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Burns and Roe Enterprises, Inc. 99649

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ENVIRONMENTAL ASSESSMENT OF ARMENIAN ENERGY SECTOR

ARMENIA

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TABLE OF CONTENTS

1 0 EXECUTIVE SUMMARY 1

1 1 Acknowledgments 3

2 0 OVERVIEW OF EXISTING CONDITIONS 3

2 1 Facilities 4

2 1 1 Yerevan TPP 5

2 1 2 Yerevan HPP No 1 7

2 1 3 Hrazdan TPP 7

2 1 4 Hrazdan HPP 8

2 1 5 Arzini HPP 8

2 1 6 Gumush HPP 9

2 2 Monitoring 9

2 3 Data Management 10

2 4 Focal Areas 10

2 4 1 Air 10

2 4 2 Water 13

2 4 2 1 Water Quality 13

2 4 2 2 Water Quantity 15

2 5 Residual Management 17

2 6 Applicable Environmental Regulations 18

2 7 Analytical Testing 20

2 7 1 Production Facilities 20

2 7 2 Switchyards 21

3 0 SITE VISITS AND OBSERVATIONS 19

3 1 Yerevan TPP 23

3 1 1 Introduction 23

3 1 2 Observations 23

3 1 2 1 Air Issues 23

3 1 2 2 Water Issues 24

3 1 2 3 Residual Management Issues 24

3 1 3 PCB Testing 24

3 1 3 1 Testing Locations 25

3 1 3 3 Testing Results 25

3 2 Yerevan HPP 28

3 2 1 Introduction 28

3 2 2 Observations 28

3 2 2 1 Water Issues 28

3 2 2 2 Residual Management Issues 28

3 2 3 PCB Testing 29

3 2 3 1 PCB Testing Locations 29

3 2 3 2 Testing Results 29

3 3 Hrazdan TPP 31

3 3 1 Introduction 31

3 3 2 Observations 31

3 3 2 1 Air Issues 31

3 3 2 2 Water Issues 32

3 3 2 3 Residual Management Issues 32

3 3 3 PCB Testing 33

3 3 3 1 PCB Testing Locations 33

3 3 3 2 Testing Results 33

3 3 4 Other Comments and Concerns 36

3 4 Hrazdan HPP 37

3 4 1 Introduction 37

3 4 2 Observations 37

3 4 2 1 Water Issues 37

3 4 2 2 Residual Management Issues 38

3 4 3 PCB Testing 39

3 4 3 1 PCB Testing Locations 39

3 4 3 2 Testing Results 39

3 5 Arzini HPP 41

3 5 1 Introduction 41

3 5 2 Observations 41

3 5 2 1 Water Issues 41

3 5 2 2 Residual Management Issues 42

3 5 3 PCB Testing 42

3 5 3 1 PCB Testing Locations 42

3 5 3 2 Testing Results 43

3 6 Gumush HPP 45

3 6 1 Introduction 45

3 6 2 Observations 45

3 6 2 1 Water Issues 45

3 6 2 2 Residual Management Issues 46

3 6 3 PCB Testing 46

3 6 3 1 PCB Testing Locations 46

3 6 3 2 Field Testing Results 46

3 7 Abovian Underground Natural Gas Storage Facility 48

3 7 1 Introduction 48

3 7 2 Observations 48

3 7 2 1 Air Issues 48

3 7 2 2 Water Issues 49

3 7 3 Other Issues 49

4 0 LOCATION OF SENSITIVE ENVIRONMENTAL RECEPTORS 50

4 1 Summary and Prioritization of Environmental Issues 54

5 0 RECOMMENDATIONS 61

5 1 Data Collection and Management 61

5 2 Non-Structural Management Recommendations for Environmental Protection 65

5 2 1 PCB Spills, Use and Management 65

5 2 2 Uncontrolled Discharge of Raw Sewage 66

5 2 3 Asbestos Use and Management 67

5 3 Recommendations for Physical Improvements 68

5 3 1 General Recommendations 68

5 3 1 1 Uncontrolled Discharge of Sewage 68

5 3 1 2 Uncontrolled Discharge of Oily Water 68

5 3 1 3 Overall Treatment of Technical Water at TPPs 69

5 3 1 4 Secondary Containment and spill/leak Management of non-PCB materials 69

5 4 Site Specific Recommendations for Physical Improvements 72

5 4 1 Yerevan TPP Recommendations 72

5 4 2 Yerevan HPP Recommendations 72

5 4 3 Hrazdan TPP Recommendations 72

5 4 4 Hrazdan HPP Recommendations 73

5 4 5 Arzini HPP Recommendations 73

5 4 6 Gumush HPP Recommendations 73

5 4 7 Abovian Underground Natural Gas Storage Facility Recommendations 73

6 0 OTHER ISSUES OF ENVIRONMENTAL CONCERN 74

6 1 Sevan- Hrazdan Cascade Issues 74

6 2 Switchyard Issues 74

6 2 General Issues 75

ATTACHMENTS

Photograph Log

Appendix A Air Monitoring Station Map and Air Data

Appendix B General Water Quality Data

Appendix C Data Analysis Reports

Appendix D Hrazdan Exhaust Duct Feasibility Study (Cover Sheet)

Appendix E Hrazdan Stack Feasibility Study (Cover Sheet)

Appendix F PCB Training Outline

Appendix G PCB Technology Overview

Appendix H Asbestos Training Outline

1 0 EXECUTIVE SUMMARY

As part of USAID's Environmental Assessment of the Armenian Energy Sector, Delivery Order No 22, an overall Work Plan was developed to conduct an environmental assessment of the electrical energy production sector As such, a number of electrical energy production facilities were selected to be assessed and were considered as being representative of the energy production sector That is, operations of the assessed facilities could be considered similar to the day-to-day operations at facilities that were not included in this assessment The facilities that were visited as part of the environmental assessment are Yerevan TPP, Yerevan HPP, Hrazdan TPP, Hrazdan HPP, Arzini HPP, Gumush HPP, the Abovian Underground Natural Gas Storage Facility, and three switchyard facilities that are to be rehabilitated through a proposed World Bank loan The switchyard facilities are Zovuny, Marash, and Shaumian-2

Preliminary data gathering activities were initiated through contacts and meetings with the World Bank and USAID in Washington From the start it was evident that there was limited existing environmental information available about Armenia in general and the energy production sector in particular Therefore, this Report constitutes a first step in addressing existing environmental conditions in Armenia and the related impacts from the energy production sector on the environment and health of the Armenian people

Initial attempts at gathering basic environmental data were initiated in Armenia in October, 1996 As a result of several meetings with the Ministry of Fuels and Energy and the Ministry of Environment it became clear that existing data related to general environmental conditions consisted of handwritten log sheets of data from ambient air monitoring stations and references to water monitoring stations on the Hrazdan River Numerous attempts were made to obtain basic data from responsible Armenian government officials The resultant data provided within the Appendices to this Report is reproduced as it was provided to the authors and its corresponding accuracy and quality has not been determined Specific pollutant data presented within the body of the Report for power facilities represent not actual measurements, but calculated figures based on the physical properties of fuel and the operating mode of the facility

In light of the above discussion, the assessment team was extremely impressed with the level of cooperation and forthrightness of the representatives from the individual facilities assessed Plant Directors and Chief Engineers at each of the production facilities met with the assessment team and were instrumental in providing information regarding past and current practices at their respective facilities

The electrical energy production sector is indeed negatively impacting the environment and health of the Armenian people The extent of this sector's contribution to countrywide pollution levels cannot be accurately estimated at this time However, existing practices occurring at the facilities that are expected to adversely impact air and water resources can be summarized as follows

- Air pollution control equipment is absent at the thermal power plants (TPPs),
- Hydropower plants (HPPs) discharge untreated sewage, plant-derived washwater, and cooling water directly to the associated water body,
- Treatment of wastewater discharges is limited to multi-level pH adjustment,
- Oil/Water separation devices are either not provided (HPPs) or are extremely inefficient and aged beyond their useful life (TPPs),
- Analytical data indicates that PCBs are present at all electrical energy production facilities assessed based on limited sampling at the TPPs and HPPs enumerated above In many cases, based on the original facility design, spills or leaks of PCB-containing materials are discharged directly to water bodies,
- Secondary containment and spill prevention measures were not implemented at any of the facilities,
- Stormwater runoff measures are not in place to control discharge to nearby bodies of water,
- Controls and regulations are not in place for management of hazardous substances such as asbestos (especially evident at TPPs),
- There was no knowledge of the presence/absence of PCBs within any of the facility's systems,
- Solid waste, hazardous waste, and/or contaminated materials originating from the facilities are either buried or burned at the sites, or are disposed of at a municipal dump No regulations regarding disposal of hazardous materials were found

The above bullet items are discussed in detail in various Sections of this Report

A series of four Tables have been provided in Section 4 1 to prioritize the environmental risks perceived from qualitative inputs based on observed practices at the sites In addition, low cost management solutions to reduce potential environmentally harmful practices as well as physical improvements of environmental benefit are presented in the Recommendations Section of this report

1 1 ACKNOWLEDGMENTS

In addition to power plant representatives, the Burns and Roe assessment team would like to acknowledge the participation and assistance provided by the following organizations and individuals

- Mr Vahram Nercissiantz, Chief Resident Mission of the World Bank, William Smith and Artashes Kazakhetsyan of USAID/Armenia for their assistance and views on project implementation and direction,
- Mr Armen Yeghiazarian, Director of EnergyInvest for general project discussions,
- Mr James Manlowe and Gahmk Markarian of the American Bar Association's Central and East European Law Initiative for assistance in obtaining environmental legislative documentation and discussions of same,
- Mr Mels Hakopian, General Director of Sevan-Hrazdan Cascade and his staff for their contributions to the team's understanding of the operating practices of the Sevan-Hrazdan Cascade system, and
- Special thanks are extended to Mr Gagik Danielian who was responsible for the overall coordination of site visits and facilitation of discussions between power plant representatives, government officials, and the assessment team In addition, the Burns and Roe Yerevan staff provided timely translation and administrative assistance

2 0 OVERVIEW OF EXISTING CONDITIONS

As a result of the Burns and Roe October, 1996, August and October, 1997 trips to Armenia and a review of limited existing documentation, there appear to be numerous deficiencies in the environmental management of the Armenian electrical energy production sector No reports on existing or past environmental practices were available and no formalized data reporting sources were found The extent of the environmental deficiencies will be enumerated in this Report and will focus primarily on those environmental elements that are most likely to impact the health and safety of the people of Armenia and sustainable development of the country The following section provides a brief overview of the existing status of electrical production facilities and environmental conditions in the electrical energy production sector Subsequent sections will detail site specific observations and recommendations

2 1 FACILITIES

Preliminary site evaluations were performed in October, 1996 at several electrical production facilities including Hrazdan TPP, Yerevan TPP, Yerevan HPP, Arzini HPP, and Gumush HPP The preliminary evaluations enabled Burns and Roe to develop the scope of work, establish a working relationship with the facilities, and investigate possible data sources The August, 1997 assessment included the above sites with the addition of Hrazdan HPP and the Abovian underground natural gas storage facility The October, 1997 assessment focused on the three switchyards affected by the proposed World Bank Rehabilitation loan The assessment portion of the project focused on recording existing and historical practices at the facilities and included onsite sampling and analysis for PCBs in soil around transformers and oil within the switchyard transformers As a result of these visits, several recurrent themes were evident

- Air pollution control equipment is absent at the thermal power plants (TPPs) Methods currently used to control emissions are considered outdated and inefficient,
- Secondary containment and spill prevention measures were not implemented at any of the facilities The assessment team was not provided with any internal regulations regarding the above measures,
- Stormwater runoff measures are not in place to control discharge to nearby bodies of water,
- Treatment of wastewater discharges is limited to multi-level pH adjustment,
- Oil/Water separation devices are either not provided (by original Soviet design) or are extremely inefficient and aged beyond their useful life,
- Hydropower plants (HPPs) discharge untreated sewage, plant derived washwater, and cooling water directly to the associated water body as per original design,
- Controls and regulations are not in place for management of hazardous substances such as asbestos (especially evident at TPPs),
- Analytical data indicates that PCBs are present at all electrical energy production facilities assessed based on limited sampling of soil at the TPPs and HPPs enumerated above In many cases, based on the original facility design, spills or leaks of PCB-containing materials are discharged directly to water bodies,
- There was no knowledge of the presence/absence of PCBs within any of the facility's systems,

- Pollution control is presently not a priority in the day to day operation of the facilities, however, some Soviet era feasibility projects did exist but were not implemented due to lack of funding,
- Solid waste, hazardous waste, and/or contaminated materials originating from the facilities are either buried or burned at the sites, or are disposed of at a municipal dump No post-burial monitoring is in place No quantitative analysis of disposed materials is performed,
- Analytical data for oil and soil samples taken at the three switchyard facilities by Burns and Roe indicate very low levels of PCBs in oil and in stained soils adjacent to transformers and oil storage tanks One oil sample that was independently analyzed by EnergyInvest at the Spandroyan substation yielded a PCB concentration of 120ppm or 120 mg/kg

Following is a brief technical outline of the production facilities visited Figure 2 1 shows the locations of all major power plants and transmission and distribution and interconnection grids

2 1 1 *Yerevan TPP*

Yerevan TPP is located in the industrial zone of Yerevan City The power plant is of combined heat-and-power (CHP) type and consists of two sections The first section has 5x50 MW units of effective capacity which came into operation in 1963-65 The second section consists of 2x150 MW units installed in 1966-68 The first section units (Units 1-5) are connected to a common header before steam delivery to the turbines The second section units are stand-alone (Block Units) and are not connected to a common header All units are of the conventional steam type with cooling towers, and are equipped with burners for dual firing

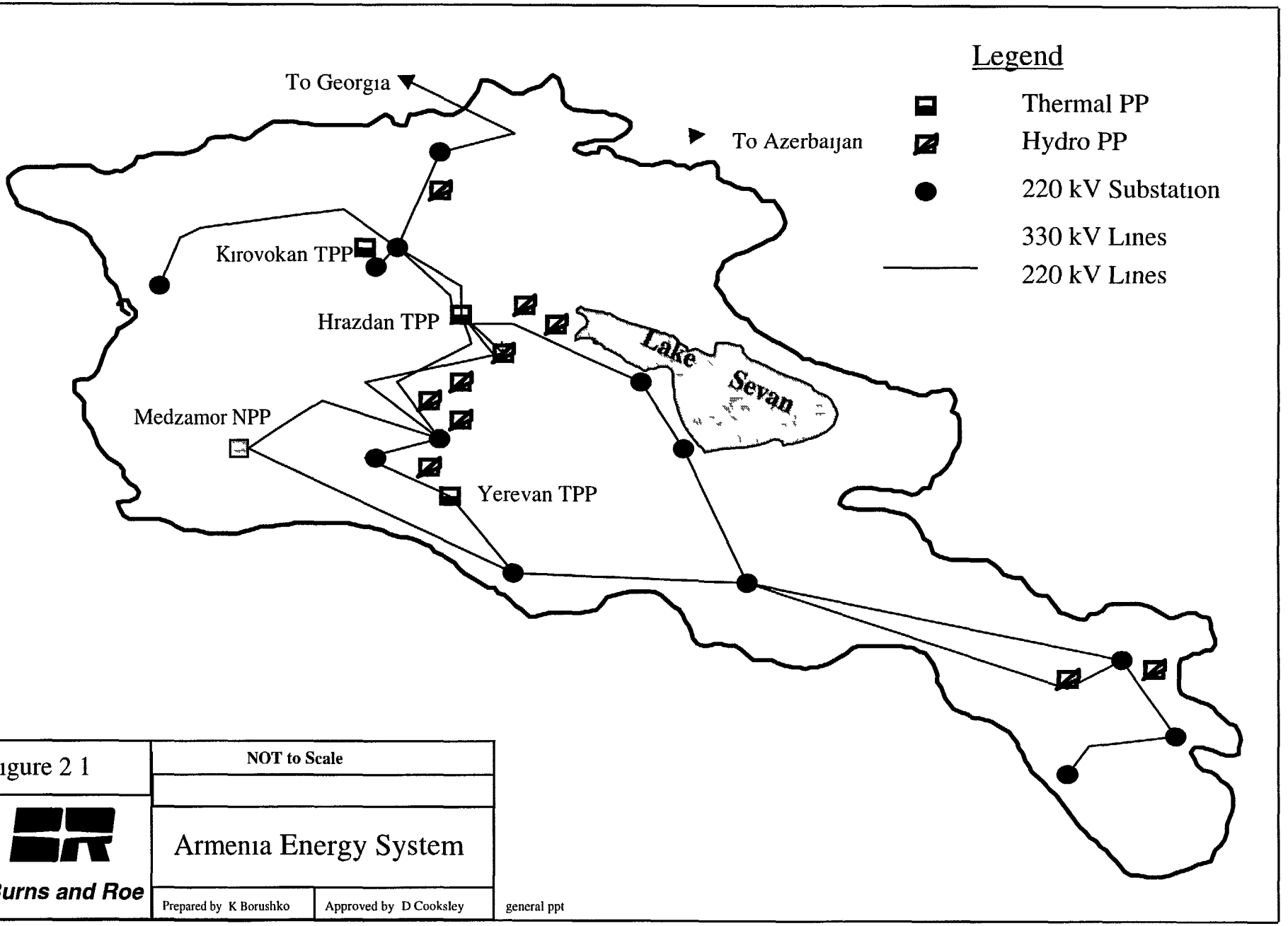

Figure 2 1

NOT to Scale

Armenia Energy System

Burns and Roe

Prepared by K Borushko | Approved by D Cooksley | general ppt

Following are the major characteristics of the **Yerevan TPP**

Category	Section 1 (Common Header Units)	Section 2 (Block Units)
Total installed capacity (by unit)	290 MW (4x60 MW, 1x50 MW)	320 MW (2x160 MW)
Total effective capacity today (by unit)	250 MW (5x50 MW)	300 MW (2x150 MW)
Steam production, Gcal/hr - Industry - District heating	 839 344	 70 260
Boiler capacity, t/hr	420	520
Superheated steam temperature, °C	560	560
Superheated steam pressure, atg	130	130
Number of cooling water pumps	16	
Capacity of each cooling water pump, t/hr	6,000	
Oil (Mazut) storage capacity	6 tanks 5,000 m^3 each, 6 tanks 10,000 m^3 each	
Usable oil storage capacity today	72,000 m^3	
Mazut sulfur content, % - From Azerbaijan - From Russia	 0 5-1 1 5-3	

Table Note Mazut purchased on the open market by USAID over the last two years has been provided with sulfur content of less than 0 5%

2 1 2 *Yerevan HPP No 1*

The Yerevan HPP No 1 consists of two (2) Russian made Francis turbines The turbines were installed in 1961 The installed capacity of the power plant is 40 MW (2x20 MW units) and the head is 84 m

2 1 3 *Hrazdan TPP*

The Hrazdan TPP is located 55 km north of Yerevan The station consists of two plants Section 1 is an industrial power plant that consists of four units (2x50

MW and 2x 100 MW) that were commissioned in 1966-69 Section 2 consists of four units (3x200 MW, 1x210 MW) that were commissioned in 1971-74 Section 2 of the power plant currently has a new Unit 5 (300 MW) under construction The work on Unit 5 is being financed by the EBRD and is scheduled to be completed in 1999

Section 1 is designed to operate as a CHP plant to satisfy the needs of local cement and concrete panel factories

Following are the major characteristics of the **Hrazdan TPP**

Category	Section 1 (CHP)	Section 2
Total installed capacity (by unit)	300 MW (2x50 MW, 2x100 MW)	810 MW (3x200 MW, 1x210MW)*
Total effective capacity today (by unit)	300 MW (2x50 MW, 2x100 MW)	810 MW (3x200 MW, 1x210MW)*
Steam production, Gcal/hr - Extraction 1 - Extraction 2	 80 80	 N/A N/A
Boiler capacity, t/hr	320	640
Superheated steam temperature, °C	560	545
Superheated steam pressure, atg	140	140
Number of cooling water pumps	8	8
Capacity of each cooling water pump, t/hr	5,000	11,300
Usable oil storage capacity today	210,000 m^3	

* New 300 MW unit is not included

2 1 4 *Hrazdan HPP*

The Hrazdan HPP consists of two (2) Austrian made (Voight) turbines The turbines were installed in 1959 The installed capacity of the power plant is 81 6 MW (2x40 8 MW units)

2 1 5 *Arzini HPP*

The Arzini HPP consists of three (3) Austrian made (Voight) turbines The turbines were installed in 1956 The installed capacity of the power plant is 81 6 MW (22 2 MW, 23 7 MW, and 24 7 MW units) and the head is 118 m

2 1 6 *Gumush HPP*

The Gumush HPP consists of two (2) Russian made (LMZ) turbines (Units 1 and 2) and two (2) Swedish made (ABB) turbines (Units 3 and 4) All turbines were installed in 1953 The installed capacity of the power plant is 211 MW (2x55 2 MW and 2x50 3 MW) and the head is 285 m

2 2 MONITORING

The present system for environmental monitoring in Armenia is ambient based and there was no evidence of system wide monitoring of plant discharges As a result of several meetings with the Ministry of Environment regarding the availability of environmental monitoring data, it is apparent that past environmental monitoring has focused on the ambient quality of air and water resources Existing facilities are not required to sample at the "end of pipe" and, therefore, data relevant to discharges from specific production facilities is unavailable Estimates of air emissions are made based on fuel type and the data quality of the calculated effluent pollutant concentrations is insufficient to accurately assess any environmental or public health impacts from the energy production sector Existing electrical energy production facilities do not have the equipment necessary to sample discharges from their facilities No plant discharge databases were found

The state of Armenia's ambient monitoring system has deteriorated significantly since the breakup of the Soviet Union Of the 18 ambient air monitoring stations located throughout the country, 12 are operational There are 7 ambient air monitoring stations in Yerevan of which 3 are operational In Yerevan, samples are obtained at 0700 hours, 1300 hours and 1900 hours and are sent to the central environmental laboratory of the Ministry of Environment for analysis The samples are analyzed for NO_x, particulates, SO_2, chlorine, formaldehyde, and CO In addition, a monopolymer residue from the Yerevan Rubber Factory is also measured in Yerevan Ambient air monitoring data and a map of air monitoring station locations is included in Appendix A

Based on a visit to an operational Ministry of Environment air monitoring station at the corner of Numbardian and Khanjian Streets in Yerevan, it is evident that budgetary constraints, lack of replacement parts, and proper maintenance have

had a significant impact on monitoring capabilities However, this monitoring station maintains its integrity and operating mode

2 3 DATA MANAGEMENT

The data that is collected from the sampling programs is handwritten and kept in paper log files Supplementary information such as maps, statistical analysis, weather conditions, etc , was not found Monitoring and analysis is still performed based on Soviet era standards There was no evidence of sampling procedures, protocols, or mechanisms to insure quality control of the data collected It is assumed, therefore, that monitoring data credibility is likely to be suspect

Data was not readily available regarding inventories of existing environmental resources Requests for information such as the location of public water intakes or well locations could not be provided This information is treated as delicate government intelligence information A major deficiency exists in the availability of data for sensitive environmental resources Without a thorough knowledge of such resources relative to energy production facilities, it is difficult to thoroughly assess environmental impacts and electrical energy production sector impacts in particular

2 4 FOCAL AREAS

Specific deficiencies in each of the following areas have been identified through site visits, review of available information, and meetings with Armenian officials

2 4 1 AIR

Air quality within many of the populated areas appears to be poor Although visible emissions were not emanating from any of the TPP stacks at the assessed sites, only several CHP units were operating due to the summer load pattern and the lack of a residential district heating load As noted above, there is no "end of pipe" testing Thus the quantity of pollutants emanating from any specific facility is computed from numerical calculations based on fuel composition and consumption It is known that continuous air pollution control equipment is not present on any of the TPP facilities assessed The periodic measurements that are conducted do not provide a realistic emissions picture

Air pollutants, and NOx in particular, at TPPs are controlled by flue gas recirculation (FGR) techniques FGR for NOx control consists of extracting a portion of the flue gas from the economizer or air heater outlet and returning it to

the furnace, admitting the flue gas through the burner windbox FGR lowers the bulk furnace gas temperature and reduces the concentration of oxygen in the combustion zone

FGR can be used effectively on oil- and gas-fired boilers to achieve significant reductions in NOx on the order of 40-65% The actual amount of reduction varies with the amount of gas recirculated Highest NOx reductions are achieved on natural gas fuel The low range of NOx reduction efficiency is associated with oil combustion It should be expected that in Armenia, where most of the fuel burned today is natural gas, greater levels of NOx reduction should be reached

Table 2 4-1 illustrates the emissions levels for SO_2 and NO_x for the two largest TPPs in Armenia Please note that the decrease of SO_2 and NO_x illustrated in Table 2 4-1 is attributable to both a fuel switch (mazut to natural gas) and to decreased operating conditions This data reflects the calculated emission levels based on fuel consumption data and mode of operation Table 2 4-2 presents selected stack emission limits for natural gas fired power plants

Table 2 4-1

	1990	1991	1992	1995	1996
Yerevan TPP					
NO_x, t/yr	6,178	5,979	3,340	1,409 0	1,398
SO_2, t/yr	14,764	16,179	12,488	426 8	313
Total (including NO_x, SO_2), t/yr	**21,291**	**22,584**	**16,093**	**1,853 6**	**1,724**
Hrazdan TPP					
NO_x, t/yr	11,485	9,269	4,499	3,373	1,445
SO_2, t/yr	46,122	40,747	25,130	672	342
Total (including NO_x, SO_2), t/yr	**58,719**	**38,245**	**30,182**	**4,056**	**1,797**

The above data has been provided by Armenian Ministry of Environment

Table 2 4-2
Power Plant Stack Emission Limits - Natural Gas Plants

Contaminant	Russia	World Bank	U S EPA
NO_x	86 mg/mJ and 125 mg/m3	0 20 lbs/mmBTU of heat input	0 20 lbs/mmBTU of heat input
SO_x		500 TPD if background air quality <50 mg/m3 100 TPD if background air quality >100 mg/m3	0 80 lbs/mmBTU of heat input
Particulates		100 mg/m3	0 030 lbs/mmBTU of heat input

The relative contribution of the electrical energy sector to ambient air pollution is a critical consideration in any future studies Existing air quality problems are a function of several sectors of the economy including transportation, industry, home heating, power production, and refuse burning For example, air quality impacts from a local cement manufacturer in the Hrazdan area are said to dwarf the impacts from other sources when the plant is in operation This was evident

during the August and October, 1997 visits as a large, dense plume was observed emanating from the cement manufacturer on several occasions

Estimates of the pollutant load from the electrical energy production sector are further complicated by the availability of fuels While natural gas is the preferred option at this time, the use of mazut containing 2 - 5 % sulfur is the alternative when gas is unavailable which can increase SO_2 emissions several times over that of natural gas The TPPs, on average, were burning mazut for one-half to two winter months during the last 2 years The use of various fuel types will greatly affect both the selection of any pollution control equipment utilized and its effectiveness

Climate and weather conditions do not appear to be considered in the overall management of air quality The status of Armenia's meteorologic capabilities should be investigated and built into any air quality management plans that are developed

2 4 2 WATER

Water resources in Armenia serve a variety of purposes including power generation, potable usage, irrigation and recreation In many cases, water resources must meet multiple needs Management of water resources from both a quantity and quality perspective is critical to the overall health of the Armenian environment and its people

2 4 2 1 Water Quality

The government sponsored ambient monitoring system provides little information in terms of the direct impacts the electrical energy production sector has on water resources The lack of readily available information regarding the juxtaposition of electrical energy production facilities relative to critical water resources makes it difficult to assess the relative impacts of the sector on water quality There are, however, existing practices occurring at the facilities which are expected to have adverse impacts on water quality They include the following

- Treatment of wastewater discharges (at TPPs) is limited to multi-level pH adjustment,
- Treatment of runoff from chemical storage areas (at TPPs) is limited to multi-level pH adjustments,
- Analytical data indicates that PCBs are present at all electrical energy production facilities assessed In many cases, spills or leaks of PCB-containing materials are discharged directly to water bodies,

- HPPs discharge untreated sewage, plant-derived washwater, and cooling water directly to the associated water body,
- Oil/Water separation devices are either not provided (at HPPs) or are extremely inefficient and aged beyond their useful life (TPPs),
- Stormwater runoff from both HPPs and TPPs flows untreated into adjoining water bodies,
- Railcar delivery areas (at TPPs) exhibit significant spillage of mazut that will eventually reach adjoining water bodies because of the lack of stormwater controls and may infiltrate to groundwater,
- Knowledge of the extent of contamination from hazardous substances such as PCBs and asbestos is very poor In many cases, there are no accurate inventories of the types of hazardous materials present and their usage at a facility Those hazardous substances are typically not protected from precipitation and eventually reach adjoining water bodies because of lack of stormwater controls,
- Erosion from the disrepair of aqueducts and auxiliary spillways contributes to sediment loading in the adjoining water bodies

Given the extent of problems identified above, the potential quality impacts to both surface and groundwater supplies from electrical energy production can be significant

The following table represents typical maximum allowable water discharge limits for TPPs

Table 2 4-3
Yerevan TPP Maximum Pollutant Concentrations

Components	Max. Allowable Concentration, g/m^3	Max. Allowable Discharge Amount, g/hr
Chloride	375 7	43,130 36
Sulfate	609 6	69,982 08
Oil Products	0 542	62 22
Hazardous Materials	0 214	24 57
Dry Residue	1655 2	190,017

Source Yerevan TPP Management Data is approved for 1995-2000 by Ministry of Environment

According to interviews with plant managers at 2 TPPs and 4 HPPs, the actual water discharges were basically within the maximum allowable limits The

existing practice in Armenia is to consider a "preset" Ministry of Environment limit as actual until proven differently

In spite of numerous detailed requests, Burns and Roe was provided with a general water quality table (see Appendix B) which provides averaged annual concentrations within the Hrazdan River Although average annual data can provide a general indication of overall stream health, it does not allow an assessment of localized seasonal impacts or industrial stresses

2 4 2 2 Water Quantity

The dependence of the electrical energy production sector on hydropower requires significant water usage that may or may not be compatible with other needs such as irrigation and preservation of Lake Sevan There are seven HPPs that form the Hrazdan cascade system Figure 2 4 depicts the location of HPPs on the cascade The cascade system relies on water derived from the open channel, concrete lined Hrazdan Canal which originates at Lake Sevan and flows for a length of 60 kilometers terminating at the Ararat Valley irrigation system The HPPs receive their input water from the Canal and discharge water to the Canal or to the Hrazdan River which roughly parallels the Canal There are emergency relief channels that connect the Hrazdan Canal to the Hrazdan River In addition, there are irrigation distribution channels that originate from the cascade system Water flow for electrical production volume for each HPP in the Hrazdan cascade is dictated by the Ministry of Agriculture in the months May through October The Ministry of Energy dictates electrical production output of the HPPs in the months November through April

During the August, 1997 assessment visits, the HPPs were operating at 10% to 70% of their established capacities Up to one half of the Canal flow is diverted for agricultural use prior to its final Ararat Valley destination

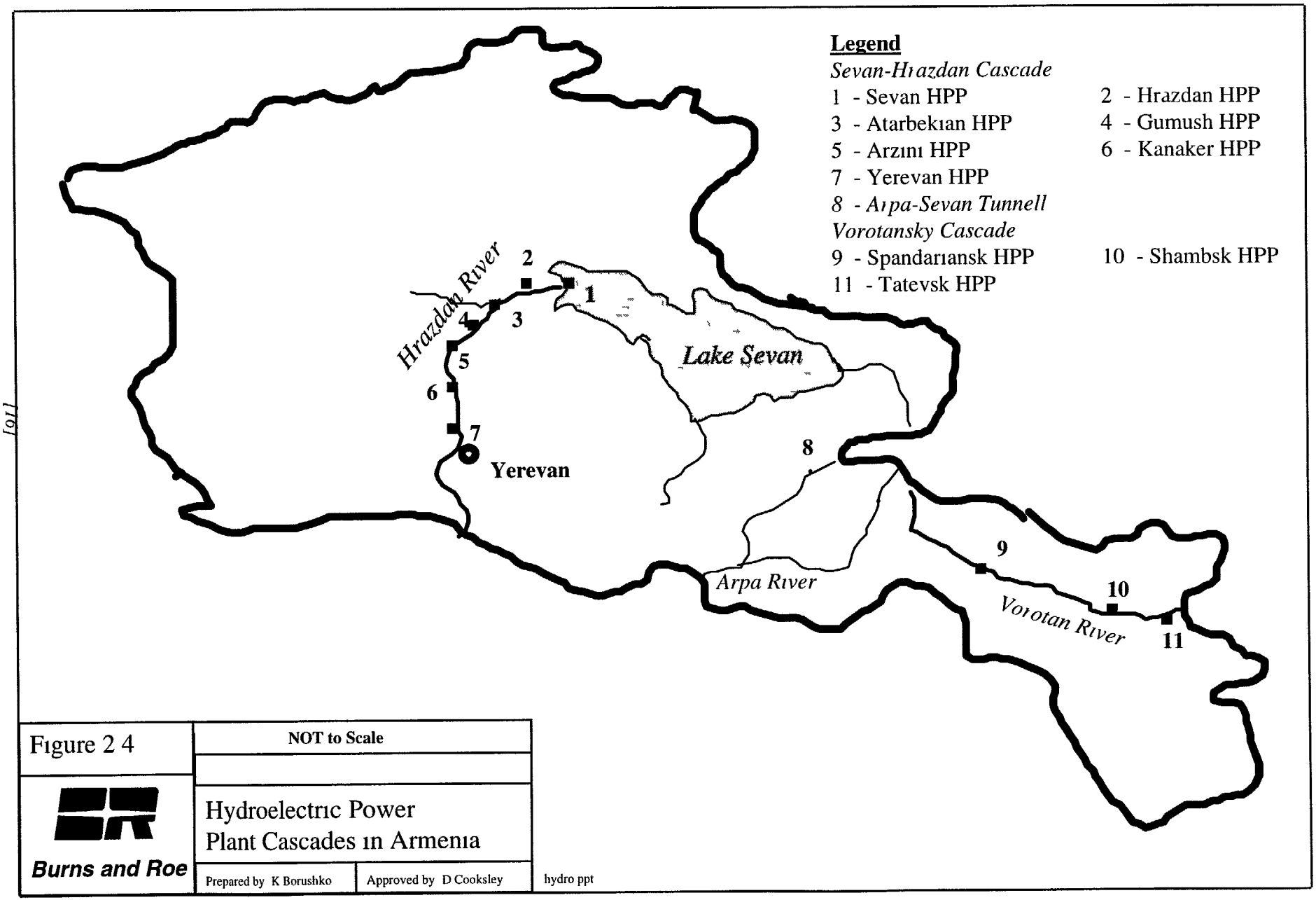

Figure 2 4

NOT to Scale

Burns and Roe

Hydroelectric Power Plant Cascades in Armenia

Prepared by K Borushko | Approved by D Cooksley

hydro ppt

2 5 RESIDUAL MANAGEMENT

In addition to impacts to air and water resources from the electrical energy production sector, residual management practices are of concern Specifically, the disposal of used equipment, contaminated soil and gravel, and hazardous waste raise long term health and safety issues for the Armenian population Evidence of random disposal practices was observed during the site visits to energy producing facilities Mechanisms for tracking disposal of waste materials were not readily available Photo No 1 illustrates disposal practices at one of the assessed facilities

Most of the facilities visited have used in the past and continue to use asbestos for insulation Asbestos continues to be the only available insulation material in Armenia Examples of poor insulation maintenance were prevalent throughout the energy sector Disposal of used asbestos and its threat to workers within the facilities are significant environmental concerns Photo Nos 2 and 3 depict poor asbestos maintenance and storage practices

Most facilities use a combination of onsite disposal, onsite burning, and offsite municipal disposal for residual and solid wastes As was evident throughout Armenia, air emissions resulting from the uncontrolled burning of residential and commercial solid waste is a contributing factor to diminished air quality Of immediate concern in the energy sector, is the practice of burning paper filters and residual wastes derived from the cleaning of transformer oil Since PCBs were discovered in samples at each facility visited in August 1997, significant health effects can result due to burning PCB containing materials In addition, burial of PCB contaminated materials poses long-term health threats to energy workers and the general population Photo No 4 depicts the typical oil soaked residue to be burned

In general, the management of hazardous waste is poorly conceived and understood Long term environmental and health impacts from poor management practices are inevitable

2 6 APPLICABLE ENVIRONMENTAL REGULATIONS

A fee and fine mechanism is in place for air and water emissions Fees are paid based on the volume of planned/estimated annual emissions Fines are imposed for any exceedence of the planned/estimated emissions Figure 2 6 presents air and water discharge fees and fines for the Hrazdan TPP which were assessed in 1989 The fine for above normal emergency water discharges is 94,600 rubles which equates to approximately $ USD 120,000 00 (1989) No information was available for the current fee and fine arrangement

The World Bank has extensively addressed the state of Armenian environmental regulations and legal and institutional issues in their Lake Sevan Environmental Action Plan (final-June 1998) and National Environmental Action Plan (final-September 1998) Reports

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FIGURE 2.6

Payments and Fines for Excessive Discharges (x1000 roubles)

Таблица 13

13 Плата за выбросы (сбросы) загрязняющих веществ в окружающую среду и размещение отходов, тыс руб

Показатели	1989	1990	1991	1992	1993	1994	19
AIR DISCHARGES							
1 За выбросы тысяч загрязняющих веществ	562,0						
WITHIN THE LIMITS PLANNED / ACTUAL							
1 1 В пределах установленных лимитов план/факт	601,2						
	562,0						
FINES FOR EXCESS ABOVE LIMIT							
1 2 За превышение допустимых лимитов	-						
FINES FOR EMERGENCY DISCHARGES							
1 3 Штрафы за аварийные сбросы	-						
WATER DISCHARGES							
2 За сброс в водные объекты загрязняющих веществ	105,0						
WITHIN THE LIMITS PLANNED / ACTUAL							
2 1 В пределах установленных лимитов план-факт	8,1						
	10,4						
FINES FOR EXCESS ABOVE LIMIT							
2 2 За превышение допустимых лимитов	94,6						
FINES FOR EMERGENCY DISCHARGES							
2 3 Штрафы за аварийные сбросы	-						
RESIDUAL WASTE MANAGEMENT							
3 За размещение (захоронение) отходов	-						
WITHIN THE LIMITS PLANNED / ACTUAL							
3 1 В пределах установленных лимитов план-факт	-						
FINES FOR EXCESS ABOVE LIMIT							
3 2 За превышение допустимых лимитов	-						
FINES FOR EMERGENCY DISCHARGES							
3 3 Штрафы за аварийные выбросы	-						
TOTALS							
4 Общая сумма платы	667,0						
FINES FOR WITHIN THE LIMITS PARAMETERS, PLAN / ACTUAL							
4 1 В пределах установленных лимитов план-факт	609,3						
FINES FOR EXCESS OF DISCHARGE LIMITS							
4 2 За превышение допустимых лимитов	572,4						
FINES FOR EMERGENCY DISCHARGES							
4 3 Штрафы за аварийные	94,6						
5 Платежи за сверхнормативные и некомплексное использование (потери) природных ресурсов и получаемого из них сырья	-						
6 Средства, взыскиваемые в возмещение ущерба, причиненного государству нарушением природоохранного законодательства в результате хозяйственной деятельности предприятия	-						
7 Всего за год	667,0						

Approximate exchange rate in 1989
1 rouble = 1.27 US$

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2 7 ANALYTICAL TESTING

2 7 1 PRODUCTION FACILITIES

As part of assessment activities, 3 types of analytical analyses for PCBs were performed at production facilities

Initial testing at the production facilities focused on stained soils adjacent to transformers and oil storage tanks Samples were obtained and detailed measurements were made to identify and map the sample location The samples were then analyzed under controlled conditions using field test kits designed specifically to detect the presence of PCBs The remainder of the soil samples obtained from the production facilities were then sent to a nationally recognized laboratory in the United States for confirmatory testing The confirmatory analysis evaluated the soil samples for the seven (7) most common PCB congeners (Aroclor 1016, 1221, 1232, 1242, 1248, 1254, and Aroclor 1260) Due to minor discrepancies in the field analysis versus laboratory analysis results, three (3) samples underwent PCB "fingerprinting" analysis This "fingerprinting" analysis determines the levels of 48 PCB congeners including those typically monitored in Europe as well as the 36 most toxic and environmentally prevalent congeners

Based on the above testing, it has been determined that the most prevalent PCB congener encountered at the energy production facilities is Aroclor 1254 The highest PCB levels were found at thermal power plants (150ppm) and the lowest levels (< 0 16ppm) at hydropower facilities Tables summarizing the analytical results of PCB testing at the production facilities can be found in the Site Observation subsections for each respective facility The combined analytical data and analysis reports can be found in Appendix C

The discrepancies in the field analysis versus laboratory analysis results were exhibited in samples with low levels (1 to 5 ppm) of PCBs It should be noted that several of the soil samples obtained for analysis contained silica beads that had been previously discarded around various transformer locations The silica beads are used as part of a treatment system designed to remove moisture and particulates from transformer oil It is believed that the silica beads may also have the potential to adsorb PCBs onto their surface It is postulated that the presence or absence of the silica beads in any given sample aliquot may affect the level of PCBs subsequently detected in the sample Therefore, deviations in sample results especially at low levels may be attributed to the presence of discarded transformer oil treatment system silica beads

The Draft September 1997 version of this Report included only the field test analysis results since the laboratory analytical results were still pending at that time Because of the discrepancies noted above, only the laboratory analytical results will be reported and discussed in this Final version of the Report Therefore, the field test results that were "positive" for PCBs at the Yerevan HPP and Hrazdan HPP (based on 2 samples at each facility) will be reported as having PCB concentrations of less than 0 16 ppm which is the laboratory analytical detection limit for those 4 samples

2 7 2 SWITCHYARDS

In addition to the above testing, testing for PCBs was conducted at three of the switchyards (Zovuny, Marash, and Shaumian-2) affected by the proposed World Bank loan Since the loan will be used to rehabilitate transformers and circuit breakers within the switchyards, oil samples as well as soil samples were obtained for analysis Burns and Roe conducted "Split sampling" in conjunction with the Ministry of Energy's Project Implementation Unit, EnergyInvest Burns and Roe sent its samples to the same analytical laboratory used for the production facility analyses and EnergyInvest sent its samples to a Swiss analytical laboratory The data sets detected no PCBs in transformer oil Low level PCBs (0 1 to 1 0 ppm) were detected in the soils below the transformer oil storage tanks at all three switchyards Elevated levels of PCBs were detected in two circuit breakers (8 1 to 120 ppm) Please note that the 120 ppm result was obtained by EnergyInvest's sampling efforts at a circuit breaker located at the Spandroyan substation

EnergyInvest was provided with the Environmental Protection Agency (EPA) analytical testing methodology (Method 8081) for PCBs that was agreed to be used as the basis for the split sample analysis Unfortunately, the subcontractor and analytical laboratory that performed the analysis (via DIN 51527 standard) for EnergyInvest tested for six congeners of PCBs which are typically monitored in Europe that Method 8081 does not target Therefore, although identical samples were submitted to both the US and Swiss laboratories, a direct comparison of the analytical results cannot be performed because the samples were analyzed for different constituents

It is interesting to note that as a result of using the two different test methods a broader "variety" of PCB congeners were determined The six PCB congeners included in the DIN 51527 standard are included within the 48 congeners in the "fingerprinting" analysis discussed in Section 2 7 1 Based on inquiries made to the analytical laboratory that conducted the PCB analysis the following items are of note

- The sum total of the 48 congeners (analyzed as part of the "fingerprinting" analysis) accounts for 94% of the concentration of Aroclor 1254 Therefore, a strong correlation can be made between Aroclor 1254 and the 48 congeners

- Aroclor 1254 does not contain a significant amount of the 6 PCB congeners determined via the DIN 51527 standard However, from a presence/absence standpoint, the 6 congeners would provide an indication of Aroclor 1254 presence

Therefore, from the limited amount of data obtained from 4 different sampling events it is evident that both American "Aroclor" type PCBs as well as "European" type PCBs are present in the Armenian power sector

Table 2 7 presents the Burns and Roe sample results from the switchyard sampling effort

Table 2 7

February 1998 Armenia PCB Sampling at Selected Substation Switchyards

LOCATION	PCB-1254 (ug/kg)	PCB-1260 (ug/kg)
Oil Samples		
Marash T1 140434	< 2500	< 2500
Marash T2-110955	< 2500	< 2500
Marash CB-2470	8100	< 2500
Zovuny T1-88921	< 2500	< 2500
Zovuny T2-105923	< 2500	< 2500
Zovuny CB 1328	< 2500	< 2500
Shaumian2 T1-133353	< 2500	< 2500
Shaumian2 T2-140188	< 2500	< 2500
Soil Samples		
Marash Tank Storage	1000	< 170
Zovuny Under Transformer	< 34	91
Zovuny Tank Storage	1050	< 170
Shaumian2 Under Transformer	4380	< 850
Shaumian2 Tank Storage	< 17	136

Table Notes T = Transformer followed by serial number
CB = Circuit Breaker followed by serial number
Tank Storage = The soil under the transformer oil storage tank
ug/kg = micrograms per kg and can be expressed as Parts-per-billion

3 0 SITE VISITS AND OBSERVATIONS

3 1 YEREVAN TPP

3 1 1 INTRODUCTION

Yerevan TPP was visited for the assessment portion of the program on 5 and 7 August 1997 Preliminary inspections took place in October 1996 Meetings were held with Mr Hovakim Ovanessian, Plant Director and Mr Edward Khazarian, Deputy Chief Engineer of the facility Mr Khazarian escorted the assessment team on a tour of the facility

3 1 2 OBSERVATIONS

Yerevan TPP is an "outdoor type" power plant That is, all major facility components are exposed to ambient climatic conditions which can cause premature aging of the components Two more power plants of this type currently exist in the Former Soviet Union (FSU) in Uzbekistan and Kazakhstan The development of the "outdoor type" power plants occurred as a result of Kruschev's visit to the United States when he saw "outdoor type" stations in California The design was relatively inexpensive to build and could be put into operation quickly Unfortunately, the Soviet authorities failed to recognize at that time that California has a very mild climate compared to Armenia (and Uzbekistan and Kazakhstan for that matter) Only three "outdoor type" facilities were built subsequent to the design being prohibited in the FSU Spare parts for external maintenance of the facility are unavailable

The following observations or statements are of note

3 1 2 1 Air Issues

- No control systems are in place to reduce air emissions Excess air and flue gas are manipulated to control NOx when gas and mazut are burned When burning mazut, the facility tries to purchase low sulfur mazut and to maintain a constant temperature to reduce SOx emissions The currently used mazut contains up to 5 % sulfur,
- Ash removal is not necessary when burning mazut as the facility maintains a high enough air velocity that the particulates remain entrained and are exhausted through the stack thereby increasing particulate emissions,
- Power plant representatives stated that the facility equipment is located very close together and, as a result of a 1989 study, they would not be able to fit

pollution control equipment (e g , flue gas desulfurization installation) into the facility if such equipment became available,

- A computer program is used to calculate the quantity of air pollutants based on the amount and quantity of fuel burned and expected electrical and district heating outputs on a monthly basis No real time monitoring is provided,
- 5 boilers discharge into one 70 meter stack, 2 boilers discharge into one 130 meter stack,
- Power plant representatives stated that the stacks are in poor condition and that the flue gas ducts have many leaks which lowers the overall efficiency of the units The leaky ducts were apparent during our inspection - See Photo Nos 5 and 6,
- Facility personnel displayed a USAID-provided multigas analyzer (Bacharach Model 300 w/USAID stickers) which they received in 1994 Facility personnel stated they are in urgent need of consumable supplies for the analyzer, especially an oxygen sensor,

3 1 2 2 Water Issues

- 200 tons/hour of technical water is discharged to drainage channels following pH adjustment No other treatment has been provided according to the original plant design Periodic checks of water quality are made by the facility and by the Yerevan Environmental Inspection (YEI) According to facility representatives, the annual limits correspond to the site specific standards,

3 1 2 3 Residual Management Issues

- Power plant representatives stated that a "1/2 tank" (or metal liner) is present under the gravel at the transformer station to collect spilled oil Apparently this transformer oil is collected and re-used The liner has not been inspected since station construction,
- Mazut storage area is surrounded by uncompacted, loose earthen berms,
- The bulk asbestos storage area is a crude room piled with loose asbestos Asbestos was visibly tracked outside the storage area onto a major outdoor power plant walkway Asbestos pipe insulation was in an adjacent storage area with conditions similar to the bulk storage Power plant workers seem to have no awareness of the health effects of asbestos No protective equipment (e g , dust masks) were worn by the asbestos workers - See Photo Nos 7 and 8,
- Soil samples for PCB analysis were taken at a limited number of inactive transformers

3 1 3 PCB TESTING

Please refer to Table 4 1 in Section 4 0 for PCB International Regulatory Limits

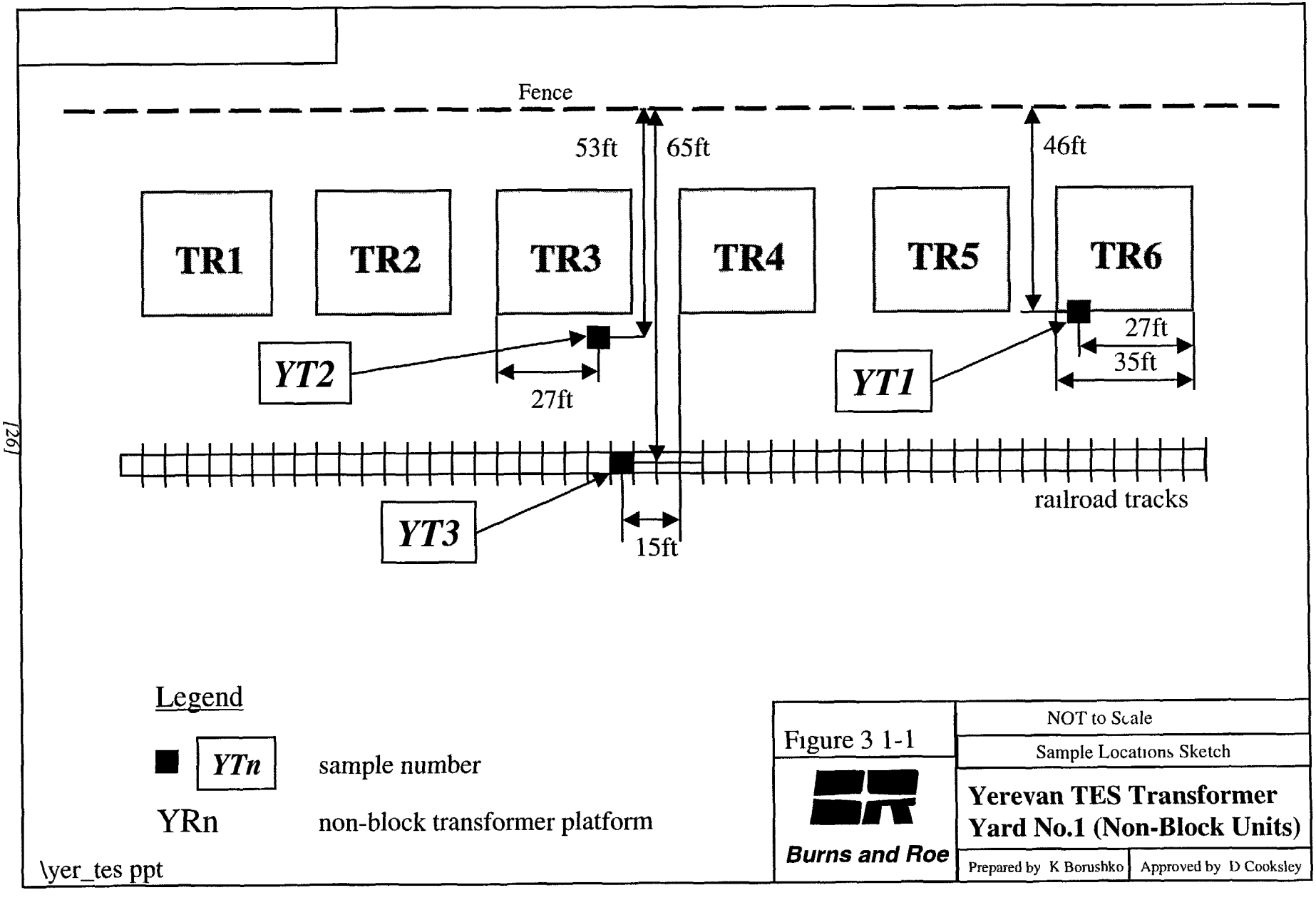
3 1 3 1 Testing Locations

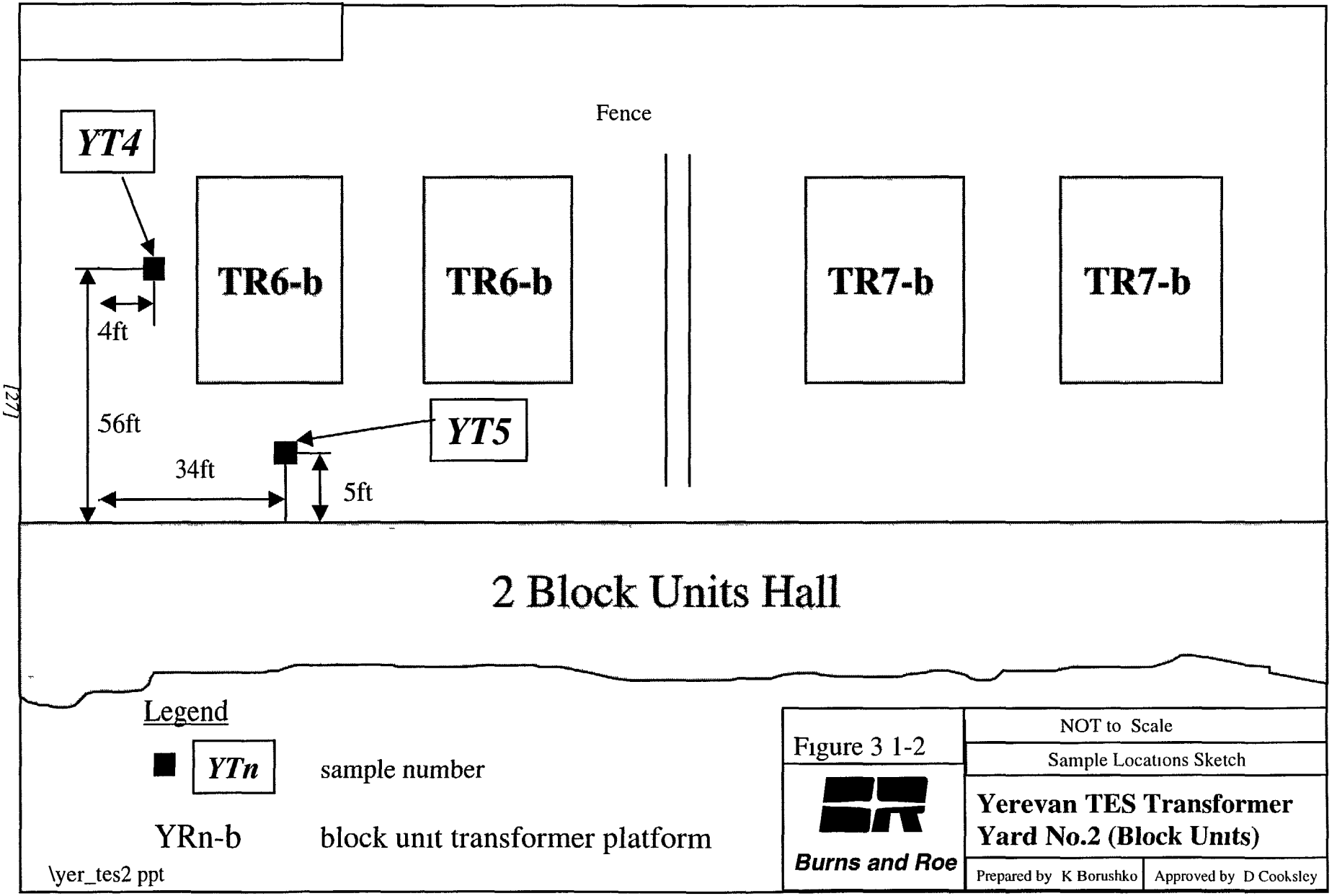
Yerevan TPP has two operational transformer yards Figure Nos 3 1-1 and 3 1-2 represent the layouts and sample locations for PCB testing At the time of the inspection, two (2) transformers were not operational at the non-block unit transformer yard and all transformers were in operation at the block unit transformer yard A total of three samples were taken at the non-block transformer yard, two (2) at non operational transformers Nos 3 and 6 (Samples YT2 and YT1), and one (1) on the railroad tracks near an oil delivery tank (Sample YT3) Two (2) samples were taken at the block unit transformer yards (Samples YT4 and YT5)

3 1 3 2 Testing Results

Following is the summary of analytical testing

Sample No	Results in PPM (mg/kg)	Comments
YT1	0 31	Aroclor 1254
YT2	0 26	Aroclor 1254
YT3	< 0 16	Additional "fingerprinting" analysis for 48 PCB congeners yielded a total PCB concentration of 0 0057 mg/kg
YT4	3 96	Aroclor 1254
YT5	28 4	Aroclor 1254


Fence
53ft
65ft
46ft
TR1
TR2
TR3
TR4
TR5
TR6
YT2
27ft
YT1
27ft
35ft
YT3
15ft
railroad tracks
Legend
YTn
sample number
YRn
non-block transformer platform
\yer_tes ppt
Figure 3 1-1
Burns and Roe
NOT to Scale
Sample Locations Sketch
Yerevan TES Transformer Yard No.1 (Non-Block Units)
Prepared by K Borushko
Approved by D Cooksley


Fence
YT4
TR6-b
TR6-b
TR7-b
TR7-b
4ft
56ft
34ft
5ft
YT5
2 Block Units Hall
Legend
YTn
sample number
YRn-b
block unit transformer platform
\yer_tes2 ppt
Figure 3 1-2
Burns and Roe
NOT to Scale
Sample Locations Sketch
Yerevan TES Transformer Yard No.2 (Block Units)
Prepared by K Borushko
Approved by D Cooksley

3 2 YEREVAN HPP

3 2 1 INTRODUCTION

Yerevan HPP 1 (No 1) was visited on 6 August 1997 Preliminary inspections took place in October 1996 A meeting was held with Mr Meruzhan Galstian, Director of the facility and Mr Galstian escorted the assessment team on a tour of the facility

3 2 2 OBSERVATIONS

Yerevan HPP 1 is the last of 7 hydropower facilities in the Hrazdan Cascade system

The following observations or statements are of note

3 2 2 1 Water Issues

- Untreated plant derived wastewater is discharged to the Hrazdan River It is unclear whether raw sewage is discharged to the River,
- On 6 August the facility was generating 3 - 3 5 MW of electricity with a corresponding flow of approximately 7 1 m^3/sec through the turbines The capacity of Yerevan HPP is 22 MW
- Recovery wells under the transformer area are possibly contaminated with transformer oil Depending upon site specific hydrologic conditions, transformer oil from the recovery wells may be a source of surface water or groundwater contamination,
- Any major leaks or spills in the bulk oil storage area would be directed to the Hrazdan River

3 2 2 2 Residual Management Issues

- Facility representatives stated that their main environmental problem is transformer and turbine oil leakage,
- No secondary containment is provided under transformers The facility relies on recovery wells under the transformers to recover oil in case of a spill,
- Facility representatives stated their desire for development of secondary containment under the transformers as well as under the bulk oil storage area,
- Turbine No 2 is planned to undergo refurbishment in one month,
- Four tanks, each capable of storing 10 tons, are present in the bulk oil storage area - Two tanks are dedicated to transformer oil and two tanks are dedicated to generator oil The facility recently completed refurbishment of the concrete bases of the tanks

- Since both turbines share a common transformer yard, soil samples for PCB analysis were taken (for safety reasons) outside the active transformer yard

3 2 3 PCB TESTING

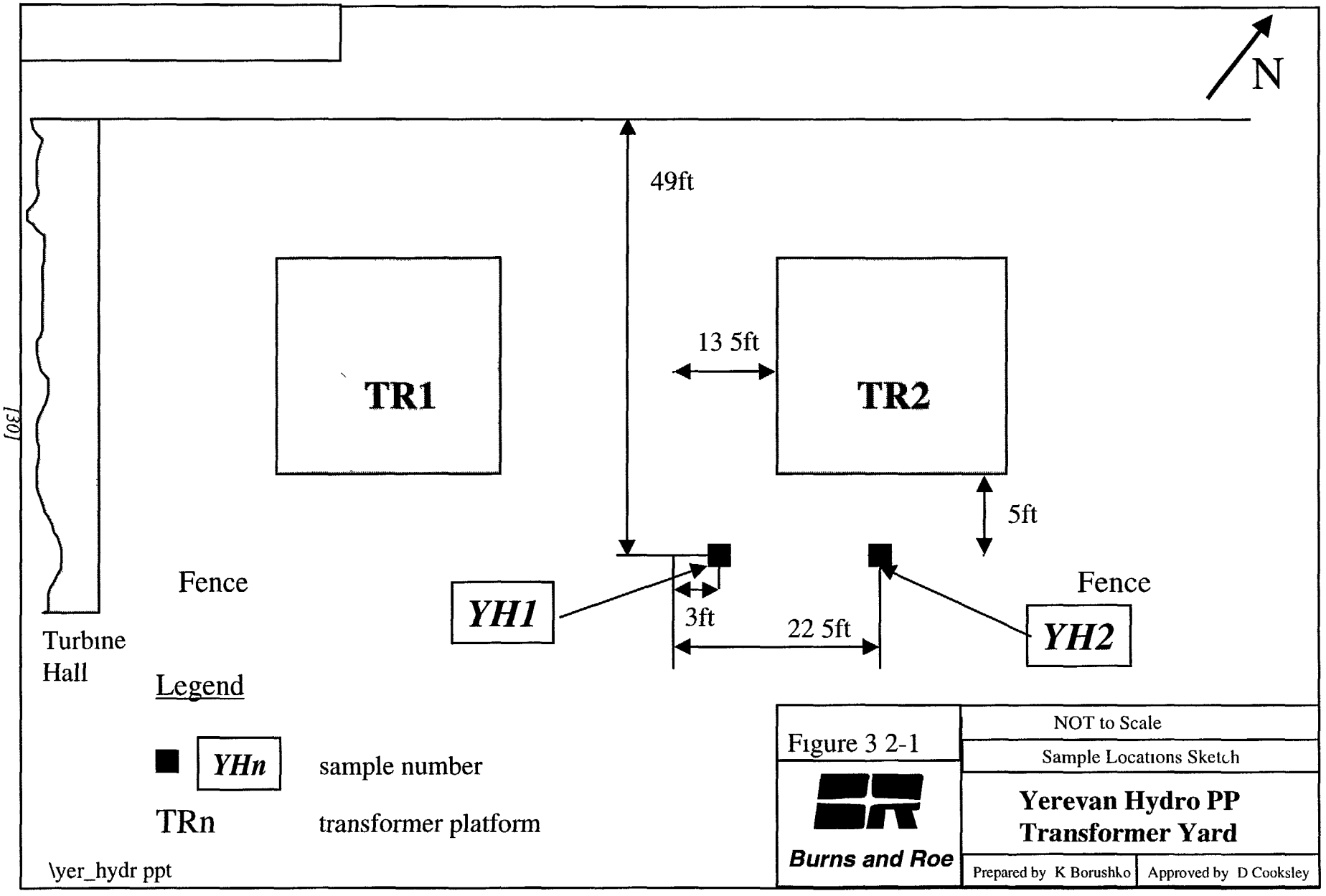
3 2 3 1 Testing Locations

Yerevan HPP 1 has one transformer yard Figure No 3 2-1 represents the layout and sample locations for testing At the time of the inspection, both transformers were operating at the transformer yard A total of two (2) samples were taken (Samples YH1 and YH2)

3 2 3 2 Testing Results

Following is the summary of analytical testing

Sample No	Results in PPM (mg/kg)	Comments
YH1	< 0 16	Preliminary field testing indicated the presence of PCBs The analytical results are below the limit of quantitation Therefore, it is unclear whether PCBs exist in the onsite soils
YH2	< 0 16	


N
49ft
13 5ft
TR1
TR2
5ft
Fence
Fence
YH1
YH2
3ft
22 5ft
Turbine
Hall
Legend
YHn
sample number
TRn
transformer platform
\yer_hydr ppt
Figure 3 2-1
Burns and Roe
NOT to Scale
Sample Locations Sketch
Yerevan Hydro PP
Transformer Yard
Prepared by K Borushko
Approved by D Cooksley

3 3 HRAZDAN TPP

3 3 1 INTRODUCTION

Hrazdan TPP was visited for the assessment portion of the program on 8 and 11 August 1997 Preliminary inspections took place in October 1996 Meetings were held with Mr Haik Arabian, Plant Director and Mr Edward Narcissian, Deputy Director of the facility Mr Narcissian escorted the assessment team on a tour of the facility

3 3 2 OBSERVATIONS

The Hrazdan TPP is the largest fossil fuel fired power plant in Armenia At the time of the August 1997 assessment, no visible emissions were being discharged from the facility stacks However, the adjacent concrete manufacturing facility had a significant plume being discharged from its stack

The following observations or statements are of note

3 3 2 1 Air Issues

- The facility is currently firing natural gas 90% of the time and mazut at a rate of 10% Mazut is typically fired in winter time only,
- Air emissions are currently controlled by - Temperature control, Flue gas recirculation, and Oxygen injection No air pollution abatement systems are installed at the facility,
- The facility has been receiving "high sulfur" mazut The facility has the capability to perform basic analyses of the mazut they receive,
- The facility completed construction of a new 270 m stack in 1990 which remains unused (see Plant Director concerns below)

The following calculated data has been provided for air emissions from Hrazdan TPP for 1992-96 Decreases are attributable to both a fuel switch (mazut to natural gas) and to decreased operating conditions Actual operating data which would be used to correlate emissions reductions to fuel type has been requested This data reflects the calculated emission levels based on fuel consumption data and mode of operation

	1992	1993	1994	1995	1996
Ash, t/yr	449 8	21 1	9 1	5 4	5 2
V_2O_5	96 5	4 1	4 3	4 7	4 8
SO_2, t/yr	25,131 3	1,985 1	1,280 2	672 9	342 2
NO_2, t/yr	4,514 6	1,558 9	2,465 4	3,373 9	1,445 6

Source Hrazdan TPP Management

3 3 2 2 Water Issues

- The facility derives its process water from the Marmarik River According to power plant officials, wastewater discharges are currently over the facility limit for mazut and wastewater discharges rarely exceed the limit for lubricating oil and transformer oil No actual water quality data was available,
- At full capacity when the facility is burning mazut, approximately 30 m^3 per hour of mazut contaminated wastewater is discharged to the Marmarik River The mazut contaminated wastewater is derived from contaminated mazut heating condensate and from other areas within the mazut storage area The oil/water separator located in the vicinity of the mazut storage area is "admittedly inefficient and beyond its useful life" according to facility representatives Prior to its discharge in the Marmarik River, the oil/water separator effluent flows to a settlement pond Note The Marmarik River is a tributary to the Hrazdan River,
- Reclaimed mazut from the above system is diverted to an underground temporary storage area which may be a source of groundwater contamination

3 3 2 3 Residual Management Issues

- The transformer oil and turbine oil storage area abuts a building and has earthen berms on 3 sides and above ground piping This storage area is sparsely lined with gravel, has vegetation growing between tanks, and the tanks are resting directly on the ground The facility has no formal tank testing or monitoring program,
- Soil samples for PCB analysis were taken below a limited number of inactive transformers

3 3 3 PCB TESTING

3 3 3 1 PCB Testing Locations

Hrazdan TPP has two operational transformer yards Figure Nos 3 3-1 and 3 3-2 represent the layouts and sample locations for PCB testing At the time of the inspection, two (2) transformers were not operational at the non-block unit transformer yard and three (3) transformers were not operational at the block unit transformer yard A total of four (4) samples were taken at the non-block transformer yard (Samples HT4, HT5, HT6, and HT7) Three (3) samples were taken at the block unit transformer yard (Samples HT1, HT2, and HT3)

3 3 3 2 Testing Results

Following is the summary of analytical testing

Sample No	Results in PPM (mg/kg)	Comments
HT1	1 42	Aroclor 1254
HT2	< 0 16	
HT3	1 15	Aroclor 1254
HT4	56	Aroclor 1254
HT5	12 8	Aroclor 1254
HT6	103	Aroclor 1254
HT7	**150**	Aroclor 1254 – Highest measured PCB result of the Assessment

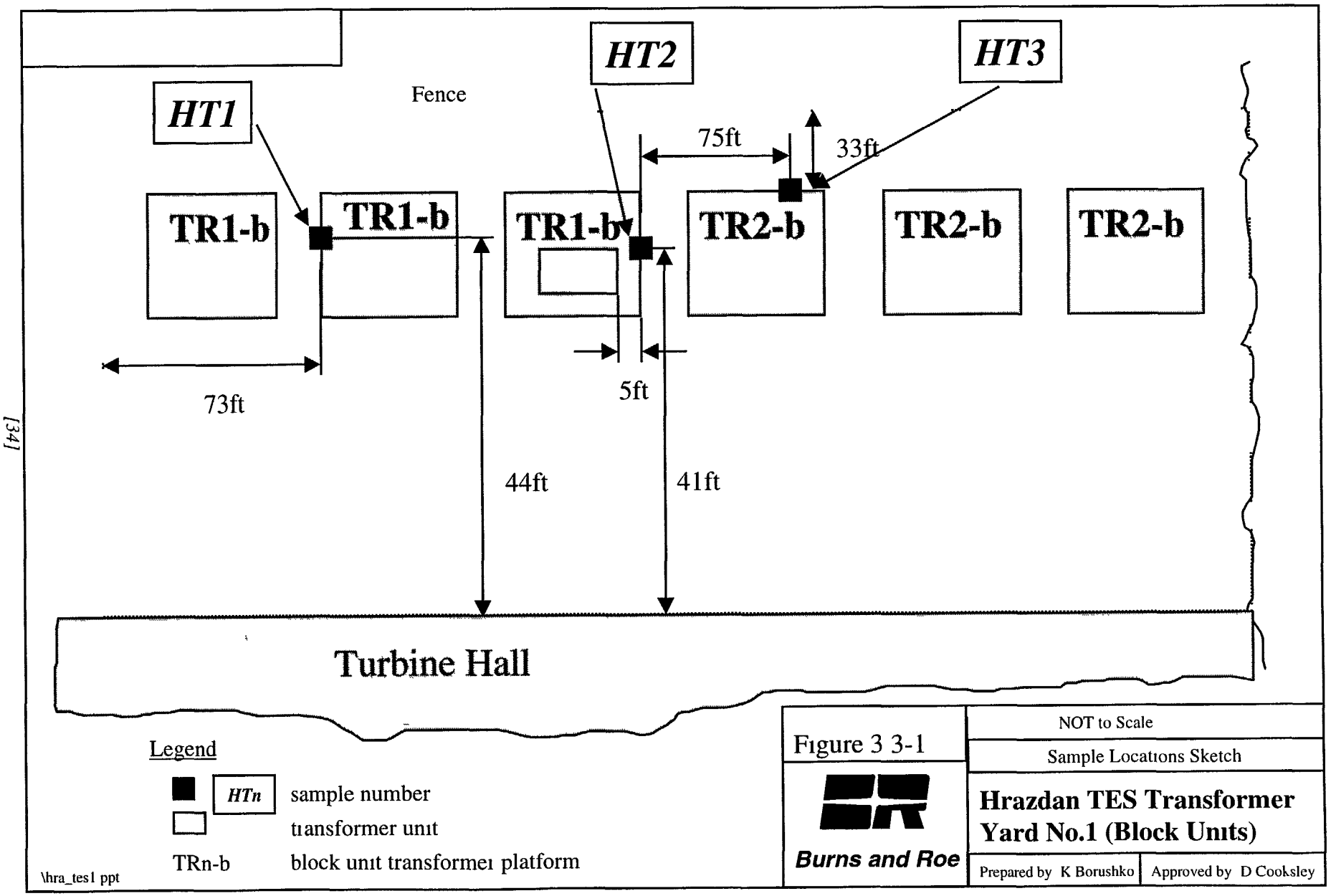
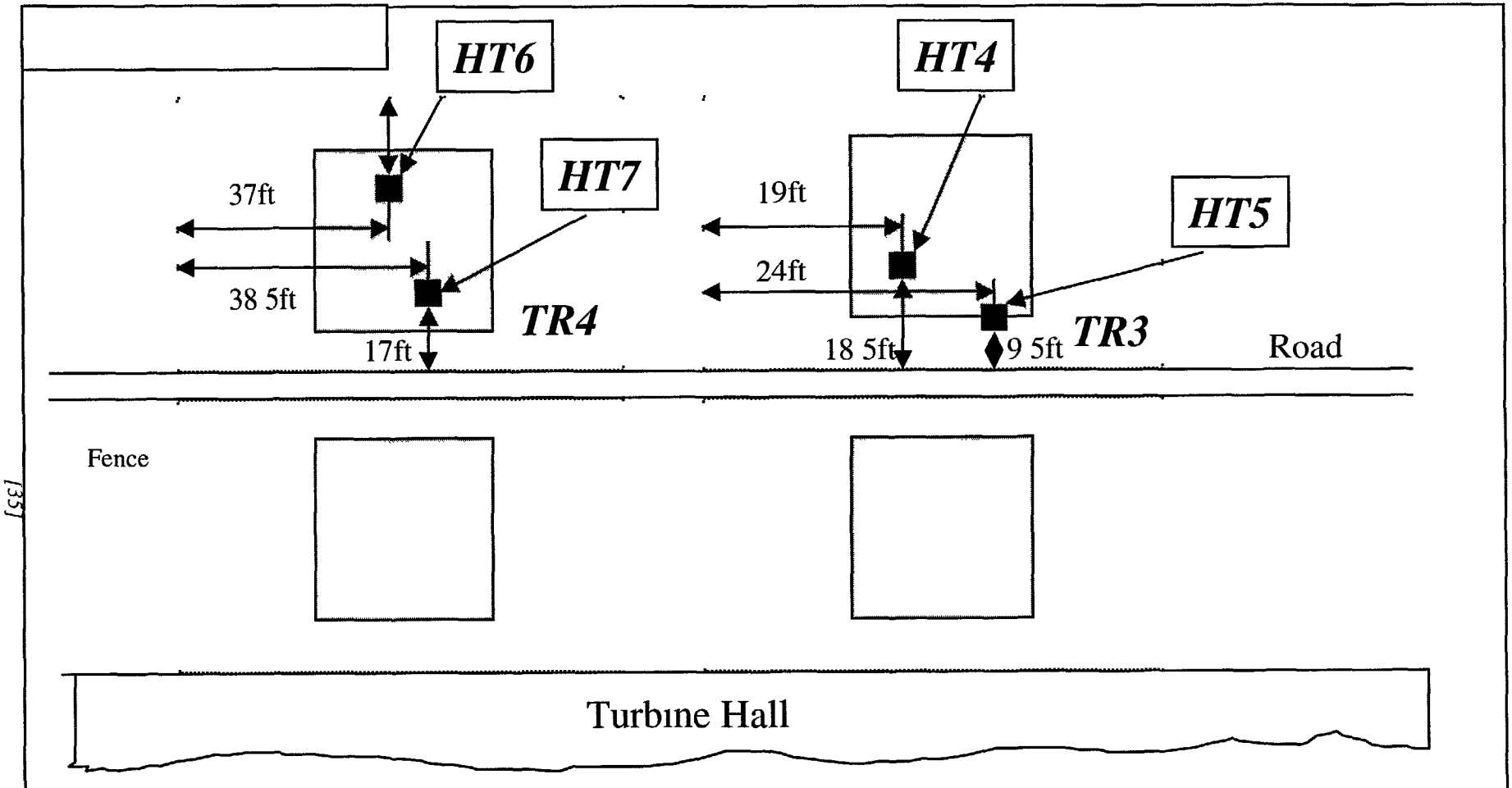

HT1
HT2
HT3
Fence
TR1-b
TR1-b
TR1-b
TR2-b
TR2-b
TR2-b
75ft
33ft
73ft
5ft
44ft
41ft
Turbine Hall
Legend
HTn
sample number
transformer unit
TRn-b
block unit transformer platform
NOT to Scale
Sample Locations Sketch
Burns and Roe
Hrazdan TES Transformer Yard No.1 (Block Units)
Prepared by K Borushko
Approved by D Cooksley
\hra_tes1 ppt

Figure 3 3-1



Legend

■ HTn sample number

TRn non-block unit transformer platform

Figure 3 3-2

Burns and Roe

NOT to Scale

Sample Locations Sketch

Hrazdan TES Transformer Yard No.2 (Non-Block Units)

Prepared by K Borushko | Approved by D Cooksley

\hra_tes2 ppt

3 3 4 OTHER COMMENTS AND CONCERNS

In our initial meeting, the Hrazdan Plant Director enumerated concerns with environmental overtones as follows

- There is a shortage of modern equipment to monitor the quality of stack emissions,
- There is a shortage of equipment to analyze the quality of mazut,
- Hrazdan TPP would like to phase out its reliance on asbestos insulation A German firm was proposing (two years ago) to set up a gypsum insulation plant, but the deal fell through Asbestos is the only insulation material currently available,
- The facility currently has a mazut storage capacity of 15,000 tons The Director believes that the mazut storage capacity should be able to accommodate 15 days of operation at full load which would require a capacity of 250,000 tons,
- There is significant exhaust gas leakage in the ducts leading from the boilers to the stack There is a project planned to replace the concrete duct panels with metal ducts, but there is a lack of funds (See Photo Nos 9, 10, and 11) The cover sheet of the Feasibility Study is included for reference as Appendix D,
- The facility has completed project plans and a feasibility study to reroute exhaust ducts to a larger (270 m) stack to aid in dispersion The boilers are currently connected to a smaller (180 m) stack (See Photo No 12) The cover sheet of the Feasibility Study is included for reference as Appendix E,
- The facility generates a sizable amount of secondary/unburned mazut that needs to be cleaned for reuse at the power plant Historically, this mazut was sold to other companies (asphalt plants) Hrazdan TPP lacks adequate storage systems for this mazut Hrazdan TPP currently stores this secondary/unburned mazut in small tanks which the Director feels are in an unsafe condition No assessment has been performed on these tanks,
- (Separate from the mazut contaminated wastewater described in the Observation Section above) The facility lacks oil/water separators to remove oil from feed water and technical water This equipment should function at approximately 10 liters per second

3 4 HRAZDAN HPP

3 4 1 INTRODUCTION

Hrazdan HPP was visited for the assessment portion of the program on 12 August 1997 Meetings were held with Mr Avakian, Facility Director Mr Avakian also escorted the assessment team on a tour of the facility

3 4 2 OBSERVATIONS

The Hrazdan HPP's major equipment is of German design and it was commissioned in 1959

The following observations or statements are of note

3 4 2 1 Water Issues

- Fifteen years ago the facility conducted a feasibility study to connect the plants sewage system to the neighboring town - this project was never completed As per original design the facility currently discharges its untreated sewage into the reservoir below the station which connects to the Hrazdan Canal,
- Generator oil passes through a water cooled heat exchanger This system has had leaks in the past,
- There are no oil/water separators present at the facility Any spills are cleaned up with water and discharged to the lower reservoir,
- The facility has two types of transformers
  Type 1 is called a unit transformer These transformers are connected to the local power grid There was a significant spill/accident in the unit transformer area in 1965 Currently, any spills or leaks in the unit transformer area are collected in a concrete basin and discharged to the lower reservoir The facility discharges oil products to the lower reservoir "because its storage was deemed a fire hazard " In addition, rainwater also collects in this concrete basin and, thus, oily rainwater is also discharged to the lower reservoir
  Type 2 is called a distribution transformer These transformers were connected to the former 330kV Caucasus Grid These transformers have been nonoperational for six years because "there is no longer a Caucasus Grid " The distribution transformers are currently filled with oil and are in a standby condition and are tested on a yearly basis The distribution transformer area is also underlain by the same concrete basin as described above,
- There was a series of concrete floor channels around the turbine house equipment which discharge to the turbine house water collector Water was present on most floors of the turbine house above the normal elevation The

turbine house water collector was covered with oil (See Photo No 13) The turbine house water collector discharges to the lower reservoir,

- Children were observed swimming at the water discharge outlet of the HPP In addition, a boat was observed with two men fishing from it in the lower reservoir No warning or restriction signs were in place,
- When asked about equipment needs, the Director stated that they are lacking an oil/water separator to remove turbine oil and transformer oil,
- On 12 August the facility was generating 56 - 58 MW of electricity with a corresponding flow of approximately 55 m^3/sec through the turbines The capacity of Hrazdan HPP is 82 MW and self-consumption of electricity is approximately 1 7 MW

3 4 2 2 Residual Management Issues

- The facility utilizes a small treatment system for used transformer oil The system employs a small centrifuge and filter presses The cleaned transformer oil is then reused The facility admits a lot of "losses" during the treatment process through leaks and spills which are then discharged to the lower reservoir Residuals from the cleaning process (including used filter media) are disposed of in an onsite burial ground/landfill (See Photo Nos 14 and 1) This burial ground/landfill is approximately 50 meters above the lower reservoir,
- The facility's turbine oil and generator oil has not been treated or drained and flushed for 15 years,
- There are two villages upstream of the Hrazdan HPP which discharge sewage and agricultural waste into the Hrazdan Canal The HPP has a coarse prefilter system (a steel net) to collect debris (pig skins, wood, etc) which requires daily cleaning to prevent these materials from fouling the intake and reducing water flow into the turbines The residuals that are removed from the prefilter system are "stored" adjacent to the intake area,
- Soil samples for PCB analysis were taken below inactive distribution transformers (Type 2) For safety reasons no samples were taken in the active unit transformer (Type 1) area,
- The facility has one emergency spillway which is perpendicular to the water supply channel The emergency spillway trends straight down the hillside and has no bends,

3 4 3 PCB TESTING

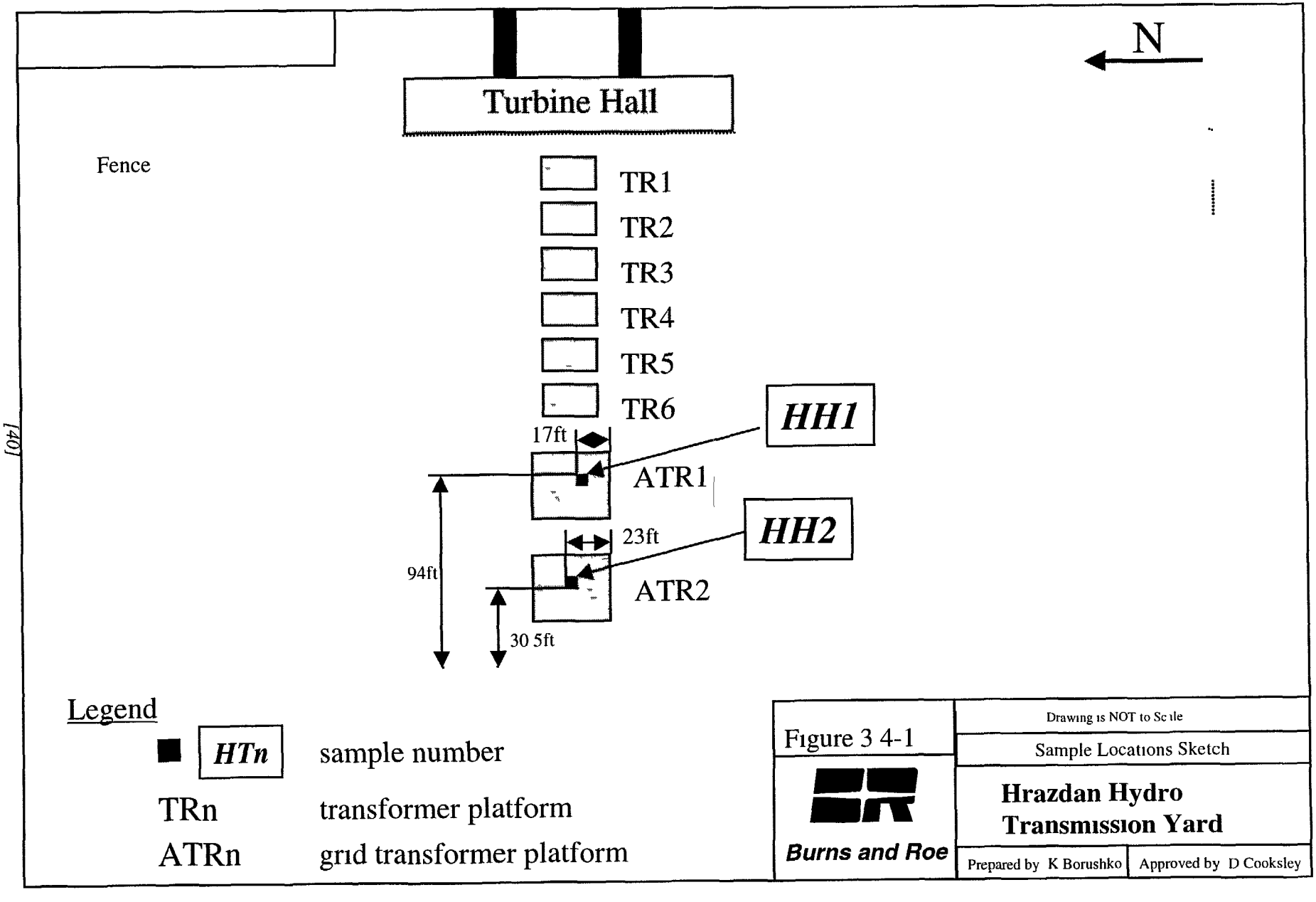
3 4 3 1 PCB Testing Locations

Hrazdan HPP has one transformer yard Figure No 3 4-1 represents the layout and PCB sample locations The yard consists of six (6) unit transformers and two (2) distribution connection transformers All unit transformers were in operation during the assessment A total of two (2) samples were taken (Samples HH1 and HH2) at the non-operating distribution connection transformers

3 4 3 2 Testing Results

Following is the summary of analytical testing

Sample No	Results in PPM (mg/kg)	Comments
HH1	< 0 16	Preliminary field testing indicated the presence of PCBs The analytical results are below the limit of quantitation Therefore, it is unclear whether PCBs exist in the onsite soils
HH2	< 0 16	


N
Turbine Hall
Fence
TR1
TR2
TR3
TR4
TR5
TR6
HH1
17ft
ATR1
HH2
23ft
94ft
ATR2
30 5ft
Legend
HTn
sample number
TRn
transformer platform
ATRn
grid transformer platform
Figure 3 4-1
Burns and Roe
Drawing is NOT to Scale
Sample Locations Sketch
Hrazdan Hydro
Transmission Yard
Prepared by K Borushko
Approved by D Cooksley

3 5 ARZINI HPP

3 5 1 INTRODUCTION

Arzini HPP was visited for the assessment portion of the program on 13 August 1997 Preliminary inspections took place in October 1996 A meeting was held with Mr Survesian, Facility Director Mr Survesian also escorted the assessment team on a tour of the facility

3 5 2 OBSERVATIONS

The Arzini HPP is unusually located inside a mountain of basalt which took 3 years to excavate All power plant components including transformers are located within the mountain The generators and turbines are over 40 years old and, on the mechanical side, spare parts are almost used up In addition, the facility's supply of sealing rings has been exhausted for the large globe valves which are used to regulate water flow to the turbines Both the inlet and outlet water pipes developed leaks in 1995 The facility receives its operating water supply from an 8 kilometer pipeline originating at the Hrazdan Canal and the facility discharges to the Hrazdan River On 13 August the initial flow drawn off the main Canal was 25 m^3/sec of which 16 m^3/sec was diverted for local irrigation needs and 8 m^3/sec was directed through the turbines

The following observations or statements are of note

3 5 2 1 Water Issues

- The facility uses a central drain system that collects water accumulated from throughout the station The central drain flows into 2 wells which are directed to an underground reservoir Pumps are used to withdraw the accumulated water out of the reservoir, through the wells, and discharge it to the Hrazdan River Historically, the facility used 4 pumps to transfer this wastewater Currently, only 2 pumps are serviceable and are leaking oil due to a lack of spare parts and age,
- As per original design the facility currently discharges its untreated sewage into the Hrazdan River,
- An oil/water heat exchanger is used to cool turbine and generator oil This system experienced a major leak in 1994 which has since been repaired,
- The transformer area has a spill/leak collection system which discharges to the River The transformers are washed down once per year for maintenance Wash water is discharged to the River untreated,
- The facility has four emergency side channels off of the water supply pipeline,

- The bottom floor of the turbine room was covered with 2 - 5 cm of water attributed, by the Director, to geological/groundwater intrusion,
- As a result of running the facility at a high capacity the last several years, significant erosion of soil has occurred behind a concrete revetment intended to protect the facility from high flows in the Hrazdan River (See Photo Nos 15 and 16) No comprehensive assessment of this problem has been conducted,
- Two transformer and two turbine oil storage tanks are located within an open air concrete walled storage area located approximately 10 meters from the River The storage area has drainage grates which discharge to the River side of the storage area Any rainwater, leaks , or spills within the oil storage area would flow unimpeded into the River,
- On 13 August the facility was generating 7 MW of electricity with a corresponding flow of 8 m^3/sec through the turbines The capacity of Arzini HPP is 70 MW and self-consumption of electricity is approximately 0 3 MW

3 5 2 2 Residual Management Issues

- Lubrication and cooling oil is periodically cleaned via a centrifuge and filter press system Paper filters and residue from the cleaning system are burned onsite One centrifuge and one filter press is available for this use (See Photo No 17,
- A dedicated centrifuge and filter press system is used to periodically clean transformer oil Paper filters and residue from the transformer oil cleaning system are burned onsite,
- According to the Director, agricultural facilities upstream of the HPP add a lot of soil, manure, and other wastes to the Hrazdan Canal The HPP employs a self-cleaning bar screen device to remove accumulated debris prior to the HPP's intake system The accumulated debris is stored onsite,
- Soil samples for PCB analysis were taken in the bulk oil storage area The transformer area is concrete lined and does not contain soil

3 5 3 PCB TESTING

3 5 3 1 Testing Locations

Arzini HPP has two (2) concrete transformer yards No soil was available for testing at the transformer yards Instead, an oil storage area was inspected Figure No 3 5-1 represents the layout and PCB sample locations The oil storage area consists of four (4) oil tanks, two (2) for transformer oil and two (2) for turbine oil A total of two (2) samples were taken (Samples AH1 and AH2) at the oil storage area

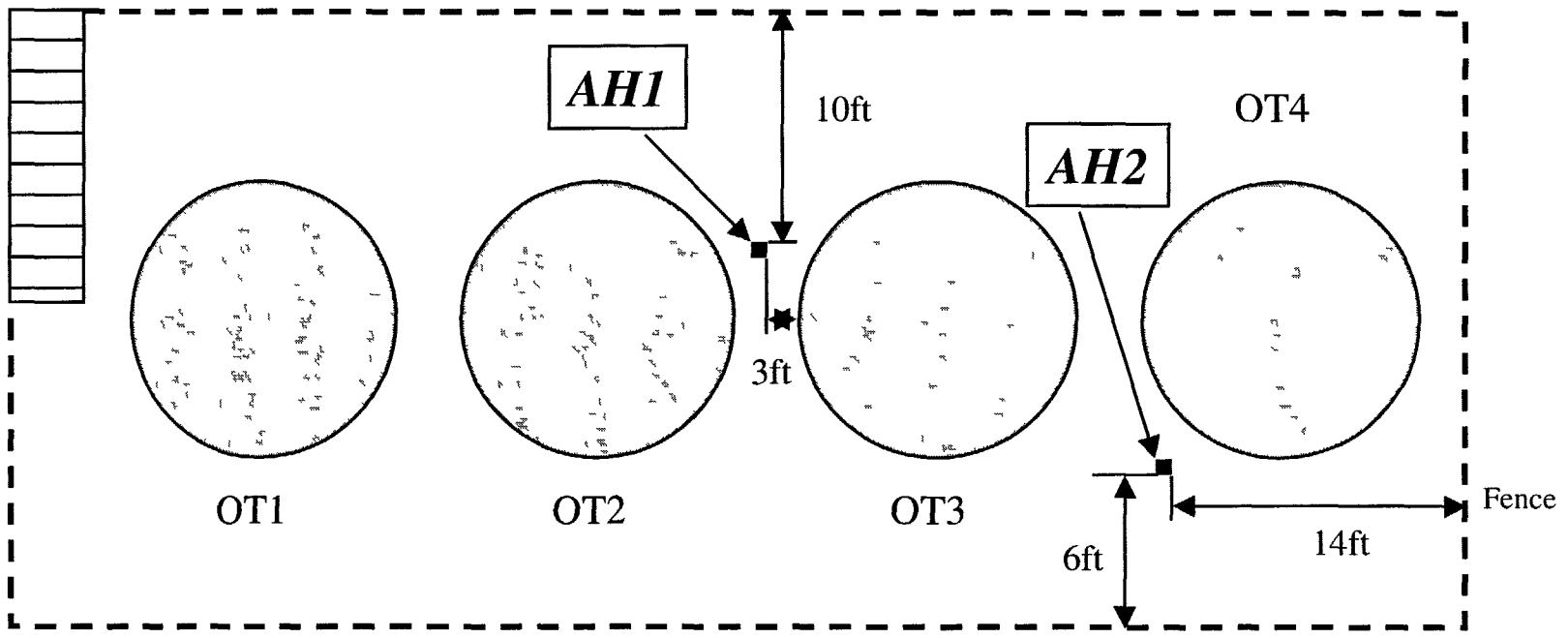
3 5 3 2 Testing Results

Following is the summary of analytical testing

Sample No	Results in PPM (mg/kg)	10 PPM Test
AH1	< 0 16	
AH2	0 18	Aroclor 1254 – Additional "fingerprinting" analysis for 48 PCB congeners yielded a total PCB concentration of 0 0304 mg/kg

Note Since the concentrations in sample AH2 are very low to begin with, a strong correlation cannot be made between Aroclor 1254 and the 48 congeners determined from the "fingerprinting" analysis However, the sum total of the 48 congeners accounts for 94% of the concentration of Aroclor 1254 Therefore, in higher concentration samples a strong correlation can be made between Aroclor 1254 and the 48 congeners

Transformer yard at Arzini HPP has no soil and is fully made out of concrete



Legend

■ *AHn* sample number

OTn oil tank platform

Figure 3 5-1

Burns and Roe

Drawing is NOT to Scale

Sample Locations Sketch

Arzini Hydro Oil Storage Yard

Prepared by K Borushko | Approved by D Cooksley

\arz_hyd ppt

3 6 GUMUSH HPP

3 6 1 INTRODUCTION

Gumush HPP was visited for the assessment portion of the program on 14 August 1997 Preliminary inspections took place in October 1996 A meeting was held with Mr Targom, Facility Director Mr Targom also escorted the assessment team on a tour of the facility

3 6 2 OBSERVATIONS

The Gumush HPP has experienced three emergencies due to landslides in the past The most recent event occurred in 1995 when a landslide destroyed most of the emergency spillway (See Photo No 18) The Landslide effectively created a "plug" in the Hrazdan River causing massive flooding and destruction at the facility The facility has been cleaned and placed back in partial service Due to the absence of the emergency spillway the facility cannot operate more than one turbine at a time for safety considerations An international tender was issued to reconstruct the spillway Eight companies have submitted bids and a decision/award was expected in September 1997 Funding for the project is being arranged through the Hrazdan Cascade Management Organization

The facility receives its operating water supply from an 18 kilometer channel originating at the Hrazdan Canal and the facility discharges to the Hrazdan River On 14 August the initial flow drawn off the main Canal was 32 m^3/sec of which 9 5 m^3/sec was diverted for local agricultural needs and 22 5 m^3/sec was directed through the turbines

The following observations or statements are of note

3 6 2 1 Water Issues

- As per original design the facility currently discharges its untreated sewage into the Hrazdan River,
- The transformer area is above and adjacent to the Hrazdan River All oil spills, leaks, and rainwater from the transformer area are directed to the River as per original design (See Photo Nos 19 and 20)
- On 14 August the facility was generating 56 MW of electricity with a corresponding flow of 22 5 m3/sec through the turbines The capacity of Gumush HPP is 211MW and self-consumption of electricity is approximately 2 MW

3 6 2 2 Residual Management Issues

- According to the Director, there are several villages along the length of the 18 km channel which supplies operating water to the HPP The facility has had problems with garbage and debris in the intake water and employs a mechanical net system to intercept this debris The residual material removed from the net system is either reused (e g , wood) or is placed in a pit and burned onsite,
- Prior to the most recent landslide, the facility used two centrifuge/filter press systems to clean turbine oil and transformer oil The oil cleaning systems were lost as the oil treatment facility they were located in was washed away in the landslide Prior to the landslide, oil treatment residuals were stored in a tank and sent offsite for reuse Spent paper filters were burned onsite The HPP is currently rebuilding the oil treatment facility and has been using a mobile oil treatment system which visits the HPP once per year,

3 6 3 PCB TESTING

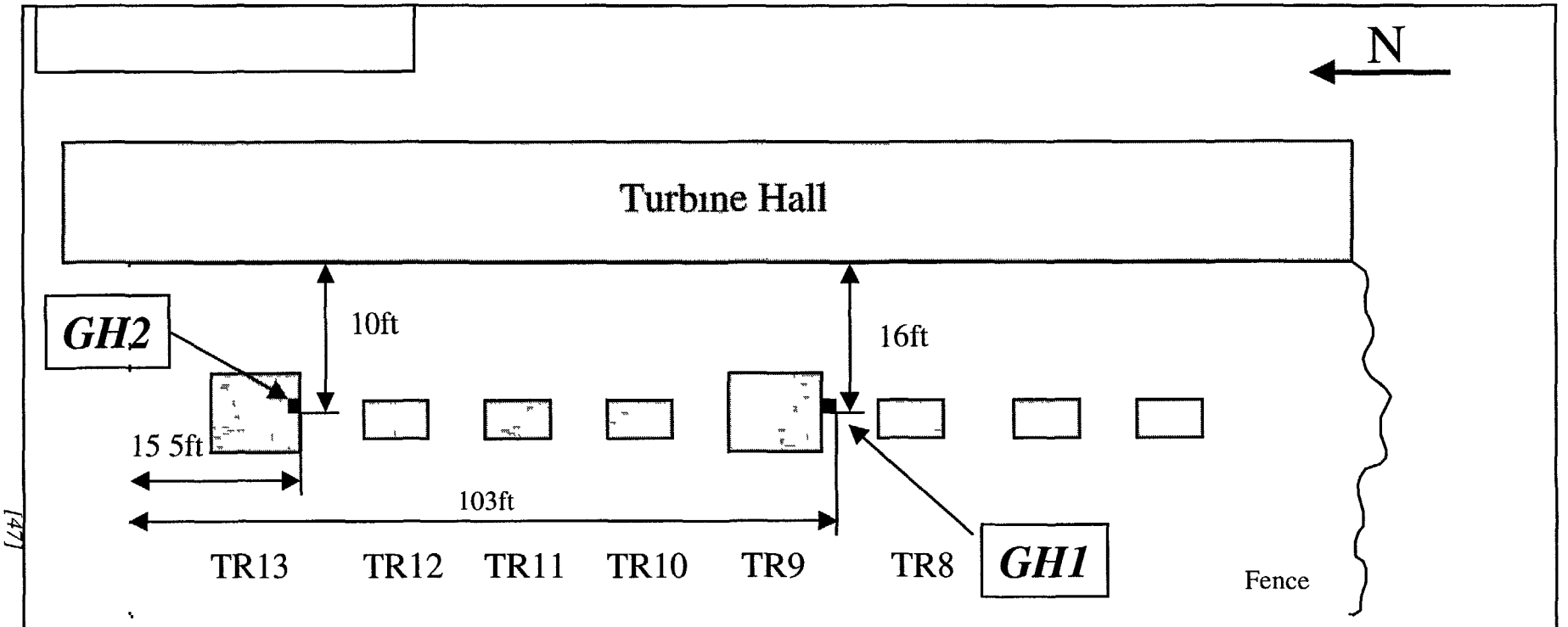
3 6 3 1 PCB Testing Locations

Gumush HPP has one transformer yard Figure No 3 6-1 represents the layout and PCB sample locations The yard consists of thirteen (13) transformers All, but two (2) transformers were in operation during the assessment A total of two (2) samples were taken (Samples GH1 and GH2) at the non-operating grid connection transformers Nos 13 and 9

3 6 3 2 Testing Results

Following is the summary of analytical testing

Sample No	Results in PPM (mg/kg)	Comments
GH1	2 79	Aroclor 1254
GH2	1 7	Aroclor 1254



Legend

■ *GTn* sample number

TRn transformer platform

Figure 3 6-1	Drawing is NOT to Scale
	Sample Locations Sketch
Burns and Roe	**Gumush Hydro Transmission Yard**
	Prepared by K Borushko / Approved by D Cooksley

\gumu_hyd ppt

3 7 ABOVIAN UNDERGROUND NATURAL GAS STORAGE FACILITY

3 7 1 INTRODUCTION

The Abovian storage facility uses 16 bedded salt caverns, which are in various stages of availability, for natural gas storage Storage operations at the site were begun in 1966 Some of the Abovian gas storage wells were harmed by the 1988 earthquake A comprehensive Report detailing inspection and maintenance requirements at the facility was issued in March 1997 for USAID Delivery Order No 20 and is entitled Natural Gas Storage and Transmission System Rehabilitation Program by Burns and Roe's subcontractor, International Gas Consultants, Inc

As part of the August 1997 site assessment activities, the assessment team visited the Abovian facility to review operations and to check on the status of recommendations detailed in the above mentioned Report Prior to meeting Mr Markalian, the Chief Engineer of the storage facility, the team had a brief meeting with Levon Mikaelyan, Deputy Head of Foreign Affairs at Armgazprom Mr Markalian escorted the team on a tour of the Abovian facility and compressor station

3 7 2 OBSERVATIONS

The following observations or statements are of note

3 7 2 1 Air Issues

- The Ministry of Environment conducts inspections at the facility with regard to leaks and emissions from the facility The inspection department "performs some calculations of leaks and emissions which are compared to various standards" and then issues an operating certificate The operating certificate is valid for a 2 year period The Abovian facility was undergoing the recertification procedure in August 1997 According to facility personnel, Abovian "has complied with the established norms 100% in the past " A copy of the "established norms" was unavailable,
- According to the Chief Engineer, leaks of natural gas occur primarily when the compressors are in operation After compressor operation has been completed, the facility performs "technical drainage" of the upstream and downstream lines This "technical drainage" which is vented to the atmosphere, releases approximately 50 m^3 of natural gas from each compressor,
- Once gas is in storage, the facility conducts daily walkdowns of active storage areas for leak detection No leak detection equipment is used, instead,

inspectors rely on smell and sound to detect leaks An official log book is maintained for leak inspection activities Previously supplied USAID leak detection equipment is being used to inspect the main gas distribution lines for leaks The Chief Engineer stated a need for leak detection equipment specifically ear-marked for the Abovian facility,

- The facility uses gas-fired compressors which, according to facility representatives, "discharge a large amount of CO " Also, the compressors "are burning a lot of oil " The Chief Engineer stated that he would have good use of a multigas (CO, SO_2, NO_x) monitor to measure the compressor emissions,
- Asbestos is only used to insulate the compressor exhaust manifolds Asbestos is requested as needed and is not stored onsite

3 7 2 2 Water Issues

- Brine storage is, potentially, a major water quality issue at the Abovian facility Previous users of brine (salt production and chemical facilities) are no longer taking deliveries due to reduced production needs Onsite brine storage facilities at Abovian are nearly full Four 1000 m^3 tanks are full, Of three storage wells - One well is 100% full - One well is 50% full - One well is 30% full The facility currently has approximately 75,000 m^3 of brine in storage The facility partially completed a brine storage pond but currently lacks the funds to complete the project (approximately $US 1 Mln needed) Previous inspections of the facility noted leaking brine transmission pipelines,
- The facility has no oil/water separators The facility generates oily water during maintenance activities and occasionally through leaks and spills This oily wastewater "is discharged to the Hrazdan River because (they) have no use for it (onsite) "

3 7 3 OTHER ISSUES

A number of environmental, safety and health (ES&H) related issues are discussed in the International Gas Consultants, Inc (IGC) Report referenced above As part of the August 1997 assessment, the status of several ES&H issues were discussed to see if the facility had taken any action on them The issues discussed below contain subject page references to the March 1997 version of the IGC Report All information is current as of the 19 August 1997 site visit

- Compressor unit safety devices (IGC pg 10) continue to be nonfunctional The facility initiated repair of these items but ran out of funding,
- No dew point measurement device (IGC pg 10) has been installed No action or procurement plans have been made through USAID or independent financial sources,

- With regard to upgrading the testing laboratory (IGC pg 20), the facility received a new gas chromatograph through USAID
- No contingency plans have been developed for brine storage,
- With regard to well and cavern inspections (IGC pg 33) - The caverns that currently contain brine were (according to facility representatives) most detrimentally affected by the 1988 earthquake Since the facility has no place to put the brine, these caverns cannot be inspected In caverns that do not have brine - the facility performs maintenance on these areas but lacks the funding to inspect them,
- With regard to freshwater cooling pumps (IGC pg 32) - Four new pumps are being delivered as part of the USAID spare parts assistance

4 0 LOCATION OF SENSITIVE ENVIRONMENTAL RECEPTORS

Since the focus of this Report is the environmental effects from the electrical energy production sector that are most likely to impact the health and safety of the Armenian people, the primary receptors are recreational users of the Canal and River, foodstuffs and consumers of those products that receive irrigation water from the Hrazdan River and Canal, all power plant personnel, and, potentially, local and distributed water supply systems

As was witnessed in the August 1997 site visits, scores of individuals were observed fishing and swimming along and within the Hrazdan River At the Hrazdan HPP, children were observed diving into the lower reservoir immediately downstream of the turbulent discharge waters Currently, dilution may be mitigating adverse impacts to recreational users of the River from sewage-borne contaminants and their associated illnesses No warning signs were installed along the Hrazdan River in the areas that the assessment team visited

As discussed in Section 2 4 2 2, a portion of the Hrazdan Canal is used throughout the Cascade system for irrigation purposes The final destination of the Canal is the Ararat Valley irrigation system As previously noted, raw sewage, oil and PCB contaminated wastewater and nominally treated waste technical water is discharged to the Hrazdan Canal and the Hrazdan River Since current discharge practices have been occurring for decades, it is postulated that an overall increase of organic and inorganic contaminants may be measurable on lands receiving irrigation water from the Canal and River Threshold limit values may or may not have been exceeded which would have an overlying heath impact to farm workers and, depending on the crop, consumers of foodstuffs

Power plant personnel are at risk at each of the assessed facilities due unrestricted exposure to asbestos, PCBs and residuals of PCB combustion According to the USEPA, there are a number of adverse health effects associated with PCBs Tests on animals show that PCBs can harm reproduction and growth, and can cause skin lesions and tumors When PCB fluid is partially burned - as it may be in a transformer fire or when paper filters and residuals of transformer oil cleaning systems are ignited - the PCB fluid produces by-products, which include polychlorinated dibenzodioxin and polychlorinated dibenzofurans (dioxins and furans), that are much more toxic than the PCBs themselves Tests on rats show that furans can cause anemia and other blood problems Dioxin is associated with a number of health risks, and has been shown to cause cancer of the liver, mouth, adrenal gland, and lungs in laboratory animals

In addition, The World Health Organization, in its Fiftieth World Health Assembly which met in Geneva in May 1997, adopted a resolution on the promotion of chemical safety, with special attention to persistent organic pollutants (POPs), including PCBs POPs are compounds that resist photolytic, chemical and biological degradation and are characterized by high lipid solubility, which results in accumulation in fatty tissues of living organisms The International Programme on Chemical Safety (IPCS) has carried out a toxicological assessment of twelve persistent organic pollutants which includes PCBs and it concluded that there was sufficient evidence to demonstrate the need for international action on these substances

Current international limits for PCBs and Dioxin are included below as Tables 4 0-1 and 4 0-2

Table 4 0-1
Selected PCB International Regulatory Limits

Location	Workplace Air TWA[1] (mg/m3)	Drinking Water (ug/l)	Permissible Cleanup Levels in Soil (mg/kg)[2]
USEPA	0 5 - 1 0	0 000044	-
Average US State Limit	-	0 28	0 6, n/a, 4 2
Canada	-	0 001	5, 0 5, 50
England	0 5 - 1 0	-	-
Japan	0 01	-	-
Germany	-	-	0 2, 0 5, 5

Notes
[1] - TWA = Time-weighted average the average concentration for normal 8-hour work day and a 40-hour work week to which nearly all workers may be repeatedly exposed without adverse effect
[2] - Permissible cleanup levels in soil are surface soil concentrations Limits are given in the following order Residential limit, Agricultural limit, Industrial limit
- A dash "-" or n/a means no established limit
- PCBs are typically expressed as $C_{12}H_6Cl_4$

Table 4 0-2
Selected Dioxin International Regulatory Limits

Location	Ambient Air Annual Average (ug/m3)	Drinking Water (ug/l)	Permissible Cleanup Levels in Soil (mg/kg)[1]
USEPA	-	0 000000013	-
Average US State Limit	0 000015	0 0018	0 0000082, n/a, 0 00002
Canada	-	-	0 0001, 0 00001, n/a
Germany	-	-	0 000001, n/a, n/a

Notes
[1] - Permissible cleanup levels in soil limits are given in the following order Residential limit, Agricultural limit, Industrial limit
- A dash "-" or n/a means no established limit
- Dioxin is typically expressed as $C_{12}H_4Cl_4O_2$

Asbestos was present at all facilities assessed The carcinogenity of asbestos to exposed individuals is well documented In addition, links to workplace exposure and subsequent exposure to family members due to asbestos fibers on work clothes is a very real danger

Asbestos regulatory limits are printed below in Table 4 0-3

Table 4 0-3
Selected Asbestos International Regulatory Limits

Location	Workplace Air TWA[1] (fibers/l)	Drinking Water	Ambient Air Annual Average (ug/m^3)
USA (NIOSH)	100	-	-
Average US State Limit	-	5 3 million fibers/L	1 0
Australia	100	-	-
England	200	-	-
Israel	400	-	-
Germany	250	-	-

Notes
[1] TWA = Time-weighted average, the average concentration for normal 8-hour work day and a 40-hour work week to which nearly all workers may be repeatedly exposed without adverse effect
- NIOSH = National Institute for Occupational Safety and Health

Local and distributed water supply systems may be at risk due to storage, handling and disposal practices at the facilities assessed Unfortunately, minimal information regarding the location of public and private potable water supply sources was available to the assessment team

4 1 SUMMARY AND PRIORITIZATION OF ENVIRONMENTAL ISSUES

Tables 4 1-1 through 4 1-4 have been provided to prioritize the environmental risks perceived from qualitative inputs based on observed practices at the sites Although a formal risk assessment was not conducted as part of project activities, nor was there sufficient data to support such an undertaking, the following Tables have been assembled based on the observations and judgement of assessment staff and senior project management

Table 4 1-1
Summary of Environmental Conditions

	Yerevan TPP	Yerevan HPP	Hrazdan TPP	Hrazdan HPP	Arzini HPP	Gumush HPP	Abovian	Switch-yards
OPERATIONS								
PCB Issues								
Lack of knowledge of PCB presence/hazards	●	●	●	●	●	●	na	●
Burning of transformer oil residuals	●	●	●	●	●	●	na	nd
Disposal of transformer oil residuals	●	●	●	●	●	●	na	nd
Water Issues								
Discharge of untreated sewage	nd	nd	nd	●	●	●	nd	nd
Wastewater discharges impact on agriculture	nd	nd	nd	nd	nd	nd	nd	na
Wastewater discharges impact on fisheries and recreation	nd	nd	nd	nd	nd	nd	nd	na
Lack of oil/water separators	na	●	na	●	●	●	na	na
Inefficient oil/water separators	●	na	●	na	na	na	na	na
Treatment and disposal of technical water	◉	na	◉	na	na	na	(brine) ●	na
Lack of actual water emissions monitoring	◉	O	◉	O	O	O	nd	na
Air Issues								
Impact of air emissions	nd	na	nd	na	na	na	nd	na
Flue gas duct integrity	◉	na	●	na	na	na	na	na
Lack of actual air emissions monitoring	◉	na	◉	na	na	na	O	na
Solid Waste Issues								
Burning of solid waste	◉	◉	◉	◉	◉	◉	nd	O
Disposal of solid waste	O	O	O	◉	◉	◉	nd	O
Other Issues								
Structural integrity of spillway(s)	na	nd	na	nd	nd	●	na	na
Asbestos storage practices	●	O	◉	O	O	O	O	na

Table 4 1-1
(Continued)

	Yerevan TPP	Yerevan HPP	Hrazdan TPP	Hrazdan HPP	Arzini HPP	Gumush HPP	Abovian	Switch-yards
PCB SOIL CONTAMINATION	●	⊙	●	⊙	⊙	●	na	⊙
SECONDARY CONTAINMENT								
Transformer oil leaks/spills into water bodies	O	●	O	●	●	●	na	O
Transformer oil leaks/spills onto soils	⊙	⊙	⊙	⊙	na	na	na	⊙
Mazut leaks/spills into water bodies	⊙	na	⊙	na	na	na	na	na
Mazut leaks/spills onto soil	⊙	na	⊙	na	na	na	na	na
Bulk liquid (chemicals, oil, etc) leaks/spills	O	●	O	⊙	●	●	na	⊙
MANAGEMENT								
Spill response/management plans	⊙	●	⊙	●	●	●	O	⊙
PCB management plan	●	●	●	●	●	●	nd	●
PCB oil and residual materials disposal	nd	nd	nd	nd	nd	nd	nd	nd
Asbestos management procedures	●	O	⊙	O	O	O	O	na

Legend
● - major concern
⊙- median concern
O - minor concern
nd - not determined
na - not applicable

Table 4 1-2
Recommended Corrective Measures

Environmental Condition	Corrective Measure
OPERATIONS	
PCB Issues	
Lack of knowledge of PCB presence/hazards	Institute onsite PCB Awareness and Handling Training Initiate testing of transformer oil for PCBs at all switchyards which will be rehabilitated under the World Bank project
Burning of transformer oil residuals	Due to dioxin concern - Ministry of Energy should issue a "Cease and Desist" Order immediately to eliminate this activity
Disposal of transformer oil residuals	Development of a comprehensive Energy Sector Solid Waste Management Plan Containerize residuals onsite until final disposition is determined
Water Issues	
Discharge of untreated sewage	Initiate a Point Source Inventory Study for the Hrazdan River and Hrazdan Canal This Inventory will assist in the subsequent Scope of Work development for future infrastructure improvements
Wastewater discharges impact on agriculture	Determine quantity and quality of wastewater discharges and estimate effects Develop monitoring programs to include sampling of agricultural soils
Wastewater discharges impact on fisheries and recreation	Determine quantity and quality of wastewater discharges and estimate effects Develop monitoring programs to include sampling of river sediments
Lack of oil/water separators	Procurement of and operator training on low maintenance oil/water separation equipment This equipment should meet or exceed any anticipated water quality discharge standards
Inefficient oil/water separators	Procurement of and operator training on low maintenance oil/water separation equipment This equipment should meet or exceed any anticipated water quality discharge standards
Treatment and disposal of technical water	Determine quantity and quality of wastewater discharges and estimate effects Include new treatment regime provision in long term power plant rehabilitation planning
Lack of actual water emissions monitoring	Develop monitoring programs in conjunction with the Ministry of Environment Determine equipment needs frequency of measurements, etc
Air Issues	
Impact of air emissions	Determine quantity and quality of air emissions and estimate effects Adopt an appropriately modified USEPA air model Compare modeled and expected impacts with available ambient air data to refine air model and establish a basis for impact assessment of new and existing enterprises
Flue gas duct integrity	Include provision to replace ducts in long term power plant rehabilitation planning
Lack of actual air emissions monitoring	Develop monitoring programs in conjunction with the Ministry of Environment Determine equipment needs frequency of measurements, etc

Table 4 1-2 (Continued)

Environmental Condition	Corrective Measure
Solid Waste Issues	
Burning of solid waste	The Ministry of Energy should issue a "Cease and Desist' Order immediately to eliminate this activity
Disposal of solid waste	Development of a comprehensive Energy Sector Solid Waste Management Plan
Other Issues	
Structural integrity of spillway(s)	Civil engineering surveys are required to assess the current conditions and integrity of all HPP spillways as well as active discharge revetments
Asbestos storage practices	Institute onsite asbestos awareness and handling training Initiate relocation and low-cost reconstruction (e g , modular building) of asbestos storage areas
PCB SOIL CONTAMINATION	
1 - 10 PPM	Initiate site assessments to further define the extent of PCB contamination
> 10 PPM	Initiate site assessments to further define the extent of PCB contamination and support development of remediation plan
SECONDARY CONTAINMENT	
Transformer oil leaks/spills into water bodies	Immediately block (seal) transformer area drainage points which discharge directly to water bodies
Transformer oil leaks/spills onto soils	Rehabilitate existing structures OR provide structurally sound secondary containment
Mazut leaks/spills into water bodies	Rehabilitate existing structures OR provide structurally sound secondary containment AND procure oil/water separation equipment for mazut condensate treatment
Mazut leaks/spills onto soil	Rehabilitate existing structures OR provide structurally sound secondary containment
Bulk liquid (chemicals, oil, etc) leaks/spills	Immediately block (seal) bulk liquid storage area drainage points which discharge directly to water bodies
MANAGEMENT	
Spill response/management plans	Develop site specific Spill Response/Management Plans for all energy sector facilities
PCB management plan	Develop and implement a phase out program as outlined in Section 5 2 1 of the Environmental Assessment Report
PCB oil and residual materials disposal	Adoption, by the Ministry of Environment, of an overall hazardous materials treatment, storage, and disposal protocol/management plan to include possible arrangements with other FSU Republics on PCB contaminated materials disposal
Asbestos management procedures	Ministry of Energy should develop a formal Asbestos Management Program to include, at a minimum training and onsite availability of personal protective equipment

Table 4 1-3
Recommendations For Prioritization of Environmental Issues

Issue	Rank*	Comments
PCB management plan	22	Initiate development of plan in conjunction with PCB Awareness and Handling Training
Lack of knowledge of PCB presence/hazards	21	Initiate testing of transformer oil for PCBs at all switchyards involved with the World Bank project Institute onsite PCB Awareness and Handling Training at all applicable energy sector facilities
Spill response/management plans	19	
Burning of transformer oil residuals	18	Issue a "Cease and Desist" Order immediately due to dioxin concern
Disposal of transformer oil residuals	18	
PCB soil contamination	17	
Transformer oil leaks/spills into water bodies	15	Initiate Corrective Measures immediately due to imminent and ongoing threat
Bulk liquid (chemicals, oil, etc) leaks/spills	15	Initiate Corrective Measures immediately due to imminent and ongoing threat
Burning of solid waste	13+	
Lack of oil/water separators	12	
Disposal of solid waste	10+	
Asbestos storage practices	10	
Transformer oil leaks/spills onto soils	10	
Asbestos management procedures	10	
Discharge of untreated sewage	9+	Pending further study, this issue may have significant public health ramifications
Treatment and disposal of technical water	9	
Lack of actual water emissions monitoring	8+	
Inefficient oil/water separators	6	
Flue gas duct integrity	5	
Lack of actual air emissions monitoring	5	
Mazut leaks/spills into water bodies	4	
Mazut leaks/spills onto soil	4	
Structural integrity of spillway(s)	3+	Pending further study, this issue may have significant public safety ramifications
Wastewater discharges - impact on agriculture	nd	Not determined pending further study
Wastewater discharges - impact on fisheries and recreation	nd	Not determined pending further study
Impact of air emissions	nd	Not determined pending further study
PCB oil and residual materials disposal	nd	Not determined pending further study

Notes * - Numerical rank is based on a sum of the concerns presented in **Table 4 1-1** as follows
● - major concern = 3 "points" ○ - median concern = 2 "points" O - minor concern = 1 "point"
This subjective ranking is based on information available at the time of the issuance of the Final Environmental Assessment Report
- Some "not determined " issues may have greater health and safety consequences than higher ranked issues

Table 4 1-4
Recommendations For Prioritization of Environmental Issues by Site

Issue	Overall Issue Rank*	Site Rank							
		Yerevan TPP	Yerevan HPP	Hrazdan TPP	Hrazdan HPP	Arzini HPP	Gumush HPP	Abovian	Switch-yards
PCB management plan	22	●	●	●	●	●	●	na	●
Lack of knowledge of PCB presence/hazards	21	●	●	●	●	●	●	na	●
Burning of transformer oil residuals	20	●	●	●	●	●	●	na	⭘
Disposal of transformer oil residuals	20	●	●	●	●	●	●	na	⭘
Spill response/management plans	19	⭘	●	⭘	●	●	●	O	⭘
PCB soil contamination	17	●	⭘	●	⭘	⭘	●	na	⭘
Transformer oil leaks/spills into water bodies	15	O	●	O	●	●	●	na	O
Bulk liquid (chemicals, oil, etc) leaks/spills	15	O	●	O	⭘	●	●	na	⭘
Burning of solid waste	13+	⭘	⭘	⭘	⭘	⭘	⭘	nd	O
Lack of oil/water separators	12	na	●	na	●	●	●	na	nd
Disposal of solid waste	10+	O	O	O	⭘	⭘	⭘	nd	O
Asbestos storage practices	10	●	O	⭘	O	O	O	O	na
Transformer oil leaks/spills onto soils	10	⭘	⭘	⭘	⭘	na	na	na	⭘
Asbestos management procedures	10	●	O	⭘	O	O	O	O	na
Discharge of untreated sewage	9+	nd	nd	nd	●	●	●	nd	nd
Treatment and disposal of technical water	9	⭘	na	⭘	na	na	na	(brine)●	na
Lack of actual water emissions monitoring	8+	⭘	O	⭘	O	O	O	nd	na
Inefficient oil/water separators	6	●	na	●	na	na	na	na	nd
Flue gas duct integrity	5	⭘	na	●	na	na	na	na	na
Lack of actual air emissions monitoring	4	⭘	na	⭘	na	na	na	na	na
Mazut leaks/spills into water bodies	4	⭘	na	⭘	na	na	na	na	na
Mazut leaks/spills onto soil	4	⭘	na	⭘	na	na	na	na	na
Structural integrity of spillway(s)	3+	na	nd	na	nd	nd	●	na	na
Wastewater discharges - impact on agriculture	nd	nd	nd	nd	nd	nd	nd	nd	na
Wastewater discharges - impact on fisheries and recreation	nd	nd	nd	nd	nd	nd	nd	nd	na
Impact of air emissions	nd	nd	na	nd	na	na	na	nd	na
PCB oil and residual materials disposal	nd	nd	nd	nd	nd	nd	nd	na	nd

Notes * - Overall Issue Rank is based on a sum of the concerns presented in **Table 4 1-1** as follows
● - major concern = 3 "points' ⭘ - median concern = 2 "points" O - minor concern = 1 "point"
- This subjective ranking is based on information available at the time of the issuance of the Draft Environmental Assessment Report
- Some "not determined " issues may have greater health and safety consequences than higher ranked issues

5 0 RECOMMENDATIONS

5 1 DATA COLLECTION AND MANAGEMENT

Since no guidance documentation was found in Armenia regarding data collection and management with regard to environmental contamination studies, the following Section provides an overview of recommended site investigation data collection and management criteria

A site investigation is conducted to determine the nature and extent of contamination on site, evaluate the environmental and public risk associated with contamination and support the development of a remedial action to clean-up the site Physical and chemical data as well as site background information collected during the site investigation and regulatory guidelines identified during the project planning stage will drive the selection, design, and implementation of the remedial action

This approach is illustrated in Figure 5 1-1 and consists of the following major tasks

Development of Work Plan -- The Plan will define the technical approach for the site, costs for investigation, and determine project responsibilities It shall include sampling and analysis, quality assurance/quality control measures, and health and safety measures

Review of Existing Site Information -- This is done to develop a preliminary risk assessment and to help in the sampling and analysis The information collected in this stage shall help to identify and establish baseline soil, water and ground water characteristics

Risk Assessment -- The Assessment will provide the baseline risk analysis for a no-action alternative and give guidance in evaluating whether remedial technologies considered for the site will meet health and environmental goals established by the project The Assessment is based on the type and extent of contamination, potential migration pathways, distance to potential receptors, and the effect this contamination may have on a receptor Figure 5 1-2 provides the logic behind the risk assessment approach

Development of Project Plans -- Plans typically developed are the Sampling and Analysis Plan, QA Plan, Health and Safety Plan The Sampling and Analysis

Plan (SAP) should be developed for any site investigation where field work shall be conducted The plan provides site specific guidance on sampling methods and design, location and number of samples, QA protocols, lab analysis and data reporting, and health and safety procedures The following items shall be reflected in the SAP

- Sampling objectives and Scope
- Standard operating procedures for sampling
- Instrument calibration procedures
- Sampling equipment specifications
- Number, location and types of samples
- Analysis to be performed on a sample

A QA Plan shall contain the requirements for all field activities and laboratory procedures A Health and Safety Plan (HSP) is prepared to insure that all safety aspects of site operations are thoroughly examined prior to commencing field work

Data Evaluation -- Analytical procedures for PCB analysis are available from various organizations, including USEPA, ANSI, ASTM, FDA, and others Selection of an analytical method for determination of PCB concentration in soil depends on the following criteria

- Detection level required
- Clean-up objectives
- Required country regulations governing site clean-up
- Site specific clean-up goals
- Analysis cost and timeframe

Analysis in the field can be used for preliminary site assessments to determine the presence or absence of PCBs on site In this case, the field analysis is used as a screening tool providing qualitative results, rather than a method for determining the exact nature and concentration of on-site PCB contamination

A detailed data evaluation is conducted for data generated during the site characterization The existing conditions and the environmental assessment data are combined and evaluated to assist in data sorting and trend tracing Data, in this case, would include description and quantification of contaminants, contaminant vertical and horizontal distribution, chemical characteristics of the pollutant and its migration path

Figure 5 1-1

Site Characterization Approach

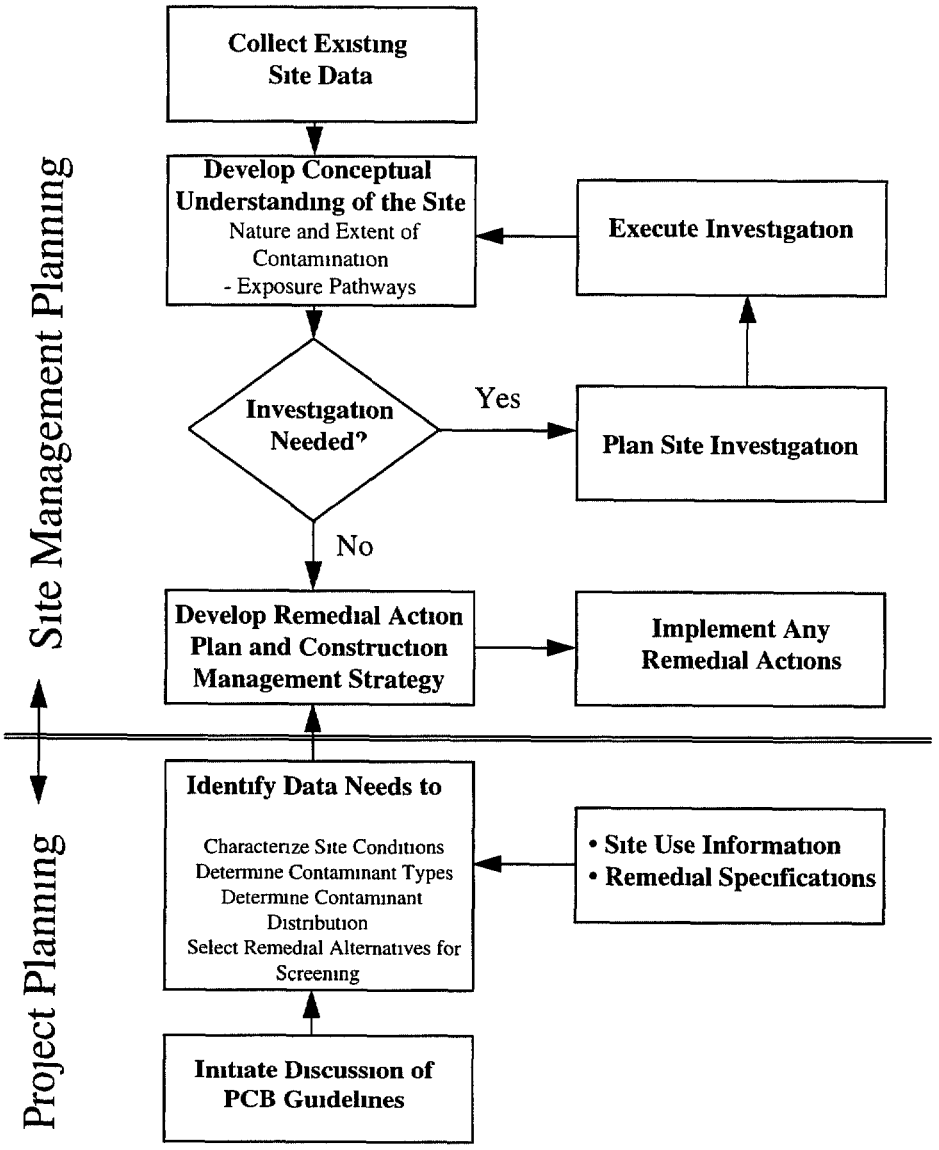
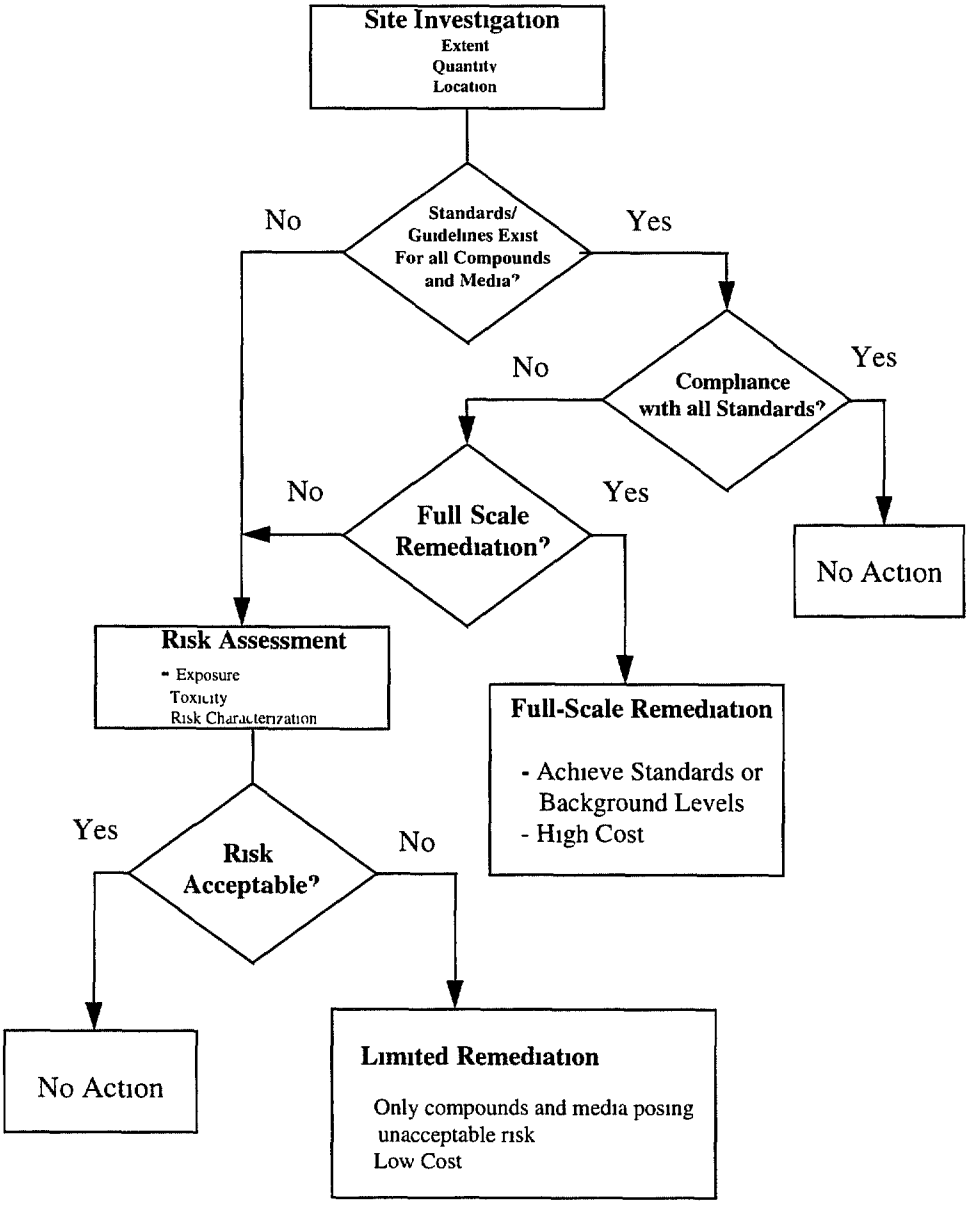


Figure 5 1-2

Risk Assessment Approach



5 2 NON-STRUCTURAL MANAGEMENT RECOMMENDATIONS FOR ENVIRONMENTAL PROTECTION

The following Section will make recommendations for non-structural solutions to the highest ranked environmental priorities The recommendations will focus on management strategies that will aid in reducing impacts from the electrical energy production sector The development of non-structural management opportunities for reducing both discharges and the potential for discharges is often more cost effective than structural emission control and treatment systems

Although the Ministry of Energy may need to buy off on the proposed management programs outlined below, cooperation may be ensured via a link between programmatic ES&H improvements and facility mechanical investment

5 2 1 PCB SPILLS, USE AND MANAGEMENT

The following recommendations will enable facility managers to reduce and/or eliminate future discharges of PCB containing materials and begin to phase out the current stockpile of PCB containing transformer oil

1) Since facility managers and power plant employees are unaware of the presence and hazards of PCBs at their facilities, education and familiarization should be the first step in addressing PCBs An onsite PCB awareness seminar at each facility to include the Director, Lead Engineer and transformer yard maintenance personnel as well as presentations on fate-transport scenarios of PCBs would develop appropriate "stakeholder" dedication on the part of the participants Appendix F presents an example outline of such PCB training

2) Implementation of spill response plans primarily addressing transformer oil but modularly expandable to include other onsite liquids should be the second step These plans can be based on generic spill response plans with site specific modifications agreed to and debated among seminar attendees to ensure implementation and workability at each facility Once a consensus is reached and roles and responsibilities assigned, additional steps may include closure of drainage channels at transformer yards and other low cost methods to reduce migration of existing contaminants All above mentioned items can be highlighted during the PCB awareness seminar if such activities are authorized by USAID

3) The most direct way to begin to phase out PCB containing transformer oil is to institute acceptance testing at the facility level via onsite immunoassay test kits prior to unloading/receiving transformer oil Current standards (GOSTstandard) in the electrical energy production sector prohibit PCB additives in transformer oil Reliance on such a broad based standard has obviously not worked since PCBs were detected in various degrees at all assessed facilities Therefore, simple and low-cost testing of each transformer oil delivery would eliminate additional PCBs from coming into the facilities Appropriate training sessions for use of the test kits could be conducted with appropriate plant personnel if such activities are authorized by USAID

4) As part of the PCB phase out program, a testing and tagging procedure could be employed to identify PCB and non-PCB containing transformers For example, as maintenance is performed or equipment is upgraded in transformer areas, a dated tag could be affixed to non-PCB containing equipment Likewise, as production units are off-line for maintenance and repairs, associated transformer banks could be tested for a threshold value of PCBs and appropriately tagged In this way, the gradual elimination of PCBs from electrical production facilities becomes a manageable issue The same immunoassay test kits discussed in item 3) above could be used to test the transformer oil

5) One obvious deficiency in the management of PCBs in Armenia is the absence of hazardous waste facilities to receive and safely process PCB containing materials Establishment, through the Ministry of Energy, of a facility capable of safely disposing of PCB containing material is one option Appendix G outlines the U S approach to eliminating PCBs and presents current technologies available to remediate and destroy PCBs

5 2 2 UNCONTROLLED DISCHARGE OF RAW SEWAGE

In addition to physical improvements outlined in subsequent sections, a point source inventory is recommended to establish all existing energy production, industrial, agricultural, and municipal/village discharges to the Hrazdan River and Canal Such a study would be required to enumerate regional contributors in order to fully understand the scope of necessary infrastructure improvements It is anticipated that power and industrial sector sources are the major contributors of effluent to the Hrazdan River and Canal

The location and capacity of existing sewage treatment works in the region and capital improvements required therein would also be cataloged Existing information sources would be ground-truthed so realistic predictions and plans could be made Logical groupings of electrical energy production facilities with

associated villages and other industries may offer a cost effective benefit to all parties

The current volume of flow has evidently diluted the discharged sewage to the point that it has not affected recreational and agricultural use of these waters However, if flow of the Hrazdan Canal or River is reduced as part of the Lake Sevan restoration effort, serious health issues may arise in the communities bordering the Canal and River

As the World Health Organization states "Lack of a supply of safe water and adequate means of sanitation is blamed, at least in part, for as much as 80% of all disease in developing countries Contaminated drinking water is a prime cause of diarrhoeal disease - a major killer of infants and young children It also costs many millions of working days each year for adults and massive expenditure on health care Cholera epidemics, frequently also transmitted by unsafe water, are on the increase, aggravated by the rapidly growing populations in urban settlements Great strides have been made in the last ten years in developing low-cost solutions and sustainable community management approaches, so governments have all the tools they need to implement cost-effective programmes for improved water supplies and sanitation facilities, benefiting health, the environment and the national economy "

5 2 3 ASBESTOS USE AND MANAGEMENT

Since eliminating the use and presence of asbestos or asbestos containing materials (ACM) is currently not a feasible alternative, informed use, maintenance, and handling of ACM is the most cost effective way of reducing health impacts due to ACM

1) Since facility managers and power plant employees may be unaware of the hazards of ACM at their facilities, education and familiarization should be the first step in addressing ACM An onsite ACM seminar at each facility to include the Director, Lead Engineer and appropriate maintenance personnel would develop appropriate "stakeholder" dedication on the part of the participants Seminar topics would include health and safety issues, introduction to personal protective equipment, handling and storage At all facilities, a preliminary meeting would be held with facility management to establish need and consensus on revised storage and handling agreements with regard to ACM Appendix H presents an example outline of such ACM training

2) A modest investment in signage and personal protective equipment would be required to implement the above recommendation

5 3 RECOMMENDATIONS FOR PHYSICAL IMPROVEMENTS

The following Section will present general recommendations which are applicable to all electrical energy production facilities assessed and specific recommendations on a site by site basis Although all of the electrical energy production facilities in Armenia were not visited as part of this assessment, it is believed that current operating practices at the facilities not visited are similar to practices at the assessed sites Therefore, the following general recommendations may be applicable to the entire Armenian electrical energy production sector

5 3 1 GENERAL RECOMMENDATIONS

5 3 1 1 Uncontrolled Discharge of Raw Sewage

Upon completion of the study outlined in the Non-structural Management recommendations, energy production facilities will need to segregate currently commingled wastewater Onsite infrastructure improvements to isolate sewage waste streams would be a prerequisite to a connection to a treatment works Opportunities to "bundle" treatment works needs with others in similar need (villages, industries, etc) would greatly decrease the impact these wastewaters have on the Hrazdan River and Canal and would allow for innovative funding scenarios Logical groupings could be made and sizing and cost estimates would then be generated

5 3 1 2 Uncontrolled Discharge of Oily Water

As mentioned previously, all assessed HPPs lack oil/water separators and the assessed TPPs have oil/water separators that are inefficient and beyond their useful life The above discussion in the Non-structural management Section regarding spill control plans and low cost measures such as blocking drains will reduce nonsystematic discharges to affected water bodies However, this will not address oil residues in plant washdown water, oily water generated in HPP turbine halls, and other oil contaminated wastewater generated on a regular basis Good maintenance practices would greatly reduce the oil present in

cooling water Therefore, a manageable amount of regularly generated oily wastewater could be treated at facilities with appropriately sized oil/water separators

5 3 1 3 Overall Treatment of Technical Water at TPPs

The assessment team did not evaluate water treatment practices in detail The water treatment systems discussed below are used to treat incoming water for facility internal use such as boiler makeup water and heating system makeup water In general, water treatment plants at both TPPs visited seemed to be in reasonable operating condition Hrazdan TPP recently upgraded/rehabilitated part of their water treatment plant A typical Soviet era design water treatment diagram is included for general information purposes as Figure 5 3-1

Although not present at either of the two TPPs visited, a Soviet era design for environmental wastewater treatment is included as Figure 5 3-2 This design is included for general information purposes as this design would be familiar to existing plant personnel If capital improvements are considered to augment the current lack of wastewater processing (only pH adjustment is currently performed), a design similar to Figure 5 3-2 may be a practical application

5 3 1 4 Secondary Containment and Spill/Leak Management of non-PCB Materials

With the exception of Arzini HPP and Yerevan HPP Secondary containment for bulk liquid material storage requires improvements Non compacted earthen berms in various stages of disrepair typifies the current secondary containment conditions In the event of a large leak or catastrophic occurrence, appropriately sized secondary containment would restrain the flow of ruptured containers into water systems

Secondary containment of transformer yards at all facilities needs to be evaluated

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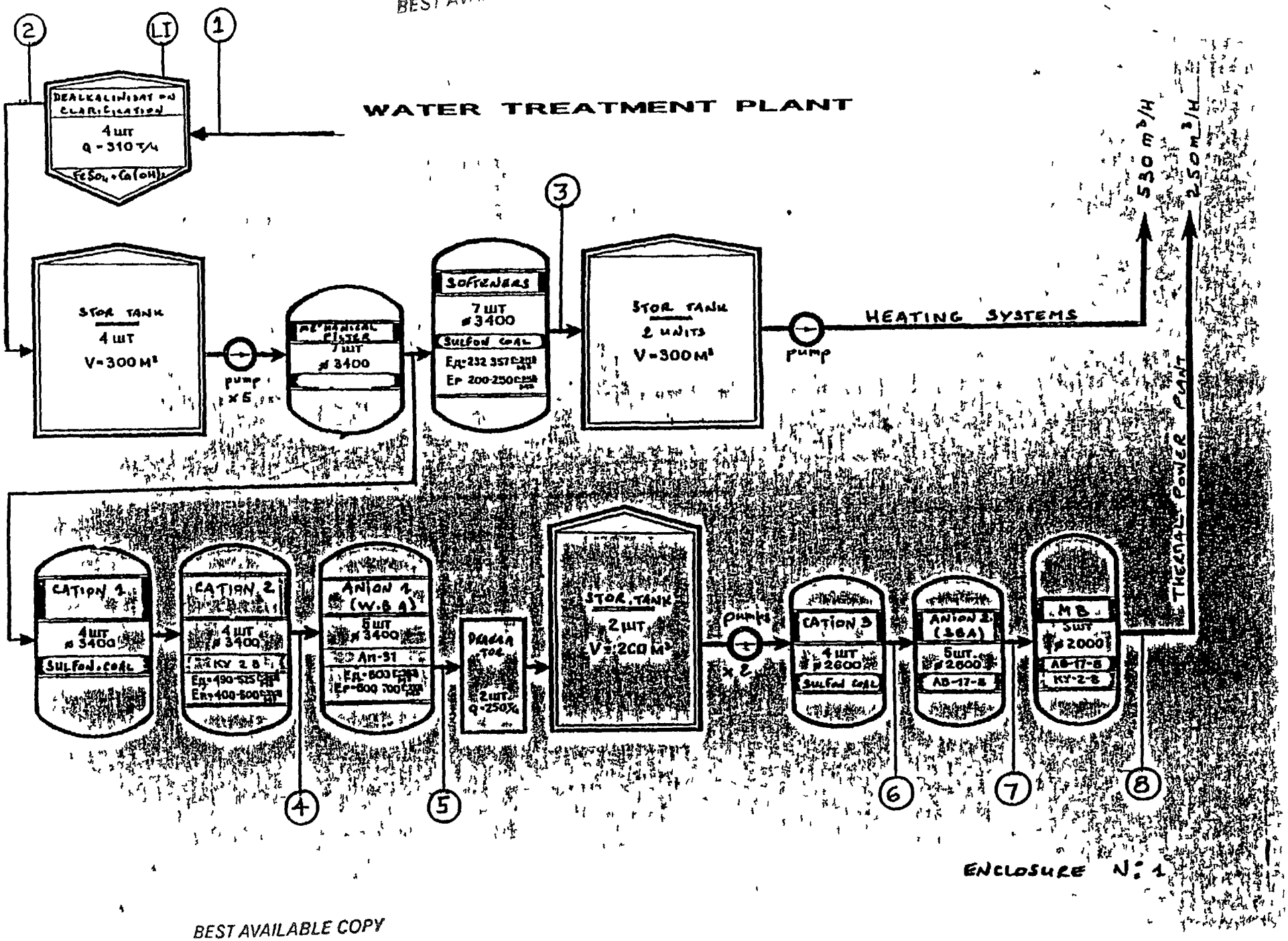

ENCLOSURE N: 1

Figure 5 3-1

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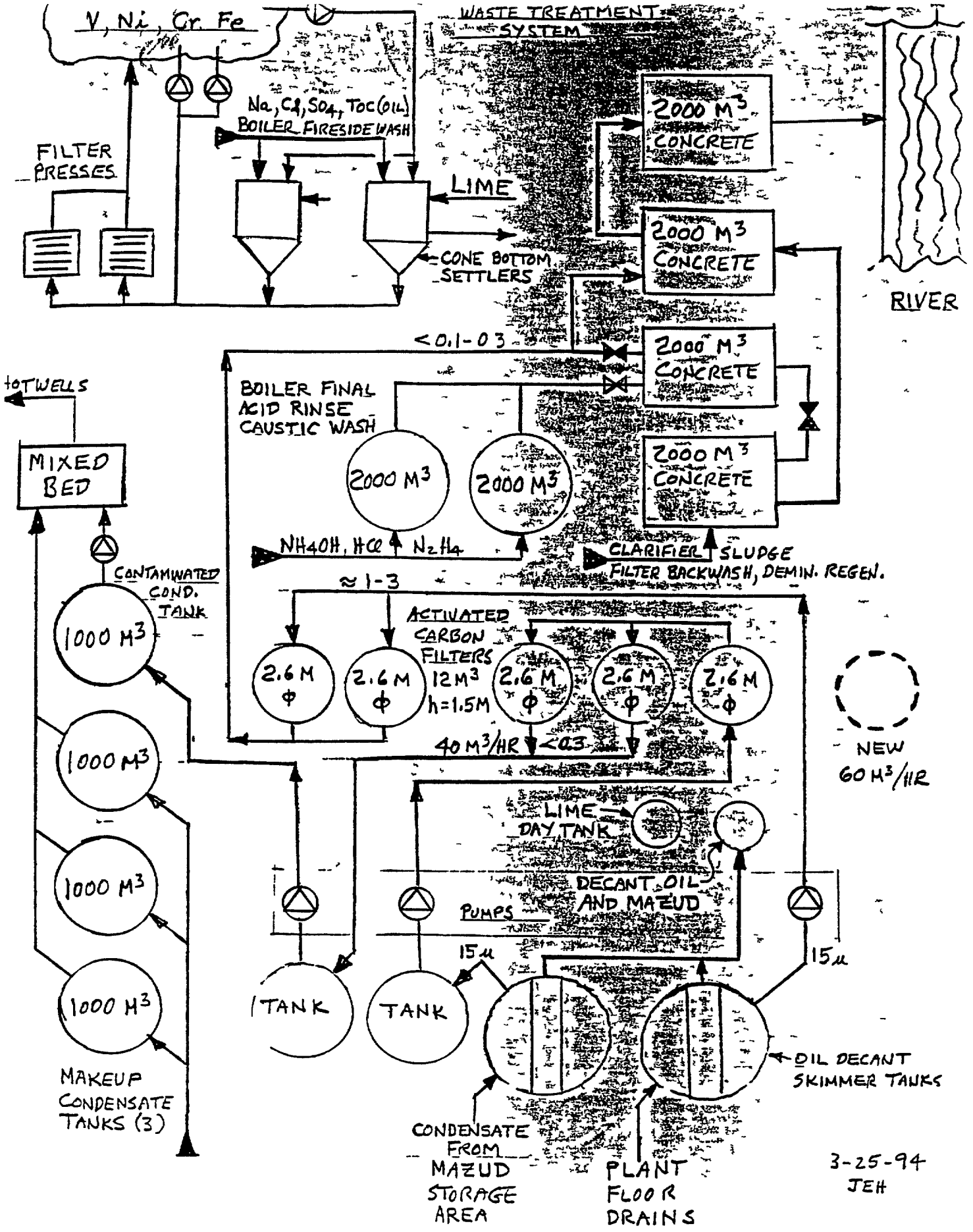

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Figure 5 3-2

5 4 SITE SPECIFIC RECOMMENDATIONS FOR PHYSICAL IMPROVEMENTS

5 4 1 YEREVAN TPP RECOMMENDATIONS

- Secondary containment in the mazut storage area including reinforcement of existing earthen berms should be considered Secondary containment under the transformer areas is in place, according to site representatives,
- Oil/water separation needs and adaptability of piping infrastructure should be further investigated

5 4 2 YEREVAN HPP RECOMMENDATIONS

- The recovery wells underlying the transformer area should be properly closed in place,
- Secondary containment in the form of a monolithic concrete structure should be installed around the bulk oil storage area,
- Barrier containment in the form of concrete curbing should be installed around the transformer yard Current conditions at the site (lack of space and the existence of a common transformer yard for both turbines) preclude installation of a monolithic concrete secondary containment structure Such a secondary containment structure could only be installed during a major shutdown and reconstruction scenario,
- Provision for a packaged oil/water separator should be further investigated at the facility,
- The condition of emergency relief channels/spillways should be investigated

5 4 3 HRAZDAN TPP RECOMMENDATIONS

- According to facility representatives, wastewater discharges are currently over the limit for mazut Based on observations of the oil/water separation devices in the mazut storage area, this exceedence has probably been an ongoing problem Therefore, the provision for a packaged oil/water separator should be further investigated at this facility,
- Installation of the above-mentioned oil/water separator would precipitate closure of the onsite settlement pond which would no longer be needed An environmental assessment of the settlement pond should be performed possibly concluding with revegetation of the pond area In addition, the current underground temporary storage area for reclaimed mazut should be cleaned and closed and an above ground storage option be provided
- Replacement of leaky ducts and rerouting of exhaust ducts to the new, 270 m stack should be further investigated This would increase overall plant efficiency and reduce ambient workplace pollutant levels Currently existing Feasibility Study documents prepared by the facility should be reviewed for

constructability and cost estimating purposes In addition, an air dispersion modeling study should be conducted to ensure that the new deposition area from the 270 m stack is environmentally favorable,

- Secondary containment, establishment of concrete bases for storage tanks, and integrity testing of existing tanks should be provided in the transformer oil and turbine oil storage area,
- Reclamation options for secondary/unburned mazut should be investigated

5 4 4 HRAZDAN HPP RECOMMENDATIONS

- Provision for a packaged oil/water separator should be further investigated at the facility,
- The structural integrity of the emergency spillway should be investigated

5 4 5 ARZINI HPP RECOMMENDATIONS

- Sealing rings for the facility's globe valves should be provided The cause of inlet and outlet pipe leaks should be investigated Eliminating the causes of water infiltration into the facility would improve the correspondingly entrained oil concentration that is currently being discharged to the Hrazdan River,
- Provision for a packaged oil/water separator should be further investigated at the facility,
- In conjunction with the oil/water separator above, the feasibility of closure of the central drain collecting/discharge wells and the associated underground reservoir should investigated

5 4 6 GUMUSH HPP RECOMMENDATIONS

- Provision for a packaged oil/water separator should be further investigated at the facility

5 4 7 ABOVIAN UNDERGROUND NATURAL GAS STORAGE FACILITY RECOMMENDATIONS

- Leak detection equipment specifically ear-marked for the Abovian facility should be provided,
- Options for reclamation of the "technical drainage" of natural gas from the compressors should be investigated,
- Contingency plans for brine storage should be developed Brine transport pipelines should be repaired Assistance should be offered to find creative funding options for the unfinished brine storage pond

6 0 OTHER ISSUES OF ENVIRONMENTAL CONCERN

6 1 SEVAN-HRAZDAN CASCADE ISSUES

As part of general discussions with Mr Mels Hakopian, General Director of the Sevan-Hrazdan Cascade, a number of issues were raised regarding other facilities which were not visited as part of the environmental assessment Mr Hakopian raised the following concerns

- At Sevan HPP - Existing fish protection devices are in need of major reconstruction and currently have limited availability for use,
- At Kanaker HPP - Although an intergovernmental accord has been reached with Germany to provide financial assistance for equipment refurbishment (approx $USD 5 4 Mln), environmental concerns are not being addressed by this loan and rehabilitation package Significant oil leakage is reportedly occurring at the Kanaker facility

6 2 SWITCHYARD ISSUES

Low level PCB contamination (0 1 to 4 4 ppm) was detected in soils below transformers and in soil samples below transformer oil storage tanks at the 3 switchyards which may be subject to rehabilitation by the proposed World Bank loan No PCBs were detected in the transformers sampled at the 3 switchyards Two circuit breakers at Marash and Spandroyan tested positive for PCBs (8 1 and 120ppm, respectively) In addition to the general recommendations made with respect to PCB contamination at the production facilities in Section 5 2 1, the following points are recommended with respect to rehabilitation activities at the switchyards

- In consultation with International guidance documents and regulations, the Ministry of Energy should develop a definition of acceptable PCB concentration in both oil and soil United States Environmental Protection Agency (USEPA) guidance, for example, is 50 mg/kg for oil and 5 mg/kg for industrial soil,

- An acceptance testing/monitoring program for PCBs in new oil deliveries should be developed and implemented at all MOE switchyard facilities This would be done to eliminate PCBs from being introduced into new and existing equipment,

- Health and Safety PCB awareness training for management and operations and maintenance personnel as well as contractors involved in the proposed rehabilitation Project should be conducted,

- Since it has been demonstrated that PCBs have been in historical use at substation switchyards affected by the World Bank Project, any civil works in the transformer areas will impact existing potentially contaminated underdrain collection and transfer systems Although these collection systems are, in many cases, not functioning, they can be a source for accumulated past spills of PCB containing materials Therefore, all underdrain piping, appurtenances, and associated oil contaminated soils should be tested for PCBs during initial Project civil works and handled/disposed properly The use of field test kits for both soil and oil applications may be a means to rapidly screen for the presence of PCBs Based on the experience of field testing for this Assessment, a detection limit of 20 to 50ppm is recommended,

- Opportunities for low cost future hazard mitigation should be included in Rehabilitation Project construction plans and specifications as follows

  A) Any concrete work required as part of the Rehabilitation Project should include provision for secondary containment development That is, if a new concrete pad is planned under an area which may be susceptible to spillage, the Project engineer should include nominal additional concrete and forms for raised edges (20 - 30 cm) to reduce the ability for a future spill to migrate from the area,

  B) Provision should be made in the design of the Project for oil collectors and oil/water separation devices to replace the existing (in most cases, non-functioning) underdrain systems

6 3 GENERAL ISSUES

Although this environmental assessment focused on environmental impacts from the electrical energy production sector, several other environmentally related issues were observed or brought to the team's attention As a result of many kilometers logged throughout Armenia and official and nonofficial discussions, the assessment team notes the following

- No current infrastructure exists for the treatment, storage, and disposal of hazardous materials,
- Widespread use of pesticides has been reported by other sources,

- The existing infrastructure for residential and industrial solid waste transportation and disposal appears inefficient Numerous plumes were observed in and around Yerevan as the result of solid waste being burned,
- Ambient conditions were excessively dusty in Yerevan during windy periods,
- Wide use of lead piping was observed for potable water distribution,
- The observed, widespread, unregulated distribution of petroleum fuels can contribute to non-point source discharges,
- The topography of the Yerevan region can likely increase the potential for atmospheric inversions,
- Excessive air emissions and oil leakage was observed in the transportation sector (especially buses and commercial vehicles)

PHOTOGRAPH LOG

Photo 2 - Yerevan TPP
Asbestos Maintenance Issues

Photo 1 - Hrazdan HPP
Waste Burial Area

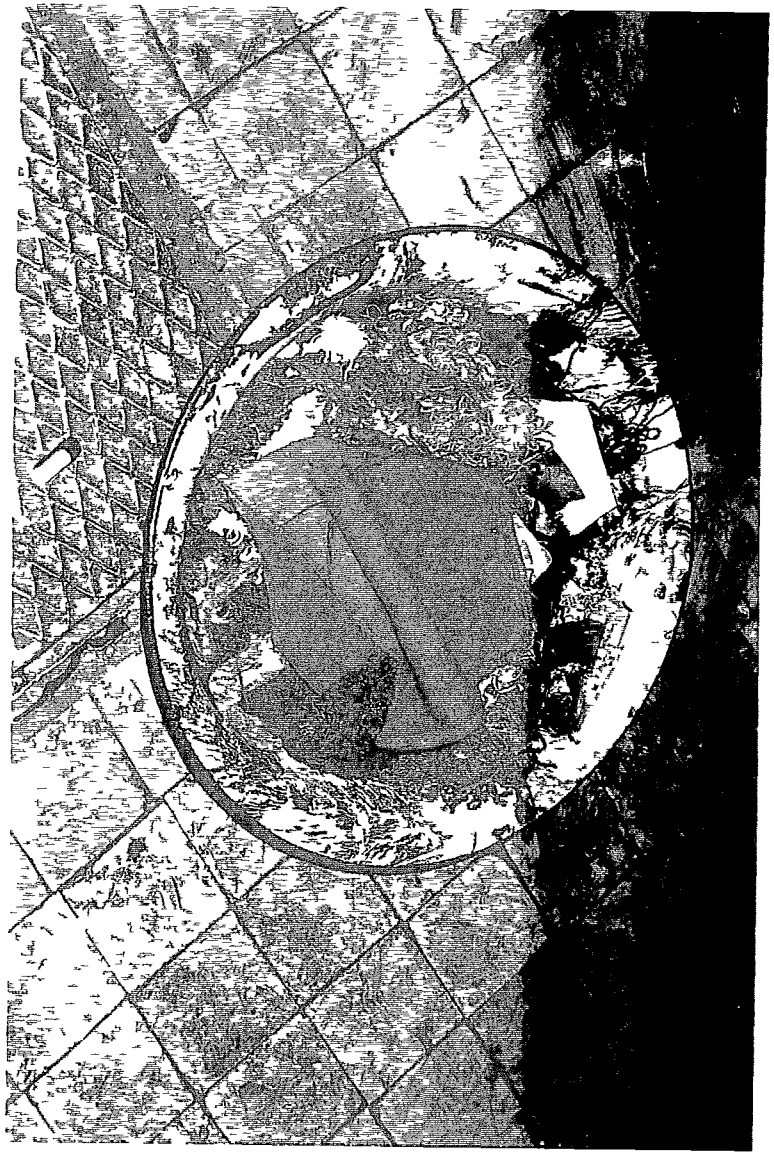


Photo 4 Arzini HPP
Oil Soaked Residue (not including paper filters)

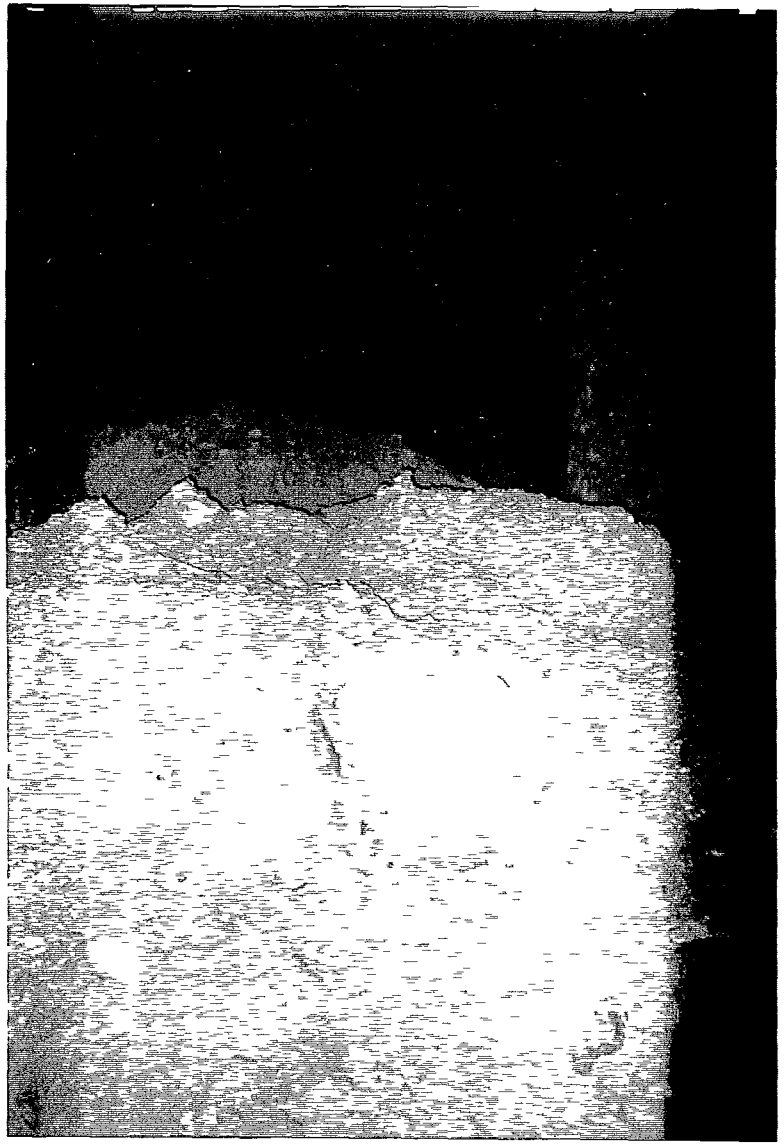


Photo 3 - Yerevan TPP
Bulk Asbestos Storage Area

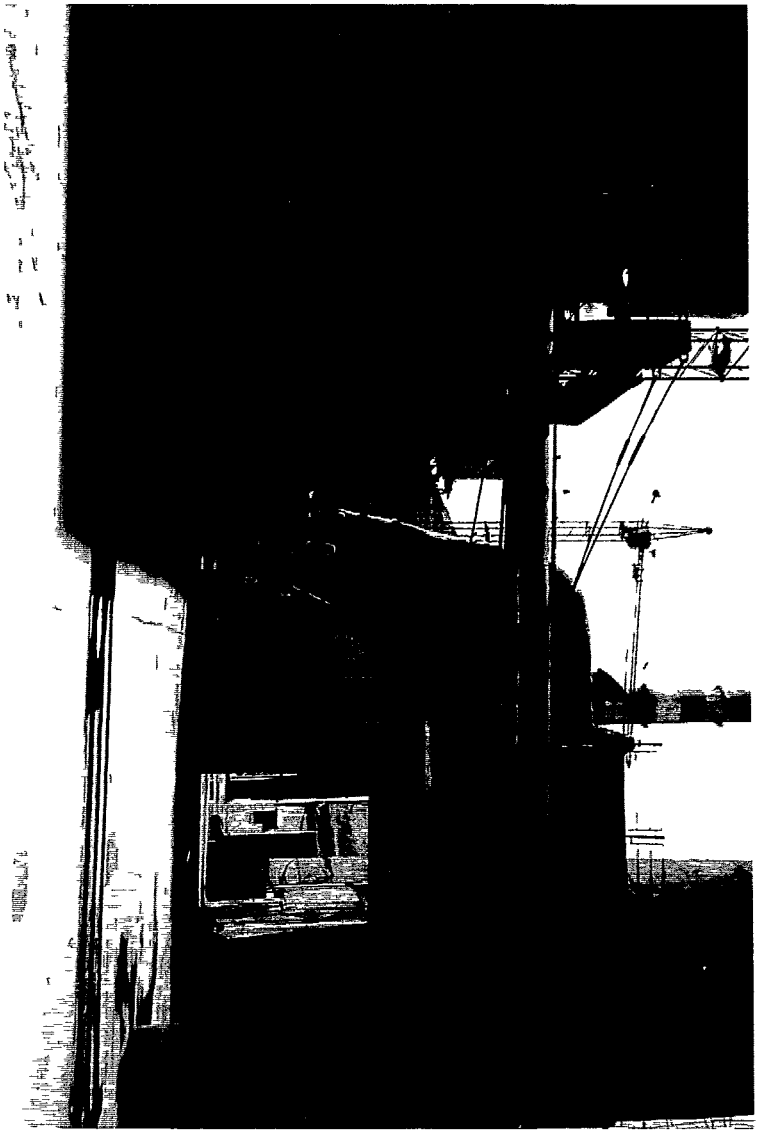


Photo 6 - Yerevan TPP
Outdoor Exhaust Ducts

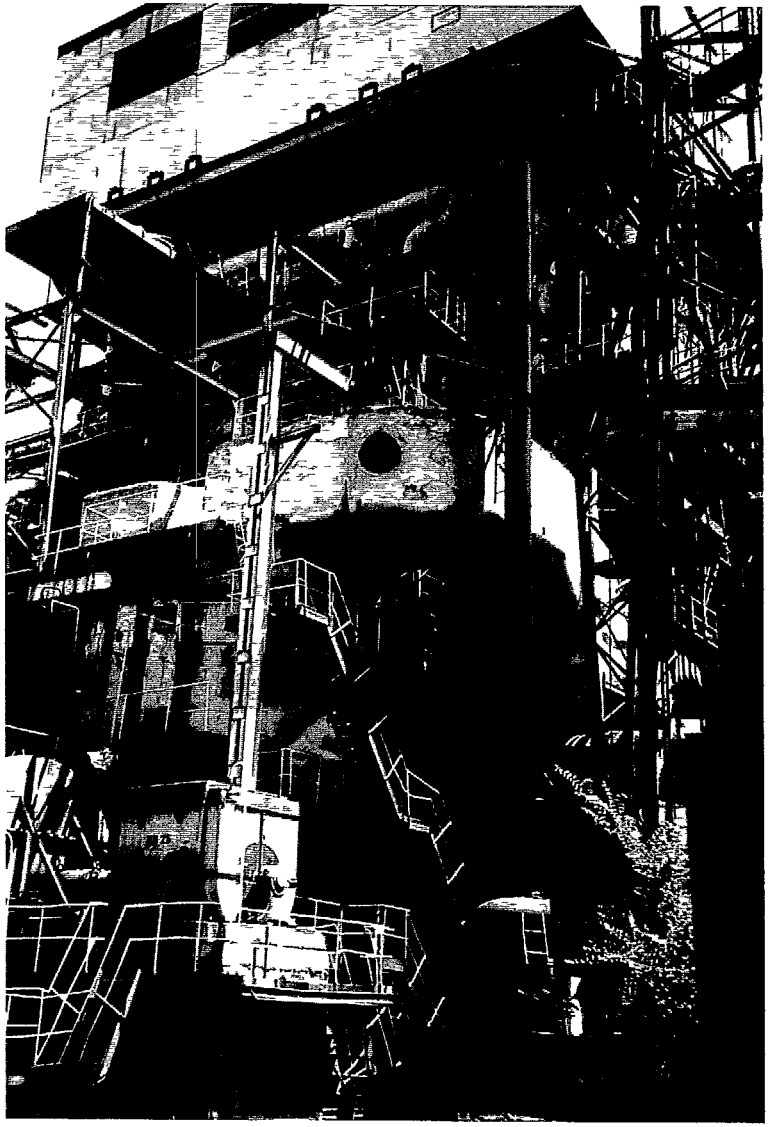


Photo 5 - Yerevan TPP
Outdoor Exhaust Ducts

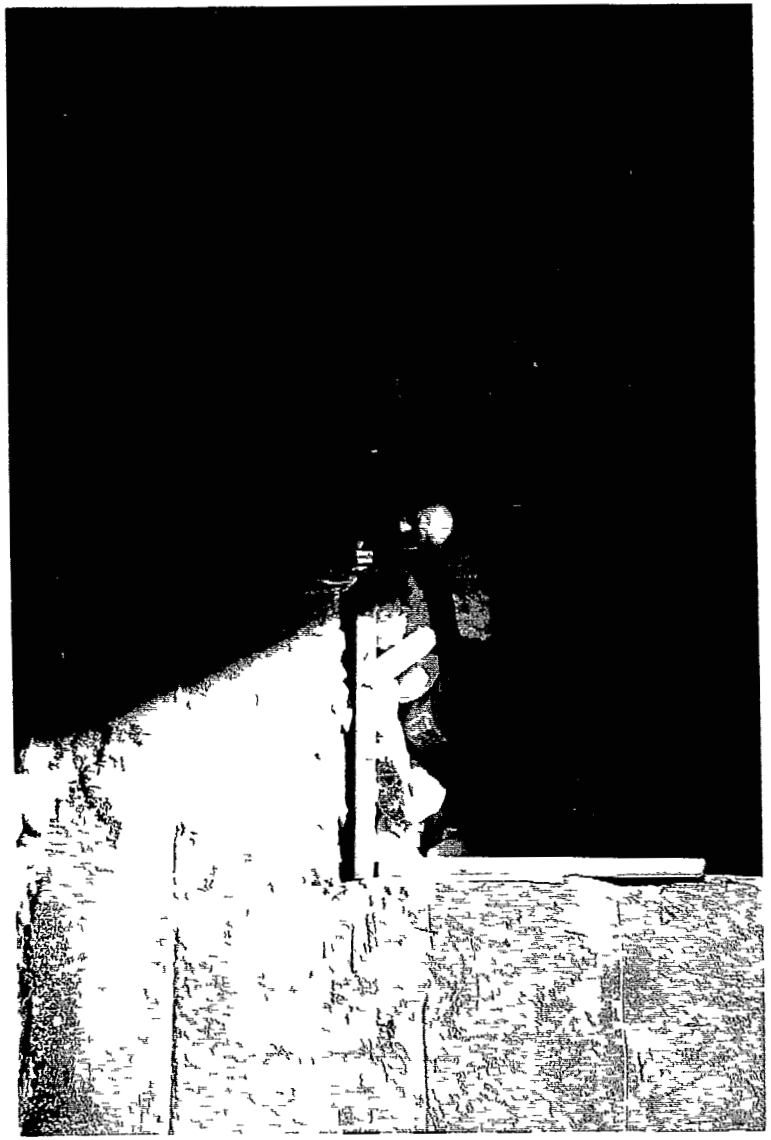


Photo 8 - Yerevan TPP
Asbestos Workers and Asbestos Pipe Storage Area

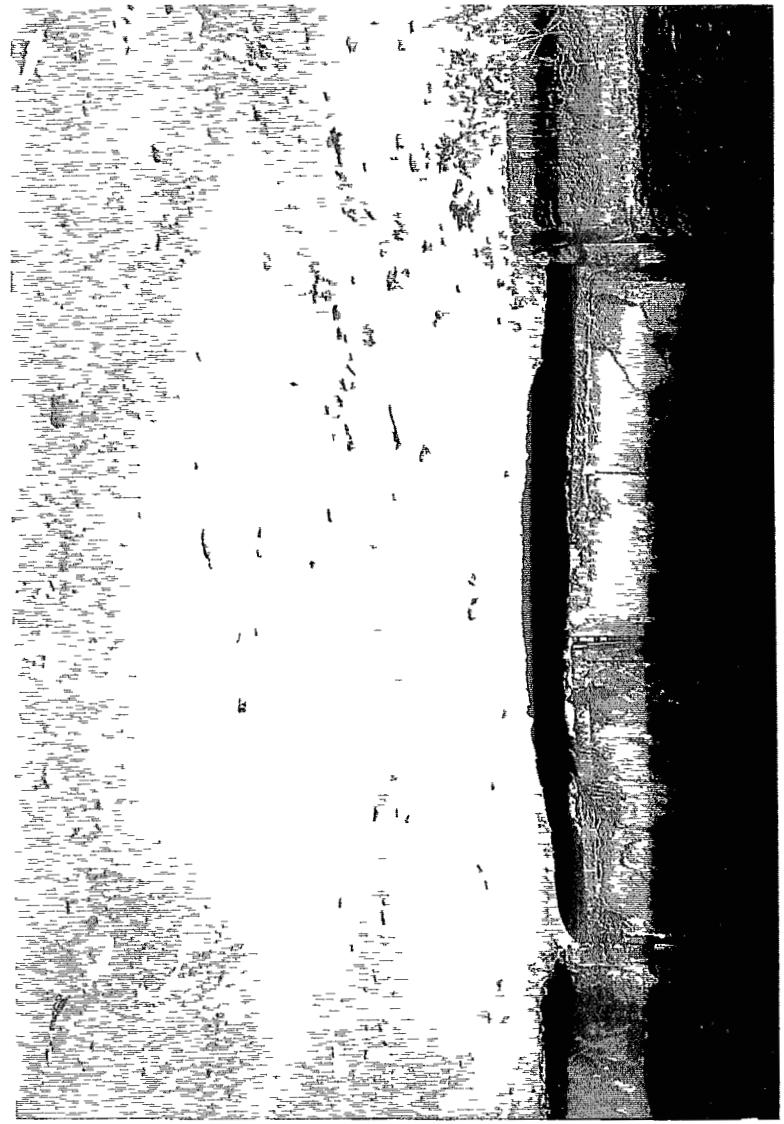


Photo 7 - Yerevan TPP
Outside Bulk Asbestos Storage Area

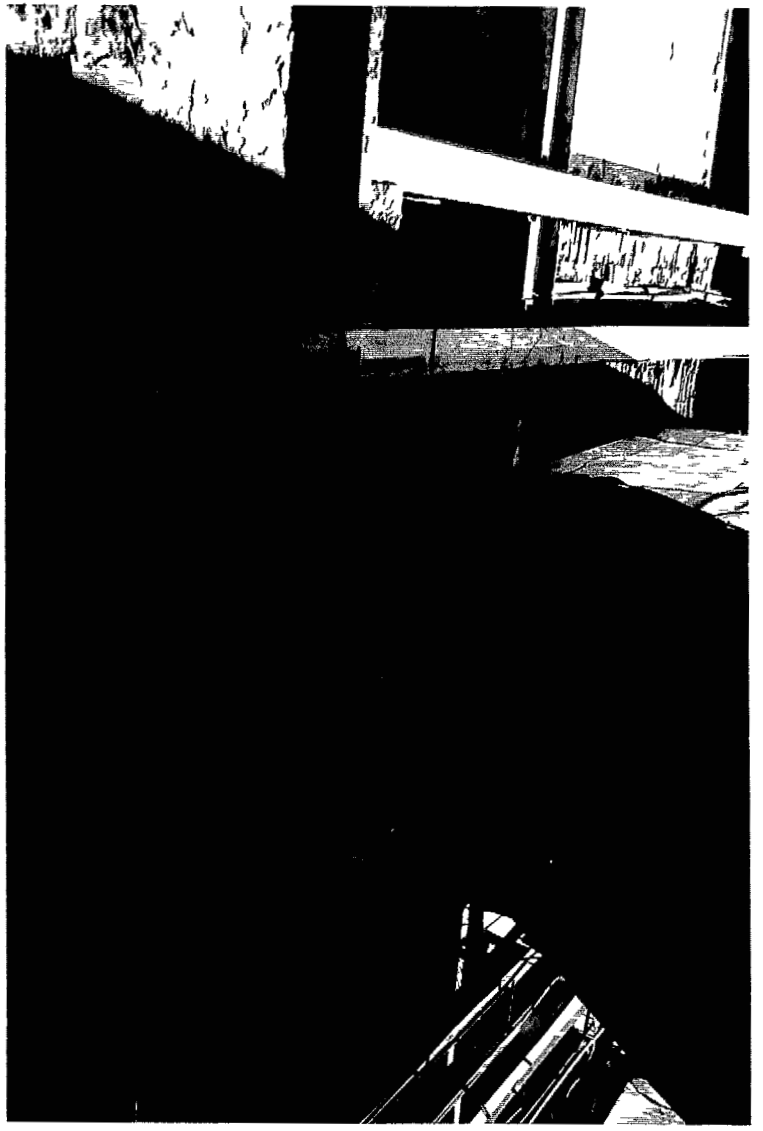


Photo 10 - Hrazdan TPP
Duct Connection

Photo 9 - Hrazdan TPP
Ducts

28

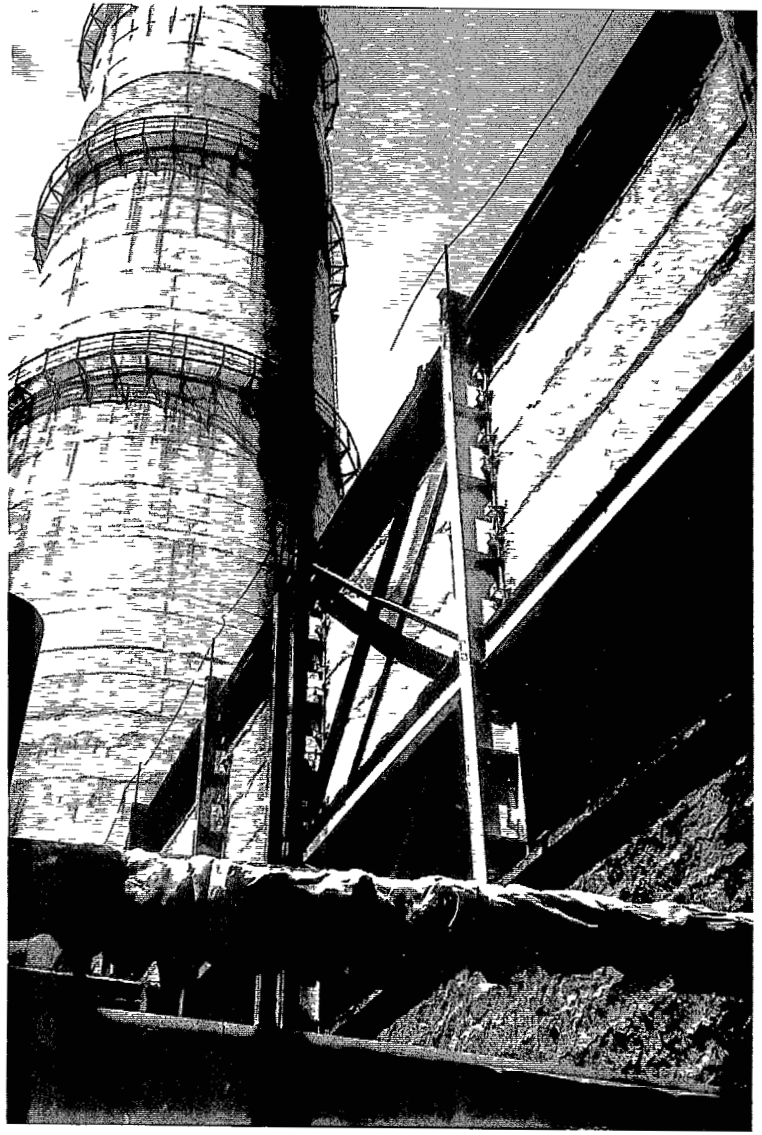


Photo 12 - Hrazdan TPP
Existing Stack with Concrete Duct

Photo 11 - Hrazdan TPP
Concrete Duct Joints

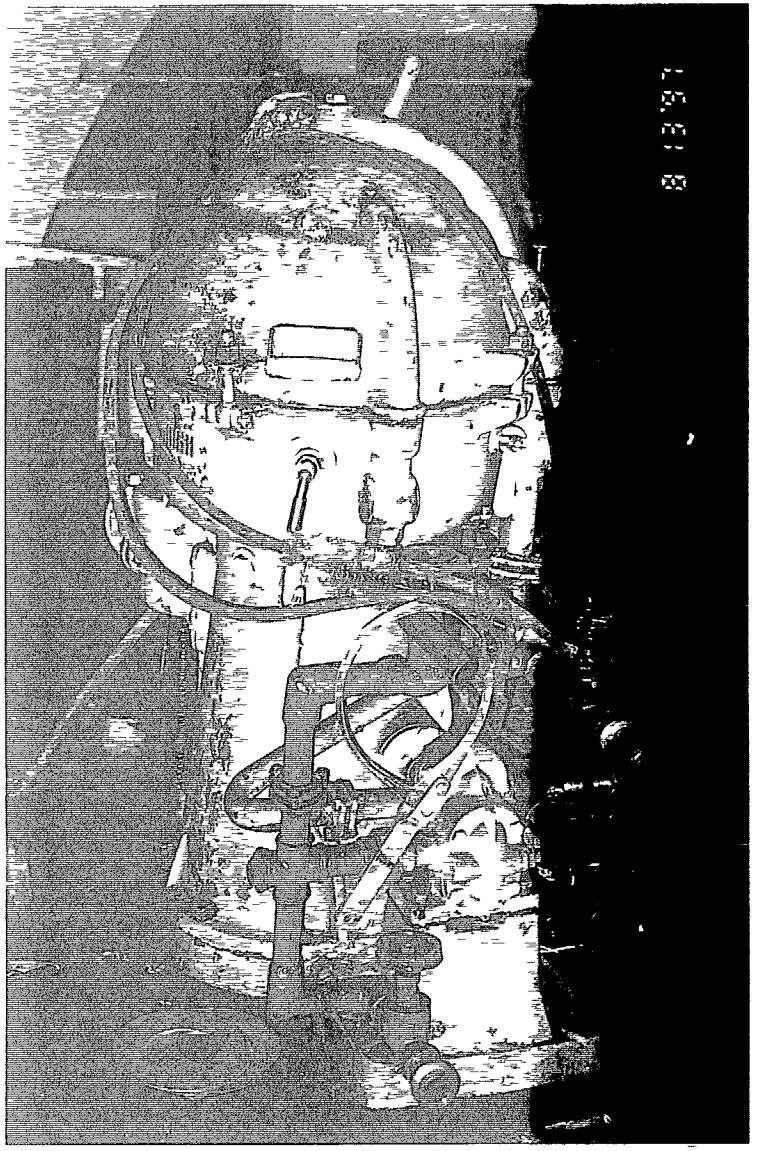


Photo 14
Typical Oil Centrifuge

Photo 13 - Hrazdan HPP
Turbine House Water Collector

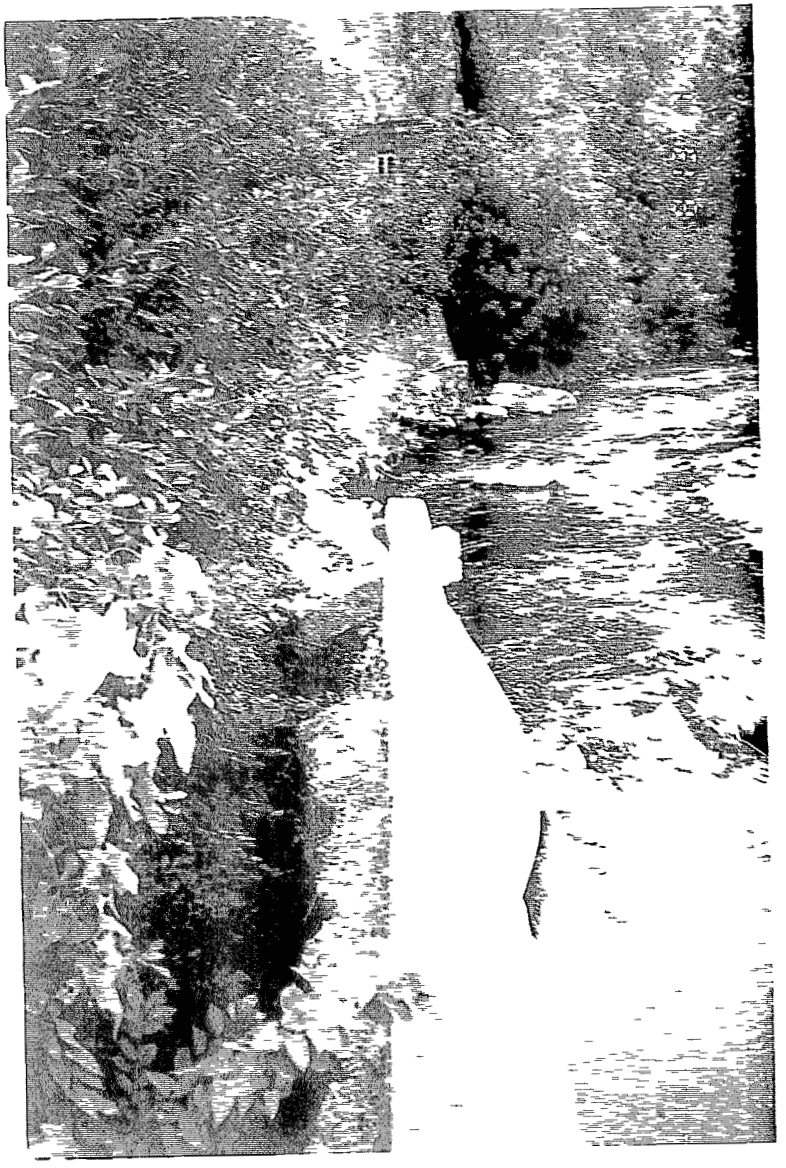


Photo 16 - Arzini HPP
Eroded Concrete Revetment

Photo 15 - Arzini HPP
Eroded Concrete Revetment

Photo 18 - Gumush HPP
Spillway Area Landslide

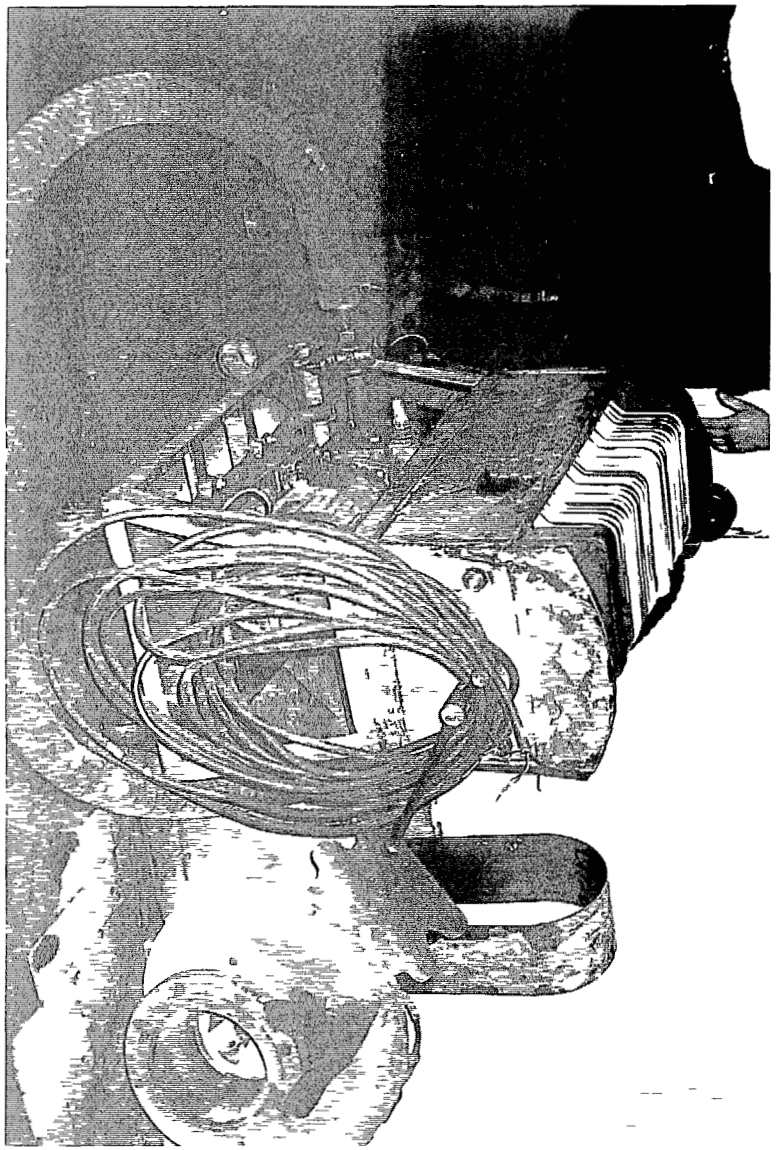


Photo 17
Typical Filter Press System

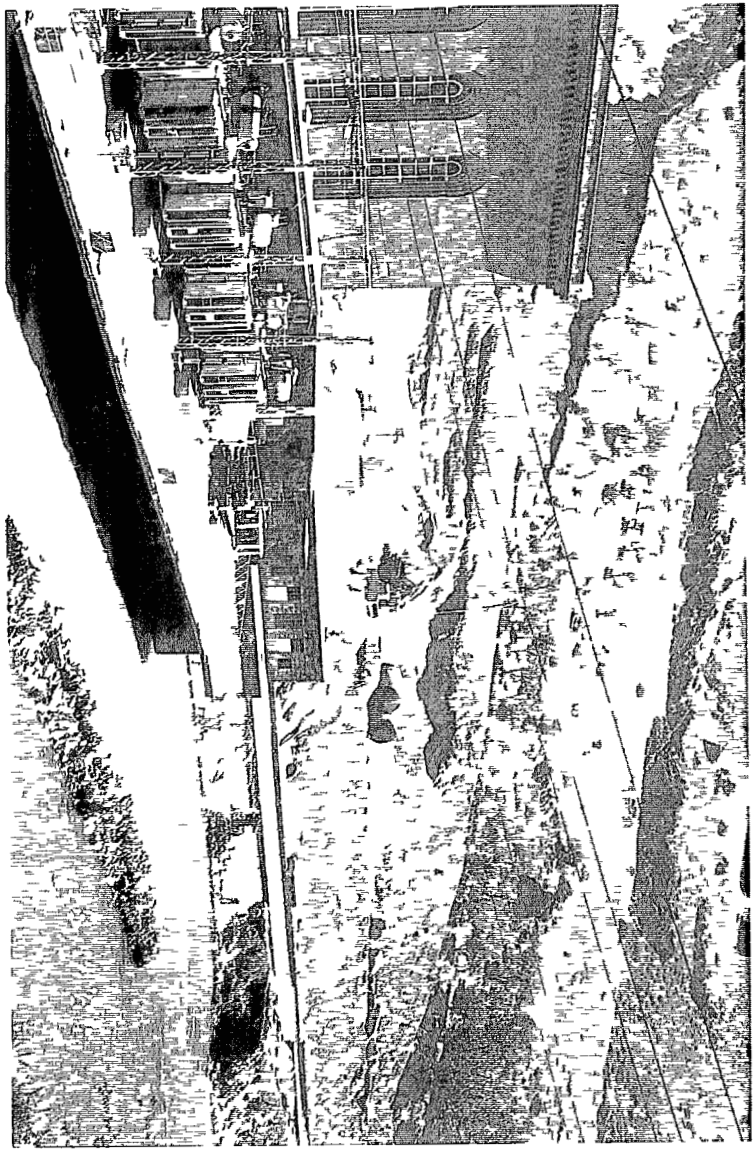
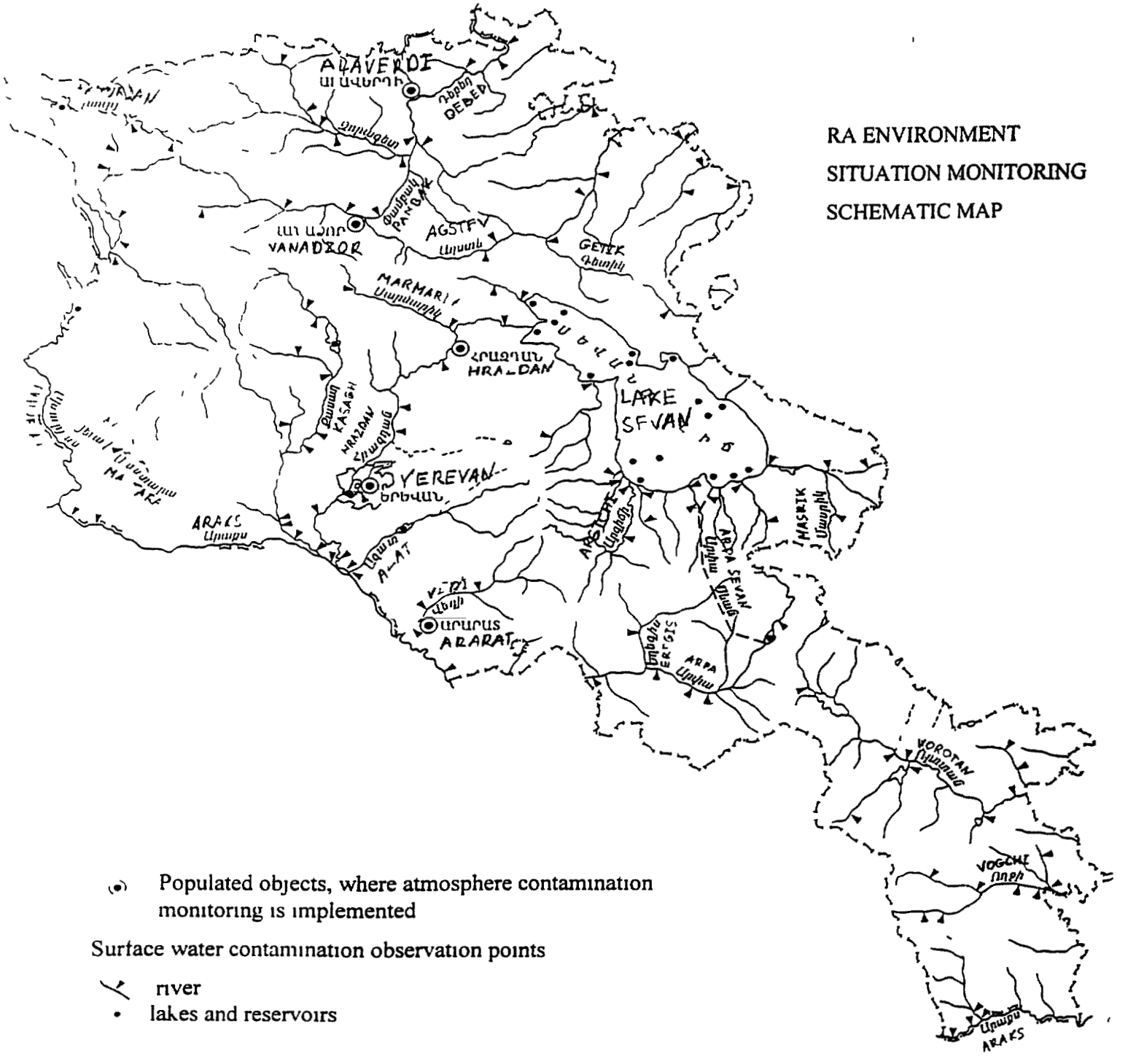


Photo 20 - Gumush HPP
Transformer Area Above Hrazdan River

Photo 19 - Gumush HPP
Transformer Oil Collection/Drainage Grate

APPENDIX A



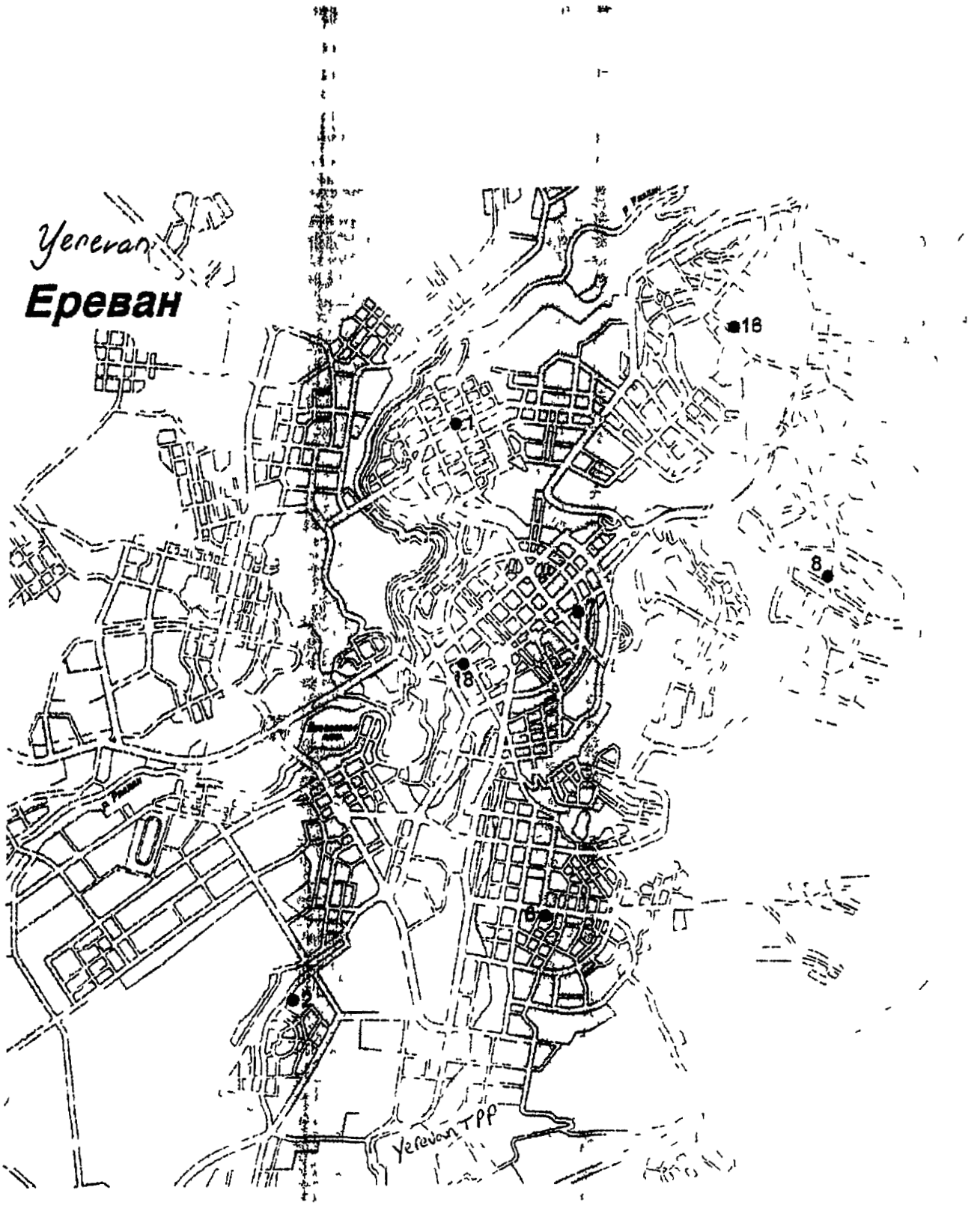
RA ENVIRONMENT
SITUATION MONITORING
SCHEMATIC MAP

(•) Populated objects, where atmosphere contamination monitoring is implemented

Surface water contamination observation points

river

• lakes and reservoirs



2● Посты наблюдений за загрязненностью атмосферы

Observation station for air pollution

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APPENDIX A TABLE

Ambient Air Concentration Limits - Yerevan City

Contaminant	Concentration Limit (mg/m^3)	
	Single Event Maximum	Annual Daily
Dust	0 5	0 15
Sulfur Dioxide	0 5	0 05
Carbon Oxide	5	3
Nitrogen Dioxide	0 085	0 04
Nitrogen Oxide	0 4	0 06
Chlorine	0 1	0 03
Chloroform	0 1	-
Formaldehyde	0 035	0 003
Benzene	1 5	0 1
Toluene	0 6	0 6
Xylene	0 2	0 2
Ethyl-Benzene	0 02	0 02

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ATMOSPHERIC POLLUTION DATA t YEREVAN
PERIOD 1989-1996
(FOR 7 (ALL) OBSERVATION STATIONS IN YEREVAN)

*- **materials annual monthly concentration**
- **materials max (valid for one occasion) concentration

Station No.	Months	Characteristics	Materials concentrations											
			Dust	Sulphur dioxide	Carbon oxide	Nitrogen dioxide	Nitrogen oxide	Chloride	Cloropren	Formaldehyde	Benzol	Toluene	Xilol	Ethil-benzol
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	02	q amc*	0 2	0 09	2	0 12	0 11		0 000					
		q max**	1 7	0 38	7	0 32	0 36		0 000					
	08	q amc*	0 3	0 22	2	0 15	0 15		0 001					
		q max**	1 4	0 58	9	0 32	0 48		0 009					
2	02	q amc*	1 2	0 08	10	0 13		0 01	0 002					
		q max**	2 1	0 24	27	0 27		0 03	0 056					
	08	q amc*	1 4	0 24	8	0 18		0 01	0 051					
		q max**	3 3	0 63	20	0 53		0 09	0 817					

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	02	$q_{ср}^{ан}$	0 6	0 08	4	0 08	0 08	0 00	0 006					
		$q_{мак}$	3 6	0 28	13	0 24	0 20	0 03	0 248					
	08	$q_{ср}$	0 4	0 26	3	0 16	0 18	0 01	0 005					
		$q_{мак}$	1 4	0 78	14	0 46	0 75	0 03	0 036					
7	02	$q_{ср}$	1 1	0 06	5	0 21	0 37							
		$q_{мак}$	3 4	0 19	15	0 59	0 99							
	08	$q_{ср}$	0 5	0 21	4	0 23	0 21							
		$q_{мак}$	1 7	0 79	15	0 45	0 55							
8	02	$q_{ср}$	0 5	0 08	8	0 16	0 23							
		$q_{мак}$	1 9	0 98	19	0 57	0 82							
	08	$q_{ср}$	0 5	0 24	6	0 12	0 27							
		$q_{мак}$	3 6	0 55	25	0 38	1 29							
16	02	$q_{ср}$	0 9	0 09	7	0 23								
		$q_{мак}$	4 9	0 25	36	0 47								
	08	$q_{ср}$	0 5	0 24	4	0 19								
		$q_{мак}$	2 2	0 63	12	0 42								

ср - средн

мак - max

| Конц - мг/м3 |

Environmental Monitoring Center
Ministry of the Environment of the Republic of Armenia

1990

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	02	$q_{ср}$	0 2	0 15	4	0 09	0 08		0 000					
		$q_{мак}$	0 9	0 49	13	0 23	0 45		0 000					
	08	$q_{ср}$	0 3	0 27	3	0 14	0 13		0.000					
		$q_{мак}$	1 3	1 30	9	0 45	0 35		0 000					
2	02	$q_{ср}$	1 1	0 09	12	0 10		0 01	0 000					
		$q_{мак}$	3 5	0 30	22	0 33		0 02	0 000					
	08	$q_{ср}$	1 0	0 25	5	0 12	0 11	0 01	0 000					
		$q_{мак}$	2 9	1.53	15	0 33	0 27	0 11	0 000					
6	02	$q_{ср}$	0 4	0 12	7	0 10	0.11	0.00	0 000					
		$q_{мак}$	1 7	0 31	23	0 27	0 60	0 04	0 000					
	08	$q_{ср}$	0 5	0 24	4	0 10	0 09	0 02	0 000					
		$q_{мак}$	1 0	0 92	10	0 31	0 23	0 14	0 000					
7	02	$q_{ср}$	0 6	0 08	7	0 15	0 15							
		$q_{мак}$	2 6	0 24	20	0 34	0 46							
	08	$q_{ср}$	0 6	0 22	4	0 14	0 13							
		$q_{мак}$	1 9	0 94	17	0 40	0 66							
8	02	$q_{ср}$	0 4	0 09	8	0 13	0 14		0 000					
		$q_{мак}$	2 2	0 39	20	0 35	0 86		0 000					

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
8	08	$q_{ср}$	0 5	0 25	5	0 15	0 16		0 000					
		$q_{мак}$	4 9	0 86	18	0 60	1 26		0 000					
16	02	$q_{ср}$	0 6	0 14	7	0 13								
		$q_{мак}$	2 6	0 37	18	0 33								
	08	$q_{ср}$	0 6	0 24	4	0 14	0 13							
		$q_{мак}$	1 9	0 93	10	0 45	0 46							
18	08	$q_{ср}$	0 2	0 22	4	0 16	0 14							
		$q_{мак}$	0 5	0 78	10	0 46	0 54							

1991

1	02	$q_{ср}$	0 2	0 03	6	0 14	0 14							
		$q_{мак}$	0 6	0 04	22	0 32	0 35							
	08	$q_{ср}$	0 3	0 02	4	0 17	0 17			0 000				
		$q_{мак}$	1 0	0 05	11	0 40	0 44			0 000				
2	02	$q_{ср}$	0 2	0 03	9	0 13	0 13	0 01						
		$q_{мак}$	0 7	0 09	18	0 32	0 29	0 09						
	08	$q_{ср}$	0 6	0 02	7	0 16	0 16	0 00		0 002				
		$q_{мак}$	1 2	0 06	12	0 35	0 34	0 01		0 040				

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	02	$q_{ср}$	0 3	0 03	5	0 12	0 13	0 00						
		$q_{мак}$	1 3	0 06	19	0 24	0 27	0 04						
	08	$q_{ср}$	0 5	0 02	4	0 16	0 16	0 00	0 048	0 002				
		$q_{мак}$	1 3	0 07	8	0 33	0 31	0 00	0 066	0 020				
7	02	$q_{ср}$	0 5	0.03	6	0 14	0 13							
		$q_{мак}$	2 6	0 07	26	0 40	0 31							
	08	$q_{ср}$	0 6	0 02	3	0 19	0 17		0 049					
		$q_{мак}$	1 3	0 07	8	0 54	0 36		0 082					
8	02	$q_{ср}$	0 3	0 03	6	0 16	0 16							
		$q_{мак}$	0 9	0 06	19	0.36	0 62							
	08	$q_{ср}$	0 4	0 02	4	0 20	0 21		0 049	0.000				
		$q_{мак}$	1 2	0 07	8	0 43	0 59		0 075	0 000				
16	02	$q_{ср}$	0 3	0 03	4	0 16	0 16							
		$q_{мак}$	1 4	0 05	10	0 33	0 51							
	08	$q_{ср}$	0 4	0 02	3	0 19	0 19							
		$q_{мак}$	0 7	0 03	8	0 37	0 39							
18	02	$q_{ср}$	0 2	0 03	9	0 12	0 13							
		$q_{мак}$	0 5	0 05	27	0 27	0 30							
	08	$q_{ср}$	0 1	0 02	6	0 14	0 15		0 053					
		$q_{мак}$	0 3	0 04	10	0 32	0 31		0 074					

1992

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	08	$q_{ср}$		0 05	6	0 14	0 14			0 048				
		$q_{мак}$		0.10	10	0 36	0.33			0 136				
7	08	$q_{ср}$	0 7	0 05	4	0 17	0 18			0 043				
		$q_{мак}$	2 0	0 12	9	0 39	0 45			0 067				
8	08	$q_{ср}$	0 5	0 06	5	0 13	0 13			0 044				
		$q_{мак}$	0 7	0 14	10	0 41	0 44			0 062				
16	08	$q_{ср}$	0 4	0 05	3	0.17	0 14			0 043				
		$q_{мак}$	1.1	0.09	7	0.43	0.42			0 061				
18	08	$q_{ср}$	0 1			0 12	0 12			0 045				
		$q_{мак}$	0 4			0 29	0 32			0 062				

1993

1	08	$q_{ср}$		0 18	4	0 09	0 11			0 028				
		$q_{мак}$		0 27	10	0 17	0 17			0 046				
2	08	$q_{ср}$	0 6	0 18	5	0 10	0 10	0 01	0 008	0 031	0 033	0 000	0 070	0 000
		$q_{мак}$	1 3	0 27	12	0 17	0 17	0 11	0 040	0 056	0 103	0 000	0 160	0 000

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	08	$q_{ср}$		0 19	4	0 10	0 10	0 00	0 005	0 030	0 044	0 000	0 083	0 000
		$q_{мак}$		0 27	8	0 19	0 17	0 04	0 039	0 048	0 113	0 000	0 158	0 000
7	08	$q_{ср}$			4									
		$q_{мак}$			8									
8	08	$q_{ср}$		0.20	4	0 11	0 11			0 027				
		$q_{мак}$		0 29	8	0 16	0 18			0 055				
16	08	$q_{ср}$			4									
		$q_{мак}$			9									
18	08	$q_{ср}$		0 18	4	0 10	0 11	0 00		0 021				
		$q_{мак}$		0.26	6	0 15	0 17	0 03		0 045				

1994

2	08	$q_{ср}$	0 4	0 12	5	0 13	0 11	0 01	0 000	0 017	0 211	0 044	0 000	0 000
		$q_{мак}$	1 0	0 21	9	0 26	0 30	0 05	0 000	0 036	2 220	0 128	0 000	0 000
7	08	$q_{ср}$	0 3	0 12	4	0 14	0 11			0 018				
		$q_{мак}$	0 7	0 27	8	0 34	0 30			0 042				
18	08	$q_{ср}$		0 12	4	0 10	0 10	0 01		0 018				
		$q_{мак}$		0 26	7	0 18	0 19	0 04		0 036				

1995

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	08	q_{cp}	0 4	0 09	4	0 07	0 07	0 00		0 011				
		$q_{мак}$	1 2	0 21	9	0 15	0 16	0 02		0 025				
6	08	q_{cp}		0 10	4	0 07	0 07	0 00		0 012				
		$q_{мак}$		0 21	8	0 15	0 12	0 02		0 025				
7	08	q_{cp}	0 4	0 10	3	0 06	0 08			0 009				
		$q_{мак}$	1.0	0.21	7	0.15	0 12			0.025				
8	08	q_{cp}		0 09	4	0 07	0 06			0 011				
		$q_{мак}$		0 17	8	0 12	0 12			0 025				
18	08	q_{cp}		0 10	4	0 07	0 07	0 00		0 010				
		$q_{мак}$		0 20	8	0 11	0 13	0 02		0 020				

1996

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	08	q_{cp}	0 4	0 17	3	0.14	0 12	0 01	0 000	0 025	0.139	0 109	0 000	0 000
		$q_{мак}$	0 8	0 42	7	0 26	0 25	0 03	0 000	0 054	0 360	0 205	0 000	0 000
6	08	q_{cp}	0 3	0 16	4	0 15	0 14	0 01	0 000	0 022	0 151	0 113	0 000	0 000
		$q_{мак}$	0 8	0 42	8	0 32	0 27	0 04	0 000	0 047	0 310	0 288	0 000	0 000
7	08	q_{cp}	0 3	0 16	3	0 15	0 12			0 020				
		$q_{мак}$	0 7	0 42	7	0 28	0 24			0.046				
18	08	q_{cp}		0 18	2	0 13	0 11	0 00		0.023				
		$q_{мак}$		0 36	6	0 23	0 20	0 05		0 041				

ENVIRONMENT MONITORING CENTER
ATMOSPHERE CONTAMINATION DATA IN RA
(by years)

City	1992		1993		1994		1995		1996	
Hazardous compound	Observation points qty	Average annual concentration (mg/m)	Observation points qty	Average annual concentration (mg/m)	Observation points qty	Average annual concentration (mg/m)	Observation points qty	Average annual concentration (mg/m)	Observation points qty	Average annual concentration (mg/m)
1	2	3	4	5	6	7	8	9	10	11
Yerevan										
Dust	6	0 4	4	0 5	2	0 4	2	0 4	2	0 4
Sulfur Dioxide	11	0 05	7	0 20	7	0 16	7	0 09	4	0 14
Carbon Oxide	11	5	7	4	7	4	7	4	4	4
Nitrogen Dioxide	7	0 12	7	0 11	7	0 10	7	0 08	4	0 12
Nitrogen Oxide	7	0 12	7	0 10	7	0 10	7	0 07	4	0 09
Chlorine	2	0 02	3	0 00	3	0 01	3	0 00	3	0 00
Cloropiene	2	0 005	3	0 001	3	0 000	2	0 000	2	0 000
Formaldehide	9	0 042	7	0 029	7	0 016	7	0 011	4	0 024
Benzene			3	0 044	2	0 130	2	0 173	2	0 138
Toluol			3	0 073	2	0 056	2	0 103	2	0 104
Vanadzor										
Dust	4	0 2	4	0 2	4	0 1	4	0 2	4	0 2
Sulfur Dioxide	4	0 04	4	0 02	4	0 05	4	0 04	4	0 03
Carbon Oxide	4	3	4	2	4	2	4	2	4	2
Nitrogen Dioxide	4	0 06	4	0 04	4	0 02	4	0 02	4	0 02
Alaverdi										
Dust	2	0 1	2	0 1	2	0 1	2	0 1	2	0 1
Sulfur Dioxide	2	0 02	2	0 02	2	0 02	2	0 02	2	0 01
Carbon Oxide	2	1	2	1	2	1	2	1	2	1
Nitrogen Dioxide	2	0 03	2	0 04	2	0 04	2	0 03	2	0 03
Ararat										
Dust	-	-	1	0 4	1	0 5	1	0 6	1	0 6
Sulfur Dioxide	2	0 01	2	0 001	-	-	-	-	-	-
Carbon Oxide	2	1	2	1	-	-	-	-	-	-
Nitrogen Dioxide	2	0 04	2	0 03	-	-	-	-	-	-

Yerevan TPP is situated within Yerevan city

Director of Environment Monitoring Center T Hovhannissian

APPENDIX B

RA Surface Water Contamination Data

Water object observation point observation points location	Water quality index	Annual average concentration (mg/dm³)				
		1992	1993	1994	1995	1996
1	2	3	4	5	6	7
Hrazdan river-	Dissolved oxygen	-	-	8 2	7 4	7 4
t Hrazdan		-	-	1 9	1 9	2 3
Next to Geghamavan	Ammonium ions	-	-	0 00	0 00	0 00
village	Nitrates	-	-	1 89	3 82	2 12
	Nitrites	-		0 017	0 067	0 022
	Phosphates	-	-	0 08	0 10	0 06
		-	-	30 3	28 0	19 7
	Weighted particles	-	-	8 7	32 6	6 2
	Copper	-	-	0 014	0 015	0 013
Hrazdan river-	Dissolved oxygen	-	-	8 0	7 9	8 1
t Hrazdan		-	-	2 6	2 2	1 7
0 5 km down the	Ammonium ions	-	-	0 89	0 29	0 08
village	Nitrates	-	-	2 92	2 39	2 27
	Nitrites	-	-	0 047	0 040	0 007
	Phosphates	-	-	0 06	0 09	0 11
		-	-	30 2	25 6	20 7
	Weighted particles	-	-	7 5	31 9	13 0
	Copper	-	-	0 013	0 011	0 011
Hrazdan river-	Dissolved oxygen	-	-	7 9	8 5	7 7
Lusakert river		-	-	2 5	1 6	2 8
0 5 km down the	Ammonium ions	-	-	0 13	0 00	0 05
village	Nitrates	-	-	3 58	3 17	2 54
	Nitrites	-	-	0 039	0 025	0 008
	Phosphates	-	-	0 06	0 10	0 09
		-	-	27 8	31 0	18 6
	Weighted particles	-	-	7 0	32 9	16 5
	Copper	-	-	0 012	0 013	0 013
Hrazdan river-	Dissolved oxygen	10 0	7 9	8 2	8 5	7 6
Yerevan city		1 3	2 1	2 1	1 6	2 1
0 5 km down the	Ammonium ions	0 15	0 76	0 07	0 00	0 03
Arzni HPS	Nitrates	4 94	4 51	3 38	3 35	2 41
	Nitrites	0 008	0 014	0 040	0 029	0 010
	Phosphates	0 09	0 08	0 05	0 11	0 08
		38 4	23 3	27 3	28 5	20 4
	Weighted particles	33 8	18 4	7 2	39 8	45 8
	Copper	0 013	0 010	0 012	0 011	0 014
Hrazdan river-	Dissolved oxygen	6 4	5 2	6 2	4 9	6 5
Yerevan city		7 5	6 1	6 1	6 8	5 4
6 km down the city	Ammonium ions	3 85	3 18	4 10	3 34	5 54
close to Demirchi village	Nitrates	4 03	3 23	2 83	3 04	2 66
	Nitrites	0 040	0 080	0 166	0 028	0 081
	Phosphates	0 22	0 17	0 30	0 09	0 25
		41 6	28 1	27 7	28 9	21 1
	Phtorides	0 11	0 15	0 14	0 14	0 15
	Weighted particles	38 7	59 2	119 9	45 8	85 0
	Copper	0 014	0 011	0 014	0 016	0 014
	DDT	0 000	0 000	0 000	0 000	0 000
	DDE	0 004	0 000	0 000	0 000	0 000
	Lindan	0 018	0 044	0 069	0 023	0 050

1	2	3	4	5	6	7
Hrazdan river-	Dissolved oxygen	7 4	6 9	7 7	7 9	7 2
from the mouth		6 6	3 9	2 6	1 5	2 7
	Ammonium ions	1 64	0 88	1 24	0 60	3 22
	Nitrates	4 46	3 36	3 83	2 84	3 46
	Nitrites	0 086	0 088	0 128	0 034	0 057
	Phosphates	0 15	0 13	0 23	0 09	0 21
		41 6	28 1	22 3	29 1	20 9
	Weighted particles	53 4	18 0	33 9	34 2	98 3
	Copper	0 013	0 011	0 014	0 010	0 011
Lake Sevan Peninsula	Dissolved oxygen	9 0	9 4	-	-	8 1
		1 6	1 8	-	-	2 0
	Ammonium ions	0 08	0 08	-	-	0 06
	Nitrates	0 05	0 09	-	-	0 46
	Nitrites	0 017	0 019	-	-	0 000
	Phosphates	0 08	0 03	-	-	0 01
		0 04	16 5	-	-	19 5
	Weighted particles	14 4	2 5	-	-	151 7
	Copper	0 007		-	-	0 008
	Oil products	0 08	0 07	-	-	-
Lake Sevan -	Dissolved oxygen	9 2	9 3	-	-	7 5
7 5 km south from		1 6	2 0	-	-	2 3
Chkalovka village	Ammonium ions	0 07	0 08	-	-	0 17
	Nitrates	0 06	0 05	-	-	0 80
	Nitrites	0 017	0 013	-	-	0 000
	Phosphates	0 02	0 22	-	-	001
		12 7	15 0	-	-	17 0
	Phtorides	0 7	2 6	-	-	5 4
	Weighted particles	-	-	-	-	0 009
	Copper	0 08	0 03	-	-	-
	DDT	-	-	-	-	0 000
	DDE	-	-	-	-	0 000
	Lindan	-	-	-	-	0 090

Director T Hovhannissian

APPENDIX C

Production Facilities Analysis Reports

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2775709
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

YT 1 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns & Roe Enviro Services ATTN Mr David Cooksley

Questions? Contact your Client Services Representative
at (717) 656 2300
19 26 18 D 0001 20 581169
104 0 00 00012500 ASR000

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
2425 New Holland Pike
PO Box 12425
Lancaster PA 17605 2425
717 656 2300 Fax 717 656 2681

See reverse side for explanation of symbols and abbreviation

107

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2775709
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

YT 1 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	0 31	0 16	mg/kg
1501	PCB 1260	< 0 32	0 32	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
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717 656 2300 Fax 717 656 2681

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LLI Sample No. SW 2775710
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

YT 2 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns & Roe Enviro Services ATTN Mr David Cooksley

Questions? Contact your Client Services Representative
at (717) 656 2300
19 26 28 D 0001 20 581169
104 0 00 00012500 ASR000

Respectfully Submitted
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YT 2 Gravel Sample

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	0 26	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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Respectfully Submitted
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LLI Sample No. SW 2775711
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
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YT 3 Gravel Sample

Armenia

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Suite #120
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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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Collected

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Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 80	0 80	mg/kg
1496	PCB 1221	< 0 80	0 80	mg/kg
1497	PCB 1232	< 0 80	0 80	mg/kg
1498	PCB 1242	< 0 80	0 80	mg/kg
1499	PCB 1248	< 0 80	0 80	mg/kg
1500	PCB 1254	3 96	0 80	mg/kg
1501	PCB 1260	< 0 80	0 80	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
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Respectfully Submitted
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Collected

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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Suite #120
Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 8 0	8 0	mg/kg
1496	PCB 1221	< 8 0	8 0	mg/kg
1497	PCB 1232	< 8 0	8 0	mg/kg
1498	PCB 1242	< 8 0	8 0	mg/kg
1499	PCB 1248	< 8 0	8 0	mg/kg
1500	PCB 1254	28 4	8 0	mg/kg
1501	PCB 1260	< 8 0	8 0	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

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HT 1 Gravel Sample

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Account No 05267
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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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HT 1 Gravel Sample

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	1 42	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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Respectfully Submitted
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LLI Sample No. SW 2775703
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HT 2 Gravel Sample

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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Lancaster [illegible] 17605 2425
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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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LLI Sample No SW 2775704
Collected

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HT 3 Gravel Sample

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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	1 15	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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Respectfully Submitted
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LLI Sample No SW 2775705
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HT 4 Gravel Sample

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 16	16	mg/kg
1496	PCB 1221	< 16	16	mg/kg
1497	PCB 1232	< 16	16	mg/kg
1498	PCB 1242	< 16	16	mg/kg
1499	PCB 1248	< 16	16	mg/kg
1500	PCB 1254	56	16	mg/kg
1501	PCB 1260	< 16	16	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
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HT 5 Gravel Sample

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Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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HT 5 Gravel Sample

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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 1 6	1 6	mg/kg
1496	PCB 1221	< 1 6	1 6	mg/kg
1497	PCB 1232	< 1 6	1 6	mg/kg
1498	PCB 1242	< 1 6	1 6	mg/kg
1499	PCB 1248	< 1 6	1 6	mg/kg
1500	PCB 1254	12 8	1 6	mg/kg
1501	PCB 1260	< 1 6	1 6	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

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LLI Sample No. SW 2775707
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HT 6 Gravel Sample

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Lancaster PA 17605 [illegible]
71 656 2300 Fa 717 [illegible] 268

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 16	16	mg/kg
1496	PCB 1221	< 16	16	mg/kg
1497	PCB 1232	< 16	16	mg/kg
1498	PCB 1242	< 16	16	mg/kg
1499	PCB 1248	< 16	16	mg/kg
1500	PCB 1254	103	16	mg/kg
1501	PCB 1260	< 16	16	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
2425 New Holland Pike
PO Box 12425
Lancaster PA 17605 2425
717 656 2300 Fax 717 656 2689

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2775708
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

HT 7 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns & Roe Enviro Services ATTN Mr David Cooksley

Questions? Contact your Client Services Representative
at (717) 656 2300
19 26 05 D 0001 20 581169
104 0 00 00012500 ASR000

Respectfully Submitted
Jenifer E Hess B S
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2425 New Holland Pike
PO Box 12425
Lancaster PA 176 5 2425
717 656 230 Fa 717 656 2681

See reverse side for explanation of symbol and abbreviations

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LLI Sample No. SW 2775708
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

HT 7 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 16	16	mg/kg
1496	PCB 1221	< 16	16	mg/kg
1497	PCB 1232	< 16	16	mg/kg
1498	PCB 1242	< 16	16	mg/kg
1499	PCB 1248	< 16	16	mg/kg
1500	PCB 1254	150	16	mg/kg
1501	PCB 1260	< 16	16	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
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LLI Sample No. SW 2775698
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

HH 1 Gravel Sample

Armenia

Account No 05267
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2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Questions? Contact your Client Services Representative
at (717) 656 2300
19 23 51 D 0001 20 581169
104 0 00 00012500 ASR000

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Lancaster PA 17605 2425
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135

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LLI Sample No. SW 2775698
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

HH 1 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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Respectfully Submitted
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230 Fax 71 656 2681

136

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A division of Thermo Analytical Inc

LLI Sample No SW 2775699
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

HH 2 Gravel Sample

Armenia

Account No 05267
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2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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104 0 00 00012500 ASR000

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LLI Sample No SW 2775699
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

HH 2 Gravel Sample

Armenia

Account No 05267
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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

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at (717) 656 2300

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Group Leader Pesticides/PCBs

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LLI Sample No. SW 2775694
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

AH 1 Gravel Sample

Armenia

Account No 05267
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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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104 0 00 00012500 ASR000

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Lan 3 1 24
7 C 5 2 8

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LLI Sample No. SW 2775694
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

AH 1 Gravel Sample

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Account No 05267
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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	< 0 16	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
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Respectfully Submitted
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Phone 2500 Fax 717 656 2630

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A division of Thermo Analytical Inc

LLI Sample No SW 2775695
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

AH 2 Gravel Sample

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Account No 05267
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Suite #120
Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns & Roe Enviro Services ATTN Mr David Cooksley

Questions? Contact your Client Services Representative
at (717) 656 2300
19 23 17 D 0001 20 581169
104 0 00 00012500 ASR000

Respectfully Submitted
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P.O. Box 12425
Lancaster, PA 17605-2425
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141

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LLI Sample No SW 2775695
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

AH 2 Gravel Sample

Armenia

Account No 05267
Burns & Roe Enviro Services
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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 16	0 16	mg/kg
1496	PCB 1221	< 0 16	0 16	mg/kg
1497	PCB 1232	< 0 16	0 16	mg/kg
1498	PCB 1242	< 0 16	0 16	mg/kg
1499	PCB 1248	< 0 16	0 16	mg/kg
1500	PCB 1254	0 18	0 16	mg/kg
1501	PCB 1260	< 0 16	0 16	mg/kg

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
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L aste PA 1760 42
71 656 2300 fax 71 656 65

142

Lancaster Laboratories
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LLI Sample No SW 2775696
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

GH 1 Gravel Sample

Armenia

Account No 05267
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2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Questions? Contact your Client Services Representative
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LLI Sample No SW 2775696
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

GH 1 Gravel Sample

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2570 Blvd of the Generals
Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 0 80	0 80	mg/kg
1496	PCB 1221	< 0 80	0 80	mg/kg
1497	PCB 1232	< 0 80	0 80	mg/kg
1498	PCB 1242	< 0 80	0 80	mg/kg
1499	PCB 1248	< 0 80	0 80	mg/kg
1500	PCB 1254	2 79	0 80	mg/kg
1501	PCB 1260	< 0 80	0 80	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
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LLI Sample No SW 2775697
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

GH 2 Gravel Sample

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Suite #120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

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Questions? Contact your Client Services Representative
at (717) 656 2300
19 23 39 D 0001 20 581169
104 0 00 00012500 ASR000

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Lancaster PA 17605 2425
717 656 2300 Fa 717 656 2681

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LLI Sample No. SW 2775697
Collected

Submitted 9/ 8/97 Reported 10/ 6/97
Discard 10/21/97

GH 2 Gravel Sample

Armenia

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Suite #120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 1 6	1 6	mg/kg
1496	PCB 1221	< 1 6	1 6	mg/kg
1497	PCB 1232	< 1 6	1 6	mg/kg
1498	PCB 1242	< 1 6	1 6	mg/kg
1499	PCB 1248	< 1 6	1 6	mg/kg
1500	PCB 1254	1 7	1 6	mg/kg
1501	PCB 1260	< 1 6	1 6	mg/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
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Respectfully Submitted
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See reverse side for explanation of symbol and abbreviation

"Fingerprinting" (48 Congener) Analysis Reports

141

Lancaster Laboratories
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LLI Sample No SW 2812808
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

YT 3 Gravel Sample
Previous Lab #2775711
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
7732	PCB Congeners Soils			See Page 2
7733	PCB Congeners Soils Cont			See Page 5

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Questions? Contact your Client Services Representative
at (717) 656 2300
21 16 42 D 0001 3 589118
232 0 00 00035000 ASR000

Respectfully Submitted
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MEMBER ACIL

148

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812808
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

YT 3 Gravel Sample
Previous Lab #2775711
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
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Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
7734	PCB 1	< 0 0020	0 0020	mg/kg
7735	PCB 5	< 0 0020	0 0020	mg/kg
7736	PCB 8	< 0 0020	0 0020	mg/kg
7737	PCB 18	< 0 00020	0 00020	mg/kg
7738	PCB 28	< 0 00020	0 00020	mg/kg
7739	PCB 31	< 0 00020	0 00020	mg/kg
7740	PCB 37	< 0 00020	0 00020	mg/kg
7741	PCB 44	< 0 00020	0 00020	mg/kg
7742	PCB 49	< 0 00020	0 00020	mg/kg
7743	PCB 52	< 0 00020	0 00020	mg/kg
7744	PCB 66	0 00048	0 00020	mg/kg
7745	PCB 70	< 0 00020	0 00020	mg/kg
7746	PCB 74	< 0 00020	0 00020	mg/kg
7747	PCB 77	< 0 00020	0 00020	mg/kg
7748	PCB 81	< 0 00020	0 00020	mg/kg
7749	PCB 87	< 0 00030	0 00030	mg/kg
7750	PCB 99	< 0 00020	0 00020	mg/kg
7751	PCB 101	0 00023	0 00020	mg/kg
7752	PCB 105	0 00150	0 00020	mg/kg
7753	PCB 110	< 0 00070	0 00070	mg/kg
7754	PCB 114	< 0 00020	0 00020	mg/kg
7755	PCB 118	0 00133	0 00020	mg/kg
7756	PCB 119	< 0 00040	0 00040	mg/kg
7757	PCB 123	< 0 00020	0 00020	mg/kg
7758	PCB 126	< 0 00020	0 00020	mg/kg
7759	PCB 128	< 0 00020	0 00020	mg/kg
7760	PCB 138	0 00051	0 00020	mg/kg
7761	PCB 141	0 00022	0 00020	mg/kg
7762	PCB 151	0 00021	0 00020	mg/kg
7763	PCB 153	0 00062	0 00020	mg/kg
7764	PCB 156	< 0 00020	0 00020	mg/kg
7765	PCB 157	< 0 00020	0 00020	mg/kg
7766	PCB 158	0 00022	0 00020	mg/kg
7767	PCB 167	< 0 00020	0 00020	mg/kg
7768	PCB 168	< 0 00020	0 00020	mg/kg
7769	PCB 169	< 0 00020	0 00020	mg/kg
7770	PCB 170	< 0 00020	0 00020	mg/kg

Questions? Contact your Client Services Representative
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Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER
ACIL

1449

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A division of Thermo Analytical Inc

LLI Sample No. SW 2812808
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

YT 3 Gravel Sample
Previous Lab #2775711
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
7771	PCB 177	< 0 00020	0 00020	mg/kg

IUPAC #	Congener
PCB 1	2 Chlorobiphenyl
PCB 5	2 3 Dichlorobiphenyl
PCB 8	2 4 Dichlorobiphenyl
PCB 18	2 2 5 Trichlorobiphenyl
PCB 28	2 4 4 Trichlorobiphenyl
PCB 31	2 4 5 Trichlorobiphenyl
PCB 37	3 4 4 Trichlorobiphenyl
PCB 44	2 2 3 5 Tetrachlorobiphenyl
PCB 49	2 2 4 5 Tetrachlorobiphenyl
PCB 52	2 2 5 5 Tetrachlorobiphenyl
PCB 66	2 3 4 4 Tetrachlorobiphenyl
PCB 70	2 3 4 5 Tetrachlorobiphenyl
PCB 74	2 4 4 5 Tetrachlorobiphenyl
PCB 77	3 3 4 4 Tetrachlorobiphenyl
PCB 81	3 4 4 5 Tetrachlorobiphenyl
PCB 87	2 2 3 4 5 Pentachlorobiphenyl
PCB 99	2 2 4 4 5 Pentachlorobiphenyl
PCB 101	2 2 4 5 5 Pentachlorobiphenyl
PCB 105	2 3 3 4 4 Pentachlorobiphenyl

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Group Leader Pesticides/PCBs

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LLI Sample No SW 2812808
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Previous Lab #2775711
Armenia

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Norristown PA 19403 6974

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Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
	PCB 110 2 3 3 4 6 Pentachlorobiphenyl			
	PCB 114 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 118 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 119 2 3 4 4 6 Pentachlorobiphenyl			
	PCB 123 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 126 3 3 4 4 5 Pentachlorobiphenyl			
	PCB 128 2 2 3 3 4 4 Hexachlorobiphenyl			
	PCB 138 2 2 3 4 4 5 Hexachlorobiphenyl			
	PCB 141 2 2 3 4 5 5 Hexachlorobiphenyl			
	PCB 151 2 2 3 5 5 6 Hexachlorobiphenyl			
	PCB 153 2 2 4 4 5 5 Hexachlorobiphenyl			
	PCB 156 2 3 3 4 4 5 Hexachlorobiphenyl			
	PCB 157 2 3 3 4 4 5 Hexachlorobiphenyl			
	PCB 158 2 3 3 4 4 6 Hexachlorobiphenyl			
	PCB 167 2 3 4 4 5 5 Hexachlorobiphenyl			
	PCB 168 2 3 4 4 5 6 Hexachlorobiphenyl			
	PCB 169 3 3 4 4 5 5 Hexachlorobiphenyl			
	PCB 170 2 2 3 3 4 4 5 Heptachlorobiphenyl			
	PCB 177 2 2 3 3 4 5 6 Heptachlorobiphenyl			

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Armenia

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Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils Cont			
7772	PCB 180	< 0 00020	0 00020	mg/kg
7773	PCB 183	< 0 00020	0 00020	mg/kg
7774	PCB 184	< 0 00020	0 00020	mg/kg
7775	PCB 187	< 0 00020	0 00020	mg/kg
7776	PCB 189	< 0 00020	0 00020	mg/kg
7777	PCB 194	< 0 00020	0 00020	mg/kg
7778	PCB 195	< 0 00020	0 00020	mg/kg
7779	PCB 199	< 0 00020	0 00020	mg/kg
7780	PCB 206	< 0 00020	0 00020	mg/kg
7781	PCB 209	< 0 00020	0 00020	mg/kg

IUPAC #	Congener
PCB 180	2 2 3 4 4 5 5 Heptachlorobiphenyl
PCB 183	2 2 3 4 4 5 6 Heptachlorobiphenyl
PCB 184	2 2 3 4 4 6 6 Heptachlorobiphenyl
PCB 187	2 2 3 4 5 5 6 Heptachlorobiphenyl
PCB 189	2 3 3 4 4 5 5 Heptachlorobiphenyl
PCB 194	2 2 3 3 4 4 5 5 Octachlorobiphenyl
PCB 195	2 2 3 3 4 4 5 6 Octachlorobiphenyl
PCB 199	2 2 3 3 4 5 5 6 Octachlorobiphenyl
PCB 206	2 2 3 3 4 4 5 5 6 Nonachlorobiphenyl
PCB 209	Decachlorobiphenyl

The total PCB concentration for the analytes listed is 0 0057 mg/kg

The sample displayed surrogate recoveries which fell outside the laboratory limits This was determined to be due to matrix effects

The sample matrix created chromatographic effects which altered analyte retention times Chromatographic identification of analytes was based on a spiked extract evaluation

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ASII

152

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LLI Sample No SW 2812806
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

AH 2 Gravel Sample
Previous Lab #2775695
Armenia

Account No 05267
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Suite 120
Norristown PA 19403 6974

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CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
7732	PCB Congeners Soils			See Page 2
7733	PCB Congeners Soils Cont			See Page 5

1 COPY TO Burns & Roe Enterprises Inc ATTN Mr David Cooksley

Questions? Contact your Client Services Representative
at (717) 656 2300
21 15 31 D 0001 3 589118
232 0 00 00035000 ASR000

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

153

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812806
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

AH 2 Gravel Sample
Previous Lab #2775695
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
7734	PCB 1	< 0 0020	0 0020	mg/kg
7735	PCB 5	< 0 0020	0 0020	mg/kg
7736	PCB 8	< 0 0020	0 0020	mg/kg
7737	PCB 18	< 0 00020	0 00020	mg/kg
7738	PCB 28	< 0 00020	0 00020	mg/kg
7739	PCB 31	< 0 00020	0 00020	mg/kg
7740	PCB 37	< 0 00020	0 00020	mg/kg
7741	PCB 44	< 0 00020	0 00020	mg/kg
7742	PCB 49	< 0 00020	0 00020	mg/kg
7743	PCB 52	0 00049	0 00020	mg/kg
7744	PCB 66	0 00055	0 00020	mg/kg
7745	PCB 70	0 00023	0 00020	mg/kg
7746	PCB 74	< 0 00020	0 00020	mg/kg
7747	PCB 77	< 0 00030	0 00030	mg/kg
7748	PCB 81	< 0 00020	0 00020	mg/kg
7749	PCB 87	0 00164	0 00020	mg/kg
7750	PCB 99	< 0 00020	0 00020	mg/kg
7751	PCB 101	0 00051	0 00020	mg/kg
7752	PCB 105	0 00215	0 00020	mg/kg
7753	PCB 110	0 00585	0 00020	mg/kg
7754	PCB 114	< 0 00020	0 00020	mg/kg
7755	PCB 118	0 00343	0 00020	mg/kg
7756	PCB 119	< 0 00060	0 00060	mg/kg
7757	PCB 123	< 0 00020	0 00020	mg/kg
7758	PCB 126	< 0 00020	0 00020	mg/kg
7759	PCB 128	0 00043	0 00020	mg/kg
7760	PCB 138	0 00689	0 00020	mg/kg
7761	PCB 141	0 00090	0 00020	mg/kg
7762	PCB 151	0 00051	0 00020	mg/kg
7763	PCB 153	0 00364	0 00020	mg/kg
7764	PCB 156	0 00051	0 00020	mg/kg
7765	PCB 157	< 0 00020	0 00020	mg/kg
7766	PCB 158	0 00057	0 00020	mg/kg
7767	PCB 167	< 0 00020	0 00020	mg/kg
7768	PCB 168	< 0 00020	0 00020	mg/kg
7769	PCB 169	< 0 00020	0 00020	mg/kg
7770	PCB 170	0 00048	0 00020	mg/kg

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

154

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2812806
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

AH 2 Gravel Sample
Previous Lab #2775695
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
7771	PCB 177	< 0 00020	0 00020	mg/kg
	IUPAC # Congener			
	PCB 1 2 Chlorobiphenyl			
	PCB 5 2 3 Dichlorobiphenyl			
	PCB 8 2 4 Dichlorobiphenyl			
	PCB 18 2 2 5 Trichlorobiphenyl			
	PCB 28 2 4 4 Trichlorobiphenyl			
	PCB 31 2 4 5 Trichlorobiphenyl			
	PCB 37 3 4 4 Trichlorobiphenyl			
	PCB 44 2 2 3 5 Tetrachlorobiphenyl			
	PCB 49 2 2 4 5 Tetrachlorobiphenyl			
	PCB 52 2 2 5 5 Tetrachlorobiphenyl			
	PCB 66 2 3 4 4 Tetrachlorobiphenyl			
	PCB 70 2 3 4 5 Tetrachlorobiphenyl			
	PCB 74 2 4 4 5 Tetrachlorobiphenyl			
	PCB 77 3 3 4 4 Tetrachlorobiphenyl			
	PCB 81 3 4 4 5 Tetrachlorobiphenyl			
	PCB 87 2 2 3 4 5 Pentachlorobiphenyl			
	PCB 99 2 2 4 4 5 Pentachlorobiphenyl			
	PCB 101 2 2 4 5 5 Pentachlorobiphenyl			
	PCB 105 2 3 3 4 4 Pentachlorobiphenyl			

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812806
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

AH 2 Gravel Sample
Previous Lab #2775695
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
	PCB 110 2 3 3 4 6 Pentachlorobiphenyl			
	PCB 114 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 118 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 119 2 3 4 4 6 Pentachlorobiphenyl			
	PCB 123 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 126 3 3 4 4 5 Pentachlorobiphenyl			
	PCB 128 2 2 3 3 4 4 Hexachlorobiphenyl			
	PCB 138 2 2 3 4 4 5 Hexachlorobiphenyl			
	PCB 141 2 2 3 4 5 5 Hexachlorobiphenyl			
	PCB 151 2 2 3 5 5 6 Hexachlorobiphenyl			
	PCB 153 2 2 4 4 5 5 Hexachlorobiphenyl			
	PCB 156 2 3 3 4 4 5 Hexachlorobiphenyl			
	PCB 157 2 3 3 4 4 5 Hexachlorobiphenyl			
	PCB 158 2 3 3 4 4 6 Hexachlorobiphenyl			
	PCB 167 2 3 4 4'5 5 Hexachlorobiphenyl			
	PCB 168 2 3 4 4 5 6 Hexachlorobiphenyl			
	PCB 169 3 3 4 4 5 5 Hexachlorobiphenyl			
	PCB 170 2 2 3 3 4 4 5 Heptachlorobiphenyl			
	PCB 177 2 2 3 3 4 5 6 Heptachlorobiphenyl			

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

156

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812806
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

AH 2 Gravel Sample
Previous Lab #2775695
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils Cont			
7772	PCB 180	0 00093	0 00020	mg/kg
7773	PCB 183	< 0 00020	0 00020	mg/kg
7774	PCB 184	< 0 00020	0 00020	mg/kg
7775	PCB 187	< 0 00020	0 00020	mg/kg
7776	PCB 189	< 0 00020	0 00020	mg/kg
7777	PCB 194	< 0 00020	0 00020	mg/kg
7778	PCB 195	< 0 00020	0 00020	mg/kg
7779	PCB 199	< 0 00020	0 00020	mg/kg
7780	PCB 206	< 0 00020	0 00020	mg/kg
7781	PCB 209	< 0 00020	0 00020	mg/kg

IUPAC #	Congener
PCB 180	2 2 3 4 4 5 5 Heptachlorobiphenyl
PCB 183	2 2 3 4 4 5 6 Heptachlorobiphenyl
PCB 184	2 2 3 4 4 6 6 Heptachlorobiphenyl
PCB 187	2 2 3 4 5 5 6 Heptachlorobiphenyl
PCB 189	2 3 3 4 4 5 5 Heptachlorobiphenyl
PCB 194	2 2 3 3 4 4 5 5 Octachlorobiphenyl
PCB 195	2 2 3 3 4 4 5 6 Octachlorobiphenyl
PCB 199	2 2 3 3 4 5 5 6 Octachlorobiphenyl
PCB 206	2 2 3 3 4 4 5 5 6 Nonachlorobiphenyl
PCB 209	Decachlorobiphenyl

The total PCB concentration for the analytes listed is 0 0304 mg/kg

The sample displayed surrogate recoveries which fell outside the laboratory limits This was determined to be due to matrix effects

The sample matrix created chromatographic effects which altered analyte retention times Chromatographic identification of analytes was based on a spiked extract evaluation

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

157

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2812807
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

GH 1 Gravel Sample
Previous Lab #2775696
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME		AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
7732	PCB Congeners	Soils			See Page 2
7733	PCB Congeners	Soils Cont			See Page 5

1 COPY TO Burns & Roe Enterprises Inc ATTN Mr David Cooksley

Questions? Contact your Client Services Representative
at (717) 656 2300
21 16 13 D 0001 3 589118
232 0 00 00035000 ASR000

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

158

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812807
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

GH 1 Gravel Sample
Previous Lab #2775696
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
7734	PCB 1	< 0 010	0 010	mg/kg
7735	PCB 5	< 0 010	0 010	mg/kg
7736	PCB 8	< 0 010	0 010	mg/kg
7737	PCB 18	0 0028	0 0010	mg/kg
7738	PCB 28	0 0020	0 0010	mg/kg
7739	PCB 31	0 0022	0 0010	mg/kg
7740	PCB 37	0 0055	0 0010	mg/kg
7741	PCB 44	0 0069	0 0010	mg/kg
7742	PCB 49	0 0048	0 0010	mg/kg
7743	PCB 52	0 0136	0 0010	mg/kg
7744	PCB 66	0 0156	0 0010	mg/kg
7745	PCB 70	0 0158	0 0010	mg/kg
7746	PCB 74	< 0 011	0 011	mg/kg
7747	PCB 77	< 0 019	0 019	mg/kg
7748	PCB 81	< 0 0010	0 0010	mg/kg
7749	PCB 87	< 0 0090	0 0090	mg/kg
7750	PCB 99	< 0 0010	0 0010	mg/kg
7751	PCB 101	0 0532	0 0010	mg/kg
7752	PCB 105	0 0602	0 0010	mg/kg
7753	PCB 110	0 0755	0 0010	mg/kg
7754	PCB 114	0 0024	0 0010	mg/kg
7755	PCB 118	0 0898	0 0010	mg/kg
7756	PCB 119	< 0 0040	0 0040	mg/kg
7757	PCB 123	< 0 0010	0 0010	mg/kg
7758	PCB 126	< 0 0010	0 0010	mg/kg
7759	PCB 128	0 0314	0 0010	mg/kg
7760	PCB 138	0 133	0 0010	mg/kg
7761	PCB 141	0 0255	0 0010	mg/kg
7762	PCB 151	0 0166	0 0010	mg/kg
7763	PCB 153	0 128	0 0010	mg/kg
7764	PCB 156	< 0 0080	0 0080	mg/kg
7765	PCB 157	0 0068	0 0010	mg/kg
7766	PCB 158	0 0218	0 0010	mg/kg
7767	PCB 167	0 0130	0 0010	mg/kg
7768	PCB 168	< 0 0010	0 0010	mg/kg
7769	PCB 169	< 0 0010	0 0010	mg/kg
7770	PCB 170	0 0268	0 0010	mg/kg

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

459

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2812807
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

GH 1 Gravel Sample
Previous Lab #2775696
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
7771	PCB 177	< 0 0010	0 0010	mg/kg
	IUPAC # Congener			
	PCB 1 2 Chlorobiphenyl			
	PCB 5 2 3 Dichlorobiphenyl			
	PCB 8 2 4 Dichlorobiphenyl			
	PCB 18 2 2 5 Trichlorobiphenyl			
	PCB 28 2 4 4 Trichlorobiphenyl			
	PCB 31 2 4 5 Trichlorobiphenyl			
	PCB 37 3 4 4 Trichlorobiphenyl			
	PCB 44 2 2 3 5 Tetrachlorobiphenyl			
	PCB 49 2 2 4 5 Tetrachlorobiphenyl			
	PCB 52 2 2 5 5 Tetrachlorobiphenyl			
	PCB 66 2 3 4 4 Tetrachlorobiphenyl			
	PCB 70 2 3 4 5 Tetrachlorobiphenyl			
	PCB 74 2 4 4 5 Tetrachlorobiphenyl			
	PCB 77 3 3 4 4 Tetrachlorobiphenyl			
	PCB 81 3 4 4 5 Tetrachlorobiphenyl			
	PCB 87 2 2 3 4 5 Pentachlorobiphenyl			
	PCB 99 2 2 4 4 5 Pentachlorobiphenyl			
	PCB 101 2 2 4 5 5 Pentachlorobiphenyl			
	PCB 105 2 3 3 4 4 Pentachlorobiphenyl			

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

160

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812807
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

GH 1 Gravel Sample
Previous Lab #2775696
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils			
	PCB 110 2 3 3 4 6 Pentachlorobiphenyl			
	PCB 114 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 118 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 119 2 3 4 4 6 Pentachlorobiphenyl			
	PCB 123 2 3 4 4 5 Pentachlorobiphenyl			
	PCB 126 3 3 4 4 5 Pentachlorobiphenyl			
	PCB 128 2 2 3 3 4 4 Hexachlorobiphenyl			
	PCB 138 2 2 3 4 4 5 Hexachlorobiphenyl			
	PCB 141 2 2 3 4 5 5 Hexachlorobiphenyl			
	PCB 151 2 2 3 5 5 6 Hexachlorobiphenyl			
	PCB 153 2 2 4 4 5 5 Hexachlorobiphenyl			
	PCB 156 2 3 3 4 4 5 Hexachlorobiphenyl			
	PCB 157 2 3 3 4 4 5 Hexachlorobiphenyl			
	PCB 158 2 3 3 4 4 6 Hexachlorobiphenyl			
	PCB 167 2 3 4 4 5 5 Hexachlorobiphenyl			
	PCB 168 2 3 4 4 5 6 Hexachlorobiphenyl			
	PCB 169 3 3 4 4 5 5 Hexachlorobiphenyl			
	PCB 170 2 2 3 3 4 4 5 Heptachlorobiphenyl			
	PCB 177 2 2 3 3 4 5 6 Heptachlorobiphenyl			

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2812807
Collected

Submitted 11/ 4/97 Reported 11/26/97
Discard 12/11/97

GH 1 Gravel Sample
Previous Lab #2775696
Armenia

Account No 05267
Burns and Roe Enterprises Inc
2570 Blvd of the Generals
Suite 120
Norristown PA 19403 6974

P O 22 USAID
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCB Congeners	Soils Cont			
7772	PCB 180	0 0415	0 0010	mg/kg
7773	PCB 183	0 0089	0 0010	mg/kg
7774	PCB 184	< 0 0060	0 0060	mg/kg
7775	PCB 187	0 0087	0 0010	mg/kg
7776	PCB 189	0 0017	0 0010	mg/kg
7777	PCB 194	0 0030	0 0010	mg/kg
7778	PCB 195	0 0011	0 0010	mg/kg
7779	PCB 199	< 0 0030	0 0030	mg/kg
7780	PCB 206	0 0010	0 0010	mg/kg
7781	PCB 209	< 0 0010	0 0010	mg/kg

IUPAC #	Congener
PCB 180	2,2 3 4 4 5,5 Heptachlorobiphenyl
PCB 183	2 2 3 4 4' 5 6 Heptachlorobiphenyl
PCB 184	2,2 3 4 4 6 6 Heptachlorobiphenyl
PCB 187	2 2 3 4 5 5 6 Heptachlorobiphenyl
PCB 189	2 3 3 4 4 5 5 Heptachlorobiphenyl
PCB 194	2 2 3 3 4 4 5 5 Octachlorobiphenyl
PCB 195	2 2 3 3 4 4 5 6 Octachlorobiphenyl
PCB 199	2 2 3 3 4 5 5 6 Octachlorobiphenyl
PCB 206	2 2 3 3 4 4 5 5 6 Nonachlorobiphenyl
PCB 209	Decachlorobiphenyl

The total PCB concentration for the analytes listed is 0 824 mg/kg

The sample matrix created chromatographic effects which altered analyte retention times Chromatographic identification of analytes was based on a spiked extract evaluation

Questions? Contact your Client Services Representative
at (717) 656 2300

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
2425 New Holland Pike
PO Box 2117
Lancaster PA 17605 2117

162

Switchyard Oil Analysis Reports

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887118
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T1 140434 Marash Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 13 33 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
PO Box 12
Lancaster PA 17

0164

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887118
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T1 140434 Marash Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories Inc
Holland Pike

165

ANALYSIS REPORT

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887119
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T2 110955 Marash Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 13 49 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
2425 New Holland Pike
PO Box 2425
Lancaster PA 17605
Telephone 230

See reverse side for definitions, symbols and abbreviations

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887119
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T2 110955 Marash Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
2425 New Holland Pike
PO Box 12425
Lancaster PA 17605-2425

167

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887120
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

CB 2470 Marash Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 14 06 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

168

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. G5 2887120
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

CB 2470 Marash Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	8 100	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Stone
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

169

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887121
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T1 88921 Zovuny Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 14 20 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

170

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887121
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T1 88921 Zovuny Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
42 New Holland Pike
P O Box 1642
Lancaster PA 17605

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887122
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T2 105923 Zovuny Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 14 33 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

172

Lancaster Laboratories
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LLI Sample No G5 2887122
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T2 105923 Zovuny Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

173

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887123
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

CB 1328 Zovuny Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 14 48 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887123
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

CB 1328 Zovuny Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887124
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T1 133353 Shaumian 2 Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 15 04 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M. Lowe
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887124
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T1 133353 Shaumian 2 Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No G5 2887125
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T2 140188 Shaumian 2 Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
0174	PCBs in Oil			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 15 23 D 0001 13 134128 605360
320 0 00 00012000 ASR000

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

178

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. G5 2887125
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

T2 140188 Shaumian 2 Oil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Oil				
4815	PCB 1016	< 2 500	2 500	ug/kg
4816	PCB 1221	< 2 500	2 500	ug/kg
4817	PCB 1232	< 2 500	2 500	ug/kg
4818	PCB 1242	< 2 500	2 500	ug/kg
4819	PCB 1248	< 2 500	2 500	ug/kg
4820	PCB 1254	< 2 500	2 500	ug/kg
4821	PCB 1260	< 2 500	2 500	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Switchyard Soil Analysis Reports

180

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2887126
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

M Tank Marash Tank Storage Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 15 40 D 0001 13 134128 605360
320 0 00 00018800 ASR000

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

181

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887126
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

M Tank Marash Tank Storage Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 170	170	ug/kg
1496	PCB 1221	< 170	170	ug/kg
1497	PCB 1232	< 170	170	ug/kg
1498	PCB 1242	< 170	170	ug/kg
1499	PCB 1248	< 170	170	ug/kg
1500	PCB 1254	1 000	170	ug/kg
1501	PCB 1260	< 170	170	ug/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

182

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887127
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

Z Trans Zovuny Under Transformer Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 16 03 D 0001 13 134128 605360
320 0 00 00018800 ASR000

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887127
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

Z Trans Zovuny Under Transformer Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 34	34	ug/kg
1496	PCB 1221	< 34	34	ug/kg
1497	PCB 1232	< 34	34	ug/kg
1498	PCB 1242	< 34	34	ug/kg
1499	PCB 1248	< 34	34	ug/kg
1500	PCB 1254	< 34	34	ug/kg
1501	PCB 1260	91	34	ug/kg

Due to insufficient sample size we were unable to report our usual quantitation limits The values reported represent the lowest quantitation limits obtainable

A disparity of >40% between the primary and confirmatory analysis occurred Due to suspected interference the lower result was reported for Aroclor 1260

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
425 New Holland Pike
P O Box 2425
Lancaster PA 17603

134

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2887128
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

Z Tank Zovuny Tank Storage Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 16 22 D 0001 13 134128 605360
320 0 00 00012500 ASR000

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No. SW 2887128
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

Z Tank Zovuny Tank Storage Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 170	170	ug/kg
1496	PCB 1221	< 170	170	ug/kg
1497	PCB 1232	< 170	170	ug/kg
1498	PCB 1242	< 170	170	ug/kg
1499	PCB 1248	< 170	170	ug/kg
1500	PCB 1254	1 050	170	ug/kg
1501	PCB 1260	< 170	170	ug/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
2425 New Holland Pike
PO Box 1742

186

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887129
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

S Trans Shaumian 2 Under Transformer Gravel Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 16 40 D 0001 13 134128 605360
320 0 00 00018800 ASR000

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887129
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

S Trans Shaumian 2 Under Transformer Gravel Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 850	850	ug/kg
1496	PCB 1221	< 850	850	ug/kg
1497	PCB 1232	< 850	850	ug/kg
1498	PCB 1242	< 850	850	ug/kg
1499	PCB 1248	< 850	850	ug/kg
1500	PCB 1254	4 380	850	ug/kg
1501	PCB 1260	< 850	850	ug/kg

The values reported for the Aroclors represent the lowest quantitation limits obtainable This is due to dilutions or interfering peaks from the presence of Aroclor 1254

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL

188

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887130
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

S Tank Shaumian 2 Oil Storage Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
1216	PCBs in Solids			See Page 2

1 COPY TO Burns and Roe Enterprises Inc ATTN Mr Dave Cooksley

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300
12 16 59 D 0001 13 134128 605360
320 0 00 00012500 ASR000

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
2425 New Holland Pike
PO Box 12425
Lancaster PA 17605 2425
717 656 2300 Fax 717 656 2681

See reverse side for explanation of symbols and abbreviations

Lancaster Laboratories
A division of Thermo Analytical Inc

LLI Sample No SW 2887130
Collected

Submitted 3/ 4/98 Reported 3/18/98
Discard 4/18/98

S Tank Shaumian 2 Oil Storage Soil Sample

Account No 05267
Burns and Roe Enterprises Inc

PO Box 222
Oradell NJ 07649

P O 5825 578
Rel

CAT NO	ANALYSIS NAME	AS RECEIVED RESULTS	LIMIT OF QUANTITATION	UNITS
PCBs in Solids				
1495	PCB 1016	< 17	17	ug/kg
1496	PCB 1221	< 17	17	ug/kg
1497	PCB 1232	< 17	17	ug/kg
1498	PCB 1242	< 17	17	ug/kg
1499	PCB 1248	< 17	17	ug/kg
1500	PCB 1254	< 17	17	ug/kg
1501	PCB 1260	136	17	ug/kg

Questions? Contact your Client Services Representative
Marianne Bragg at (717) 656 2300

Dorothy M. Love
for

Respectfully Submitted
Jenifer E Hess B S
Group Leader Pesticides/PCBs

MEMBER ACIL
Lancaster Laboratories
2425 New Holland Pike
PO Box 12425
Lancaster PA 17605 2425
717 656 2300 Fax 717 656 2681

See reverse side for explanation of symbols and abbreviations

190

APPENDIX D

МИНИСТЕРСТВО ЭНЕРГЕТИКИ И ЭЛЕКТРИФИКАЦИИ СССР

ГПО "ЭНЕРГОПРОМ"

ВСЕСОЮЗНЫЙ ГОСУДАРСТВЕННЫЙ
НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ И ПРОЕКТНО КОНСТРУКТОРСКИЙ ИНСТИТУТ

«ВНИПИЭНЕРГОПРОМ»

СЕВЕРО ЗАПАДНОЕ ОТДЕЛЕНИЕ

[illegible]

[illegible]

Рабочий проект

Реконструкция неблочной части Гдыгинской ТЭЦ, связанной с переключением газоходов котлов ст. № 1, 2 на дымовую трубу № 2 и увеличением сечения газоходов котлов ст. № 3, 4

Книга [illegible]

Сводный сметный расчет, объектные и локальные сметные расчеты. Договорная цена.

Договор № 10-[illegible]

Директор [illegible] Ф.Ф. Сенько

Главный инженер [illegible] Г.Б. Фалов

Главный инженер проекта [illegible] А.А. Коростелевский

Ленинград 19[illegible]

СЗО ВЭП Зак. № [illegible] Тир. [illegible] экз. [illegible] Год [illegible]

192

Состав рабочего проекта

Книга I

Общая пояснительная записка

Часть I. Общая

I.I. Содержание рабочего проекта

I.2. Технико-экономические показатели

Часть 2. Технологическая

2.I. Теплотехнический раздел

Часть 3. Строительная

3.I. Архитектурно-строительный раздел

Часть 4. Организация строительства

Часть 5. Приложения.

Чертежи.

Книга 2

Сводный сметный расчет, объектные и локальные сметы. Договорная цена

Книга 3

Паспорт проекта

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APPENDIX E

194

МИНИСТЕРСТВО ЭНЕРГЕТИКИ И ЭЛЕКТРИФИКАЦИИ СССР

ТЕПЛОЭЛЕКТРОПРОЕКТ

Ленинградский научно-исследовательский

и проектно-конструкторский институт

ЭНЕРГОСТРОМ

Ленинградское отделение

ОТС. ПЬ-СС. 309. 01

111/5

Раздел РоС

Наименование

Реконструкция небл[illegible]ной части [illegible]ВПС, связанной с переключением газоходов котлов от [illegible] на [illegible] трубу № 2

Стадия [illegible]

Сводный [illegible] расчет, объектные и локальные смет[illegible]

Экземпляр [illegible]

BEST AVAILABLE COPY

ЛЕНИНГРАД

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APPENDIX F

Appendix F

Proposed Outline for PCBs Awareness Training

1 0 PCBs General Overview

- 1 1 PCBs Nomenclature
- 1 2 Basic PCBs Chemistry
- 1 3 PCBs Properties

2 0 History of PCBs

- 2 1 PCBs Production
- 2 2 Use of PCBs
- 2 3 Initial PCBs Regulations and their Applicability to Armenia
- 2 4 Environmental Transport of PCBs

3 0 Health Implications of PCBs

- 3 1 PCB Toxicology
- 3 2 Health Studies
- 3 3 Occupational Exposure Criteria

4 0 PCBs Analysis

- 4 1 PCBs Identification
- 4 2 PCBs Testing
  - 4 2 1 Field Testing
  - 4 2 2 Detailed Analysis
- 4 3 PCBs Data Collection
- 4 4 Investigations
- 4 5 Management Strategy
- 4 6 Remediation Planning
  - 4 6 1 Technical Feasibility
  - 4 6 2 Implementation Feasibility
  - 4 6 3 Environmental Feasibility
  - 4 6 4 Economic Feasibility
- 4 7 Project Planning
  - 4 7 1 Risk Management and PCBs

5 0 Selection of Remedial Technologies

5 1 Identification of Applicable Requirements
5 2 PCB Guidelines and Regulations
5 3 Cleanup Levels
5 4 Identification of General Response Actions
5 5 Screening of Technologies
5 6 Alternatives

6 0 Institutional Evaluation

6 1 Legal Basis in Armenia
6 2 Long- Short-Term Effects
6 3 No Action Plan Limitations in Armenia

APPENDIX G

PCB-CONTAMINATED SOILS CLEAN-UP

KONSTANTIN A BORUSHKO

Burns and Roe Enterprises, Inc
800 Kinderkamack Rd
Oradell, NJ 07649

DAVID COOKSLEY

Burns and Roe Enterprises, Inc
3000 Atrium Way, Suite 310
Mount Laurel, NJ 08054

ABSTRACT

This paper summarizes some of the recent trends in PCB applications, manufacturing, chemistry, health and occupational effects, and various remediation technologies for PCB-contaminated soils clean-up The main purpose of this paper is to educate appropriate authorities and operational bodies in the developing countries and countries with economies in-transition on the PCBs awareness and methods of environmental clean-up

1. Introduction

1 1 History

PCBs as a chemical substance is known to mankind since the beginning of the 20th century However, the commercial manufacturing has started in early 1920s in Europe First commercial production in the United States has been started in 1929

In 1976, it was estimated that 1 25 billion pounds of PCB were manufactured in the United States and 1 3 billion pounds were generated worldwide In 1980, the estimated worldwide production was 2 4 billion pounds Japan, Germany, Great Britain, Italy, France, Spain, Czechoslovakia, Poland, Argentina, Brazil, Russia, and India also produced large quantities of PCBs

1 2 Chemical Nomenclature

Polychlorinated biphenyls (PCBs) are a family of 209 discrete chemical compounds composed of carbon, hydrogen, and chlorine, and named congeners The general chemical formula is $C_{12}H_{x-1}Cl_y$, where x is the hydrogen atom and y is the chlorine atom, x and y may contain up to 10 atoms The biphenyl is chlorinated by replacing any of the hydrogen atoms with a chlorine atom The chlorobiphenyl molecule is designated by the position of the chlorine atom on the biphenyl molecule

The same physical and chemical properties of PCBs which made the compound so valuable to industry, also made these materials hazardous to the environment and public In general, PCBs are inert and stable

compounds thus yielding excellent electrical insulation and heat transfer properties

1 3 PCBs USE

PCBs can be used in variety of applications and products The primary use of PCBs was historically for transformers and capacitors In addition, heat transfer units, gas transmission turbines hydraulic systems, and electric motors have also contained PCBs Common products such as paints, lubricants, oils, caulking compounds, inks, plasticizers, and carbonless copying paper also formerly known to contain PCBs

Up to 1971, PCBs production in the United States was primarily associated with electrical capacitors and transformers In 1971, an estimated five (5) percent (or about 135,000 transformers) in the United States contained PCBs In addition, French and Italian PCBs were imported into the United States Approximately 80 to 90 percent of the PCBs were used for investment casting waxes, and 10 to 20 percent was imported for use in semi-closed heat transfer applications

The Organization for Economic Cooperation and Development (OECD) classified PCB uses into three following categories in 1973 report

- **Controllable closed systems** -- systems which utilize PCBs for dielectric purposes such as transformers and large capacitors PCBs in the system have a service life equal to that of the equipment, and typically leaks do not occur if proper maintenance is performed The quantity of dielectric fluid contained in this equipment is large enough to justify regeneration
- **Uncontrollable closed systems** -- systems which utilize PCBs in hydraulic systems and heat transfer systems Small capacitors and fluorescent light ballasts are considered uncontrollable closed systems PCBs in the system have a small service life and typically there is a potential for leakage The quantity of dielectric fluid contained in this equipment is very small encouraging disposal rather than regeneration of fluid
- **Dissipative uses** -- a system that contain the PCBs which are in direct contact with the environment Products such as paints, adhesives, sealants, and plastics are classified in this category Thus, because of their matrix, the PCB can not be recovered for regeneration

1 4 HEALTH ISSUES

Health problems associated with exposure to PCBs can be traced back to the 1930s when employees working with PCBs developed chloracne This acne is know to be caused by some chlorinated hydrocarbons

Few fatalities and serious hospital conditions of workers exposed to PCBs, triggered the first studies of airborne concentrations in the workplace

In 1968, Japan had an epidemic associated with ingestion of PCB-contaminated

cooking oil The oil was contaminated by a heat exchange unit containing PCBs used in the pasteurization process The symptoms of "Yusho Disease" included acne eruptions and eye discharges, and hyper pigmentation of the skin, nails, and mucous membranes

Studies were performed on the tissues and body fluids of men, women, pregnant women, babies born to these women, and children It was found that PCB accumulated primarily in the liver and heart, and fatty tissue, and secondly in the brain and skin

1 4 1 Natural Degradation of PCBs

PCBs are very stable compounds and tend not to degrade in the environment Two degradation processes that might be considered afterall are photodegradation, and microbial degradation These degradation processes depend on the degree of chlorination, and to some extent the position of the chlorine atom on the biphenyl molecule

Bio degradation as a remediation technology is discussed further in this paper

2. United States Regulations

Several US regulations can be highlighted as being most influential for PCB problem

2 1 General Regulations

TSCA Regulations

Toxic Substance Control Act (TSCA) has been driven by increasing public and Environmental Protection Agency (EPA) awareness and concern surrounding exposure to PCBs in the workplace and presence in the environment Public Law 94-469 of TSCA in 1976 required that the EPA must develop regulations for the marking and disposal requirements for PCBs by mid 1977 The main objective was to limit the manufacturing, distribution and disposal of PCBs in the United States Regulations were compiled in 1978 and included the requirements for identification and disposal procedures for facilities

In 1979 the manufacturing of PCBs was banned by law except for some few specific applications Furthermore this legislation stipulates that PCBs are not to be processed, distributed or used except in a totally enclosed manner unless authorized

EPA regulations, for controlling the use, storage, and disposal of PCBs are outlined in 40 CFR Part 761

This legislation also includes concentration categories to be used to determine cleanup goals for PCB-contaminated sites or facilities, and the remediation options available

Part 761 has been amended in October 1990 and places additional restrictions and conditions on the use of PCB transformers containing 500 ppm or greater This rule was amended after the EPA determined that the continued use of PCB transformers without additional restrictions presents an unreasonable risk of injury to public health and the environment

RCRA Regulations

The Resource Concentration and Recovery Act (RCRA) regulates the generation, transportation, treatment, and disposal of hazardous wastes It does not specifically address PCBs, however as stipulated under 40 CFR 268 if PCBs are mixed with a RCRA hazardous waste, then the waste is subject to land disposal restrictions under this rule

CWA and SDWA Regulations

The Clean Water Act (CWA) and Safe Drinking Water Act (SDWA) may also affect the selection of a remedial action if the contaminated media is ground water or surface water

2 2 PCB Specific Regulations

The EPA PCB Spill Cleanup Policy of May 1987, regulated under TSCA, provides guidance for the clean up of PCB spills It is an important policy that defines notification and cleanup requirements for spills containing PCBs at a concentration of 50 ppm or greater which occurred prior to enactment of the policy

The major effect of the policy on industry is that responsible parties are to notify the appropriate regulatory agency of a spill, and cleanup must be initiated within 24 hours of discovery of the spill The major advantage of the spill policy is that is provides uniform, statistical methods to investigate and remediate PCB incidents

One of the rules effecting remediation of PCB-contaminated material is the PCB Manifest Rule This rule requires that all generators having PCB storage facilities to notify EPA of any PCB waste handling activities and obtain a generators EPA Identification Number Manifest Rule requires the owner or operator of the disposal facility to prepare a Certificate of Disposal for PCBs at the facility

Other regulations for PCBs include, but not limited to EPA's

- Field Manual for Grid Sampling of PCB Spill Sites to Verify Cleanup
- Verification of PCB Spill Cleanup by Sampling and Analysis
- Development of Advisory Levels for PCB Cleanup
- Draft Guidelines for Permit Applications and Demonstrations

3. Clean-up Technologies

Various technologies are currently available to remediate PCBs-contaminated sites The choice of technology primarily typically depends on the environmental assessment data, risk assessment projections, appropriate local and country regulations, clean-up schedules and target, technical feasibility, and cost

Following actions are normally performed before the technology is selected

- Environmental assessment
- Site characterization and risk management study
- Investigation of remedial alternatives
- Detailed evaluation of alternatives
- Selection of remedial action

- Final remedial design

3 1 Selection of Technology

3 1 1 General Analysis of Alternatives

Technical Feasibility Evaluation

The ease of implementability criteria is typically used to measure both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative In addition, the availability of the technologies involved in a remedial alternative shall be considered

Evaluation of Effectiveness

The effectiveness evaluation shall consider the capability of each remedial alternative to protect human health and the environment Each alternative shall be evaluated as to the protection it would provide, and the reductions in toxicity, mobility or volume of contaminants which it would achieve

Cost Evaluation

Cost evaluation shall include estimates of capital costs, annual operation and maintenance cost

3 1 2 Analysis of Clean-up Alternatives

Each remedial alternative shall be evaluated for performance, reliability, implementability, and safety

The *performance* evaluation considers both the effectiveness of each alternative to prevent or minimize substantial danger to human health or the environment, and the useful life of the alternative to maintain this level of effectiveness

Reliability is evaluated in terms of the operation and maintenance (O&M) requirements, such as frequency and complexity of O&M and costs to install and operate, as well as demonstrated performance

Implementability considers factors such as contractibility and the time necessary to implement the alternative and to achieve beneficial results

Following are the remedial technologies available for remediation of PCB-contaminated soils Three primary options are accepted by the EPA, and compliant with TSCA These are

- *Incineration*
- *Separation/Extraction*
- *Solidification/Stabilization*
- *Chemical Dechlorination*
- *Disposal at landfill*

A no-action alternative, or passive remediation, will result in leaving contaminated soils in place The no-action alternative is typically used as a baseline alternative to compare to other remedial options considered for the site This option can not be accepted as a remedial action

(a) Incineration

Technology Description

Thermal processes are the most successful and commonly employed technologies utilized for treatment of PCB-contaminated soils High temperatures destroy PCBs or convert PCB to less hazardous materials depending on the process used Incineration achieves or exceeds the 99 9999 percent Destruction Removal Efficiency (DRE) required by TSCA This technology is the most efficient, but often not selected as the final remedial action due to its cost and public resistance

There are several thermal technologies that should be considered for a site These technologies have either been proven or are in various development stages Technologies considered in this paper are

- ◊ Rotary kiln incineration
- ◊ Fluidized bed combustion
- ◊ Infrared thermal treatment
- ◊ Wet air oxidation
- ◊ Vitrification

Rotary Kiln Incinerators

Rotary kiln incinerators are cylindrical, refractory-lined vessels which typically operate at temperatures between 1600 and 3000F Soils are fed into the rotating kiln, while air and fuel (natural gas, oil, or coal) are injected into the oxidation chamber This situation creates combustion of the waste in the chamber to gas and ash under oxidation conditions Gases are treated through an afterburner and scrubber, then are emitted via a stack to ensure air emission standards are met Ashes are collected and removed at the rear of the kiln Residence times may range from seconds to hours depending on the degree of contamination and the moisture content of the soil

Rotary kilns are categorized by BTU value Small rotary kiln systems are less than 20 MMBTU/hr with soil capacities of one to two tons per hour for low moisture and low organic soils The small kilns are used when treating small quantities of soil

Fluidized Bed Incinerators

Fluidized bed incineration destroys PCBs by controlling combustion using inert fluidized particles such as sand, limestone, or other granular material Bed temperatures range from 1400 to 1600F The particles contained within the refractory-lined vessel are kept in motion and provide for waste agitation and heat transfer Soils conveyed directly into the chamber, along with combustion air and fuel, is forced upward through the bed creating combustion of the waste This situation also maintains temperature and retention time which otherwise would exist due to variations in soil moisture, ash, or BTU value A secondary chamber assures that adequate retention time for PCB combustion is maintained Residence times may range from seconds to minutes, depending on the degree of contamination and the moisture content of the soil First acid gases are treated and neutralized at the end of the secondary chamber Then, the off-gases are circulated through a cyclone which removes large particulates from the off gas stream, followed by final air pollution equipment Ash is removed from the base of the fluidized bed

Infrared Thermal Treatment

Infrared thermal treatment is a high temperature radiation technology Silicon carbide is used in the combustion chamber to destroy materials conveyed on a belt through the system Soils are exposed to radiant heat which is sufficient to destroy the PCB molecules Gases are circulated through a flue gas cooler before exiting through the exhaust stack Ash is removed from the base of the primary combustion chamber

These units can be operated at two temperatures If operating temperatures are maintained in the primary and secondary chambers from 1400 to 1600F, it is considered the incineration mode When operating at lower temperatures, it is considered in the pyrolysis mode Residence times may vary from 5 to 50 minutes

Wet Air Oxidation

Wet air oxidation involves the oxidation of oxidizable inorganic and organic materials in a high temperature and pressure reactor (300 to 3,000 psi) Soils are fed via a feed pump and interjected with compressed air before entering a heat exchanger where the waste mix is heated to reaction conditions An exothermic reaction takes place within the reactor The air contributes oxygen to the waste mixture, causing an oxidation reaction in which heat is produced The residence time and the temperature will vary The resulting gas from the reactor is recycled back through the process heat exchanger and is then separated from the oxidized liquid stream via a separator Gases are circulated to an off-gas treatment system, and liquid to a wastewater treatment system

The resulting residuals (liquid and gas) may be hazardous and will also have to be treated appropriately Ash is insoluble and may be dewatered prior to disposal

Vitrification

Vitrification is a process which incinerates organic constituents and vitrifies inorganic materials This is primarily accomplished by two units a counter-rotating vortex (CRV) combustor and a cyclone melter Soils are fed into the CRV where air, fuel, and chemical additives are injected into the waste stream Glass formers, such as sand or limestone, and fluxing agents such as sodium carbonate, aid to bind the PCB to a glass matrix In the CRV, combustion occurs and PCBs are destroyed The stream then enters the cyclone melter where inorganics are melted, followed by a reservoir where gases, CO2, and water vapor are separated from the molten material, or "frit " The gases are treated by conventional air pollution devices

Feasibility

Incineration is a process in which organic compounds are vaporized from the soils into combustible gases in the presence of oxygen at the heat of combustion Therefore, two key components to consider in design are oxygen requirements and temperature The amount of oxygen required depends on the characteristic of the waste, which can be determined theoretically, or by analysis Minimum temperatures must be maintained so that destruction of the waste is accomplished Oxygen and temperature requirements will vary according to the incineration process being considered

The principle by-products are carbon dioxides, scrubber water, and ash While the volume of ash is relatively small as compared to the original volume of contaminated material, it is usually considered hazardous and requires further treatment This is also true for the scrubber water It is an important factor to consider during the feasibility screening process

Incinerators may be mobile or stationary Soils are excavated and then either treated on site with a mobile unit, or transported to an off-site incinerator Generally, smaller quantities of soils are treated off site, while larger quantities of soil are incinerated on site

Costs of technologies will vary, depending on the physical characteristics of the soil, transportation costs (off-site incineration), permitting requirements, by-product disposal, and the volume of soil to be treated Costs for excavation and transportation and cost for treatment would vary based on the location Generally speaking, costs are relatively high, however, they can be easily justified if large volumes of soil need to be treated

(b) Separation/Extraction

Technology Description

Separation technologies involve the removal of PCBs from soils through the use of chemicals This process is a non-reactive chemical process Chemicals which may be used are solvents, surfactants, or alkaline agents The resulting extraction is treated, usually by incineration, to destroy the PCB waste, and clean soils are used for backfill

There are several separation technologies which can be considered for a site Following technologies considered in this paper

- ◊ Soil Washing
- ◊ Supercritical extraction
- ◊ LEER
- ◊ BEST
- ◊ Thermal desorption

Soil Washing

Soil washing is accomplished using surfactants and other washing agents to release PCBs from the soil The slurry enters various countercurrent scrubbing units that mechanically aid in the release of contamination from the soils Surfactants aid in the desorption process by changing the interfacial tension

Supercritical Extraction

Supercritical extraction utilizes propane in a liquefied gas form to extract PCBs from contaminated sediment, sludge, and soils The process has two essential parts

Extractor - Soils are fed in from the top of the reactor, allowing contact with the propane which is condensed by compression at 70F Propane, acting as the solvent or extraction agent, extracts PCBs from the soil, and clean soil is removed from the extractor

Separator - Pressurizes the waste stream (PCB, organic and solvent), vaporizes solvent for recycling, and separates PCBs for treatment

A pilot scale unit has been tested, and a mobile unit is being developed commercially

Basic Extraction Sludge Treatment (BEST)

The BEST system was developed to treat oily sludge containing organics and has been used to treat low-level PCB contamination The process consists of two stages

Cold Stage - The cold stage combines aliphatic amine (secondary or tertiary) and waste to form a liquid slurry By lowering the temperature in this stage, the process achieves the following (a) Solvent becomes miscible with the oil and water, providing a means of separation, and (b) Solvent extracts organics adsorbed on particles Solids are removed or separated by filtration or centrifugation Finally, solids are dried to recover the solvent for recycling purposes

Hot Stage - Liquid from the cold stage is heated and separated into two distinct phases solvent (amine and oil) and water The top fraction, containing solvent/amine and oil, exits to a column where the solution is recovered by distillation The water is passed through a steam stripping column to remove residual, and recover amine

Low Energy Extract Process (LEEP)

This process is an extraction technique involving removal of PCBs using organic solvents Typically acetone is used, however, any hydrophilic or hydrophobic organic solvents can be utilized The soil is mixed with the solvent in an extraction unit and agitated to promote contaminant removal The agitation step may be performed several times until the cleanup level required is achieved

Soils are heated to remove excess solvent, then used for backfill The residual PCB is contained in the hydrophilic solvent and water mixture which must be treated and disposed of accordingly The solvent is usually separated from the water and treated by chemical destruction or incineration

Thermal Desorption

A thermal desorption system uses an indirect fired rotary dryer system to vaporize, PCBs at approximately 450 to 850F Nitrogen is used as an inert carrier gas to carry vaporized organic compounds to the gas treatment system The gas treatment system condenses and collects the gases Three waste streams are produced and are treated in the following manner

Float Organics - Float organics are reclaimed for fuel or disposed

Bottom Organics - Bottom organics are disposed

Water - Water is recycled through the system or used for solids cooling

The process is most efficient when soils with less than 10 percent organic contaminant concentration are used

Feasibility

The removal of PCBs through this technology depends on the agent being used to remove PCB from the soil Thus, non-polar agents, such as organic solvents, will be effective in removing PCB from the soil

Secondly, the degree to which PCB is adsorbed to the soil particulates, or the relative affinity (partitioning), also determines the technical effectiveness of the process

The chemical and physical characteristics of the soil will determine the separation agent and process method selected This is primarily determined by bench scale treatability studies using the site soil Typical excavation equipment is used if soils are to be treated on or offsite

Treatment and disposal requirements include recovery and recycling of chemical agents and PCB generated effluent The concentrated PCB is usually incinerated

Treatability tests run to date have indicated that the percent reduction is approximately 99 5 percent

(c) Solidification/Stabilization

Solidification/stabilization is a technology which prevents leaching of contaminants, either by encapsulation or hardening (solidification), or chemical reaction/bonding (stabilization)

Encapsulation which is sometimes confused with solidification/stabilization is when a solidification agent surrounds waste particles and binds them into a mass In either case, the soil is mixed with a stabilizer or additive to form a solid mass which reduces the mobility and toxicity of the contaminated soil Typically, cement, pozzolanic, or silica compounds are used as binding agents Recent developments include stabilization with organic and inorganic polymers

Often, the technology is used as an interim measure until the material can be removed and transported off site for treatment

Following is the list of some existing solidification/stabilization technologies

- Thermoplastic/Organic polymer
- Pozzolanic solidification
- Cement-based processes
- Inorganic polymer
- Vitrification

(d) Chemical Dechlorination

Chemical dechlorination involves dechlorination (removal of chlorine atom) of the PCB molecule by utilization of an alkaline solution (AOH) or polyethylene glycol (PEG) This process has been most successful in treating water, however, it has also been effective in treatment of highly contaminated soils The PCBs are essentially transformed into a low-toxicity, water-soluble waste We believe that this technology might not be appropriate for the applications in the developing countries at this moment due to high costs and practically no commercial operation experience

(e) Excavation and disposal at landfield

Excavation entails removal of soils on-site with conventional heavy construction equipment Excavation is followed by on site or off-site disposal and treatment and is generally used in combination with the other remedial technologies

In the past, excavation and disposal of soils at a landfill was the remediation method

commonly used because it provided fast and total cleanup However, due to limited landfill space, rising costs, and stricter regulations (land ban), landfilling is now the least preferred technology in the United States

The primary mechanism for PCB destruction with landfilling is biodegradation of the PCB Because PCBs can not be expected to fully degrade, this is not considered a destruction method Therefore, future liability associated with disposal of contaminated soils in a landfill is reduced, although, not eliminated, as with incineration

Excavation and removal is applicable to most sites regardless of conditions However, the activities associated with excavation and removal will vary according to the site, level of contamination to be removed, and volume and depth to be excavated

Excavation, removal, and loading of contaminated soils can be accomplished by a variety of methods and equipment Three general categories of excavation equipment and their primary function are as follows

Backhoes - Primarily used for trenching and subsurface excavation to a depth of approximately 10 meters

Cranes and attachments - Primarily used in subaqueous excavation, or large areas which require remediation (draglines)

Dozers and loaders - Dozers are best used for excavation of surface soil (top 30 to 45 cm), or in areas where mobility is limited, such as marshes Loaders are primarily used for digging, lifting, and hauling soil

The selection of equipment is based on a number of factors including, but not limited to the following

- Extent of contamination/site-specific conditions
- Limitations of equipment
- Equipment mobilization
- Operators' experience
- Equipment capability

Mitigative measures must be established during excavation and in the soil segregation area to prevent the release of contaminants to the environment and protect workers from exposure to contaminants

Treatment may be required prior to landfilling, as stipulated by the RCRA land ban requirements, if soil contains greater than 1,000 ppm of chlorinated organic compounds Otherwise, soils of any PCB concentration may be disposed of in a TSCA-permitted landfill TSCA-permitted landfills are limited and becoming less readily available

An on-site landfill may be constructed to contain contaminated soils The landfill design would then have to meet the requirements of TSCA standards

Long-term monitoring requirements, such as soil sampling, are usually not required, because post-remedial sampling should indicate that contaminated soils were removed to cleanup levels established by the project

Excavation can be an effective way of eliminating on-site contamination Post-soil sampling can confirm and document the effectiveness of the removal and ensure that soils were removed to the cleanup level established for the site While on-site cleanup is achieved, on-site or off-site disposal in a landfill does not effectively treat contaminated soils, or eliminate long-term liability associated with contaminated soil

4. Conclusions

This paper has attempted to introduce key aspects associated with remediation of sites containing PCB-contaminated soils As one can see, the remedial selection process can be a lengthy technical process and is based on many considerations The process begins in the early stages of the site characterization process where existing data is collected, an understanding of the site is developed, and applicable PCB guidelines are defined The site investigation provides supplementary information in support of a remedial action plan which will ultimately document the decision-making process of the technology selected to remediate contaminated soils
on site

Exhibit I summarizes remedial technologies discussed in this paper to consider during selection of a remedial action

Thermal processes are still the most widely used (and accepted) technologies, however, the technologies are costly and generally depend on the volume of soil to be treated in order to be cost-effective

Bioremediation effectively destroys PCBs, and significant research has been conducted in this area, however, it is still in the development stages

Physical processes concentrate PCBs into another form, increases the volume to be treated, and requires further treatment This is also the case with solidification/stabilization methods, an increase in volume results, future liability remains because long-term effectiveness is uncertain

Chemical dechlorination also seems promising for treating soils with higher contamination levels, however, the cost is still moderately high and this technology is in the developmental stage

The most influential factors in the selection process are proven effectiveness, cost, cleanup levels, and regulatory requirements

APPENDIX H

Appendix H

Proposed Outline for Asbestos Awareness Training

1.0 History, Types and Use of Asbestos

2 0 Health Hazards of Asbestos

2 1 Medical Surveillance

3 0 Regulations

3 1 International, OSHA, EPA and State Regulations
3 2 Other Safety and Health Hazards

4 0 Protection

4 1 Respiratory Protection
4 2 Respiratory Protection / Fit Testing

5 0 Protective Equipment

5 1 Glove Bags
5 2 Cleaning Respirators

6.0 Control Measures and Work Practices

7 0 Use of Mini-Enclosures and Cleaning Contaminated Areas

8 0 Removing Pipe Insulation

9 0 Alternatives to Asbestos and their Use