9. Dilution calibrator with GPT (1)
   Routine evaluation of calibration necessitates the use of a dilution calibrator with GPT (gas phase titration). This facility enables verification of the quality of the NO_x and O_3 calibration gasses and can also be used for SO_2 gas dilution.

10. Data loggers with modems (10)
    The efficient transfer of data from instruments is best achieved by the incorporation of modems where telecommunications systems are dependable; or, alternatively dataloggers can be employed, which permit local personnel to download from the data logger to laptop computers.

11. Laptop computers (16)
    Portable computers are needed to download data from data loggers and numerous other similar tasks will be found for these tools.

12. Calibration gases (4 sets)
    A set of calibration gases housed at a central location is necessary for the calibration of monitoring instruments. Regular checks are essential to ensure that the date is reliable. Several sets of gases are desirable in order to make calibration more convenient, and thus more likely to be done on a regular and frequent basis.

13. High volume TSP samplers for high particle areas (10)
    The three monitoring sites in Tallinn, in addition to incorporating the recommended meteorological instruments and continuous analyzers, should be capable of making measurements of total suspended particulates (TSP) and lead. There are two identifiable lead sources in the city of Tallinn, a mobile source as a result of auto exhaust emissions and a stationary source as a result of thermal fly-ash. As vehicle numbers are steadily increasing, particularly in Tallinn and Tartu, there is a necessity to provide data showing

long- and short-term changes in air pollutants in these areas. Ideally it would be desirable to provide facilities capable of monitoring in compliance with EC 24 hr lead limits.

14. Flu gas analyzer (1)
    This item should be capable of analysis for SO_2, NO_x, CO, temperature and flow.
    Stack testing that this instrument is capable of will permit monitoring personnel to routinely check on data reported by local industry. In addition it will serve as a means of checking on the current system of estimating emissions from fuel combustion product calculations.

15. NO_x monitor (1)
    Add an NO_x monitor at Lahemaa to meet EMEP monitoring requirements.

16. MET instruments (1 set)
    Add basic meteorological monitoring instrumentation at Vilsandi to meet EMEP monitoring requirements.

17. Equipment needs related items
    a. Supplies and expendables
    b. Five-year preventative maintenance agreement for all new equipment including installation and training.
    c. Provisions for installation and pre-training for all major equipment acquisitions.

Water

1. Atomic absorption analysis systems (4)
   Trace analysis of metals is needed for environmental background monitoring as well as for drinking water analysis both before abstraction and after treatment. This equipment should be provided with an autosampler to increase precision of measurements and allow unattended runs of samples. In addition the following two items will be required for proper and safe operation of the AA system:

   Milli-Q systems (7)
   Water of high purity is required for metals analysis which involves detection at low concentrations. Laboratories in Estonia currently do not have the capacity to supply such high purity water.

   Vents for AA (4)
   Suitable venting systems are an absolute necessity for the safe operation of AA's. Purchase of AA systems should be made if and only if provisions are made for proper venting.

2. Field sampling vans (5)
   The operation of a field monitoring scheme is dependent on a good transport on the ground. Each of the four laboratories involved in sampling should have proper vehicles for this purpose. Without reliable transportation, safe transport and timely collection of samples are likely to be compromised.

3. HPLC systems (4)
   The problems of oil pollution of ground water combined with the reported high levels of PAH from the burning of oil shale necessitate the monitoring of polynuclear aromatic hydrocarbons (PAH) in water down to the accepted levels in surface and drinking water. The permitted level of PAH in the EU water Directives is 200ng/l and this level can only be monitored by HPLC with fluorescence detection, after first concentrating the sample.

4. GC/MS (1)

The unknown nature of the pollution caused by former military bases and other point sources in Estonia means that the risks to health are unknown and it is recommended that a survey of organic pollutants be undertaken.

5. Autoanalyser systems (2)
   The automation of methodology for nutrient analysis will allow an increased throughput of samples with a greater precision than before and will contribute to QA operations leading to better data quality.

6. pH meters (9)
   These are replacements for existing meters.

7. Conductivity meters (8)

These are replacements for existing older instruments.

8. Digestion systems (2)
   Desirable for sample preparation of metals in soils and sediments. Microwave digestion systems are preferred because they conserve expensive reagents.

9. UV spectrophotometer (2)
   This upgrades current equipment.

10. TOC analyzer (1)
    This instrument will serve monitoring needs, such as for effluent monitoring, as well as for research purposes for the Environmental Institute at Tallinn Technical University.

11. GPS systems (6)
    GPS is needed for field work to properly locate field sampling sites for both air and water monitoring.

12. Ion chromatograph (2)
    To be used in quantitating sulfate in rain water for the EMEP programmed and for air pollution traps.

13. D.O. meters (8)
    To be used to replace existing systems made in Estonia.

14. Hach
    colorimeter (5)
    digesters (3)
    Replaces current colorimeters which are not be suitable for effluent measurements intended to meet EU or other international standards.

15. Fume Hoods (6)
    In the interest of health and safety, proper ventilation is necessary for using many of the reagents called for in the technologies recommended above.

16. Bacteriology laboratory needs
    Filtration units (18)
    Incubators (4)
    Sterilizing Units (4)
    PC's (2)
    Drying Oven (4)
    Shaking Water Bath (4)

17. Other Equipment Related Needs
    - Consumable supplies
      The increased costs of more modern equipment will necessitate the provision of a considerable support to general laboratory supplies in the system. This should include

provisions of the considerable supply needs of the microbiology laboratories for water testing in the Ministry of Health.

- Five-year preventative maintenance agreements on all major equipment acquisitions.

- Provisions for manufacturer installation and pre-training on all major equipment acquisitions.

Information Management

See page 33.

Landscape Monitoring

See page 34.

All Areas

See page 34.

Part IV - Equipment Needs Priorities

Air

Item	Priority (1=Highest) 1	2	3	4
1. Automatic background stations (for NO_x, SO_x, O_3, NH_4, CO, HF, & basic meteorology)	0	4	0	0
2. Urban stations* (for NO_x, SO_x, O_3, NH_4, CO, & HF)	3	1	0	0
3. Mobile monitoring station (for NO_x, SO_2, O_3, NH_4, CO, HF)	0	0	1	0
4. Portable GC for measuring organics	0	1	0	0
5. Computer software for modeling†††	1	0	0	0
6. Laboratory balances	1	2	1	0
7. pH meters	2	1	1	0
8. Particulate samplers for EMEP	2	0	0	0
9. Dilution calibrator with GPT	1	0	0	0
10. Data loggers with modems	10	0	0	0
11. Laptop computers	4	4	4	4
12. Calibration gases (sets)	2	2	0	0
13. High volume TSP samplers (for high particle areas)	2	4	4	0
14. Flu gas analyzer*	1	0	0	0
15. NO_x monitor (Lahemaa)	0	1	0	0
16. MET station (Vilsandi)	0	1	0	0
17. Related items				
Supplies and expendables	x			
Preventative maintenance agreements	x			
Installation and pre-training provisions	x			

- The flu gas analyzer and at least two urban stations are believed to deserve the highest priority if resources are extremely limited.

† Items for Health Ministry Water Testing
†† Items for Academy of Sciences Biomonitoring
††† Many of these are available from the US EPA at no charge.

Water

Item	Priority (1=Highest) 1	2	3	4
1. Atomic absorption analysis systems*	1 (1)†	0	1	(1)††
Milli-Q systems (purify water for metals analysis)	1 (1)†	1	3	(1)††
Vents for AA	1 (1)†	0	1	(1)††
2. Field sampling vans	3	0	2	0
3. HPLC systems*	1 (1)†	0	1	(1)††
4. GC/MS	0	0	1	0
5. Autoanalyser systems	1	0	1	0
6. pH meters	2	3	3	(1)††
7. Conductivity meters	0	0	8	0
8. Digestion systems	2	0	0	0
9. UV spectrophotometers	0	0	2	0
10. TOC analyzers	0	0	1	0
11. GPS systems	2	2	1	(1)††
12. Ion chromatographs	1	1	0	0
13. D.O. meters	0	4	4	0
14. Hach				
Colorimeters	2	0	3	0
Digesters	0	0	3	0
15. Fume hoods	4 (1)†	0	0	(1)††
16. Bacteriology laboratory needs				
Filtration units*	(18)†	0	0	0
Incubators	(2)†	(2)†	0	0
Sterilizing units	(1)†	0	(1)†	2
PC's	(2)†	0	0	0
Drying ovens	(2)†	(1)†	(1)†	0
Shaking water baths	(1)†	(1)†	2	0
17. Related items				
Consumable supplies	x			
Preventative maintenance agreements	x			
Installation and pre-training provisions	x			

* The filtration units, at least one AA, one HPLC, and two sampling vans are believed to deserve the highest priority if resources are extremely limited.

† Items for Health Ministry Water Testing
†† Items for Academy of Sciences Biomonitoring
††† Many of these are available from the US EPA at no charge.

Information Management

Item	Priority (1=Highest) 1	2	3	4
1. Computer Workstations				
PC's	2	0	0	0
Server	2	0	0	0
2. Other computer hardware				
Large format printer	1	0	0	0
Digitizer	1	0	0	0
Plotter	1	0	0	0
Modems	20	0	0	0
LAN hardware (set)	1	0	0	0
3. Software				
GIS, SAS, Oracle, LAN, word processing, presentation, etc.	x			

Landscape Monitoring

Item	Priority (1=Highest) 1	2	3	4
1. Satellite image frame (sets)	0	1	1	1
2. Software for processing	0	1	1	1

All Areas

Item	Priority (1=Highest) 1	2	3	4
1. Capital improvements				
Modifications required to meet QA needs	x			
Modifications required to accommodate Health & Safety needs	x			
Modifications required to accommodate Security needs (i.e. alarm systems)	x			

† Items for Health Ministry Water Testing
†† Items for Academy of Sciences Biomonitoring
††† Many of these are available from the US EPA at no charge.

U.S. GOVERNMENT PRINTING OFFICE: 1995—647-696

United States
Environmental Protection
Agency

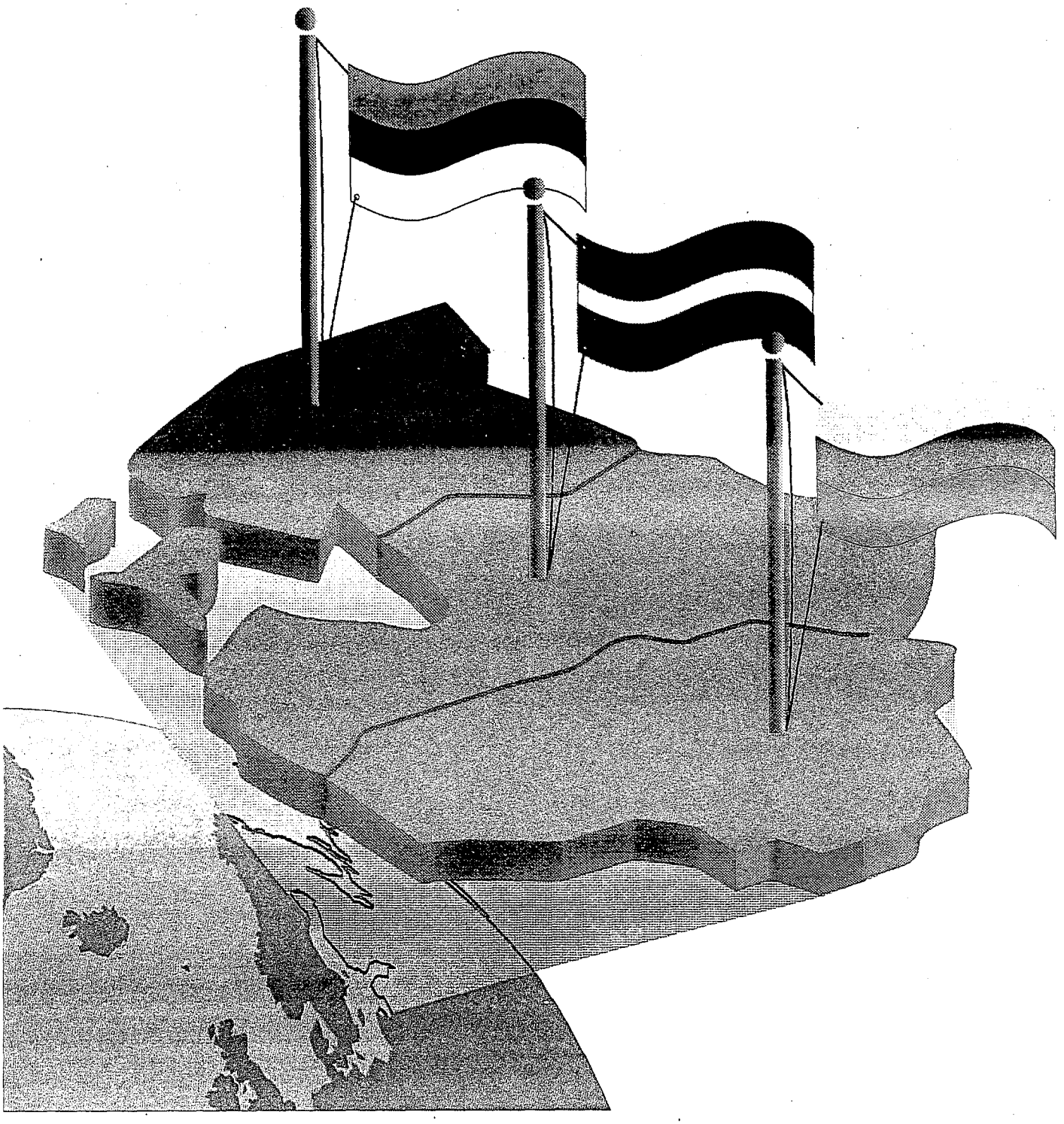
State of Illinois
Environmental Protection
Agency

Vol. 2
Appendices

EPA

Baltic Republics Environmental Monitoring Review Project

Findings and Recommendations



43

CONTENTS

Section 1	Design of Networks for Monitoring Water Quality
Section 2:	Field Guide for Environmental Sampling
Section 3:	Illinois Ambient Water Quality Monitoring Network Parameters
Section 4:	Effluent Biomonitoring and Toxicity Assessment
Section 5:	A Biological and Water Quality Survey of Sugar Creek and Tributaries
Section 6:	Hazardous Waste Transportation Office of Chemical Safety 1993 Annual Report
Section 7:	Outline for the Development of a Groundwater Monitoring Program
Section 8:	ASTM Standard Practice for Generation of Environmental Data Related to Waste Management Activities

Note: The material provided in this Appendix is intended to illustrate and provide supporting examples to recommendations and comments provided in Volume 1 of the Report. It is based on current practices used by Illinois EPA practices and is hoped to be of assistance in revising and strengthening similar programs in the Baltic Countries. The Editors.

SECTION 1

DESIGN OF NETWORKS FOR MONITORING WATER QUALITY

by

Thomas G. Sanders
Robert C. Ward
Jim C. Loftis
Timothy D. Steele
Donald D. Adrian
Vujica Yevjevich

WATER RESOURCES PUBLICATIONS

140

For information and correspondence:

WATER RESOURCES PUBLICATIONS
P.O. Box 2841
Littleton, Colorado 80161, U.S.A.

DESIGN OF NETWORKS FOR MONITORING WATER QUALITY

by

Thomas G. Sanders
Robert C. Ward
Jim C. Loftis
Timothy D. Steele
Donald D. Adrian
Vujica Yevjevich

IBSN 0-918334-51-9

U.S. Library of Congress Catalog Card Number 83-061028

Copyright © 1983 by Water Resources Publications. All rights reserved. Printed in the United States of America. The text of this publication may not be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, without a written permission from the Publisher.

This publication is printed and bound by BookCrafters, Inc., Chelsea, Michigan, U.S.A.

47

CHAPTER 4

LOC TION OF WATER QUALITY MONITORING STATIONS

The location of a permanent sampling station is probably the most critical design factor in a monitoring network which collects water quality data. If the samples collected are not representative of the water mass, the frequency of sampling as well as the mode of data interpretation and presentation becomes inconsequential. Nevertheless, criteria to establish station locations for representative sampling have received relatively little attention from both state and federal agencies responsible for the collection and dissemination of water quality data. Quite understandably the factors which influence the selection of stream sampling station locations are different from those which influence the selection of groundwater monitoring stations. The dominant space coordinate of a stream is its length, with its width and depth playing a lesser role in water quality variation. By contrast groundwater flow is not visible, its course is poorly predictable and it is difficult to specify a priori a dominant space coordinate. The contrast in the cost of establishing a new stream water quality monitoring station (Adrian et al., 1980) as opposed to a new groundwater quality station has led to a reliance on mathematical modeling in groundwater quality monitoring as an aid in interpreting and interpolating results. Development of a groundwater monitoring network may be in response to a desire to obtain information about a large area such as a portion of a state or an entire aquifer, or it may be in response to a specific localized problem such as the need to monitor groundwater quality near a sanitary landfill. The monitoring network cost is likely to encourage the incorporation of pre-existing wells into a regional network, whereas the monitoring network developed in response to a localized problem is likely to require installation of additional wells designed specifically for monitoring. The approaches used in locating stream monitoring stations and groundwater quality monitoring stations are sufficiently distinct to justify discussing them separately. In this chapter the principles applicable to river water quality monitoring station location will be discussed first; the latter third of the chapter will discuss the principles applicable to groundwater quality monitoring station location.

INTRODUCTION TO RIVER QUALITY MONITORING STATION LOCATION

There are three levels of design criteria in the discussion of river sampling station location which are considered. They are: the macrolocation--river reaches which will be sampled within the river basin; the microlocation--station location relative to outfalls or other unique features within a river reach; and representative locations--points in

BEST AVAILABLE COPY

the river's cross section from which samples will provide a lateral profile of the stream. The microlocation is essentially a river reach assigned a sampling station which draws samples from the river's transect, while the designation of a microlocation remains site specific, i.e., a transect would be selected following examination of specific characteristics of the macrolocation. The macrolocation is specified systematically so elements of personal bias are largely removed from the selection. The utility of data collected from a water quality network will be largely dependent upon the consideration given to each level in the planning of the data collection network. The macrolocation will be a function of the specific objectives of the sampling agency while the microlocation, which defines a zone of complete mixing, is a function of the hydraulic and mixing characteristics of the stream.

Development of a river basin monitoring network may be thought to include four steps: 1) selection of a river reach to sample, 2) identification of a specific station or transect within the reach, 3) specification of the sampling points within each transect, and 4) determination of a sampling frequency which will detect water quality trends. This chapter addresses the first three of these: selection of a reach of river, a transect at which to sample, and the sampling points within the transect. The fourth, sampling frequency, is addressed in Chapter 5.

Basis for River Quality Sampling Station Allocations

Location of sampling stations is closely tied to the number of station locations available which, in turn, is often a function of the number of samples to be taken at each station. Thus, prior to a detailed evaluation of sampling station location, the general sampling frequency ranges and the total number of stations available needs to be determined. These should not be too difficult to estimate if the purpose of the network is well defined, and the budget and sampling costs are known.

If the water quality monitoring network covers a political jurisdiction (e.g., a state), some allocation of monitoring resources must be made between the different basins being managed. If the network has two or more objectives, allocations must be made between the objectives. A measure of monitoring resources is the number of stations (combined with average number of samples to be collected at the stations). Thus, in allocating resources between basins and/or objectives, deciding how many stations (and samples) to give to a basin or objective is a major first step.

How can this allocation be achieved in a logical or rational way? Again, the purpose of monitoring must play a major role.

Allocation by Objective

Allocation between objectives can be achieved by determining the emphasis the decision makers place on the different objectives. If an agency has two monitoring objectives (e.g., determine water quality trends and detect streams in violation of their standards), then the policymakers can be questioned (e.g. by a questionnaire) to determine their opinion as to how much of the monitoring resources should be allocated to each objective (Ward, 1973).

An even more concrete expression of emphasis on objectives is the budget allocations among activities within an agency. Sixty percent of a budget going to enforcement related activities indicates a quantitative commitment to the detection of streams in violation of standards. Such a determination injects the network designer much further up and into organizational purposes and activities. The information obtained by such examinations of purpose, however, enhances the basis for designing a network.

Once the objectives are determined, the monitoring resources (samples and, thus, stations) can be divided. Returning to the above example to illustrate, stations allocated to detect trends can generally be assigned fewer samples than stations allocated to detect streams in violation of their standards. Stations designed to detect standard violations will detect trends, but those detecting trends will not necessarily be able to detect stream standard violations very well if they have fewer samples (GAO, 1981).

If stations are to receive different levels of samples for different objectives, this implies, in the case of our example, two "networks." One, perhaps referred to as the primary network, collects information on standards violations and trends while the other, the secondary network, collects information on trends only. An example of this approach is in Ward (1973).

A network can often be designed from a location point of view, sample allocations being made to the stations prior to determination of whether a station is primary, secondary, or whatever division is used. On the other hand, certain areas can be designated as primary station areas and others as secondary station areas, depending upon the projected water quality problems in the different areas. These projections can be based on factors which may include historical water quality data, water use priorities, flows, population, industrial concentration, and agricultural operations.

The major point of the above discussion is that monitoring objectives must be defined if a rational basis for allocating stations (resources) to an objective is to be made. If the network has one objective, the problem is simplified, but this is rarely the case.

BEST AVAILABLE COPY

As alluded to above, different areas of an agency's jurisdiction may be classified as more important than others based on potential water quality management problems. Such a classification may be a basis for allocating monitoring resources. A basin that has little population and development would probably not need an extensive amount of monitoring. On the other hand, a basin with a large population and high industrial activity would probably need a more extensive water quality management program and, therefore, more monitoring than the undeveloped basin.

Differences in basins can be quantified via an index approach. A management need index could include population, industrial activities, agricultural use, and mining location. The monitoring resources, in parallel with management resources, could then be allocated among the basins using the index as the basis.

Once the monitoring resources are allocated to each basin, a further breakdown by objectives could be made. Regardless of how the allocation of resources between basins and objectives is made, there remains the question, "How does one allocate the given number of stations within the basins?"

IDENTIFYING WATER QUALITY SAMPLING REACHES IN A RIVER BASIN — MACROLOCATION

If the intent of sampling were to study a limited portion of a river, as required to discover the immediate downstream effects of a given discharge (synoptic surveys), the placement of sampling transects might not be too critical to the generation of information descriptive of the reach in question (GAO, 1981). However, when the intent of sampling is to monitor entire rivers or river basins any sample taking must be preceded by a thoughtful selection of reaches in the river basin to be sampled.

The water quality of a river reflects natural background conditions and the wastes it is required to carry. Because both conservative and nonconservative pollutants are added to a stream along its entire length, water quality varies along the entire length also. It would be unrealistic to expect that a few water samples drawn at will could adequately characterize spatial and temporal variations in the stream. Nor would it be realistic to expect that samples drawn from a particular reach could be used to infer anything beyond local conditions, except with caution.

With passage of PL 92-500, the Water Pollution Control Act Amendments of 1972, the emphasis on water quality management shifted from the maintenance of stream standards to the maintenance of effluent quality. Stream standards expressed as limits not to be exceeded may be easily violated, especially if monitoring data used to indicate need for

enforcem are collected intermittently rather than continuously. For many of the water quality variables which could be measured as indicators of stream quality, continuous monitoring is either not possible, not feasible, or not affordable. Two important complications accompany intermittent monitoring. One cannot be sure that what appears to be a violation is not really a random rather than a continuous event. Secondly, it is difficult to identify a violator when only in-stream data are available. Furthermore, one must determine whether an apparent violation is an artifact of a sampling location wherein measurements have been taken close enough to a discharge point so that the discharge has not been able to disperse sufficiently within a mixing zone (EPA, 1976).

A shift in emphasis from limitations on stream quality to limitations on effluent quality shifts in-stream monitoring objectives from detection of stream standard violations to assessment of overall trends in water quality. This shift in objectives places enormous demands on a water quality monitoring network. To perform at the expected level, the network must be capable of characterizing trends which, in turn, enable assessment of the effectiveness of abatement programs and determination of needed future abatement measures within the entire river basin. To these ends water quality trend analysis should not be undertaken to find "critical quality points" or points having a high probability of stream standards violation to sample, but to identify sampling station locations which will yield information characteristic of reaches of the river and, in composite with other stations, will yield information characteristic of the condition of the river system in general. Monitoring to detect fugitive discharges or to identify specific violators is an important subject in its own right (Sharp, 1970) but is beyond the scope of this chapter.

Basic approaches to identifying macrolocations include one based upon percentage areal coverage and the second based upon the density of some indicator of population, where the density of population is considered to correspond to the likelihood of polluting episodes and overall discharge of pollutants. Beckers et al., (1972) selected sampling station sites as a function of possible stream standards violations or as a function of stream segments below outfalls. Ward (1973) placed sampling stations at critical quality points in reference to each major source of pollution. In the percentage areal coverage approach stations are placed systematically to generate data on water quality in the entire river basin, an approach which lends itself to characterizing trends.

Sampling station locations for some monitoring programs (Florcyk, 1971; ORSANCO, 1976) were selected by finding points along the length of a stream at which various water quality

BEST AVAILABLE COPY

variables of interest have been shown by rience to be approximately homogeneous in the cross section.

Some sampling programs generate data of questionable value because their sampling station locations were selected without reference to the spatial distribution of waste inputs. When an attempt is made to relate station density to some measure of population density--such as placement of outfalls--the methods prescribed lack quantitative guidelines and by default become highly subjective. Budgetary constraints and limited availability of manpower usually dictate an arbitrary and inadequate sampling frequency. Consequently, current sampling programs may not provide information representative of the stream (along its length as well as in the cross section) and the sampling frequency may not be sufficient to detect average quality and to detect trends.

Samplers often draw samples at bridges or other sites which give convenient access to the river, without there necessarily being any relationship between sampling site and sources of stream pollution. In such a case sampling station location has been considered minimally. When the importance of sampling station location is recognized, it is often expressed by finding reaches along the length of the river which are judged by some criterion to be completely mixed in the cross section. While sampling in these reaches is greatly simplified, a single grab sample is presumed to be representative of the entire cross section, there still is no clear relationship between sampling site and sources of pollution. A zone of complete mixing (if such can in fact exist, other than in relation to a specific discharge) may not be found for many miles below an outfall, at which point one is hard put to find a valid means by which to relate concentrations and water quality variables at the sampling site with specific conditions upstream.

Another approach is to designate sampling sites according to some logical basis: for example, to concentrate sampling near known sources of pollution. While this approach may come closest to generating data which reflect the quality of a stream as it varies with longitudinal position, it will nevertheless reflect bias unless a rational systematic procedure for designating sampling stations is employed.

Many authors have presented methods of characterizing a stream network. Perhaps the best known of these is Horton (1945) who defined stream order by designating the smallest unbranched tributary in the headwaters of a system as first order, a stream made up only of first order tributaries as second order; a third order stream as one in which all tributaries are of second or first order, and so on.

Sharp (1970) points out that Horton's stream ordering may be considered a measure of the uncertainty associated with locating the source of a pollutant detected at the outlet of a network. Shreve (1967) described a procedure which used the number of tributaries or sources in a network to assign

magnitude to individual sections or links, where a link is a section of channel that starts at a point termed the source and ends at a point termed the fork or junction. Sharp (1971) employed this system to describe the design of a river basin monitoring network capable of locating the source of a pollutant which employed a trade-off between uncertainty and intensity of sampling. The procedure for selection of macro-locations is based upon earlier work of Sharp (1971) on the design of sampling networks intended for use in identifying the source of a stream standard violation.

The following discussion presents a method for selection of a river reach which should be allocated a sampling station. It is based on modifications of Sanders' application (1974) of Sharp's procedure to the design of a water quality monitoring network for a large river basin. The method is general enough that it may be tailored to a number of special sampling requirements. In its original form, the framework for Sharp's procedure is the number of tributaries that contribute to a river network. The original framework will be retained in the first of three examples applied to the Massachusetts portion of the Connecticut River basin. In a second example the framework will be changed to a consideration of the number and placement of outfalls discharging to the river network, and in a third example to a measure of BOD loading from each of these outfalls (Clarkson, 1978).

Selection of Sampling Sites Based on Number of Contributing Tributaries

Sharp's procedure for specifying sampling station locations systematically subdivides the river network into portions which are relatively equal in terms of the number of contributing tributaries. The method was proposed for use in defining a water quality sampling network having a primary objective to detect, isolate and identify a source of pollution.

Each exterior tributary or link contributing to the mainstem of a river is assigned a magnitude of one. The overall number of exterior tributaries included in the procedure is a function of judgment and the scale of map used. An exterior tributary is considered to be a stream fed by no other defined tributaries or having a specified minimum mean discharge. A stream which is formed by the intersection of two exterior tributaries becomes a second order tributary. Continuing downstream in the same manner, a section of river formed by the intersection of two upstream tributaries would have a magnitude equal to the sum of magnitudes of the intersecting streams. At the mouth of the system the magnitude of the final river section will be equal to the number of contributing exterior tributaries. Figure 4-1 illustrates stream ordering for the Massachusetts portion of the Connecticut River basin. It is assumed in the example that

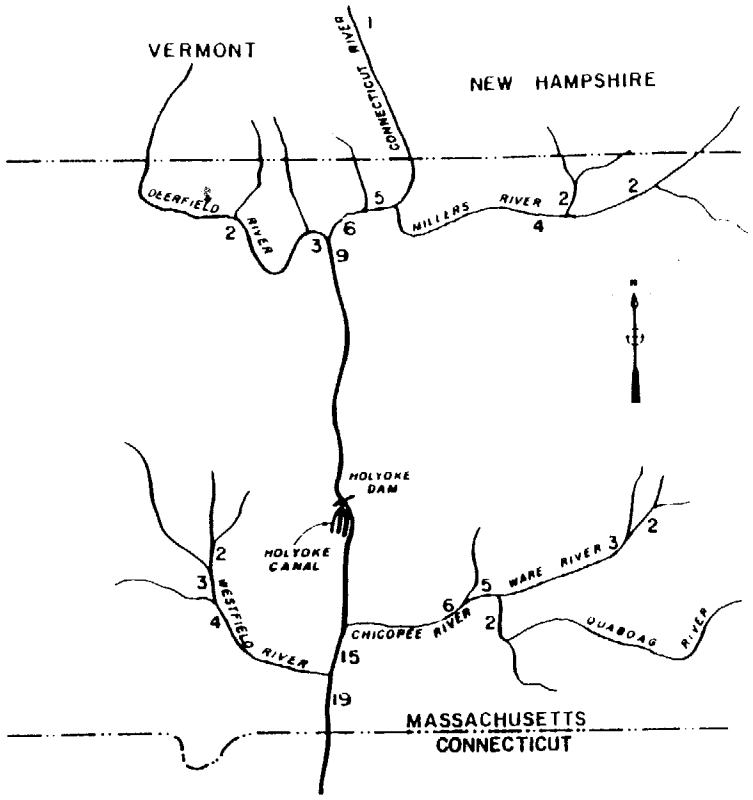


Figure 4-1. Stream ordering by Sharp's procedure for the Massachusetts portion of the Connecticut River

all tributaries crossing into Massachusetts from Vermont and New Hampshire are first order.

The centroid of the basin is defined by dividing the magnitude of the final stretch of the river by two. The first centroid divides the river network into two approximately equal portions and a new centroid may be found for each. The location designated by the first division is referred to as a first-hierarchy sampling reach. Division of the entire network into quarters defines second-hierarchy sampling reaches. Successive subdivisions define increasing levels of hierarchy. The transects within these reaches at which samples are to be taken are termed sampling stations.

To isolate a source of pollution, Sharp proposed that samples be drawn at one hierarchy and analyzed to select those portions of the river network which should be sampled at stations of the next hierarchy, and so on, until the pollutant source had been found by a process of elimination. A modified

BEST AVAILABLE COPY

Sharp's procedure is proposed to designate sampling sites, except that hierarchies will denote priorities for sampling rather than a sequence in which to sample. If the budget permitted, one could sample simultaneously at all first and second-hierarchy sites, then third-hierarchy sites would be added, and so on, where sampling at additional hierarchies in effect steadily improves the resolution of the picture obtained of the whole river network. Increasing levels of hierarchy correspond to decreasing levels of sampling priority when trying to isolate a pollutant source.

Example 4-1. Application of the procedure to tributaries of the Massachusetts portion of the Connecticut River basin leads to assignment of link numbers shown in Figure 4-1 and identification of river links within which samples would be taken, as shown in Figure 4.2. Due to political realities it

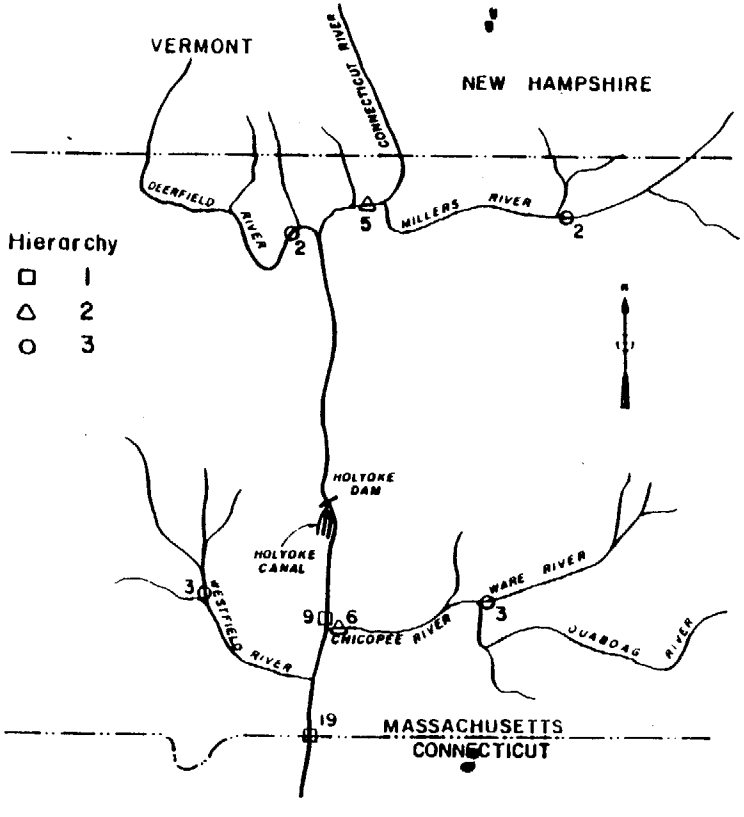


Figure 4-2. Location of sampling stations by Sharp's procedure based on number of tributaries.

is always assumed that there is a first-hierarchy sampling station at the Massachusetts/Connecticut boundary and that streams flowing into Massachusetts from Vermont and New Hampshire are first order.

The major centroid where a first hierarchy station is to be placed is located in that link whose magnitude is closest to:

$$M_1 = \left[\frac{N_o}{2} + \frac{1}{2}\right] \qquad (4\text{-}1)$$

$$M_1 = \left[\frac{19}{2} + \frac{1}{2}\right]$$

where M_1 denotes a first-hierarchy link, N_o denotes the total number of exterior tributaries and the squared brackets indicate that the enclosed value will be truncated to the integer value. For $N_o = 19$, as in Figure 4-1, the first-hierarchy station would be placed in link number 10; however, there is no link with this number so the nearest in magnitude, link 9, is selected. Note that a link specified at a given hierarchy is not necessarily the value of M_1 which will be selected since a link of that number may not exist. In this case, the link closest in magnitude is chosen as the centroid. Once a link is specified, a sampling location is designated at its downstream junction which in this case is just above the confluence of the Connecticut and Chicopee rivers. Placement of transects at the downstream end of a link follows Sharp's example and simplified presentation of the illustrations which follow. However, reaches in an actual sampling program should be considered site specific and are best not treated rigidly, in contrast to the examples. Thus, each designated reach should be examined individually in light of such factors as accessibility, presence of zones of complete mixing or other unique conditions which may exist, before a transect is selected at which to sample. As will be seen in the examples, judgement may often be required in selecting from alternative reaches indicated by Sharp's procedure.

If the first-hierarchy link were erased, two systems result which are approximately equal in magnitude. The upstream portion has a magnitude of 9 for which the centroid is:

$$M_{1+1} = \left[\frac{M_1}{2} + \frac{1}{2}\right] \qquad (4\text{-}2)$$

$$M_2 = \left[\frac{9}{2} + \frac{1}{2}\right] = 5$$

BEST AVAILABLE COPY

In Sharp's treatment of the downstream portion, one can either renumber tributaries, using the same procedure outlined above, or the centroid may be found by selecting that link which is closest to either:

$$M_i' = \left[\frac{M_d - M_u + 1}{2}\right] \qquad (4\text{-}3)$$

or

$$M_i'' = M_u + M_i' \qquad (4\text{-}4)$$

where M = magnitude of the link
i = hierarchy level
M_d = magnitude where the basin is divided on the downstream side
M_u = magnitude where the basin is divided on the upstream side
M_i', M_i'' - alternative possible centroids

In this example, exterior tributaries of the downstream portion may be renumbered to form a system with a magnitude of 11, as in Figure 4-3, where the mainstem is considered a tributary, and the centroid designated by Equation 4-1:

$$M_1 = \left[\frac{N_u + 1}{2}\right]$$

$$M_2 = \left[\frac{11 + 1}{2}\right]$$

or the original numbers may be used with Equations 4-3 and 4-4:

$$M_2' = \left[\frac{19 - 9 + 1}{2}\right] = 5$$

or

$$M_2'' = 9 + 5 = 14$$

While there is not a link 14, a choice must be made between links 5 and 6. Link 6 is selected because it more nearly divides the system into halves (a subjective evaluation) and because placement at the junctions of the Chicopee River would enable assessment of the specific contribution of the Chicopee and its tributaries to the mainstem. Here is an instance in which judgement (or bias) is required to select among alternatives. Any river basin subjected to this type of analysis will

present many situations for which the procedure is not definitive.

With the second-hierarchy stations specified, third-hierarchy stations may be selected by a similar procedure. For the upstream half these become:

$$M_{i+1} = \left[\frac{M_i + 1}{2}\right] \qquad (4\text{-}2)$$

$$M_3 = \left[\frac{5 + 1}{2}\right] = 3$$

With no link numbered 3, the nearest link in magnitude would be selected; however, there are two link 2's and a link 4. It is decided to sample where the system (essentially the Millers River and its tributaries) is most nearly divided into halves, and a link 2 is chosen as shown in Figure 4-3.

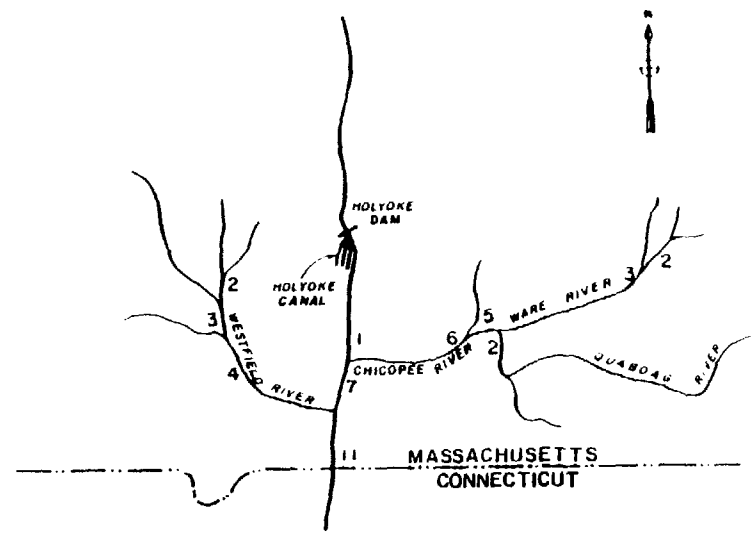


Figure 4-3. Stream order, lower half of basin by Sharp's procedure.

Still in the upper half of the river network, a lower third-hierarchy station should be specified. Using Equations 4-3 and 4-4:

$$M_3' = \left[\frac{9 - 5 + 1}{2}\right] = 2$$

or

$$M_3'' = 5 + 2 = 7$$

BEST AVAILABLE COPY

In this case link 2 is chosen on the Deerfield River.

Selection of third-hierarchy stations in the downstream half may be illustrated by first renumbering tributaries, as in Figure 4-3. Renumbering will often be found useful when locating links downstream from others already designated, especially when M_d and M_u fall separately on a stream and a tributary of that stream.

With the second-hierarchy station in link 6, as previously designated, the upper third-hierarchy station is at:

$$M_3 = \left[\frac{6 + 1}{2}\right] = 3$$

on the Ware River, and the lower third-hierarchy station at:

$$M_3' = \left[\frac{11 - 6}{2} + 1\right] = 3$$

or

$$M_3'' = 6 + 3 = 9$$

Link 3' on the Westfield River is chosen. In designating sites up to the third-hierarchy, sampling may be done at as many as eight different stations: two first-hierarchy, two second-hierarchy and four of the third-hierarchy.

If desired, sites beyond the third-hierarchy may also be designated; whether sampling is conducted at these sites would be dictated both by budgetary constraints and by determining whether additional data from sampling at higher hierarchies are necessary. For example, if a fourth-hierarchy site were to fall in an area that received no industrial discharge and was essentially pristine, one might decide to forego additional sampling.

Selection of Sampling Sites Based on Indicators of Stream Use

In this section the framework upon which to base the sampling network is changed and Sharp's procedure is applied, in a second example, to the number of outfalls which discharge into the Connecticut River and its tributaries, and in a third example to a measure of BOD loadings from these outfalls. All information is taken from a 1972 survey of point source discharges to the Connecticut River basin in Massachusetts (Bayon and Ramsay, 1972).

BEST AVAILABLE COPY

Example 4-2. The number of outfalls can be taken into account in designating sampling transects by treating each outfall as if it were an exterior tributary of order one. Using the procedure outlined above, the centroids and subcentroids of the basin may then be specified as a function of population and industrial activity. Figure 4-4

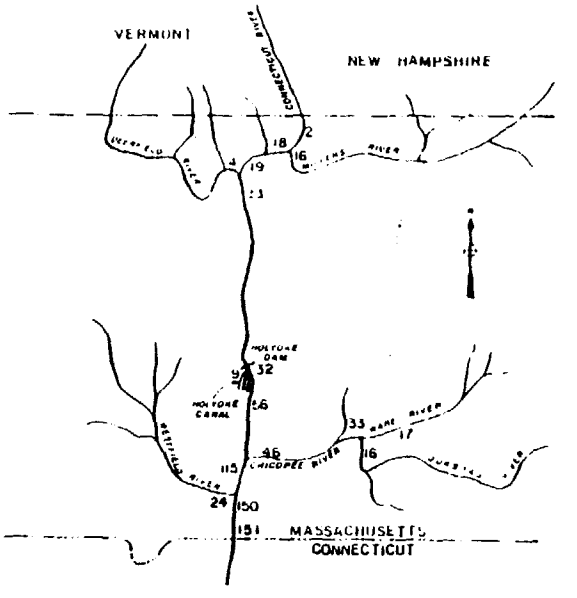


Figure 4-4. Cumulative distribution of outfalls.

shows a cumulative numbering of outfalls (not all outfalls are shown) and Figure 4-5 placement of sampling points. Treating outfalls as if they were tributaries in the earlier application of Sharp's procedure, the major centroid is placed at:

$$M_1 = \left[\frac{151}{2} + 1\right] = 76$$

The outfall closest in magnitude to 76 is number 69, the Chicopee Sewage Treatment Plant on the mainstem just above the Chicopee River.

SECTION 2

Illinois
Environmental
Protection Agency

Division of Laboratories
2200 Churchill Road
P.O. Box 19276
Springfield, IL 62794-9276

April 1992

A FIELD GUIDE FOR ENVIRONMENTAL SAMPLING

1991 Revised Edition

Second Printing

Printed on Recycled Paper

56

TABLE OF CONTENTS

Title	Revision Date
INTRODUCTION	July 1991
SAMPLE CHAIN OF CUSTODY	July 1991
SAMPLE RETENTION	July 1991
SAMPLE PRESERVATION	July 1991
PARAMETERS REQUIRING PRESERVATION	July 1991
SAMPLE COLLECTION CONTAINER/BOTTLE REQUIRED	July 1991
LABORATORY OPERATING SCHEDULE AND PHONE NUMBERS	July 1991

INTRODUCTION

The Field Guide for Environmental Sampling has been prepared as a handy reference for field personnel. It contains guidelines on sample collection and preservation.

SAMPLE CHAIN OF CUSTODY

Samples collected by the Agency may be used as evidence in regulatory or enforcement proceedings. For this reason, it is important that the Chain of Custody be observed during sample collection and analyses. The Chain of Custody begins when the sample collector takes sample request forms into the field. These forms usually are partially completed in the office as to location and facility information, while the balance of the information is completed at the site when the samples are collected. The sample request form and the bottles representing that sample are identified by the sample collector with a number marked on the form and on the bottles. (There may be several bottles representing one sample site since various parameters require different preservatives or types of bottles.) The sample request form is signed and the date and time noted by the sample collector.

If the sample is not delivered to the laboratory by the sample collector, a place is provided on the sample request form for the signature of the person or persons transporting the samples to the laboratory. Each time the samples are transferred from custody of one person to another, the sample request form should reflect this action via signature on the form at the time of transfer.

The sample collector is responsible for getting samples to the appropriate laboratory as the Division of Laboratories has no resources for messenger service. When a collector brings samples to the laboratory, the collector must properly align all of the sample bottles applicable to each sample request form. Proper alignment allows for correct sample identification by laboratory personnel. After the collector has matched the bottles to the sample request form, the person receiving the samples for the laboratory must check the sample request form for completeness of all information and double check the sample bottles against the sample request form. The bottles are then checked to determine if the appropriate bottles match the parameters requested. A laboratory sample number is then assigned to the sample request form. The sample number and other pertinent information regarding sample source is recorded in the master log book or LIMS. The date and time of sample receipt, and the analyst receiving the samples are noted in the appropriate location on the sample request form. The collector should witness the complete sample receiving procedure.

58

SAMPLE RETENTION POLICY

Samples which will be needed for evidence in court or to meet other needs of the control divisions will be stored for a period of one year from the date on which analytical work is completed. If samples need to be retained beyond one year, the Division of Laboratories will return the samples to the control divisions. The control division will then be responsible for storing those samples in a safe and secure manner. All other samples will be discarded in an appropriate manner immediately following the completion of analytical work.

When a sample is to be retained after analytical work is complete, the laboratory must be notified when that sample is delivered to the laboratory. The request must be in writing and specifically identify the samples to be retained.

SAMPLE PRESERVATION

Care must be taken to minimize sample degradation during the time between collection in the field and analysis in the laboratory. Regardless of the nature of the sample, complete stability for every constituent can never be achieved. Preservation techniques can only retard the chemical and biological changes that inevitably continue after the sample is removed from the parent source. Changes can occur in the chemical structure of the constituents that are a function of physical conditions. Metal cations may precipitate as hydroxides or form complexes with other constituents; cations or anions may change valence states under certain reducing or oxidizing conditions; other constitutents may also dissolve or volatilize with the passage of time. Metal cations, such as iron and lead, may also absorb on to surfaces (glass, plastic, quartz, etc.). Biological changes taking place in a sample may change the valence of an element or a radical to a different valence. Soluble constituents may be converted to organically bound materials in cell structures, or cell lysis may result in the release of cellular material into solution. The well-known nitrogen and phosphorus cycles are examples of biological influence on sample composition.

Preservation methods are generally limited to pH control, chemical addition, refrigeration and freezing. A listing of the various chemical preservatives, their preparation and uses, is provided on the following pages.

The preservation methods listed are intended for samples which are aqueous in nature, except where indicated otherwise. The preservation methods are not applicable to solids, sludges, or organic wastes. Such samples

should be collected in a clean glass or plastic bottle for inorganic analysis, or a solvent-rinsed glass bottle for organic analysis, and refrigerated for transport to the laboratory.

PARAMETERS REQUIRING PRESERVATION

Parameter	Color Code	Container Type	Preservative	Maximum Holding Time[1]
		INORGANIC COMPOUNDS		
Acidity	None	Plastic	Refrigeration @ 4°C	14 days
Alkalinity	None	Plastic	Refrigeration @ 4°C	14 days
Ammonia	Yellow	Plastic	10 ml 20% H_2SO_4/L + Refrigeration @ 4°C	28 days
BOD	None	Plastic	Refrigeration @ 4°C	48 hours[2]
COD	Yellow	Plastic	10 ml 20% H_2SO_4/L + Refrigeration @ 4°C	28 days
Chloride	None	Plastic	Refrigeration @ 4°C	28 days
Chlorine Residual	None	Glass	Determined on Site	None
Coliform, total	None	Sterile	0.15 ml 10% Thiosulfate	*
Coliform, fecal		6 oz. Glass	+ Refrigeration @ 4°C	*
Cyanide	Gray	Plastic	5 ml 5 N NaOH/L	14 days
Dissolved Oxygen	None	Glass	Fixed on Site, Titrate in Laboratory	8 hours
Fecal Strep	None	Sterile 6 oz. Glass	0.15 ml/ 10% Thiosulfate + Refrigeration @ 4°C	*
Fluoride	None	Plastic	Refrigeration @ 4°C	28 days
Hardness	None	Plastic	Refrigeration @ 4°C	14 days
METALS:				
In Benthic Muds	None	Plastic	Freezing	6 months[4]
In Fish	None	Plastic	Freezing	6 months[4]
In Water	Green	Plastic	20 ml 50% HNO_3/L	6 months[4]
METALS EXCEPTIONS:				
Hex. Chromium	None	Plastic	Refrigeration @ 4°C	24 hours
Mercury	Gray	Glass	20 ml 50% HNO_3, 2.5% $K_2Cr_2O_7$/L	28 days

**Holding times 30 hours for drinking water and 6 hours or for any non-drinking water sample*

Parameter	Color Code	Container Type	Preservative	Maximum Holding Time[1]
Nitrate + Nitrite	Yellow	Plastic	10 ml 20% H_2SO_4/L + Refrigeration @ 4°C	28 days
Nitrogen Kjeldahl	Yellow	Plastic	10 ml 20% H_2SO_4/L + Refrigeration @ 4°C	28 days
Oil and Grease	Orange	Glass	4 ml 50% H_2SO_4/L + Refrigeration @ 4°C	28 days
pH	None	Plastic	Refrigeration @ 4°C	24 hours
Phenolics	Pink	Glass	10 ml 20% H_2SO_4/L + Refrigeration @ 4°C	28 days
Phosphorus, Total	Yellow	Plastic	10 ml 20% H_2SO_4/L + Refrigeration @ 4°C	28 days
Radiological[3] Alpha, Beta and Radium	Red	Plastic	20 ml 50% HNO_3/L	6 months
Residue, Filterable	None	Plastic	Refrigeration @ 4°C	7 days
Settleable Solids	None	Plastic	Refrigeration @ 4°C	48 hours
Silica	None	Plastic	Refrigeration @ 4°C	28 days
Specific Conductance	None	Plastic	Refrigeration @ 4°C	28 days
Std Plate Count	None	Glass(6 oz.)	Refrigeration @4°C	6 hours
Sulfate	None	Plastic	Refrigeration @ 4°C	28 days
Sulfide	White	Plastic	2 ml 2 N Zinc Acetate/L	7 days
Suspended Solids (TSS)	None	Plastic	Refrigeration @ 4°C	7 days
TOC	Purple	Glass	10 ml 20% H_2SO_4/L +Refrigeration @ 4°C	28 days
Turbidity	None	Plastic	Refrigeration @ 4°C	48 hours

Parameter	Container Type	Preservative	Maximum Holding Time[1]
ORGANIC COMPOUNDS *No Color Codes Used for Organic Samples*			
PESTICIDES: In Benthic Muds	Glass	Freezing	12 months[4]
In Fish	Aluminum Foil	Freezing	12 months[4]

Parameter	Container Type	Preservative	Maximum Holding Time[1]
VOLATILES: In Water	40 ml glass bottle with teflon caps	Refrigeration to 4°C 4 drops of HCl until pH2, use dechlorinating agent if chlorine present	14 days until analysis if acid preserved
In Sediment	2 ounce glass bottle with teflon lined cap	Refrigeration to 4°C	14 days
SEMI-VOLATILES/ PESTICIDES/HERBICIDES/ PCBs/TCLP/FLASHPOINT: Soils/sludges	32 oz glass bottle with teflon lined cap	Refrigeration to 4°C	7 days until extraction 14 days for RCRA
Water	1 gallon glass container with teflon cap	Refrigeration to 4°C	7 days until extraction
Soils/sludges TCLP:	32 oz glass bottle with teflon lined cap	Refrigeration to 4°C	7 days until TCLP procedure, 7 days until extraction
Waste Oils/ Solvents	6 oz. glass bottle with teflon cap	Refrigeration to 4°C	14 days
PW30 PESTICIDES/ HERBICIDES	1 qt glass bottle	Refrigeration to 4°C	7 days until extraction

1. *USEPA RULES/40 CFR, Part 136, as amended. Holding times (collection to analysis) indicated would be the maximum permissible under the rules.*
2. *Composite samples should be kept at or below 4°C during compositing. The composite period should be limited to 24 hours and analysis should be started within 24 hours after the end of the compositing period.*
3. *Analysis is through the Illinois Department of Public Health.*
4. *There is no proposed maximum holding time for benthic sediments and fish. 12 months is arbitrary.*

60

ECOTOXICOLOGY ANALYSIS

Parameter	Color Code	Container[1] Type	Preservative	Maximum Holding Time[2]
Algal Growth Test	Yellow & Green	Glass	Cool, 4°C	36 hrs
Ames (&/or SV50) Assay All except DAPC[3]	Red	Glass	Cool, 4°C Protected from light, and moisture	7 days before extraction
Daphnid 7-Day Survival and Repro-duction Chronic	Yellow & Green	Glass	Cool, 4°C	36 hrs/72 hrs[4]
Daphnid Static 48-Hr Acute Toxicity Screen	Yellow	Glass	Cool, 4°C	36 hrs
Daphnid Static 48-Hr Acute Toxicity	Yellow & Green	Glass	Cool, 4°C	36 hrs
Fathead Minnow Flow-Through 96-Hour Acute	NA	NA	NA	NA
Fathead Minnow 7-Day Survival & Growth Chronic	Yellow & Green	Glass	Cool, 4°C	36 hrs/72 hrs[4]
Fathead Minnow Static 96-Hr Acute Screen	Yellow	Glass	Cool, 4°C	36 hrs
Microtox	Yellow & Green	Glass	Cool, 4°C	36 hrs/72 hrs[4]
Toxicity Reduction Evaluation	Yellow	Glass	Cool, 4°C	36 hrs

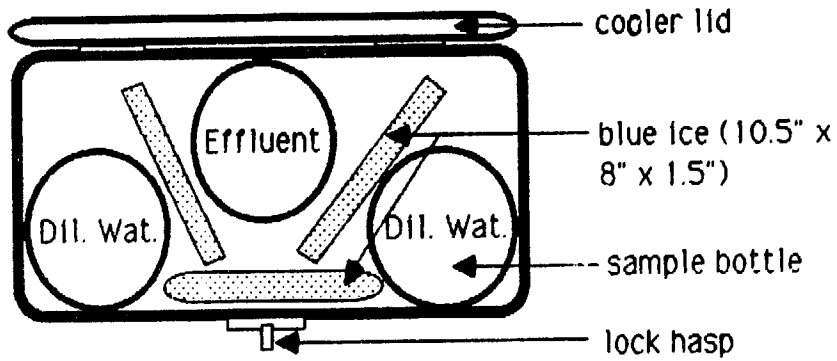
1. *All sample bottles are amber glass with teflon-lined caps*

2. *As outlined in proposed rules for 40 CFR Part 135*

3. *Air particulates are collected on glass or quartz for fiber filters using a Hi-Vol sampler. Filters are transported by collectors or US Mail as soon as possible after the end of the collection period, preferably within 24 hrs to the ecotoxicology laboratory. Upon receipt in the ecotoxicology laboratory, air filters are forwarded to the Champaign Laboratory for weighting and then returned via US Mail. When in the ecotoxicology laboratory, the filters are stored at -80°C until extracted.*

4. *For chronic toxicity tests, the initiation of the test must take place within 36 hrs of initial sample collection. Renewal samples must be used within 72 hrs of collection. While the holding time for renewal samples may not fall within the proposed rules for 40 CFR Part 135, IEPA logistics require that samples are to be used within 72 hrs. of collection.*

ECOTOXICOLOGY LABORATORY SAMPLE PACKING DIAGRAM



For the chronic test battery: Never ship all effluent bottles in the same cooler in case a cooler is lost or destroyed

SAMPLE COLLECTION: CONTAINER/BOTTLE REQUIRED FOR WATER

Parameters	Container/Bottle
Acidity Alkalinity BOD Chloride Fluoride Hardness Hex Chrome pH Residue Filterable Settleable Solids Silica Specific Conductance Sulfate Suspended Solids Turbidity	32 oz. plastic, no color code, refrigerate at 4°C. (Note: if BOD or SS are requested, use 1/2 gal. plastic)

Parameters	Container/Bottle
Ammonia COD Nitrate/Nitrite Nitrogen/Kjeldahl Phosphorus, Total	4 oz. plastic, yellow color code, w/10 ml 20% H_2SO_4L, refrigerate at 4°C.

Parameters	Container/Bottle
TOC	2 oz. glass, purple color code, w/10 ml 20% H_2SO_4/L, refrigerate at 4°C

Parameters	Container/Bottle
Coliform-Fecal Coliform-Total Fecal Strep Standard Plate Count	6 oz. sterile glass w/0.15 ml of 10% thiosulfate, referigerate at 4°C, no color code.

Parameter	Container/Bottle
Cyanide	4 or 32 oz. plastic, gray color code, 5 ml 5N NaOH Solution/L.

Parameter	Container/Bottle
Dissolved Oxygen	300 ml DO bottle, no color code, fix on site, titrate at laboratory.

Parameters	Container/Bottle
All Metals Except Mercury and Hex Chrome	8 or 16 oz. plastic, green color code, 20 ml of 50% HNO_3/L.

Parameter	Container/Bottle
Mercury	2 oz. glass, gray color code, 20 ml 50% HNO_3 + 2.5% potassium dichromate/L.

Parameters	Container/Bottle
Oil and Grease	32 oz. glass, orange color code, 4 ml 50% H_2SO_4/L, refrigerate at 4°C.

Parameters	Container/Bottle
Semi-volatiles, Pesticides, Herbicides, PCBs, Fuels: In water	Except for the programs listed below use teflon lined cap 1 gallon glass, no color code. Solvent rinsed in laboratory, refrigerate at 4°C. Exceptions: 1) Use liquid quart bottles for PW30 and 2) Use one-half gallon bottles for the DLPC pre-remedial program.

Parameters	Container/Bottle
Semi-volatiles, Pesticides, Herbicides PCBs: Sediment/waste	32 oz wide-mouth glass bottle. Solvent rinsed in laboratory, refrigerate at 4°C

Parameters	Container/Bottle
Pesticides/PCBs: In Benthic Mud and Waste Oils or Solvents	6 ounce wide-mouth glass bottle, teflon-lined cap, no color code. Solvent rinsed in laboratory, refrigerate at 4°C, freeze in laboratory - for oil samples, 2 bottles may be needed if flashpoint is required.
Pesticides/Herbicides/ PCBs: In fish	Wrap in aluminum foil and freeze.

Parameters	Container/Bottle
Volatiles in Sediment	2 ounce glass jar, no color code, teflon-lined cap. Solvent rinsed in laboratory, refrigerate at 4°C

Parameters	Container/Bottle
Volatiles: In water	40 ml glass vial, 4 drops 1:1 HCl, dechlorinating agent if free chlorine present

Parameter	Container/Bottle
Phenolics	8 oz. glass, pink color code, 10 ml $CuSO_4$ + H_3PO_4/L, refrigerate at 4°C.

Parameter	Container/Bottle
Radioactivity	32 oz. plastic, red color code, 20 ml of 50% HNO_3/L.

Parameter	Container/Bottle
Sulfide	8 oz. plastic, white color code, 2 ml 2N zinc acetate/L, (Not used for sulfate).

Parameter	Container/Bottle
Ames Assay	Two 4L, amber, glass, Teflon-lined cap w/red tape, Chill on ice or refrigerate at 4°C.

Parameter	Container/Bottle
Acute Test Battery for DWPC.	Effluent: One 4L, amber glass, teflon-lined cap, with yellow tape; AND receiving: two 4L, amber glass, teflon-lined cap, with green tape.
Includes the following: Daphnid 48-hr Survival Fathead Minnow 96-hr Survival Microtox	ALL: Chill on ice or refrigerate at 4°C.

Parameter	Container/Bottle
Screening Test Battery for DWPC.	Effluent: One 4L, amber, glass, Teflon-lined cap, with yellow tape. Chill on ice or refrigerate at 4°C (No receiving water collected).
Includes the following: Daphnid 48-hr Survival Fathead Screen Minnow 96-hr. Survival Screen Microtox	

Parameter	Container/Bottle
Acute Test Battery for DPWS, DLPC.	Ambient or Leachate: One 4L, amber glass, Teflon-lined cap, with yellow tape.
Includes the Following: Daphnid 48-hr Survival Fathead Minnow 96-hr Survival Microtox	ALL: Chill on ice or refrigerate at 4°C.

Parameter	Container/Bottle
Chronic Test Battery for DWPC Only. Includes the Following: Algal 96-hr Growth Test	Effluent: 1st collection, three 4L 2nd collection, two 4L 3rd collection, three 4L amber glass, Teflon-lined cap, with yellow tape;
Daphnid 7-Day Survival and Reproduction Fathead Minnow 7-Day Survival & Growth Microtox	AND Receiving: 1st collection, six 4L 2nd collection, four 4L 3rd collection, six 4L amber glass, Teflon-lined cap, with green tape ALL: Chill on ice or refrigerate at 4°C.

Parameter	Container/Bottle
Microtox Only	100 mL, glass Chill on ice or refrigerate at 4°C.

Parameter	Container/Bottle
Toxicity Reduction Evaluation	Two 4L, amber glass, Teflon-lined cap, with yellow tape. Chill on ice or refrigerate at 4°C.

LABORATORY OPERATING SCHEDULE AND TELEPHONE NUMBERS

		Phone Number
Champaign Laboratory 2127 South First Street Champaign, Illinois 61820 *Roy Frazier - Laboratory Manager*	8:30 a.m. to 5:00 p.m. Monday - Friday	217/333-6907
Chicago Laboratory 2121 West Taylor Street Chicago, Illinois 60612 *Jim Daugherty - Laboratory Manager*	8:00 a.m. to 5:30 p.m. Monday - Friday	312/793-4770
Springfield Organic Lab. 825 North Rutledge Springfield, Illinois 62702 *John Hurley - Laboratory Manager*	8:00 a.m. to 11:30 p.m. Monday - Friday	217/782-9780
Springfield Ecotoxicology Laboratory 2200 Churchill Road Springfield, Illinois 62706 *Mike Henebry - Lead Worker* *Mary Beth Lawhorn - Lead Worker*	8:30 a.m. to 5:00 pm Monday - Friday	217/782-8700
FOR SPECIAL ASSISTANCE John P. Anderson Karl Reed	Manager's Office	217/782-6455

TO REPORT AN INCIDENT

Illinois EPA Emergency Response	217/782-3637
Illinois Emergency Management Agency	1-800-782-7860

Printed by Authority of
the State of Illinois
Job No. 21903 4/92 150

Printed on Recycled Paper

64

SECTION 3

ILLINOIS AMBIENT WATER QUALITY MONITORING NETWORK PARAMETERS

UNIVERSAL (includes metals)

Air Temperature
Field D.O.
Field Conductivity
VSS
Nitrate
Turbidity
Dissolved P
Water Temperature
Field pH
COD
Ammonia N
Nitrite N
Total P
Fecal Coliform

METALS

Aluminum
Boron
Cadmium
Chromium
Cobalt
Lead
Manganese
Potassium
Sodium
Vanadium
Barium
Beryllium
Calcium
Copper
Iron
Magnesium
Nickel
Silver
Strontium
Zinc

ORGANICS

Polychlorinated Biphenyls (PCBs)
Dieldrin
Total Chlordane
Endrin
Hexachlorocyclohexane
Hexachlorobenzene
Chlordance cis isomer
Dichlorobromomethane
Bromoform
Chloride
1-Dichloroethane
1,2-Dichloroethane
Carbon Tetrachloride
Tetrachloroethylene
Dichlorobenzene
Toluene
Zylenes
Aldrin
Total DDT & isomers
Chlordane & isomers
Methoxychlor
gamma BHC-Lindane
Pentachlorophenol
Chloroform
Chlorodibromomethane
Methylene
1-Dichloroethylene
Trans-1,2-Dichloroethylene
1, 1, 1-Trichloroethane
Trichloroethylene
Chlorobenzene
Benzene
Ethylbenzene
CIS-1,2-Dichloroethylene

SECTION 4

EFFLUENT BIOMONITORING AND TOXICITY ASSESSMENT - Aquatic Life Concerns

January 4, 1992 - Revised February 23, 1993 and March 3, 1994.

I. Introduction

Biomonitoring pertains to the use of organisms to assess or predict the impact of pollutants on aquatic ecosystems. The ultimate biological monitors are the aquatic community resident in the receiving water and the terrestrial organisms utilizing the water or the organisms therein. The *in situ* study of macroinvertebrates and fish in relation to an effluent may be termed a biosurvey. A bioassay is an analysis of the effects of an effluent on a given aquatic organism, usually conducted in a laboratory. Although both methods have advantages, this document will focus primarily on the bioassay, i.e., effluent toxicity assessment through toxicity testing.

The Illinois toxics strategy will increasingly rely on biomonitoring to assess the potential toxic effects of NPDES discharges on aquatic communities and human health. This type of assessment provides a more direct indication of toxicity than does prediction from knowledge of chemical content. When included in permit requirements, biomonitoring may lead to effluent toxicity limits and toxicity control measures. Initially, biomonitoring is a tool to define and correct toxicity problems in effluents; later it can serve as a compliance check.

This guidance may be used by municipal and industrial dischargers and their consultants. It is intended to be used in conjunction with existing regulations and other Agency policies and guidance documents. Among the concerns addressed will be:

1. Selection of dischargers subject to biomonitoring,

2. Suggested procedures for effluent biomonitoring,

3. Interpretation of Results, and,

4. Toxicity Reduction Evaluations.

II. Identification of Candidate Discharges

Any facility discharging into the Waters of the State is subject to investigation under biomonitoring procedures. While all NPDES discharges should receive at least a minimal review of toxic substance or toxicity

Printed on Recycled Paper

concerns, Facilities in a few general categories will require a more intensive review and, in many cases, additional data gathering efforts. The information needed for an adequate assessment will be somewhat site-specific; however, the following guidelines should be followed as appropriate:

1. Major Industries (USEPA reviewed permit except power plants): During the next round of permit reissuence, selected major industries discharging process wastewater will be required to provide biomonitoring data in addition to their 2C application form. Acute testing will be required for all discharges. Testing must have been completed within two years of the permit expiration date. For those facilities discharging to General Use waters with a dilution ratio of less than 100 to 1, chronic testing may also be required. Data requirements will be further discussed in Part III. For many facilities, additional biomonitoring results will be available from IEPA or USEPA testing programs. It is the Agency's intent to perform screening tests on most facilities as permits approach renewal dates.

2. Power Plants: Biomonitoring will not usually be required with the application, but any available results will be reviewed by the Agency. See number 4 below.

3. Minor Industries: Biomonitoring will not usually be required with the application, but any available results will be reviewed. Chemical data or instream biological survey results may trigger a requirement for biomonitoring to be placed in the permit, with a reopener for follow-up based on the results. Considerations for making this determination include:

   a. One or more substances discharged at levels of concern for acute or chronic toxicity.

   b. A potential to discharge a number of organic substances whose identities or effects are not known, or whose effects may be additive.

   c. Available dilution in the receiving stream.

   d. Type of industry.

   e. Proximity to other discharges.

   f. Site-specific information provided through IEPA or USEPA surveillance or monitoring activities.

4. Cooling Water Discharges: Toxics information is generally not required, beyond the evaluation of additives and water treatment chemicals. Cooling tower blowdown should receive more scrutiny than once-through discharges. Biomonitoring may be required when system maintenance chemicals have not been adequately characterized for toxicity and environmental fate.

5. Mines: Same as power plants, above.

69

6. Major Municipals: (USEPA reviewed permit) Permits are currently being written which require biomonitoring test results with the application for renewal. Any available results such as those from IEPA and USEPA surveillance or monitoring will be reviewed as well as chemical data submitted in conjunction with the pre-treatment program. It is the Agency's intent to perform screening tests on most facilities as permits approach renewal dates.

7. Minor Municipals: Same as major municipals, except that the Agency will perform screening tests only on facilities where a toxicity problem has been indicated by stream surveys, etc. No biomonitoring will be required with application for renewal.

8. Non-Municipal Domestic Plants: Unless site-specific information to the contrary is available, no further toxics evaluation will be required at this time.

9. Other Discharges: The review engineer will use judgment based on similarities to the above categories.

In most cases, Agency bioassay screening for the potential need for biomonitoring in permits will be conducted approximately one to one and one half years before expiration of permits. Permits will not usually be reopened during their term to incorporate biomonitoring or chemical-specific testing unless screening has been done by IEPA or USEPA. Modified permits will usually allow additional testing (Biological, chemical, or both) to confirm Agency findings. Toxicity limits or control requirements will not be based on the results of a single screening test except in exceptional circumstances.

III. Definition of Toxic Concerns

In water pollution programs there are two principal toxic concerns; human health effects and aquatic life impacts. Evaluation of aquatic life impacts will be required for essentially all discharges (General Use waters) chosen for biomonitoring. Procedures for addressing human health concerns are based on a review of the chemical composition of the effluent compared to derived human health criteria. The Technical Support Document (TSD) is a valuable source of information on biomonitoring and toxics control (4).

Aquatic Life Impact Assessment -

Assessment of impacts on aquatic life may be conducted using a phased testing approach to minimize requirements for unnecessary or redundant biomonitoring. The complexity of analysis required for the first phase of testing will be dependent on available dilution of the receiving waterbody and the availability of biosurvey data. The Agency will consider alternate test protocol and/or test organisms upon receipt of adequate justification by the discharger. The algae test is usually reserved for industrial discharges where algicidal substances may be present.

70

1. Dilution Ratio: For purposes of this guidance "dilution ratio" (DR) is defined as the ratio of the receiving stream flow immediately above the point of discharge at the 7 day, 10 year low flow recurrence interval, to the average dry weather flow of municipal discharges and to the design average flow or other appropriate representative flow from industrial discharges. If the total discharge from a given facility consists of more than one discharge point (except cooling water) to the same receiving stream, the dilution ratio is the stream flow (7Q10) upstream of the furthest upstream discharge point to the sum of the appropriate flow for all discharge points. For discharges occurring during wet weather periods, dilution ratio will be determined on a case-by-case basis giving consideration to the frequency of discharge and anticipated receiving stream flow at the time when discharge is expected to occur.

   a. High Dilution Streams - For discharges to General Use Streams with a dilution ratio of greater than or equal to 100:1, the first phase of biomonitoring will require testing at three trophic levels for industrial dischargers while the algae test will usually be omitted for municipals. The following acute tests are recommended based on their appropriateness for Illinois waters and the availability of detailed test protocols and literature information. These tests may be replaced or augmented as advancements in bioassay technology are achieved. Non-renewed static tests are usually adequate although renewals of effluent solution may be made as special objectives dictate. Flow through tests may be required on a site specific basis. Exceptions to cited federal protocol are given in the footnotes below.

      - Fish - 96 hour static renewal LC_{50} bioassay using one to five day old fathead minnows (*Pimephales promelas*)(1)*

      - Invertebrate - 48 hour static EC_{50} bioassay using neonate (< 24 hours old) *Ceriodaphnia dubia* (1) This is an unfed test.

      - Plants - 96 hour static Algae bioassay (*Selenastrum capricornutum*) (2) using EDTA medium**

*24 hour or less age range of fatheads within the one to five day age window is preferred in tests but a 48 hour range is acceptable.

71

b. Low Dilution Waters - For discharges to General Use streams with a dilution ratio of less than 100:1 and all lakes, chronic bioassays may be required in addition to or in lieu of the battery of acute tests listed above. Generally, chronic tests are required on a site specific basis where more detailed toxicity data is thought to be needed. Chronic testing may be required at three trophic levels. The following short term chronic tests have been well documented in the literature and USEPA has provided detailed protocols for their use.

- Fathead Minnow (*Pimephales promelas*) Larval Survival and Growth Test (2)

- *Ceriodaphnia* Survival and Reproduction Test (2)

- Plants - 96 hour static algae bioassay (*Selenastrum capricornutum*) using EDTA medium (2).

Protocols for other species are available from USEPA and other sources (e.g., ASTM) and may be acceptable for use, however, test species should be selected so that chronic data can be directly compared with the acute test utilized. Detailed information on these tests and two other short term chronic tests is included in the USEPA publication "Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms". (2)

Under some circumstances, the standard test battery of three species may be reduced. Algal tests usually will not be required for municipal effluent testing. Where prior data strongly suggest that one species is consistently more sensitive than another, only the more sensitive species may required in the monitoring program. In some cases permit biomonitoring requirements will recognize that a sensitive species has been determined and only one or two species must be tested. The permit may also contain language that allows a reduction in the number of species tested if the first few test series indicate consistent sensitivity patterns. An important factor when reducing the species

**The effluent concentration shown to be algicidal (lethal) will be determined. Aliquots from test concentrations showing no measurable growth after 96 hours (less than 25,000 cells/ml) are added to fresh growth media. If no growth occurs after seven days, the concentration is considered algicidal (3). The lowest exposure concentration producing an algicidal effect at 96 hours is then reported as the acute result. A chronic result, based on inhibition of algal growth, is also obtained in this test and should be reported.

72

tested from the three given above is the perceived variability of the effluent. Requests to reduce species tested from an effluent that is known to vary in composition will be denied.

The Agency's Toxicity Testing Unit (TTU) is continually gaining the ability to perform more sophisticated tests. Often, procedures conducted during routine effluent screening can identify a toxicant (particularly ammonia) as the primary or exclusive source of toxicity in the sample. When the substance identified is permitted in the facility's permit at a level over the toxic level due to the availability of dilution and the recognition of best degree of treatment, the Agency may not require additional testing as a permit requirement. Such facilities will be monitored by the Agency at least once per permit period to check for additional toxicity from other causes.

2. Scope and Frequency of Testing - Unless historical biomonitoring data are available to provide an initial characterization of the effluent comparable to that outlined below, the discharger will be required to collect this information as part of NPDES permit requirements.

   a. Frequency and duration of initial effluent characterization. Generally, data collection should occur over a six month period with at least one round of bioassays conducted every month. This period may be expanded to one year where seasonal conditions or effluent variability warrant. Likewise, the once per month frequency of testing may be altered based on facility or process variation. For example, the number of chronic tests required over this initial period may be reduced when effluent homogeneity can be demonstrated. Changes in process or source of raw materials may necessitate more frequent testing. Dischargers will be required to submit a biomonitoring plan (see (g) below) for Agency approval prior to the onset of testing. This plan must provide justification for any deviations from the basic six month testing period and monthly frequency.

      Where daily variation is evident, several samples collected over a 24 hour period will be tested. The Agency will base sampling frequency requirements on effluent chemistry data, process information, past experience with the effluent in question and other pertinent information.

      Where conditions dictate a less rigorous biomonitoring program, such as at minor municipal facilities, quarterly sampling may be required. This increment of testing may also be utilized where biomonitoring for compliance rather than discovery and characterization is desired. Semi-annual and yearly testing may also be instituted under these circumstances.

b. Sample collection. Composite (24 hour) samples shall be collected for effluent bioassays. A 24 hour composite sample shall consist of at least eight sample aliquots of at least 100 mL, collected at periodic intervals during the operating hours of the facility over a 24 hour period. However, certain special circumstances may allow or require that grab samples be utilized. The sample should be chilled to approximately 4°C during collection and shipping. Seven day chronic tests will be conducted on composites collected on Monday, Wednesday and Friday or similar intervals. Sufficient sample must be collected to provide for daily renewals of test solutions. The consulting laboratory will give instructions on volume of samples needed.

The sample must be shipped to arrive at the laboratory within 36 hours of collection. Composite samples should be initiated with air express or other transportation mode deadlines in mind.

The discharger must ensure that variability is accurately depicted by conducting required tests on samples that are typical of the day-to-day output of the facility. Sampling should occur at the same time of the month throughout the duration of the biomonitoring plan. Upset events or process changes that occur during scheduled sampling should not be avoided. The Agency should be consulted during these events to determine if additional samples should be collected subsequent to the unusual event to represent normalized operation during this period. Other unusual events that would prevent normal treatment from occurring, such as malfunction of treatment equipment or heavy rainfall resulting in flow beyond design maximum, should be reported to the Agency before samples are collected. Depending on circumstances, the Agency may advise to delay the scheduled bioassays. Standards Unit of DWPC Planning Section should be contacted immediately at 217/782-3362.

c. Dilution water. Dilution water for use in a bioassay should be obtained from the receiving stream at a point upstream from the discharge. Care should be taken to collect a dilution water sample that has not been contaminated with the effluent of concern through a backflow situation or by eddy currents. If the upstream receiving water is deemed unsuitable for use in bioassays because of ambient toxicity or other reasons, laboratory dilution water may be used. This water must be similar to area surface water in regard to hardness, alkalinity and pH. In many cases a better alternative would be to collect dilution water from a local lake or stream of known good quality. Illinois lakes and streams are often highly loaded with suspended solids. It is permissible to allow dilution water to settle before being used in a bioassay. Settling should remove any potentialtoxicants from ambient waters. The procedure for determining acceptability of dilution water found in reference (1) should be followed. This decision should be justified in the biomonitoring plan.

74

d. Definitive vs. Screening tests. Generally, definitive tests using a 100, 50, 25, 12.5 and 6.25% dilution series will be required. After initial characterization, the dilution series should be altered to insure that at least one concentration with no mortalities exists. In certain situations, screening tests may be allowed but these instances will not usually entail routine biomonitoring plans.

e. Agency review of data. The discharger must provide the Agency with a copy of the biomonitoring results within one week of its release from the laboratory and no later than one month from the initiation of the tests. Based on review of these reports the Agency may require changes in the biomonitoring plan. These may range from technical caveats, directed at the bioassay laboratory, to decisions regarding the continuation of the toxicity characterization process in light of recently gathered evidence. Should two or more bioassay results indicate that one species is more sensitive to the effluent than the others, this species may be used exclusively in the remaining tests upon Agency approval. The initial biomonitoring plan may also be terminated completely if two separate sampling dates produce unacceptable toxicity results. Should this occur, the initial characterization process would conclude and the effluent would be evaluated as described in the next section.

f. Bioassay reports. Laboratories should generally follow the reporting guidelines in USEPA methods manuals (1)(2). Total ammonia (as N) and total residual chlorine measurements on the effluent used for bioassays must be reported. Reports should pay close attention to reporting LC_{50}, EC_{50} or NOAEL values and any unusual circumstances either at the facility or during testing.

g. Biomonitoring Plan. A permit Special Condition will notify the discharger that effluent biomonitoring is required. It will request that the permittee submit a plan of study referred to as a "biomonitoring plan". Also contained in the permit Special Condition will be the Agency's recommendation of the types of tests required, species to be used and frequency and duration of testing. Submittal of the biomonitoring plan allows the permittee and the Agency to agree to all details associated with effluent biomonitoring at the facility so that fewer surprises are discovered once tests have already been completed. The permittee may describe unique circumstances present at the facility in the biomonitoring plan and negotiations will be held before testing is initiated. Changes in the recommendations may or may not require permit modification.

Items to be covered in a biomonitoring plan should include, at a minimum, the following:

1. Facility name, permit number, outfall number, Special Condition number containing biomonitoring requirement.

2. Bioassay types to be conducted and species to be used, frequency and duration of testing (usually a reiteration of permit language).

3. Sampling procedure and method of shipment, i.e. grab or composite sampling, air express or hand carried delivery to laboratory, etc.

4. Source of dilution water. A reasonable attempt should be made to utilize upstream receiving water for this purpose. Questionable waters can be subjected to the screening procedures outlined in the EPA's method for performing acute tests (1) ahead of time. Using a laboratory water for dilution of the effluent is more convenient but does not as accurately represent the true environmental situation of effluent mixing with upstream receiving water.

5. Contract Laboratory. If the contract lab for biomonitoring has been determined, this should be given in the biomonitoring plan. Often these firms can aid dischargers in the writing of the plan. A prospective contract lab should have QA/QC and test protocols on file with the Agency. Any lab on the Agency's "Combined Lists of Environmental Laboratories" has these already on file. Due to the complexity of bioassays, the Agency strongly discourages permittees from attempting to perform these tests on their own.

6. Any unique circumstances should be explained and procedures may be proposed for necessary changes to Agency biomonitoring recommendations. The permittee may wish to add tests or accelerate the frequency of testing to better solve a problem. Questions should be directed to the Division of Water Pollution Control, Planning Section. The plan should be submitted to the Compliance Assurance Section.

7. The Agency will promptly respond to the biomonitoring plan by letter either approving the plan and setting a time frame for testing, or itemizing deficiencies and offering explanation of why the plan is not acceptable.

3. Evaluation of Findings

Bioassay results will be reviewed for compliance to 35 Ill. Adm. Code Section 302 in light of the Illinois Permitting Guidance for Mixing Zones. Bioaccumulative substances present in concentrations greater than the water quality criteria as determined in Subpart F will be evaluated with due concern for this characteristic as described in the mixing zone document. Discharges that do not meet toxicity criteria will be required to perform a Toxicity Reduction Evaluation (TRE). Whole effluent toxicity limits or chemical specific limits as toxicants become known, may be established through permit

modification or reissuence. Newly applied discharge limits will be accompanied by an appropriate compliance schedule, typically not to exceed three years.

a. Acute Toxicity - The LC_{50} (Lethal Concentration causing 50% mortality to test organisms) or EC_{50} value for an effluent (expressed as a percent of whole effluent) may not be less than the effluent concentration at the edge of the Zone of Initial Dilution (ZID). See Part 6 below.

b. Chronic Toxicity - Chronic effects expressed as NOAEL or NOEC values (No Observable Adverse Effect Level or No Observable Effect Level) will not occur outside the mixing zone.

4. Multiple Source Considerations - Dilution water will usually be taken from the receiving stream at a point immediately upstream of the discharge. When toxicity associated with upstream sources is suspected, additional biomonitoring runs can be made with uncontaminated upstream water or other water with pH and hardness charactertistics similar to the receiving stream. Such additional biomonitoring must be done in parallel with tests using receiving stream dilution water and the same test organisms and sampling frequency. If control toxicity associated with receiving stream water is statistically significant when compared to controls using "uncontaminated" water, the results may be submitted to the Agency for review prior to development of a "Toxicity Reduction Evaluation" (see below).

5. Instream Biological Surveys - The Agency considers instream biological surveys to be the definitive method of assessing overall toxic inputs to a waterbody. Bioassay findings (i.e. toxicity test results) may be substantiated with biosurvey results where similar habitat exists upstream and downstream of the effluent or when other comparative methods are available. Biosurveys are practical on most medium and smaller sized streams but become costly and less conclusive on large rivers.

   Biosurveys are a valuable method of determining effluent variability since native aquatic communities are exposed to potential toxicity continuously. Short term, sporadic upsets at a facility may be nearly impossible to detect by routine bioassays but may have a profound and lasting effect on the aquatic community. Biosurveys will be conducted in conjunction with toxicity testing whenever possible. Discharges which show no appreciable toxicity during the bioassay period yet have been demonstrated by a biosurvey to cause a significant impact on the instream aquatic community will be targeted for periodic bioassays. This work can be done at times of critical process changes, seasonal loadings or other circumstances that may result in the identification of whole effluent toxicity.

   In other cases, toxicity identified in the laboratory may not be reflected in the aquatic community. This may result from factors such as instream degradation of the toxicant or acclimation of native aquatic organisms. Biosurvey results that substantiate this situation may reduce or eliminate the need for bioassay requirements in the permit.

77

6. Mixing Zone Considerations - Mixing zones for toxic effluents must not interfer with the natural processes of the aquatic ecosystem. Critical ecological areas must not be impacted by chronic toxicity (e.g. tributaries, spawning areas, mussel beds, etc.) nor may greater than 25% of the channel width fall in an area of chronic effects (50% where less than 3:1 mixing is present). Acute toxicity is not allowed except in cases where a Zone of Initial Dilution (ZID) has been granted. The ZID is always a small area where initial dilution is allowed to occur before standards must be met. If no ZID is allowed, acute mortality may not exceed 50% in 100% effluent (LC50 = 100%). Acute toxicity is evaluated in terms of the allowable size of the ZID. Consult the "Illinois Permitting Guidance for Mixing Zones" for details. The regulatory mixing zone must be applied for and granted to the discharger by the Agency.

IV. Toxicity Reduction Evaluation

All Toxicity Reduction Evaluations (TRE) will be negotiated but plans will be developed expeditiously. USEPA has guidelines for conducting a Toxicity Identification Evaluation (TIE) (5), (6) and (7). Basically, these consist of a variety of laboratory procedures to localize toxicity to certain classes of compounds, then identify these compounds more specifically and confirm that they are the cause of effluent toxicity. More elaborate fractionization, chemical analysis, degradation of toxicity and correlation studies may be necessary as a follow-up, depending on the complexity of the situation.

The USEPA also has documents describing how TREs may be conducted for industrial and municipal discharges (8) and (9). The TRE usually begins with a TIE and once the problem substances are discovered, the TRE aims to find ways to eliminate them. This may be a change in raw materials, process, a housekeeping change, or additional treatment or pre-treatment. In this stage of the TRE process emphasis shifts from the laboratory to the facility. With the chemical information in hand, those most familiar with the process and/or waste stream treatment must now devise ways of eliminating toxicity or at least bringing it down to acceptable levels.

The documents referenced above deal with TREs conducted on effluent exhibiting acute toxicity. In order for these studies to be successful, effluent toxicity must be of a magnitude that will allow TIE fractionizations to produce a significantly toxic manipulated sample for comparison to unaltered effluent and controls. The effluent toxicity also must be consistent to the degree that most samples collected and shipped to the laboratory for TIE studies will exhibit the necessary magnitude of toxicity to produce results. A general rule-of-thumb is that LC50 values must be as low as 75-80% effluent to have a fair chance at identifying the toxicant. Attempting TIEs on effluents with lesser levels of toxicity will most likely prove futile. The Agency's philosophy is that as toxicity becomes more severe, frequency of effluent toxicity events could be lower (i.e., toxicity is highly variable with some samples showing no toxicity) and a TRE would still be justified. In other words, the greater the severity of toxicity, the less often it would need to be present to represent a valid environmental concern.

78

Recently, USEPA published a method for conducting chronic TIEs.[10] It is anticipated that this protocol will be used far less often than the more well-established acute procedure. The same limitations on the magnitude and frequency of toxicity probably apply but no Agency experience with this method has yet been obtained. It is anticipated that chronic TREs will be required for facilities where no acute effluent toxicity has been demonstrated yet chronic toxicity and stream community degradation (from biosurvey conclusions) are present.

V. Permitting Implications

Biomonitoring as outlined above, is utilized in NPDES Permits for the discovery and remediation of effluent toxicity. When the process has progressed to the point where toxicants are identified, the permit can be used to limit these substances based on water quality standards. These permit limits may be accompanied by a compliance schedule for additional treatment or process changes to meet these identified water quality standards. Although it is generally the Agency's policy to limit individual chemical substances in the permit, the Clean Water Act and State standards also support the use of whole effluent toxicity (WET) limits. This method is especially useful when the toxicants involved defy attempts to be identified through TIEs.

Biomonitoring may also be used as a compliance tool. Where whole effluent limits are in force, compliance monitoring will always include bioassays. For facilities where TRE programs have been utilized, compliance biomonitoring will usually be instituted to insure that all toxicity has been controlled and that treatment is indeed effective.

VI. Quality Assurance/Quality Control

A. Agency QA/QC Policy - The Toxicity Testing Unit (TTU) at IEPA conducts bioassays and other biomonitoring activities for the Agency. TTU has implemented a QA/QC program to document standardization and calibration procedures, as well as to ensure the accuracy and reliability of in-house bioassay data. A QA manual, which details unit organization, instrument calibration and general laboratory procedures, sample collection and chain-of-custody requirements, and data analysis and reporting rules, is available. This QA manual, along with the Standard Operating Procedures (SOP) manual and test protocols for each test routinely performed, forms a relatively rigid guideline for the conduct of aquatic bioassays, guaranteeing that the Agency will produce reliable, defensible data.

The TTU QA manual is written to comply with the Good Laboratory Practices Standards (GLPs) found in 40 CFR Part 792, required by USEPA for biological testing of chemicals under TSCA. These standards, which were written to regulate quality assurance in testing of potentially toxic compounds, are equally applicable to effluent testing. They delineate the proper general procedures for conducting laboratory testing, and are concerned with the conditions under which laboratory studies are planned, performed, monitored, recorded, and reported. While the GLPs are not enforceable under NPDES, they are nonetheless convenient and ultimately safe (conservative) guidelines under which to produce evidential data.

The chemistry labs (Division of Laboratories) at IEPA also have a QA plan and manual which governs analytical procedure for a variety of chemical analyses. Chemical measurement data, however, require specific objectives for precision, accuracy, and completeness which are not required or reasonable for biological testing.

B. Private Laboratory QA/QC Requirements - Most private laboratories, including contract facilities, have developed their own QA manuals for internal use. It is highly recommended that private labs conform to GLPs as outlined in the preceding section.

The permittee should request and receive a QA plan for their project along with the contractor's bid and/or proposal. The plan should include laboratory instrument calibration frequency and control, source and handling conditions of organisms used in the tests, and a reference toxicant program for the batch of organisms used to ensure that they are healthy and of average sensitivity. Test protocols supplied with the biomonitoring proposal should include the dilution series to be used, a laboratory control, number of organisms per volume of test chamber, total number of organisms exposed, and the age of the organisms.

C. Contract Laboratory for NPDES Biomonitoring - A document entitled "Combined Lists of Environmental Laboratories" is provided for the convenience of those requiring bioassay services. The list is not intended to be a complete inventory of contract labs nor does inclusion in the list constitute an endorsement by the Agency. This document is available from the DWPC Planning Section Standards Unit, (217)782-3362.

REFERENCES

1. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms. 4th Edition USEPA EPA/600/4-90/027. September, 1991.

2. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Second Edition. USEPA EPA/600/4-89/001. March 1989.

3. The Selenastrum capricornutum Printz Algal Assay Bottle Test. USEPA EPA-600/9-78-018. 1978.

4. Technical Support Document for Water Quality-Based Toxics Control. USEPA EPA/505/2-90-001. March 1991.

5. Methods for Aquatic Toxicity Identification Evaluations. Phase I. Toxicity Characterization Procedures. Second Edition. USEPA EPA/600/6-91/003. February 1991.

6. Methods for Aquatic Toxicity Identification Evaluations. Phase II. Toxicity Identification Procedures. USEPA EPA/600-3-88/035. February 1989.

7. Methods for Aquatic Toxicity Identification Evaluations. Phase III. Toxicity Confirmation Procedures. USEPA EPA/600/3-88/036. February 1989.

8. Generalized Methodology for Conducting Industrial Toxicity Reduction Evaluations (TREs). USEPA EPA/600-2-88/070. April 1989.

9. Toxicity Reduction Evaluation Protocol for Municipal Wastewater Treatment Plants. USEPA EPA/600-2-88/062. April 1989.

10. Toxicity Identification Evaluation: Characterization of Chronically Toxic Effluents, Phase I. USEPA EPA-600/6-91/005. June 1991.

RM:rmi/0997j/sp, 1-14

81

SECTION 5

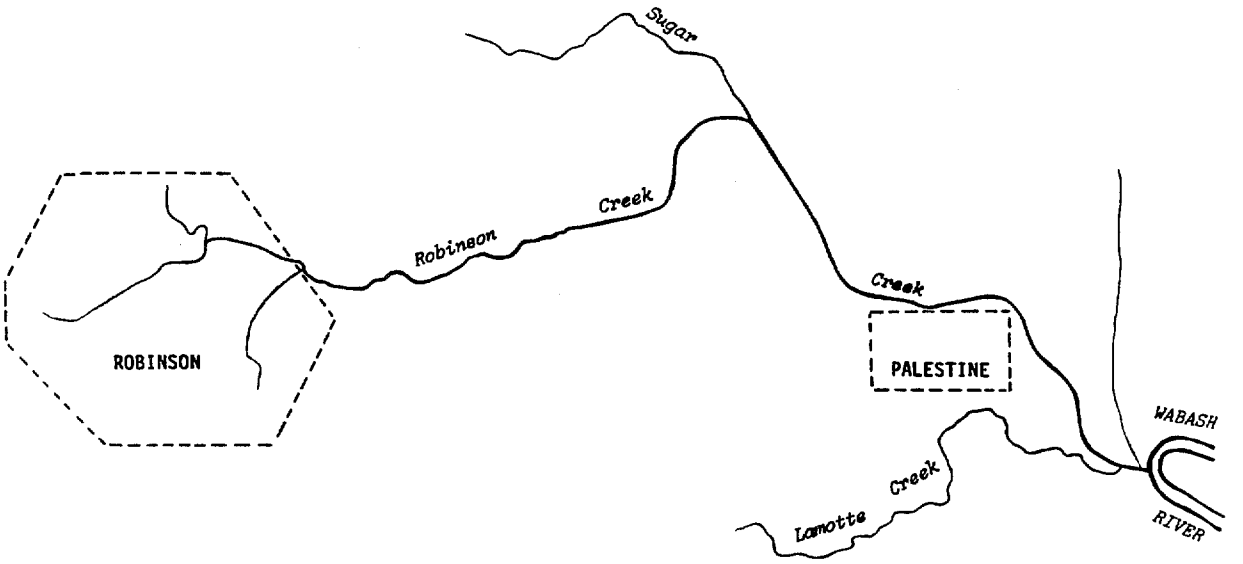
Illinois
Environmental
Protection Agency

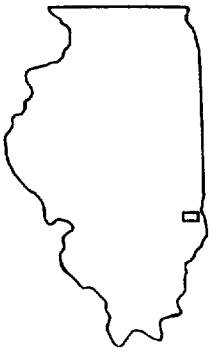
Bureau of Water
2200 Churchill Road
Springfield, IL 62706

June 1993

IEPA/WPC/93-063

A Biological and Water Quality Survey of Sugar Creek and Tributaries Crawford County, Illinois 1992





Printed on Recycled Paper

83

FORWARD

This Illinois Environmental Protection Agency (IEPA) report is a product of an ongoing state-wide effort to assess Illinois stream quality and to identify causes and sources of surface water use impairments. This report, which describes the quality of surface water resources in the Sugar Creek watershed in the vicinity of Robinson, Illinois, is one of a series of special IEPA reports which focus on the assessment of impacts from municipal and industrial wastewater point source discharges. A complete list of IEPA reports developed from this and other stream monitoring programs is provided on the last two pages of this report.

A BIOLOGICAL AND WATER QUALITY SURVEY OF SUGAR CREEK AND TRIBUTARIES, CRAWFORD COUNTY, ILLINOIS

AUGUST-SEPTEMBER, 1992

by
Marvin M. King
and
Robert L. Hite

Monitoring and Assessment Unit
2309 West Main Street
Marion, Illinois 62959

STATE OF ILLINOIS
ENVIRONMENTAL PROTECTION AGENCY
DIVISION OF WATER POLLUTION CONTROL
PLANNING SECTION

June 1993

85

CONTENTS

SECTION		PAGE
	LIST OF TABLES	ii
	LIST OF FIGURES	iii
	ACKNOWLEDGEMENTS	iv
I	SUMMARY	1
II	INTRODUCTION	3
III	PERMITTED WASTEWATER DISCHARGERS	6
IV	WATER QUALITY	8
V	MACROINVERTEBRATES	12
VI	FISH COMMUNITIES	16
VII	STREAM HABITAT AND BIOTIC INTEGRITY	19
VIII	BIOLOGICAL STREAM CHARACTERIZATION	22
IX	AQUATIC LIFE USE SUPPORT	25
X	DISCUSSION AND CONCLUSIONS	27
XI	LITERATURE CITED	30
XII	APPENDIX	32

26

LIST OF TABLES

TABLES PAGE

1 Permitted wastewater dischargers in the Sugar Creek watershed, 1992.. 6

2 Mean concentrations of selected water quality constituents from Sugar Creek ambient monitoring network site BF-01, 1987 to 1991..... 10

3 Stream quality criteria for Illinois streams..... 12

4 Fish community characteristics in Sugar Creek and tributaries near Robinson, Illinois..... 18

5 Comparison of biotic integrity (AIBI) and potential biotic integrity (PIBI) in Quail, Robinson, Sugar, and Lamotte Creeks, 1992 and 1986. 21

6 Biological Stream Characterization (BSC) criteria for the classification of Illinois streams..... 23

7 Biological Stream Characterization (BSC) ratings and stream reach descriptions for Sugar Creek and tributaries, Crawford County, Illinois, as of 1992..... 24

8 Aquatic life use support criteria for Illinois streams..... 26

APPENDIX TABLES

TABLE		PAGE
A	Stream sampling sites in Sugar Creek and tributaries and types of samples collected in the vicinity of the Robinson and Palestine MWWTP'S and the Marathon refinery, Crawford County, Illinois, 1992...	32
B	Effluent sample analysis results for samples collected by IEPA at the Robinson municipal wastewater treatment plant, 1988 to 1992.....	33
C	Field and laboratory water chemistry from Sugar Creek and tributaries and effluent samples in the vicinity of Robinson and Palestine MWWTP's and the Marathon refinery, August 20, 1992.....	34
D	Effluent sample analysis results for samples collected by IEPA at the Marathon refinery wastewater treatment plant, 1988 to 1992.....	35
E	IEPA AWQMN Data for Site BF-01, Sugar Creek at Palestine, 1985-1991..	36
F	Macroinvertebrate community sampling results from Sugar Creek and tributaries in the vicinity of Robinson MWWTP, Marathon Refinery, and Palestine MWWTP, August 1992 and July 1986.....	43
G	Fish community sampling results from Quail, Robinson, Sugar, and Lamotte Creeks, September 1992.....	44
H	Stream habitat characteristics of Sugar Creek and tributaries near Robinson, Illinois, July 1986 and August 1992.....	45
I	Aquatic life use support ratings and causes and sources of impairment for Sugar Creek and tributaries, Crawford Co., Illinois, as of 1992..	46

LIST OF FIGURES

FIGURES		PAGE
1	Stream sampling sites and wastewater dischargers in the Sugar Creek watershed, Crawford County, Illinois, summer 1992.....	5
2	Macroinvertebrate Biotic Index (MBI) values and taxa richness in Robinson Creek and Sugar Creek, in the vicinity of Robinson MWWTP and Marathon refinery, 1986 and 1992.....	14
3	Alternate Index of Biotic Integrity (AIBI) values and species richness in fish communities of Robinson, Sugar, Lamotte, and Quail Creeks, in October 1986 and September 1992.....	17

88

ACKNOWLEDGEMENTS

This survey and report were designed, conducted, and written by Southern Monitoring and Assessment Unit staff of the Division of Water Pollution Control at the IEPA Marion Regional Office. Data were tabulated by Joan Levesque. Water quality samples from streams and wastewater effluents were collected by James Bivens and Joan Levesque. Fish population sampling was conducted by Robert Hite and Christopher Bickers; fish samples were identified by Chris Bickers. Macroinvertebrate sampling and identification, stream discharge measurements, and stream habitat assessments were carried out by Marvin King and Merrill Matson. Analyses of all chemical constituents in water samples were performed at the IEPA Champaign Laboratory under the direction of Roy Frazier. Data management and quality assurance support were provided by Springfield Planning Section staff Marilyn Budd and Mike Branham. The comments and suggestions provided by Standards and Monitoring Unit Manager Bob Mosher were appreciated.

SECTION I EXECUTIVE SUMMARY

1. OVERVIEW

- A biological and water quality survey of Sugar Creek and tributaries in the vicinity of Robinson, Illinois, in Crawford County, was conducted by the IEPA during the period of August 18 to September 2, 1992. Sugar Creek, a tributary of Wabash River, is 14 miles long and has a watershed of 69.5 square miles. Major wastewater dischargers in the basin are the Robinson municipal facility (MWWTP) and the Marathon Petroleum Company refinery, both of which discharge to Robinson Creek. This survey was designed primarily to assess impacts of wastewater from these two sources upon water quality and biotic integrity of the receiving streams.

2. AMBIENT WATER QUALITY CONDITIONS

- An assessment of chemical and biotic data for Robinson Creek and Sugar Creek indicated:

  a. poor stream conditions in Robinson Creek downstream from the city of Robinson and upstream from Robinson MWWTP;
  b. additional degradation downstream from Robinson MWWTP, including elevated concentrations of total dissolved solids (TDS), chemical oxygen demand (COD), nitrate+nitrite, phosphorus, sodium, and chloride; and
  c. further degradation of ambient water quality downstream from Marathon outfall 001 and outfall 002 (via Marathon Creek), including elevated TDS, chloride, water temperature, COD, nitrate+nitrite, phosphorus, sodium, sulfate, barium, chromium, strontium, and arsenic.

3. AQUATIC LIFE -- MACROINVERTEBRATES

- Aquatic macroinvertebrate communities in an upstream-to-downstream continuum of Robinson Creek indicated:

  a. poor conditions downstream from the city of Robinson;
  b. degradation 0.4 miles downstream from the Robinson MWWTP, followed by some improvement 1.2 miles downstream from this facility;
  c. additional degradation extending more than 1.7 miles downstream from Marathon outfall 001; and
  d. poor conditions extending more than 4.0 miles downstream from Marathon outfall 001, in Robinson Creek.

4. AQUATIC LIFE -- FISH

- Fish communities in an upstream-to-downstream continuum of Robinson Creek and Sugar Creek indicated:

  a. poor stream conditions downstream from Robinson MWWTP and upstream from Marathon outfall 001, in Robinson Creek;
  b. very poor stream conditions downstream from Marathon outfall 001 in Robinson Creek, particularly as indicated by very low species richness; and
  c. poor stream conditions in Sugar Creek.

90

5. VIOLATIONS OF WATER QUALITY STANDARD FOR TEMPERATURE

- Marathon effluent at outfall 001 caused violations of the water quality standard for temperature at Robinson Creek sites 0.1 and 1.7 miles downstream from that outfall, compared to the upstream site (which displayed elevated temperature due to Robinson MWWTP effluent) on 08/20/92. However, by extrapolation and comparison to water temperatures at sites on Robinson, Quail, and Lamotte Creeks, water quality violations for temperature extended approximately 4.6 miles downstream from the Marathon main outfall.

6. CONCLUSION AND RECOMMENDATIONS

- **Aquatic Life Use Impairment.** In summary, results of this survey indicated very poor to poor ambient water quality conditions and severe to moderate impairment of aquatic life use in Robinson Creek and Sugar Creek downstream from Robinson MWWTP and the Marathon Petroleum Company refinery.

- **Comparison to 1986 Conditions.** Compared to severe degradation identified in the 1986 IEPA survey, 1992 findings reflect little improvement in stream conditions in Robinson and Sugar Creeks downstream from the Marathon refinery.

- **Variability of Marathon Refinery Effluent.** This and previous surveys have documented high variability in quality and rate of discharge of effluent at Marathon outfall 001. It is recommended that this variability, including temperature and possible toxicity, be assessed by time-intensive collection of discrete samples and flow measurements <u>at outfall 001</u>.

- **Synergistic Effects of Heat and Toxic Materials.** It is recommended that possible damage to, and/or exclusion of aquatic life from Robinson Creek due to (1) thermal shock or (2) synergistic effects of heat and toxic waste materials be investigated.

- **Treatment of Wastes at Marathon Refinery.** Consideration should be given to requiring a final catchment basin to be built, through which <u>all</u> wastewater from the Marathon refinery would pass prior to discharge to receiving waters. This basin should provide the capability to capture and contain any contaminants resulting from inadequate treatment or accidental release until treatment is complete.

91

SECTION II INTRODUCTION

Background

The Sugar Creek watershed east of Robinson, Illinois has historically been impacted by wastewater from two major dischargers, the Robinson municipal wastewater treatment plant (MWWTP) and the Marathon Refinery at Robinson. Stream surveys conducted in the watershed to date have included surveys by the Illinois Environmental Protection Agency in 1972, 1978, 1986, and 1991 (Tucker 1972, Hite and Sullivan 1979, Hite et al., 1988, and Mosher and King 1991). Additional surveys of these streams were conducted by the Illinois Natural History Survey in 1976 (INHS 1979) and Radian Corporation in 1986 (Radian 1986). All of these surveys documented stream degradation downstream from Robinson and the Marathon Refinery.

The 1986 IEPA stream survey included four rounds of stream water and effluent samples for routine laboratory analysis: samples of aquatic macroinvertebrate and fish communities; analysis of water and sediment for toxic metals and organic compounds; effluent bioassays; and measurement of instream physical habitat. The 1991 IEPA survey consisted of fish community sampling at six stream sites and sediment sampling for sediment bioassays at three of these stream sites.

In 1989, the Marathon Refinery was granted a site-specific exemption from State General Use Water Quality standards for chlorides and total dissolved solids in Robinson Creek and Sugar Creek. This exemption contained the following conditions:

(1) Effluent from Marathon Petroleum Company's outfall 001 does not exceed either 3,000 mg/l total dissolved solids or 700 mg/l chlorides.
(2) The water in the unnamed tributary /Robinson Creek/ does not exceed 2,000 mg/l total dissolved solids or 550 mg/l chlorides.

Marathon Refinery has subsequently sought additional relief from State water quality standards and in 1991 requested a site-specific water quality standard of 1,000 mg/l for chloride in the 001 effluent and 750 mg/l in the unnamed tributary/Robinson Creek. This site-specific exemption request was predicated on the inability of Marathon to meet the site-specific chloride standards previously granted.

The Marathon site-specific request prompted a survey in 1992 to assess the current status of aquatic life and ambient water quality in Robinson Creek, Quail Creek, Marathon Creek, Sugar Creek, and Lamotte Creek, particularly downstream from the Robinson MWWTP and Marathon Refinery. During the period of August 18 to September 2, 1992, IEPA staff conducted a survey consisting of one round of stream water samples at 12 sites, three wastewater effluent samples, samples of macroinvertebrate communities at 12 sites, and fish community samples at seven sites. Descriptions of stream sampling sites and types of samples collected at each site are presented in Appendix Table A.

92

Description of Study Area

Sugar Creek originates approximately four miles north of Robinson (Crawford County, Illinois), and flows southeast approximately 14 miles to its confluence with the Wabash River, 1.7 miles southeast of Palestine (Figure 1). The Sugar Creek watershed spans 69.5 square miles and includes two major tributaries, Lamotte Creek and Robinson Creek, which are approximately 11 and eight miles in length, respectively. Lamotte Creek originates 3.6 miles southwest of Palestine in a rural agricultural area and flows east-northeast, receiving effluent from the Palestine MWWTP prior to its confluence with lower Sugar Creek. Robinson Creek begins west of Robinson, flows east-northeast through town, and receives flow from Robinson MWWTP, Quail Creek, Marathon Creek, and Marathon Refinery, within 1.5 stream miles from the city of Robinson.

Land use in the Sugar Creek basin is predominantly agricultural, with row crops and pasture land abundant. Spray irrigation of cropland is common in a portion of this watershed northwest of Palestine. Portions of Sugar Creek and its tributaries are bordered by riparian woodlands. Robinson and Palestine are the only significant urban areas in the watershed. An industrial complex, including Marathon Refinery, Union Carbide Corp., Victor-Dana Corp., Robinson Transformer Co., a Chamber of Commerce industrial lagoon, and a trucking firm, is located at the southeast side of the city of Robinson. Surface drainage from this industrial complex flows to four or more streams, including (1) Marathon Creek to the north, (2) two unnamed tributaries of Robinson Creek to the north and east, respectively, and (3) an unnamed tributary of Honey Creek to the southwest (outside the Sugar Creek watershed).

Stream channelization in the Sugar Creek basin is prominent in the area of irrigated and non-irrigated croplands northwest of Palestine. The lower six stream miles of Sugar Creek and the lower two stream miles of Robinson Creek have been channelized.

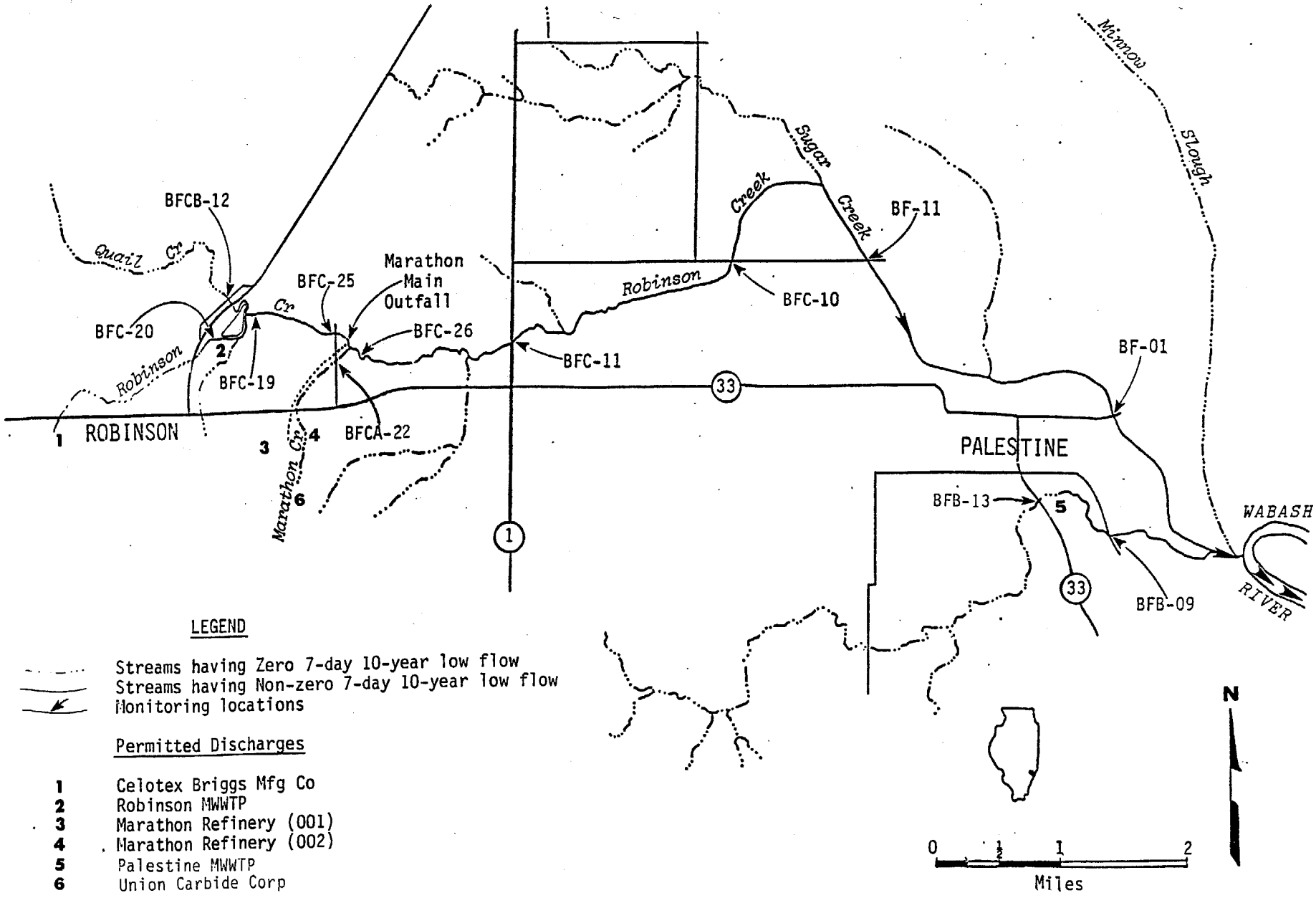


Figure 1. Stream sampling sites and wastewater discharges in the Sugar Creek watershed, Crawford County, Illinois, 1992.

96

SECTION III PERMITTED WASTEWATER DISCHARGERS

There are presently five NPDES-permitted wastewater dischargers in the Sugar Creek watershed (Table 1). Marathon Refinery and Robinson MWWTP are classified as major dischargers, with average effluent discharge rates of approximately 0.9 mgd (1.4 cfs) and 1.2 mgd (1.9 cfs), respectively. The other three facilities, Celotex Briggs, Union Carbide, and Palestine MWWTP, are classified as minor dischargers.

Table 1. Permitted wastewater dischargers in the Sugar Creek watershed, 1992.

Facility	Receiving Water Body	Stream Code	NPDES Permit Number	Design Flow (mgd)	Average Flow* (mgd)	Average Flow* (cfs)
Robinson MWWTP	Robinson Cr	BFC	27171	1.5	1.2	1.86
Marathon Refinery	Robinson Cr	BFC	4073 (001)		0.9	1.40
	Marathon Cr	BFCA	4073 (002)		**	
Celotex Briggs Co	Robinson Cr	BFC	4154		0.08	0.12
Union Carbide Corp	Marathon Cr	BFCA	4065	0.29	**	
Palestine MWWTP	Lamotte Cr	BFB	30520	0.9	0.36	**0.56

* Average effluent discharge rate, based upon Discharge Monitoring Reports.

** Discharges intermittently.

HYDROLOGY

Streamflow in Sugar Creek and tributaries is determined by surface runoff, shallow groundwater input, and wastewater from point sources. During prolonged periods of little or no rainfall, permitted effluents contribute a high percentage of the surface flow in Robinson Creek and Sugar Creek. Receiving streams of permitted effluents are shown in Table 1.

Historic effluent records of for Marathon's main outfall (001) and lagoon outfall (002) reveal great variation in discharge rates. For example, discharge monitoring reports (DMR's) for outfall 001, from October 1987 to March 1988, reported monthly effluent flows as follows: (1) minimums, 0 to 0.59 cfs, (2) means, 0.88 to 2.16 cfs, and (3) maximums, 1.22 to 3.59 cfs. IEPA staff estimated discharge rates of 6.4 and 0.2 cfs at outfall 001, on two days in July and August 1986. Marathon Refinery also discharges wastewater intermittently from a lagoon outfall (002), at the northeast side of the refinery. DMR's for October through December 1987 reported zero discharge from outfall 002 in October and November, and discharges ranging from 2.58 to 19.18 cfs in December.

95

EFFLUENT QUALITY

Quality of permitted effluents is assessed and monitored by (1) sampling and analysis by IEPA field staff and laboratories, and (2) self-monitoring by each discharger as reported in monthly DMR's. Chemical parameters for NPDES regulation and laboratory analysis are selected for each wastewater outfall on the basis of constituents which may be present and may contribute to degradation, toxicity, and/or violations of water quality standards in the receiving water body.

Robinson MWWTP

IEPA staff collected effluent samples at Robinson MWWTP on 21 dates, from June 1, 1988 to May 19, 1992. Total ammonia (as N) concentrations of 1.7, 3.6, and 3.7 mg/l were identified in three of these 21 samples (Appendix Table B). Total dissolved solids by residual on evaporation (TDS) and chloride were analyzed in only one of these samples (1/28/92), and were measured at concentrations of 897 and 285 mg/l, respectively. On August 20, 1992, the Robinson MWWTP effluent contained 1150 mg/l TDS, 499 mg/l chloride, 3.3 mg/l phosphorus, and 9 mg/l nitrate+nitrite as N (Appendix Table C).

Marathon Petroleum Company

IEPA staff collected wastewater samples inside the Marathon Refinery, presumably representing effluent at outfall 001, on 16 dates from February 23, 1988 to May 20, 1992. Total ammonia concentrations of 1.2 and 2.3 mg/l were identified in two of 14 samples (Appendix Table D). Chloride concentrations in 16 samples ranged from 23 to 714 mg/l, with a mean of 434 mg/l. Total dissolved solids concentrations in 16 samples ranged from 401 to 2200 mg/l, with a mean of 1748 mg/l. The following five components of TDS were analyzed, as total concentrations only, in 11 samples collected from 8/18/89 to 5/20/92: calcium, magnesium, sodium, potassium, and chloride. In these 11 samples, sums of concentrations of these five constituents were equivalent to the following proportions of TDS: minimum--0.50, mean--0.56, maximum--0.64. Total sulfate was analyzed in one of these samples, in which it was equivalent to an additional 35 percent of TDS.

In the Marathon effluent sample collected at outfall 001 during this survey (8/20/92), concentrations of dissolved calcium, magnesium, sodium, potassium, chloride and sulfate were essentially the same as total concentrations of these constituents. The sum of these six constituent concentrations comprised a calculated 152 percent of TDS (by ROE), for this sample. The cause of this calculated sum of component concentrations exceeding the analyzed TDS concentration in this sample has not been ascertained.

96

SECTION IV WATER QUALITY

METHODS

To characterize water quality in streams of the Sugar Creek basin, particularly in the vicinity of permitted wastewater dischargers, one round of samples was collected at 12 stream sites and three permitted wastewater outfalls. Water samples were collected in accordance with quality assurance procedures of the IEPA Field Methods Manual (IEPA 1987). Hand-held bottles or weighted bottle holders were used to collect depth-integrated samples representative of the water column. Samples were cooled on ice in the field and shipped to the IEPA laboratory for analysis. On-site measurements of pH, temperature, dissolved oxygen, and conductivity were made with Hydrolab instruments. Laboratory analyses were conducted for 36 water quality constituents. Both total and dissolved concentrations of 20 metals and metalloids were analyzed, resulting in a total of 56 laboratory parameters.

RESULTS

All stream water and effluent samples in this survey were collected on August 20, 1992. A summary of water quality findings for the five Sugar Creek basin streams sampled is presented below. Results of all field and laboratory water quality analyses are presented in Appendix Table C.

Lamotte Creek

Lamotte Creek drains a watershed of rolling terrain, with cropland, pasture, and wooded areas as major land uses. At Site BFB-13, downstream from most of the watershed of Lamotte Creek, no violations of General Use water quality standards (GUWQS) were found. At Site BFB-09, violations of GUWQS were identified for dissolved oxygen (2 mg/l) and total manganese (1400 ug/l). Phenols concentrations of 24.8 and 76.3 ug/l were measured in samples from Sites BFB-13 and BFB-09, respectively. Sources of these phenols are unknown.

Quail Creek

The Quail Creek watershed contains no NPDES-permitted wastewater point sources. This small stream displayed only one violation of GUWQS, for dissolved oxygen (1.5 mg/l).

Robinson Creek

At Site BFC-20, Robinson Creek downstream from the city of Robinson and upstream from Robinson MWWTP, no violations of GUWQS were identified. At Site BFC-19, 0.4 miles downstream from Robinson MWWTP, TDS (1200 mg/l) was the only GUWQS violation identified; chemical oxygen demand (COD, 27 mg/l), nitrate+nitrite (7.8 mg/l), phosphorus (2.8 mg/l), sodium (220 mg/l), and chloride (424 mg/l) were elevated; and phenols (18.8 ug/l) were measurable. Analysis of a sample of Robinson MWWTP effluent and comparison to upstream concentrations indicated that all of these elevated constituents at Site BFC-19 were largely attributable to that effluent. Concentrations of TDS, COD, nitrate+nitrite, phosphorus, sodium, and chloride at Site BFC-25, 1.2 miles downstream from Robinson MWWTP, were very similar to concentrations at Site BFC-19.

In Robinson Creek downstream from Marathon outfall 001 and the confluence with Marathon Creek, at Sites BFC-26, BFC-11, and BFC-10, elevated concentrations of TDS and chloride were in part attributable to Marathon 001 effluent, as indicated by effluent concentrations, and comparison of upstream to downstream concentrations. Marathon effluent at outfall 001 and Robinson Creek samples were in compliance with site-specific regulations for TDS and chlorides on August 20, 1992. Changes in water temperature at Sites BFC-26 (27.8 C) and BFC-11 (24.3 C) compared to Site BFC-25 (19.1 C) were in violation of GUWQS, and directly attributable to Marathon 001 effluent (30.1 C). Marathon 001 effluent concentrations of COD (33 mg/l), nitrate+nitrite (21 mg/l), phosphorus (1.8 mg/l), sodium (390 mg/l), sulfate (539 mg/l), barium (190 ug/l), chromium (78 ug/l), strontium (1600 ug/l), and arsenic (26.2 ug/l) also contributed to elevated concentrations of these constituents at Sites BFC-26, BFC-11, and BFC-10.

Marathon Creek

In Marathon Creek, a first-order stream downstream from Marathon outfall 002 and Union Carbide, at Site BFCA-22, the only GUWQS violation identified was the concentration of phenols (113.5 ug/l). No other strikingly elevated constituent concentrations were identified in this sample. Flow in Marathon Creek was so small compared to Robinson Creek that impact of this phenol concentration was not evident in Robinson Creek samples.

Sugar Creek

No surface flow was present in Sugar Creek upstream from the confluence with Robinson Creek during this survey. Robinson Creek was the major, and possibly the only, source of surface flow in Sugar Creek at Sites BF-11 and BF-01. This was very evident in the continuity of water quality, from Site BFC-26 to Site BF-01 (upstream to downstream). Similar or increasing concentrations of TDS, all of which exceeded the GUWQS, were present throughout the continuum from Site BFC-26 to Site BF-01. Trends of elevated but decreasing concentrations of COD, nitrate+nitrite, chloride, and chromium were evident in this continuum. Elevated and increasing concentrations of phosphorus and phenols were evident in these stream reaches (possibly due to interchange between sediment and water column). Elevated and fluctuating concentrations of sulfate, strontium, and arsenic were also evident.

Historic Water Quality (Station BF-01)

Water quality at Site BF-01 has been routinely sampled by IEPA since 1972 (except 1978) as part of the Ambient Water Quality Monitoring Network. Resulting data for October 1986 through July 1992 (USGS water years 1987-1992) are presented in Appendix Table E. Annual means of selected parameters for water years (WY, October through September) 1986 to 1992 are presented in Table 2. An elevated annual mean ammonia concentration (2.2 mg/l) in WY-1990 reflected two elevated concentrations (13.0 and 5.7 mg/l) among nine samples. Total phosphorus concentrations exceeding 1.0 mg/l were common at Site BF-01 throughout these six water years. An elevated mean concentration of phenols (110 ug/l) for WY-1991 reflected one high concentration (950 ug/l) and eight samples with phenols concentrations below the detection limit (5 ug/l). Estimated annual mean TDS concentrations, calculated as (0.6 X annual mean conductivity) did not correspond well with the sums of chloride and sulfate annual means, possibly indicating that (1) other components of TDS were important, (2) this formula for estimating TDS does not apply to the chemical composition of this stream, or (3) annual means were misleading.

Table 2. **Mean concentrations of selected water quality constituents from Sugar Creek ambient monitoring network Station BF-01, USGS water years 1987 to 1992 (October through September). All results are expressed as mg/l, except as otherwise noted.**

USGS Water Year	N	Fecal Coliform (#/100 ml)	Total Ammonia as N	Un-ionized Ammonia as N	Total Phosphorus	Phenol	Chloride	Sulfate	Total Dissolved Solids*	Conductivity (umhos/cm)
1987	9	1389	0.29	0.002	0.91	0.009	202	238	800	1333
1988	9	930	0.69	0.003	1.37	0.072	257	354	878	1463
1989	9	478	0.50	0.006	0.78	0.008	329	300	1099	1831
1990	9	373	2.21	0.022	0.89	0.008	222	243	761	1269
1991	9	919	0.21	0.004	1.70	0.110	238	335	1063	1772
1992	7	**19738	0.51	0.011	1.83	0.011	277	249	1051	1751

*Calculated as (0.6 X conductivity)

**Includes a concentration of 130,000/100 ml on 01/07/92

99

DISCUSSION

Effects of Chlorides and Other Dissolved Solids

Aquatic life is sensitive to numerous components of total dissolved solids, including chlorides, sulfates, and sodium; all were measured at elevated concentrations downstream from the Robinson and Marathon outfalls. These and many other dissolved solids components occur in unlimited combinations of salts and compounds with synergistic and antagonistic effects upon aquatic life. For this reason, available literature is not precise or rigid in establishing the concentration of each component which is harmful to aquatic life. For example, ORSANCO found that it was impossible to generalize on the effects of chloride concentrations on aquatic life, because each mixture of chlorides with other salts must be evaluated individually (McKee and Wolf 1963).

Concentrations of chlorides from 400 to 10,500 mg/l have been reported to be harmful to fish (McKee and Wolf 1963). Reed and Evans (1981) conducted laboratory bioassays to assess the acute toxicity (i.e., toxicity inducing mortality) of various concentrations of chlorides and sulfates to channel catfish, largemouth bass, and bluegill. Median tolerance limits (TLm or TL50) for chloride for each fish species ranged from 8,000 to 8,500 mg/l. This is the concentration at which 50 percent of the test specimens survive. TLm is equivalent to the currently prevalent term, LC50, which is the concentration lethal to 50 percent of the test specimens. Illinois General Use water quality standards (Section 302.210) state, "Waters of the State shall be free from any substances or combination of substances in concentrations toxic or harmful to human health, or to animal, plant or aquatic life". Acutely toxic and chronically toxic concentrations of different combinations of substances are determined by prescribed toxicity testing procedures. However, in General Use waters, fixed criteria for some individual constituents apply, including chloride (500 mg/l), sulfate (500 mg/l), and total dissolved solids (1000 mg/l).

100

SECTION V MACROINVERTEBRATES

METHODS

Field Methods

Qualitative sampling of macroinvertebrates in the Sugar Creek basin was conducted in accordance with Agency guidelines (IEPA 1987). Macroinvertebrates were sampled from all available habitats, with emphasis on riffles or runs. Organisms were collected with forceps, U.S. Standard 30-mesh sieve, and/or D-net. Similar sampling times and sampling efforts were made at all sites. This method yields a sample representing relative abundance of each taxon in the aquatic community at each sampling site. All organisms were identified and counted in the field; some specimens were preserved for laboratory verification.

Data Analysis

Macroinvertebrate data are interpreted by means of applicable biotic indices and by analysis of community composition and structure. The primary index used by IEPA is the Macroinvertebrate Biotic Index (MBI), which is a rating of community tolerance to pollution. High MBI values indicate high community tolerance to oxygen-demanding and/or toxic contaminants, and generally indicate poor ambient water quality conditions (Table 3). The MBI is derived from a similar index developed by Hilsenhoff (1982).

Each macroinvertebrate species or taxon has a pollution tolerance rating in the range of 0 to 11. A rating of 0 is assigned to sensitive or intolerant taxa which live only in waters of high quality, and a rating of 11 is assigned to insensitive or tolerant taxa which live in severely degraded waters. Intermediate ratings are assigned to other taxa based upon their relative tolerance to pollution. An MBI value is the mean tolerance rating for a sample, calculated by a formula which incorporates the relative abundance and the tolerance rating of each taxon in the sample. High MBI values are usually associated with communities of low species richness, with few sensitive species present. Low MBI values are usually associated with communities of high species richness, with sensitive species common. High taxa richness generally indicates good stream quality, and diminished taxa richness indicates stream degradation.

Table 3. Stream quality criteria for Illinois streams.

GENERAL TERMS:	Very Good	Good	Fair	Poor	Very Poor
USE IMPAIRMENT:	Non-impaired	Non-impaired	Minor	Moderate	Severe
INDICES	RANGES OF INDEX VALUES				
FISH: IBI	51-60	41-50	31-40	21-30	0-20
MACROINVERTEBRATES: MBI	0-5.0	5.1-6.0	6.1-7.5	7.6-8.9	9.0-11.0

RESULTS

Macroinvertebrate Biotic Index Values and Stream Quality

Macroinvertebrate Biotic Index (MBI) values indicated poor ambient water quality conditions in the continuum of Robinson Creek downstream from the city of Robinson, the Robinson MWWTP, and the Marathon outfall 001 (Figure 2). The MBI value (8.2) upstream from Robinson MWWTP, at Site BFC-20, indicated poor ambient water quality conditions (Appendix Table F). A similar level of degradation was evident downstream from the Robinson MWWTP at Site BFC-19 (MBI=8.4), followed by improved but still poor conditions at Site BFC-25 (MBI=7.7). Additional degradation was indicated by increasing MBI values (8.1 and 8.7) downstream from Marathon outfall 001, at Sites BFC-26 and BFC-11. MBI values indicated poor conditions extending more than 4.0 miles downstream from Marathon outfall 001, past Site BFC-10. Improvement to fair conditions was indicated by MBI values (6.8 and 7.2) in Sugar Creek, 5.4 and 8.0 miles downstream from the Marathon main outfall, at Sites BF-11 and BF-01.

Community Composition and Structure

A total of 31 macroinvertebrate taxa were collected and identified from 12 stream sampling sites in the Sugar Creek basin, August 18-20, 1992. By sampling location, macroinvertebrate taxa richness ranged from four taxa in Robinson Creek 1.7 miles downstream from the Marathon main (001) outfall (Site BFC-11), to 16 taxa at each Lamotte Creek site (BFB-13 and BFB-09). Six of 12 sampling sites exhibited less than 10 macroinvertebrate taxa. One of these low-diversity sites (BFC-20) was downstream from the City of Robinson; one site (BFC-19) was downstream from the Robinson MWWTP; and four sites (BFC-26, BFC-11, BFC-10 and BFC-01) were downstream from the Marathon main outfall.

Taxa richness further verified stream degradation indicated by MBI values in Robinson Creek downstream from the Robinson MWWTP, Marathon outfall 001, and the confluence with Marathon Creek. In an upstream-to-downstream continuum, taxa richness diminished in Robinson Creek 0.4 miles downstream from Robinson MWWTP, at Site BFC-19, and then improved 1.2 miles downstream from that facility, at Site BFC-25 (Figure 2). Taxa richness dropped sharply in a 1.7-mile reach of Robinson Creek immediately downstream from the Marathon main outfall and the confluence with Marathon Creek, at Sites BFC-26 and BFC-11. Continuing downstream, improvement in taxa richness was evident in the next 3.7-mile reach, at Sites BFC-10 and BF-11. Reduced taxa richness was present at Site BF-01, in the lower 2.6-mile reach of Sugar Creek sampled.

Lamotte Creek

A major portion of the Lamotte Creek watershed lies upstream from Site BFB-13, where the MBI value (6.0) indicated fair to good conditions, and taxa richness (16) was the highest found in this survey. The other Lamotte Creek site, BFB-09, downstream from the Palestine MWWTP (an intermittently discharging lagoon facility), displayed a similar MBI value (5.8) and the same taxa richness as Site BFB-13. Based upon these two biotic metrics, Lamotte Creek displayed the best stream conditions found in this survey. Macroinvertebrate communities did not indicate degradation of Lamotte Creek attributable to Palestine MWWTP effluent.

102

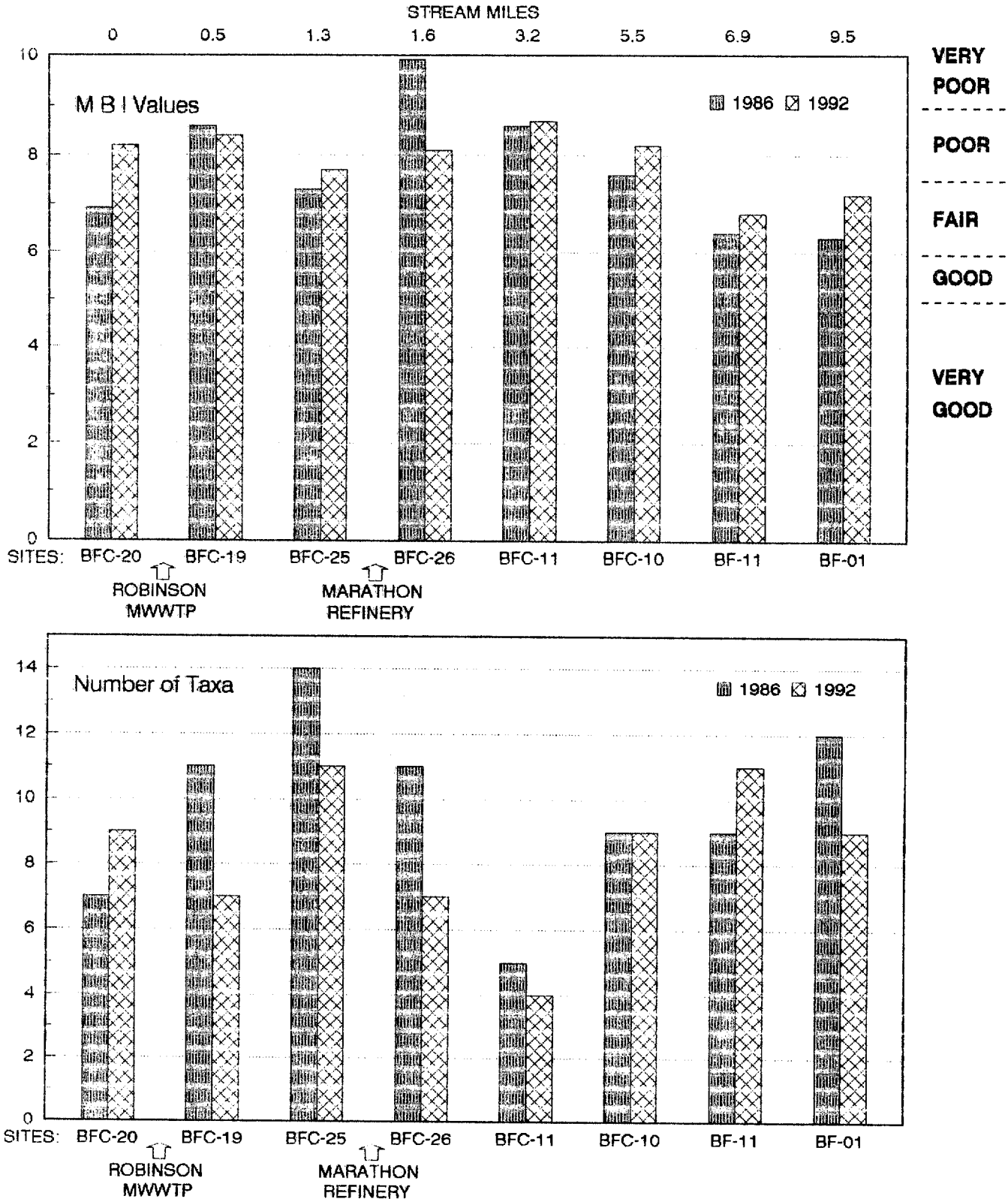


Figure 2. Macroinvertebrate Biotic Index (MBI) values and taxa richness in Robinson Creek and Sugar Creek, in the vicinity of Robinson MWWTP and Marathon Refinery, 1986 and 1992.

103

Quail Creek

Quail Creek at Site BFCB-12 displayed intermediate taxa richness (10) for streams of this survey. The MBI value (8.0) indicated poor ambient water quality and/or effects of intermittent flow.

Robinson Creek

Robinson Creek Site BFC-20, downstream from the City of Robinson, displayed intermediate taxa richness and productivity for streams of this survey, and the MBI value (8.2) indicated poor conditions. Downstream from Robinson MWWTP (as discussed above), MBI values and taxa richness indicated additional degradation at Site BFC-19 followed by some improvement evident at Site BFC-25, 1.2 miles downstream from Robinson MWWTP and 0.2 miles upstream from the Marathon main outfall. Diminishing taxa richness and increasing MBI values at Sites BFC-26 and BFC-11 indicated a 1.7-mile zone of degradation immediately downstream from Marathon outfall 001 and the confluence with Marathon Creek. Continuing downstream to Site BFC-10, increasing taxa richness and decreasing MBI value indicated improvement, but these metrics indicated continuing poor conditions.

Marathon Creek

Marathon Creek Site BFCA-22, downstream from Marathon outfall 002 and Union Carbide, displayed intermediate taxa richness (11 taxa) for this survey, and the MBI value (8.0) indicated poor water quality conditions. Oil globules with strong petrochemical odor were present in silt, detritus, and stream bottom materials.

Sugar Creek

Intermediate macroinvertebrate taxa richness (11 and 9) and MBI values (6.8 and 7.2) indicated fair ambient water quality conditions in Sugar Creek at Sites BF-11 and BF-01. Diminishing taxa richness and increasing MBI value indicated more degradation at Site BF-01 than at Site BF-11.

SECTION VI FISH COMMUNITIES

METHODS

Field Methods

Fish community samples were collected with a 20-foot 1/4-inch-mesh seine and/or a Smith-Root Model 12 backpack electrofishing unit. Three 30-foot seine hauls and/or 10 minutes of electrofishing time were standard sampling efforts, employed as appropriate for available habitats (e.g., shorter seine hauls when dictated by structural habitat). This method yielded a representative sample of the fish community at each site. Fishes were identified to species level, counted, and notes were made on size, abnormalities, and general condition at the collection site. Most fishes were returned alive to the stream following identification; however, some small cyprinids were preserved for laboratory verification.

Data Analysis

Fish data were evaluated by assessment of community structure and the Index of Biotic Integrity (Karr et al. 1986), as adapted for use in Illinois. The Index of Biotic Integrity (IBI) is calculated on the basis of 12 fish community metrics (Table 4). Individual metrics are assigned values of 1, 3, or 5, taking into consideration community expectations based upon stream size and biogeography. Metric values are then summed to produce an IBI value in the range of 12 to 60, with higher values indicating higher degrees of biotic integrity. A modified version of IBI, the Alternate Index of Biotic Integrity (AIBI) was calculated for each fish sample of this survey because information on metric 12 (fish condition) was incomplete. For the AIBI calculation, a mean of the other 11 metric values is substituted for metric 12. AIBI calculations were made on an interactive program written in BASIC for use on the IBM-PC (Bickers et al. 1988).

RESULTS

A total of 32 fish species were collected at seven sites on September 1-2, 1992. Fish communities indicated varied degrees of stream degradation in the Sugar Creek watershed. In general Sugar Creek basin fish communities were characterized as poor to good, with AIBI values ranging from 20.7 to 44.7 (Figure 3, Table 4, Appendix Table G). The numbers of species (species richness) found at stream sampling sites ranged from four to 24.

Robinson Creek and Sugar Creek

AIBI values indicated poor stream conditions at three sampling sites in Robinson Creek: Site BFC-25, 1.2 miles downstream from Robinson MWWTP (AIBI=25.1); Site BFC-26, 0.1 miles downstream from Marathon outfall 001 (AIBI=20.7); and Site BFC-11, 1.7 miles downstream from Marathon outfall 001 (AIBI=29.5). In Sugar Creek, at Site BF-01, 8.0 miles downstream from Marathon outfall 001, the AIBI value (33.8) indicated fair stream conditions. Sites BFC-26, BFC-11, and BF-01 displayed the lowest species richness (4, 4, and 5 species, respectively) found in this survey, further indicating stream degradation in the stream reaches downstream from the Marathon outfall 001. Site BFC-25, upstream from Marathon outfall 001, displayed somewhat better species richness (8 species).

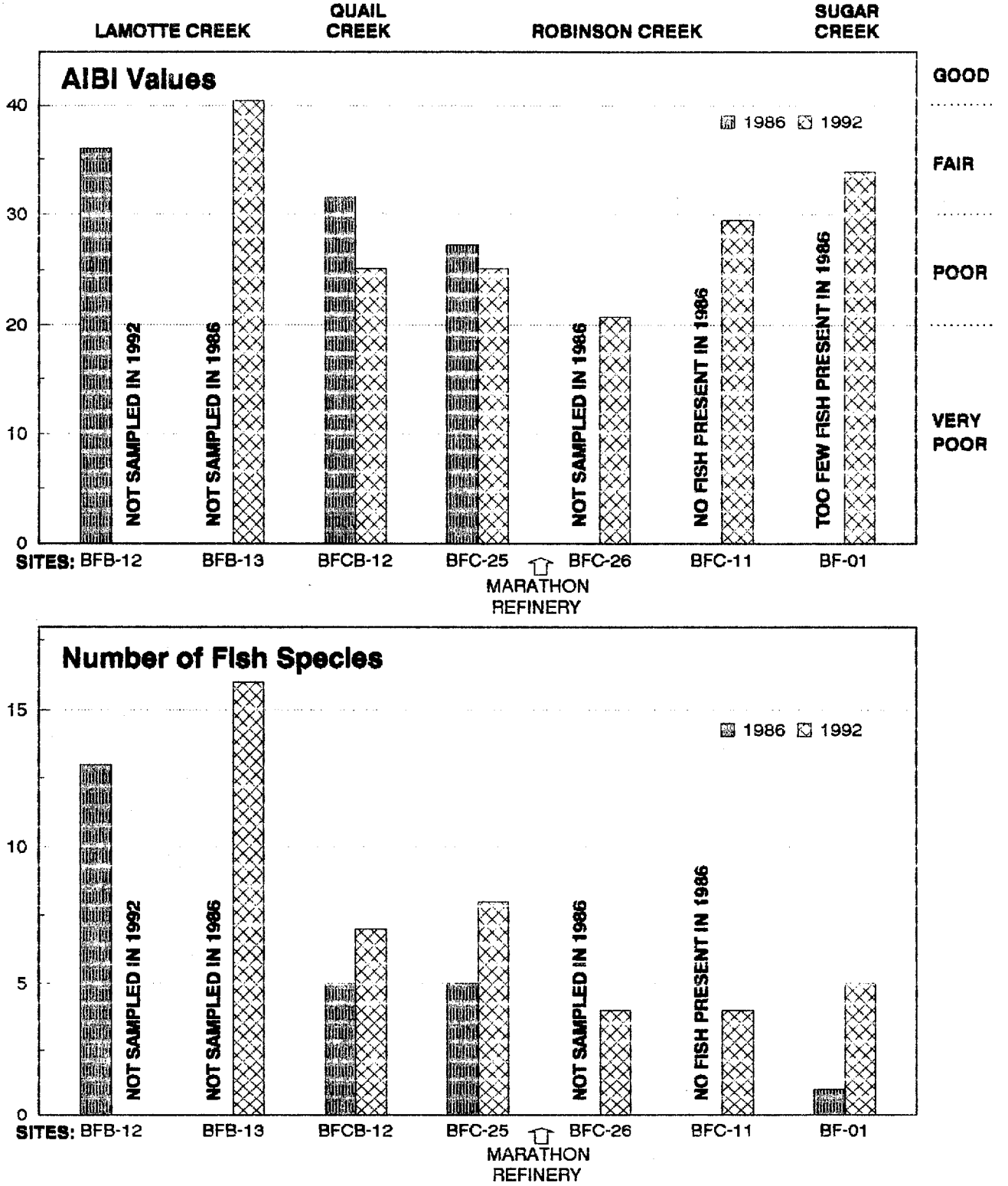


Figure 3. Alternate Index of Biotic Integrity (AIBI) values and species richness in fish communities of Robinson Cr., Sugar Cr., Lamotte Cr., and Quail Cr., in Oct. 1986 and Sept. 1992.

106

Quail Creek

At Quail Creek Site BFCB-12, the low AIBI value (25.1) and low species richness (7 species) indicated poor stream quality, which was probably caused largely by limited streamflow, localized waste input (e.g., private drains), and runoff from the Quail Creek Golf Course.

Lamotte Creek

In Lamotte Creek, at Sites BFB-13 and BFB-09, the highest AIBI values (40.4 and 44.7) and the highest species richness (16 and 24 species) found in this survey, indicated fair-to-good and good stream conditions, respectively.

Table 4. Fish community characteristics in Sugar Creek and tributaries near Robinson, Illinois, September 1992.

Stream:	Quail Creek	Robinson Creek			Sugar Creek	Lamotte Creek	
Community Metrics / Site:	BFCB-12	BFC-25	BFC-26	BFC-11	BF-01	BFB-13	BFB-09
Species Richness/composition							
1. Total number of fish species	7	8	4	4	5	16	24
2. Number of darter species	0	0	0	0	0	1	1
3. Number of sunfish species	1	1	0	0	0	4	5
4. Number of sucker species	0	1	0	0	0	0	3
5. Number of intolerant species	0	1	0	0	2	1	5
6. Proportion of individuals as green sunfish (%)	39	0	0	0	0	2	4.6
Trophic Composition (%)							
7. Proportion of individuals as omnivores	0	66.7	95.2	19.6	1.4	7.5	26.8
8. Proportion of individuals as insectivorous cyprinids	19.5	3.9	0	73.9	98.3	63.9	21.1
9. Proportion of individuals as piscivores (top carnivores)	22	5.9	0	0	0	0.8	4.6
Fish Abundance/Condition							
10. Number of individuals in sample	41	51	42	46	907	255	194
11. Proportion of individuals as hybrids	0	0	0	0	0	0	0
12. Proportion of individuals with disease, tumors, fin damage, & skeletal anomalies	--	--	--	--	--	--	--
Index of Biotic Integrity (AIBI)	25.1	25.1	20.7	29.5	33.8	40.4	44.7
Stream Quality Assessment	Poor	Poor	Poor	Poor	Fair	Good	Good

107

SECTION VII STREAM HABITAT AND BIOTIC INTEGRITY

INTRODUCTION

Rationale

The composition of aquatic communities and the distribution and abundance of individual species in lotic systems are largely governed by geographically related physical and chemical variables. Although fishes are found almost everywhere there is water, each species occurs in natural settings that are its habitat (Pflieger 1975). A local assemblage of organisms results from passage of all the world's organisms "through a series of ever finer zoogeographic, climatic, physiological and ecological screens...the local fauna represent the sum of the autecologies of the constituent species (Haedrick 1975)."

Stream quality is determined by both chemical and physical environmental variables. Suitable water quality (e.g., dissolved oxygen, pH, etc.) and desirable habitat (e.g., water flow, substrate composition, cover, etc.) are required for sustaining healthy populations of aquatic organisms. With respect to aquatic life (i.e., biotic integrity), the Illinois Environmental Protection Agency's mandate is to ensure that man's activities do not deleteriously affect the chemical habitat component. When assessing aquatic environments where biota are impacted, it is frequently necessary to determine whether the impact is attributable to man-induced changes in the chemical or the physical component. To accomplish this, it is necessary to evaluate both water quality and habitat quality.

Biotic Potential

In streams where fish populations are impacted by water quality degradation, a stream habitat assessment can be used to predict the level of fish community biotic integrity that should be present. The level of biotic integrity that would theoretically exist in the absence of water quality limitations is defined as biotic potential.

METHODS

Field Methods

Assessment of physical instream habitat characteristics (including substrate, depth, shading, etc.) was based upon visual estimates made concurrently with macroinvertebrate sampling. This method of habitat assessment, routinely used in IEPA facility-related stream surveys, facilitates a general characterization of stream habitat. Stream discharge was measured at all sampling sites with sufficient flow for measurement.

Data Analysis

Biotic potential was determined by means of a predicted Index of Biotic Integrity (PIBI), which characterizes the fish community which would be expected at a given sampling site if water quality were not limiting. This prediction is based upon the premise that in addition to water quality, habitat characteristics are major determinants of the quality of the biotic community. PIBI values are calculated by a regression equation in which percent pool and stream width are positively weighted, and percent silt and percent clay are negatively weighted. At a given stream site, comparison of the PIBI value to the AIBI value (based upon the fish community present) indicates whether (1) the fish community displayed a level of biotic integrity equal to the potential (and thus, was not limited by water quality factors), or (2) the fish community displayed a lower level of biotic integrity due to limiting water quality factors.

RESULTS

Hydrology

This survey was conducted during a period of little rainfall. Therefore, surface streamflow was low in the following four stream reaches, which did not receive input from major permitted wastewater point sources: (1) upper Robinson Creek, upstream from the Robinson MWWTP, (2) Quail Creek, (3) Marathon Creek, and (4) Lamotte Creek (Appendix Table H). There was no surface flow in Sugar Creek upstream from the confluence with Robinson Creek. In Robinson Creek downstream from Robinson MWWTP and upstream from the input of Marathon Refinery wastewater (at Sites BFC-19 and BFC-25), most of the flow consisted of Robinson MWWTP effluent. Downstream from the Marathon Refinery main outfall, flow in the Robinson Creek-Sugar Creek continuum stemmed mainly from these two major effluents.

Stream Configuration

Prominent channelized stream reaches sampled during this survey were the lower two stream miles of Robinson Creek (including Site BFC-10) and the lower five miles of Sugar Creek (downstream from the confluence with Robinson Creek, including Sites BF-11 and BF-01). Predominant run habitats, averaging 86 percent, with relatively few riffles and pools, were indicative of the effects of channelization at Sites BFC-10, BF-11, and BF-01. In addition, the four-mile reach of Robinson Creek downstream from Site BFC-19 displayed low sinuosity (i.e., few meanders), somewhat similar to channelized stream reaches. Some relatively short stream reaches of Quail Creek, Marathon Creek, and Lamotte Creek also displayed low sinuosity indicating old channelization, particularly adjacent to roads and other man-made structures, e.g., the Palestine MWWTP.

Biotic Potential

Predicted Index of Biotic Integrity (PIBI) values, ranging from 32.8 to 40.1, for Quail Creek, Marathon Creek, and Robinson Creek indicated that these streams would support fair fish communities if water quality factors were not limiting (Appendix Table H). PIBI values for Sugar Creek and Lamotte Creek ranged from 41.0 to 44.3, indicating the potential for good fish communities.

Biotic Integrity

Downstream from the Robinson MWWTP (Site BFC-25) and downstream from the Marathon main outfall (Sites BFC-26, BFC-11, and BF-01), AIBI values were well below corresponding PIBI values, indicating that biotic integrity (indicated by fish communities) and stream quality were degraded by water quality factors (Table 5).

Table 5. Comparison of biotic integrity (AIBI) and potential biotic integrity (PIBI) in Quail, Robinson, Sugar, and Lamotte Creeks, 1992 and 1986.

Stream:	Quail Cr	Robinson Creek			Sugar Cr	Lamotte Creek		
Site:	BFCB-12	BFC-25	BFC-26	BFC-11	BF-01	BFB-12	BFB-13	BFB-09
September 1992								
AIBI	25.1	25.1	20.7	29.5	33.8	--	40.4	44.7
PIBI	38.4	38.5	32.8	36.7	41.0	--	44.3	41.3
October 1986								
AIBI	31.6	27.3	--	*	**	36.0	--	--
PIBI	38.7	37.4	--	37.1	42.4	40.4	--	--

* No fish present ** Too few fish present

At a reference site, BFB-13, in Lamotte Creek, the AIBI (40.4) reflected fair to good stream quality, and the PIBI (44.3) indicated a potential for good stream quality. This relatively small difference between AIBI and PIBI values indicated relatively little degradation due to water quality factors, and illustrated biotic integrity that should have existed in sections of Robinson and Sugar Creeks.

110

SECTION VIII BIOLOGICAL STREAM CHARACTERIZATION

INTRODUCTION

(From Hite and Bertrand 1989)

Management or protection of any natural resource--either biotic or abiotic--requires that environmental managers have a detailed knowledge of the resource to be managed and an awareness of where that resource exists. The understanding of any resource is typically acquired through an environmental inventory process known as monitoring. Ultimately, judicious management of a resource usually requires some type of classification system. In Illinois, the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Conservation (IDOC) have developed programs which evaluate and classify quality of the State's rivers and streams.

The Need for Stream Classification

Stream quality varies spatially as a function of physiography, geology, climate, and anthropogenic factors such as land use and wastewater disposal. In Illinois, some streams are little more than highly turbid, nutrient-laden, channelized ditches conveying runoff from agricultural fields. Other streams, such as the Middle Fork Vermilion River in east-central Illinois, and certain streams in the Shawnee National Forest (e.g., Big and Lusk Creeks) in southern Illinois are impressive aquatic resources characterized by pleasing aesthetic surroundings, clear flowing waters, and diverse aquatic biota. Indeed, selected reaches of these streams have been designated or nominated for inclusion in the National Wild and Scenic Rivers System or designated wilderness areas.

The tremendous range in stream types and biotic quality evident in Illinois streams indicated a need to group or classify these streams to ensure adequate protection and management. A stream classification system was desirable as a vehicle to place the vast array of information gained from cooperative basin surveys in a comprehensible format and to provide both fishery and water quality managers an overall perspective of the State's stream resources. Classification of Illinois stream resources was needed to:

1. Facilitate planning and prudent allocation of State resources;

2. Inventory streams exhibiting a potential for fisheries management or restoration activities;

3. Identify stream segments of exceptional quality which warrant special consideration for protection;

4. Allocate pollution control resources for attainment of Clean Water Act Goals;

5. Focus greater emphasis on the importance of important stream resources and awareness of where these resources exist; and

6. Establish a common vehicle for the interpretation, assessment, and communication of aquatic resource values.

Characterization with IBI

In 1984, IEPA and IDOC biologists formed the Biological Stream Characterization (BSC) Work Group and developed a five-tiered stream classification utilizing two types of biotic data: fish and macroinvertebrates. BSC criteria for the classification of Illinois streams are based largely on attributes of lotic fish communities with the Index of Biotic Integrity (IBI) the priority BSC metric (Hite and Bertrand 1989). In the absence of suitable fishery data for IBI calculation, narrative fishery criteria and finally, macroinvertebrate data may be used to derive selected BSC ratings. If a valid IBI value can be determined for a fish sample, that stream reach is characterized as one of five stream classes. Values of 50-60 place a stream in the Unique Aquatic Resource or A category; 41-50 in the Highly Valued or B category; 31-40 in the Moderate or C category; 21-30 in the Limited or D category; and values of 20 or less in the Restricted or E category (Table 6).

Table 6. **Biological Stream Characterization (BSC) criteria for the classification of Illinois streams.**

RESOURCE DESCRIPTION:	UNIQUE AQUATIC RESOURCE	HIGHLY VALUED AQUATIC RESOURCE	MODERATE AQUATIC RESOURCE	LIMITED AQUATIC RESOURCE	RESTRICTED USE AQUATIC RESOURCE
BIOTIC METRIC CLASS:	A	B	C	D	E
FISHERY					
Index of Biotic Integrity (IBI) or Alternate (AIBI)	51 - 60	41 - 50	31 - 40	21 - 30	$\leq$ 20
Sport Fishery Value		Good fishery for walleye, sauger, smallmouth, spotted, or largmouth bass, northern pike, white bass, crappie, catfish, rock bass, or put and take trout fishery.	Smaller species of sport fish predominate in sport catch. Bullhead/sunfish, carp fishery. Diverse forage fish community may be present.	Carp or other less desirable species support fishery. Few if any fish of other species caught.	No sport fishery. Few fish of any species.
Spawning or Nursery Value		Tributary to an "A" stream, or used as nursery by above sport fish species.	Nursery or rearing area for common sport fish. Young of year or juveniles of above species common in fish samples.	Few if any young of year or juveniles of any sport species present.	No young of year or juveniles of sport species present.
MACROINVERTEBRATES					
Macroinvertebrate Biotic Index (MBI)	N/A	N/A	N/A	$\geq$ 7.5 $\leq$ 10.0	> 10.0
Community Structure	N/A	N/A	N/A	Predominant macroinvertebrate taxa/individuals consist of facultative and/or moderate organisms. Intolerant organisms are sparse or may be absent.	Intolerant organisms absent; benthic community consists of nearly all tolerant forms, or no aquatic macroinvertebrates may be present.
Species Richness	N/A	N/A	N/A	Notably lower than expected for geographic area, stream size or available habitat; usually limited to a moderate or few number of taxa.	Restricted to few taxa, or no taxa present.

112

Streams assessed in this survey were assigned BSC ratings using Alternate Index of Biotic Integrity (AIBI) values generated on the basis of fish samples obtained by a combination of backpack electrofishing and seining techniques. Where AIBI values warranted a change in stream reach classification, the transition point was set at an approximate midpoint (i.e., river mile) between representative sampling sites.

RESULTS

A total of 28.1 stream miles in Robinson Creek, Quail Creek, Sugar Creek, and Lamotte Creek were BSC-rated, using AIBI values and other biotic metrics in accordance with criteria in Table 6. Stream reach descriptions, BSC ratings, and biotic metrics are presented in Table 7. A 7.1-mile reach of Robinson Creek was rated as a Limited Aquatic Resource (Class D). A 4.8-mile reach of Sugar Creek was rated as a Moderate Aquatic Resource (Class C). A 0.7-mile reach of Quail Creek was rated as a Limited Aquatic Resource. A 3.5-mile reach of lower Lamotte Creek was rated as a Highly Valued Aquatic Resource (Class B), and a 5.6-mile reach of middle Lamotte Creek was rated as a Moderate Aquatic Resource. A 1.0-mile reach of Marathon Creek was rated as a Restricted Aquatic Resource (Class E).

Table 7. Biological Stream Characterization (BSC) ratings and stream descriptions for Sugar Creek and tributaries, Crawford County, Illinois, in 1992.

Stream	Order	Sampling Sites	Year	Limits	River Miles	Length	AIBI Values	MBI Values	BSC Rating
Robinson Creek	2	BFC-20	1992	0.0 to 0.7 mi U Robinson MWWTP outfall	6.4 to 7.1	0.7	--	8.2	D
Robinson Creek	3	BFC-19, BFC-25	1992	0.0 to 1.4 mi D Robinson MWWTP outfall	5.0 to 6.4	1.4	-- , 25.1	8.4, 7.7	D
Robinson Creek	3	BFC-26, BFC-11	1992	Marathon outfall 001 to mouth	0.0 to 5.0	5.0	20.7, 29.5	8.1, 8.7	D
Quail Creek	2	BFCB-12	1992	0.0 to 0.7 mi U confl Robinson Cr	0.0 to 0.7	0.7	25.1	8.0	D
Sugar Creek	4	BF-01	1992	Confl Robinson Cr to mouth	0.0 to 4.8	4.8	33.8	7.2	C
Lamotte Creek	4	BFB-13, BFB-09	1992	0.0 to 3.5 mi U mouth	0.0 to 3.5	3.5	40.4, 44.7	6.0, 5.8	B
Lamotte Creek	4	BFB-12	1986	3.5 to 9.1 mi U mouth	3.5 to 9.1	5.6	36.0	6.2	C
Marathon Creek	1	BFCA-22	1992	0.0 to 1.0 mi U mouth	0.0 to 1.0	1.0	--	8.0	E

113

SECTION IX AQUATIC LIFE USE SUPPORT

INTRODUCTION

The stated objective of the Clean Water Act (CWA) of 1987 (PL100-4) is to "restore and maintain the chemical, physical, and ecological integrity of the nation's water." To accomplish this objective, an array of legislation, policies, and comprehensive programs for water pollution control have been established at both federal and state levels. One such provision of the federal CWA (Section 305b) requires each state to submit a biennial report to the U.S. Environmental Protection Agency detailing "the extent to which all navigable waters of such state provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allow recreational activities in and on the water." The extent to which pollution control programs are successful in meeting CWA goals, and the extent to which designated uses are met in Illinois waters are assessed in part through an evaluation of aquatic life use support. Aquatic life use support in streams is determined through assessment of the biotic integrity and composition of fish and macroinvertebrate communities.

METHODS

Assessment of aquatic life use attainment involves comparison of biological, chemical, and physical information from individual stream reaches with predetermined criteria for assignment to one of four basic categories. These basic categories include: full support (water quality is not limiting and the fish population, assessed by the Alternate Index of Biotic Integrity or AIBI, is near its potential, which is in turn measured by the Predicted Index of Biotic Integrity or PIBI); partial support with minor impairment (water quality is somewhat limiting and/or the AIBI value is less than the PIBI value); partial support with moderate impairment (water quality is limiting and/or the AIBI value is significantly less than the PIBI value); and nonsupport (water quality is extremely limiting and/or the AIBI value is substantially less then the PIBI value). Biological and chemical criteria for assignment of aquatic life use support ratings are listed in Table 11.

There are a number of factors which can influence AIBI and PIBI values and thus aquatic life use support ratings. For example, elevated turbidity during fish sampling can reduce the collector's ability to see and capture fish, thus potentially reducing the AIBI value. Similarly, elevated water levels tend to increase mean stream width, and extremely low water levels tend to increase the percentage of a reach existing as "pool"; both of these phenomena have the potential to bias PIBI values upward. To account for these influences on aquatic life use support ratings, all available information must be analyzed by professionals who are familiar with the circumstances in which each data set was collected. The factor used for adjustment of criteria-based aquatic life use support ratings to account for varying field conditions has been termed "professional judgement" and is often the most important criterion for producing accurate assessments.

Most assessments of aquatic life use attainment for this survey were accomplished with the aid of biological, chemical, and physical data. These assessments were termed "monitored", designated by the letter M. Aquatic life use support was also rated for a few stream reaches which were near the survey area but were not sampled. These assessments were termed "evaluated" and were labeled with the letter E.

Table 8. Summary of use support assessment criteria for Illinois streams (IEPA 1992).

USEPA		FULL SUPPORT		PARTIAL SUPPORT MINOR	PARTIAL SUPPORT MODERATE	NON-SUPPORT
GENERAL DESCRIPTION		Good		Fair		Poor
IEPA/IDOC BIOLOGICAL STREAM CHARACTERIZATION (BSC)		Unique Aquatic Resource	Highly Valued Resource	Moderate Aquatic Resource	Limited Aquatic Resource	Restricted Aquatic Resource
FISH	Index of Biotic Integrity (IBI/AIBI)	51-60	41-50	31-40	21-30	< 20
BENTHOS	Macroinvertebrate Biotic Index (MBI)	<5.0	5.0-6.0	6.0-7.5	7.5-10.0	>10.0
WATER CHEMISTRY	STORET Water Quality Index (WQI)	0-10	10-30	30-50	50-70	>70
STREAM HABITAT	Potential Index of Biotic Integrity (PIBI)	51-60	41-50	31-40	<31	
STREAM SEDIMENT	IEPA Stream Sediment Classification	Non-elevated	Non-elevated to Slightly Elevated	Slightly Elevated	Elevated to Highly Elevated	Extreme

RESULTS

Aquatic life use support was assessed for 29.3 stream miles in the Sugar Creek basin near Robinson. A 6.3-mile reach of upper Sugar Creek and 9.1 stream miles of Lamotte Creek were considered to be in full support of aquatic life use. Approximately 4.8 miles of Sugar Creek, 2.1 miles of Robinson Creek, and 0.7 miles of Quail Creek were rated partial support with moderate impairment. About 5.1 stream miles of Robinson Creek and 1.2 miles of Marathon Creek were considered to be in nonsupport of aquatic life uses. (Appendix Table I).

115

SECTION X DISCUSSION AND CONCLUSIONS

Water quality, macroinvertebrate communities, and fish population samples indicated degraded conditions in Robinson Creek and Sugar Creek downstream from Robinson MWWTP and Marathon Refinery. Only slight improvement in stream conditions was evident in 1992, when contrasted to stream conditions documented in 1986.

Water and Effluent Quality

Downstream from Robinson MWWTP in 1986, TDS, boron, nitrate+nitrite, ammonia, and phosphorus were elevated. In 1992, TDS, COD, nitrate+nitrite, phosphorus, sodium, and chloride were elevated in this stream reach.

Downstream from Marathon Refinery in 1986, TDS, chloride, silver, and nitrate+nitrite were further elevated by Marathon effluent. In 1992, water temperature, chloride, sulfate, nitrate+nitrite, sodium, arsenic, and chromium were elevated in this stream reach.

Marathon effluent at outfall 001 caused violation of the water quality standard for temperature at Sites BFC-26 and BFC-11, compared to Site BFC-25, on 08/20/92. By extrapolation, this violation (elevation of temperature greater than 2.8 C) extended approximately 3.5 miles downstream from Marathon outfall 001. It should be noted that water temperature was elevated at Site BFC-25, due to Robinson MWWTP effluent. If temperatures at Sites BFC-26, BFC-11, and BFC-10 were compared to the mean temperature of 17.7 C at background sites BFC-20, BFCB-12, and BFB-13, then, by extrapolation, the water quality violations for temperature extended approximately 4.6 miles downstream from the Marathon main outfall, on 08/20/92.

Limited effluent temperature data collected by IEPA staff indicate that effluent collected <u>inside</u> the Marathon wastewater treatment facility <u>may</u> not be representative of final effluent quality at the Marathon 001 outfall to Robinson Creek. IEPA measurements of Marathon effluent temperatures have included the following:

(1) inside the Marathon wastewater facility, two effluent samples on 10/19/88 with temperatures of 23.9 and 22.8 C (mean of 23.4 C), and
(2) at outfall 001, effluent samples on 07/23/86, 08/27/86, and 08/20/92, with temperatures of 32.5, 29.4, and 30.1 C (mean of 30.1 C).

These data suggest the possibility that:

(1) heated wastewater <u>may</u> be added somewhere between the "inside" sampling point and outfall 001, or
(2) the heated water <u>may</u> not always be present when "inside" effluent samples (presumably representing effluent at outfall 001) are collected.

During previous IEPA stream surveys, heated effluent associated with fluctuations in discharge rate have been observed at outfall 001 on a number of occasions. For example, on 07/22/86, high-flow effluent was noticeably warmer than low-flow effluent, reflecting increased temperature with increased flow rate. These fluctuations in quantity and quality, i.e., temperature and other constituents, of effluent at outfall 001 probably have not been adequately documented.

116

Biotic Communities

Downstream from Robinson MWWTP, in both 1986 and 1992, macroinvertebrate population samples indicated poor to fair stream conditions in a 1.2-mile reach of Robinson Creek. Downstream from the Marathon main outfall, macroinvertebrates in 1986 indicated very poor to poor conditions in a 4.0-mile reach of Robinson Creek. Macroinvertebrates indicated poor conditions throughout this reach in 1992.

In both 1986 and 1992, fish population samples indicated poor to fair stream conditions in a 1.2-mile reach of Robinson Creek downstream from Robinson MWWTP. In 1986, fish communities indicated very poor stream conditions in an 8.0-mile continuum of Robinson Creek and Sugar Creek downstream from the Marathon main outfall. In 1992, while some improvement was evident, fish samples still indicated poor ambient water quality conditions in an 8.0-mile reach downstream from the Marathon outfall.

Possibility of Intermittent Toxic Discharges

It is important to recognize that the above-described stream degradation as indicated by macroinvertebrate and fish communities may not be in the form of continuous toxic concentrations of contaminants. Intermittent toxic concentrations of individual constituents and/or synergistic effects of multiple constituents can be sufficient to cause acute and chronic damage to aquatic biota. Occasional episodes of high concentrations of contaminants (e.g., phenols and ammonia) have been previously documented in Robinson Creek and Sugar Creek. The actual frequency of such episodes is largely unknown.

Synergistic Effects of High Temperatures and Toxic Materials

It is possible that toxicity in Robinson Creek and Sugar Creek downstream from the Marathon Refinery main wastewater outfall may be intermittently elevated due to synergistic effects of contaminants and elevated temperatures.

Possibility of Thermal Shock

Thermal shock to aquatic life is possible when heated effluent is intermittently added to a relatively cool stream.

Recommendations

1. Because of the apparent variability in the quality and quantity of wastewater discharged from the Marathon Petroleum Company refinery, it is recommended that an extensive toxicity reduction evaluation (TRE) be conducted at the refinery; this TRE should, include the following elements:
   A. Assess variation in quantity and quality, including temperature, of all wastewater discharged from the Marathon refinery.
   B. An evaluation of the causes and sources of stream impairment documented in Robinson and Sugar Creeks; this evaluation should identify whether stream degradation is due to (1) toxic materials and/or heat in effluent at the Marathon main outfall (001), (2) toxic materials in effluent from the Marathon lagoon outfall (002), and/or (3) inadequate wastewater treatment at these or other facilities.
   C. A characterization of potential toxic contaminants present in the refinery processes or products, and identification of probable components of toxicity.
   D. Tracing toxicity to its sources in the refinery.
   E. An evaluation of wastewater treatment alternatives for controlling both toxicity and the sporadic discharge of large quantities of such toxic contaminants which would stress or kill aquatic life in the receiving stream.

2. Routine toxicity testing of representative effluent samples should be incorporated into NPDES permit requirements for Marathon Petroleum Company, including mandatory toxicity testing prior to any discharge from a lagoon.

3. Consideration should given to the feasibility of a final catchment basin through which all wastewater from the Marathon refinery would pass prior to discharge to receiving waters. This basin should have a gate at the outlet, which could be closed immediately by remote electronic control or by oil sensors, to contain any contaminants resulting from inadequate treatment or accidental release until treatment is complete.

4. Wastewater treatment operations at the Robinson MWWTP should be examined. and any necessary changes should be made to eliminate periodic discharge of elevated ammonia concentrations.

5. The frequency of Agency effluent monitoring at the Marathon refinery should be increased, to include the following:
   A. Unannounced samples should be collected at least monthly at Marathon outfall 001 at Robinson Creek; some of these samples could be taken prior to collection of each routine sample inside the plant. This would provide a partial basis for assessing representativeness of effluent samples.
   B. Effluent samples at outfall 001 should be collected at various times of the day and night, and on various days of the week, to increase the representativeness of samples, including possible toxic episodes.
   C. Temperature should be measured in all effluent samples, at the time of collection.

SECTION XI. LITERATURE CITED

Bickers, C.A., M.H. Kelly, J.M. Levesque, and R.L. Hite. 1988. IBI-AIBI Version 2.01: a BASIC program for computing the Index of Biotic Integrity with the IBM-PC. IEPA/WPC/89-007. Illinois Environmental Protection Agency. Springfield, Illinois.

Haedrick, R.L. 1975. Diversity and overlap as measures of environmental quality. Water Research 9: 945-952.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality in streams. Wisconsin Department of Natural Resources Technical Bulletin 132, Madison, Wisconsin.

Hite, R.L. and B.A. Bertrand. 1989. Biological Stream Characterization (BSC): a biological assessment of Illinois stream quality. Special Report No. 13 of the Illinois State Water Plan Task Force. IEPA/WPC/89-275. Illinois Environmental Protection Agency. Springfield, Illinois.

Hite, R.L. and R.L. Sullivan, 1979. A water quality investigation of the Sugar Creek Basin (Wabash River basin, Crawford County) June-Aug. 1978. Illinois Environmental Protection Agency. Springfield, Illinois.

Hite, R.L., M.M. King, M.R. Matson, and C.A. Bickers, 1988. An intensive survey of the Sugar Creek basin, Crawford County, Illinois, 1986. Illinois Environmental Protection Agency. Springfield, Illinois.

Illinois Environmental Protection Agency. 1987. Quality assurance and field methods manual: Division of Water Pollution Control. Springfield, Illinois.

Illinois Environmental Protection Agency. 1992. Illinois Water Quality Report: 1990-1991. IEPA/WPC/92-055. Division of Water Pollution Control. Springfield, Illinois.

Illinois Natural History Survey. 1979. An assessment of the water quality of the Wabash river basin derived from a biological investigation. Urbana, Illinois.

Karr, J.R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters, a method and its rationale. Special Publication 5. Illinois Natural History Survey. Champaign, Illinois.

McKee, J.E. and H.W. Wolf. 1963. Water Quality Criteria, Second Edition. State Water Resources Control Board of California.

Mosher, R. and M. King 1991. A survey of the fishes of the Sugar Creek basin, Crawford County, Illinois in the proximity of the Marathon wastewater discharge, October 1991. Illinois Environmental Protection Agency, internal report.

119

Pflieger, W.L. 1975. The fishes of Missouri. Missouri Department of Conservation. Jefferson City, Missouri.

Radian Corporation. 1986. Assessment of aquatic biology in Sugar Creek tributary. (Consultant report submitted to Marathon Petroleum Company, Robinson, Illinois) Austin, Texas.

Reed, P. and R. Evans. 1981. Acute toxicity of chlorides, sulfates, and total dissolved solids to some fishes in Illinois. Illinois State Water Survey. Contract Report 283.

State of Illinois. 1990. Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter I, Rules and Regulations. Illinois Environmental Protection Agency Report IEPA/WPC/92-055, Springfield, Illinois.

Tucker, W.J. 1972. Marathon Oil Company discharge to tributary of Sugar Creek at Robinson, Illinois. Illinois Environmental Protection Agency inter-office memorandum of January 20, 1972.

APPENDIX

Table A. Stream sampling sites in Sugar Creek and tributaries and types of samples collected in the vicinity of the Robinson and Palestine municipal wastewater treatment plants (MWWTP) and Marathon Oil Refinery, Crawford County, Illinois, August 1992.

Sampling Site	Stream	Stream Order	River Mile	Latitude	Longitude	T	R	1/4 Sec	Location	Sample Type*	USGS Topo Map
BFCB-12	Quail Creek	2	0.5	39°01'10"	87°43'35"	7N	12W	SE27	Co Rd, S side of Quail Cr Country Club	F,M,W	Hutsonville 209C
BFC-20	Robinson Creek	2	6.5	39°00'50"	87°43'35"	7N	12W	SE27	Old RR Br, 150 yd upstr Robinson MWWTP outfall	D,M,W	Hutsonville 209C
BFC-19	Robinson Creek	3	6.0	39°01'02"	87°43'15"	7N	12W	SW26	50 yd dnstr confl w/ Quail Cr; 0.4 mi dnstr Robinson MWWTP outfall	D,M,W	Hutsonville 209C
BFC-25	Robinson Creek	3	5.2	39°00'45"	87°42'25"	7N	12W	NE35	Farm access road 1.5 mi NE Robinson; 1.2 mi dnstr Robinson MWWTP	D,F,M,W	Hutsonville 209C
BFCA-21	Marathon Creek	1	0.7	39°00'22"	87°42'55"	7N	12W	SW35	Rt 33, 1 mi E of Robinson; 0.2 mi dnstr Marathon lagoon outfall		Hutsonville 209C
BFCA-22	Marathon Creek	1	0.16	39 00'42"	87 42'35"	7N	12W	NE35	Farm access road, 1.5 mi NE of Robinson, 0.7 mi dnstr Marathon lagoon outfall	D,M,W	Hutsonville 209C
BFC-26	Robinson Creek	3	4.9	39°00'45"	87°42'23"	7N	12W	NE35	0.3 mi dnstr farm access road; 200 yd dnstr Marathon main outfall	D,F,M,W	Hutsonville 209C
BFC-11	Robinson Creek	3	3.3	39°00'48"	87°41'10"	7N	12W	NE36	Rt 1, 0.3 mi N of Gordon; 1.7 mi dnstr Marathon main outfall	D,F,M,W	Hutsonville 209C
BFC-10	Robinson Creek	3	1.0	39°01'12"	87°39'10"	7N	11W	SE29	Co Rd N of Robinson Muni. Airport; 4.0 mi dnstr Marathon main outfall	D,M,W	Hutsonville 209C
BF-23	Sugar Creek	3	7.0	39°02'38"	87°40'00"	7N	11W	NW20	Farm access road 1 mi E of Rt 1		Hutsonville 209C
BF-22	Sugar Creek	4	6.2	39°02'25"	87°39'25"	7N	11W	NE20	Co Rd 3 mi NW of Palestine; 1.4 mi upstr confl w/ Robinson Cr		Hutsonville 209C
BF-11	Sugar Creek	4	4.1	39°01'15"	87°38'05"	7N	11W	SE28	1 mi N of Rt 33; 5.4 mi dnstr Marathon main outfall	D,M,W	Hutsonville 209C
BF-01**	Sugar Creek	4	1.6	39°00'25"	87°35'25"	7N	11W	SE35	0.3 mi E of Palestine; 8.0 mi dnstr Marathon main outfall	D,F,M,W	Merom, Ind. 209D
BFB-12	Lamotte Creek	4	5.0	38°58'50"	87°38'10"	6N	11W	NE9	1.3 mi SW of Palestine; 3.0 mi upstr Palestine MWWTP		Heathsville 211B
BFB-13	Lamotte Creek	4	1.9	38 59'42"	87 36'28"	6N	11W	NW02	Rt 33, S of Palestine; 0.6 mi upstr Palestine MWWTP	F,M,W	Heathsville 211B
BFB-09	Lamotte Creek	4	1.0	38°59'25"	87°35'40"	6N	11W	SE2	0.5 mi SE of Palestine; 1.0 mi dnstr Palestine MWWTP	F,M,W	Flat Rock 211A

* Sample Types:
D - Stream Discharge M - Qualitative Macroinvertebrates
F - Fish Population W - Water Chemistry

** Ambient Water Quality Monitoring Network (AWQMN) site

121

Table B. Effluent sample analysis results for samples collected by IEPA at the Robinson municipal municipal wastewater treatment plant, 1988 to 1992. All units are mg/l except as otherwise noted.

Sampling Date	Time	Lab pH (units)	Est Temp (C)	Ammonia	Un-ion Ammonia	Nitrate+ Nitrite	F. Coli (#/100ml)	Carb BOD	Total BOD	TSS
88/01/06	0730							1		2
88/01/07	1245	7.8		0.1 K			120		2	1
88/04/14	1200	7.9		0.1 K					2	4
88/07/05	1200	8.0		0.1 K					2	4
88/10/11	1200	8.0		0.1 K					1 K	2
88/11/14	0001	8.1		0.1 K					1	1 K
88/11/30	1155	7.9		0.1 K					2	1
89/05/04	1300	8.1		0.1 K				1		5
89/09/19	1300	8.4		0.1 K				1 K		1
90/03/20	1430	8.2		0.1 K				2		3
90/11/27	1300	7.7	10.6	1.7				4		36
90/11/27	0900					2		4		50
91/01/24	1045	8.3	3.8	0.46				3		5
91/04/17	1230	7.4	16.8	3.6				23		7
91/06/27	1350	7.6	27.6	0.54				1		7
91/09/24	1315	7.8	17.3	0.02				2		1
92/01/28	1325	7.9		0.01 K				1 K		1
92/02/05	0700	8.2	11	0.01				1		1
92/03/09	1500	7.8	12	0.19				1		2
92/04/30	1225	8.3	17	0.06				2		4
92/05/19	1520	7.9	24	3.7				5		37
Mean		8.0	15.6	0.59				3	2	8
STD		0.2	6.8	1.11				5	0	14
Min		7.4	3.8	0.01				1	1	1
Max		8.4	27.6	3.7				23	2	50

Additional parameters tested.

STORET	Parameter	Date: 90/11/27	92/01/28	92/02/05
680	T Organic Carbon (mg/l)			8
720	Cyanide (mg/l)	0.005 K		0.01 K
745	Sulfide (mg/l)		0.02 K	0.02 K
916	Calcium (mg/l)	32.7	95	91
927	Magnesium (mg/l)	8.9	26	25
929	Sodium (mg/l)	80	180	160
937	Potassium (mg/l)	6	9.6	11
940	Chloride (mg/l)		285	
945	Sulfate (mg/l)		83	
1007	Barium Tot (ug/l)	22	34	30
1012	Beryllium Tot (ug/l)	1 K	1 K	1 K
1022	Boron Tot (ug/l)	206	240	240
1027	Cadmium Tot (ug/l)	5 K	5 K	5 K
1032	Chromium Hex (ug/l)		50 K	
1034	Chromium Tot (ug/l)	5 K	5 K	5 K
1037	Cobalt Tot (ug/l)	5 K	5 K	5
1042	Copper Tot (ug/l)	9	5 K	5
1045	Iron Tot (ug/l)	223	50 K	50 K
1051	Lead Tot (ug/l)	50 K	50 K	50 K
1055	Manganese Tot (ug/l)	74	15 K	16
1067	Nickel Tot (ug/l)	15 K	15 K	15 K
1077	Silver Tot (ug/l)	5 K	5 K	5 K
1082	Strontium Tot (ug/l)	80	170	150
1087	Vanadium Tot (ug/l)	5 K	5 K	5 K
1092	Zinc Tot (ug/l)	105	140	100
1105	Aluminum Tot (ug/l)	150 K	150 K	150 K
32730	Phenols (ug/l)		5 K	
46570	Hardness (mg/l) *	118 $	344 $	330 $
70300	Diss Solids (mg/l)		897	
71900	Mercury (ug/l)	0.05 K		0.05 K

K Less than value stated

122

Table C. Field and laboratory water chemistry from Sugar Creek and tributaries and effluent samples in the vicinity of Robinson WWTP, the Marathon Petroleum Company refinery, and Palestine WWTP, August 20, 1992.

STORET #	Parameter / Stream Code: / Site:	BFC 20	Effluent Robinson	BFCB 12	BFC 19	BFC 25	Effluent Marathon	BFCA 22	BFC 26	BFC 11	BFC 10	BF 11	BF 01	BFB 13	Effluent Palestine	BFB 09
	Sample Time	0830	0800	0700	0910	1000	1200	1040	1140	1115	1030	0945	0900	0830	0730	0815
20	Air Temp (°C)	16	15	14	18	20	22	21	22	21	24	23	20	16	17	18
10	Water Temp (°C)	17.3	23.1	17.6	21.1	19.1	30.1	16.6	27.8	24.3	21.2	19.6	18.2	18.2	25.1	18.4
11	Water Temp (°F) *	63.1	73.6	63.7	70.0	66.4	86.2	61.9	82.0	75.7	70.2	67.3	64.8	64.8	77.2	65.1
400	pH (units)	7.7	7.5	6.9	7.6	7.8	7.0	8.0	7.4	8.1	7.5	7.8	7.7	7.9	7.2	7.4
94	Conductivity (umhos/cm)	814	1920	756	1981	1976	1862	1426	1940	2790	2650	2550	2880	496	868	596
299	Diss Oxygen (mg/l)	5.9	7.2	1.5	6.5	5.6	6.7	9.0	7.4	6.5	6.7	7.0	7.2	5.6	2.0	2.0
301	Diss Oxygen Saturation (%) *	63.4	86.7	16.1	75.6	62.2	91.8	94.7	97.4	80.2	77.0	78.7	78.3	60.9	25.0	22.0
80082	BOD Carb (mg/l)	1	4	1 K	3	2	5	1 K	2	1 K	1	1 K	1 K	1	8	2
310	BOD Totel (mg/l)	2	9	2	5	3	2	1	2	2	2	1	2	2	13	4
335	COD (mg/l)	9	35	11	27	25	33	3	32	28	30	26	26	11	61	19
530	Susp Solids (mg/l)	4	17	19	13	14	9	3	26	17	20	9	41	11	23	44
70300	Diss Solids (mg/l)	507	1150	456	1200	1180	1120	843	1140	1670	1620	1540	1840	316	516	360
610	NH3+NH4 N (mg/L)	0.07	0.13	0.11	0.16	0.11	0.01	0.01 K	0.03	0.04	0.02	0.02	0.05	0.02	1.3	0.63
612	Un-ion Ammonia N (mg/l) *	0.001	0.001	0.001 K	0.005	0.003	0.001 K	0.001 K	0.001	0.003	0.001 K	0.001	0.001	0.001	0.012	0.006
630	NO2+NO3 N (mg/l)	0.59	9	0.02	7.8	7.8	21	3.2	18	18	15	12	8.71	0.15	0.17	0.24
665	Phosphorus Tot (mg/l)	0.15	3.3	0.08	2.8	2.6	1.8	0.05	1.9	2	2.2	2.3	2.4	0.08	2.7	0.27
900	Hardness (mg/l) *	245	435	236	420	410	568	320	520	522	498	489	509	223	161	242
916	Calcium Tot (mg/l)	71	130	61	120	120	160	92	150	150	140	140	150	54	40	60
915	Calcium Diss (mg/l)	--	129	--	--	122	163	94	--	148	142	138	136	53	38	59
927	Magnesium Tot (mg/l)	17	30	21	29	29	38	22	35	36	34	34	35	22	15	22
925	Magnesium Diss (mg/l)	17	30	23	29	29	37	22	35	34	33	32	31	20	14	21
929	Sodium Tot (mg/l)	84	240	51	220	220	390	150	340	350	330	310	330	11	110	25
930	Sodium Diss (mg/l)	--	--	--	--	--	383	151	350	341	323	304	305	14	106	26
937	Potassium Tot (mg/l)	3.0	12	2.9	11	11	12	2.2	11	12	11	10	8.8	4	11	5.3
935	Potassium Diss (mg/l)	3.6	12	2.6	11	11	12	2.3	12	12	11	9.6	8	4.2	9.7	5.4
940	Chloride (mg/l)	56	499	46	424	427	571	251	515	519	501	497	486	24	76	28
945	Sulfate (mg/l)	108	77	23	88	89	539	68	37	467	418	359	422	35	42	28
1105	Aluminum Tot (ug/l)	150 K	150 K	380	150 K	150 K	150 K	150 K	150 K	200	190	150 K	370	190	150 K	800
1106	Aluminum Diss (ug/l)	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K	150 K
1007	Barium Tot (ug/l)	100	35	97	47	52	190	49	150	160	140	130	140	55	26	75
1005	Barium Diss (ug/l)	98	31	84	43	48	174	45	143	147	135	116	116	49	18	61
1012	Beryllium Tot (ug/l)	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K
1010	Beryllium Diss (ug/l)	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K	1 K
1022	Boron Tot (ug/l)	240	270	47	270	280	260	66	250	260	240	240	230	30	370	83
1020	Boron Diss (ug/l)	218	249	43	257	264	227	57	250	229	215	222	199	24	316	72
1027	Cadmium Tot (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1025	Cadmium Diss (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1034	Chromium Tot (ug/l)	5 K	5 K	5 K	5 K	5 K	78	5 K	55	51	41	33	40	5 K	5 K	5 K
1030	Chromium Diss (ug/l)	5 K	5 K	5 K	5 K	5 K	68	5 K	52	44	36	30	35	5 K	5 K	5 K
1037	Cobalt Tot (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1035	Cobalt Diss (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1042	Copper Tot (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	12	5 K
1040	Copper Diss (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1045	Iron Tot (ug/l)	440	120	1100	230	260	50 K	120	76	230	220	160	380	280	700	1200
1046	Iron Diss (ug/l)	50 K	50 K	709	50 K	50 K	50 K	50 K	50 K	50 K	122	50 K	50 K	50 K	84	50 K
1051	Lead Tot (ug/l)	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K
1049	Lead Diss (ug/l)	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K
1055	Manganese Tot (ug/l)	100	53	490	60	73	15 K	83	23	53	70	46	57	420	310	1400
1056	Manganese Diss (ug/l)	100	29	--	48	88	15 K	79	20	48	64	38	44	380	279	1280
1067	Nickel Tot (ug/l)	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K
1065	Nickel Diss (ug/l)	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K	15 K
1077	Silver Tot (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1075	Silver Diss (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1082	Strontium Tot (ug/l)	230	200	150	210	210	1600	180	1200	1300	1100	970	1100	110	69	110
1080	Strontium Diss (ug/l)	222	188	--	201	200	1500	153	1190	1200	1060	897	959	99	60	104
1087	Vanadium Tot (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1085	Vanadium Diss (ug/l)	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K	5 K
1092	Zinc Tot (ug/l)	83	91	89	190	80	76	56	77	62	61	86	62	73	50 K	79
1090	Zinc Diss (ug/l)	83	--	53	65	62	76	50 K	73	--	50 K	50 K	50 K	50 K	50 K	50 K
1002	Arsenic (ug/l)	1.8	1.9	5.1	1.8	2.1	26.2	1.5	18	18.3	17.5	16.5	21.2	1.1	3.2	3.8
32730	Phenols (ug/l)	10 K	10 K	10 K	18.8	10 K	5 K	113.5	5 K	5 K	5 K	5 K	5 K	24.8	2.5	76.3
71900	Mercury (ug/l)	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K	0.05 K
720	Cyanide (mg/l)															

* Calculated
K Less than value stated

123

Table D. Effluent sample analysis results for samples collected by IEPA inside the Marathon refinery wastewater treatment plant, 1988-1992 (intended to represent effluent at outfall 001).

STORET	Parameter	Date: 88/02/23 Time: 1455	88/04/14 1300	88/10/19 1414	88/10/19 1416	88/12/12 1545	89/08/18 0900	89/09/18 24-Hr **	89/09/19 1220	90/08/06 24-Hr	90/08/07 1450	91/09/23 24-Hr	91/09/24 1220	92/01/28 1200	92/03/09 1435	92/05/19 1540	92/05/20 0750
10	Field Temp (°C)			23.9	22.8												
11	Field Temp (°F) *			75	73												
403	Lab pH (units)	7.4	7.4	7.7	7.6	8.1	7.9	8.3	8.1	6.6	7.3	7.1	7.5	7.6	7.5	7.4	7.4
556	Oil and Grease (mg/l)	1	1			2	1 K			1 K	1		1	4	2		4
310	BOD Total (mg/l)	3	5	8	11	2	2	1	1	1 K	1	2	2	8	2	7	1
335	COD (mg/l)	55	70	71	65	2		46	47	33	39	45	38	54	31	53	43
70300	Diss Solids (mg/l)	1530	1270	2200	2190	401	2160	1130	1230	2100	2160	1920	2000	1880	2170	1770	1850
530	Susp Solids (mg/l)	5	4	24	12	1	8	4	5	4	12	9	1	20	7	48	14
610	Ammonia as N (mg/l)	0.1 K	0.1 K	0.1 K	0.1 K	0.1 K		0.1 K	0.1 K	1.2	0.23	0.04	0.04	2.3		0.01 K	0.01 K
612	Un-ion Ammonia (mg/l) *			0.003 K	0.002 K												
46570	Hardness (mg/l) *						694	260	299	687	675	613	280	519	593	664	689
940	Chloride (mg/l)	427	346	714	711	23	501	219	236	469	510	380	420	500	684	375	423
945	Sulfate (mg/l)													650			
745	Sulfide	0.02 K	0.02 K				0.02 K	0.02 K	0.02 K	0.02 K	0.02 K	0.02 K	0.05	0.02 K	0.02 K	0.02	0.02 K
916	Calcium						184	66	77	196	193	173	46	150	170	200	210
927	Magnesium						57	23	26	48	47	44	40	35	41	40	40
929	Sodium (mg/l)						564	297	307	395	446	443	487	410	490	340	350
937	Potassium (mg/l)						13	6.1	5.2	7.2	6	7	4.7	6.7	7.4	12	21
1105	Aluminum Tot (ug/l)						297	90	88	139	138	150 K	193	150 K	150 K	150 K	150 K
1007	Barium Tot (ug/l)						231	71	80	267	200	79	77	120	120	120	120
1012	Beryllium Tot (ug/l)						1 K	0.5 K	0.5 K	0.5 K	0.5 K	1 K	0.5 K	1 K	1 K	1 K	1 K
1022	Boron Tot (ug/l)						291	110	111	280	250	237	211	450	270	220	220
1027	Cadmium Tot (ug/l)						3 K	3 K	3 K	10 K	10 K	5 K	3 K	5 K	5 K	5 K	5 K
1032	Chromium Hex (ug/l)	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K	50 K		50 K	50 K
1034	Chromium Tot (ug/l)	27	5 K	33	34		5 K	5 K	14	22	8	48	31	5 K	6	52	14
1037	Cobalt Tot (ug/l)						5 K	5 K	5 K	10 K	10 K	5 K	5 K	5 K	5 K	190	5 K
1042	Copper Tot (ug/l)						5 K	23	5 K	6	5 K	9	5	5 K	5 K	5 K	7
1045	Iron Tot (ug/l)						50 K	50 K	112	50 K	50 K	50 K	50 K	470	50 K	1000	73
1051	Lead Tot (ug/l)						50 K	50 K	50 K	50 K	100 K	50 K	50 K	50 K	50 K	67	60
1055	Manganese Tot (ug/l)						215	150	103	458	298	15 K	5 K	450	290	70	15 K
1067	Nickel Tot (ug/l)						6	5 K	10 K	5 K	5 K	15 K	11	15 K	15 K	15 K	15 K
1077	Silver Tot (ug/l)						3 K	3 K	3 K	3 K	3 K	5 K	3 K	5 K	5 K	5 K	5 K
1082	Strontium Tot (ug/l)						1252	472	534	701	695	993	856	1300	2000	1200	1400
1087	Vanadium Tot (ug/l)						5 K	5 K	5 K	5 K	5 K	10	8	5 K	5 K	5 K	5 K
1092	Zinc Tot (ug/l)							100 K	100 K	206	50 K	190	100 K	50 K	50 K	81	84
32730	Phenols (ug/l)	19	35	10	10		30	20	15	5 K	5 K	20	10	5 K	17	50	50

* Calculated
** 24-hr composite sample
K Less than value stated

124

Table E. IEPA Ambient Water Quality Monitoring Network (AWQMN) data for Site BF-01, Sugar Creek at Palestine, 1985-1991.

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1986 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	60/61 FLOW CFS	300 DO MG/L	400 PH SU	10 W TEMP DEG C	610 AMM-N MG/L	CALC UN-ION AMM MG/L	630 NO2+NO3 MG/L	625 TKN MG/L	680 TOC MG/L	335 COD MG/L	76 TURB MG/L	94/95 COND UMHOS	70300 TDS MG/L	530 TSS MG/L	535 VSS MG/L
851028	.	9.2	7.2	13.0	0.10K	0.000K	.	.	.	28	1.5	2680*	.	3	2
851121	.	9.0	7.0	6.5	0.25	0.000K	1.20	.	.	41	92.0	318	.	79	9
860108	.	10.7	7.3	1.5	0.10K	0.000K	7.20	.	.	23	4.0	1439	.	4	1
860211	.	14.6	7.8	0.0	0.11	0.001K	5.70	.	.	17	5.2	1017	.	5	2
860409	.	11.7	7.9	13.0	0.10K	0.002K	3.50	.	.	18	6.1	1252	.	12	2
860527	.	7.0	7.3	20.0	0.43	0.004	4.00	.	.	25	42.0	577	.	217	32
860624	.	5.5	7.2	22.0	0.17	0.001	8.60	.	.	24	24.0	1911*	178	75	14
860723	.	6.1	7.1	23.3	0.10K	0.001	11.00	.	.	30	17.0	2750*	1660*	40	.
860827	.	5.5	7.2	22.1	0.10K	0.001K	17.00	.	.	25	9.0	1958*	1140*	24	5
MEAN	.	8.8	7.3	13.5	0.16	0.001	7.27	.	.	26	22.3	1545	993	51	8
STANDARD		5.0	6.5-9.0		1.5/15	0.040						(1667)	1000		
% VIO		0.0	0.0		0.0	0.0						44.4	66.7		

DATE	31616/25 F COLI #/100ML	665 T PHOS MG/L	666 D PHOS MG/L	940 CL MG/L	945 SO4 MG/L	951 F MG/L	410 T ALK MG/L	70508 T ACID MG/L	556 OIL&GRSE MG/L	32730 PHENOL UG/L	1002 T AS UG/L	720 CN MG/L	71900 T HG UG/L	1105 T AL UG/L	1106 D AL UG/L
851028	180	1.20	1.20	525*	434	.	.	.	1.0	.	.	.	0.10K	128	.
851121	15000B*	0.46	0.29	29	46	.	.	.	1.0	.	.	.	0.10K	7653	.
860108	5K	0.60	0.50	212	220	.	.	.	1.0	.	.	.	.	64	.
860211	10K	0.48	0.42	127	157	.	.	.	1.0	.	.	.	0.10K	80	50K
860409	220 *	0.60	0.54	183	198	.	.	.	1.0	.	.	.	0.10K	283	50K
860527	5700 *	0.56	0.39	100	120	.	.	.	1.0	5K	.	.	0.10K	1284	50K
860624	3200 *	1.30	1.10	281	401	.	.	.	1.0	0	0	0.00K	0.01K	1171	50K
860723	1300B*	1.10	1.00	560*	380	.	117	.	1.0	10	18	0.00K	0.01K	610	50K
860827	2900B*	1.80	1.70	258	426	.	129	.	1.0	10	26	0.00K	0.22	654	68
MEAN	502(GEO)	0.90	0.79	253	265	.	123	.	1.0	6	15	0.00	0.09	1322	53
STANDARD	200			500	500	1.40				100	1000	0.025	0.50		
% VIO	66.7	.		22.2	0.0	.			.	0.0	0.0	0.0	0.0		

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1986 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	916 T CA MG/L	915 D CA MG/L	927 T MG MG/L	925 D MG MG/L	929 T NA MG/L	930 D NA MG/L	937 T K MG/L	935 D K MG/L	1007 T BA UG/L	1005 D BA UG/L	1012 T BE UG/L	1010 D BE UG/L	1022 T B UG/L	1020 D B UG/L	1027 T CD UG/L	1025 D CD UG/L	1034 T CR UG/L	1030 D CR UG/L	1037 T CO UG/L	1035 D CO UG/L
851028	162.0	.	42.0	.	417.0	.	11.0	.	151	.	1.0K	.	337	.	3K	.	7	.	5K	.
851121	29.0	.	8.5	.	24.0	.	5.6	.	93	.	1.0K	.	81	.	3K	.	34	.	5K	.
860108	99.0	.	28.0	.	164.0	.	5.4	.	92	.	1.0K	.	270	.	3K	.	5K	.	5K	.
860211	80.0	79.0	23.0	23.0	103.0	101.0	4.7	4.7	90	82	1.0K	2.0K	202	201	3K	3K	9	9	6	5
860409	95.0	94.0	27.0	26.0	146.0	139.0	6.1	6.0	105	94	1.0K	0.5K	169	170	3K	3K	5K	5K	5K	5K
860527	66.0	64.0	20.0	19.0	71.0	69.0	5.3	5.1	108	81	1.0K	0.5K	110	94	3K	3K	9	5K	5K	5K
860624	138.0	118.0	37.0	31.0	239.0	216.0	8.7	7.5	128	99	2.0K	3.0	272	240	3K	3K	13	6	7	5K
860723	170.0	172.0	42.0	43.0	374.0	358.0	11.0	11.0	150	143	0.5K	0.5K	265	263	3K	3K	5K	5K	8	9
860827	135.0	142.0	38.0	39.0	239.0	252.0	11.0	12.0	113	116	0.5K	0.5K	239	247	3K	3K	12	12	5	6
MEAN	108.2	111.5	29.5	30.2	197.4	189.2	7.6	7.7	114	103	1.0	1.2	216	203	3	3	11	7	6	6
STANDARD									5000				1000		50		1050			
% VIO									0.0				0.0		0.0		0.0			

DATE	1042 T CU UG/L	1040 D CU UG/L	1045 T FE UG/L	1046 D FE UG/L	1051 T PB UG/L	1049 D PB UG/L	1055 T MN UG/L	1056 D MN UG/L	1067 T NI UG/L	1065 D NI UG/L	1077 T AG UG/L	1075 D AG UG/L	1082 T SR UG/L	1080 D SR UG/L	1087 T VA UG/L	1085 D VA UG/L	1092 T ZN UG/L	1090 D ZN UG/L	900 HARD MG/L
851028	6	.	713	.	50.0K	.	57	.	5K	.	3K	.	982	.	5K	.	50K	.	577
851121	9	.	6780*	.	50.0K	.	174	.	8	.	3K	.	100	.	14	.	100K	.	107
860108	5K	.	323	.	50.0K	.	326	.	5K	.	3K	.	368	.	5K	.	100K	.	361
860211	8	6	208	50K	50.0K	50.0K	117	109	5K	5K	5	7	382	373	5K	6	50K	50K	295
860409	5K	5K	405	50K	50.0K	50.0K	166	152	5K	5K	3K	3K	439	433	5K	5K	50K	50K	347
860527	5	5K	1627*	97	50.0K	50.0K	184	93	.	93	3K	3K	289	275	8	5K	117	100K	235
860624	8	5K	1637*	90	50.0K	50.0K	271	199	23	13	6*	3K	800	695	12	6	50K	50K	496
860723	5	5K	790	50K	50.0K	50.0K	165	142	15	10	3K	3	984	978	7	7	50K	50K	603C
860827	6	6	592	50K	50.0K	50.0K	81	72	12	11	3K	3K	549	576	9	9	50K	50K	517
MEAN	6	5	1386	65	50.0	50.0	171	128	10	24	4	4	544	555	8	6	69	58	393
STANDARD	20		1000		100.0		1000		1000		5						1000		
% VIO	0.0		33.3	.	0.0		0.0		0.0		11.1						0.0		

125

Table E. IEPA AWQMN data for Site BF-01 (cont.).

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1987 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	60/61 FLOW CFS	300 DO MG/L	400 PH SU	10 W TEMP DEG C	610 AMM-N MG/L	CALC UN-ION AMM MG/L	630 NO2+NO3 MG/L	625 TKN MG/L	680 TOC MG/L	335 COD MG/L	76 TURB MG/L	94/95 COND UMHOS	70300 TDS MG/L	530 TSS MG/L	535 VSS MG/L
861008	.	6.3	.	14.0	0.23	.	6.90	.	.	240	.	1722*	1030*	10	.
861209	.	9.5	7.7	8.0	0.10	0.001	5.70	.	.	21	3.7	1160	.	22	7
870121	.	13.8	8.1	0.5	0.10K	0.001	4.30	.	.	21	5.3	1118	.	13	2
870219	.	12.5	8.3	1.0	0.10K	0.002	5.20	.	.	22	2.2	1810*	.	3	1
870415	.	9.0	7.4	12.5	0.40	0.002	3.50	.	.	39	84.0	580	.	86	12
870526	.	5.6	7.2	24.0	0.24	0.002	5.30	.	.	29	11.0	987	.	51	8
870713	.	6.1	6.9	24.0	0.10K	0.000	1.80	.	.	41	8.0	490	.	168	18
870825	.	6.7	7.0	19.0	1.20	0.005	13.00	.	.	40	7.4	1889*	.	47	4
870922	.	8.9	7.3	17.0	0.11	0.001	14.00	.	.	28	2.6	2240*	.	6	2
MEAN	.	8.7	7.5	13.3	0.29	0.002	6.63	.	.	53	15.5	1333	1030	45	7
STANDARD		5.0	6.5-9.0		1.5/15	0.040						(1667)	1000		
% VIO		0.0	0.0		0.0	0.0						44.4	100.0		

DATE	31616/25 F COLI #/100ML	665 T PHOS MG/L	666 D PHOS MG/L	940 CL MG/L	945 SO4 MG/L	951 F MG/L	410 T ALK MG/L	70508 T ACID MG/L	556 OIL&GRSE MG/L	32730 PHENOL UG/L	1002 T AS UG/L	720 CN MG/L	71900 T HG UG/L	1105 T AL UG/L	1106 D AL UG/L
861008	1800 *	1.10	.	287	254	.	132	.	1.0	10	10	0.00K	0.05K	277	.
861209	2600 *	0.68	0.62	160	200	.	142	.	2.0	5	.	.	0.05K	368	50K
870121	290 *	0.75	0.67	188	122	.	152	.	1.0	10	.	.	0.05K	213	50K
870219	80B	0.08	.	379	195	.	160	.	1.0	10	.	.	0.05K	50K	50K
870415	4900 *	0.79	0.59	66	69	.	73	.	1.0	5	.	.	0.05K	1535	50K
870526	2100 *	0.80	0.67	114	194	.	97	.	2.0	5	.	.	0.05K	1171	55
870713	4000L*	0.58	0.35	66	57	.	64	.	1.0	15	.	.	0.05K	5380	50K
870825	8600B*	2.10	1.90	235	499	.	130	.	2.0	10	.	.	0.05K	1054	50K
870922	500 *	1.30	1.20	320	550*	.	118	.	.	10	.	.	0.05K	265	50K
MEAN	1389(GEO)	0.91	0.86	202	238	.	119	.	1.4	9	10	0.00	0.05	1146	51
STANDARD	200			500	500	1.40				100	1000	0.025	0.50		
% VIO	88.9	.		0.0	11.1	.			.	0.0	0.0	0.0	0.0		

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1987 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	916 T CA MG/L	915 D CA MG/L	927 T MG MG/L	925 D MG MG/L	929 T NA MG/L	930 D NA MG/L	937 T K MG/L	935 D K MG/L	1007 T BA UG/L	1005 D BA UG/L	1012 T BE UG/L	1010 D BE UG/L	1022 T B UG/L	1020 D B UG/L	1027 T CD UG/L	1025 D CD UG/L	1034 T CR UG/L	1030 D CR UG/L	1037 T CO UG/L	1035 D CO UG/L
861008	118.0	.	29.0	.	175.0	.	7.3	.	107	.	0.5K	.	116	.	3K	.	5K	.	5K	.
861209	85.0	84.0	24.0	24.0	131.0	127.0	5.6	5.4	70	64	0.5K	0.5K	81	79	3K	3K	5K	5K	5K	5K
870121	79.0	78.0	24.0	23.0	119.0	119.0	5.1	5.0	65	61	0.5K	0.5K	70	70	3K	3K	5K	5K	5K	5K
870219	107.0	104.0	30.0	29.0	221.0	214.0	8.8	8.5	71	67	0.5K	0.5K	166	160	3K	3K	5K	5K	5K	5K
870415	48.0	44.0	14.0	13.0	40.0	36.0	5.3	4.7	76	49	0.5K	0.5K	58	51	3K	3K	6	5K	5K	5K
870526	68.0	55.0	19.0	15.0	111.0	90.0	6.9	5.0	70	51	0.5K	0.5K	130	103	3K	3K	8	5	5K	5K
870713	40.0	36.0	12.0	9.8	42.0	39.0	6.3	5.2	105	51	0.5K	0.5K	62	52	3K	3K	15	5K	5K	5K
870825	138.0	137.0	39.0	39.0	282.0	276.0	12.0	12.0	123	113	0.5K	0.5K	245	241	3K	3K	10	6	5K	5K
870922	156.0	155.0	40.0	40.0	287.0	284.0	9.6	9.4	118	115	0.5K	0.5K	163	163	3K	3K	5K	5K	5K	5K
MEAN	93.2	86.6	25.7	24.1	156.4	148.1	7.4	6.9	89	71	0.5	0.5	121	115	3	3	7	5	5	5
STANDARD									5000				1000		50		1050			
% VIO									0.0				0.0		0.0		0.0			

DATE	1042 T CU UG/L	1040 D CU UG/L	1045 T FE UG/L	1046 D FE UG/L	1051 T PB UG/L	1049 D PB UG/L	1055 T MN UG/L	1056 D MN UG/L	1067 T NI UG/L	1065 D NI UG/L	1077 T AG UG/L	1075 D AG UG/L	1082 T SR UG/L	1080 D SR UG/L	1087 T VA UG/L	1085 D VA UG/L	1092 T ZN UG/L	1090 D ZN UG/L	900 HARD MG/L
861008	5K	.	261	.	50.0K	.	102	.	5K	.	3K	.	372	.	5K	.	50K	.	413C
861209	5K	5K	496	50K	50.0K	50.0K	120	98	5K	5K	3K	3K	316	311	5K	5K	50K	50K	312C
870121	5K	5K	354	50K	50.0K	50.0K	126	118	9	5K	3K	3K	214	211	5K	5K	50K	50K	294C
870219	5K	5K	141	50K	50.0K	50.0K	127	121	5K	5K	3K	3K	487	472	5K	5K	50K	50K	390C
870415	5	5K	1909*	50K	50.0K	50.0K	148	63	12	11	3K	3K	165	148	5K	5K	50K	50K	180C
870526	5K	5K	1468*	50K	50.0K	50.0K	132	74	5K	5K	3K	3K	280	246	5	5K	100K	100K	245C
870713	6	5K	5801*	50K	50.0K	50.0K	275	64	11	8	3K	3K	139	124	7	5K	100K	50K	147C
870825	5K	5K	1188*	50K	50.0K	50.0K	137	94	5K	5K	3K	3K	593	589	5K	5K	50K	50K	503C
870922	5K	5K	341	50K	50.0K	50.0K	79	70	5K	5K	3K	3K	619	614	5K	5K	50K	50K	555C
MEAN	5	5	1329	50	50.0	50.0	138	88	7	6	3	3	354	339	5	5	61	56	338
STANDARD	20		1000		100.0		1000		1000		5						1000		
% VIO	0.0		44.4	.	0.0		0.0		0.0		0.0						0.0		

126

Table E. IEPA AWQMN data for Site BF-01 (cont.).

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1988 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	60/61 FLOW CFS	300 DO MG/L	400 PH SU	10 W TEMP DEG C	610 AMM-N MG/L	CALC UN-ION AMM MG/L	630 NO2+NO3 MG/L	625 TKN MG/L	680 TOC MG/L	335 COD MG/L	76 TURB MG/L	94/95 COND UMHOS	70300 TDS MG/L	530 TSS MG/L	535 VSS MG/L
871109	.	9.9	7.5	13.0	0.11	0.001	7.40	.	.	29	4.3	2350*	.	3	1
871216	.	12.4	7.3	2.0	.	.	4.50	.	.	26	39.0	945	.	39	5
880127	.	14.5	7.5	0.0	4.50	0.012	9.40	.	.	26	5.4	1530	.	3	1
880309	.	9.7	7.7	11.0	0.10K	0.001	3.90	.	.	25	1.9	979	.	8	2
880406	.	8.6	6.9	13.0	0.22	0.000	1.20	.	.	110	.	314	.	1170	90
880526	.	7.3	7.4	15.0	0.29	0.002	8.80	.	.	20	4.3	1360	.	22	3
880628	.	8.1	7.6	23.0	0.10K	0.002	21.00	.	.	34	9.2	2510*	.	57	7
880817	.	8.4	7.9	30.0	0.10K	0.006	15.00	.	.	34	2.8	771	.	26	5
880921	.	9.4	7.7	19.0	0.10K	0.002	13.00	.	.	30	4.2	2410*	.	7	2
MEAN	.	9.8	7.5	14.0	0.69	0.003	9.36	.	.	37	8.9	1463	.	148	13
STANDARD		5.0	6.5-9.0		1.5/15	0.040						(1667)	1000		
% VIO		0.0	0.0		0.0	0.0						33.3	.		

DATE	31616/25 F COLI #/100ML	665 T PHOS MG/L	666 D PHOS MG/L	940 CL MG/L	945 SO4 MG/L	951 F MG/L	410 T ALK MG/L	70508 T ACID MG/L	556 OIL&GRSE MG/L	32730 PHENOL UG/L	1002 T AS UG/L	720 CN MG/L	71900 T HG UG/L	1105 T AL UG/L	1106 D AL UG/L
871109	60B	1.10	1.10	374	491	.	135	.	1.0	15	.	.	0.05K	50K	50K
871216	4200 *	0.65	0.53	136	167	.	71	1	1.0	5	.	.	0.05K	1558	50K
880127	320B*	0.54	0.50	246	234	.	142	.	1.0	10	.	.	0.05K	116	50K
880309	200C	0.29	0.26	133	138	.	149	.	1.0K	575*	.	.	0.06	211	50K
880406	8000B*	1.20	0.40	29	38	.	31	.	1.0	10	.	.	0.05K	16880	50K
880526	2700 *	0.85	0.80	202	251	.	112	.	1.0	5	.	.	0.07	849	50K
880628	2500 *	5.60	5.50	360	684*	.	119	.	1.0	15	.	.	0.05K	638	50K
880817	1000 *	1.20	1.10	479	600*	.	129	.	3.0	5K	.	.	0.05K	858	50K
880921	600 *	0.89	0.84	356	581*	.	142	.	3.0	5K	.	.	0.05K	467	50K
MEAN	930(GEO)	1.37	1.23	257	354	.	114	1	1.4	72	.	.	0.05	2403	50
STANDARD	200			500	500	1.40				100	1000	0.025	0.50		
% VIO	77.8	.		0.0	33.3	.			.	11.1	.	.	0.0		

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1988 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	916 T CA MG/L	915 D CA MG/L	927 T MG MG/L	925 D MG MG/L	929 T NA MG/L	930 D NA MG/L	937 T K MG/L	935 D K MG/L	1007 T BA UG/L	1005 D BA UG/L	1012 T BE UG/L	1010 D BE UG/L	1022 T B UG/L	1020 D B UG/L	1027 T CD UG/L	1025 D CD UG/L	1034 T CR UG/L	1030 D CR UG/L	1037 T CO UG/L	1035 D CO UG/L
871109	132.0	133.0	34.0	34.0	316.0	319.0	17.0	17.0	113	113	0.5K	0.5K	225	221	3K	3K	18	15	5K	5K
871216	68.0	66.0	17.0	16.0	100.0	97.0	5.8	5.6	72	58	0.5K	0.5K	82	86	3K	3K	5K	7	5K	5K
880127	87.0	85.0	24.0	23.0	196.0	190.0	7.8	7.7	92	86	0.5K	0.5K	111	117	3K	3K	5K	6	5K	5K
880309	71.0	72.0	22.0	22.0	100.0	101.0	4.4	4.4	85	82	0.5K	0.5K	50K	50K	3K	3K	5K	5K	5K	5K
880406	35.0	25.0	12.0	7.2	20.0	20.0	5.7	3.8	254	37	2.0K	0.5K	50K	50K	3K	3K	30	5K	14	5K
880526	81.0	82.0	22.0	22.0	145.0	147.0	6.3	6.3	84	78	0.5K	0.5K	87	87	3K	3K	5K	5K	5K	5K
880628	146.0	143.0	36.0	35.0	336.0	334.0	11.0	11.0	109	98	0.5K	0.5K	170	167	3K	3K	5K	5K	5K	5K
880817	150.0	149.0	41.0	41.0	399.0	400.0	12.0	12.0	129	123	0.5K	0.5K	187	187	3K	3K	10	9	5K	5K
880921	142.0	140.0	35.0	34.0	346.0	342.0	9.6	9.5	93	88	0.5K	0.5K	160	157	3K	3K	6	5K	5K	5K
MEAN	101.3	99.4	27.0	26.0	217.6	216.7	8.8	8.6	115	85	0.7	0.5	125	125	3	3	10	7	6	5
STANDARD									5000				1000		50		1050			
% VIO									0.0				0.0		0.0		0.0			

DATE	1042 T CU UG/L	1040 D CU UG/L	1045 T FE UG/L	1046 D FE UG/L	1051 T PB UG/L	1049 D PB UG/L	1055 T MN UG/L	1056 D MN UG/L	1067 T NI UG/L	1065 D NI UG/L	1077 T AG UG/L	1075 D AG UG/L	1082 T SR UG/L	1080 D SR UG/L	1087 T VA UG/L	1085 D VA UG/L	1092 T ZN UG/L	1090 D ZN UG/L	900 HARD MG/L
871109	5K	5K	117	50K	50.0K	50.0K	31	29	9	5K	3K	3K	825	837	5K	5K	50K	50K	469C
871216	5K	5K	1719*	50K	50.0K	50.0K	145	104	5K	5K	3K	3K	240	232	5K	5K	100K	100K	237C
880127	5K	5K	266	50K	50.0K	50.0K	172	161	5K	5K	3K	3K	422	404	5K	5K	50K	50K	314C
880309	5K	5K	277	50K	50.0K	50.0K	66	57	5K	5K	3K	3K	311	314	5K	5K	50K	50K	266C
880406	25*	5K	22570*	72	100.0K	50.0K	1045*	30	24	5K	3K	3K	119	90	37	5K	122	50K	135C
880526	5K	5K	791	50K	50.0K	50.0K	99	76	5	5K	3K	3K	334	337	5K	5K	50K	50K	293C
880628	5K	5K	731	50K	50.0K	50.0K	72	35	5K	5K	3K	3K	620	611	5K	5K	100K	100K	512C
880817	5K	5K	559	50K	5.0K	5.0K	48	27	6	5	3K	3K	727	725	5K	5K	50K	50K	540C
880921	5K	5K	462	50	5.0K	5.0K	53	38	11	10	3K	3K	647	638	5K	5K	50K	.	497C
MEAN	7	5	3055	52	45.6	40.0	192	62	8	6	3	3	472	465	9	5	69	63	363
STANDARD	20		1000		100.0		1000		1000		5						1000		
% VIO	11.1		22.2	.	0.0		11.1		0.0		0.0						0.0		

127

Table E. IEPA AWQMN data for Site BF-01 (cont.).

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1989 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	60/61 FLOW CFS	300 DO MG/L	400 PH SU	10 W TEMP DEG C	610 AMM-N MG/L	CALC UN-ION AMM MG/L	630 NO2+NO3 MG/L	625 TKN MG/L	680 TOC MG/L	335 COD MG/L	76 TURB MG/L	94/95 COND UMHOS	70300 TDS MG/L	530 TSS MG/L	535 VSS MG/L
881025	.	9.3	7.5	8.0	0.10K	0.001	3.50	.	.	40	6.6	2450*	.	7	2
881129	.	12.7	7.4	6.0	3.00	0.011	14.00	.	.	42	9.3	2060*	.	3	3
890104	.	14.9	8.2	3.0	0.14	0.002	6.30	.	.	24	6.7	1506	.	6	4
890201	.	12.3	8.4	11.0	0.10K	0.005	9.20	.	.	24	1.2	1951*	.	6	2
890315	.	11.5	7.9	8.4	0.34	0.005	5.10	.	.	27	3.8	1123	.	4	3
890516	.	10.1	8.0	18.6	0.11	0.004	4.20	.	.	25	6.8	2110*	.	4	2
890620	.	7.1	7.6	22.9	0.13	0.003	7.90	.	.	25	0.9	1992*	.	30	3
890725	.	7.4	7.6	23.5	0.10K	0.002	3.30	.	.	24	5.4	1523	.	20	3
890828	.	6.6	7.9	26.0	0.49	0.024	1.10	.	.	41	3.9	1768*	.	10	2
MEAN	.	10.2	7.8	14.2	0.50	0.006	6.07	.	.	30	5.0	1831	.	10	3
STANDARD		5.0	6.5-9.0		1.5/15	0.040						(1667)	1000		
% VIO		0.0	0.0		0.0	0.0						66.7	.		

DATE	31616/25 F COLI #/100ML	665 T PHOS MG/L	666 D PHOS MG/L	940 CL MG/L	945 SO4 MG/L	951 F MG/L	410 T ALK MG/L	70508 T ACID MG/L	556 OIL&GRSE MG/L	32730 PHENOL UG/L	1002 T AS UG/L	720 CN MG/L	71900 T HG UG/L	1105 T AL UG/L	1106 D AL UG/L
881025	750B*	0.84	0.82	525*	364	.	155	.	2.0	15	.	.	0.05K	152	50K
881129	280 *	0.66	0.63	340	372	.	109	.	1.0	.	.	.	0.05K	137	81
890104	510 *	0.65	0.58	284	204	.	107	.	1.0	10	.	.	0.05K	208	110
890201	220 *	0.56	0.55	362	279	.	134	.	1.0	5K	.	.	0.05K	144	82
890315	270C*	1.20	1.20	157	169	.	136	.	2.0	5	.	.	0.05K	527	355
890516	890B*	0.76	0.73	365	374	.	162	.	3.0	0	.	.	0.05K	246	189
890620	80	0.93	0.81	439	368	.	134	.	1.0	5K	.	.	0.05K	2005	1618
890725	1700B*	0.67	0.59	226	283	.	130	.	.	5K	.	.	0.05K	557	397
890828	1700 *	0.74	0.67	264	290	.	209	.	.	20	.	.	0.05K	286	104
MEAN	478(GEO)	0.78	0.73	329	300	.	142	.	1.6	8	.	.	0.05	474	332
STANDARD	200			500	500	1.40				100	1000	0.025	0.50		
% VIO	88.9	.		11.1	0.0	.			.	0.0	.	.	0.0		

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1989 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	916 T CA MG/L	915 D CA MG/L	927 T MG MG/L	925 D MG MG/L	929 T NA MG/L	930 D NA MG/L	937 T K MG/L	935 D K MG/L	1007 T BA UG/L	1005 D BA UG/L	1012 T BE UG/L	1010 D BE UG/L	1022 T B UG/L	1020 D B UG/L	1027 T CD UG/L	1025 D CD UG/L	1034 T CR UG/L	1030 D CR UG/L	1037 T CO UG/L	1035 D CO UG/L
881025	113.0	113.0	29.0	29.0	381.0	375.0	8.7	8.7	101	98	0.5K	0.5K	237	234	3K	3K	6	7	5K	5K
881129	106.0	106.0	28.0	28.0	292.0	293.0	7.6	7.6	118	117	0.5K	0.5K	176	176	3K	3K	6	5K	5K	5K
890104	90.0	86.0	23.0	22.0	185.0	174.0	6.1	5.7	93	85	0.5K	0.5K	108	106	3K	3K	5K	6	5K	5
890201	114.0	114.0	30.0	30.0	226.0	225.0	6.6	6.5	107	105	0.5K	0.5K	126	125	3K	3K	5	5K	5K	5K
890315	74.0	69.0	22.0	20.0	146.0	135.0	5.2	4.8	35	29	0.5K	0.5K	111	106	3K	3K	5K	5K	5K	5K
890516	110.0	110.0	27.0	27.0	310.0	311.0	8.2	8.0	113	112	0.5K	0.5K	163	164	3K	3K	5K	5K	5K	5K
890620	138.0	135.0	34.0	33.0	326.0	319.0	9.0	8.7	178	172	0.5K	3.0	211	206	3K	3K	6	5	5K	5K
890725	95.0	82.0	26.0	.	188.0	7.1	6.1	1.6	115	67	0.5K	0.5K	126	50K	3K	3K	5K	5	5K	5K
890828	92.0	92.0	27.0	27.0	259.0	.	7.6	6.5	109	108	0.5K	0.5K	155	.	3K	3K	5K	5K	5K	5K
MEAN	103.6	100.8	27.3	27.0	257.0	229.9	7.2	6.5	108	99	0.5	0.8	157	146	3	3	5	5	5	5
STANDARD									5000				1000		50		1050			
% VIO									0.0				0.0		0.0		0.0			

DATE	1042 T CU UG/L	1040 D CU UG/L	1045 T FE UG/L	1046 D FE UG/L	1051 T PB UG/L	1049 D PB UG/L	1055 T MN UG/L	1056 D MN UG/L	1067 T NI UG/L	1065 D NI UG/L	1077 T AG UG/L	1075 D AG UG/L	1082 T SR UG/L	1080 D SR UG/L	1087 T VA UG/L	1085 D VA UG/L	1092 T ZN UG/L	1090 D ZN UG/L	900 HARD MG/L
881025	5K	5K	192	81	5.0K	5.0K	101	97	10K	10K	3K	3K	834	821	185	109	100K	100K	404C
881129	5K	5K	50K	50K	5.0K	5.0K	129	126	5K	5K	3K	3K	695	697	5K	5K	50K	50K	377C
890104	5K	5K	224	50K	5.0K	5.0K	85	75	5K	7	3K	5K	538	505	5K	5	50K	50K	319C
890201	5K	5K	120	50K	5.0K	5.0K	58	53	8	10	3K	3K	686	683	5K	5K	50K	50K	407C
890315	5K	5K	388	118	5.0K	5.0K	72	58	5K	5K	3K	5K	386	357	5K	5K	50K	50K	273C
890516	5K	5K	103	50K	5.0K	5.0K	59	56	9	5K	3K	3K	786	.	5K	5K	100K	100K	384C
890620	11	11	888	50K	5.0K	5.0K	188	159	5K	5K	3K	3K	988	964	7	7	100K	100K	484C
890725	5K	5K	480	470	5.0K	5.0K	75	58	5K	5K	3K	3K	390	126	5	5K	50K	50K	346C
890828	5K	5K	250	50K	5.0K	5.0K	84	72	8	8	3K	3K	419	.	5K	5K	110	.	339C
MEAN	6	6	299	108	5.0	5.0	95	84	7	7	3	3	636	593	25	17	73	69	370
STANDARD	20		1000		100.0		1000		1000		5						1000		
% VIO	0.0		0.0	.	0.0		0.0		0.0		0.0						0.0		

128

Table E. IEPA AWQMN data for Site BF-01 (cont.).

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1990 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
ACUTE VIOLATIONS = * -- CHRONIC HAVE A # NEXT TO % VIO
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	60/61 FLOW CFS	300 DO MG/L	400 PH SU	10 W TEMP DEG C	610 AMM-N MG/L	CALC UN-ION AMM MG/L	630 NO2+NO3 MG/L	625 TKN MG/L	680 TOC MG/L	335 COD MG/L	76 TURB MG/L	94/95 COND UMHOS	70300 TDS MG/L	530 TSS MG/L	535 VSS MG/L
891019	.	7.8	8.5	8.4	0.10K	0.005	1.20	.	.	37	0.2	1705*	.	6	2
891120	.	10.6	7.0	9.6	0.22	0.000	3.40	.	.	38	2.7	1650	.	4	1
900103	.	11.2	7.8	0.7	13.00*	0.075*	2.30	.	.	32	0.5	1753*	.	3	2
900213	.	11.1	7.8	11.4	0.10K	0.001	3.60	.	.	23	2.2	1401	.	11	2
900320	.	7.9	7.3	8.2	0.45	0.002	4.80	.	.	24	3.3	948	.	16	3
900509	.	9.5	7.8	17.7	0.10K	0.002	4.30	.	.	13	.	976	.	26	2
900626	.	8.0	7.5	19.6	0.11	0.001	7.00	.	.	23	9.3	1150	.	49	4
900723	.	6.8	7.6	22.2	5.70*	0.110*	3.60	.	.	25	7.2	159	.	32	6
900912	.	7.5	7.8	22.8	0.07	0.002	6.60	.	.	18	2.5	1681*	.	12	2
MEAN	.	8.9	7.7	13.4	2.21	0.022	4.09	.	.	26	3.5	1269	.	18	3
STANDARD		5.0	6.5-9.0		1.5/15	0.040						(1667)	1000		
% VIO		0.0	0.0		22.2	22.2						33.3	.		

DATE	31616/25 F COLI #/100ML	665 T PHOS MG/L	666 D PHOS MG/L	940 CL MG/L	945 SO4 MG/L	951 F MG/L	410 T ALK MG/L	70508 T ACID MG/L	556 OIL&GRSE MG/L	32730 PHENOL UG/L	1002 T AS UG/L	718 CN MG/L	71900 T HG UG/L	1105 T AL UG/L	1106 D AL UG/L
891019	260 *	0.78	0.75	269	286	.	196	.	.	15	.	.	0.05K	30	8
891120	110	0.44	0.41	214	353	.	189	.	.	10	.	.	0.05	9	6
900103	110	0.33	0.33	296	268	.	179	.	.	15	.	.	0.05K	12	10
900213	370	0.78	0.70	252	213	.	146	.	.	5K	.	.	0.05K	15	5K
900320	60B	0.40	0.40	182	177	.	142	.	.	5K	.	.	0.05K	45	8
900509	510 *	0.51	0.43	130	115	.	167	.	.	5K	.	.	0.10K	53	5K
900626	830B*	0.50	0.43	149	173	.	141	.	.	5K	.	.	0.10K	48	10
900723	3900B*	2.50	2.50	238	298	.	122	.	.	5K	.	.	0.05K	46	13
900912	1200B*	1.80	1.80	271	307	.	125	.	.	5K	.	.	0.10K	33	5K
MEAN	373(GEO)	0.89	0.86	222	243	.	156	.	.	8	.	.	0.07	328	81
STANDARD	200			500	500	1.40				100	260	0.022	0.50		
% VIO	100.0	.		0.0	0.0	.			.	0.0	.	.	0.0		

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1990 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
ACUTE VIOLATIONS = * -- CHRONIC HAVE A # NEXT TO % VIO
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	916 T CA MG/L	915 D CA MG/L	927 T MG MG/L	925 D MG MG/L	929 T NA MG/L	930 D NA MG/L	937 T K MG/L	935 D K MG/L	1007 T BA UG/L	1005 D BA UG/L	1012 T BE UG/L	1010 D BE UG/L	1022 T B UG/L	1020 D B UG/L	1027 T CD UG/L	1025 D CD UG/L	1034 T CR UG/L	1030 D CR UG/L	1037 T CO UG/L	1035 D CO UG/L
891019	105.0	105.0	29.0	29.0	226.0	226.0	8.6	8.0	106	102	0.5K	0.5K	161	162	3K	3K	5K	5K	5K	5K
891120	102.0	102.0	28.0	28.0	198.0	200.0	4.8	4.3	97	96	0.5K	0.5K	170	169	3K	3K	5K	5K	5K	5K
900103	94.0	92.0	25.0	25.0	222.0	219.0	6.7	7.4	94	91	0.5K	0.5K	97	98	3K	3K	5	5K	5K	5K
900213	89.0	87.0	26.0	26.0	174.0	172.0	5.4	5.1	109	105	0.5K	0.5K	95	93	3K	3K	5K	5K	5K	5K
900320	85.0	84.0	24.0	23.0	122.0	121.0	5.3	4.8	94	88	0.5K	0.5K	102	100	3K	3K	5K	5K	5K	5K
900509	80.0	79.0	23.0	23.0	96.0	97.0	5.2	5.1	91	81	0.5K	0.5K	89	89	3K	3K	5K	5K	5K	5K
900626	89.0	89.0	22.0	22.0	106.0	106.0	4.3	3.5	101	97	0.5K	0.5K	70	67	3K	3K	5K	5K	5K	5K
900723	110.0	110.0	27.0	26.0	190.0	190.0	5.5	5.9	124	118	0.5K	0.5K	114	112	3K	3K	5K	5K	5K	5K
900912	104.0	101.0	26.0	26.0	208.0	199.0	4.7	3.5	114	105	0.5K	0.5K	158	157	3K	3K	5K	5K	5K	5K
MEAN	95.3	94.3	25.6	25.3	171.3	170.0	5.6	5.3	103	98	0.5	0.5	117	116	3	3	5	5	5	5
STANDARD									5000				1000							
% VIO									0.0				0.0		0.0		0.0			

DATE	1042 T CU UG/L	1040 D CU UG/L	1045 T FE UG/L	1046 D FE UG/L	1051 T PB UG/L	1049 D PB UG/L	1055 T MN UG/L	1056 D MN UG/L	1067 T NI UG/L	1065 D NI UG/L	1077 T AG UG/L	1075 D AG UG/L	1082 T SR UG/L	1080 D SR UG/L	1087 T VA UG/L	1085 D VA UG/L	1092 T ZN UG/L	1090 D ZN UG/L	900 HARD MG/L
891019	5K	5K	389	8	5.0K	5.0K	169	111	7	5K	3K	3K	479	.	5K	5K	50K	50K	380C
891120	5K	5K	96	5K	5.0K	5.0K	147	145	5K	5K	3K	3K	462	465	5K	5K	50K	50K	369C
900103	5K	5K	111	5K	5.0K	5.0K	171	165	5	5K	3K	3K	654	640	5K	5K	100K	100K	337C
900213	5K	5K	243	5K	5.0K	5.0K	81	71	5	.	3K	3K	610	602	5K	5K	50K	50K	327C
900320	5K	5K	361	5K	5.0K	5.0K	63	28	5K	5K	3K	3K	442	435	5K	5K	50K	50K	310C
900509	5K	5K	724	5K	5.0K	5.0K	91	55	10K	10K	3K	3K	324	325	5K	5K	50K	50K	293C
900626	5K	5K	449	5K	5.0K	5.0K	113	92	10K	10K	3K	3K	321	322	5K	5K	50K	50K	313C
900723	5K	5K	309	5K	5.0K	5.0K	95	73	10K	10K	3K	3K	414	412	5K	5K	50K	50K	384C
900912	5K	6	322	5K	5.0K	5.0K	98	84	10K	10K	3K	3K	491	477	5K	5	50K	50K	369C
MEAN	5.0	5	334	54	5.0	5.0	114	92	7	8	3	3	466	460	5	5	56	56	342
STANDARD				1000			1000		1000		5						1000		
% VIO	0.0		0.0	.	0.0		0.0		0.0		0.0						0.0		

129

Table E. IEPA AWQMN data for Site BF-01 (cont.).

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1991 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
ACUTE VIOLATIONS = * -- CHRONIC HAVE A # NEXT TO % VIO
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	60/61 FLOW CFS	300 DO MG/L	400 PH SU	10 W TEMP DEG C	610 AMM-N MG/L	CALC UN-ION AMM MG/L	630 NO2+NO3 MG/L	625 TKN MG/L	680 TOC MG/L	335 COD MG/L	76 TURB MG/L	94/95 COND UMHOS	70300 TDS MG/L	530 TSS MG/L	535 VSS MG/L
901113	.	11.0	7.7	7.6	0.13	0.001	3.20	.	.	37	0.5	3230*	.	4	2
901212	.	9.6	7.9	9.4	0.58	0.009	7.80	.	.	20	0.1	1589	.	4	1
910122	.	12.7	7.8	0.8	0.15	0.001	4.70	.	.	11	3.5	1066	.	5	1
910306	.	10.3	8.2	9.3	0.12	0.003	2.50	.	.	17	3.2	1335	.	16	2
910410	.	10.3	7.9	13.8	0.14	0.003	5.60	.	.	16	2.9	1322	.	11	2
910515	.	6.4	7.6	23.0	0.28	0.006	2.60	.	.	29	5.6	1540	.	25	3
910604	.	7.7	7.9	24.6	0.07	0.003	3.80	.	.	24	4.6	2120*	.	16	4
910807	.	6.5	7.6	25.0	0.39	0.009	1.10	.	.	34	4.2	1770*	.	31	4
910924	.	9.5	7.9	14.3	0.06	0.001	6.00	.	.	26	2.1	1975*	.	5	2
MEAN	.	9.3	7.8	14.2	0.21	0.004	4.14	.	.	24	3.0	1772	.	13	2
STANDARD		5.0	6.5-9.0		1.5/15	0.040						(1667)	1000		
% VIO		0.0	0.0		0.0	0.0						44.4	.		

DATE	31616/25 F COLI #/100ML	665 T PHOS MG/L	666 D PHOS MG/L	940 CL MG/L	945 SO4 MG/L	951 F MG/L	410 T ALK MG/L	70508 T ACID MG/L	556 OIL&GRSE MG/L	32730 PHENOL UG/L	1002 T AS UG/L	718 CN MG/L	71900 T HG UG/L	1105 T AL UG/L	1106 D AL UG/L
901113	240	1.40	1.40	136	467	.	169	.	.	5K	.	.	0.05K	11	9
901212	1100B	2.90	2.80	243	293	.	155	.	.	5K	.	.	0.05K	17	5K
910122	150	0.41	0.38	149	129	.	157	.	.	5K	.	.	0.05K	26	
910306	350	1.18	1.10	208	209	.	167	.	.	5K	.	.	0.05K	28	5K
910410	620B	1.40	.	190	350	.	142	.	.	5K	.	.	0.05K	24	6
910515	1600B*	1.30	1.20	247	263	.	145	.	.	950*	.	.	0.05K	35	15K
910604	3100 *	2.60	2.50	375	445	.	180	.	.	5K	.	.	0.05K	44	15K
910807	12000B*	1.20	1.10	295	420	.	111	.	.	5K	.	.	0.15	48	11
910924	910B*	2.80	2.70	300	440	.	135	.	.	5K	.	.	0.05K	18	5K
MEAN	919(GEO)	1.69	1.65	238	335	.	151	.	.	110	.	.	0.06	282	91
STANDARD	200			500	500	1.40				100	260	0.022	0.50		
% VIO	100.0	.		0.0	0.0	.			.	11.1	.	.	0.0		

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY *** WATER YEAR 1991 AWQMN WATER QUALITY DATA ***
VIOLATIONS OF 35 ILL. ADM. CODE 302 GENERAL USE WATER QUALITY STANDARDS NOTED BY *.
ACUTE VIOLATIONS = * -- CHRONIC HAVE A # NEXT TO % VIO
BASIN: WABASH STATION: BF 01 SUGAR CREEK AT PALESTINE, IL COUNTY: CRAWFORD

DATE	916 T CA MG/L	915 D CA MG/L	927 T MG MG/L	925 D MG MG/L	929 T NA MG/L	930 D NA MG/L	937 T K MG/L	935 D K MG/L	1007 T BA UG/L	1005 D BA UG/L	1012 T BE UG/L	1010 D BE UG/L	1022 T B UG/L	1020 D B UG/L	1027 T CD UG/L	1025 D CD UG/L	1034 T CR UG/L	1030 D CR UG/L	1037 T CO UG/L	1035 D CO UG/L
901113	205.0	205.0	51.0	51.0	467.0	459.0	12.0	10.0	169	163	0.5K	0.5K	222	223	3K	3K	9	.	5K	5K
901212	100.0	.	28.0	29.0	146.0	149.0	5.1	4.7	104	.	0.5K	0.5K	108	105	3K	3K	7	5K	5K	5K
910122	92.0	93.0	22.0	22.0	89.0	90.0	3.8	3.5	87	88	0.5K	0.5K	91	92	3K	3K	5K	5K	5K	5K
910306	92.0	92.0	26.0	26.0	141.0	141.0	2.7	2.9	90	86	0.5K	0.5K	68	68	3K	3K	5K	5K	5K	5K
910410	91.0	88.0	24.0	23.0	163.0	159.0	4.4	3.7	72	67	0.5K	0.5K	108	103	3K	3K	5K	5K	5K	5K
910515	98.0	93.0	27.0	25.0	190.0	180.0	6.4	6.7	89	77	1.0K	1.0K	120	120	5K	5K	5K	5K	5K	.
910604	130.0	120.0	33.0	31.0	280.0	270.0	7.2	6.4	92	81	1.0K	1.0K	160	150	5K	5K	7	5K	5K	5K
910807	99.0	93.0	24.0	22.0	245.0	228.0	5.3	4.7	106	91	0.5K	0.5K	130	126	3K	3K	5K	5K	5K	5K
910924	113.0	101.0	30.0	26.0	297.0	271.0	6.1	4.6	84	71	0.5K	0.5K	325	.	3K	3K	16	7	5K	5K
MEAN	113.3	110.6	29.4	28.3	224.2	216.3	5.9	5.2	99	91	0.6	0.6	148	123	3	3	7	5	5	5
STANDARD									5000				1000							
% VIO									0.0				0.0		0.0		0.0			

DATE	1042 T CU UG/L	1040 D CU UG/L	1045 T FE UG/L	1046 D FE UG/L	1051 T PB UG/L	1049 D PB UG/L	1055 T MN UG/L	1056 D MN UG/L	1067 T NI UG/L	1065 D NI UG/L	1077 T AG UG/L	1075 D AG UG/L	1082 T SR UG/L	1080 D SR UG/L	1087 T VA UG/L	1085 D VA UG/L	1092 T ZN UG/L	1090 D ZN UG/L	900 HARD MG/L
901113	5	.	125		5.0K	5.0K	193	189	10K	5K	3K	3K	1025	1004	5K	6	50K	50K	722C
901212	5K	5K	227	5K	5.0K	5.0K	160	159	10K	10K	5K	3K	610	.	7	5K	50K	50K	364C
910122	5K	5	440	5K	5.0K	5.0K	151	.	11	10K	3K	3K	334	.	5K	5K	120	100K	320C
910306	5K	5K	515	5K	5.0K	5.0K	115	104	10K	10K	3K	3K	524	525	5K	5K	50K	50K	335C
910410	5K	5K	322	5K	5.0K	5.0K	148	130	5K	5K	3K	3K	516	505	5K	5K	50K	50K	324C
910515	5K	5K	580	5K	5.0K	5.0K	120	82	15K	15K	5K	5K	520	490	5K	5K	50K	50K	352C
910604	5K	5K	590	5K	5.0K	5.0K	230	180	15K	15K	5K	5K	620	580	5K	5K	62	66	457C
910807	5K	5K	456	5K	5.0K	5.0K	276	231	5K	5K	3K	3K	566	542	5K	5K	50K	50K	344C
910924	7	6	165	5K	5.0K	5.0K	90	72	5K	5K	3K	3K	604	564	8	5K	110	100K	407C
MEAN	5.2	5	380	50	5.0	5.0	165	143	10	9	4	3	591	601	6	5	66	63	403
STANDARD				1000			1000		1000		5						1000		
% VIO	0.0		0.0	.	0.0		0.0		0.0		0.0						0.0		

130

Table E (cont). IEPA AWQMN data for Site BF-01, Sugar Creek at Palestine.

INITIAL DATE				91/11/13	91/12/17	92/01/07	92/03/12	92/04/22	92/05/20	92/07/06
INITIAL TIME				1000	1500	1600	0800	1300	1400	1400
MEDIUM				WATER	WATER	WATER	WATER	WATER	WATER	WATER
00010	WATER	TEMP	CENT	5.4	5.0	7.4	4.3	14.1	22.1	24.8
00011	WATER	TEMP	FAHN	41.7$	41.0$	45.3$	39.7$	57.4$	71.8$	76.6$
00020	AIR	TEMP	CENT	9.0	5.0	8.0	-4.0	16.0	26.5	25.5
00027	COLLECT	AGENCY	CODE	17002	17002	17002	17002	17002	17002	17002
00028	ANALYZE	AGENCY	CODE	17002	17002	17002	17002	17002	17002	17002
00076	TURB	TRBIDMTR	HACH FTU		2.2	2.4	1.8	4.9	3.7	.2
00094	CNDUCTVY	FIELD	MICROMHO	2540	1920	1490	1805	763	1854	1886
00299	DO	PROBE	MG/L	11.2	13.3	12.0	10.5	10.8	8.7	8.3
00301	DO	SATUR	PERCENT	87.5$	104.3$	98.4$	80.4$	103.9$	99.1$	99.1$
00335	COD	LOWLEVEL	MG/L	23.0	25.0	26.0	30.0	30.0	27.0	24.0
00400	PH		SU	7.70	8.20	8.20	8.20	7.80	7.90	7.70
00410	T ALK	CACO3	MG/L	133			136	121	139	165
00530	RESIDUE	TOT NFLT	MG/L	5	4	4	8	15	18	9
00535	RESIDUE	VOL NFLT	MG/L	1	1	1	3	5	5	2
00610	NH3+NH4-	N TOTAL	MG/L	.030	.090	.670	2.100	.170	.190	.320
00612	UN-IONZD	NH3-N	MG/L	.0002$	.002$	.016$	.038$	.003$	.007$	.009$
00619	UN-IONZD	NH3-NH3	MG/L	.0002$	.002$	.019$	.047$	.003$	.008$	.011$
00630	NO2&NO3	N-TOTAL	MG/L	4.70	4.90	5.60	3.40	5.90	7.80	2.20
00665	PHOS-TOT		MG/L P	3.300	2.100	1.600	2.020	.710	1.300	1.800
00666	PHOS-DIS		MG/L P		2.000		1.900	.800	1.200	1.700
00900	TOT HARD	CACO3	MG/L	524C	401C	364C	342C	241C	416C	415C
00915	CALCIUM	CA,DISS	MG/L	140.0	110.0	86.0		63.0	110.0	120.0
00916	CALCIUM	CA-TOT	MG/L	150.0	110.0	100.0	97.0	66.0	120.0	120.0
00925	MGNSIUM	MG,DISS	MG/L	34.0	27.0	23.0		18.0	28.0	29.0
00927	MGNSIUM	MG,TOT	MG/L	36.0	28.0	27.0	24.0	19.0	30.0	30.0
00929	SODIUM	NA,TOT	MG/L	410.00	280.00	180.00	250.00	59.00	220.00	210.00
00930	SODIUM	NA,DISS	MG/L	390.00	240.00	150.00	210.00	58.00	200.00	200.00
00935	PTSSIUM	K,DISS	MG/L	7.00	5.90	6.60	5.60	4.40	8.40	6.20
00937	PTSSIUM	K,TOT	MG/L	7.40	5.80	8.00	6.30	4.70	9.50	6.50
00940	CHLORIDE	TOTAL	MG/L		340		341	85	296	321
00945	SULFATE	SO4-TOT	MG/L				285	99	354	259
01005	BARIUM	BA,DISS	UG/L	95	67	70	73	59	88	76
01007	BARIUM	BA,TOT	UG/L	100	81	85	84	66	98	79
01010	BERYLIUM	BE,DISS	UG/L	1.00K	1.00K	1.00K	1.00K	1.00K	1.00K	1.00K
01012	BERYLIUM	BE,TOT	UG/L	1.00K	1.00K	1.00K	1.00K	1.00K	1.00K	1.00K
01020	BORON	B,DISS	UG/L		190	150	150	58	140	
01022	BORON	B,TOT	UG/L	320	200	160	150	61	150	170
01025	CADMIUM	CD,DISS	UG/L	5K	5K	5K	5K	5K	5K	5K
01027	CADMIUM	CD,TOT	UG/L	5K	5K	5K	5K	5K	5K	5K
01030	CHROMIUM	CR,DISS	UG/L	10	5K	5K	5K	5K	5K	5K
01034	CHROMIUM	CR,TOT	UG/L	11	6	5K	5K	5K	5K	6
01035	COBALT	CO,DISS	UG/L	5K	5K	5K	5K	5K	5K	5K
01037	COBALT	CO,TOTAL	UG/L	5K	5K	5K	5K	5K	5K	5K
01040	COPPER	CU,DISS	UG/L	5K	5K	5K	5K	5K	5K	5K
01042	COPPER	CU,TOT	UG/L	5K	5K	26	5K	5K	6	5K
01045	IRON	FE,TOT	UG/L	110	130	110	140	430	170	82
01046	IRON	FE,DISS	UG/L	50K	50K	50K	50K	50K	50K	50K
01049	LEAD	PB,DISS	UG/L	5K	5K	5K	5K	5K	5K	5K
01051	LEAD	PB,TOT	UG/L	5K	5K	5K	5K	5K	5K	5K
01055	MANGNESE	MN	UG/L	160.0	58.0	55.0	160.0	48.0	73.0	88.0
01056	MANGNESE	MN,DISS	UG/L	150.0	57.0	44.0	160.0	31.0	62.0	78.0
01065	NICKEL	NI,DISS	UG/L	15K	15K	15K	15K	15K	15K	15K
01067	NICKEL	NI,TOTAL	UG/L	15K	15K	15K	15K	15K	15K	15K
01075	SILVER	AG,DISS	UG/L	5.0K	6.0	5.0K	5.0K	5.0K	5.0K	5.0K
01077	SILVER	AG,TOT	UG/L	5.0K	5.0K	5.0K	5.0K	5.0K	5.0K	5.0K
01080	STRONTUM	SR,DISS	UG/L	960	670	480	790	260	540	640
01082	STRONTUM	SR,TOT	UG/L	1000	760	580	880	270	580	650
01085	VANADIUM	V,DISS	UG/L	5K	5K	5K	5K	5K	5K	5K
01087	VANADIUM	V,TOT	UG/L	5K	5K	5K	5K	5K	5K	5K
01090	ZINC	ZN,DISS	UG/L	50K	91	50K	58	50K	50K	50K
01092	ZINC	ZN,TOT	UG/L	50K	50K	50K	87	50K	120	50K
01105	ALUMINUM	AL,TOT	UG/L	150K	150K	150K	150K	260	150K	150K
01106	ALUMINUM	AL,DISS	UG/L	150K	150K	150K	150K	150K	150K	150K
31616	FEC COLI	MFM-FCBR	/100ML	1240B	130	1300008	2300	980	2500	1020
32730	PHENOLS	TOTAL	UG/L	25	5K	5K	20K	10K	10K	5K
46570	CAL HARD	CA MG	MG/L	490$	386$	309$	341$	231$	390$	419$
70300	RESIDUE	DISS-180	C, MG/L					451	1110	1190
71900	MERCURY	HG,TOTAL	UG/L	.05K	.2	.05K	.05K	.05K	.05K	.05K
74041	WQF	SAMPLE	UPDATED	920319	920319	920416	920828	920916	921201	921201

131

Table F. Macroinvertebrate community sampling results from Sugar Creek and tributaries in the vicinity of Robinson WWTP, Marathon Refinery, and Palestine WWTP, August 1992 and July 1986. (Data for 1986 were modified to conform with taxonomic levels of identification employed in 1992, i.e., field identification levels.)

Tolerance Rating	Taxon	Stream:	Robinson Creek	Quail Creek	Robinson Cr		Marathon Creek	Robinson Cr			Sugar Cr		Lamotte Cr		Robinson Creek	Quail Creek	Robinson Cr		Marathon Creek	Robinson Cr			Sugar Cr	
		Code:	BFC	BFCB	BFC	BFC	BFCA	BFC	BFC	BFC	BF	BF	BFB	BFB	BFC	BFCB	BFC	BFC	BFCA	BFC	BFC	BFC	BF	BF
		Site:	20	12	19	25	22	26	11	10	11	01	13	09	20	12	19	25	21	26	11	10	11	01
		Mo/Yr:	8/92	8/92	8/92	8/92	8/92	8/92	8/92	8/92	8/92	8/92	8/92	8/92	7/86	7/86	7/86	7/86	7/86	7/86	7/86	7/86	7/86	7/86
6.0	Turbellaria (flatworms)													1		16	6							
10.0	Oligochaeta (worms)		40	25	120	60	70	45	120	50	27	25				11	50	80	28	751	150	45	14	12
8.0	Hirudinea (leeches)					4							1	2										
6.0	Cascidotea (sowbugs)												20	43										
4.0	Amphipoda (scuds)			2																	4			
5.0	Hyalella azteca (scuds)													10		7							1	11
5.0	Cambaridae (crayfish)		2	1				12	25	14	10	16	9	10	12	3	2	8	1	6	18	30	12	26
4.0	Stenacron (mayflies)										1		23	56		15		1						
4.0	Baetidae (mayflies)														1									6
6.0	Caenis (mayflies)			10		1							15	23		14		1						1
4.5	Anisoptera (dragonflies)		1													1				1		1		1
4.5	Gomphidae (dragonflies)										2													
3.0	Boyeria (dragonflies)						1						1											
4.5	Libellulidae (dragonflies)				3	3	2																	
3.5	Calopterygidae (damselflies)						4				8				1		2	2				1	5	2
6.0	Lestidae (damselflies)						1																	
5.5	Coenagrionidae (damselflies)			5		6	8	7		3	5	10				9	2	4		4	1	3	7	
5.0	Argia (damselflies)					10		9	25	8	15	20	8	15			2	10		2	34	9	9	26
6.0	Enallagma (damselflies)												15	11										
5.5	Hydropsychidae (caddisflies)											1						1						
5.0	Leptoceridae (caddisflies)															2								
4.0	Helichus (beetles)												2	3		2								1
5.0	Dubiraphia (beetles)												9	9		8		3						
7.0	Stenelmis (beetles)												5	4										
8.0	Culicidae (mosquitos)			14			16						8				1							
6.0	Simuliidae (blackflies)		26		60	60	26			3	16							48						
4.0	Tipulidae (craneflies)																							
5.0	Ceratopogonidae (biting midges)																		6			4		
11.0	Red Chironomidae (midges)		12	16	20	8	12	12	15	10	5	15	5	14	11	9	15	13		12		6		14
6.0	Non-red Chironomidae (midges)		24	8	40	18	42	30		8	18	30	12	13	14	21	21	69		12		1	2	48
10.0	Other Diptera (flies)		5																20				1	
9.0	Physa (snails)		10	2	24	12	20	26		5	2	8	10	13	9		1	3		4				1
7.0	Lymnaea (snails)															2				1				
5.0	Helisoma (snails)																			1				
7.0	Ferrissia (limpets)		2																					
5.0	Sphaerium (clams)				4	1				5		2	4	13	12		1			1				
5.0	Pisidium (clams)			14												28		17						
Number of Organisms			122	97	271	183	202	141	185	106	109	127	147	240	60	148	103	260	55	795	207	100	51	149
Number of Taxa			9	10	7	11	11	7	4	9	11	9	16	16	7	15	11	14	4	11	5	9	8	12
Macroinvertebrate Biotic Index (MBI)			8.2	8.0	8.4	7.7	8.0	8.1	8.7	8.2	6.8	7.2	6.0	5.8	6.9	6.0	8.6	7.3	9.4	9.9	8.6	7.6	6.4	6.3

Table G. Fish community sampling results from Quail Cr, Robinson Cr, Marathon Cr, Sugar Cr, and Lamotte Cr, September 1992.

			Quail Creek	Robinson Creek			Sugar Creek	Lamotte Creek		Basin Total	
		Site:	BFCB-12	BFC-25	BFC-26	BFC-11	BF-01	BFB-13	BFB-09		
Common Name	Scientific Name	Date: Method:*	Sept 1 BP	Sept 2 SH	Sept 2 SH	Sept 1 SH	Sept 1 SH	Sept 1 BP+SH	Sept 1 BP+SH	# of Fish	# of Sites
Gizzard shad	Dorosoma cepedianum								6	6	1
Central stoneroller	Campostoma anomalum							29		29	1
Carp	Cyprinus carpio			3	34	3	12	8	11	71	6
Silverjaw minnow	Ericymba buccata							11	1	12	2
Silvery minnnow	Hybognathus nuchalis						2		2	4	2
Bigeye chub	Hybopsis amblops						1			1	1
Golden shiner	Notemigonus crysoleucas			31	4	6	1			42	4
Emerald shiner	Notropis atherinoides					34	891			925	2
Spotfin shiner	N. spilopterus			1				28	5	34	3
Redfin shiner	N. umbratilis			1				75	29	105	3
Suckermouth minnow	Phenacobius mirabilis							7	6	13	2
Bluntnose minnow	Pimephales notatus							11	31	42	2
Fathead minnow	P. promelas				2					2	1
Bullhead minnow	P. vigilax								1	1	1
Creek chub	Semotilus atromaculatus		8					42		50	2
River carpsucker	Carpiodes carpio								3	3	1
Smallmouth buffalo	Ictiobus bubalus			4					2	6	2
Shorthead redhorse	Moxostoma macrolepidotum								1	1	1
Black bullhead	Ictalurus melas		1							1	1
Yellow bullhead	I. natalis		1					7	3	11	3
Tadpole madtom	Noturus gyrinus								1	1	1
Pirate perch	Aphredoderus sayanus							6	11	17	2
Blackstripe topminnow	Fundulus notatus		3						2	5	2
Mosquitofish	Gambusia affinis		3	6	2	3		3	24	41	6
Green sunfish	Lepomis cyanellus		16					5	9	30	3
Warmouth	L. gulosus								1	1	1
Orangespotted sunfish	L. humilis							1		1	1
Bluegill	L. macrochirus			2				1	10	13	3
Longear sunfish	L. megalotis								6	6	1
Largemouth bass	Micropterus salmoides		9	3					1	13	3
White crappie	Pomoxis annularis							2	8	10	2
Johnny darter	Etheostoma nigrum							19	20	39	2
Total Abundance			41	51	42	46	907	255	194	1536	
Number of Species			7	8	4	4	5	16	24	32	
Index of Biotic Integrity (AIBI)			25.1	25.1	20.7	29.5	33.8	40.4	44.7		

* Method: BP = Backpack electrofishing, SH = Seine haul

133

Table H. Stream habitat characteristics of Sugar Creek and tributaries near Robinson, Illinois, July 1986*** and August 1992****.

Month-Year:	AUG-92	AUG-92	AUG-92	AUG-92	JUL-86	AUG-92	AUG-92	AUG-92	JUL-86	AUG-92	AUG-92	JUL-86	AUG-92	JUL-86	AUG-92	AUG-92
Stream:	Robinson Creek	Quail Creek	Robinson Creek			Marathon Creek	Robinson Creek				Sugar Creek				Lamotte Creek	
Site:	BFC-20	BFCB-12	BFC-19	BFC-25	BFC-25	BFCA-22	BFC-26	BFC-11	BFC-11	BFC-10	BF-11	BF-11	BF-01	BF-01	BFB-13	BFB-09
SAMPLING REACH																
Stream Order	2	2	3	3	3	1	3	3	3	3	4	4	4	4	4	4
Habitat Reach Length (feet)	--	--	--	--	300	--	--	--	300	--	--	300	--	300	--	--
Number of Habitat Transects	0	0	0	0	6	0	0	0	6	0	0	6	0	6	0	0
SUBSTRATES (percent, i.e., relative abundance)																
Silt/Mud (<0.063 mm)	10	12	10	6	7	1	5	49	7	12	5	0	18	4	1	15
Sand (0.063 - 2 mm)	40	38	48	66	13	75	15	25	20	76	83	76	65	66	20	28
Fine Gravel (0.08 - 0.3 inches)	12	5	5	2	0	3	2	5	1	4	3	21	5	18	20	5
Medium Gravel (>0.3 - 0.6 inches)	10	5	2	1	10	2	0	4	11	0	2	2	5	13	27	10
Coarse Gravel (>0.6 - 2.5 inches)	6	3	1	1	13	1	0	3	8	0	1	0	5	0	20	10
Small Cobble (>2.5 - 5 inches)	4	0	1	1	2	0	0	0	2	0	0	0	0	0	5	3
Large Cobble (> 5 - 10 inches)	4	0	1	1	2	0	0	0	0	0	0	0	0	0	5	2
Boulder (>10 inches)	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	5
Bedrock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Claypan - Compacted Soil	10	30	30	20	44	14	76	10	48	5	4	2	0	0	0	0
Plant Detritus	3	5	1	1	0	2	1	1	1	2	1	0	1	0	1	1
Vegetation	1	1	1	1	8	1	1	2	0	1	1	0	1	0	0	0
Submerged Logs	0	1	0	0	0	1	0	1	1	0	0	0	1	0	1	1
Other (e.g., debris, junk)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HYDRAULIC FEATURES																
Discharge (cfs) **	0.15	0.01 *	2.58	2.54	2.20	0.15	9.57	5.46	8.40	7.71	9.24	4.80	8.94	7.60	0.05 *	0.10 *
Mean Channel Width (ft)	20	30	30	40	33	10	50	70	40	60	60	40	80	38	50	70
Mean Width of Water (ft)	3	10	10	9	22	2	25	25	29	20	20	32	25	29	15	15
Mean Velocity (ft/sec @ Q)	0.3	--	1.2	0.6	0.4	0.5	1.1	0.5	0.7	1.0	1.0	0.5	0.7	0.5	--	--
Mean Reach Velocity (ft/sec)	0.2	0.0	1.0	0.5	0.2	0.3	1.0	0.1	0.6	1.0	0.3	0.6	0.3	0.6	0.0	0.0
Mean Reach Depth (ft)	0.3	0.3	0.2	0.8	0.7	0.2	0.4	1.0	0.6	0.4	0.3	0.3	0.4	0.3	0.3	0.4
Pool (%)	40.0	60.0	10.0	18.0	37.0	40.0	10.0	40.0	27.0	6.0	5.0	13.0	20.0	2.0	70.0	40.0
Riffle (%)	10.0	0.0	30.0	5.0	15.0	10.0	15.0	1.0	10.0	3.0	2.0	6.0	5.0	4.0	2.0	1.0
Run (%)	50.0	40.0	60.0	77.0	35.0	50.0	75.0	59.0	20.0	91.0	93.0	85.0	75.0	94.0	28.0	59.0
Shading (%)	60	50	85	65	26	70	50	80	47	50	40	66	60	58	60	70
Depth of sediment (in)	0.5	1	0.5	0.5	3	0.5	0.5	3.0	3	1.0	0.5	1	3.0	3	1.0	1.0
Depth of sludge (ft)	0.05	0	0.05	0	0.0	0.05	0.05	0.05	0.0	0	0	0.0	0	0.0	0	0
Predicted Index of Biotic Integrity (PIBI)	39.6	38.4	36.5	38.5	37.0	40.2	32.8	36.7	37.0	40.1	41.0	43.0	41.0	42.0	44.3	41.3

* Estimated
** Discharge data are measurements, except as otherwise indicated
*** Most 1986 data are measurements
**** Most 1992 data are estimates

Table I. Aquatic life use support ratings and causes and sources of impairment for Sugar Creek and tributaries, Crawford County, Illinois, as of 1992.

WBID	STATION	REACH	NAME	TYPE	SIZE	YEAR	AL	DU	USE SUPPORT	CAUSES	SOURCES	WQI	MBI	AIBI	PIBI
ILBF22	BF-01	05120111-011/off	Sugar Cr.	R	2.9	1992	M	01	Partial/Moderate	04S,05S,09S	01H,02S,40S		7.2	33.8	
ILBF22	BF-11	05120111-011/off	Sugar Cr.	R	1.9	1992	M	01	Partial/Moderate	02S,03S,04S,05S,09S	01H,02S,40S,71M		6.8	*27.3	
ILBF22	BF-22	05120111-011/off	Sugar Cr.	R	6.3	1986	M	01	Full				5.7	--	
ILBFB09	BFB-09	05120111-011/off	Lamotte Cr.	R	1.7	1992	M	01	Full				5.8	44.7	
ILBFB09	BFB-13	05120111-011/off	Lamotte Cr.	R	1.8	1992	M	01	Full				6.0	40.4	
ILBFB09	BFB-12	05120111-011/off	Lamotte Cr.	R	5.6	1986	M	01	Full				5.8	29.5	
ILBFC10	BFC-10	05120111-011/off	Robinson Cr.	R	1.9	1992	M	01	Nonsupport	02S,03S,05S,09S	01H,02S,40S,71M		8.2	*27.3	
ILBFC10	BFC-11	05120111-011/off	Robinson Cr.	R	2.1	1992	M	01	Nonsupport	02S,03S,04S,05S,09S	01H,02S,40S		8.7	29.5	
ILBFC10	BFC-26	05120111-011/off	Robinson Cr.	R	1.1	1992	M	01	Nonsupport	02M,03M,04S,05M,09S	01H,02M,40S		8.1	20.7	
ILBFC10	BFC-25	05120111-011/off	Robinson Cr.	R	0.5	1992	M	01	Partial/Moderate	02M,03M,04S,05M,09S	02M,40M		7.7	25.1	
ILBFC10	BFC-19	05120111-011/off	Robinson Cr.	R	0.9	1992	M	01	Partial/Moderate	02M,03M,05M,07S,09S	02H,40M		8.4	--	
ILBFC10	BFC-20	05120111-011/off	Robinson Cr.	R	0.7	1992	M	01	Partial/Moderate	01S,02S,03S,04S	01S,40S		8.2	--	
ILBFC10	BFCA-22	05120111-011/off	Marathon Cr.	R	0.6	1992	M	01	Nonsupport	02M,03M,04M,05M	01H		8.0	--	
ILBFC10	BFCA-21	05120111-011/off	Marathon Cr.	R	0.6	1986	M	01	Nonsupport	02M,03M,04M,05M	01H		8.6	--	
ILBFC10	BFCB-12	05120111-011/off	Quail Cr.	R	0.7	1992	M	01	Partial/Moderate	02M,03M,04S	11S,40S		8.0	25.1	

CAUSES:
02 = Pesticides
03 = Priority organics
04 = Nonpriority organics
05 = Metals
07 = Chlorine
09 = Nutrients
11 = Siltation
12 = Organic enrichment/D.O.
21 = Suspended solids

SOURCES:
01 = Industrial point source
02 = Municipal point source
11 = Nonirrigated crop production
14 = Pasture land
16 = Feedlots - all types
40 = Urban runoff/storm sewers

* 1991 data

135

Cooperative IEPA-IDOC Intensive Basin Survey Reports: 1981-1990

Year	Report Title	IEPA Report No.
1982	An intensive survey of the Fox River basin from the Wisconsin State line to Ottawa, Illinois	IEPA/WPC/88-003
1982-83	An intensive survey of the Kaskaskia River basin	IEPA/WPC/89-105
1983	An intensive survey of the Kiswaukee River and its tributaries	IEPA/WPC/88-009
1983	An intensive survey of the DuPage River basin	IEPA/WPC/88-010
1983	An intensive survey of the DesPlaines River basin from the Wisconsin State line to Joliet, Illinois	IEPA/WPC/88-014
1984	An intensive survey of the American Bottoms basin	IEPA/WPC/89-211
1984-85	An intensive survey of the Kyte River basin	IEPA/WPC/88-013
1984-85	An intensive survey of the Pecatonica River basin	IEPA/WPC/88-012
1985	An intensive survey of Rock River tributaries	IEPA/WPC/88-011
1985	An intensive survey of the Elkhorn Creek basin	IEPA/WPC/88-017
1985-86	An intensive survey of the Vermilion River basin	IEPA/WPC/89-262
1986-87	An intensive survey of Shawnee National Forest Region streams of Southern Illinois	IEPA/WPC/90-171
1987	Biological and water quality survey of the Carol Creek watershed, Carol County, Illinois	IEPA/WPC/89-163
1987	An intensive survey of the Embarras River basin	IEPA/WPC/89-212
1987	An intensive survey of the Mackinaw River basin	IEPA/WPC/88-034
1988	An intensive survey of the La LaMoine River basin	IEPA/WPC/89-117
1988	An intensive survey of the Big Muddy River main stem from Rend Lake to the Mississippi River	IEPA/WPC/91-56
1989-90	An intensive survey of the Little Wabash River basin	IEPA/WPC/92-053
1990	An intensive survey of the Big Bureau Creek watershed	IEPA/WPC/92-002

IEPA Special Stream and Intensive Basin Reports: 1980-1990

Year	Report Title	IEPA Report No.
1977-80	Re-establishment of aquatic macroinvertebrate communities after drought in Solomon Creek, an intermittent stream	N/A
1980	Investigation of six intermittent streams, April-Sept 1980	N/A
1980	An intensive survey of the Apple River from the Illinois/ Wisconsin state line to Hanover, Illinois	N/A
1974-80	Evaluation of Illinois stream sediment from 1974-1980	IEPA/WPC/84-004
1986	An intensive survey of the Sugar Creek Basin, Crawford County, Illinois	IEPA/WPC/88-030
1986-87	An intensive survey of the Eagle Creek basin, Saline and Gallatin Counties, Illinois	IEPA/WPC/88-019
1987	An intensive survey of the Embarras River Basin	IEPA/WPC/89-212
1988	User's guide to IBI-AIBI Version 2.01: a BASIC program for computing the Index of Biotic Integrity with the IBM-PC	IEPA/WPC/89-007
1988	Low flow water quality characteristics of the Mississippi River in the vicinity of St. Louis, July 1988	N/A
1989	Biological Stream Characterization (BSC): A biological assessment of Illinois stream quality. Special Report # 13 of the Illinois State Water Plan Task Force.	IEPA/WPC/89-275
1992	Effects of livestock wastes on small Illinois streams: lower Kaskaskia and upper Little Wabash River basins, 1991	IEPA/WPC/92-114
1993	A Biological and water quality survey of Sugar Creek and tributaries, Crawford County, Illinois	IEPA/WPC/93-063

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. IEPA/WPC/93-063	2.	3. Recipient's Accession No.

4. Title and Subtitle
A Biological and Water Quality Survey of Sugar Creek and Tributaries, Crawford County, Illinois, 1992

5. Report Date

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Illinois Environmental Protection Agency
Division of Water Pollution Control
2200 Churchill Road, P.O. Box 19276
Springfield, Illinois 62794-9276

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Illinois Environmental Protection Agency
Division of Water Pollution Control
2200 Churchill Road, P.O. Box 19276
Springfield, Illinois 62794-9276

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

In August 1992, the Illinois Environmental Protection Agency investigated water quality and biological conditions in Sugar Creek and tributaries, Robinson Creek, Quail Creek, Marathon Creek, and Lamotte Creek, in Crawford County, Illinois. The primary purpose was to assess impacts of wastewater from the two major dischargers, the Robinson municipal wastewater treatment plant (MWWTP) and the Marathon Petroleum Company refinery, upon the water quality and aquatic life use of Robinson Creek and Sugar Creek. Water quality degradation downstream from Robinson MWWTP included elevated dissolved solids, chemical oxygen demand, nitrates, phosphorus, and chloride, and downstream from the Marathon refinery included additional elevations of all of the above constituents, along with elevated water temperatures caused by Marathon effluent. Aquatic life, including macroinvertebrates and fish, indicated poor conditions in Robinson Creek downstream from the Robinson MWWTP, and very poor conditions downstream from the Marathon refinery. These conditions reflected some improvement, compared to more extensive severe degradation assessed in 1986. However, severe to moderate impairment of aquatic life use persisted in an 8.0-mile continuum of Robinson Creek and Sugar Creek downstream from the Marathon refinery in 1992.

17. Document Analysis a. Descriptors

Water Quality
Stream Pollution
Aquatic Macroinvertebrates
Fish Populations
Stream Classification
Use Support
Aquatic Life
Refinery Wastes

b. Identifiers/Open-Ended Terms

Illinois

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) Unclassified	21. No. of Pages 50
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

138

SECTION 6

Hazardous Waste Transportation

SPILL PREVENTION

- A large proportion of preventable spills during transportation are caused by containers inside a truck tipping over and damaging themselves or other containers. Adequate blocking and bracing will prevent such spills. The reason that this type of spill occurs so frequently is that it is inconvenient for the driver, especially for short trips and multiple stops. Management must therefore be aggressive to assure compliance.

- Another cause of spills is due to vehicle accidents, especially where the driver becomes inattentive because of too long a period driving without adequate rest. Again management controls, scheduling and routing that tend to reinforce appropriate driver rest periods are the best preventive tool.

- Many spills also occur during loading and unloading when containers are damaged by being punctured by forklifts or other containers. This is prevented by encouraging safe handling practices among material handlers, by assuring adequate lighting and sufficient aisle space to maneuver, and by assuring that containers are undamaged and properly sealed before loading.

- For bulk transportation of solid wastes, covers such as tarps are appropriate to prevent loss of material. These should be constructed so as to minimize contact with waste by the drivers while installing and removing the covers. Washdown pads may be appropriate as the trucks leave the loading and unloading sites to remove traces of waste from the exterior of the vehicles. Drainage from the washdown pads should be collected and treated appropriately.

SPILL PREPAREDNESS

- In the event of an accident it is important that the public safety officials who first respond can recognize the presence of a abnormal hazard and the type of hazard presented. Container and vehicle marking systems such as that specified by international agreement have been adopted in modified form by many governments for internal use. These usually specify labelling of each container with a distinctive label indicating a specified hazard class that can be identified from a distance. Often vehicles must be marked similarly on all four sides. This greatly assists first responders in deciding on appropriate action to prevent exposure of response personnel and the public and on the other hand to prevent overreaction to a spill which poses a hazard in only a very small area.

- It is also a good practice, and often required by regulation, that the vehicle driver carry a manifest of the vehicle contents showing the hazards of the materials in each container and who to contact for emergency technical advice.

- Another good practice is to provide drivers with periodic training on the hazards of the types of materials that they carry and how to read container markings and labels. First responding public safety officials must often rely on drivers for information until communication can be established with more competent technical advisors.

- To quickly address small spills, drivers can carry small amounts of materials such as sorbents to soak up or chemicals to neutralize small spills (i.e., peat moss, sawdust, granulated clay, powdered limestone, sodium bicarbonate, etc.) as appropriate for the hazard. Pieces of rubber, wooden wedges and plugs can be carried to seal off small punctures. Oversize drums can be carried in which leakers can be overpacked. Large tank trucks often leak only from vapor-relief vents when overturned, such that plugs designed to fit these vents can minimize spillage. Personal protective equipment such as chemical protective gloves, splash suits and respirators can be carried for use by the driver or by responding local safety crews.

- Communication with and training support to local first response safety officials is important. They need to understand the basic hazards and appropriate responses. Often it is better to let vehicle contents burn up if on fire than to attempt to put out the fire with water and in doing so washing toxins into nearby surface waters or into groundwater.

The key to minimizing public health threats and the economic consequences of a spill is a rapid but technically competent response and cleanup. Better yet is to prevent the spill through appropriate physical and management controls.

Prepared by James O'Brien, Manager, Office of Chemcial Safety, 5-0830

Illinois
Environmental
Protection Agency

2200 Churchill Road
P. O. Box 19276
Springfield, IL 62794-9276

August 1994

IEPA/ENV/94-154

OFFICE OF CHEMICAL SAFETY

1993 ANNUAL REPORT

Printed on Recycled Paper

142

1.0 INTRODUCTION

Program Description

The chemical safety program addresses multimedia issues both directly and by providing services to other programs within the Agency. It does this through the interactive efforts of specialists and experts in specific fields such as toxicology, industrial hygiene, chemical engineering, emergency management, chemistry, environmental biology, hydrogeology and biostatistics. The chemical safety program can be visualized as having three branches: emergency management; toxics management; and response and remediation site safety.

The Emergency Response Unit (ERU) has for many years coordinated the Agency's actions in environmental emergencies. Experienced ERU staff manage the evaluation and oversight of all reported spills; a task which has increased significantly over time. In addition to assuring that responsible parties take appropriate action, ERU uses state funds to dispose of abandoned hazardous substances and pesticides. The Illinois Chemical Safety Act has been enforced since 1985 to assure that chemical process and manufacturing facilities have contingency plans sufficient to address the consequences of off-site releases. The Emergency Planning Unit leads such efforts which have included oversight of facility process safety audits. To date that type of audit involvement has been limited to those negotiated as part of consent decrees.

The toxics management aspect of the program is currently comprised of: a database of chemical releases to the State's environment; toxicological experts who evaluate that and other, more site specific data; and focused efforts to address specific toxics problems not fully covered within the context of other Agency programs. The efforts which comprise this aspect are:

- The Toxicity Assessment Unit currently serves as the Agency's expertise in toxicology. They review remedial investigation/feasibility studies, other risk assessments, air permit emission limits, public water supply health advisory recommendations, as well as giving support to regulatory proposals for toxics and providing toxicological advice throughout the Agency.

- Toxic release inventory (TRI) data are currently received, processed and computerized by staff of the Emergency Planning Unit. Availability of this data throughout the Agency is limited by hardware and data communication constraints that will soon be overcome. The number of data elements handled is vast and expanding. For instance, the database size exceeded sixteen million bytes for the 1991 reporting year, and increased to approximately twenty million for calendar 1992 due to the submittal of additional chemicals and facilities. Quality control and compliance efforts currently strain staff resources but are attained.

- Education and compliance efforts are currently focused on exposure priorities that include: lead based paint removal from exterior surfaces; a cooperative agreement with USEPA on inspection and compliance activity for PCB use, storage and disposal; and the prohibition of hexavalent chromium use in certain applications. It also supports the State's Fish Contaminant Monitoring Program, which tries to reduce the public's exposure to contaminants in fish.

To address response and remediation site safety, the Agency has in place a health and safety program that addresses the requirements of applicable regulations of the Illinois Department of Labor, the USEPA and the Occupational Safety and Health Administration (OSHA).

143

Agriculture Liaison

Agricultural activities affect the environment and, potentially, human health; such activities are nearly ubiquitous in Illinois. An Agriculture Advisor coordinates with the Office of Chemical Safety on issues concerning agrichemical safety and pesticide waste management. This Advisor also works closely with other Agency programs which address issues with agriculturally related components.

144

2.0 FLOOD ACTIVITIES

The Office of Chemical Safety (OCS) was involved in a number of programs and initiatives aimed at various problems resulting from the Great Flood of 1993. OCS provided extensive technical assistance on problems related to public water supplies, wastewater treatment facilities, landfills and hazardous waste sites. Staff worked closely with the operators of facilities in flooded areas and provided technical advice on the protection of equipment and facilities during the flood. Staff were also available to respond to inquiries and complaints regarding areas potentially contaminated by wastes that may have been released during the flood.

From July 14 to August 13 the Emergency Response staff logged over 550 work hours performing liaison duties at the state Emergency Operations Center (EOC). This provided an important communications link between the EOC and Agency field and program staff dealing with public drinking water supply, wastewater disposal, solid waste (landfills) and contaminated sites as well as emergency response personnel.

The Emergency Response Unit assisted with problems with community public water supplies. During the flood twenty-two community public water supplies were without water service for varying periods of time. Thirteen other community public water supplies had serious problems but never lost service. An additional thirty-nine facilities were monitored during the emergency but did not experience major problems. Thirty-four water supplies were under emergency advisories for varying periods of time due to the flooding. The emergency advisories varied from precautionary "boil water" orders to "don't drink" orders.

Although protective measures had been taken, the record high crest combined with severe storms and wave action resulted in the flooding of Illinois American Water Company's Alton facility (serving 70,000 persons) on August 1, 1993. When the public water supply was rendered ineffective by the flood, Emergency Response personnel worked closely with Illinois Department of Public Health staff to plan for and to implement the provision of drinking water distribution to the public in the Alton area. Eighteen drinking water distribution sites were established and over three million gallons of drinking water were distributed.

OCS was involved in various surveillance and sampling activities. Greatly increased efforts were focused upon surveillance of the flooded areas and of facilities and sites threatened by the flood. A number of aerial overflights and several boat patrols were conducted in cooperation with the U.S. Coast Guard both to generally observe and to check out reports of potential spills. During the boat patrols, floating drums, propane tanks and other large containers were tied off to trees for later recovery when the water receded.

The Agency monitored all water supplies along the Mississippi and tributaries. Technical advice and assistance was provided as needed to these supplies. Daily calls were made to each affected water supply in order to track problems or potential problems and keep management and the Emergency Response personnel informed. Field visits were made to facilities with problems. Monitoring for bacterial quality, chemical quality and organic chemical quality was done for these impacted water supplies as they started to come back on line to assure a safe supply of water was being provided.

Utilizing a USEPA grant, the Agency conducted a flood needs assessment of underground storage tanks (USTs) in declared disaster counties. Record searches were performed to determine the number of USTs and reported LUSTs (leaking underground storage tanks) located in areas inundated by flood waters. County Emergency Services and Disaster Agency coordinators were surveyed by both mail and phone to help identify problem tanks. During these site evaluations, the Agency logged over 1200 miles travelling to the following counties: Adams, Calhoun, Greene, Hancock, Jersey, Monroe, Pike and Randolph. In one instance, the confirmation of drinking water contamination at a residence hooked up to a public water supply has the Agency's LUST program preparing to expend grant dollars to determine the source and extent of the petroleum contamination.

145

Post flood cleanup and assistance was conducted by the Office of Chemical Safety. Several hundred tanks and drums were reportedly sighted as stranded by receding flood waters. As water levels receded, staff checked these drums to determine which ones presented a toxic hazard. Those that did were recovered and staged for disposal. Empty drums were handled with other flood debris. During the fall of 1993 over 150 drums or tanks were located and sampled in portions of St. Clair, Monroe and Madison Counties. Water levels, at that time, were still too high to access all reported drums in areas of Greene, Jersey and Randolph Counties but were eventually addressed as water levels and weather permitted. The types of materials found in drums were generally petroleum products such as lube oil, fuel oil, motor oil, etc. and pesticide/fertilizer products. About half of the drums investigated appeared to contain only river water.

Since so many drums apparently containing river water were observed, it was decided that a mobile laboratory would be more efficient in some locations to evaluate their contamination status. Consequently a mobile laboratory was deployed in Valmeyer, Monroe County from October through December 1993. The mobile laboratory tested for overall toxicity and for specific problem toxics such as certain pesticides, heavy metals, and PCBs.

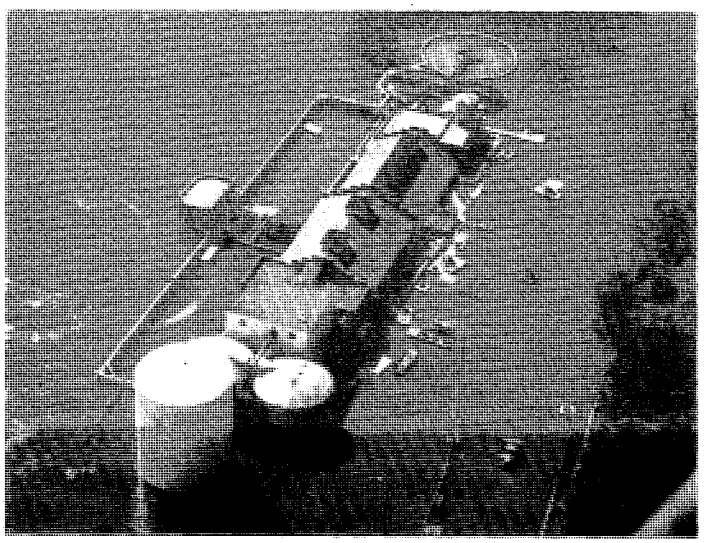
The Office of Chemical Safety assessed the need for flood debris collection efforts and guidance. OCS helped in the development and coordination with other Agency staff. Flood debris collection locations were set up and the Agency developed guidance to assist in the proper classification, storage, and ultimate disposal of various flood debris.

The Agency also prepared fact sheets with concise information statements covering guidance on Spills and Emergencies, Waste Disposal, Open Burning and Debris Management. The fact sheets were designed to provide citizens tips on how to dispose of flood-related waste in an environmentally sound manner. The information was distributed to all flood-impacted counties through the state Emergency Operations Center and the media outlets.

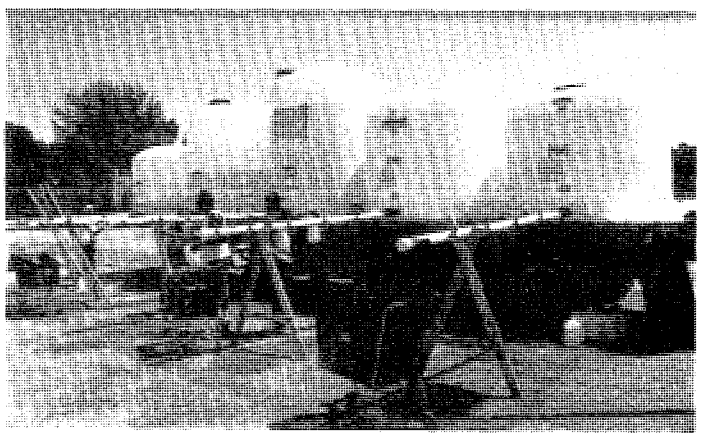
146

Levee break at Columbia, Illinois.

Flooded areas in Greene/Jersey counties.

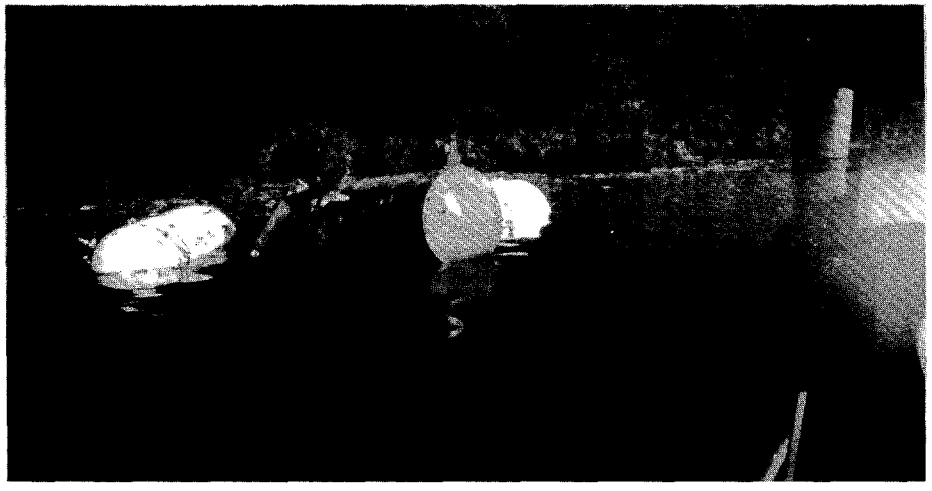


Alton Water Plant.



Water distribution site in Alton, Illinois.

147



Drums and tanks floating in the Illinois River near Hillview.

Tying off orphaned floating containers in Greene County

Drum recovery in Monroe County.

148

3.0 ILLINOIS ENVIRONMENTAL PROTECTION AGENCY EMERGENCY MANAGEMENT

The primary concern in any chemical emergency incident is the protection of public health and safety. In an effort to respond to such emergencies occurring in or mediated by the outdoor environment, IEPA has an Emergency Response Unit (ERU).

ERU is responsible for coordinating the Agency's response to environmental emergencies involving chemicals and ensuring that subsequent environmental contamination is appropriately cleaned up. ERU collects information about these environmental emergencies and responds directly and/or notifies other divisions within IEPA of any needed action. Technical expertise is provided to first responders and public officials and addresses such issues as the physical characteristics of the materials involved, effective response and treatment actions, and precautions to be taken to prevent further injury and damage to public health and the environment.

ERU works within the state response system in which the Illinois Emergency Management Agency (IEMA) serves as the central receiving and dispatching point for response to any emergency or disaster requiring state notification or involvement. IEPA responsibility involves response to:

- oil and chemical spills on water or land;
- releases of harmful quantities of toxic substances into the atmosphere;
- emergencies involving public water supplies;
- emergencies involving wastewater treatment systems;
- emergencies involving solid waste disposal sites;
- fish kills caused by pollutants;
- emergency disposal or treatment of hazardous materials;
- abandoned hazardous waste incidents posing immediate hazards; and
- transportation incidents involving hazardous materials which pose an imminent threat of release.

After an incident is under control, cleanup, remediation and disposal are sometimes required. ERU monitors those activities to assure that a proper conclusion is reached.

3.1 Incident Statistics

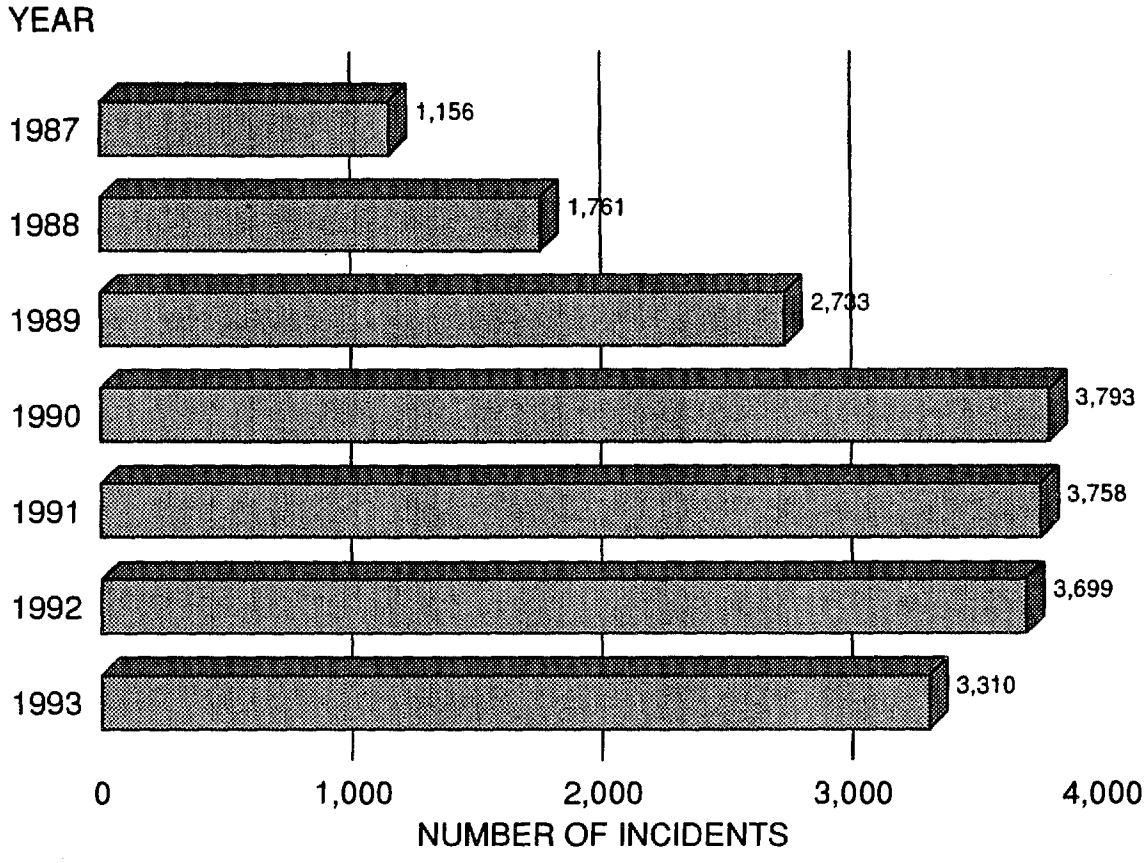
During 1993, the total number of incident notifications received by ERU was 3310. Of the total incidents, 1820 (55%) involved LUSTs. The number of incidents involving LUSTs has been decreasing over time. Seven (7) of these incidents were hazmat related in which there were a total of twelve (12) fatalities. There were 112 hazmat related incidents which resulted in the hospitalization of a total of 306 members of the general public. The number of people injured or evacuated are not normally known at the time of the original incident report. Even after the incident is over, the numbers may be sketchy at best, particularly for larger incidents. One incident was reported that involved the evacuation of 10 people. Additional

evacuations are believed to have occurred but were not included in the data because the evacuation occurred after the incident was reported. In addition to the emergency incidents, ERU received 737 complaints in 1993.

Figure 3-1 illustrates the long-term changes in annual incidents received.

FIGURE 3-1

NUMBER OF INCIDENTS ANNUALLY

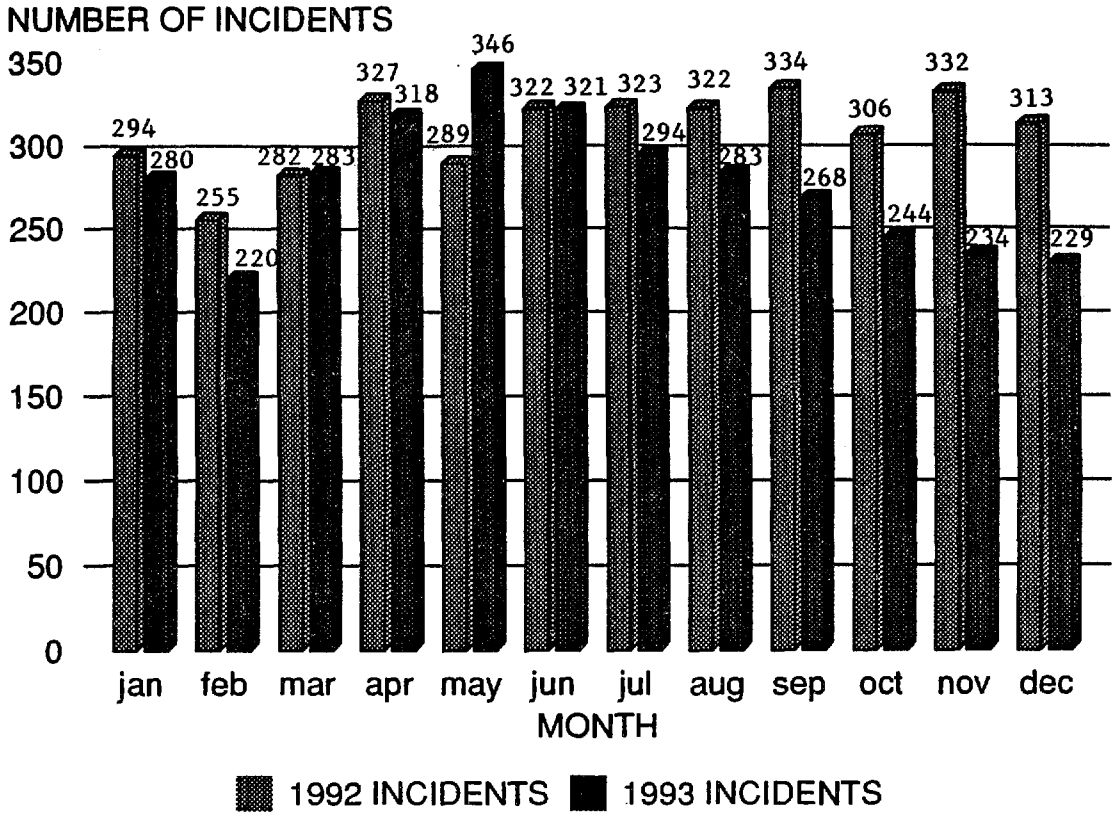


There is only a slight seasonal variation in incident occurrence as shown in Figure 3-2. Fewer incidents occur or are discovered during winter months, probably as a result of less agricultural and construction activity. Also because groundwater levels are often lowest in these months, the detection of underground leaks is reduced.

150

FIGURE 3-2

1992 VS 1993 INCIDENTS MONTHLY COMPARISONS



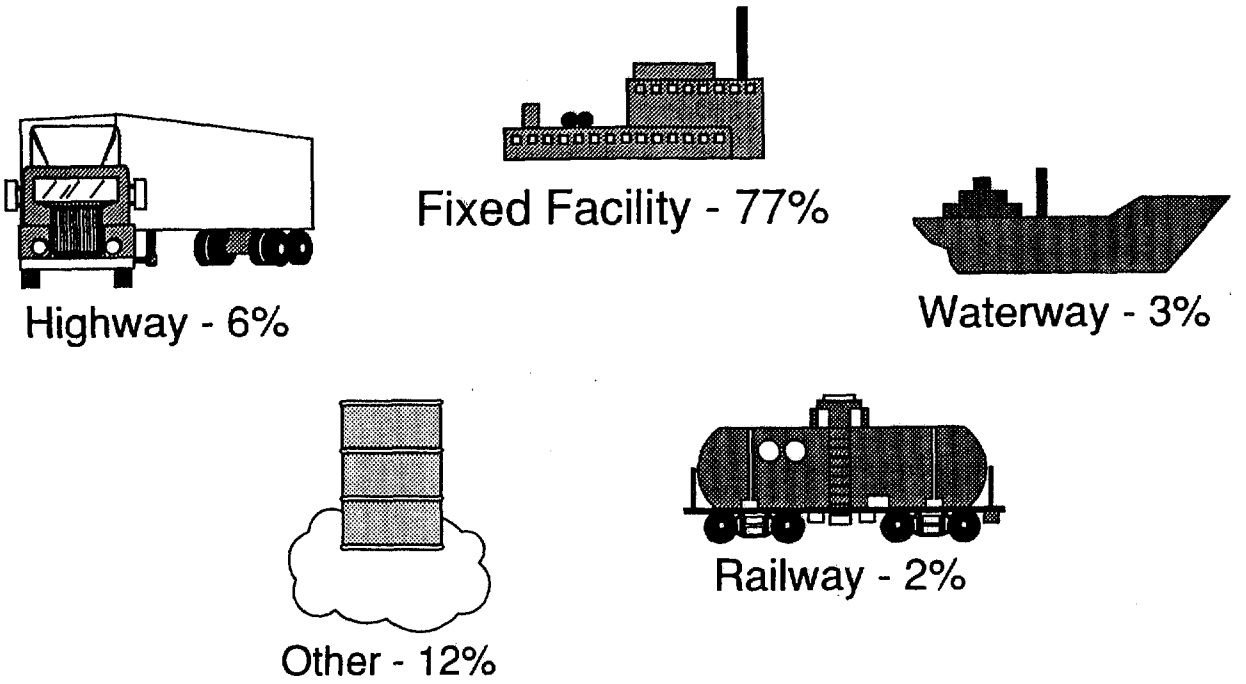
In order to insure IEPA capability to assess emergencies on an around-the-clock basis, ERU maintains a duty officer system. Each volunteer duty officer is an IEPA professional who is available on-call to the IEMA dispatchers during non-office hours for a week at a time. IEMA receives spill notifications on their toll free hotline (800/782-7860) on a 24-hour basis and also receives calls on ERU phones (217/782-3637) during non-office hours. The duty officer evaluates each notification and can contact an on-call ERU staffer in each of the three ERU offices in the State (Maywood, Collinsville, and Springfield) for further technical advice or to request them to respond in person to an incident. Additionally, over 100 technical staff from the Agency's field offices are distributed in seven regions throughout the State and may be called on to respond to incidents when they either are closest or when individuals have unique technical expertise.

151

Emergency incidents can be categorized by the type of release or by location. The breakdown by county is indicated by Figure 3-4. Figure 3-3 illustrates the incident distribution based on the character of the area in which it occurred. Table 3-1 shows a breakdown of the incidents according to the nature of the release.

FIGURE 3-3

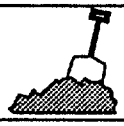
1993 INCIDENTS BY LOCALITY



152

TABLE 3-1

FREQUENCY OF 1993 INCIDENTS BY RELEASE NATURE

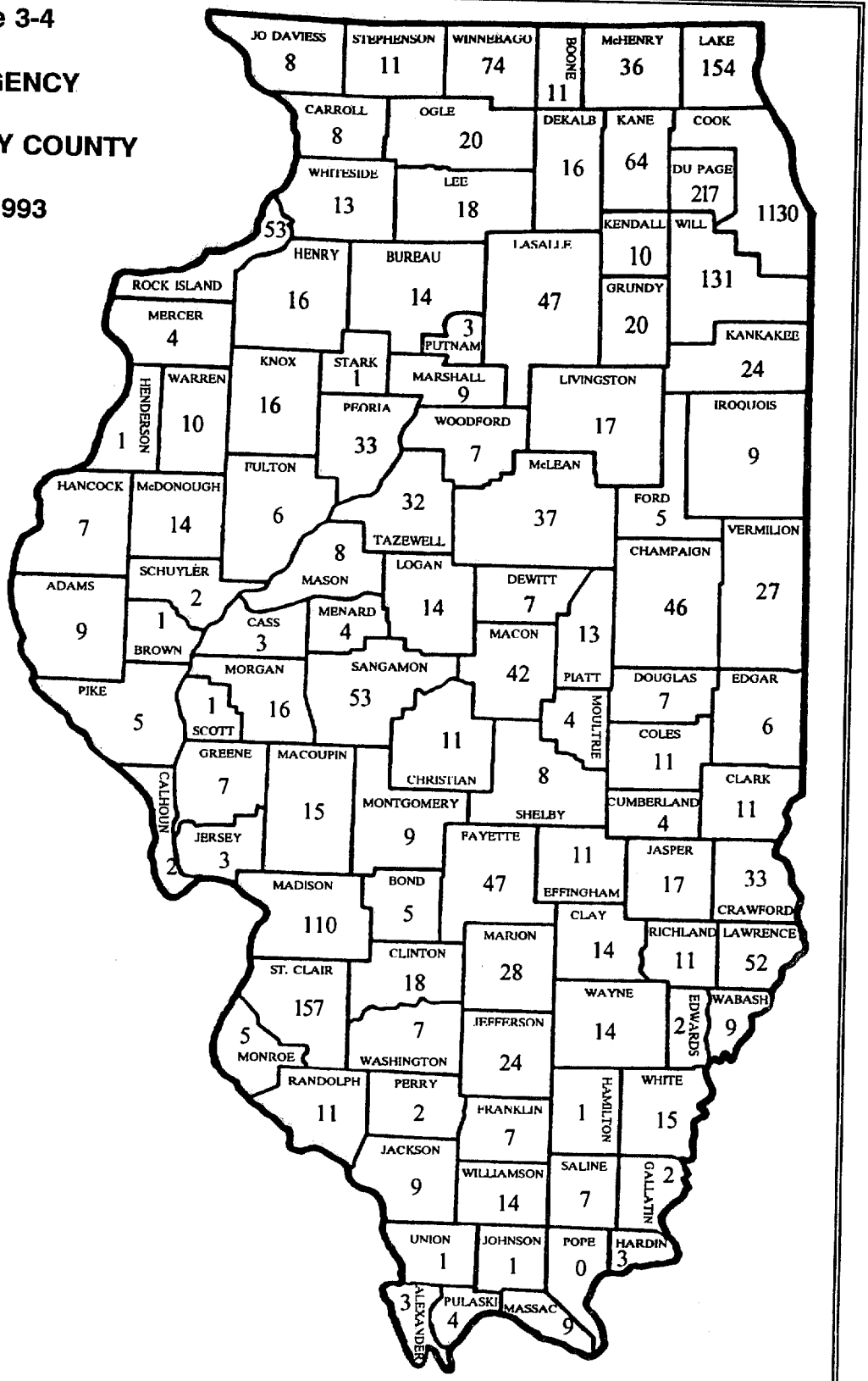
	Number of Incidents	Percentage
Leak or Spill 	3245	92
Water Involvement	82	2
Gas or Vapor Cloud	79	2
Fire	48	1
Other	98	3

The kinds of materials involved in the 1993 chemical emergencies are listed in Table 3-2 along with their frequency of occurrence. Occurrence and frequency of specific materials are highly correlated with their use, storage, and production volumes in Illinois. Major sectors of the state economy account for the most common types of materials spilled. Fuels are used, stored and transferred by a majority of citizens and businesses. Not surprisingly they constitute a large portion of spills. Agricultural activities utilize large quantities of fertilizer and pesticides, which also can result in spills. The manufacturing sector commonly uses large quantities of solvents, acids and bases with which accidents can, and do, occur.

153

Figure 3-4

EMERGENCY INCIDENTS BY COUNTY FOR 1993



154

TABLE 3-2
FREQUENCY OF COMPOUND INVOLVEMENT IN 1993 INCIDENTS

Acetic acid - 1
Acetic anhydride - 1
Acetone - 3
Acetylene - 1
Acid NOS - 3
Adhesive NOS - 4
Alcohol NOS - 3
Alkylamine - 1
Alumina Silicate catalyst - 1
Aluminum dross - 1
Aluminum sulfate - 1
4-Aminodiphenylamine - 1
Ammonia - 10
Ammonium nitrate - 4
Anhydrous ammonia - 31
Anti-freeze - 7
Argon - 1
Arsenic - 1
Arsenic trihydride - 1
Asbestos - 3
Benzene - 4
Boron trifluoride - 2
Brine (salt water) - 27
Bromine - 1
3-Bromo-1-chloro-5,5-Dimethylhydantoin - 1
1,3-Butadiene - 4
Butane - 1
1-Butanethiol - 1
Butyl alcohol - 1
Butyl Carbitol* - 1
Butyl Cellosolve* - 1
Cadmium chloride - 1
Carbon - 1
Carbon black - 1
Carbon monoxide - 2
Castor oil - 1
Cellosolve* - 2
Chlorine - 10
1-Chloro-2-nitrobenzene - 1
Chromic acid - 2
Chromium - 2
Cleaning compound - 7
Coal dust - 1
Coal tar - 4
Cobalt compound - 1
Coke oven emissions - 6
Cooking oil - 2
Copper Sulfate - 1
Corrosive material NOS - 6
Cyanide compounds - 1
Dichlorodifluoromethane - 1
Diisobutyl ketone - 1
Dimethyl sulfide - 1
Dimethylformamide - 1
Dry cleaning solvent - 1
Dye - 2
Erythromycin thiocyanate - 1
Ethyl acetate - 1
Ethyl acrylate - 1
Ethyl alcohol - 2
Ethyl benzene - 1
Ethyl ether - 1
Ethylene glycol - 15
Ethylene oxide - 2
Ferrous chloride - 1
Ferrous sulfide - 1
Fertilizers NOS - 6
Flammable liquid NOS - 13
Flammable solid NOS - 1
Formaldehyde - 2
Freon - 2
Garbage - 3
Hazardous waste NOS - 32
Heptane - 3
Hexane - 1
Hhydrazine - 2
Hydrochloric acid - 9
Hydrogen chloride gas - 1
Hydrogen peroxide - 2
Hydrogen sulfide - 5
Ink NOS - 6
Isopropanol - 6
Lab chemicals NOS - 1
Leachate - 1
Lead waste - 2
Lime - 1
Lithium sulfide - 1
Medical waste - 9
Mercaptan - 1
Mercury - 3
Methyl alcohol - 2
Methyl bromide - 1
Methylene chloride - 3
Methyl ethyl ketone - 3
Methyl isobutyl ketone - 1
Monoethylamine - 1
Naphthalene - 1
Natural gas - 4

155

TABLE 3-2 (CONTINUED)

Neoprene rubber - 1
Nickel catalyst - 1
Nitric acid - 1
Nitrogen (liquid) - 2
Nitrogen (28%) fertilizer - 11
Nonylphenol polyethylene glycol ether - 1
Oxygen (liquid) - 1
Paint and paint thinner - 26
Perchloroethylene - 1
Perfluorooctane - 1
Phenol - 1
Phosphoric acid - 5
Phosphorus oxychloride - 1
Phosphorus pentoxide - 1
Phosphorus (red) - 1
Phosphorus (white) - 2
Photographic developers - 1
Polychlorinated biphenyls (PCBs) - 11
Potassium cyanide - 1
Potassium ferrocyanide - 1
Potassium hydroxide - 1
Propane - 2
1-Propanol - 1
Propanol - 1
Propylene - 1
Pseudocumene- 1
Radioactive material - 3
Resin - 11
Sewage - 1
Sodium - 1
Sodium dichromate - 1
Sodium hydrosulfite - 1
Sodium hydroxide - 7
Sodium hypochlorite - 5
Sodium silicate - 3
Sodium solution - 1
Solvent NOS - 10
Starch -1
Styrene - 2
Sulfur - 3
Sulfur dioxide - 4
Sulfur hexafluoride - 1
Sulfur trioxide - 2
Sulfuric acid - 15
Tetrahydrofuran - 1
Toluene - 5
Transmission fluid - 5
Trichloroethylene - 2
Unknown - 38
Uranium nitrate - 1
Vinyl acetate - 1
Vinyl chloride - 2
Wastewater - 28
Xylene - 13
Zinc phosphate - 1
Zinc sulfate - 1

Petroleum and Petroleum Products

Asphalt/Asphalt sealer - 11
Gasoline - 589
Hydrocarbons NOS - 20
Jet fuel - 9
Kerosene - 18
Liquified petroleum gas - 5
Mineral spirits - 8
Naphtha - 4
Oil NOS - 58
Oil (#1) - 1
Oil (#2) - 69
Oil (#4) - 1
Oil (#5) - 9
Oil (#6) - 12
Oil (crude) - 119
Oil (diesel) - 408
Oil (engine) - 16
Oil (fuel) - 217
Oil (hydraulic) - 13
Oil (lubricating) - 7
Oil (machine) - 1
Oil (mineral) - 26
Oil (quench) - 2
Oil (waste) - 124
Roofing tar and sealer - 3
Tire fire oil - 2

156

TABLE 3-2 (CONTINUED)

Pesticides

Atrazine (AAtrex*) - 2
Bicep* (atrazine & metolachlor) - 3
Bullet* (alachlor & atrazine) - 1
Canopy* (metribuzin & chlorimuron-ethyl) - 1
Chlorpyrifos - 1
2,4-D - 1
Diazinon - 1
Dithane* (dithiocarbamate) - 1
Dual* (metolachlor) - 3
Dursban* (chlorpyrifos) - 1
Extrazine* (atrazine & cyanazine) - 3
Freedom* (alachlor & trifluralin) - 1
Gramoxone* (paraquat) - 1
Herbicide NOS - 6
Lorsban* (chlorpyrifos) - 1
Malathion - 1
Marksman* (dicamba & atrazine) - 1
Pesticide NOS - 5
Pounce* (permethrin) - 2
Salvo* (2,4-D) - 1
Sonolan* (ethalfluralin) - 1
Sutan* (butylate) - 1
2,4,5-T - 1
Thimet* (phorate) - 1
Treflan* (trifluralin) - 2

NOS = Not Otherwise Specified

* **Trade Name**

Pesticides are listed by the name that was reported in the incident (either common name or trade name). The common name for a trademarked pesticide is given as additional information. After a common name listing, a typical trade name product containing that material is given for the reader's information only and does not imply that the trade name product in parentheses was actually involved.

3.2 Computerized Incident Data Tracking

In 1990 the Emergency Response Unit switched from using their office-based microcomputer for incident data tracking to an on-line direct link with the Agency mini-computer system. All key information from active incidents is entered into the computer on a daily basis and updated as new information arrives. The use of the mini-computer has allowed each staff member to have a terminal at his/her desk which allows immediate access to the system. This permits timely searching of incident files to find particular items of interest or particular groups of incidents. Unique incident identification numbers, assigned by IEMA, have facilitated the tracking and retrieval of data from the computer database. The use of these incident identification numbers also helps in following up on incidents with other state agencies, potentially responsible parties, and IEPA field investigations by providing a common reference thereby reducing confusion and time spent trying to match files.

Legislation known as the Responsible Property Transfer Act became effective in 1989. This act mandates that the seller of certain classes of commercial properties file an environmental disclosure document which may indicate that chemical contamination is associated with the particular property being sold. Consequently, ERU has received a significant increase in requests for searches of its records, pursuant to Freedom of Information Act (FOIA) access rights to public records. A total of 777 requests for ERU records were processed for FOIA information in 1993. That is over three per workday on average.

3.3 Abandoned Materials - Hazardous Waste Fund

The occurrences of abandoned materials, which posed an imminent hazard to the public or the environment, continued to increase during 1993. ERU responded to 31 incidents where Hazardous Waste Fund monies were spent to properly contain and/or dispose of such abandoned materials or such materials where the potentially responsible parties (PRP) declined to take appropriate action. Since July 1989, ERU has had contracts in place with outside contractors to assist with responses to emergencies involving these situations. Prior to that time ERU established separate contractual arrangements for each such incident. Significantly increased administrative efficiency has resulted from the new arrangement.

One contractor now handles all disposal arrangements. Another contractor responds to incidents involving many small containers and subsequently packs them for disposal as lab packs. Two other contractors are available to immediately respond to larger emergencies to mitigate and stabilize the situation.

Investigations pursued by the Department of State Police, by IEPA Bureau of Land staff, or by ERU staff have resulted in the identification of potentially responsible parties in several of the incidents. Cost recovery efforts have been started in these cases and may involve property liens and lawsuits.

3.4 Leaking Underground Storage Tank Program

In prior years, ERU bore the responsibility of response and oversight for Leaking Underground Storage Tank (LUST) incidents involving petroleum products. With new federal regulation and funding responsibility, the follow-up and non-emergency oversight shifted to the Bureau of Land (BOL) in 1988. This area of operations is now principally overseen by the Underground Tank Section of the BOL and a companion Underground Tank Unit at the State Fire Marshall's Office. The ERU works closely with these two groups in the areas of response activities and oversight of leaks or spills from underground storage tanks, especially when situations of an emergency nature occur.

The State Fire Marshall handles oversight for tank installation, removals, and other equipment related issues or problems. The ERU handles response and follow-up activities associated with tank leaks that have created an immediate environmental or public health hazard. The ERU also receives all initial leak or spill

158

reports and initiates the Agency's formal record of each LUST incident. After the immediate hazards have been mitigated or the initial notification made, the primary incident oversight is transferred to the Underground Tank Section of the BOL for follow-up on remedial action to be taken at the site. There were 1820 new LUST incidents reported and screened by the ERU in 1993.

3.5 Monitoring Capabilities

Over the years, the ERU has acquired the equipment and expertise to obtain environmental and contaminant samples for immediate analyses. Some of the equipment is direct reading and can be used in a real-time mode. Other instruments may enable samples to be quickly analyzed in the field for select parameters of interest. This capability is one of the unique attributes that the ERU can bring to an incident to assist and support the first responding local agencies. It cannot be overstated that the expertise of knowing when to use the equipment, the limitations of each instrument or method, and the appropriate interpretation to be given to results is an integral and crucial part of this capability. Listed below are sampling and detection equipment currently utilized by ERU.

Air and Vapor Monitoring

Flammable Gases and Vapors

- MSA 360 & 361 - These instruments have proven to be rugged and dependable. In addition to detecting explosive mixtures of flammable vapors or gases, they simultaneously sample for oxygen deficiency and either carbon monoxide (MSA 360) or hydrogen sulfide (MSA 361). These instruments incorporate a battery driven motorized pump and samples can be remotely obtained through tubing (up to about 20 feet).

Trace Organic Vapors - Survey Instruments

- HNU PI 101 - This instrument can detect parts per million levels of hydrocarbons and other compounds which have an ionization potential lower than 11.7 electron volts. This instrument is particularly sensitive to aromatic hydrocarbons such as benzene, toluene, and xylene. However, it does not identify specific chemicals and as a result is often referred to and used as a "survey" instrument.

- Photovac Tip I - This instrument is very similar to the HNU PI 101 using the same photoionization detection technology, but it is made by a different manufacturer who has compacted it into a smaller package.

- Century OVA 108 - This instrument has similar general capabilities and uses as the HNU and TIP in that it is a survey instrument for organic vapors. However, because its detector is based on flame ionization, a small tank of hydrogen is part of the unit. This creates an additional logistic burden of recharging hydrogen for every eight hours of operation. Additionally, this instrument has more parts than the HNU and consequently, has had a higher repair frequency. On the other hand, it is more sensitive to aliphatic hydrocarbons and can detect methane, which the photoionization devices (HNU and TIP) cannot.

Organic and Inorganic Vapors - Chemical Specific Detection

- Draeger Detector Tubes - A chemical analysis system in a sealed tube is used by breaking both ends off of the tube and pumping a specific volume of air or vapor through it. The tubes are intended to be chemical specific, but a user must be aware of possible

interferences and/or false readings attributable to chemically related compounds. ERU has tried several manufacturers but has found Draeger to be easier to use and to have the largest variety of tubes. Tubes have a two year shelf life. Use of these tubes is of a "grab" nature, not continuous like the above mentioned instruments. ERU maintains a stock of tubes to detect the following gases:

Acetone	Hydrazine	Nitrous Fumes
Acrylonitrile	Hydrocarbons	Olefins
Alcohol	Hydrochloric Acid	Perchloroethylene
Ammonia	Hydrocyanic Acid	Petroleum Hydrocarbons
Benzene	Hydrogen Fluoride	Phosgene
Carbon Disulfide	Hydrogen Sulfide	Phosphoric Acid Esters
Carbon Monoxide	Mercaptan	Sulfur Dioxide
Chlorine	Methyl Bromide	Toluene
Ethyl Acetate	Methyl Methacrylate	Toluene Diisocyanate
Ethylene Oxide	Methylene Chloride	Trichloroethane
Formaldehyde	Monostyrene	Trichloroethylene
Formic Acid	Natural Gas	Vinyl Chloride
n-Hexane	Nitric Acid	Xylene

- Draeger Quantimeter 1000 - This is a battery powered pump unit for use with Draeger tubes. It supplements the use of hand pumps, reducing fatigue and improving accuracy of operation.

- Miran 1B - This is the most sophisticated instrument used by ERU for real-time continuous vapor monitoring. It is based on infrared (IR) detection and can measure specific chemicals. It has a fixed library of over 100 chemical "fingerprints" and up to 10 additional compounds can be user programmed. Its detection limit is one-tenth to one part per million. This unit is relatively heavy and very fragile. Because most maintenance must be performed at the factory, the Miran 1B is expensive to maintain. However, its capabilities are unmatched.

Mercury Vapor

- Jerome 411 - This is a gold film mercury vapor analyzer that was procured in 1989. Mercury vapor is a very pernicious chronic toxicant. No other instrument in our inventory duplicates this important capability.

Cyanide Gas

- Compur Monotox 4100 - This meter measures hydrogen cyanide gas at the parts per million level in air. It is an important safety device when investigating electroplating operations and abandoned hazardous waste.

Radiation

- Victoreen V-700 - This is a civil defense type radiation survey meter used to screen abandoned waste sites for radiation hazards. It is supplied by and maintained as a courtesy by IEMA.

Ambient Air Sampling

- Aircon 520 Act - This is a portable high volume air sampling pump that captures contaminants on a variety of media for later laboratory identification and quantification. With different filter media, a wide range of samples can be analyzed at very low concentrations.

- Personal Sampling Pumps - Over a half-dozen low volume air sampling pumps are available that are usually used for monitoring IEPA worker exposures by the Health and Safety Unit staff.

Water and Liquid Monitoring

Liquid Sampling

- Masterflex - This peristaltic pump can be operated on internal battery or line power, has variable speed, and can be run in reverse at the flick of a switch.

- Kemmerer Sampler - This is used to collect subsurface water samples. The depth of samples can be chosen by sliding a weighted messenger down the tether line to close the sampler.

- Collapsable Tank Stick - This is used for measuring liquid levels in tanks and can be treated with special paste indicators to detect water under petroleum product or petroleum on water.

- Well Bailers - These are used to sample small diameter monitoring wells.

Liquid Testing

- Setaflash - Tests for ignitability characteristics of hazardous waste. It can be operated by line or battery power.

- EM Quant Test Paper Strips - Semi-quantitative and quick field tests for Ammonium, Nitrite, Peroxide, Nitrate, Sulfite, Chromate and pH.

- Chlor-n-oil - A disposable commercial test kit for detecting the probable presence of PCBs in oil.

- Ecolab Cyanide Test Kit - For aqueous solutions from 0.05 ppm to 10 ppm cyanide.

- Enzytec Pesticide Detector - Kit to detect cholinesterase inhibition which is characteristic of organophosphate and carbamate pesticides.

- Spill-Fyter Chemical Classifier - This is a one step dip test that identifies pH extremes, oxidizers, organic solvents, chloride and fluoride.

- Immunoassay Test Kits - These field test kits are accurate to the low part per billion range. Kits sensitive to several pesticide classes are kept in stock.

Solids and Soil Monitoring

Soil Sampling

- Soil Probe - A half-inch diameter steel rod is insertable with a hammerhead attachment that, with extensions, can reach twenty feet. A similar device is also available with an electric powered impact hammer.

- Soil Auger - This two-inch diameter flighted auger can reach a twenty foot depth with extensions.

- Subsoil Sampler - Several of these are available for wet or dry soil conditions and can reach fifteen feet. Acetate liners can be used to maintain the vertical integrity of a sample. These can be removed from the sampler, the ends plugged, and the encased sample may be used in vertical leaching studies.

Soil and Solids Testing

- Cyanide Kit - Solid waste samples can be safely acidified to release hydrogen cyanide gas which is identified with a Draeger detector tube for cyanide.

- Clor-n-soil - A disposable commercial test kit for detecting the probable presence of PCB's in soil samples.

- Additionally, soil and solids can be extracted non-quantitatively in the field and the extraction liquid tested by many of the liquid tests listed above.

3.6 Upper Mississippi River Spill Plan

An effort to enhance the status of existing interstate cooperation affecting the entire western border of our state was initiated through the Upper Mississippi River Basin Association. A formal, unified plan was developed which incorporated detailed notification and updated response protocols as well as maps and lists of resources and potential spill sources. An interagency memorandum of agreement has been signed between the cooperating states and federal agencies to implement the plan. During 1993 improvements to the plan appendices were made to enhance its usefullness as an ajunct to the Area Plan required by the Oil Pollution Act of 1990.

3.7 Great Lakes Spill Task Force

The Great Lakes Commission, at the request of the Great Lakes Governor's Association, organized a task force of emergency response managers from states, provinces and national agencies whose jurisdictions border on the Great Lakes. The outcome was a common position and an agreement signed by the Great Lakes Governors which focuses on the vulnerability of the Great Lakes to chemical and oil spills as well as measures that are needed to improve response capabilities. During 1993, the task force continued developing an inventory of basin-wide spill response equipment and resources. It is planned to put this inventory on a computer bulletin board maintained by the federal Department of Transportation's Hazardous Materials Information Exchange (HMIX) where it will be instantly available to anyone with a computer and a telephone modem.

162

4.0 Toxics Management

The management of toxics is currently comprised of three aspects; experts who evaluate potential risks based upon relative hazards of chemicals and exposure, a database of chemical releases to the State's environment, and focused efforts to address specific toxics problems through education and inspection.

Efforts toward environmental protection over the last two decades have been marked by increased technical and scientific sophistication in many areas. The analytical capability of chemistry laboratories has reduced the detection limits for many chemicals from the parts per million range to the parts per billion, parts per trillion, or even into the parts per quadrillion range for some compounds. Paralleling this increasing capability in the laboratory has been the enhancement of the technology involved in pollution control. Thus, the early efforts to rectify gross pollution problems, such as "dead" lakes and streams, smog alerts, and burning rivers, have evolved into attempts to protect against more subtle environmental hazards involving long-term latent effects. The methods used to assess the effects of chemicals on public health, public welfare, and the environment have also grown in sophistication from "dilution is the solution to pollution" to the current use of toxicological, pharmacological, physiological, biochemical, biological, physical, chemical, statistical, etc. inputs into the process of regulating toxic chemicals.

4.1 Risk Information

The Toxicity Assessment Unit (TAU) serves as the Agency's experts in providing risk information. They review environmental contamination reports and risk assessments and provide advice for air emission limits, public water supply health advisories, and provide general toxicology advice throughout the Agency.

4.1.1 Toxicology Information

As of 1993, there have been over 11,000,000 individual chemicals uniquely identified by scientists worldwide, and it is estimated that at least 70,000 of these chemicals are used in industry in the United States. Very few have been tested for the full range of toxic effects, although most of the important industrial chemicals have been tested for a fairly wide range of toxic effects. In contrast, many of the chemicals having limited uses in industry (and even a few of the major industrial chemicals) have limited toxicology databases, and toxicological data for the vast majority of the 11,000,000 known unique compounds (such as research and development chemicals, by-products, contaminants, etc.) are scant to nonexistent. This state of affairs, when coupled with the large populations which may be exposed to such chemicals, often results in a focus of attention on chemical hazards in research, regulations, and press coverage.

The key to assessing the potential health and environmental risks of chemical substances is in the gathering of a wide variety of appropriate information. Gathering this information requires the meticulous search of many data sources encompassing books, journals, computerized databases, USEPA and other government documents, and data files. OCS has a toxicology information center that lends support to the various Bureaus and Divisions within IEPA. The core for providing these services includes knowledgeable scientific staff, ready access to computerized information sources, and hard copy information resources.

Information is available from standard print sources and on-line computer databases. An example of an on-line database used by OCS is the Chemical Information System (CIS) which is a collection of computerized data storage and retrieval modules for chemical information. Chemical/physical properties, environmental fate, aquatic data, human toxicity, and regulatory actions are but a few of the areas addressed. Access is also available to all the databases supported by the National Library of Medicine such as Toxline, Chemline, Medline, and Toxnet.

OCS also has the capability to access IRIS (Integrated Risk Information System). IRIS is a computer-housed, electronically communicated catalogue of USEPA risk assessment and risk management information for chemical substances. This system is designed especially for federal, state, and local environmental and health agencies as a source of the latest information about USEPA health assessments and regulatory policies for specific chemicals.

4.1.2 Toxicity Impact Assessment

OCS has developed a process for assessing the possibility of adverse effects on public health, public welfare, or the environment due to known or potential releases of toxic substances into the environment. The Toxicity Impact Assessment (TIA) process provides decision-makers with an assessment of the nature and extent of a problem, allowing them to weigh the alternatives and select a course of action based on the best information available at that time. This assessment process supports a number of IEPA activities, such as permitting, setting of cleanup objectives, setting of standards, and ranking priorities for the control of chemicals and/or facilities. TIA is a means for providing specialized scientific input into control division decision-making activities where more routine inputs may be insufficient.

TIA is a process of assembling and evaluating complex scientific and technical data in an organized and systematic fashion. Its strength lies in the team approach, which allows input from various disciplines such as toxicology, engineering, chemistry, biology, and geology. While special emphasis is placed upon the protection of human health, TIA also addresses the impacts of toxic chemicals on other environmental receptors such as plant, wildlife, and aquatic species. Since "cookbook" answers are seldom applicable for most of the questions regarding toxic substances which are referred to the TIA process, it has been necessary for professional toxicologists to assemble, interpret, and report the toxicological data for a TIA.

4.1.3 Programmatic Applications

The TAU frequently acted as a source of information on toxic chemicals for the private and public sector in 1993. In response to information requests, the TAU either personally provided the necessary information or acted in an intermediary fashion by directing questions to the proper sources.

The TAU continued to develop a series of chemical information sheets which are summaries of available data regarding the general nature and effects of particular chemicals. These information sheets are distributed to the general public, the press, etc. in an effort to communicate general information about a particular chemical. During 1993, two new information sheets were developed, for a cumulative total of 39. The chemicals currently covered by a chemical information sheet are as follows:

164

alachlor
aldrin/dieldrin
arsenic
benzene
bis-2-ethyl hexyl phthalate
1,3-butadiene
cadmium
carbon monoxide
carbon tetrachloride
chlordane
chloroform
chromium
creosote
cyanide
dichlorobenzenes
dichloroethanes
dichloroethylenes
dioxins and furans
ethylbenzene
lead
mercury
methyl ethyl ketone
methyl isobutyl ketone
methylene chloride
naphthalene
nickel
ozone
pentachlorophenol
polychlorinated biphenyls (PCBs)
polycyclic aromatic hydrocarbons (PAHs)
sulfur dioxide
tetrachloroethylene
triazine herbicides
1,1,1-trichloroethane
trichloroethylene
trifluralin
toluene
vinyl chloride
xylene

In 1993, TAU personnel provided document review and comment, project development input, and project oversight for 81 major projects. These projects involved the in-depth critical review of 139 major documents including remedial investigations, feasibility studies, endangerment assessments, risk assessments, Illinois Department of Public Health health assessments, and preliminary investigations. Additionally, 11 major TIAs were conducted in 1993 including the assessment of personal protective gear contaminated by a pesticide fire; evaluation of the potential adverse health effects due to composting, excess chlorine in drinking water, nerve agent VX, and exposure to various pesticides; and evaluation of contamination resulting from gasoline spills. Additionally, TAU staff focused time and resources on:

- evaluating air emissions from various facilities and developing health-based screening levels for these emissions (24);
- maintaining a summary list of current regulatory standards and criteria for intra-agency utilization;
- developing cleanup criteria for contaminants detected in soil and groundwater;
- providing scientific input in the fish contaminant monitoring program; and
- providing expert testimony for Pollution Control Board hearings and court cases.

In 1993, TAU personnel were involved in numerous seminars and training courses aimed at increasing their professional knowledge and awareness. The following are a list of the courses that TAU staff attended.

- USEPA Radiation Training,
- Radionuclide Ingestion Pathway Exercise,
- Steel Structures Painting Council 6th Annual Conference on Lead-Based Paint,

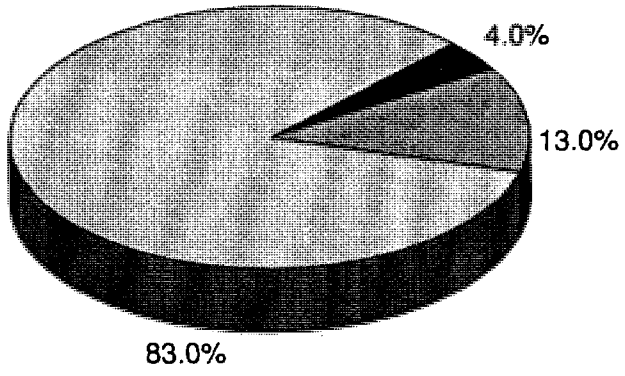
165

- Indoor Pesticides,
- Electromagnetic Frequencies (EMF),
- CPR/First Aid,
- Soil Standards Workshop,
- Illness and Environmental Exposures,
- Seminar of Carcinogenic Weight-of-Evidence Software,
- Volatile Organic Chemicals in Drinking Water,
- Meta Analysis,
- Adverse Reproductive Outcomes, and
- Environmental Exposures Via Fish.

A breakdown of toxicity assessment projects, by the media divisions supported, is shown in Figure 4-1. The major toxicity assessment projects are listed in Table 4-1. Table 4-1 is followed by representative examples of related TAU projects which illustrate some of the ways in which the TAU staff has provided scientific input into Agency activities.

FIGURE 4-1

TOXICITY ASSESSMENT UNIT 1993 ACTIVITIES BREAKDOWN



Breakdown by Bureau

Bureau of Land Bureau of Air Bureau of Water

Percent Direct Time Charges per Agency Bureau

166

TABLE 4-1
1993 MAJOR TOXICITY ASSESSMENT PROJECTS

AB Dick
Acme Solvents
A. G. Communications Systems
Airsheds
Air Toxics
American Milling Company
Amoco Pipeline - Chillicothe
Astec/North Aurora LUST
Baxter Healthcare
Behn Drum
Beloit Corporation
Blackwell Forest
Bohn Heat
Byron Johnson Salvage Yard
Carpentersville Sites
Chanute Air Force Base
Chemical Information Sheets (2)
Cleanup Objective Recommendations (375) and Human Threshold Toxicant Advisory Concentration Calculations (20)
CIPS - Taylorville
CPC Products
Crab Orchard
Dowell-Schlumberger
DuQuoin Manufactured Gas Plant
Fansteel/Escast
Fish Contaminant Monitoring Program
Flood Activities
Fort Sheridan
General Electric
Great Lakes Naval Training Center
Harris Broadcast
Hevi-Duty Electric
H.O.D. Landfill
IDOT - Sauk Trail
Illinois Power - Belleville
Illinois Power - Cairo
Illinois Power - Danville
Illinois Power - Hillsboro
Jennison-Wright
Joliet Army Ammunition Plant
Kerr-McGee
Koppers - Carbondale
Koppers - Galesburg
LaSalle Electric
Lead
LeSage Farm
Lincoln Park Gun Club
Lindberg Heat Treating
London Chemical Company
Lyons Metals
M.I.G. Landfill
Modern Plating
Monsanto/Sauget Sites
MOPAC - Dupo
Morton Chemical
Motorola
Navy Pier Headlands Project
Northern Farm Supply
O'Hare Air Reserve Station
O.M.C.
PACCAR
Pagel's Pit
Palos Park
Panhandle Pipeline
Parson's Casket Hardware
Peoples Gas - 110th Street
Pesticide Reviews (1)
Quincy Municipal Landfill
Radionuclides
Rockford Products
Sandoval Zinc
Savanna Army Depot
Saw Wee Kee Park
SCA - Wilsonville
Scott Air Force Base
Screening Level Ambient Air Concentrations (DAPC) (24)
Southeast Rockford Groundwater Contamination
Standard Scrap Metal
Toxicity Impact Assessments (11)
TSCA CBI Policy
Velsicol
Woodstock Landfill
Yeoman Creek Landfill

167

Recommendations for Cleanup Objectives

One of the more controversial issues facing the Agency is that of establishing appropriate objectives for the cleanup of chemically contaminated groundwater, surface water, soil, and sediment; the onerous question of "how clean is clean". OCS is a major contributor of time and effort to this process at the IEPA.

The year 1993 represented a transition year for the procedural and organizational mechanisms by which cleanup objectives are established at the Illinois Environmental Protection Agency (IEPA). In March, 1993, the nearly decade-old Cleanup Objectives Team (COT)/Coordinated Review of Permit Applications committee (CROPA) process was retired. It was replaced by a more efficient and responsive approach involving the Office of Chemical Safety and a committee based in the Bureau of Land known as Cleanup Objectives Review and Evaluation (CORE) group. The two old and new approaches have many similarities and one major difference. COT/CROPA was designed to be utilized by all major divisions within the Agency while CORE is anchored within the Bureau of Land. Initially the COT/CROPA process addressed a small number of cleanup issues originating fairly equally from the various Agency media divisions. As time went on, however, requests originating from Bureau of Land programs increased exponentially to the point where those cases effectively monopolized the old process.

While the memberships of both the COT and CROPA committees were purposefully diverse to represent their mission, CORE is comprised solely of land bureau managers, the manager of the OCS, and a representative from the enforcement division. The bicameral structure of the process has been retained with the OCS Toxicity Assessment Unit (TAU) providing the expertise for assigning toxicity-based objectives; the service previously provided by COT. The function of the corresponding groups remains the same with OCS providing the risk analysis component of the process and CORE providing the risk management component.

The function of performing the toxicological and technical evaluation of chemical contamination is rightly placed with the OCS. The OCS possesses the experience and expertise in physical, chemical, and biological sciences and toxicology. The OCS develops its recommendation based upon human health, public welfare, and environmental protection while taking into consideration unique site characteristics.

When deemed necessary, OCS's recommendations are submitted to the CORE group for risk management policy consideration. The CORE membership is comprised of BOL section managers for regulatory programs who possess extensive experience in regulatory issues. Their concerns are diverse and include legal and regulatory issues, engineering feasibility issues, analytical detection limits, economic issues, and the overall priority and magnitude of the projects.

The COT/CROPA and CORE processes represent a significant and continuing effort from the TAU and the manager of the OCS. In 1993, 375 cleanup objective recommendations were issued by the OCS-TAU. In addition, the TAU calculated and documented development of 20 interim Human Threshold Toxicant Advisory Concentration (HTTAC) values. HTTAC calculations are prescribed in the Illinois Groundwater Quality Standards regulations and cover contaminants that have no standard, no Maximum Contaminant Concentration Goal (MCLG), and are not carcinogens.

The TAU also provides critical review of risk assessments submitted to the Agency in support of alternative cleanup objectives. These documents are often lengthy, thorough, technical reports that require significant time and effort to review. Requests for risk-based alternative cleanup objectives have been steadily on the rise and the Agency anticipates a significant increase in the number of such applications since this process has been gaining favor with the regulated community. Additionally, the TAU provides advice and support to the BOL project managers as well as expert testimony at Illinois Pollution Control Board proceedings and for court cases when requested.

TSCA CBI Information

Because of Confidential Business Information (CBI) related provisions, no protocol exists for regular and convenient access by state agencies to facility-related Toxic Substances Control Act (TSCA) information housed at USEPA. TSCA contains important information on production and use volumes of chemicals in Illinois and could be valuable in the state's toxics control programs. IEPA agreed to conduct a pilot project with USEPA during 1993 to assess the availability of TSCA information on a request basis from the regulated facilities.

Previous to this pilot, only grossly aggregated data were provided by USEPA and chemical identities were mostly unavailable. This project began with IEPA requesting copies of the 1990 Inventory Update Rule Reports (Form U) from a list of filing facilities in Illinois provided by USEPA. USEPA excluded a number of facilities from this list because the location of the facility was marked CBI on the report. In fact, CBI was a concern of many of the responding facilities. Some companies asked for confidential status from the Agency and others sent in a sanitized version with CBI information deleted. Only 62% of the facilities contacted provided some form of information. This information was then analyzed and compared to other relevant data such as the Toxic Release Inventory (TRI Form R) and significant releases under the Illinois Chemical Safety Act.

There was not much overlap in the data from From U and other sources of chemical information such as Form R. Very few chemicals were reported on both forms. In other words, Form U provided previously unavailable information on chemicals which may be found at facilities throughout Illinois. Many of the chemicals reported on Form U were process intermediates or complex mixtures that could be part of environmental releases. At this point, the Agency has neither real working knowledge of the potential hazards that these chemicals may represent nor an understanding of the effects these substances may have on people or the environment. The information contained in the Form U may specifically be useful in the agency's air toxics control and emergency preparedness programs. Based on the results that the agency obtained from this pilot project, USEPA has decided to expand this TSCA data sharing project to another sixteen states.

Great Lakes Toxic Substances Control Agreement

On May 21, 1986, then Governor James Thompson signed the Great Lakes Toxic Substances Control Agreement along with the governors of the other seven Great Lakes states. This agreement provides a framework for the Great Lakes states to coordinate regional actions for common problems facing the states and the region in the area of toxic chemicals. The agreement covers a range of topics, and IEPA personnel from throughout the Agency are involved.

One area covered under the Toxic Substances Control Agreement is consistent sport fish consumption advisories throughout the Great Lakes. Toward this end, a Great Lakes Fish Advisory Task Force was formed in 1985, with Illinois initially represented by personnel from the Division of Water Pollution Control. OCS became actively involved in this Task Force late in 1989, and has continued to participate in the various activities. This Task Force has investigated numerous issues having to do with consistency in sport fish consumption advice such as: appropriate species and sizes of fish; appropriate numbers and types of samples (e.g., whole fish or fillet, skin on or skin off); selection of sample sites; sample handling; analytical procedures; data handling and evaluation; appropriate criteria for determining acceptability of contaminant levels; and nature of the advice given to the anglers. Some success has been achieved by the Task Force, notably an agreement by the four Lake Michigan states on a lake-wide fish consumption advisory. This Task Force has investigated a methodology for evaluating the health risks posed by contaminants in fish which is not tied into the Action Levels used by the U.S. Food and Drug Administration to evaluate commercially-caught fish. Specifically, a risk-based approach focusing on the reproductive and developmental effects of polychlorinated biphenyls (PCBs) has been submitted to the Council of Great Lakes Governors and the

governors of each state. The advisory protocol and structure was developed by the Task Force and has been critically evaluated by the health, environmental, and natural resource agencies of the eight Great Lakes states and by outside peer reviewers. If accepted by the Council and the Governors, the protocol will be used in developing each state's fish consumption advisory for its Great Lakes waters.

4.2 Release Information Analysis

The Emergency Planning Unit (EPU) is charged with duties related to emergency planning and community right-to-know as specified in the Illinois Chemical Safety Act (ICSA), the Illinois Environmental Protection Act (Act), and the Federal Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). Other duties include release prevention activities; contingency planning efforts by IEPA and other state agencies; activities associated with the Illinois Hazardous Materials Advisory Board (HMAB), and Freedom of Information Act (FOIA) requests directed to OCS.

4.2.1 Illinois Chemical Safety Act (ICSA)

The Illinois Chemical Safety Act (ICSA) establishes an orderly approach, such that facilities are adequately prepared to respond to the release of chemical substances into the environment and to improve the ability of state and local authorities to respond to such releases.

In 1988, the ICSA was amended to enable the state to add specific businesses to the universe of covered facilities. Since these amendments became effective, EPU has visited 16 facilities and recommended the addition of 13 facilities. The Illinois Emergency Management Agency (IEMA) is a partner in implementation of the ICSA. One of IEMA's roles is to act on the IEPA addition recommendations to extend coverage to specific facilities. EPU is currently preparing a list of facilities to be visited based on EPCRA Sections 302 and 313 data. In addition, the Agency may review in advance the contingency plans required under the ICSA. In previous years, a significant release must have occurred at a facility before the plan could be reviewed by the State. Under this amendment, 14 contingency plans have been requested and 12 have been reviewed.

In 1993, 510 off-site releases from a variety of facilities were evaluated by EPU staff. Eighty of these were releases of chemical substances from ICSA covered facilities, compared to 73 in 1992, 106 in 1991, 64 in 1990, 52 in 1989 and 48 in 1988. Upon review of applicable information, and in some cases following an on-scene inspection, six of the eighty were declared significant, as defined in the ICSA.

170

The off-site public impact of all ICSA significant releases to date is tabulated as follows:

YEAR	# RELEASES	# KILLED	# INJURED	# EVACUATED
1986	2	0	3	0
1987	4	0	2	10
1988	8	0	707	990
1989	10	0	1	226
1990	11	0	2	90
1991	14	0	9	32
1992	5	0	5	493
1993	6	0	0	20
TOTALS	**60**	**0**	**729**	**1861**

Following the declaration of a release as significant, each facility was required to submit a written report containing information on the release along with a copy of their chemical safety contingency plan for review. The Agency evaluated these reports when submitted and recommended revisions as necessary to improve the contingency plans.

4.2.2 Emergency Planning and Community Right-To-Know Act of 1986 (EPCRA)

The Illinois General Assembly amended the Illinois Environmental Protection Act in 1987 to provide for a coordinated state implementation of data collection from facilities regarding their annual toxic emissions. This was required by the federal EPCRA. Under the Act, the IEPA is designated as the agency responsible for the administration of Section 313 of EPCRA which requires industry to report annually to the USEPA and state governments via the Toxic Chemical Release Inventory Form (Form R). This form shows all releases of "toxic chemicals" by a facility to the environment that occur within a calendar year, as a result of normal operations and emergency releases. Form R includes all routine and non-routine releases of toxic chemicals to the air, water, land, and transfers of wastes to off-site treatment, storage, and disposal facilities. The federal government has a primary responsibility of disseminating these data to the public; however, the state legislature directed IEPA to use the information as the core of a state database. Data requests for this information via FOIA are honored by EPU staff.

A total of 4848 valid submissions were filed by 1,359 facilities in Illinois for the 1992 reporting year as of December 1, 1993. The forms themselves were due on July 1, 1991; however, many forms were submitted late. After subjecting the data to systematic quality control, the data were entered into a computer database. Serious errors, such as pages missing from the Form R or a submittal on a wrong form, resulted in the data being incomplete. In these cases, the EPU contacted the facility by letter asking the owner or operator to correct the noted deficiency(s). A total of 158 compliance inquiry letters were sent to facilities which filed for 1991 but not for 1992; 45 of those facilities responded that they were not required to file, 95 submitted the required information and six did not respond. Enforcement is being considered for these six facilities. The data were summarized in a Sixth Annual Toxic Chemical Report for 1992 which was published in April, 1994 by OCS.

171

EPU provides support to the regulated industries, the public, and responds to intra-agency requests for information involving Section 313 data and its collection. Many telephone and written requests were received from facilities for guidance in filing Form R. In addition, EPU continues to assist the Bureau of Air (BOA) in development of it's Air Toxics Program by reporting the Form R data in various ways which will be beneficial to the BOA. Also EPU has generated Form R information in a form which has assisted the Office of Pollution Prevention in targeting facilities for pollution prevention activities. An additional use of Form R data has been the evaluation of various facilities and Standard Industrial Code (SIC) groups for coverage under the ICSA.

4.2.3 Freedom of Information Act (FOIA)

During 1993, EPU processed 778 requests for information under FOIA compared to 791 requests in 1992, 878 in 1991, 874 in 1990, 649 in 1989 and 143 in 1988. This demand for OCS information results primarily from two program areas: the availability of Annual Toxic Chemical Release Inventory Reports (Form R) mandated by EPCRA; and environmental audits related to ownership transfers of business property which generated numerous requests for historical chemical emergency incident information.

4.3 Education, Planning, and Compliance

Another tool in the management of toxics is through the dispersal of information, careful planning, and diligent site inspections to assure regulatory compliance.

4.3.1 Toxics Education

Lead Hazard

A lengthy list of health effects have been attributed to lead exposure: damage to the kidneys and to the nervous, reproductive, cardiovascular, immune, and gastrointestinal systems. Lead has a particularly damaging effect on intellectual development in children and interferes with the manufacture of heme, the oxygen-carrying part of hemoglobin in red blood cells. Extremely high levels of lead in the body causes encephalopathy (or degenerative brain disease) which, if untreated, results in coma and death.

While severe acute and chronic lead poisoning of children was the typical form of the disease at one time, the hazard associated with lead exposure is now also viewed in terms of low-level effects. Various studies have found evidence that exposure to lower levels of lead can produce IQ deficits, impaired learning and behavior, hyperactivity, hearing impairment, and inattentiveness. Lead readily crosses the placenta and exposure of the fetus to lead has been associated with adverse neurobehavioral effects, shortened gestation, and reduced birth rate. Children are generally exposed to more lead due to their normal hand-to-mouth activity and their greater absorption efficiency for lead. Most commonly, children ingest dust contaminated with lead from paint which has flaked or chalked during aging or which has been disturbed during renovation, remodeling, and removal activities.

Today, there is an ever increasing interest in lead exposure to construction workers who weld, burn, and blast steel structures (e.g., bridges, water towers, etc.) painted with lead-based paint. Intact lead-based paint poses little hazard to workers. However, a serious hazard can be created when leaded coatings are disturbed during the welding, cutting, grinding, or abrasive blasting of painted steel structures. The Occupational Safety and Health Administration (OSHA) has estimated that 850,833 workers are exposed to lead-based paint and lead-based paint debris every year. Occupational exposure to lead has historically been associated with decreased fertility, spontaneous abortion, stillbirth, and increased infant mortality.

172

During the majority of this century, paint containing more than 0.06% lead by weight was utilized for a wide range of consumer, commercial, and industrial uses. In particular, it was used on steel structures such as bridges and water towers to protect these surfaces from corrosion. Although the Consumer Product Safety Commission in 1978 banned the use of paint containing more than 0.06% lead by weight on interior and exterior residential surfaces, toys and furniture, approximately three million tons of lead remain in an estimated 57 million private housing units built before 1980.

The standard methods of removing hazardous paint, by their very nature, create conditions under which substantial exposure to lead may occur. Blasting the painted surface with abrasive particles is the most frequently used removal method and is also the method that creates very high levels of lead-containing dust in the air. Abrasive blasting creates very small particles of lead some of which are so small, they are invisible to the human eye. These particles can be easily inhaled by anyone located close to the removal site and if released to the air, these particles will eventually settle out and contaminate neighboring properties.

The uncontrolled removal of lead-based paint can create the following adverse consequences:

- the contamination of property;
- water and air pollution;
- human exposure to poisonous lead;
- extra costs for cleanup of areas contaminated by removal activities; and
- greater legal liabilities due to lead contamination.

In addition, we should not overlook the sobering fact that once lead is released into the environment it does not degrade or go away. It remains as a hazard and will only grow more dangerous as more lead gets loose and accumulates in soils, waters, and living things.

During 1993, OCS responded to 686 inquiries (double that of 1992) on lead-based paint from citizens; federal, state, and local governments/agencies; consultants/engineers; and private organizations. The types of inquiries included complaints and problems involving the uncontained removal of lead-based paint and questions on regulations, disposal, and containment. All complaints registered with the Agency were investigated promptly and field sampling conducted to confirm the presence of elevated levels of lead and the necessity of cleanup operations. In addition, OCS staff made presentations on the removal of lead-based paint to the Midwest Chapter of the Steel Structures Painting Council, Farmers Home Administration, Illinois Environmental Information Group, Illinois Potable Water Supply Operators, and the Springfield Chamber of Commerce.

As required under House Bill 1532, which amended the Environmental Protection Act (Act) in 1993 by adding Section 4.1, IEPA conducted a study during 1993 in order to determine the extent and severity of environmental hazards associated with the uncontained removal and release of hazardous paint from structures and buildings. The Illinois General Assembly mandated that the study address potential approaches to effective hazard reduction. "Hazardous paint" was defined, for the purposes of the study, as paint or other surface coating material containing greater than 0.5% total lead by weight calculated as lead metal in the dried paint film which had been placed on an exterior surface of a building or structure.

The study included a documentation of a number of cases that clearly show how the uncontrolled removal of hazardous paint from the exterior surfaces of buildings and structures has resulted in airborne emissions

and deposition of high levels of lead onto soils and other outdoor surfaces of neighboring properties. The IEPA has also documented instances where proper planning, management, public outreach, worker training, and application of control measures have reduced, if not eliminated, the risk to workers and nearby residents from the removal of hazardous paint.

In order to gather more information about removal needs and practices, the OCS conducted three surveys. These surveys were sent to contractors and painters, state and local officials and operators, and industrial sites. The results from these surveys provided the IEPA with valuable information and have helped to focus on the primary issues related to the safe removal of hazardous paint. The training and certification of contractors and workers was ranked by the respondents as an issue of primary importance. Approved removal technologies, further guidance on waste disposal, better containment methods, and enforcement to deal with problem sites were also ranked as important concerns. Some comments provided by the survey respondents also supported the development of specific performance expectations and uniform requirements by the State in order to identify exactly what is required of those conducting or contracting for the removal of hazardous paint.

The Agency also sponsored a conference on the safe removal of hazardous paint in order to bring together speakers that could provide a variety of government, industry, consultant, and contractor perspectives on the safe removal of hazardous paint. In general, speakers emphasized the importance of taking preventive action whenever possible. Training and certifying workers and contractors was a specific issue that was consistently viewed as important regardless of the speaker's particular perspective.

Based upon all of the information compiled for the study, the IEPA concluded that hazardous paint removal, if improperly managed, creates undue risks for workers and other persons near removal sites. These risks can be greatly reduced, if not eliminated, by advance planning and application of suitable control measures. The Agency has concluded that opportunities exist in all parts of the State for unnecessary exposures to hazardous paint wastes and that safe removal of hazardous paint has been hampered by a lack of codified performance expectations. The proper training of hazardous paint removal workers and contractors can be beneficial in terms of reducing releases of hazardous paint during removal. In addition, persons living or working in close proximity of a removal project should receive advance notification so that they can take certain precautions to limit their exposure to lead.

Summary Report on Selected Background Conditions

During 1993, the Office of Chemical Safety completed the second phase of data collection efforts aimed at compiling information on selected background soil conditions for inorganics. The main objectives of these efforts were (1) to ascertain a reasonable indication of statewide background concentrations of inorganics in soil; (2) to support the Agency's efforts in determining the levels of lead present in background soils across the state; and (3) to utilize, to the extent possible, existing site-specific studies and background data which represent a major undeveloped data resource existing within Agency files.

Sample results were obtained from Preliminary Assessment/Site Investigation reports performed since 1986 plus sample results from State Superfund and Federal Superfund site investigations in Illinois. In addition, sampling was conducted by Agency staff in those counties where background data were lacking. The current database includes 275 data points from sample locations in all 102 counties in Illinois.

These data will be used by programs in the Agency to evaluate the validity of site-specific background data collected for various cleanup sites across the state and as a general screening check for determining the potential presence of inorganic contamination at a site. These data appear to present a reasonable indication of background conditions in Illinois and can be used in comparison to site data to identify which, if any, inorganic contaminants are present in concentrations above what could be viewed as "normal". The summary report will be available for distribution in 1994.

174

4.3.2 Emergency Preparedness

Pre-positioning of Emergency Response Trailers

In its first annual report, the Illinois Hazardous Materials Advisory Board (HMAB) recommended that emergency response equipment and supplies be pre-positioned at nine sites throughout the state to supplement the capabilities of local emergency response agencies in their response to chemical emergencies. In 1989, four response trailers were procured to test this concept.

The four trailers were deployed in 1992 at the following locations (the available response areas are indicated in parentheses): Pekin Fire Department (IDOT District 4); Champaign Fire Department (IDOT District 5); Triad Industries, Inc., South Roxana, two trailers (IDOT Districts 7, 8, and 9).

All trailers are equipped with 84 sorbent booms and 2600 sorbent pads to mitigate spills to water. Local response agencies can request their deployment to the scene of an incident on a 24-hour basis by contacting the ERU duty officer. The requesting agency is expected to provide personnel to use sorbents once they are on site.

Response Materials Availability on State Contract

Under this on-going statewide program coordinated by ERU, state and local agencies are able to purchase sorbent booms, sorbent pillows, and sorbent pads to initially control spills of oil and hazardous materials which may threaten waterways such as lakes, streams, and ponds. Fire departments and other public agencies order these items quickly at reasonable prices without having to individually obtain competitive bids. This is a result of arranging for these items to be purchased from a state contract which is available to local agencies through the authorities of the Joint Purchasing Act. This contract also was initiated by recommendation of the Hazardous Materials Advisory Board.

4.3.3 Toxics Compliance

Toxic Substances Control Act (TSCA) Grant

In 1990 the Office of Chemical Safety entered into a cooperative agreement with the USEPA to conduct inspections for compliance with federal regulations promulgated under TSCA. Those regulations govern the use, production, recordkeeping, storage and disposal of polychlorinated biphenyls (PCBs). Six persons from the ERU's Springfield, Collinsville, and Maywood offices have been certified to conduct these inspections. Facilities inspected are chosen under a neutral inspection scheme and include: disposers; brokers, storers, and intermediate handlers; commercial buildings; and general inspections which are divided into ten facility categories. Facilities with reported spills are evaluated for prioritization since they are likely to have PCB management deficiencies. During 1993, 76 inspections were performed by the ERU staff. This inspectional and compliance activity is supported by a matching grant from USEPA.

Hazard and Operability Studies (HAZOPs)

In response to repeated releases of chemical substances at several chemical facilities in Illinois, the IEPA has initiated a number of lawsuits which resulted in consent decrees containing provisions which required facilities to take substantive and effective measures to prevent pollution. As part of this pollution prevention effort, the EPU recommended that a Hazard and Operability (HAZOP) study be conducted at each of these facilities. A HAZOP is a specific systematic technique for identifying hazards at a chemical facility which may lead to releases of hazardous chemicals. A HAZOP consists of examining every individual segment (e.g., valve, pipe run, reactor, etc.) of a process to identify all possible deviations from normal operation conditions

and how they might occur. Through the Office of the Illinois Attorney General, the consent decrees are being negotiated with these facilities and will require each to conduct a HAZOP. From these evaluations, process and operation vulnerabilities may be identified and those vulnerabilities that may potentially cause off-site hazards will be eliminated. Information obtained from HAZOP studies also may be useful in improving ICSA Chemical Safety Contingency Plans. HAZOP studies also have been specified as permit requirements and in permit reviews. To date, HAZOP studies for all or parts of 15 facilities have been recommended. Nine HAZOP studies have been reviewed by EPU staff and the recommendations from them are in various stages of completion. The remaining six HAZOP studies are in various stages of development for scope and/or content and are reviewed, on a timely basis, as they are submitted to EPU. Future HAZOP studies are anticipated, due to the demonstrated utility of this tool in preventing accidents and because they often result in efficiency improvements at facilities which have positive economic effects.

176

5.0 AGRICULTURAL PROGRAMS

Media division programs within the Agency affect agricultural industries through regulatory and permitting activities. Although most farming activities other than livestock operations are generally not covered in Illinois under environmental regulations, environmental pollution (including the release of toxic chemicals) can result from some agricultural related practices, and, therefore, requires IEPA involvement. An Agriculture Advisor is assigned to the Environmental Policy Program to provide technical assistance on agricultural matters, coordinate inter-divisional agricultural activities, and serve as liaison to agricultural organizations, agricultural industries, and other governmental agencies.

The IEPA Chemical Safety Agenda includes elements aimed at minimizing environmental exposure to agrichemical pollutants. The following activities were carried out in 1993 to augment Agency programs and procedures related to pesticide waste management, agrichemical spill control, pesticide registration review, and rural watershed pollution control.

5.1 Pesticide Registration -- FIFRA 24(c) Reviews

The Illinois Department of Agriculture (IDOA) is responsible for registering pesticides for special local needs uses under Section 24(c) of the Federal Insecticide Fungicide and Rodenticide Act. It is their general procedure to request members of the Interagency Committee on Pesticides, which includes IEPA and six other state agencies, to provide recommendations on proposed registrations.

To ensure consistent and comprehensive Agency reviews of the 24(c) applications, each IEPA media division and OCS have designated one of their staff to participate in assessing potential environmental impacts of granting the registrations. The comments are combined into one response by the Agriculture Advisor and forwarded to IDOA. There were three reviews requested by IDOA during 1993.

5.2 State Pesticide Strategy Subcommittee

The State Pesticide Strategy Subcommittee was organized under the direction of the Interagency Coordinating Committee on Groundwater (ICCG) to develop a Generic State Management Plan for Pesticides and Groundwater. The plan is to address agrichemical/groundwater issues identified in USEPA's Agrichemicals in Groundwater Strategy and related guidance documents. During 1993, efforts of the subcommittee focused on revising a preliminary draft of the plan and developing an assessment procedure for determining aquifer sensitivity to contamination by pesticides. Agency personnel serving on the subcommittee include the Agriculture Advisor and the Public Water Supply Groundwater Section Manager.

5.3 State FIFRA Issues Research Evaluation Group (SFIREG)

The SFIREG Working Committee on Groundwater Protection and Pesticide Waste Disposal met three times during 1993. The IEPA Agriculture Advisor represents both solid waste and water pollution control interests on this committee. The committee forum provides for an interface between USEPA's Office of Pesticide Programs, Office of Solid Waste Management, Office of Drinking Water, Office of Groundwater Protection, and state regulatory entities. The primary topics addressed by the group have been the identification of technical and regulatory concerns about pesticide waste disposal, the promulgation of USEPA's pesticide disposal regulations, the development of State Management Plans for Pesticides and Groundwater, atrazine contamination issues, and agrichemical site remediation, including the land application of pesticide contaminated soils.

177

5.4 Agrichemical Containment Program

Secondary containment rules for agrichemical facilities, which were adopted by IDOA, became effective on January 1, 1990. Key provisions in the regulations address diking systems for bulk storage; rinse pads for mixing, loading and washing equipment; cross-connection control; spill reporting; and dry fertilizer blending. The Agency and IDOA have entered into a cooperative working agreement to implement the regulations. Under the agreement, IDOA assumes the lead in overseeing installation and day-to-day operation of the required containment structures. IEPA is involved in co-reviewing of permit applications and incident follow-up when chemical releases occur. The IEPA Agriculture Advisor is responsible for coordinating the implementation of the Interagency Agreement.

The primary activities relating to the containment program during 1993 involved permit application reviews conducted by staff engineers from the Bureau of Water (BOW) and Bureau of Air (BOA) Permit Sections as well as the Bureau of Water Agricultural Engineers. Applicants whose plans met the required specifications were issued an Agency endorsement. There were 331 endorsements issued during 1993. Another year of intensive reviews is planned for 1994 when an additional 330 agrichemical facility permit applications are expected to be submitted.

5.5 Cooperative Groundwater Protection Program

A Cooperative Groundwater Protection Program was established through the collective efforts of the Agency, IDOA, industry and environmental organization representatives. IDOA is to carry out the program with support from the Agency. This new program provides an alternative for lawncare and agrichemical storage and handling facilities subject to the Illinois Pollution Control Board's (IPCB) groundwater technical standards provisions. The regulated entities can choose to comply with the IPCB standards or participate in the cooperative program. The Agency's Environmental Policy Advisor, Agriculture Advisor, and BOW staff were instrumental in this endeavor.

5.6 Technology Transfer

Formal presentations were made by the Agriculture Advisor at the following meetings/conferences to convey information regarding pesticide waste management, pesticide waste disposal rules and regulations, agrichemical site remediation, agrichemical nonpoint source pollution control, public water supply standards compliance, and provisions of the Groundwater Protection Act.

- Illinois Agricultural Pesticides Conference
- Raymond Kiwanis Club Farm Night
- Southern Illinois University - Agriculture and Environmental Issues Class
- Southern Illinois University - Plant and Soil Science Graduate Seminar
- Cooperative Extension Service Regional Tillage Conference
- Association of Illinois Soil and Water Conservation Districts Water Quality Seminars
- Illinois Agricultural Leadership Program Environmental Issues Seminar
- American Chemical Society Agrochemicals Division Symposium

178

- Governor's Conference on the Management of the Illinois River System
- Illinois Agricultural Aviation Association Fall Convention
- Sangamon County Farm Managers Meeting

6.0 HEALTH AND SAFETY

Industrial hygiene is the science of recognition, evaluation, and control of environmental factors or stresses -- chemical, physical, biological, and ergonomic -- that may result in death, sickness, impaired health, or significant discomfort to workers. Safety management is the science of controlling hazards to prevent accidents, injuries and fatalities. The Health and Safety Program uses industrial hygiene and safety management techniques to protect the health and welfare of IEPA employees and ultimately the public.

IEPA activities may involve potential exposures to toxic or hazardous chemicals. Obviously this can occur at emergency incidents. Furthermore, the Bureaus of Air, Land, and Water perform field inspections which may result in such exposures at a wide variety of chemical manufacturing and processing facilities and hazardous waste sites. Laboratory staff also handle samples of hazardous wastes everyday and use a variety of chemicals to analyze the samples. Additionally, employees in the IEPA print shop, graphics studio, microfilm processing, photography darkroom, word processing center, and maintenance departments also use some potentially toxic chemical products routinely.

The IEPA promotes employee safety for all of its activities. OCS is responsible for developing and implementing an industrial hygiene and safety program. The objectives of this program are to ensure that IEPA employees:

- recognize and identify hazardous chemicals and physical safety problems associated with their work;
- are fully aware of the potential health effects of exposure to chemical and physical hazards;
- use safety equipment when appropriate, including respirators and protective clothing;
- limit their exposures to chemical and physical hazards through safe work practices; and
- have appropriate knowledge to deal with emergencies, such as chemical spills, fires, or situations which may cause injury to persons or damage to property because of reactivity, instability, spontaneous decomposition, flammability, or volatility.

The program also assures compliance by the Agency with all state and federal regulations relating to health and safety in the work place. The following program areas are continually being strengthened and expanded to meet these objectives.

6.1 Employee Training: Hazardous Waste Operations and Emergency Response.

OCS manages a training program for personnel working at hazardous waste site operations or in emergency response incidents in order to comply with the OSHA 29 CFR 1910.120; Final Rule, Standard.

A description of these courses is as follows:

A. Initial Training Courses

- General site workers (such as equipment operators and supervisory personnel) engaged in hazardous substance removal or other activities which expose or potentially expose them to hazardous substances and health hazards receive a minimum of 40 hours of instruction off the site. In addition, these workers receive a minimum of three days actual field experience under the direct supervision of a trained, experienced supervisor.

180

- Workers who are occasionally on site for a specific limited task (such as, but not limited to, groundwater monitoring, land surveying, or geo-physical surveying) and who are unlikely to be exposed over permissible exposure limits receive a minimum of 24 hours of instruction off the site, and a minimum of one day actual field experience under the direct supervision of a trained, experienced supervisor. Workers who are regularly on site and work in areas which have been monitored and fully characterized indicating that exposures do not exceed permissible exposure limits and no potential health hazards exist receive similar training.

B. Refresher Training

- Employees, managers and supervisors receive eight hours of refresher training annually. OCS travels to each region to provide this training.

C. Management and Supervisor Training

- On-site management and supervisors directly responsible for, or who supervise employees engaged in, hazardous waste operations receive the same amount of training as the employees they supervise and at least eight additional hours of specialized management training. Training topics include personal protective equipment, spill containment, and health hazard monitoring procedures and techniques.

D. Hazardous Materials Specialist

- Hazardous materials specialists are individuals who respond with and provide support to hazardous materials responders and require a more directed or specific knowledge of the various substances they may be called upon to contain. The hazardous materials specialist also acts as the site liaison with Federal, state, local and other government authorities with respect to site activities. Hazardous materials specialists receive 24 hours of training.

The total number of Agency personnel trained in these courses during 1993 was 250 individuals.

6.2 Employee Training: Hazard Awareness

OCS also provides several hazardous awareness training courses for employees who to comply with various OSHA standards. This initial and periodic training is provided for Bureau of Air and Bureau of Water field inspectors and laboratory workers. The total number of Agency personnel trained in these courses during 1993 was 100 individuals.

6.3 Employee Training: Cardiopulmunary Resuscitation/First Aid

OCS conducts CPR and first aid training for selected employees to insure that, in the event of a heart attack or other serious emergency, appropriate care will be available until an ambulance arrives. CPR training is provided annually and first aid training is provided every three years. OCS travels to each region to provide this training. The OCS instructors are certified by the American Red Cross. The total number of Agency personnel trained in these courses during 1993 was 300 individuals.

6.4 Site Safety Plans

Site safety plans establish industrial hygiene and safety requirements for hazardous waste site investigations and cleanup operations. The site safety and health plan, which must be maintained at each site, addresses the safety and health hazards of each phase of site operations and includes the requirements and procedures for employee protection.

The site safety and health plan, at a minimum, addresses the following:

- a safety and health risk or hazard analysis for each site task and operation found in the work plan;
- employee training assignments;
- personal protective equipment to be used by employees for each of the site tasks and operations being conducted as required by the personal protection equipment program;
- medical surveillance requirements;
- frequency and type of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used, including methods of maintenance and calibration of monitoring and sampling equipment to be used;
- site control measures in accordance with site security needs;
- decontamination procedures;
- an emergency response plan which meets the requirements for safe and effective responses to emergencies, including the necessary personal protective equipment and other equipment;
- confined space entry procedures; and
- a spill containment program.

OCS reviews site safety plans prepared by both contractor and Agency personnel. Recommendations are made for personal protective equipment and safe work practices as necessary. OCS also reviews and evaluates modifications to site safety plans when site conditions change or new information becomes available.

6.5 Occupational Medical Monitoring

Physical examinations are conducted annually for assessing certain specified employees' fitness to perform their duties and for identifying potential exposure problems or employees at risk because of existing health problems. OCS administers this medical monitoring program for employees who are potentially exposed to toxic or hazardous chemicals at waste sites as required by the federal Occupational Safety and Health Administration (OSHA).

182

During 1993, Health Evaluation Programs, Inc. performed medical exams under contract for IEPA. They also reviewed the results of each annual physical for significant changes or other indications of health problems. The Clinic staff is required to notify IEPA of situations which may indicate a need for work restrictions or a change in work practices.

One hundred and seventy-eight Bureau of Land personnel involved in hazardous waste inspection or cleanup programs, fifteen OCS emergency personnel, and nineteen Bureau of Air staff members were involved in the medical monitoring program during 1993. Participation in the program is determined by the exposure potential reflected in each employees written job description.

Since 1986, Biological Exposure Indices (BEI), as outlined by the American Conference of Governmental Industrial Hygienists (ACGIH), have been utilized by IEPA and contractor personnel. Blood and urine levels of contaminants have been used to:

- screen out potentially susceptible employees from participating at specific sites;
- monitor personnel for work practices which might allow for the spread of contamination outside the site; and
- substantiate the *a priori* decision on the type of personal protective equipment used at the site.

6.6 Worker Right-To-Know Compliance

Illinois' "Worker Right-to-Know" law requires employers to inform their employees of hazards associated with handling listed chemicals in the workplace. OCS is responsible for compliance with this law for IEPA employees. The safety staff maintain copies of Material Safety Data Sheets (MSDS) for listed chemicals routinely handled by Agency employees. OCS presents annual training seminars for potentially exposed employees to explain how to read a MSDS and how to handle chemicals safely in the workplace. Periodic inspections verify that employees are using the protective equipment covered in the MSDSs and that safe work practices learned in the training courses are followed.

6.7 Illinois Health and Safety Act

The Health and Safety Act requires state agencies to provide a workplace free from recognized hazards that could cause death or serious physical harm to their employees. It incorporates all of the OSHA regulations covering worker health and safety into requirements for state employees. The Illinois Department of Labor administers and enforces this Act.

OCS is responsible for coordinating compliance with this Act within IEPA. The industrial hygienists evaluate Agency activities and recommend safe work practices or other controls to protect employees from workplace hazards. Training classes are also conducted to comply with the Act's requirements.

6.8 Workplace Inspections/Investigations

OCS conducts inspections of the Agency's own facilities, equipment, work sites, and work activities to identify hazards that need to be controlled. When hazards are discovered, corrective actions are identified to protect IEPA employees from the hazards.

In order to determine whether recommended personal protective equipment and safe work practices have been sufficient to protect the employees potentially exposed to chemicals, it is necessary to take

representative samples of the air at work sites and identify the quantity and type of chemicals actually present. To determine exposure levels to atmospheric contaminants and measure possible physical stresses, the industrial hygienists use either direct reading instruments or laboratory analytical methods. Direct reading instruments give an immediate indication of the levels present at a given point in time. Analytical methods utilize vacuum sampling pumps which are used to collect samples from which to eventually measure average concentrations in air over a specified length of time. The pumps pull air through filters or sorbent media which collect contaminants of interest. The sorbent media must then be analyzed in a chemical laboratory to determine the amount of each contaminant collected. The results are then used to confirm or modify safe worker activities and protective equipment.

When an occupational incident or accident occurs which results in injury or illness, the Agency worker compensation coordinator notifies OCS. OCS then conducts an investigation to determine the causes and to determine actions that need to be taken to prevent a similar incident or accident. In 1993 there were 23 occurrences, which involved 84 days away from work.

6.9 Industrial Hygienists Licensing

The Illinois Industrial Hygienists Licensure Act became law on August 20, 1993. The Act declares that it is necessary to protect the public health and safety by regulating title usage by the profession of industrial hygiene. OCS was assigned the responsibility to implement the Act. Activities during 1993 included the formation of an advisory board, development of program documentation, development of program rules, and publication of the program. During 1993, 296 industrial hygienists registered for a license.

6.10 Recordkeeping

Accurate recordkeeping is an essential part of IEPA's safety and health program. OCS maintains hardcopy records of employee training, personal exposure monitoring, Material Safety Data Sheets, worker right-to-know compliance inspections, reviews of site safety plans, and results of field performance and safety reviews. Medical monitoring records are confidential and are kept by the Agency's medical monitoring contractor. Certifications that employees are physically fit to perform their specified job duties are released to OCS and are maintained in confidential Agency files. OCS also maintains OSHA form 200, "Log and Summary of Occupational Injuries and Illnesses," as required by OSHA standards. The log is used for recording and classifying injuries and illnesses and provides data for conducting trend analysis.

SECTION 7

OUTLINE FOR THE DEVELOPMENT OF A GROUNDWATER MONITORING PROGRAM

I. REASONS FOR SAMPLING

A. The primary general reasons for sampling groundwater is to assess the general conditions, and to determine whether health threatening chemicals are present. Monitoring programs also help to measure the effectiveness of control technologies and protection programs.

II. DEVELOPMENT OF A SAMPLING PROTOCOL

A. Before a sampling program is actually begun a, detailed protocol, or plan, should be developed that precisely describes its objectives. The protocol should both clearly establish chemical constituents to be investigated as well as describe the sampling process in detail. The following questions should be addressed when developing a sampling protocol:

1. Why are we sampling?
2. What are we sampling for?
3. What will be the ultimate use of the data we generate?

B. A sampling protocol for a groundwater assessment program should include the following factors:

1. chemical constituents to be monitored
2. selection of sampling sites
3. determination of sampling frequency
4. preparation before sampling
5. amount of water to be removed from the well prior to sampling
6. sample collection techniques
7. documentation of sampling sites
8. sample preservation and storage
9. special packaging and procedures required for transport of samples to the laboratory
10. selection of an analytical laboratory
11. details on transportation of samples to the laboratory
12. chain of custody procedures
13. quality assurance
14. data management

C. A checklist should be written which includes items needed for sampling as well as tasks to be completed before

fieldwork begins. This assures that all necessary items will be taken into the field, and that equipment will be in working order.

D. Sampling procedures or methodologies can differ according to the reason for sampling. For example, the primary purpose of a program may be to check whether a parameter, such as trichloroethylene (TCE), is present in wells near a degreasing operation that used the chemical. Or a sampling program may involve looking for a wide range of volatile organic chemicals (VOC) moving in groundwater away from an industrial landfill. **The more specific the protocol, the greater the chance of getting the most for the dollar spent on the program.**

E. Costs should be kept in mind continually when developing a sampling program. Field personnel should be aware that sampling is an extremely expensive undertaking and field work must be done responsibly and consistently to ensure reliable results. **Conscientious field personnel are vital to collecting useful and accurate water quality data.**

F. Realistically, the development of a sampling protocol will probably be an exercise in compromise. Ideal sampling procedures cannot always be followed because of expense, lack of time, or lack of properly trained personnel. However, given the chemical parameters of interest, the program must developed so that reliable data can be generated despite program constraints.

G. In summary, before sampling starts, a protocol outlining chemical parameters of interest and sampling procedures should be developed. **Every effort must be made to develop a cost efficient sampling program while preserving quality assurance.**

III. SAMPLING PROCEDURES

A. Sampling Frequency-Once chemical parameters of interest have been chosen the sampling timetable should be established. Usually the frequency is determined by the following factors:

1. known or suspected concentrations of the chemical contaminants
2. mobility of the chemicals
3. toxicity of the chemicals
4. location of the chemicals in the aquifer with respect to water wells and human populations
5. velocity of groundwater movement

B. Sampling Sites-Determination of wells or sites to be sampled depends on several considerations, many of which are identical to those determining sampling frequency. In addition to the chemical, physical and biological factors listed above, financial resources available to the program must be evaluated, and limitations acknowledged. **Financial constraints will require selection of priority wells (see Section IV).**

C. General Groundwater Quality Parameters-Parameters that provide a geenral overview of groundwater quality relate to total dissolved solids content (e.g., Na^+, Cl^-, $SO_4^=$) and traditional water treatemnt difficulties associated wuth groundwater.

D. Pollution Indicator Parameters-A generic approach to a contaminant monitoring program requiers the determination of parameters indicative of gross disruption of the inorganic or organic chemistry of subsurface conditions [e.g., pH, solution conductivity* (Ω^{-1}), total organic carbon (TOC) and total organic halogen (TOX)]. This generic approach is a low cost altenative, generally applied to detection mnonitoring situations.

E. Well Purging Parameters*-Stagnant water should be remove by purging the well before taking samples representative of groundwater. Well purging should be monitored in the field by in-line monitoring (e.g.,

---

* ***Denotes analytical determinations that should be collected in the field.***

188

Hydrolab) of stablized well purging parameters (e.g., Eh, pH, T, and Ω^{-1}).

F. Immunoassay Screening-Immunoassay screening is also a low cost alternative (20 times less than GC/MS) for certain organic contaminants (e.g., triazines, alachlor, BETX and PNAs, etc.,).

3. Generalized flow diagram of groundwater sampling steps:

Step	Procedure	Essential Elements
Well Inspection	Hydrologic Measurements	Representative Water Access
	Well Purging or Isolation of Stagnant Water	
	Determination of Well-Purging Parameters (pH, Eh, T, Ω [illegible])	Verification of Representative Water Sample Access
Sample Collection Filtration Field Determination	Unfiltered Field Filtered	Sample Collection by Appropriate Mechanism
		Minimal Sample Handling
	VOCs, TOX	Head-Space Free Samples
	Dissolved Gases, TOC	" "
	Large Volume Samples for Organic Compound Determinations	Minimum Aeration or Depressurization
	Alkalinity /Acidity	Minimal Air Contact, Field Determination
Preservation Field Blanks Standards	Assorted Trace Sensitive Metals Inorganic Species NO_2^-, NH_4^-, Fe(II)	Adequate Rinsing Against Contamination
	$S^=$, Sensitive Inorganics	Minimal Air Contact
	Major Cations and Anions	

190

IV. MONITORING NETWORK DESIGN

A. Financial constraints will require a phased selection of priority wells.

1. Pilot Network of Public Water Supply Wells

   a. Sample all the public wells if it is feasible. By sampling existing wells, this approach will minimize sample collection costs.

   b. Sample a subset of wells utilizing some selection criteria as described with the following examples:

      - the facility has at least one well open only to the aquifer(s) of interest
      - the geographic location of the facility
      - facility serves a population greater than 10,000?
      - the well(s) of interest is active
      - accessibility to the well
      - ability to collect a raw water sample
      - ability to obtain a water level measurement
      - confident that a well log is available
      - competence of the facility operator

2. Random Statistical Selection of Public Wells

   a. The use of a statistically based sampling program is the most cost effective approach providing the most accurate estimate of contamination. If a list of the total population of public wells is available a random statistical selection can be made to represent the overall population.

3. Random, Probability of Occurrence Based Selection of Public Wells

   a. The use of a statistically based sampling program is the most cost

effective approach providing the most accurate estimate of contamination. If a list of the total population of public wells is available a random statistical selection can be made to represent the overall population.

b. The random selection will be more accurate if it is based on the probability of the occurrence of a contaminant. However, in addition to needing a list of all the wells to choose from this approach requires an initial guess about the percentage of occurrence of the contaminants of concern (e.g., agrichemicals in 50 % of the rural private wells).

c. Table I shows the number of samples that will be needed to make statistically valid inferences about the status of that population of wells at different confidence limits and estimates of probability of occurrence:

Table I Required sample sizes for population of 900 to 1,000

Probability of occurrence	Number of samples 95 % confidence	Number of samples 90 % confidence
0.50	278	213
0.10	122	89

4. Random, Probability of Occurrence, Stratified, Statistical Selection of Public Wells

a. The use of a statistically based sampling program is the most cost effective approach providing the most accurate estimate of contamination.

b. The most appropriate statistical sampling technique is stratified random sampling, which involves the division of a population (public/private wells) into non-overlapping subpopulations called strata. Although this type of monitoring network design is the most data intensive (see d below) it is the most

192

accurate, and in the long run may be the most cost effective.

c. The use of stratified random sampling is recommended because the potential for contamination of aquifers or water wells can vary across an area of study. (see Attachment I)

d. The key elements of stratified random sampling design are:

- sample population (public or rural private wells)
- analytes recommended on the basis of their usage and their potential to contaminate groundwater
- stratified random sampling with the potential for contamination of shallow aquifers and depth to the well opening or screened interval as the stratification variable
- sampling plan for random selection of well within each of the strata (generate several alternate lists because of unforeseen problems with the wells selected)
- well-sampling schedule that addresses the potential for temporal variability

e. The other benefit of utilizing a stratified random sampling design are that pairing down the size of the network can be done based on the synoptic survey results. For example, if there is a statistically significant correlation between contamination occurrence and certain stratification variable(s) (e.g., aquifers within 20 feet of land surface) then the network can be re-designed to only represent those **hot spot areas** or for continuous trend site analyses.

V. Data Management

A. It is recommended that data obtained be stored in a relational data base system (e.g., Oracle, Fox Pro, etc.,) for comprehensive storage and analyses. In addition, information in this type of data base will allow for integration with Geographic Information System software such as ARC/INFO. Integration with

ARC/INFO will provide for geospatial analyses of the data sets in relation to other resource coverages (see Attached)

194

SECTION 8

Designation: D 5283 - 92

Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation[1]

This standard is issued under the fixed designation D 5283; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 Environmental data generation efforts are composed of four parts: (*1*) establishment of data quality objectives (DQOs); (*2*) design of field measurement and sampling strategies and specification of laboratory analyses and data acceptance criteria; (*3*) implementation of sampling and analysis strategies; and (*4*) data quality assessment. This practice addresses the planning and implementation of the sampling and analysis aspects of environmental data generation activities (Parts (*1*) and (*2*) above).

1.2 This practice defines the criteria that must be considered to assure the quality of the field and analytical aspects of environmental data generation activities. Environmental data include, but are not limited to, the results from analyses of samples of air, soil, water, biota, waste, or any combinations thereof.

1.3 DQOs should be adopted prior to application of this practice. Data generated in accordance with this practice are subject to a final assessment to determine whether the DQOs were met. For example, many screening activities do not require all of the mandatory quality assurance (QA) and quality control (QC) steps found in this practice to generate data adequate to meet the project DQOs. The extent to which all of the requirements must be met remains a matter of technical judgement as it relates to the established DQOs.

1.4 This practice presents extensive management requirements designed to ensure high-quality environmental data. The words "must," "shall," "may," and "should" have been selected carefully to reflect the importance placed on many of the statements made in this practice.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—A complete table of contents of this practice is given in Appendix X1.

2. Referenced Documents

2.1 *ASTM Standards:*

D 1129 Terminology Relating to Water[2]

E 1187 Terminology Relating to Laboratory Accreditation[3]

2.2 *U.S. Environmental Protection Agency Documents:*[4]

SW-846, *Test Methods for Evaluating Solid Waste*, Vol 1, Third Edition (NTIS No. PB88239223/LL), November 1986

QAMS-005/80 (NTIS No. PB83170514/LL), *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans*, Office of Monitoring Systems and Quality Assurance, December 29, 1980

EPA/QAMS, *Development of Data Quality Objectives, Description of Stages I and II*, July 16, 1986

QAMS 004/80 (NTIS No. PB83219667/LL), *Guidelines and Specifications for Preparing Quality Assurance Program Plans*, Office of Monitoring Systems and Quality Assurance, September 20, 1980

2.3 Other documents related to the subject matter of this practice are cited in Appendix X2. This list is not intended to be comprehensive.

3. Terminology

3.1 *Definitions*—The terms most applicable to this practice have been defined in Terminologies D 1129 and E 1187.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *background sample*—a sample taken from a location on or proximate to the site of interest and used to document baseline or historical information.

3.2.2 *collocated samples*—independent samples collected as close as possible to the same point in space and time and intended to be identical.

3.2.3 *data quality objectives* (DQOs)—statements on the level of uncertainty that a decision maker is willing to accept in the results derived from environmental data (see EPA/QAMS, July 16, 1986).

3.2.4 *environmental data generation activity*—tasks associated with the production of environmental data, including planning, sampling, and analysis.

3.2.5 *equipment rinsate (equipment blank)*—a sample of analyte-free media that has been used to rinse the sampling equipment. This blank is collected after the completion of decontamination and prior to sampling and is useful for documenting the adequate decontamination of sampling equipment.

3.2.6 *field blank*—a sample of analyte-free media similar

---

[1] This practice is under the jurisdiction of ASTM Committee D-34 on Waste Management and is the direct responsibility of Subcommittee D34.02 on Physical and Chemical Characterization.

Current edition approved Aug. 15, 1992. Published February 1993.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from Superintendent of Documents, Government Printing Office, Washington, DC 20402.

BEST AVAILABLE COPY

196

to the sample matrix that is transferred from one vessel to another or exposed to the sampling environment at the sampling site. This blank is preserved and processed in the same manner as the associated samples and is used to document contamination in the sampling and analysis process.

3.2.7 *field duplicates*—collocated samples that are analyzed independently and are useful in documenting the precision of the sampling and analytical process.

3.2.8 *laboratory control sample*—a known matrix spiked with compound(s) representative of the target analytes and used to document laboratory performance.

3.2.9 *material blank*—a sample composed of construction materials such as those used in well installation, well development, pump and flow testing, and slurry wall construction. Examples of these materials are bentonite, sand, drilling fluids, and source and purge water. This blank documents the contamination resulting from use of the construction materials.

3.2.10 *matrix duplicate*—an intralaboratory split sample used to document the precision of a procedure in a given sample matrix.

3.2.11 *matrix spike*—an aliquot of sample spiked with a known concentration of target analyte(s) and used to document the bias of an analytical process in a given sample matrix. The spiking occurs prior to sample preparation and analysis.

3.2.12 *matrix spike duplicates*—intralaboratory split samples spiked with identical concentrations of target analyte(s) and used to document the precision and bias of a procedure in a given sample matrix. The spiking occurs prior to sample preparation and analysis.

3.2.13 *method blank*—an analyte-free media, to which all reagents are added in the same volumes or proportions used in sample processing. The method blank must be carried through the complete sample preparation and analytical procedure and is used to document contamination resulting from the analytical process.

3.2.14 *project*—single or multiple data collection activities that are related through the same planning sequence.

3.2.15 *project planning documents*—all documents related to the definition of the environmental data collection activities associated with a project.

3.2.16 *quality assurance program plan (QAPP)*—an orderly assemblage of management policies, objectives, principles, and general procedures by which an organization involved in environmental data generation activities outlines how it intends to produce data of known quality.

3.2.17 *quality assurance project plan (QAPjP)*—an orderly assemblage of detailed procedures designed to produce data of sufficient quality to meet the DQOs for a specific data collection activity.

3.2.18 *reference material*—a material containing known quantities of target analytes in either solution or a homogeneous matrix and used to document the bias of the analytical process.

3.2.19 *split samples*—aliquots of sample taken from the same container and analyzed independently. These are usually taken after mixing or compositing and are used to document intra- or interlaboratory precision.

3.2.20 *standard addition*—the practice of adding a known amount of an analyte to a sample immediately prior to analysis, typically used to evaluate matrix effects.

3.2.21 *standard operating procedures (SOPs)*—the established written procedures of a given organization. Special project plans may require procedures different from the established SOPs.

3.2.22 *surrogate*—an organic compound that is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but is not normally found in environmental samples.

3.2.23 *trip blank*—a sample of analyte-free media taken from the laboratory (or appropriate point of origin) to the sampling site and returned to the laboratory unopened. A trip blank is used to document the contamination attributable to shipping and field handling procedures and is also useful in documenting the contamination of volatile organics samples.

4. Summary of Practice

4.1 This practice describes the criteria and activities for field and laboratory organizations involved in generating environmental data in terms of human and physical resources, QA and QC procedures, and documentation requirements depending on the DQOs.

5. Significance and Use

5.1 Environmental data are often required for making regulatory and programmatic decisions. These data must be of known quality commensurate with their intended use.

5.2 Data generation efforts involve the following: establishment of the DQOs; design of the project plan to meet the DQOs; implementation of the project plan; and assessment of the data to determine whether the DQOs have been met.

5.3 Certain minimal criteria must be met by the field and laboratory organizations generating environmental data. Additional activities may be required based on the DQOs of the data collection effort.

5.4 This practice defines the criteria for field and laboratory organizations generating environmental data and identifies some other activities that may be required based on the DQOs.

5.5 This practice emphasizes the importance of communication among those involved in establishing DQOs, planning and implementing the sampling and analysis aspects of environmental data generation activities, and assessing data quality.

5.6 Environmental field operations are discussed in Section 7, and environmental laboratory operations are discussed in Section 8.

6. Project Specification

6.1 Project activities should be defined prior to the start of any field or laboratory activities. At a minimum, project specifications should address the following topics:

6.2 *Data Quality Objectives*—DQOs for the data generation activity should be defined prior to the initiation of field and laboratory work. It is desirable that the field and laboratory organizations be aware of the DQOs so that the personnel conducting the work are able to make informed decisions during the course of the project.

6.3 *Project Plan*—The project should be designed to meet

the DQOs, and the project plan should define the following:

6.3.1 *Project Objectives*—Project objectives provide background information, state reasons for the data collection effort, identify any regulatory programs governing data collection, define specific objectives for each sampling location, and describe the intended uses for the data.

6.3.2 *Project Management*—A person(s) shall be designated as having responsibility and authority for the following: (*1*) developing project documents that implement the DQOs; (*2*) selecting field and laboratory organizations to conduct the work; (*3*) coordinating communication among the field and laboratory organizations and government agencies, as required; and (*4*) reviewing and assessing the final data.

6.3.3 *Sampling Requirements*—Sampling locations, equipment, and procedures and sample preservation and handling requirements shall be specified.

6.3.4 *Analytical Requirements*—The analytical procedures, analyte list, required detection limits, and required precision and bias values shall be specified. Regulatory requirements and DQOs shall be considered when developing the specifications.

NOTE 2—This does not imply that the specified analytical requirements can be met.

6.3.5 *Quality Assurance and Quality Control Requirements*—The QA and QC requirements shall address both field and laboratory activities. The means for controlling false positives and false negatives shall be specified. Standard practices for field and laboratory operations as described in Sections 7 and 8 of this practice shall be required.

6.3.5.1 *Field Quality Control*—The types and frequency of field QC samples to be collected, including field blanks, trip blanks, equipment rinsates, field duplicates, background samples, reference materials, material blanks, and split samples, shall be specified. Control parameters for field activities shall also be described (see 7.6.4).

6.3.5.2 *Laboratory Quality Control*—The types and frequency of use of laboratory QC samples, such as laboratory control samples, laboratory blanks, matrix spikes, matrix duplicates, and matrix spike duplicates, shall be specified. Any specific performance criteria shall be specified. Data validation criteria shall be defined.

6.4 *Project Documentation*—All documents required for planning, implementing, and evaluating the data collection effort shall be specified. These may include, although not limited to, a statement of work, technical and cost proposals, work plan, sampling and analysis plan, quality assurance project plan (QAPjP), health and safety plan, community relations plan, documents required by regulatory agencies, requirements for raw field and analytical records, technical reports assessing the environmental data, and records retention policy. Planning documents shall specify the required level of document control and identify the personnel having access. Document formats that may be required to ensure that all data needs are satisfied shall be specified. In addition, a project schedule that identifies critical milestones and completion dates should be available.

7. Standard Practices for Environmental Field Operations

7.1 *Purpose*—The field organization must conduct its operations in such a manner as to provide reliable information that meets the DQOs. To achieve this goal, certain minimum policies and procedures must be implemented in order to meet the DQOs.

7.2 *Organization*—The field organization shall be structured such that each member of the organization has a clear understanding of his or her duties and responsibilities and the relationship of those responsibilities to the total effort. The organizational structure, functional responsibilities, levels of authority, job descriptions, and lines of communication for activities shall be established and documented. One person may cover more than one organizational function.

7.2.1 *Management*—The management of the field organization is responsible for establishing organizational, operational, health and safety, and QA policies. Management shall ensure that the following requirements are met: (*1*) the appropriate methodologies are followed, as documented in the standard operating procedures (SOPs); (*2*) personnel clearly understand their duties and responsibilities; (*3*) each staff member has access to appropriate project documents; (*4*) any deviations from the project plan are communicated to project management; and (*5*) communication occurs between the field, laboratory, and project management, as specified in the project plan. Management shall foster an attitude within the organization that emphasizes the importance of quality and supports implementation of the quality assurance program plan (QAPP).

7.2.2 *Quality Assurance Function*—The organization shall appoint a person or persons to be responsible for monitoring field operations in order to ensure that the site facilities, equipment, personnel, procedures, practices, and documentation are in conformance with the organization's QAPP and any applicable QAPjP. The QA monitoring function should be entirely separate from, and independent of, personnel engaged in the work being monitored. The QA function shall be responsible for the QA review, as per 7.7.

7.2.3 *Personnel*—It is the responsibility of the organization to establish personnel qualifications and training requirements for all positions. Each member of the organization shall possess the education, training, technical knowledge, and experience, or a combination thereof, to enable that individual to perform his or her assigned functions. Personnel qualifications shall be documented in terms of education, experience, and training. Training shall be provided for all staff members, as necessary, so that they can perform their functions properly.

7.2.4 *Subcontractors*—The use of subcontractors shall not jeopardize data quality. Therefore, subcontractors shall comply with the requirements of Sections 7 and 8, as appropriate to the specific task(s) they are performing.

7.3 *Field Logistics:*

7.3.1 *General*—Sampling site facilities shall be examined prior to the start of work in order to ensure that all required items are available. The actual sampling area shall be examined to ensure that trucks, drilling equipment, and personnel have access to the site. Security, health and safety, and protection of the environment shall be controlled at the site support areas and sampling site.

7.3.2 *Field Measurements*—Project planning documents shall both address the type of field measurements to be performed and plan for the appropriate area to perform the

198

work. Planning documents shall address ventilation, protection from extreme weather and temperatures, access to stable power, and provisions for water and gases of required purity. Plans shall be made to identify and supply applicable safety equipment, as specified in the project health and safety plan.

7.3.3 *Sample Handling, Shipping, and Storage Area*—The determination of whether sample shipping is necessary shall be made during project planning. This need is established by evaluating the analyses required, holding times, and location of the site and laboratory. Shipping or transporting of the samples to a laboratory shall be completed in a timely manner, ensuring that the laboratory is allowed sufficient time to perform its analysis within any required holding times.

7.3.3.1 Samples shall be packaged, labeled, and documented in an area that minimizes sample contamination and provides for safe storage. The level of custody and whether sample storage is required shall be outlined in the planning documents.

7.3.4 *Chemical Storage*—Safe storage areas for solvents, reagents, standards, and reference materials shall be adequate to preserve their identity, concentration, purity, and stability prior to use.

7.3.5 *Decontamination*—Decontamination of sampling equipment may be performed at the location at which sampling occurs, prior to transfer to the sampling site, or in designated areas near the sampling site. Project documentation shall specify where this work will be performed and how it will be accomplished. If decontamination is to be conducted at the site, water and solvents of appropriate purity shall be available. The method of accomplishing decontamination and the materials, solvents, and water purity shall be specified in planning documents or standard operating procedures (SOPs).

7.3.6 *Waste Storage Area*—Waste materials may be generated during both the sampling process and on-site or *in situ* analysis. Planning documents and SOPs shall outline the method for storage and disposal of these waste materials. Adequate facilities shall be provided for the collection and storage of all wastes. These facilities shall be operated so as to minimize environmental contamination. Waste storage and disposal facilities shall comply with applicable federal, state, and local regulations.

7.3.7 *Data Storage Area*—Planning documents shall specify the location of long- and short-term storage for field records. The storage environment shall be maintained to ensure the integrity of the data. Access shall be limited to authorized personnel only.

7.4 *Equipment and Instrumentation:*

7.4.1 *Equipment and Instrumentation*—The equipment, instrumentation, and supplies required at the sampling site shall be appropriate to accomplish the activities planned. The equipment and instrumentation shall meet the requirements of pertinent specifications, methods, and SOPs. Before the field staff arrives at the site, a list of required items shall be prepared and checked to ensure availability at the site.

7.4.2 *Maintenance and Calibration of Equipment and Instrumentation*—An SOP or operation and maintenance manual shall set forth the methods, materials, and schedules to be used in the routine inspection, cleaning, maintenance, testing, and calibration of the equipment and instrumentation used in performing geophysical, analytical, or *in situ* measurements. For common malfunctions, procedures or manuals may outline typical problems, methods of trouble-shooting, and possible corrective actions to be taken. Procedures shall designate a person(s) or organizations responsible for maintenance and calibration. Records of all inspections, maintenance, repairs, testing, and calibration shall be maintained.

7.5 *Standard Operating Procedures*—The organization shall have written SOPs for all procedures performed routinely that affect data quality. SOPs shall be available for the following areas and shall contain the information described:

7.5.1 *Sample Management*—These SOPs describe the numbering and labeling system, chain-of-custody procedures, and tracking of samples from collection to shipment or relinquishment to the laboratory. Sample management also includes the specification of holding times, volume of sample required by the laboratory, preservatives, and shipping requirements.

7.5.2 *Reagent and Standard Preparation*—These SOPs describe the procedures used to prepare standards and reagents. Information should be included concerning the specific grades of materials used in reagent and standard preparation, appropriate glassware and containers for preparation and storage, labeling and record keeping for stocks and dilutions, and safety precautions to be taken.

7.5.3 *Decontamination*—These SOPs describe the procedures used to clean field equipment before and during the sample collection process. The SOPs should include the cleaning materials used, the order of washing and rinsing with the cleaning materials, requirements for protecting or covering cleaned equipment, procedures for disposing of cleaning materials, and safety considerations.

7.5.4 *Sample Collection Procedures*—SOPs for sample collection procedures shall describe how the procedures are actually performed in the field and shall not be a simple reference to standard test methods, unless a procedure is performed exactly as described in the published test method. If possible, industry-recognized test methods from source documents published by the U.S. Environmental Protection Agency, ASTM, U.S. Department of the Interior, National Water Well Association, American Petroleum Institute, or other recognized organizations should be used. The SOP for sample collection procedures should include the following information:

7.5.4.1 Applicability of the procedure,

7.5.4.2 Equipment and reagents required,

7.5.4.3 Detailed description of the procedures to be followed in collecting the samples,

7.5.4.4 Common problems encountered,

7.5.4.5 Precautions to be taken, and

7.5.4.6 Health and safety considerations.

7.5.5 *Equipment Calibration and Maintenance*—These SOPs describe the procedures used to ensure that field equipment and instrumentation are in working order. The SOPs describe calibration and maintenance procedures and schedules, maintenance logs, service contracts or service arrangements for equipment, and spare parts available in-house. The calibration and maintenance of field equipment and instrumentation should generally be in accordance with manufacturers' specifications and shall be documented.

7.5.6 *Field Measurements*—These SOPs describe all

199

methods used in the field to determine a chemical or physical parameter. The SOPs shall address criteria from section 8, as appropriate.

7.5.7 *Corrective Action*—These SOPs describe procedures used to identify and correct deficiencies in the sample collection process. These should include specific steps to take in correcting deficiencies, such as performing additional decontamination of equipment, resampling, or additional training of field personnel in methods procedures. The SOP shall specify that each corrective action must be documented with a description of the deficiency, the corrective action taken, and the person(s) responsible for implementing the corrective action.

7.5.8 *Data Reduction and Validation*—These SOPs describe procedures used to compute the results from field measurements and to review and validate these data. They should include all formulas used to calculate the results and procedures used to verify independently that the field measurement results are correct.

7.5.9 *Reporting*—These SOPs describe the process for reporting the results of field activities.

7.5.10 *Records Management*—These SOPs describe the procedures for generating, controlling, and archiving field records. The SOPs should describe the responsibilities for record generation and control and the policies for record retention, including type, time, security, and retrieval and disposal authorities. Records should include project-specific and field operations records.

7.5.10.1 Project-specific records relate to field work performed for a group of samples. Project records may include correspondence, chain-of-custody, field notes, all reports issued as a result of the work, project planning documents, and procedural SOPs used.

7.5.10.2 Field operations records document overall field operations. These records may include equipment performance and maintenance logs, personnel files, general field SOPs, and corrective action reports.

7.5.11 *Waste Disposal*—These SOPs describe policies and procedures for the disposal of waste materials resulting from field operations. The disposal of all wastes must conform to federal, state, and local regulations, including those associated with the Resource Conservation and Recovery Act, Superfund Act Reauthorization and Amendments, Department of Transportation, and Occupational Safety and Health Administration.

7.5.12 *Health and Safety*—These SOPs describe policies and procedures designed both to provide a safe and healthy working environment for field personnel and to comply with federal and state regulations.

7.6 *Field Quality Assurance and Quality Control Requirements:*

7.6.1 *Quality Assurance Program Plan*—The field organization shall have a written QAPP that describes the organization's QA policy. The plan shall specify the responsibilities of the field management and field staff and the QA function in the areas of QA and QC, and it shall also describe the QC procedures followed by the organization (see EPA QAMS-004/80 for an example).

7.6.2 *Quality Assurance Project Plan*—Some projects, particularly those that are large or complex, require a QAPjP. The QAPjP details the QA and QC goals and protocol for a specific data collection activity to ensure that the data generated by sampling and analysis activities are of quality commensurate with their intended use. QAPjP elements should include a discussion of the quality objectives of the project, identification of those involved in the data collection and their responsibilities and authorities, enumeration of the QC procedures to be followed, and reference to the specific SOPs that will be followed for all aspects of the project. Elements may be added or removed, as required by the project or the end-user of the data (see EPA QAMS-005/80 for an example).

7.6.3 *Control Samples*—Control samples are QC samples that are introduced into a process to monitor the performance of the system. Control samples, which may include blanks, duplicates, spikes, analytical standards, and reference materials, can be used in different phases of the overall process, beginning with sampling and continuing through transportation, storage, and analysis. The types of control samples used, and the frequency of usage, are dependent on the DQOs of the data collection effort and must be specified for each project.

7.6.4 *Procedures for Establishing Acceptance Criteria*—Procedures shall be in place for establishing acceptance criteria for field activities, as required in the project planning documents. Acceptance criteria may be qualitative or quantitative. Field events or data that fall outside of the established acceptance criteria may indicate a problem with the sampling process that must be investigated.

7.6.5 *Deviations*—Any activity not performed in accordance with the SOPs or project planning documents is considered a deviation from the plan. Deviations from the plan may or may not affect data quality. All deviations from the plan shall be documented as to the extent of, and reason for, the deviation.

7.6.6 *Corrective Action*—Errors, deficiencies, deviations, or field events or data that fall outside the established acceptance criteria require investigation. Corrective action may be necessary to resolve the problem and restore proper functioning to the system in some instances. Investigation of the problem and any subsequent corrective action taken shall be documented.

7.6.7 *Data Handling Procedures:*

7.6.7.1 *Data Reduction*—All field measurement data are reduced according to protocol described in the appropriate SOP. Computer programs used for data reduction shall be validated before use and verified on a regular basis. All information used in the calculations shall be recorded to enable reconstruction of the final result at a later date.

7.6.7.2 *Data Review*—All data are reviewed according to SOPs to ensure that the calculations are correct and to detect transcription errors. Spot checks are performed on computer calculations to verify program validity.

7.6.7.3 *Data Reporting*—Data are reported in accordance with the requirements of the end-user.

7.7 *Quality Assurance Review:*

7.7.1 *General*—The QA review consists of internal and external assessments to ensure that both QA and QC procedures are in use and field staff conform to these procedures. Planning documents shall specify the requirements for internal, external, and on-site assessment. These

200

documents shall specify the frequency and documentation of these assessments.

7.7.1.1 *Internal Assessment*—Personnel responsible for performing field activities are responsible for continually monitoring individual compliance with the QA and QC programs and planning documents. A QA officer or an appropriate management designee shall review the field results and findings for compliance with the QA and QC programs and planning documents. The results of this internal assessment should be reported to management with requirements for a plan to correct the observed deficiencies.

7.7.1.2 *External Assessment*—The field staff may be reviewed by personnel external to the organization. The results of the external assessment should be submitted to management with requirements for a plan to correct the observed deficiencies.

7.7.1.3 *On-Site Evaluation*—On-site evaluations may be conducted as part of both internal and external assessments. On-site evaluations may include, but are not limited to, a complete review of the facilities, staff, training, instrumentation, SOPs, methods, field analysis, sample collection, QA and QC policies, and procedures related to the generation of environmental data. Records of each evaluation shall be maintained until superseded or according to policy. These records should include the date of the evaluation, area or site, areas reviewed, person performing the evaluation, findings and problems, actions recommended and taken to resolve the problems, and scheduled date for re-inspection. Any problems identified that are likely to affect data integrity shall be brought to the attention of management immediately.

7.7.2 *Evaluation of Field Records*—The review of field records shall be conducted by one or more persons knowledgeable in the field activities, evaluating the following subjects at a minimum:

7.7.2.1 *Completeness of Field Reports*—This review ensures that all requirements for field activities in the planning documents have been fulfilled, that complete records exist for each field activity, and that the procedures specified in the planning documents have been implemented. The emphasis on field documentation will help assure sample integrity and sufficient technical information to recreate each field event. The results of this completeness check shall be documented, and environmental data affected by incomplete records shall be identified.

7.7.2.2 *Identification of Invalid Samples*—This review involves interpretation and evaluation of the field records to detect problems affecting the representativeness of environmental samples. Examples of items that could indicate invalid samples include improper well development, improperly screened wells, instability of pH or conductivity, and collection of volatiles near combustion engines. The field records shall be evaluated against planning documents and SOPs. The reviewer shall document the sample validity and identify the environmental data associated with poor or incorrect field work.

7.7.2.3 *Correlation of Field Test Data*—The results of field measurements obtained by more than one method shall be compared. For example, surface geophysics may be surveyed using both ground penetrating radar and a resistivity survey.

7.7.2.4 *Identification of Anomalous Field Test Data*—Anomalous field test data should be identified. For example, a water temperature for one well that is five degrees higher than any other well temperature in the same aquifer should be noted. The impact of anomalous field measurement results on the associated environmental data shall be evaluated.

7.7.2.5 *Validation of Field Analysis*—All data from field analysis that are generated *in situ* or from a mobile laboratory shall be validated per 8.7.2. The results of the validation shall be reported. The report shall discuss whether the QC checks meet the acceptance criteria and whether corrective actions were taken for any analysis performed when acceptance criteria were not met.

7.7.3 *Quality Assurance Reports to Management*—The QA program shall provide for the periodic reporting of pertinent QA and QC information to management to allow assessment of the overall effectiveness of the QA program. There are three major types of QA reports to management:

7.7.3.1 *Report on Measurement Quality Indicators*—This report shall include the assessment of QC data (such as that generated per 7.6.3) gathered over the period, the frequency of repeating work due to unacceptable performance, and corrective action taken.

7.7.3.2 *Report on Quality Assurance Assessments*—This report shall be submitted immediately following any internal or external on-site evaluations or upon receipt of the results of any performance evaluation studies. The report shall include the results of the assessment and the plan for correcting identified deficiencies.

7.7.3.3 *Report on Key Quality Assurance Activities During the Period*—A report shall be delivered to management summarizing key QA activities during the period. The report shall stress measures that are being taken to improve data quality and shall include a summary of the significant quality problems observed and corrective actions taken. The report shall also include a summary of involvements in resolution of quality issues with clients or agencies, QA organizational changes, and notice of the distribution of any revised documents controlled by the QA function.

7.8 *Field Records*—Records provide direct evidence and support for the necessary technical interpretations, judgments, and discussions concerning project activities. These records, particularly those that are anticipated for use as evidentiary data, must directly support current or ongoing technical studies and activities and must provide the historical evidence necessary for later reviews and analyses. Records shall be legible, identifiable, and retrievable and protected from damage, deterioration, or loss. Field records generally consist of bound field notebooks with prenumbered pages, sample collection forms, personnel qualification and training forms, sample location maps, equipment maintenance and calibration forms, chain-of-custody forms, sample analysis request forms, and field change request forms. All records shall be completed with black, waterproof ink. Procedures for reviewing, approving, and revising field records must be defined clearly, with the lines of authority included. At a minimum, all documentation errors shall be corrected by drawing a single line through the error and initialing by the responsible individual, along with the date of change. The correction is written adjacent to the error.

701

Deviations from field SOPs shall be documented.

7.8.1 *Personnel Training and Qualification Records*—It is the responsibility of the organization to establish personnel qualifications and training requirements. Each staff member shall possess the education, training, technical knowledge, and experience, or a combination thereof, to enable that individual to perform his or her assigned functions. Personnel qualifications shall be documented in terms of education, experience, and training. Training shall be provided for all staff members so that they can perform their functions properly.

7.8.2 *Standard Operating Procedures*—SOPs shall be available to those performing the task outlined. Any revisions to field SOPs shall be written and distributed to all affected individuals to ensure the implementation of changes. The areas covered by SOPs are given in 7.5.

7.8.3 *Quality Assurance Plans*—The QAPP and all applicable QAPjPs shall be on file.

7.8.4 *Equipment Maintenance*—Maintenance procedures shall be defined clearly and written for each measurement system and required support equipment. When maintenance is necessary, it shall be documented in either standard forms or in logbooks. A history of the maintenance record of each system serves as an indication of the adequacy of maintenance schedules and parts inventory.

7.8.5 *Calibration and Traceability of Standards and Reagents*—Calibration is a reproducible reference base to which all sample measurements can be correlated. A sound calibration program shall include provisions for documentation of the frequency, conditions, standards, and records reflecting the calibration history of a measurement system. The accuracy of calibration standards is an important point to consider because all data will be in reference to the standards used. A program for verifying and documenting the accuracy of all working standards against primary grade standards shall be followed routinely.

7.8.6 *Sample Collection and Tracking Records*—To ensure maximum utility of the sampling effort and resulting data, documentation of the sampling protocol, as performed in the field, is essential. At a minimum, sample collection records shall contain the persons conducting the activity, sample number, sample location, equipment used, climatic conditions, documentation of adherence to protocol, and unusual observations. The actual sample collection record is usually one of the following: a bound field notebook with prenumbered pages, a pre-printed form, or digitized information on a computer tape or disc.

7.8.6.1 Sample tracking records involving the possession of samples from the time at which they are obtained until they are relinquished shall be documented with the following minimum information: (*1*) project name; (*2*) signatures of the samplers; (*3*) sample number, date and time of collection, and grab or composite sample designation; (*4*) signatures of the individuals involved in sample transfer; and (*5*) the air bill or other shipping number, if applicable.

7.8.7 *Maps and Drawings*—Project planning documents and reports often contain maps. The maps are used to document the location of sample collection points and monitoring wells, and as a means of presenting environmental data. Information used to prepare maps and drawings is normally obtained through field surveys, property surveys, surveys of monitoring wells, aerial photography, or photogrammetric mapping. The final, approved maps shall have a revision number and date and shall be subject to the same controls as other project records.

7.8.8 *Results from Control Samples*—Documentation for the collection of QC samples, such as field, trip, and equipment rinsate blanks, duplicate samples, spikes, and reference materials, shall be maintained.

7.8.9 *Correspondence*—Project correspondence can provide evidence supporting technical interpretations. Correspondence pertinent to the project shall be kept and placed in the project files.

7.8.10 *Deviations*—Field changes and deviations from the planning documents shall be reviewed and approved by either the authorized personnel who performed the original technical review or their designees. All deviations from the procedural and planning documents shall be recorded in the site log.

7.8.11 *Final Report*—The final report shall summarize the field activities, data, results of deviations from the planning documents, and interpretation of the data. The planning documents shall outline the items to be included in the report, which may include any special formats required, QC reporting requirements, conclusions, and recommendations.

7.9 *Documentation Storage:*

7.9.1 *Documentation Archive*—Procedures shall be established to ensure that documents required to recreate the sampling, analysis, and reporting of information are stored. These documents may include, but are not limited to, planning documents, SOPs, logbooks, field data records, sample tags and labels, chain-of-custody records, photographs, and any other information noted in 7.8.

7.9.2 *Storage Time*—The length of storage time for field records shall comply with regulatory requirements, organizational policy, or project requirements, whichever is/are more stringent.

7.9.3 *Filing System*—The control of records is essential in providing evidence of technical adequacy and quality for all project activities. These records shall be identified, retrievable, and organized to prevent loss.

7.9.4 *Personnel Authorized to Enter Archive*—Access to project files shall be controlled to restrict unauthorized personnel from having free and open access. An authorized access list shall be prepared for the project files and shall name the personnel who have unrestricted access to the files.

8. Standard Practices for Environmental Laboratory Operations

8.1 *Purpose*—Each laboratory must conduct its operations in such a way as to provide reliable information. To achieve this goal, certain minimum policies and procedures must be implemented.

8.2 *Organization*—The laboratory shall be structured such that each member of the organization has a clear understanding of his or her duties and responsibilities and the relationship of those responsibilities to the total effort. The organizational structure, functional responsibilities, levels of authority, job descriptions, and lines of communication for activities shall be established and documented. The laboratory shall also maintain a current list of accredi-

BEST AVAILABLE COPY

202

tations from government agencies or private associations.

8.2.1 *Management*—The management of the laboratory is responsible for establishing organizational, operational, health and safety, and QA policies. These responsibilities include the following: oversight of personnel selection, development, and training; review, selection, and approval of analysis methods; and development, implementation, and maintenance of a QA program. Management shall foster an attitude within the organization that emphasizes the importance of quality and supports implementation of the QAPP.

8.2.2 *Quality Assurance Function*—The laboratory shall appoint a person or persons to be responsible for monitoring laboratory operations to ensure that the facilities, equipment, personnel, methods, practices, and documentation are in conformance with the laboratory QAPP and any applicable QAPjP(s). The QA monitoring function shall be entirely separate from, and independent of, personnel engaged in direct supervision or performance of the work being monitored. The QA function shall inspect records to ensure that analyses have been performed correctly and within the proper time frame; maintain copies of the QAPP and QAPjPs pertaining to all analyses; perform assessments of the laboratory to ensure adherence to the QAPP; periodically submit written status reports to management, noting any problems and the corrective actions taken; ensure that any deviations from the approved QAPP, QAPjP, or SOPs have been authorized and documented properly; and ensure that the results reported reflect the raw data accurately. The responsibilities of the QA function and procedures used in conducting those responsibilities shall be in writing and shall be maintained.

8.2.3 *Personnel*—It is the responsibility of the organization to establish personnel qualifications and training requirements for all positions. Each member of the organization shall possess the education, training, technical knowledge, and experience, or a combination thereof, which enables that individual to perform his or her assigned functions. Personnel qualifications shall be documented in terms of education, experience, and training. Training shall be provided for all staff members, as necessary, so that they can perform their functions properly.

8.2.4 *Subcontractors*—The use of subcontractors shall not jeopardize data quality. Subcontractors shall therefore comply with the requirements of Sections 7 and 8, as appropriate to the specific task(s) they are performing.

8.3 *Facilities:*

8.3.1 *General*—Each laboratory shall be of a size and construction suitable to facilitate proper conduct of the analyses. Adequate bench space or working area per analyst shall be provided. The space requirement per analyst depends on the equipment or apparatus being used, the number of samples the analyst is expected to handle at any one time, and the number of operations to be performed concurrently by a single analyst. The laboratory shall be well-ventilated, adequately lit, free of dust and drafts, protected from extreme temperatures, and offer access to a stable source of power. Laboratories shall be designed so that there is adequate separation of functions in order to ensure that no laboratory activity has an adverse effect on the analyses. The laboratory may require specialized facilities such as a perchloric acid hood or glovebox.

8.3.2 *Sample Handling, Receiving, and Storage Area*—As necessary to ensure safe and secure storage and prevent contamination or misidentification, there shall be adequate facilities for the receipt and storage of samples. The level of custody required and any special requirements for storage, such as refrigeration and lighting, shall be described in the planning documents.

8.3.3 *Chemical Storage*—Storage areas for reagents, solvents, standards, and reference materials shall be adequately safe to preserve their identity, concentration, purity, and stability.

8.3.4 *Laboratory Operations Area*—Separate spaces for laboratory operations and appropriate ancillary support shall be provided, as necessary, for the performance of routine and specialized procedures.

8.3.5 *Waste Storage Area*—Adequate facilities shall be provided for the collection and storage of all wastes, and these facilities shall be operated so as to minimize environmental contamination. Waste storage and disposal facilities shall comply with applicable federal, state, and local regulations.

8.3.6 *Data Storage Area*—Space shall be provided for the storage and retrieval of all documents, as specified in 8.8. The storage environment shall be maintained to assure the integrity of the materials stored. Access shall be limited to authorized personnel only.

8.4 *Equipment and Instrumentation:*

8.4.1 *Equipment and Instrumentation*—Equipment and instrumentation shall meet the requirements and specifications of the specific test methods and other SOPs. The laboratory shall maintain an equipment and instrument description list that includes the manufacturer, model number, year of purchase, accessories, and any modifications, updates, or upgrades that have been made.

8.4.2 *Maintenance and Calibration of Equipment and Instrumentation*—Equipment and instrumentation shall be adequately inspected, cleaned, maintained, tested, and calibrated, as required in the SOP or operations manual. SOPs or manuals shall specify the identification and repair of common maintenance problems. Procedures shall designate a person(s) or organizations responsible for maintenance. Records of all inspections, maintenance, repairs, testing, and calibration shall be maintained.

8.5 *Standard Operating Procedures*—The laboratory should have written SOPs for all laboratory functions that affect data quality. Procedures and methods shall be performed in the laboratory as described in the SOPs. Any modification of an SOP made during a data collection activity must be documented. SOPs shall be available for the following areas and shall, at a minimum, contain the information described:

8.5.1 *Sample Management*—These SOPs describe the receipt, handling, and storage of samples.

8.5.1.1 *Sample Receipt and Handling*—These SOPs describe precautions to be used in opening sample shipment containers, as well as procedures used to perform the following tasks: verify that chain-of-custody has been maintained, examine samples for damage, check for proper preservatives and temperature, assign the testing program, and log samples into the laboratory sample streams.

8.5.1.2 *Sample Scheduling*—These SOPs describe proce-

203

dures and criteria used for scheduling work in the laboratory, including procedures used to ensure that holding time requirements are met.

8.5.1.3 *Sample Storage*—These SOPs describe the storage conditions for all samples and procedures used both to verify and document daily storage temperature, and to ensure that custody of the samples is maintained while in the laboratory.

8.5.2 *Reagent and Standard Preparation*—These SOPs detail procedures used to prepare standards and reagent mixtures. In addition, these SOPs shall specify requirements concerning the following: purity of materials used, including water; appropriate glassware and containers; record keeping and labeling, including dating; procedures used to verify concentration, purity, and stability; and safety precautions necessary to meet the requirements of the DQOs or test methods.

8.5.3 *General Laboratory Techniques*—These SOPs detail all of the essentials of laboratory operations not addressed in other SOPs. These techniques include, but are not limited to, glassware cleaning procedures, operation of analytical balances, pipetting techniques, and use of volumetric glassware.

8.5.4 *Analytical Methods*—SOPs for analytical methods for sample analysis shall be a description of how the analysis is actually performed in the laboratory and not a simple reference to standard test methods, unless the analysis is performed exactly as described in the published test method. If possible, industry-recognized test methods from source documents published by the U.S. Environmental Protection Agency, American Public Health Association, ASTM, the National Institute for Occupational Safety and Health, or other recognized organizations should be used. The SOP for analytical methods should include the following:

8.5.4.1 Sample preparation and analysis procedures, including the applicable holding time, extraction, digestion, or preparation steps, as appropriate to the method; procedures for determining the appropriate dilution to analyze; and any other information required to perform the analysis accurately and consistently.

8.5.4.2 Instrument standardization, including the concentration and frequency of analysis of calibration standards, linear range of the method, and calibration acceptance criteria.

8.5.4.3 Raw data recording requirements and documentation, including the sample identification number, analyst, data verification analyst, date of analysis and verification, and computational method(s).

8.5.4.4 Detection and reporting limits for all analytes in the method.

8.5.4.5 Reference to the applicable QC SOPs and any specific exceptions or additions.

8.5.5 *Equipment Calibration and Maintenance*—These SOPs describe procedures used to assure or verify that the laboratory equipment and instrumentation are in working order. The SOPs describe calibration and maintenance procedures and schedules, maintenance logs, service contracts or service arrangements for all equipment, and spare parts available in-house. Calibration and maintenance of the laboratory equipment and instrumentation shall be in accordance with manufacturers' specifications and shall be documented.

8.5.6 *Quality Control Data*—These SOPs detail the type, purpose, and frequency of QC samples analyzed in the laboratory and establish acceptance criteria. They should include information on applicability of the QC sample to the analytical process, statistical treatment of the data, and responsibility of laboratory staff and management in generating and using the data.

8.5.7 *Corrective Action*—These SOPs describe procedures used to identify and correct deficiencies in the analytical process. These include specific steps to take in correcting deficiencies, such as the preparation of new standards and reagents, recalibration and restandardization of equipment, reanalysis of samples, or additional training of laboratory personnel in methods and procedures. The SOP shall specify that each corrective action must be documented with a description of the deficiency, corrective action taken, and person(s) responsible for implementing the corrective action.

8.5.8 *Data Reduction and Validation*—These SOPs describe the procedures used to review and validate the data. They should include procedures for computing and interpreting the results from QC samples and procedures used to verify independently that the analytical results are correct. In addition, routine procedures used to monitor precision and bias, including evaluations of reagent, field, and trip blanks, calibration standards, control samples, duplicate and matrix spike samples, and surrogate recovery should be detailed in an SOP.

8.5.9 *Reporting*—These SOPs describe the process for reporting the analytical results.

8.5.10 *Records Management*—These SOPs describe the procedures for generating, controlling, and archiving laboratory records. The SOPs should detail the responsibilities for record generation and control and the policies for record retention, including type, time, security, and retrieval and disposal authorities. Records shall include project-specific and laboratory operations records.

8.5.10.1 Project-specific records related to analyses performed for a group of samples shall be maintained. These records may include an index of documents, correspondence, chain-of-custody records, request for analysis, calibration records, raw and finished analytical and QC data, data reports, and project planning documents.

8.5.10.2 Laboratory operations records, which document the overall laboratory operation, shall be maintained. These records may include the following: laboratory notebooks, instrument performance and maintenance logs in bound notebooks with prenumbered pages; laboratory benchsheets; software documentation; control charts; reference material certification; personnel files; laboratory SOPs; and corrective action reports.

8.5.11 *Waste Disposal*—These SOPs describe policies and procedures for the disposal of chemicals, including standard and reagent solutions, process waste, and samples. The disposal of these materials shall conform to federal, state, and local regulations, including those associated with the Resource Conservation and Recovery Act, Superfund Act Reauthorization and Amendments, Department of Transportation, and Occupational Safety and Health Administration.

8.5.12 *Health and Safety*—These SOPs describe policies and procedures designed both to provide a safe and healthy

BEST AVAILABLE COPY

BEST AVAILABLE COPY

working environment for laboratory staff and to comply with federal and state regulations.

8.6 *Laboratory Quality Assurance and Quality Control Procedures:*

8.6.1 *Quality Assurance Program Plan*—The laboratory shall have a written QAPP that describes the organization's QA policy. The plan shall specify the responsibilities of the laboratory staff and management and the QA function in the areas of QA and QC and describe the QC procedures followed by the laboratory, including the following: (*1*) use of control samples; (*2*) statistical and mathematical basis for assigning warning and rejection limits; (*3*) detection of shifts, trends, or biases; (*4*) how an out-of-control condition is detected; (*5*) how control is re-established; (*6*) how out-of-control events and corrective actions are documented; (*7*) how reporting limits are established, including their dependence on serial dilutions and sample size; (*8*) how instrument calibration and maintenance logs, corrective action reports, and routine QC data summaries are maintained; and (*9*) QA assessment procedures used (see EPA QAMS-004/80 for an example).

8.6.2 *Quality Assurance Project Plan*—Some projects, particularly those that are large or complex, require a QAPjP. The QAPjP details the QA and QC goals and protocol for a specific data collection activity in order to ensure that the data generated by sampling and analysis activities are of quality commensurate with their intended use. QAPjP elements should include a discussion of the quality objectives of the project, identification of those involved in data collection and their responsibilities and authorities, enumeration of QC procedures to be followed, and reference to the specific SOPs that will be followed for all aspects of the project. Elements may be added or removed, as required by the project or the end-user of the data (see EPA QAMS-005/80 for an example).

8.6.3 *Method Proficiency*—The laboratory shall have procedures for demonstrating proficiency with each analytical method used in the laboratory. These shall include procedures for demonstrating the precision and bias of the method as performed by the laboratory and procedures for determining the method detection limit (MDL). All terminology, procedures, and frequency of determinations associated with the laboratory's establishment of one MDL and the reporting limit shall be well-defined and well-documented. Documented precision, bias, and MDL information shall be maintained for all methods performed in the laboratory.

8.6.4 *Laboratory Control Procedures*—The laboratory shall have procedures for demonstrating that it is in control within laboratory established limits or project specified limits during each data collection activity.

8.6.4.1 *Laboratory Control Samples*—The laboratory shall analyze control samples for each analytical method. A laboratory control sample consists of a control matrix spiked with analytes representative of the target analytes. Laboratory control sample(s) shall be analyzed with each batch of samples processed in order to verify the precision and bias of the analytical process. The results of the laboratory control sample(s) are compared to the control limits established for both precision and bias to determine the usability of the data (see 8.6.6). Analytical data generated with laboratory control samples that fall within the prescribed limits are judged to be generated while the laboratory was in control. Data generated with laboratory control samples that fall outside of the established control limits are judged to be generated during an "out of control" situation. These data are considered suspect and must be repeated or reported with qualifiers.

8.6.4.2 *Method Blank*—To assess contamination levels in the laboratory, a method blank shall be run with each batch of samples processed, unless it is not appropriate for the method. The laboratory shall have guidelines in place for accepting or rejecting data based on the level of blank contamination.

8.6.5 *Determination of Matrix Effects*—The laboratory shall have procedures for documenting the effect of the matrix on method performance. The type of matrix-specific information required for a specific data collection activity is dependent on the DQOs of the activity.

8.6.5.1 *Matrix Spikes*—Procedures shall be in place for determining the bias of the method in the matrix unless not appropriate for the method. These procedures should include the analysis of matrix spikes, use of surrogates for organic methods, and method of standard additions for metal and inorganic methods. The frequency of use of these techniques shall be based on the DQOs of the data collection activity.

8.6.5.2 *Matrix Duplicates and Matrix Spike Duplicates*—Procedures shall be in place for determining the precision of the method in the matrix. These procedures should include the analysis of matrix duplicates or matrix spike duplicates, or both. The frequency of use of these techniques shall be based on the DQOs of the data collection activity.

8.6.5.3 *Sample-Specific Detection Limit*—Procedures shall be in place for determining the MDL in a specific sample or group of samples. The frequency of use of these procedures shall be based on the DQOs of the data collection activity.

8.6.6 *Procedures for Establishing Control Limits:*

8.6.6.1 Procedures shall be in place for establishing and updating the control limits for analysis control. Control limits shall be established in order to evaluate laboratory precision and bias based on the analysis of control samples (see 8.6.4.1). Control limits for bias are typically based on the historical mean recovery plus or minus three standard deviation units, and control limits for precision range from zero (no difference between duplicate control samples) to the historical mean relative percent difference plus three standard deviation units.

8.6.6.2 Procedures shall be in place for monitoring historical performance, and they should include graphical (control charts) or tabular presentations of the data.

8.6.7 *Deviations*—Any activity not performed in accordance with laboratory SOPs or project planning documents is considered a deviation from the plan. Deviations from the plan may or may not affect data quality. All deviations from the plan shall be documented as to the extent of, and reason for, the deviation.

8.6.8 *Corrective Action*—Errors, deficiencies, deviations, or laboratory events or data that fall outside of the established acceptance criteria require investigation. Corrective action may be necessary in some instances to resolve the problem and to restore proper functioning to the analytical system. Investigation of the problem and any subsequent corrective action taken shall be documented.

205

8.6.9 *Data Handling Procedures:*

8.6.9.1 *Data Reduction*—Data resulting from the analyses of samples are reduced according to protocol described in the laboratory SOPs. Computer programs used for data reduction shall be validated before use and verified on a regular basis. All information used in the calculations shall be recorded in order to enable reconstruction of the final result at a later date. This information may include the weight or volume of sample used, percent dry weight for solids, extract volume, dilution factor used, and blank- or background-correction protocol followed.

8.6.9.2 *Data Review*—All data are reviewed by a second analyst or supervisor according to laboratory SOPs in order to ensure that calculations are correct and to detect transcription errors. Spot checks are performed on computer calculations to verify program validity. Errors detected in the review process are referred back to the analyst(s) for corrective action.

8.6.9.3 *Data Reporting*—Data are reported in accordance with the requirements of the end-user. The data report may include the following:

(*1*) Laboratory name and address;

(*2*) Sample information (including unique sample identification, sample collection date and time, date of sample receipt, and date(s) of sample preparation and analysis);

(*3*) Analytical results reported with appropriate significant figures;

(*4*) Detection limits that reflect dilutions, interferences, or correction for equivalent dry weight;

(*5*) Method reference;

(*6*) Appropriate QC results as described in 8.6.4 and 8.6.5; and

(*7*) Data qualifiers with appropriate references and narrative on the quality of the results.

8.7 *Quality Assurance Review:*

8.7.1 *General*—The QA program shall provide for routine evaluations of the effectiveness of laboratory QA and QC procedures and conformance of the laboratory to these procedures. These evaluations can be performed by persons internal or external to the organization and can involve on-site evaluations or performance evaluation studies, or both.

8.7.1.1 *Internal Assessment*—The analyst is responsible for continually monitoring individual compliance with the QA and QC programs. In addition, on some frequent basis, the QA officer, or an appropriate management designee, must review the laboratory data and operations for compliance with the QA and QC programs. The results of the internal assessment should be reported to management with requirements for a plan to correct observed deficiencies.

8.7.1.2 *External Assessment*—The laboratory should periodically be subject to evaluation by an assessor who is independent of the laboratory. This may be a representative of a government agency or other independent organization. The results of the external assessment should be submitted to management with requirements for a plan to correct the observed deficiencies.

8.7.1.3 *On-Site Evaluation*—On-site evaluations should be conducted as part of both internal and external assessments. An on-site evaluation includes a complete evaluation of the facilities, staff, instrumentation, SOPs, analytical methods, sample management procedures, and QA and QC policies and procedures as they relate to the generation of data for specific analytical and regulatory applications. Records of each evaluation shall be maintained by the laboratory. These records should include the date of the evaluation, area(s) or analyses inspected, person performing the evaluation, findings and problems, actions recommended and taken to resolve existing problems, and scheduled date for re-inspection. Any problems identified during the course of an on-site evaluation that are likely to affect data integrity shall be brought to the attention of management immediately.

8.7.1.4 *Performance Evaluation Studies*—Performance evaluation (PE) studies are used to measure the performance of the laboratory on unknown samples. PE samples are typically submitted to the laboratory as blind samples by an independent, outside source. The results are compared to predetermined acceptance limits set by the submitting agency. PE samples can also be submitted to the laboratory by the laboratory QA officer or an appropriate management designee as part of an internal assessment of laboratory performance. Records of all PE studies shall be maintained by the laboratory. Problems identified as a result of participation in PE studies shall immediately be investigated and corrected.

8.7.2 *Evaluation of Laboratory Data*—The evaluation of laboratory data shall be conducted by one or more persons knowledgeable in laboratory activities. Such evaluations often occur in the QA section of the laboratory. Data evaluation should include the following subjects:

8.7.2.1 *Completeness of Laboratory Data*—This ensures that (*1*) all samples and analyses required by the project planning documents have been processed, (*2*) complete records exist for each analysis and the associated QC samples, and (*3*) the procedures specified in project planning documents and SOPs have been implemented. The results of the completeness check should be documented.

8.7.2.2 *Evaluation of Data with Respect to Detection Limits*—Analytical results should be compared to required detection limits. Any detection limits that exceed regulatory limits or action levels, as specified in the project planning documents, should be identified.

8.7.2.3 *Evaluation of Data with Respect to Control Limits*—The results of QC and calibration check samples should be compared to control criteria. Data not within the control limits require corrective action, and reviewers should check that both corrective action reports and the results of reanalysis are available. Samples associated with out-of-control QC data should be identified in a written record or the data review, and an assessment of the utility of such analytical results should be recorded.

8.7.2.4 *Review of Holding Time Data*—Sample holding times should be compared to those required by the project planning documents, and all deviations should be noted.

8.7.2.5 *Evaluation of Performance Evaluation Results*—PE study results can be helpful in evaluating the impact of out-of-control conditions. Recurring trends or problems evident in PE studies should be documented in the review, and their effect on environmental data should be evaluated.

8.7.2.6 *Correlation of Laboratory Data*—The results of data obtained from related laboratory tests, such as purgeable

organic hallides (POX) and volatile organics, shall be documented and the significance of differences discussed in the review reports.

8.7.3 *Quality Assurance Reports to Management*—The QA program shall provide for the periodic reporting of pertinent QA and MQC information to management in order to allow management to assess the overall effectiveness of the QA program. Three examples of QA reports to management are as follows:

8.7.3.1 *Report on Measurement Quality Indicators*—This report should include the assessment of QC data gathered over the period, the frequency of analyses repeated due to unacceptable QC performance, and, if possible, the reason for the unacceptable performance and corrective action taken.

8.7.3.2 *Report on Quality Assurance Assessments*—This report should be submitted immediately following any internal or external on-site evaluation or upon receipt of the results of any PE studies. The report should include the results of the assessments and the plan for correcting the identified deficiencies.

8.7.3.3 *Report on Key Quality Assurance Activities During the Period*—A report summarizing key QA activities during the period should be delivered to management. The report should stress measures that are being taken to improve data quality and include a summary of the significant quality problems observed and corrective actions taken. The report should also include a summary of any changes in certification and accreditation status; involvements in the resolution of quality issues with clients or agencies; QA organizational changes; and notice of the distribution of revised documents controlled by the QA organization (that is, SOPs, QAPP).

8.8 *Laboratory Records:*

8.8.1 All information relevant to environmental QA and QC activities relating to laboratory facilities, equipment, personnel, methods, and practices shall be documented. Copies of the SOPs, and the equipment manuals provided by the manufacturer, shall be accessible in the workplace.

8.8.2 Handwritten test data shall be recorded legibly in ink in laboratory notebooks or on designated benchsheets. Each page shall be signed and dated by the person who performed the analysis and entered the data. Corrections shall be made by drawing a single line through the information to be changed and initialling and dating the change. The reason for the change shall be indicated.

8.8.3 Strip-chart recorder printouts shall be signed by the person who performed the instrumental analysis. If corrections need to be made in computerized data, a system parallel to the corrections for handwritten data shall be in place.

8.8.4 Records of sample management shall be available to permit the re-creation of an analytical event for review in the case of an audit or investigation of a dubious result.

8.8.5 *Personnel Training and Qualification Records*—It is the responsibility of the organization to establish personnel qualifications and training requirements. Each staff member shall possess the education, training, technical knowledge, and experience, or a combination thereof, to enable that individual to perform his or her assigned functions. Personnel qualifications shall be documented in terms of education, experience, and training. Training shall be provided for all staff members so that they can perform their functions properly.

8.8.6 *Standard Operating Procedures*—SOPs shall be written and available for all methods and practices.

8.8.7 *Quality Assurance Plans*—The QAPP and all applicable QAPjPs shall be on file.

8.8.8 *Equipment Maintenance*—Maintenance and performance logs shall be kept on all equipment and instrumentation and must include the following: (*1*) name of the equipment and manufacturer; (*2*) model and serial number of the equipment; (*3*) date the equipment was placed in service; (*4*) instructions for proper maintenance procedures; (*5*) dates of the maintenance and performance checks and the names of personnel performing them; and (*6*) if nonroutine repairs were performed as a result of a malfunction, nature and cause of the malfunction, and name of the person performing the repair.

8.8.9 *Proficiency*—Proficiency information on all parameters reported shall be maintained and shall include the following: (*1*) precision; (*2*) bias; (*3*) method detection limits; (*4*) spike recovery, where applicable; (*5*) surrogate recovery, where applicable; (*6*) checks on reagent purity, where applicable; and (*7*) checks on glassware cleanliness, where applicable.

8.8.10 *Traceability*—Traceability of standards, reagents, and weights shall be documented, with the traceability to national or international sources indicated.

8.8.11 *Calibration*—Calibration and standardization data records for each instrument and method shall include the following: (*1*) data of the last calibration; (*2*) calibration history; (*3*) frequency of calibration; (*4*) outside sources of calibration, if used, for example, the manufacturer; (*5*) date of preparation, expiration date, and name of the person performing the preparation of standards; and (*6*) written procedures for instrument calibration.

8.8.12 *Sample Management*—All required records pertaining to sample management shall be maintained and updated regularly. These include chain-of-custody forms, sample receipt forms, and sample disposition records.

8.8.13 *Original Data*—The raw data and calculated results for all samples shall be maintained in laboratory notebooks and logs, benchsheets, files, and other sample tracking or data entry forms. Instrumental output shall be stored in a computer file or a hardcopy report.

8.8.14 *Quality Control Data*—The raw data and calculated results for all QC and field samples and standards shall be maintained in the manner described in 8.8.13. QC samples include, but are not limited to, control samples, method blanks, matrix spikes, and matrix spike duplicates.

8.8.15 *Correspondence*—Project correspondence can provide evidence supporting technical interpretations. Correspondence pertinent to the project shall be kept and placed in the project files.

8.8.16 *Final Report*—A copy of the final report submitted to the sponsor of the work, or other designated individual, shall be retained.

8.9 *Document Storage:*

8.9.1 A written policy concerning the minimum length of time that documentation is to be retained shall be in place and understood by the appropriate personnel, including the sponsor of the work. Deviations from this policy shall be

207

documented and readily available to those individuals responsible for the deletion or destruction of expired documentation.

8.9.2 Documentation shall be stored securely in a facility that adequately addresses or minimizes its deterioration for the length of time it is to be retained. A system allowing for the expedient retrieval of information shall exist.

8.9.3 Access to archived information shall be controlled to restrict unauthorized personnel from having free and open access. An authorized access list shall be prepared and shall name the personnel who have unrestricted access to the archived information.

8.9.4 All accesses to archived information shall be documented. This documentation shall include the name of the individual, date, reason for accessing the data, and all changes, deletions, or withdrawals that may have occurred.

8.9.5 If a facility conducting testing or an archive contract facility goes out of business before the time period specified in the policy (8.9.1), all documentation shall be transferred in whole to the archives of the sponsor of the work.

9. Data Quality Assessment

9.1 The assessment of environmental data occurs in two phases. Field records and analytical data are reviewed during the first phase to identify whether the data are accurate and defensible. The data are interpreted in the second phase with respect to meeting DQOs.

9.2 Technical reports of environmental data collection efforts should summarize the information contained in the field records and the results of the laboratory data review, as described in 7.7.2 and 8.7.2. This information should be used to identify clearly the data that are not representative of environmental conditions or that have been generated using poor field or laboratory practices.

9.3 The combined field and laboratory data are then subject to a final assessment to determine whether the DQOs have been met. Although the data quality assessment process is beyond the scope of this practice, a general description of the items that should be considered in the assessment process is given below.

9.4 Data quality assessment typically includes, but is not limited to the following:

9.4.1 Evaluation of field duplicate results;

9.4.2 Comparison of the results of all field blanks, trip blanks, and equipment rinsates, with the full data set to provide information concerning contaminants that may have been introduced during sampling or shipping;

9.4.3 Evaluation of matrix effects to assess performance of the analytical method with respect to the sample matrix and determine whether the data have been biased high or low due to matrix effects;

9.4.4 Integration of the field and laboratory data with geological, hydrogeological and meteorological data to provide information on the extent of contamination; and

9.4.5 Comparison of precision, bias, completeness, representativeness, and defensibility of the data generated with that required to meet the DQOs.

APPENDIXES

(Nonmandatory Information)

X1. TABLE OF CONTENTS

	Section
Scope	1
Referenced Documents	2
Terminology	3
Summary of Practice	4
Significance and Use	5
Project Specification	6
Data Quality Objectives	6.2
Project Plan	6.3
Project Objectives	6.3.1
Project Management	6.3.2
Sampling Requirements	6.3.3
Analytical Requirements	6.3.4
Quality Assurance and Quality Control Requirements	6.3.5
Field Quality Control	6.3.5.1
Laboratory Quality Control	6.3.5.2
Project Documentation	6.4
Standard Practices for Environmental Field Operations	7
Purpose	7.1
Organization	7.2
Management	7.2.1
Quality Assurance Function	7.2.2
Personnel	7.2.3
Subcontractors	7.2.4
Field Logistics	7.3
General	7.3.1
Field Measurements	7.3.2
Sample Handling, Shipping, and Storage Area	7.3.3
Chemical Storage	7.3.4

BEST AVAILABLE COPY

208

	Section
Decontamination	7.3.5
Waste Storage Area	7.3.6
Data Storage Area	7.3.7
Equipment and Instrumentation	7.4
Equipment and Instrumentation	7.4.1
Maintenance and Calibration of Equipment and Instrumentation	7.4.2
Standard Operating Procedures	7.5
Sample Management	7.5.1
Reagent and Standard Preparation	7.5.2
Decontamination	7.5.3
Sample Collection Procedures	7.5.4
Equipment Calibration and Maintenance	7.5.5
Field Measurements	7.5.6
Corrective Action	7.5.7
Data Reduction and Validation	7.5.8
Reporting	7.5.9
Records Management	7.5.10
Waste Disposal	7.5.11
Health and Safety	7.5.12
Field Quality Assurance and Quality Control Requirements	7.6
Quality Assurance Program Plan	7.6.1
Quality Assurance Project Plan	7.6.2
Control Samples	7.6.3
Procedures for Establishing Acceptance Criteria	7.6.4
Deviations	7.6.5
Corrective Action	7.6.6
Data Handling Procedures	7.6.7
Data Reduction	7.6.7.1
Data Review	7.6.7.2
Data Reporting	7.6.7.3
Quality Assurance Review	7.7
General	7.7.1
Internal Assessment	7.7.1.1
External Assessment	7.7.1.2
On-Site Evaluation	7.7.1.3
Evaluation of Field Records	7.7.2
Completeness of Field Reports	7.7.2.1
Identification of Invalid Samples	7.7.2.2
Correlation of Field Test Data	7.7.2.3
Identification of Anomalous Field Test Data	7.7.2.4
Validation of Field Analysis	7.7.2.5
Quality Assurance Reports to Management	7.7.3
Report on Measurement Quality Indicators	7.7.3.1
Report on Quality Assurance Assessments	7.7.3.2
Report on Key Quality Assurance Activities During the Period	7.7.3.3
Field Records	7.8
Personnel Training and Qualification Records	7.8.1
Standard Operating Procedures	7.8.2
Quality Assurance Plans	7.8.3
Equipment Maintenance	7.8.4
Calibration and Traceability of Standards and Reagents	7.8.5
Sample Collection and Tracking Records	7.8.6
Maps and Drawings	7.8.7
Results from Control Samples	7.8.8
Correspondence	7.8.9
Deviations	7.8.10
Final Report	7.8.11
Documentation Storage	7.9
Documentation Archive	7.9.1
Storage Time	7.9.2
Filing System	7.9.3
Personnel Authorized to Enter Archive	7.9.4
Standard Practices for Environmental Laboratory Operations	8
Purpose	8.1
Organization	8.2
Management	8.2.1
Quality Assurance Function	8.2.2
Personnel	8.2.3
Subcontractors	8.2.4
Facilities	8.3
General	8.3.1
Sample Handling, Receiving, and Storage Area	8.3.2
Chemical Storage	8.3.3
Laboratory Operations Area	8.3.4
Waste Storage Area	8.3.5
Data Storage Area	8.3.6
Equipment and Instrumentation	8.4

BEST AVAILABLE COPY

209

	Section
Equipment and Instrumentation	8.4.1
Maintenance and Calibration of Equipment and Instrumentation	8.4.2
Standard Operating Procedures	8.5
Sample Management	8.5.1
Sample Receipt and Handling	8.5.1.1
Sample Scheduling	8.5.1.2
Sample Storage	8.5.1.3
Reagent and Standard Preparation	8.5.2
General Laboratory Techniques	8.5.3
Analytical Methods	8.5.4
Equipment Calibration and Maintenance	8.5.5
Quality Control Data	8.5.6
Corrective Action	8.5.7
Data Reduction and Validation	8.5.8
Reporting	8.5.9
Records Management	8.5.10
Waste Disposal	8.5.11
Health and Safety	8.5.12
Laboratory Quality Assurance and Quality Control Procedures	8.6
Quality Assurance Program Plan	8.6.1
Quality Assurance Project Plan	8.6.2
Method Proficiency	8.6.3
Laboratory Control Procedures	8.6.4
Laboratory Control Samples	8.6.4.1
Method Blank	8.6.4.2
Determination of Matrix Effects	8.6.5
Matrix Spikes	8.6.5.1
Matrix Duplicates and Matrix Spike Duplicates	8.6.5.2
Sample-Specific Detection Limit	8.6.5.3
Procedures for Establishing Control Limits	8.6.6
Deviations	8.6.7
Corrective Action	8.6.8
Data Handling Procedures	8.6.9
Data Reduction	8.6.9.1
Data Review	8.6.9.2
Data Reporting	8.6.9.3
Quality Assurance Review	8.7
General	8.7.1
Internal Assessment	8.7.1.1
External Assessment	8.7.1.2
On-Site Evaluation	8.7.1.3
Performance Evaluation Studies	8.7.1.4
Evaluation of Laboratory Data	8.7.2
Completeness of Laboratory Data	8.7.2.1
Evaluation of Data with Respect to Detection Limits	8.7.2.2
Evaluation of Data with Respect to Control Limits	8.7.2.3
Review of Holding Time Data	8.7.2.4
Evaluation of Performance Evaluation Results	8.7.2.5
Correlation of Laboratory Data	8.7.2.6
Quality Assurance Reports to Management	8.7.3
Report on Measurement Quality Indicators	8.7.3.1
Report on Quality Assurance Assessments	8.7.3.2
Report on Key Quality Assurance Activities During the Period	8.7.3.3
Laboratory Records	8.8
Personnel Training and Qualification Records	8.8.5
Standard Operating Procedures	8.8.6
Quality Assurance Plans	8.8.7
Equipment Maintenance	8.8.8
Proficiency	8.8.9
Traceability	8.8.10
Calibration	8.8.11
Sample Management	8.8.12
Original Data	8.8.13
Quality Control Data	8.8.14
Correspondence	8.8.15
Final Report	8.8.16
Document Storage	8.9
Data Quality Assessment	9

BEST AVAILABLE COPY

BEST AVAILABLE COPY

X2. REFERENCE LIST

X2.1 *ASTM Standards:*

D 1192 Specification for Equipment for Sampling Water and Steam[2]

D 1357 Practice for Planning the Sampling of the Ambient Atmosphere[5]

D 2777 Practice for Determination of Precision and Bias of Applicable Methods of Committee D-19 on Water[2]

D 3370 Practices for Sampling Water[2]

D 3614 Guide for Laboratories Engaged in Sampling and Analysis of Atmospheres and Emissions[5]

D 3670 Guide for Determination of Precision and Accuracy of Methods of Committee D-22[5]

D 3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents[6]

D 3856 Guide for Evaluating Laboratories Engaged in Sampling and Analysis of Water and Waste Water[2]

D 4210 Practice for Interlaboratory Quality Control Procedures and a Discussion on Reporting Low-Level Data[2]

D 4411 Guide for Sampling Fluvial Sediment in Motion[6]

D 4447 Guide for the Disposal of Laboratory Chemicals and Samples[7]

D 4448 Guide for Sampling Groundwater Monitoring Wells[7]

D 4489 Practice for Sampling of Waterborne Oils[6]

D 4687 Guide for General Planning of Waste Sampling[7]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[3]

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process[3]

E 178 Practice for Dealing with Outlying Observations[3]

X2.2 *U.S. Environmental Protection Agency Documents:*[4]

A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001 (NTIS No. PB88181557/LL), December 1987.

Blackman, Benson, Hardy, and Fisher, "Enforcement and Safety Procedures for Evaluation of Hazardous Waste Disposal Sites," *Management of Uncontrolled Hazardous Waste Sites*, National Enforcement Investigations Center, Denver, CO, 1980.

Characterization of Hazardous Waste Sites: A Methods Manual, Vol II, *Available Sampling Methods*, EPA-600/4-83-040 (NTIS No. PB84-12692/LL), Environmental Monitoring and Support Laboratory, Las Vegas, NV, 1983.

Characterization of Hazardous Waste Sites: A Methods Manual, Vol II, *Available Sampling Methods*, 2nd Edition, EPA 600/4-84-076 (NTIS No. PB85-168771/LL), December 1984.

Data Quality Objectives for Remedial Response Activities: 1987a-OSWER Directive 9355, 0-14 and 1987-OSWER Directive 9355, 0-7A; EPA 540/G-87/004 and 003; and NTIS-PB88-131388, PB88131370/LL.

DeVera, Emil R., Simmons, Bart P., Stephens, Robert D., and Storm, David L., *Samplers and Sampling Procedures for Hazardous Waste Streams*, EPA-600/2-80-018 (NTIS No. PB80-135353/LL), Municipal Environmental Research Laboratory, Cincinnati, OH, 1980.

Field Screening Methods Catalog: User's Guide, USEPA/540-2-88/005 (NTIS PB89-134159/LL), September 1988.

Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive 9335.3-01, Draft (NTIS No. PB89184626/LL), 1988.

Guide for Decontamination of Buildings, Structures and Equipment at Superfund Sites, EPA-600/2-85-028 (NTIS No. PB85-201234/LL), Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, 1985.

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019 (NTIS No. PB297451/LL), Environmental Monitoring and Support Laboratory, Washington, DC, 1979.

Handbook for Sampling and Sample Preservation of Water and Wastewater, EPA-600/4-82-029 (NTIS No. PB83124503/LL), Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1982.

Kerr, R. S., *Practical Guide for Groundwater Sampling*, EPA-600/2-85/104 (NTIS No. PB86-137304/LL), Environmental Research Laboratory, Ada, OK, 1985.

Manual of Ground-Water Quality Sampling Procedures, EPA-600/2-81-160 (NTIS No. PB82103045/LL), 1981.

Manual of Water Well Construction Practices, EPA-570/9-75-001 (NTIS No. PB267371/LL), National Technical Information Service, 1977.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020 (NTIS No. PB84-128677/LL), Environmental Monitoring and Support Laboratory, Cincinnati, OH, 1983.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020 (NTIS PB84128677/LL), March 1979.

NPDES Compliance Inspection Manual, 4211-545/11828, 1984.

NPDES Compliance Inspection Manual (NTIS No. PB88-221098/LL), Office of Water Enforcement and Permits (EN-338), Washington, DC, May 1988.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, DHHS (NIOSH) Publication No. 85-115 (NTIS No. PB87-162855/LL), NIOSH, OSHA, USCG, EPA, October 1985.

Preparation of State Lead Remedial Investigation Quality Assurance Project Plans for Region V, Office of Monitoring Systems and Quality Assurance, Washington, DC, April 4, 1984.

RCRA Groundwater Monitoring Technical Enforcement Document, 0-172-437, 1986.

Scalf, Marion R., et al., *Manual of Ground Water Sampling Procedures*, U.S. EPA and National Well Water Association, Worthington, OH, 1981, pp. 92 and 93.

Soil Sampling Quality Assurance User's Guide, EPA-600/4-84-043 (NTIS No. PB84198621/LL), 1984.

Standard Operating Safety Guides, Office of Emergency and Remedial Response, Hazardous Response Support Division, November 1984.

[5] *Annual Book of ASTM Standards*, Vol 11.03.
[6] *Annual Book of ASTM Standards*, Vol 11.02.
[7] *Annual Book of ASTM Standards*, Vol 11.04.

211

X2.3 *Other Government Documents:*[A]

Barcelona, Gibb, and Miller, *A Guide to the Selection of Materials for Monitoring, Well Construction and Ground Water Sampling* (NTIS No. PB84-141779/LL), Champaign, IL, August 1983.

Chemistry Quality Assurance Handbook, Vol I, U.S. Department of Agriculture Food Safety and Inspection Service, July 2, 1987.

Environmental Survey Manual, DOE/EH-0053, Vols 1 to 5, U.S. Department of Energy, Washington, DC, January 1989.

National Handbook of Recommended Methods for Water-Data Acquisition, U.S. Department of Interior, U.S. Geological Survey, Reston, VA, 2 Vols, 1977.

Soil Survey Handbook, 0-336-718:QL3, U.S. Department of Agriculture, 1981.

Soil Taxonomy, 0-470-728, U.S. Department of Agriculture, 1975.

X2.4 *Books:*

Barth, D. S., and Mason, B. J., *Soil Sampling Quality Assurance and the Importance of an Exploratory Study*, *ACS Symposium Series 267: Environmental Sampling for Hazardous Waste*, ACS Publications American Chemical Society, Washington, DC, 1984.

Compton, R. R., *Manual of Field Geology*, John Wiley and Sons, Inc., New York, NY, 1962.

Driscoll, Fletcher, G., *Groundwater and Wells*, 2nd Edition, Johnson Division, St. Paul, MN, 1987, pp. 885–891.

Keith, L. D., *Principles of Environmental Sampling*, American Chemical Society, Washington, DC, 1988.

Kratochvil, B., and Taylor, J. K., "Sampling for Chemical Analysis," *Analytical Chemistry*, American Chemical Society, Washington, DC, July 1981, pp. 924A–938A.

Quality Control in Remedial Site Investigation: Hazardous and Industrial Solid Waste Testing, 5th Vol, *ASTM STP 925*, C. L. Perket, Ed., ASTM, Philadelphia, PA, 1986.

RCRA Ground Water Monitoring Technical Enforcement Guidance Document, NWWA/EPA Series, National Water Well Association, Dublin, OH, September 1986.

Taylor, J. K., *Quality Assurance of Chemical Measurements*, Lewis Publishers, Inc., Chelsea, MI, 1987.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

BEST AVAILABLE COPY

212