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Ukraine
Suggested Priorities for Environmental Protection and Natural Resource Management

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CURRENCY EQUIVALENTS AND ACRONYMS

Currency unit = Karbovanets, abbrev. krb
US$1 = 47,000 krb (as of June 15, 1994)
Rb1 = 7 krb (as of June 6, 1994)

WEIGHTS AND MEASURES

b	Billion
bcm	billion m^3
Bq	becquerel : decay of one nucleus per second
cm	centimeter
Ci	curie (3.7 x 10^{10} Bq)
GJ	Gigajoule (0.948 x 106 Btu or 238.8 x 103 kcal)
GW	Gigawatt
ha	Hectare(s)
kcal	Kilocalorie (3.968 Btu)
kg	Kilogram (2.2046 lbs)
km^2	Square kilometer
m	Meter
m^3	Cubic meter (35.3147 cubic feet)
mg	Milligram
MW	Megawatt
MWh	Megawatt hour (860 x 103 kcal)
ng	Nanogram
person-rem	1 person receiving 1 rem, or 10 people receiving 0.1 rem, or 1,000 people receiving 0.001 rem
PM10	Particulate matter below 10 microns
ppm	Part per million
rem	Roentgen equivalent man: the amount of ionizing radiation equivalent to biological effect of one roentgen of x or gamma rays 1 rem = 1 mSv
Sv	Sievert (mSv = millisivert) : international measure of the biological equivalent of an absorbed dose of radiation. 1 Sv = 100 rem
t	Ton (metric)
tpa	Tons per annum
toe	Ton of oil equivalent (= 10 million kcal = 39.68 million Btu)
μg	Microgram

CHEMICAL COMPOUNDS AND TECHNICAL TERMS

AlF_3	Aluminum fluoride
BAP	Benzo-a-pyrene
BOD	Biochemical oxygen demand (BOD5 = over a 5 day period)
Cd	Cadmium
Ce^{137}	Cesium 137
CFCs	Chlorofluorocarbons
CO	Carbon monoxide
CO_2	Carbon dioxide
Cu	Copper
Hg	Mercury
N	Nitrogen
NO_x	Nitrogen oxide
O_3	Ozone
ODS	Ozone Depleting Substances
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
pH	Logarithmic indicator of acidity or alkalinity
Pu^{139}	Plutonium 239
SO_2	Sulfur dioxide
Sr^{90}	Strontium 90
TSP	Total Suspended Particles
VOCs	Volatile Organic Compounds
Zn	Zinc

ABBREVIATIONS AND ACRONYMS

CAC	Command and Control
CEE	Central and Eastern Europe
DPRA	Department of Protected and Recreational Areas (MEP)
EC	European Community
EIA	Environmental Impact Assessments
ESP	Electrostatic Precipitators
FGD	Flue Gas Desulphurization
FSU	Former Soviet Union
GDP	Gross Domestic Product
GEF	Global Environmental Facility
Hydrômet	Hydrometeorological Service
IUCN	International Union for Conservation of Nature and Natural Resources
MAC	Maximum Acceptable Concentration
MAD	Maximum Acceptable Discharge
MAE	Maximum Acceptable Emissions
MB	Market Based
MEP	Ministry for Environmental Protection
MFO	Ministry of Forestry
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOI	Ministry of Industry
NGO	Non-Governmental Organization
SPZ	Sanitary Protection Zone
UNCED	UN Conference on Environment and Development
WHO	World Health Organization

UKRAINE

SUGGESTED PRIORITIES FOR ENVIRONMENTAL PROTECTION AND NATURAL RESOURCE MANAGEMENT

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ANNEXES

ANNEX 1: RECOMMENDATIONS FOR TECHNICAL ASSISTANCE

Recommendations for Technical Assistance, Modest Investments In Associated Equipment and Training

The World Bank has identified the following technical assistance needs for environmental management in Ukraine. This is not an exhaustive list, but it offers some priorities.

I.	**Pilot Programs to Introduce Improved Regulatory Approaches and Pollution Abatement Strategies in Priority Cities, with Emphasis on Air Pollution Abatement**
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I. Pilot Programs in Priority Cities: Short Term Action Plans and Programs to Improve Regulatory Management and Pollution Abatement Strategies in Priority Cities

An important and highly visible activity would be to select a city which has serious pollution problems and assist it in identifying and implementing short term action plans in key plants. Resources permitting, this would also be an opportunity to help develop a better regulatory capability at the local level to evaluate and prioritize pollution problems and solutions, strengthen plant permitting, develop reasonable compliance schedules, and improve enforcement capabilities. Such TA might also lead to identification of Municipal Environmental Management Projects, which could be considered for funding by the multilateral banks.

Priority cities are: *Donetsk & surrounding communities (including Kostiantynivka); Mariiupil; Zaporizhzhia; Dnipropetrovsk & nearby Dniprodzerzhinsk; Kryvyi Rih; Odessa.* All of the cities mentioned have serious pollution problems. These are cities where TA programs could be structured in conjunction with other related activities of the World Bank, EBRD and the GEF Black Sea program. In addition, a special program is recommended for *Kostiantynivka* (formerly Kostantinovka), a small community in Donetsk Oblast where lead emissions appear serious (*see* activity II below).

A. Short Term Action Plans

Strongly recommended are programs which concentrate on a municipal area, working with municipal and environmental authorities to identify *and implement* short term, low cost action plans in major plants and municipal operations to improve operating efficiency and reduce pollution, *particularly hazardous air pollution.* This would involve undertaking environmental audits at major industrial plants to identify low cost safety, operational and environmental improvements *and* to reduce energy, water or material use.[1] The results could be used in drafting a short term action plan for the plant. City and environmental authorities could work with plants to implement these measures. Donor agencies could support implementation by offering some incentives, e.g. small equipment or investments, to help realize the needed changes. The action plans would include the following:

(i) Identification of and Support for Short Term Action Plans at Industrial Plants

- Improved safety procedures
- Aggressive sweeping and cleaning programs
- Repair of operating and control equipment to reduce emissions and leakages
- Development of operating plans to reduce energy and water use
- Improvements in boiler and utility operations
- improvements in instrumentation and controls
- Installation of meters and control equipment, where cost effective
- Attention to waste minimization opportunities
- Improvements in waste management measures and containment of any hazardous wastes

1/ Such audits could also support *privatization or restructuring* by providing improved baseline information about pollution problems.

The operational/environmental audits associated with identifying short term action plans would be an important training exercise for both plant personnel and environmental inspection team.[2]

(ii) Identification of and Support for Short to Medium Term Measures at Water/Wastewater Utilities.

Water Treatment
- improvements in instrumentation and controls
- improvements in the efficiency of filtration (including cleaning of backwash filters)
- introduction of mechanical dewatering of sludge

Wastewater Treatment
- improvements in design and operation of anaerobic sludge digestion
- improvements in aeration efficiency
- utilization of methane gas from anaerobic digestion of sludge
- introduction of mechanical dewatering of sludge
- identification of plants which are priorities for industrial pre-treatment in the municipal area

The intent would be to focus on how to improve existing operations (in some cases thereby enhancing capacity) before making investments to expand treatment capacity. Some of the operating measures mentioned above would still be relatively expensive and might form the basis for a modest investment project which might, in part, be financed by a multilateral bank. Attachment 4 lists some specific ideas for technical assistance at four individual plants visited during the study.

Identification and support for the action plans could be combined with assisting municipal Vodocanals, in charge of water and wastewater treatment, in putting themselves on a more commercial basis, in particular undertaking a study: (a) to calculate the tariffs necessary to achieve cost recovery and allow some self-financing of investments, and (b) to develop a phase-in program.

(iii) Identification of and Support for Short Term Action Plans at Coal Mines and Thermal Power Plants

Another priority is to identify and implement improved safety procedures in coal mines. A start could be made through municipal programs covering coal mines in or near municipal areas.

The identification of short term action plans could also be extended to thermal power plants and combined heat/power plants in or near the municipal area. Support for improvements in operating performance and in ESP/venturi scrubber performance is badly needed (an example of useful equipment which could be supplied would be portable combustion analyzers). Introduction of common regulatory techniques, such as visual "stack opacity" checks, would also be useful. See also the suggestions under regulatory programs and air quality management for better monitoring and site characterization at thermal

2/ Ideally, these audits should be part of broader exercises to help firms develop practical business plans (or in some industries restructure). Environmental officers in donor agencies will want to liaise closely with colleagues working on privatization and industrial restructuring to coordinate opportunities.

plants to establish whether emissions from these plants have a strong impact on local ambient air pollution.

B. Support for Regulatory Improvements Through Pilot Programs in Cities

Beyond sponsoring short term action plans in a municipal area, if resources are available for further support, the pilot program could be extended to include direct support for regulatory improvements and development of strategies for pollution abatement within a municipal area; these two activities go hand in hand. The steps involved are outlined below:

- **Evaluation and Characterization:** review of existing regulatory practices and their effectiveness (including the application of existing standards and enforcement mechanisms); introduction of modern evaluatory techniques; selective introduction of improved monitoring and testing equipment; assistance in improved information management; and, very importantly, associated training in all these activities;

- **Analytical and Costing Phase**. This would include: (a) analysis of priorities within one medium and across media; (b) analysis of options for pollution abatement over the medium and longer term, and costing of those options; and (c) development of a least cost or low cost abatement strategy for a municipal area (using techniques of cost-benefit analysis).

- **Finalization of a Medium to Long Term Management Plan.** Preparation of tailored regulatory programs for the pilot area, based on cost effectiveness criteria.

- **Implementation and Enforcement.** Introduction of the plan, with attention to improving permitting and enforcement capabilities.

- **Related special programs:** introduction special programs for small-scale or mobile polluters.

These pilot programs would also provide feedback on policy issues that will ultimately need to be addressed at the national level--e.g. revising national standards, improving staff professional development and enforcement capabilities, and improving monitoring and information management.

Significant external assistance would be needed for the short term action plans and regulatory support. Estimated cost would be: US$ 2-3.5 million per city (to be shared with other donors).

Specific actions under different environmental media are discussed below.

(i) Air Quality Management Programs

Upgrading of Evaluatory Techniques. This exercise would start with the following: (a) an evaluation of ambient air quality, the practicality of existing standards, emissions data, and methods of measurement and evaluation (e.g. ambient monitoring, source testing, emission factors used in estimation, and dispersion modeling) with the intent to help modernize the techniques currently used; (b) evaluation of priorities in improving monitoring equipment, giving special consideration to improving particulate monitors, along with network design, siting and quality assurance procedures in testing samples; and (c) review of data management needs and system based on improved monitoring and evaluatory capabilities. The evaluatory phase would be followed by introduction of new or improved evaluatory and regulatory techniques, selective upgrading of monitoring and testing equipment and lab equipment (the latter perhaps at a regional center) to improve the ability of regulators to understand the pollution problems they have, and associated training.

Development of a Plan. Preparation of an individual air quality management plan for the city or airshed, considering both stationary (industrial and non-industrial) and mobile sources, to reach over a specified period of time designated ambient targets for selected "criteria" pollutants. In devising this plan, receptor-source screening and more complex dispersion models could be employed to evaluate both the collective impact as well as individual contributions to pollution in the airshed. This exercise would be followed by costing and prioritization of options, leading to an abatement strategy for the area. It should also include revision and strengthening of emergency action plans for periods when pollution becomes extreme (e.g. weather inversions).

Also, included in the evaluation should be use of improved monitoring and dispersion analysis to identify the contributions to ambient pollution from: nearby thermal power plants, more dispersed sources (household and small industrial boilers), and auto and truck traffic.

Implementation. Once the air quality management plan is agreed, revised targets and compliance schedules would be developed and negotiated with individual plants. New permits would be issued for individual sources, outlining longer term actions and a clear timetable for reductions of emissions. Those compliance plans would be made publicly available. The air quality management plan should also include special programs for dispersed or mobile sources of pollution, such as a plan for use of cleaner fuels in smaller boilers or inspection programs for vehicles and improved traffic management.

Attachment 1 summarizes the steps in developing an air quality management plan. Attachments 2 and 3 list the type of equipment needed, over time, for improved ambient monitoring, and monitoring for regional deposition of toxic emissions, respectively.

(ii) Water Quality Management Programs

Municipal water quality management programs would need to consider the overall water quality of the river sub-basin to which municipal sources discharge. In this regard, a complementary program to undertake a baseline survey of parts of the Dnieper River is complementary to water management programs in cities along the Dnieper (see activity III).

Strengthening Monitoring & Regulatory Techniques. In regard to surface water, monitoring is focused on traditional physical and chemical analyses. Monitoring should be expanded to cover biological indicators, ecosystem changes and collection of biologic material for analysis of anorganic and organic micropollutants; sediment sampling should also be expanded. The sensitivity and effectiveness of existing monitoring equipment also should be evaluated in greater detail. Better monitoring would help to identify the most seriously polluted sections and sources of pollution. Implementing these measures would also require the strengthening of laboratory capabilities (perhaps at the regional level), both equipment and quality assurance techniques.

Right now, the point of compliance for water discharge permits is set at the outermost boundary of a facility or sometimes further downstream beyond the boundaries of a facility, encouraging both on-site or off-site discharges which are not controlled. Having one point of compliance at a large facility is not very effective. Such practices need to be revised.

Finally, review of current water standards and comparison with practical needs and current practices would provide important feedback for national policy in this area.

Prioritizing Investments and Developing an Abatement Plan. Some cities, such Dnipropetrovsk and Zaporizhzhia, are identified as hot spots along the Dnieper River. Similarly, Odessa and Mariiupil are considered hot spots in terms of pollution problems of the Black and Azov Seas respectively. Thus, these cities are good candidates for identifying the key sources of water pollution, costing solutions and developing a medium to long term abatement plan. Once this plan is developed, permitting and compliance schedules for regulatory purposes would be revised.

(iii) Solid and Hazardous Waste Management Municipality-wide

This media program would address the problems of both solid hazardous waste. A first step would be to distinguish between non-hazardous and hazardous waste, indeed developing a practical methodology to classify wastes and differentiate treatment. The second step would be to identify any hazardous sites likely to be jeopardizing health and to recommend low cost mitigation or containment measures. The third step would involve several activities: suggesting cost effective approaches to solid and lower level hazardous waste management and identifying opportunities for waste minimization and recycling programs. Again prioritization of recommended activities and development of an implementation program would be expected. Such efforts would provide feedback to the national level on needed legislation for hazardous waste management and transportation.

II. Lead Testing Program at Kostiantynivka

At Kostiantynivka, funding is needed to conduct blood lead testing (blood lead and protophyrin tests) in workers and children and soil sampling to determine the health impact from lead and other emissions from longstanding operations of the secondary lead/zinc smelter there (estimated cost: US$ 250,000). International assistance is also needed for a detailed environmental audit and evaluation of the economic viability of smelter with a view to determine whether or not to continue operations (US$ 200,000).

III. Suggested Water Management Programs

Dnieper River Baseline Survey. Existing water quality data for the Dnieper River appear unreliable and were acquired using equipment available in the 1960s, much less accurate than the equipment available today. What is needed is a baseline survey of water quality along the river, which would also provide an opportunity to train Ukrainian researchers in use of more modern monitoring and laboratory equipment. The survey would help to identify any especially polluted sections of the river and possible health or ecological risks. It would also support international efforts to address the serious pollution problems of the Black Sea (eg. the GEF-supported Black Sea Cooperative Program). It would also provide input to the Dnieper River Commission, established by the Ministry for Environmental Protection to evaluate pollution problems along the river.

The Ministry for Environmental Protection has responsibility for a water quality institute in Odessa, which owns several research ships. One of these ships might be equipped with a mobile laboratory, staffed by Ukrainian and international experts, to conduct a survey (water and sediment sampling) along the river and its reservoirs. Estimated cost: US$350,000.

Action Plans for Two Other Rivers. Two other rivers--the Inhulets and the Siverskodonets--would benefit from studies to develop action plans for addressing water pollution and water shortage issues.

Study of Fishery Revival in Azov Sea. An important economic need is to identify opportunities to reduce the dramatic decline in fishing in the Azov Sea, considering reduced river flows (Don and Kuban rivers), water quality and probably overfishing. This should be a practical study which quickly tries to identify steps which can be taken in the short to medium term. It would be a complementary activity to the Black Sea program.

IV. Management of Hazardous Waste and Review of the Ammonia Pipeline

Environmental and local authorities would benefit from assistance in surveying, prioritizing and seeking low cost solutions for management of hazardous waste problems, at the same time instituting preventive measures for the future. As a first effort, the authorities need to start identifying those problems which may be immediate hazards to health so that cost effective actions can be taken, versus problems which are less urgent and will have to be addressed over a much longer period of time, as resources permit. Such surveys will also be helpful in establishing baselines and assigning liability in respect of land or plant privatization. The process would start with hazardous waste evaluations either by categories of industry (eg. segments of the chemical industry) or by regions. Two regional candidates are: Donetsk and Kryvyi Rih (Krivoi Rog). Estimated cost: US$400,000.

A hazard and risk assessment is needed of the pressurized ammonia pipeline that crosses the country. The study should include an evaluation of the following: design, construction and installation of the pipeline (and provisions for land subsidence along the route); corrosion prevention and detection of leaks; emergency shutdown systems; and evaluation procedures.

V. Needed Improvements in the Regulatory Infrastructure

The Ministry should seek opportunities to work with foreign authorities in strengthening the elements of its regulatory policy and making the system less complex and more practical to carry out. Changes could be introduced gradually over the next 5 years. Below are listed some of the areas where changes are needed and where interaction with environmental authorities in other countries would be constructive:

Revision of Ambient Standards for Air and Water: A review is needed to suggest changes, including reducing the number and, in some cases, making them less strict, so that they are practical and based on modern health risk assessments.

Selective Introduction of Technology-based Standards: For water quality management, it is appropriate to develop some minimum technology standards for different types of entities discharging into the river (eg. Industrial waste discharge and sewage discharge). In regard to air quality management, there are situations or industries where setting technology standards may be appropriate (eg. plants releasing known toxins).

Improvements in Regulatory Infrastructure: Among the most important activities are:

Monitoring. A study is needed to develop an action plan for integrating and strengthening existing monitoring and analytical activities for both air and water quality management, which are now scattered among various institutions, and then to selectively update monitoring, testing, and lab equipment[3]. The intent would be to develop a monitoring system which better aids regulatory objectives.

Regulatory Techniques. Steps at the national level to improve evaluatory, site characterization, permitting, and inspection techniques, as outlined in I (B), should be supported by working with other national environmental agencies.

Information Systems. As improved data becomes available, MEP would benefit from support for better information systems, so that data on emissions, discharges, and permits can be accessed and exchanged between the oblasts and the center.

Improvements in Enforcement Actions and Related Environmental Legislation: MEP is constrained by the small number of enforcement mechanisms available to it, which include assessment of fees and, in a few cases, temporary suspension of plant operations. It needs more flexible enforcement authority and a graduated spectrum of enforcement tools that can be tailored to the

3/ For air quality, upgrading of particulate monitors is the highest priority; for water quality analysis, it is developing the monitoring and analytical capability to measure important micropollutants for which high concentrations could be expected (e.g. expanding monitoring to include biological indicators).

circumstances of each case. These include: the authority to place conditions on individual emissions/discharge permits, violation of which can be sanctioned independently from violation of the permit limits; authority to negotiate detailed compliance schedules which outline a realistic path to compliance, and provide the Ministry with incremental stages at which to monitor progress and apply sanctions; and multiple-factor penalty calculations which allows fines and other penalties to be adjusted upward or downward in appropriate cases. Each of these tools avoids saddling MEP with an all-or-nothing decision between ignoring the violation or threatening a high fine (or plant closure) that will be overturned because of economic hardship. Most of these actions will need to be codified in environmental legislation.

To aid in drafting legislation, recommended is the formation of a small external committee of legal advisors to aid the understaffed legal unit in the Ministry by reviewing and commenting on environmental legislation, particularly suggesting ways to strengthen enforcement mechanisms. Another important subject for future environmental legislation is hazardous waste regulations for management and transport.

Privatization and Environmental Liability: MEP would benefit from support in developing a policy and implementation mechanisms to address the issue of assigning environmental liability in privatization transactions.

Improvements in the Pollution Fee System (Medium term): Following improvements in standards and basic regulatory infrastructure, it would be useful to make improvements in the structure and administration of the existing pollution fee system.

Central Laboratory. There is a good case for establishing one national laboratory, equipped with modern instrumentation and staffed by trained technicians, to ensure quality testing for water and air media. Rather than starting up a completely new lab, it would be more cost effective to strengthen one existing laboratory, perhaps under the joint auspices of MEP and MOH. Any equipment supplied must be accompanied by sufficient training. Institution of this laboratory should follow improvements in monitoring equipment and quality control techniques in transport.

Central Laboratory (including training)	US$
Computer Systems	20,000
Gas Chromatograph	50,000
Mass Spectrometer	300,000
Atomic Absorption Spectrophotometric	100,000
Wet Chemical Lab Equipment	25,000
Heavy Metals Lab Equipment	120,000
Organics Lab Equipment	400,000
Microbial Lab Equipment	10,000
Total	1,025,000

VI. Institutional Development within the Ministry for Environmental Protection

1. **Training Needs**. Training programs for individual staff of MEP, both at central and local levels should cover the following: comparative approaches to regulatory policy and environmental management; information management; technical training in specific industries and sectors and in types of diagnostic instruments or pollution control equipment (industrial pollution should be emphasized here); methodologies in undertaking environmental impact assessments; environmental economics and policymaking; health risk assessments; and comparative approaches to public information and participation. A standard program of technical training should be introduced for inspectors, as they must earn the respect of their industrial counterparts by demonstrating a technical knowledge of processes and options for pollution control. Both individual media and cross media training is recommended, as some experts should become familiar with the range of environmental problems related to particular industries.

2. Carefully-designed study tours to introduce approaches taken in other countries would be an important adjunct, as it helps to demonstrate other approaches. It would be important that, not only staff at the center in Kiev participate, but also those at the oblast and municipal level, where most of the enforcement activity takes place. It is also important that the selection process tries to identify highly motivated individuals.

3. **Information Management**. The entire Ministry possesses only about 40-50 computers, about 8 in headquarters and the rest distributed among the various oblast level offices. Very few people are familiar with using computers. Most administrative, monitoring and other data are still written or typed, which is very time consuming and makes the data less usable. Recommended equipment includes:

> a. Acquisition of 50 to 100 personal computers, to be distributed throughout the Ministry and oblast offices, would best serve the needs and capabilities of the Ukrainians at this time. Each computer would have access to near-universal spreadsheet and word-processing programs, as well as to some of the more sophisticated PC-based database management system. The system would have the capacity to support a limited database, desktop publishing software, standard spreadsheets and statistical analysis utilities. It would also be able to support basic business management software, for example to track permits and to monitor fees and fines.
>
> b. Portable PCs (perhaps 10-20) for distribution to regional offices for on-site data gathering and monitoring purposes. These portables should be equipped with data collection software to support consistent sampling and collection techniques.

Such a program might start with a pilot phase, in parallel with a pilot program in one city along with support at the national level, to rationalize environmental information. Training in use of the abovementioned equipment would be essential. The cost of the total package would be US$200-350,000 depending on how many computers are purchased and the extent of training.

VII. Industrial and Environmental Issues

(i) Introduction of short-term action plans in all major plants over time.

(ii) Fundamental environmental problems in some heavy industries cannot be divorced from the underlying restructuring needed in those industries. Hence, technical assistance is needed for comprehensive restructuring analyses in the following industries: steel, coal, iron ore, ammonia/fertilizer production, and refineries. (Draft terms of reference can be supplied by the World Bank, as necessary.)

VIII. Energy and Environmental Issues

A. Thermal Power Industry

(i) Improved air quality characterization around major thermal power plants to understand better the resulting impacts on ambient air concentrations (TSP, SO_2 and NOx) and longer distance transport. This would entail introduction of improved monitoring equipment and dispersion modeling. The results would help in assessing investment priorities related to pollution control at major thermal power stations.

(ii) Training for power plant operators and environmental regulatory authorities in the following areas:

- Operational adjustments using portable combustion analyzers (equipment to be supplied with training)
- Fuel blending strategies
- ESP troubleshooting
- Power plant inspections
- Visible emissions training

See Annex 5 for specific recommendations for four thermal power plants.

B. SO_2 Control Strategy

Review of options across sectors for reductions in SO^2 emissions, including reduction of sulfur in oil products (as part of refinery modernization), improved coal quality, energy conservation, and sulfur control in the power industry

C. Coal Industry (items i) and ii) preferably in conjunction with a restructuring study)

(i) Development and implementation of improved safety procedures in coal mines

(ii) Review of opportunities to improve coal quality by (a) better blending practices and (b) coal washing. Constraints due to lack of a coal market would also need to be examined.

(iii) Review of opportunities and cost effectiveness of greater coalbed methane recovery and use.

IX. Environmental Issues Related to Agriculture and Forestry

The following areas would provide assistance in reducing environmental pressures in the agricultural sector:

- Legal assistance with land privatization to assure sound land management practices and removal of marginal lands to forest or grassland. Cost: $150,000

- Evaluation of problems of agricultural runoff along southern reaches of the Dnieper River. Cost: $150,000

- A later program might include support for demonstration projects to reduce erosion and runoff (the principal non-point source of water pollution)--eg. reduced tillage systems and land contouring--and to introduce methods for low-input agriculture.

- A review of forestry operations to suggest more environmentally benign practices and to introduce modern concepts of planning and economic analysis.

X. Protected Areas and Coastal Zone Management

Review of emergency needs in the protected areas and RAMSAR-designated wetlands to avoid irrecoverable damage or neglect. After the review, support would be needed for the implementation of the program. Estimated cost of technical assistance: US$200,000.

Technical assistance is also needed to devise longer term financing mechanisms to support the protected area network, eg. ecotourism, carrying capacity studies, visitor fees, concessions and leasing. Estimated cost: US$50,000.

Review of coastal areas, particularly near Odessa, Yalta and Mariiupil to assess conservation needs and opportunities for promotion of ecologically sustainable tourism.

XI. Improvements in Epidemiology

Design and implementation of collaborative studies, involving Ukrainian experts responsible for occupational and environmental health and external experts, to apply the concepts of modern epidemiology (standardization and controls) and exposure assessment to specific cases in Ukraine, e.g. case studies reviewing data and cross-checking/testing results of health studies in Mariiupil, Zaporizhzhia and Kryvyi Rih. (US$200,000-400,000)

Development of programs for in-country training in the application of modern epidemiology, exposure assessment, and public policy for the recognition, evaluation, and control of occupational and environmental health problems in Ukraine. Training of Ukrainian trainers to implement this program. (Combined est. cost $300,000). Note: Also see programs suggested under Kostiantynivka and Chernobyl.

XII. Activities Concerning Chernobyl

The outstanding problems related to Chernobyl, for which technical assistance is needed, are the following: (i) addressing problems at the plant itself; (ii) improving containment of hazardous waste in the 30 km zone; (iii) establishing more definitively the health impact and health risks with concurrent public education; (iv) finding ways to reduce the heavy fiscal burden caused by the ambitiousness of Chernobyl mitigation programs; and (v) prioritizing planned further mitigation and remediation measures.

A. Feasibility Study for Managing Problems at Unit 4

Technical assistance is needed for a feasibility study to identify a low cost solution to existing problems at unit 4. This requires the input of both engineers and water quality experts familiar with radiation contamination, and radiation epidemiologists. Note: EBRD is currently working with the Ukrainian government in planning such a study.

Further technical assistance is needed for the other activities; suggested actions are outlined below.

B. Suggested Actions Within the 30 Km Zone

Ukrainian authorities need assistance in evaluating potential surface or ground water contamination from hazardous sites in the 30 km zone (using modern monitoring equipment); it should include an analysis of potential health impacts at the level of radionuclide seepage which might be found. This requires the input of both engineers and water quality experts familiar with radiation contamination and radiation epidemiologists. In parallel with the evaluation, assistance is needed in identifying low cost mitigation or containment measures inside the 30 km zone to rectify any problems creating serious health risks.

C. Suggested Follow Up Actions Outside the 30 Km Zone

The following (in some cases sequential) actions are recommended as part of a re-examination of ongoing compensation and mitigation programs in Ukraine, in order to assure their cost effectiveness. *A similar program would be appropriate for Belarus.*

- **Reassessment of the Statutory Dose Limit** -- Reconsideration of this limit is recommended in order to design a cost effective and affordable mitigation program for the future. The epidemiological and contamination studies mentioned below should help provide the basis for this recommended reassessment.

- **Introduction of Modern Epidemiological Studies and Techniques** -- Collaboration is strongly recommended between the Ukrainian and foreign health experts in conducting controlled health studies using modern epidemiological methods (e.g. careful standardization and use of morbidity and mortality data) and the risk assessment techniques to evaluate data from Ukrainian studies in order to determine more clearly what the health impacts from Chernobyl are and what are the ongoing health risks.

- **Quality Assurance of Ongoing Contamination Measurements and Human Dose Assessments** -- In selected communities, it would be useful to seek donor assistance for short, selective studies to confirm current levels of surface contamination, improve estimates of internal doses, and thus assess better the overall expected human dosage of people living in areas categorized as contaminated. These studies should be conducted using modern monitoring equipment, cross checked by selectively employing whole body monitoring, and body dosimeters (TLDs); measurements of radionuclide levels in food should also be reconfirmed through these studies. An experienced radiation epidemiologist should review the results of these studies to establish the likely health risks.

- **Improved Information Management** -- In parallel with reconfirmation of data, as suggested above, should be an effort to consolidate existing monitoring and health data into a consistent and comprehensive database, so that all information concerning Chernobyl effects is readily accessible.

- **Reexamination of the Health Risk Basis for Compensation** -- With information from the epidemiological and contamination/dose studies, it should be possible to re-examine the existing compensation program to make it more cost effective and affordable.

- **Quality Assurance in Food Control Procedures** -- It is important to have good quality control assurances--on state farms and in monitoring food products generally from the contaminated areas. Existing measures have been effective but could be supplemented by regular checks of control procedures (including recalibration of instruments). In addition, they might be supplemented further by external reviews periodically.

- **Improved Public Awareness Campaigns** -- The public needs greater information about background radiation, radon levels in the country (a major contributor to natural background radiation), and health risks from radiation exposure.

- **Development of a Cost Effective Waste Management Strategy** -- Greater attention to prioritization of the current decontamination program is recommended, considering cost effectiveness of dose reduction. Such an effort will be improved by securing better data on current external and internal contamination and expected human doses. Recommended first is a policy of improving existing low cost measures to reduce crop uptake and internal exposures. Low cost containment measures to restrict and contain particularly hazardous areas should also be examined. Also needed is a program to classify hazardous nuclear wastes using international standards is recommended as a first step in distinguishing how to contain or dispose of wastes of varying danger. Caution is recommended in seeking high technology solutions to waste management, as these may not be the most cost effective way to reduce exposures; any such investments should be subject to careful cost-benefit analyses.

Attachment 1

Suggested Air Quality Management Programs in Priority areas

First Phase: Short Term, Low Cost Action Plans in Major Plants. These short term measures would be actions which are not capital intensive and could be implemented relatively easily to decrease pollution at the source. They could be as basic as an aggressive sweeping program of particulate matter at the plant site. Other measures might include repair of existing equipment in a timely manner (e.g., repair of leaking coke oven doors), while still others could be minor changes to existing processes or control equipment which would improve their efficiency as well as reduce unorganized emissions

The first phase should also include revision and strengthening of emergency action plans for periods when pollution becomes extreme (e.g. weather inversions). The major industries are supposed to have plans to undertake temporary measures to reduce pollution during extreme episodes. With installation of continuous air quality monitors (second phase), giving "real time" air quality information to regulatory authorities, enforcement of these emergency action plans could be more aggressively pursued.

Second Phase: Development of Air Quality Management Plans (beginning with pilot programs). Steps would include the following:

(i) An increase in the staff and equipment available to the local branch of the Ministry for Environmental Protection. A priority would be introduction of improved monitoring equipment, for example installation of new high volume particulate sampling monitors for particulate matter and related toxic compounds, such as lead and other heavy metals. As funding permits, installation of continuous air quality monitoring systems should be introduced to supplement the current system of wet chemistry methods for gaseous pollutants. The increase in equipment might also include a modern emission monitoring van to be used in verifying the self-reporting of major sources and sampling smaller sources.

(ii) Preparation of an individual air quality management plan for the city or airshed, considering both stationary (industrial and non-industrial) and mobile sources, to reach over a specified period of time (e.g. the year 2000) designated ambient targets for selected "criteria" pollutants. In devising this plan, receptor-source screening and more complex dispersion models could be employed to evaluate both the collective impact as well as individual contributions to pollution in the airshed. This exercise would be followed by costing and prioritization of options, leading to an abatement strategy for the area. It would also take into account opportunities for creation of new economic activities and diversification of industry in the region.

(iii) Using the air quality management plan, revised targets and compliance schedules would be developed and negotiated with individual plants. New permits would be issued for individual sources, outlining longer term actions (7 years) and a clear timetable for reductions of emissions. Those compliance plans would be made publicly available.

(iv) The air quality management plan should also identify efforts to reduce more dispersed or mobile sources of pollution, such as a plan for use of cleaner fuels in smaller boilers or inspection programs for vehicles.

(v) Finally, the plan should allow opportunities to introduce market based regulatory approaches (emissions offsets or "bubbling" of one or more plants) as the regulatory infrastructure (and baseline information) becomes more robust and property rights are better defined.

Attachment 2

PRIORITY AIR POLLUTION AREAS ESTIMATED TOTAL MONITORING EQUIPMENT COSTS

The equipment listed in the following tables is recommended as a minimally acceptable system for the seven priority areas. These areas are:

a. Donetsk and surrounding area
b. Mariiupil
c. Zaporizhzhia
d. Dnipropetrovsk
e. Kryvyi Rih
f. Dniprodzerzhinsk
g. Odessa

Table 1: Stationary Monitors

Item	Number	Unit Cost	Total
Shelter	16	$12,190	$195,040
Total Suspended Particulate[4]	32	$6,095	$195,040
SO_2/H_2S	16	$11,960	$191,360
NOx	16	$14,375	$230,000
CO	7	$13,800	$96,600
Ozone	7	$13,800	$96,600
NH_3	16	$14,375	$230,000
PM10[1]	1	$17,875	$17,875
Met	16	$16,733	$267,728
Calibrator	16	$16,100	$257,600
Zero Air	16	$4,370	$69,920
Data System	16	$7,522	$120,352
Manifold	16	$1,438	$23,008
Modem	16	$661	$10,576
Lab Support Equipment	7	$13,000	$91,000
Recorders	16	$7,820	$125,120
Total			$2,217,819

4/ The PM10 monitor should be moved from priority area to priority area and co-located for a period of time with the particulate monitor to determine the proportion of the particulates being measured which are less than 10 microns in size.

Table 2: Mobile Ambient Air Quality Monitoring Laboratory[5]			
Item	Number	Unit Cost	Total Cost
Shelter	7	$12,190	$85,330
SO_2	7	$11,960	$83,720
NO_x	7	$14,375	$100,625
CO	7	$13,800	$96,600
NH3	7	$14,375	$100,625
Ozone	7	$13,800	$96,600
PM10	7	$17,875	$125,125
Total Hydrocarbons (THC)	7	$16,100	$112,700
Meteorological Equipment	7	$14,432	$101,024
Calibrator	7	$16,100	$112,700
Zero Air	7	$5,520	$38,640
Data System	7	$6,762	$47,334
Manifold	7	$1,438	$10,066
Modem	7	$661	$4,627
Spare parts & misc.	7	$10,000	$70,000
Recorder	7	$7,820	$54,740
Transporter	7	$6,670	$46,690
Total			$1,287,146

5/ Each priority area should receive one mobile ambient air quality monitoring laboratory.

Table 3: Emissions Monitoring Van and Associated Equipment[6]			
Item	Number	Unit Cost	Cost
Shelter	7	$30,590	$214,130
Van (Truck)	7	$31,625	$221,375
SO_2	7	$16,560	$115,920
NO_x	7	$16,675	$113,925
CO	7	$16,100	$112,700
O_2	7	$19,033	$133,231
Particulate Matter	7	$25,875	$181,125
Total Hydrocarbons (THC)	7	$22,534	$157,738
Sample Conditioner	7	$13,800	$96,600
Probes	7	$22,511	$157,577
Zero Air w/dryer	7	$8,395	$58,765
OVM Monitor (portable organic vapor monitors)	7	$6,670	$46,690
Cables, Wires, etc.	7	$17,825	$124,775
Cal. gases w/regulators	7	$9,775	$68,425
Recorders	7	$7,820	$54,740
Total Cost			$1,857,716

6/ Each priority area should have one emissions monitoring van and associated equipment.

Table 4: Other related costs[7]	
Item	Cost
Gas Chromatograph w/samplers - 7	$ 75,000
Central Computer - 7	$ 25,000
Shipping & Installation (from Western Europe)	$120,000
Training - 21 staff @ $4,000 each	$ 84,000
Total	$252,000

Table 5: Summary of Total Ambient and Emission Monitoring Costs	
Stationary Monitoring Stations	$2,217,819
Mobile Ambient Monitoring	$1,287,146
Emissions Monitoring Van	$1,857,716
Miscellaneous Costs	$ 220,000
Total Cost	$5,582,681

Note: These are the initial costs to set-up a comprehensive monitoring program for this area. These costs do not include the annual costs of operating and maintaining this system. It also does not include costs for doing sophisticated laboratory analysis for certain toxic pollutants such as heavy metals and persistence organic compounds (dioxin, PCB's, etc.). It is assumed that the capability for such analysis will be provided in Kiev or some other national central laboratory.

7/ Each priority area should receive one gas chromatograph and central computer. The cost of training assumes that the one individual primarily responsible for each of the stationary monitoring systems, the one individual primarily responsible for the mobile monitoring system, and the one individual responsible for the emissions monitoring system in each of the priority areas would receive the training needed.

Attachment 3

REGIONAL AIR TOXICS DEPOSITION MONITORING SITE

The following estimates report the capital and analytical costs for a dry and wet toxics deposition monitoring station. The estimates are based on costs developed by the monitoring section for monitoring stations in a North American Great Lakes deposition monitoring network. The sampling schedule for monitored parameters could vary from weekly, bi-weekly, monthly and/or quarterly and would be dependent on both the monitoring objectives and the amount of available funds.

Target Compounds

The target compounds for a deposition monitoring study include, but are not limited to, the compounds listed below. These compounds are of concern to aquatic ecosystems such as those found in Ukraine.

PCBs
Chlorinated pesticides
-DDT and metabolites
-Dieldrin
-Chlordane
-Hexachlorobenzene
-Toxaphene
Dioxins/Furans
PAHs
-Benzo(a)pyrene
Non-volatile Metals
-Cadmium
-Chromium
-Lead
-Zinc
Mercury

Regional Toxic Deposition Site
Analytical Methodology

Table 6: Dry Deposition			
Parameter	Sampling Method	Analytical Method	References
PCB/pesticide	PS-1 sampler	GC/ECD	T04, 1
Dioxin/Furans	PS-1 sampler	HRCG/HRMS	T09, 1
PAHs	PS-1 sampler	HPLC/fluorescence	T013, 1
Non-volatile Metals	High volume sampler	AAS	2, 3
Mercury	Solid absorbent	AF	6, 7

Analytical Methodology

Table 7: Wet Deposition			
Parameter	Sampling Method	Analytical Method	References
PSC/pesticides	MIC sampler	GC/ECD	EPA Method 608
Dioxin/Furans	MIC sampler	HRCG/HRMS	SW Method 8290
PAHs	MIC sampler	HPLC/fluorescence	---
Non-volatile metals	MIC sampler	ICP-MS	2, 3
Mercury	MIC sampler	AF	5, 6

Table 8: Capital Cost Estimates for a Model Atmospheric Deposition Station					
Sampling Equipment Item	Parameter	Vendor	Quantity	Unit Price	Total Price
Ambient Hg sampler	Hg-gas/part.	Custom	1	$5,000	$5,000
IVL (Swedish pass. sampler	Hg - depos.	Custom	3	$300	$900
TSP HV air sampler	metals	GMW	1	$3,000	$3,000
Dichotomus sampler	metals	Anderson	1	$8,100	$8,100
PS-1 (PUF) sampler	PCBs/pest./PAHs	GMW	1	$2,750	$2,750
MIC deposition sampler	PCBs/pest./PAHs	M.I.C.	2	$4,500	$9,000
Recording Rain Gauge	deps	Belford	1	$1,800	$1,800
Subtotal*					$30,550
* Site total (Tables 8&9) = $55,270					

Monitoring Site Set-up:

Table 9: Monitoring Site Set-up			
Item	Quantity	Unit Price	Total Price
Meteorological Tower	1	$500	$500
Meteorological sensors (WS/WD/T/delta-T/Rel. Hum./Sol. Rad.)	1	$8,000	$8,000
Data logger and modem	1	$2,800	$2,800
Telephone installation	1	$120	$120
Electrical power installation	1	$600	$600
Trailer	1	$8,000	$8,000
Enclosure Fence	1	$1,200	$1,200
Sampler Platforms	1	$1,000	$1,000
Subtotal*			$22,220
* Site total (Tables 8&9) = $55,270			

Table 10: Regional Toxic Deposition Site Analytical Costs	
Parameter	Cost/sample
PCBs/Chlorinated pesticides	$200 to $500
PAHs	$300
Dioxins/Furans	$1,500
Non-volatile Metals	$150 to $250
Mercury	$300

Table 11: Capital Equipment Costs for the Laboratory Analysis of Samples	
Analytical Balance	$3,500
Gas Chromatograph with Electron Capture Detector (ECD)	$35,000
Two dimensional Gas Chromatograph with ECD	$60,000
High Performance Liquid Chromatograph with Fluorescence Detection (HPLC/FD)	$50,000
Atomic Absorption Spectrophotometer (AAS)	$65,000
Atomic Floruence Spectrophotometer (AFS)	$15,000
Ion Coupled Plasma Spectrometer/Mass Spectrometer Detection (ICP/MS)	$225,000
High Resolution Gas Chromatograph/High Resolution Mass Spectrometer (HRGC/HRMS)	$500,000

Attachment 4

Estimated Cost of Technical Assistance for Needed Studies for Wastewater Treatment (US$)	
Dniprodzerzhinsk, Azot chemical plant - wastewater treatment	80,000
Donetsk oblast - toxic, hazardous and municipal solid waste disposal	560,000
Water treatment works - Kiev, Kryvyi Rih, Dnipropetrovsk and Zaporizhzhia: provision of instrumentation	560,000
Dnipropetrovsk - industrial wastewater discharge control scheme	100,000
Lysychansk, soda factory - feasibility study on water recycling and lagoon treatment	60,000
Luhansk, coal mine water disposal - hydrological feasibility study	320,000
Zaporizhzhia - leakage control in the water supply distribution system	540,000
Kryvyi Rih - mine water from iron ore plant	260,000
Rubezhnoye, Krasital dye factory - study for demineralization and recycling effluent	60,000
Odessa - oil interceptors	40,000
Siverskodonetsk, Azot chemical plant - sludge digestion at wastewater treatment plant	120,000

ANNEX 2: GENERAL INFORMATION: POPULATION DENSITY, SOURCES OF LAW, ENERGY INTENSITY AND DATA ON HAZARDOUS AND GENERAL AIR POLLUTANTS

Table 1: Data on Selected Oblasts
Area and Population (on January 1, 1991)

	Territory (thousand km^2)	Population (thousands)	Percent of Urban Population	Population Density (people/km^2)
Ukraine Total	*603.7*	*51,944.4*	*68*	*86*
Dnipropetrovsk	31.9	3,908.7	84	122.5
Donetsk	26.9	5,346.7	90	201.8
Zaporizhzhia	27.2	2,099.6	78	77.2
Luhansk	26.7	2,871.1	87	107.5
Kharkiv	31.4	3,194.8	79	101.7
Odessa	33.3	2,635.3	88	79.1

Box 1: Sources of Law in Ukraine

Ukraine declared the "Act of State Independence of Ukraine" on August 24, 1991, followed by a national referendum in December 1991. From the point of view of legal power and continuity of law, Ukraine is the legal successor of the Ukrainian Socialist Republic (UkrSSR). A Ukrainian parliamentary resolution of 1991 states that laws of the USSR will continue to operate for those areas not covered by new Ukrainian laws, as long as the laws of the former USSR do not contradict the Constitution and laws of Ukraine.

The existing constitution of Ukraine is an amended version of the 1978 Constitution for the Soviet Republic of Ukraine. A new Constitution of Ukraine, still in draft form, will eventually be an important source of law for the country. Beyond the Constitution, the next level of law are the legislative acts (zakon) adopted by the Supreme Soviet of Ukraine (the Parliament). Prepared by working groups under the sponsorship of parliamentary committees or the Cabinet of Ministers, draft zakons go through first and second readings in Parliament before enactment. The President may veto the act, but can be overridden by a majority vote. Parliament also passes resolutions (postanova) which do not usually create rules of law. Another important source of law are the decrees of the President of Ukraine. While difficult to categorize, these decrees are not simply executive orders; they create new rules of law, which sometimes contradict the acts of the legislative body, thus raising uncertainty about the law. Finally, there are decrees, rules and standards issued by the Cabinet of Ministers and government agencies (Ministries and State Committees).

Table 2: Energy Intensity, Selected Countries of the FSU

	GDP (bill Rb)	GDP (bill US$)	POP (mill)	Total Energy Consumption (ktoe)	Energy Intensity (koe/$ of GDP)
Estonia	17.3	5.8	1.6	3,997	0.69
Latvia	22.3	7.4	2.7	6,650	0.89
Lithuania	39.4	13.1	3.7	13,493	1.03
Georgia	23.5	7.8	5.4	8,659	1.11
Tadjikistan	13	4.3	5.3	5,316	1.23
Kyrghyzstan	15.3	5.1	4.4	7,073	1.39
Moldova	20.7	6.9	4.4	9,925	1.44
Belarus	71.8	23.9	10.3	39,960	1.67
Azerbaijan	22.4	7.5	7.1	14,237	1.91
Armenia	15.7	5.2	3.3	10,026	1.92
Russia	1,130	376.7	148.5	838,160	2.23
Kazakhstan	92	30.7	16.9	70,160	2.29
Turkmenistan	18.6	6.2	3.8	15,209	2.45
Uzbekistan	56.3	18.8	21.3	47,919	2.55
UKRAINE	***262***	***87.3***	***51.7***	***230,025***	***2.63***
TOTAL	1,820.3	606.8	290.4	1,320,809	2.18
OECD					0.27
China					1.69
Upper middle-income countries					0.60

Sources:
GDP (Rbs): IMF, 1991
GDP (US$): 3 Rbl/US$
Material developed by Bjorn Larsen and Sunita Gandhi (1992)

Box 2: Environmental Legislation

During the years 1992 - 1993 the following legal provision were adopted by the Supreme Council of Ukraine:

- Law of Ukraine "On Protection of Atmosphere" valid since October 16, 1992.
- Law of Ukraine "On Wildlife" valid since March 3, 1994.
- Law of Ukraine "On Changes and Amendments to the Code of Ukraine with concern to Administrative Infringements" valid since May 4, 1993, which empowers the bodies of the Ministry for Environmental Protection of Ukraine to take legal steps in the case of administrative infringements in the field of environmental safety.
- Resolution of the Supreme Council of Ukraine "On the Red Book of Ukraine" valid since October 29, 1992.
- Resolution of the Supreme Council of Ukraine "On Adopted Terms and Conditions of Restriction, Temporary Suspension (Stoppage), or Cessation of Activities of Enterprises, Institutions, Organizations and Projects in the Case of their Infringement of the Law on Environmental Protection Provisions" valid since October 29, 1992.
- Resolution of the Supreme Council of Ukraine "On Conditions of Import (or Transit) of Waste Products and Utility Waste on the territory of Ukraine" valid since November 17, 1993.
- Law of Ukraine "On Changes and Amendments to the Criminal Code and Criminal Procedure Code of Ukraine" valid since February 25, 1994, which specify criminal and fiduciary responsibilities for infringement of conditions of import (or transit) of waste products and utility waste on the territory of Ukraine.

Besides, some Decrees of the President of Ukraine were enforced, namely:

- "On Protection and Development of Natural Reserves of Ukraine" which came into effect on September 8, 1993.
- "On Wildlife Reserves in Ukraine" which came into effect on November 26, 1993.

Some draft laws are currently pending agreement and adoption, namely:

- "On Ecological Examination" (currently is under consideration of the Commission for Ecological Matters and Rational Use of Natural Resources" of the Supreme Council of Ukraine).
- "On Areas of Ecological Emergency, their Classification and Status" (currently is agreed with the relevant ministries and administrative bodies).

Box 3: Description of Hazardous and General Air Pollutants

Hazardous Pollutants

High **lead** exposures among children can affect their mental development and create neuro-behavioral deficiencies. Exposures occur through air emissions and ingestion as a result of, for example, playing in contaminated soil.

Mercury is a particularly harmful pollutant due to its effects on the central nervous system, especially in unborn fetuses and children. It is a persistent pollutant which bioaccumulates in the food chain and can reach dangerous concentrations in predator fish and animals which feed on such fish.

Benzo-a-pyrene is a chemical most often associated with products of incomplete combustion from the burning of plant matter, biomass and petroleum products. It is associated with fine particulate matter that has a particle size of about 2.5 microns, which means that the particles can reach the lower portions of the lungs. Two commonly used names for the mixtures of hundreds of compounds that contain products of incomplete combustion are: polycyclic organic matter (POM) and polynuclear aromatic hydrocarbons (PAHs). They have both carcinogenic and non-carcinogenic effects.

Hydrogen fluoride, an inorganic acid, is corrosive to living tissues, causing severe burns that are not immediately painful. High concentrations can cause a build-up of fluid in the lungs and death. At lower levels, it is an irritant, and long-term exposure can lead to lung damage or chronic bronchitis. Some evidence from epidemiological studies indicate it may cause reproductive effects.

Other toxic substances are suspected of causing cancer, reproductive problems and birth defects. Other heavy metals (e.g. cadmium) are hazardous. Benzene and asbestos are known carcinogens; aldehydes and ketones irritate the eyes, cause short-term respiratory and skin irritation and may be carcinogenic.

General Air Pollutants

Particulates irritate mucous membranes and can cause a variety of respiratory problems. Fine and ultra-fine particles (≤ 10 microns and ≤ 2 microns respectively) can penetrate the lining of the lungs. They also combine with sulfur ions, trace hydrocarbons and metals; for example, they have the ability to adhere to carcinogens emitted by motor vehicles. Chronic exposures to fine particulates may lead to cancer or can cause more serious morbidity or even mortality from respiratory dysfunctions.

Carbon monoxide interferes with absorption of oxygen by hemoglobin (red blood cells). It impairs perception and thinking, slows reflexes, causes drowsiness, brings on angina and can cause unconsciousness and death. It affects fetal growth in pregnant women and tissue development of young children. It has a synergistic action with other pollutants to promote morbidity in people with respiratory or circulatory problems; it is associated with lower worker productivity and general discomfort.

Sulfur dioxide is a harsh irritant, which exacerbates asthma, bronchitis and emphysema and causes coughing and impaired lung function. Combined with particulates, the synergistic effect on health is particularly serious, during both extreme and chronic exposures.

Nitrogen oxides can increase susceptibility to viral infections such as influenza; irritate the lungs and cause oedema, bronchitis and pneumonia; and result in increased sensitivity to dust and pollen in asthmatics. Most serious health effects are in combination with other air pollutants.

Hydrocarbons (HC) and other volatile organic compounds (VOCs). The low-molecular weight compounds cause unpleasant effects such as eye irritation, coughing and sneezing, drowsiness and symptoms akin to drunkenness. Heavy-molecular weight compounds may have carcinogenic or mutagenic effects. Some hydrocarbons associate with diesel particulates and contribute to lung disease.

Ozone (precursors: HC and NOx) irritates mucous membranes of respiratory system, causing coughing, choking and impaired lung function. It causes headaches and physical discomfort and reduces resistance to colds and pneumonia. It can aggravate chronic heart disease, asthma, bronchitis and emphysema.

Table 3: Carbon Emissions, FSU

	Energy intensity (koe/Rb)	Total carbon emissions (000 tons)	C/GDP (kg/$)	C/capita (kg/cap)
Estonia	0.23	3,175	0.55	1,984
Latvia	0.30	4,999	0.67	1,851
Lithuania	0.34	9,473	0.72	2,560
Georgia	0.37	5,738	0.73	1,063
Tadjikistan	0.41	3,273	0.76	618
Kyrghyzstan	0 46	5,384	1.06	1,224
Moldova	0.48	8,302	1.20	1,887
Belarus	0.56	31,638	1.32	3,072
Azerbaijan	0.64	9,673	1.30	1,362
Armenia	0.64	6,982	1.33	2,116
Russia	0.74	655,232	1.74	4,412
Kazakhstan	0.76	66,347	2.16	3,926
Turkmenistan	0.82	10,321	1.66	2,716
Uzbekistan	0.85	34,735	1.85	1,631
Ukraine	0.88	188,129	2.15	3,639
West Europe		956,200	0.14	
U.S.A.		1,330,300	0.25	5,375
World		5,973,500		1,150

Sources: GDP (Rbs): IMF, 1991
GDP (US$): 3 Rbl/US$
G. Gandhi and B. Larsen, "Greenhouse Gas Strategy for States of the Former Soviet Union and Eastern Europe," January 1993, World Bank.

Table 4: Emissions of Major Pollutants by Stationary Sources in Major Sectors (000 tons per year)								
	1980	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**
Total Emissions of All Pollutants		11860	11520	10950	10440	9440	9439	8775
Fuel-Energy Complex		4530	4520	4280	4110	3660	2710	2551
Metallurgy		4483	4060	3900	3650	3260	3260	2861
Chemical-Forestry Complex		1000	1015	910	840	740	--	767
Machine Building		340	330	310	310	290	--	324
SO_2 Emissions								
For all sectors	3849	3390	3260	3210	3070	2780	2782	2538
Fuel-Energy Complex		2480	2330	2290	2180	1900	1690	1547
Metallurgy		400	360	370	340	335	335	279
Chemical-Forestry Complex		150	120	150	130	120	--	132
Machine Building		33	34	33	36	35	--	56
NOx Emissions								
For all sectors	841	754	802	795	788	767	761	709
Fuel-Energy Complex		460	480	470	460	440	414	377
Metallurgy		160	140	140	130	140	145	132
Chemical-Forestry Complex		46	44	42	38	37	--	36
Machine Building		14	15	14	13	14	--	21
VOC Emissions								
For all sectors		550	538	606	527	469	462	509
Fuel-Energy Complex		108	08	170	110	80	--	--
Metallurgy		22	22	20	20	18	18	16
Chemical-Forestry Complex		330	300	260	260	260	232	222
Machine Building		26	26	29	30	35	--	--

Source: Ministry of Environmental Protection and State Hydrometeorological Committee, Ukraine (1992).

Table 5: Estimated Emissions of NOx and SOx From Ukraine, 1990		
Emissions To	SOx (000 tons)	NOx (000 tons)
Austria	0.832	0.216
Belarus	27.450	7.508
Bosnia	0.855	0.333
Bulgaria	10.013	3.278
Croatia	0.608	0.252
Czech State	0.900	0.272
Estonia	0.923	0.504
Finland	2.453	1.354
Germany	1.486	0.680
Hungary	2.970	2.599
Latvia	2.093	0.853
Lithuania	2.948	0.889
Moldova	19.530	2.977
Netherlands	0.000	0.018
Norway	0.540	0.387
Poland	10.058	2.939
Romania	28.384	10.078
Russia inc Kalingrad	219.958	70.234
Sweden	3.195	1.467
Slovak State	2.138	0.650
Turkey	31.748	12.366
Former Yugoslavia	3.578	1.303
Ukraine	577.969	72.380
Total To These Countries	950.623	193.536
Total Emissions From Ukraine in 1990	2782.000	1097.000

Source: EMEP

Table 6: Emissions Data--Ukrainian Cities and Towns					
	Population	Emissions			Number of Enterprises
		Total	Source		
			Transport	Stationary	
Horlivka	337	17.4	28	79.4	70
Dnipropetrovsk	1,189	336.2	254.1	82.1	
Dniprodzerzhinsk	284	284.7	16.5	268.2	
Donetsk	1,121	271.9	100.9	171	171
Genakievo	120	136.6	11.2	125.4	36
Zaporizhzhia	897	354.3	108	264.4	
Kramatorsk	201	32.2	8.2	24	26
Kryvyi Rih	724	1,100.8	59.1	1,041.7	
Lysychansk	126	142.7	13.6	129.1	
Makiivka	424	338.9	33.7	305.2	92
Mariiupil	522	645.1	35	810.1	53
Odessa	1,101	187.6	107	80.6	
Rubeshoye	75	19.8	7	12.8	
Severskodonetsk	133	28.1	11.2	16.9	
Sloviansk	137	97.5	13.5	84	36
Kharkiv	1,623	173.3	120.6	52.7	
Kostiantynivka	108	36.2	8.4	27.8	29
Debalsevo		231.7			5

Table 7: Air Quality Measurements in Residential Areas 1990, HydroMet (selected components) Annual Mean Values in $\mu g/m^3$

City	Dust	SO_2	CO (mg/m^3)	NO_2	NH_3	H_2S
Armiiansk	200	50	2	90	60	--
Bila Tserkva	100	5	1	60	--	--
Vinnytsia	600	10	4	50	90	--
Horlivka	200	70	4	120	--	14
Grigorievka	300	30	2	10	5	--
Dniprodzerzhinsk	300	10	1	50	80	20
Dnipropetrovsk	200	10	2	40	30	4
Donetsk	500	40	2	90	110	3
Zaporizhzhia	300	20	1	90	--	3
Kerch	300	30	2	70	--	--
Kiev	100	20	1	70	13	--
Kirovohrad	300	10	1	20	--	--
Alchevsk	300	60	4	10	80	6
Kramatorsk	300	20	2	40	--	6
Kostiantynivka	400	20	2	50	0	--
Krasnoperekopsk	200	30	2	70	70	--
Kremenchuk	200	20	2	40	20	2
Kryvyi Rih	400	30	2	80	12	5
Lysychanska	100	20	1	30	10	1
Luhansk	200	10	1	30	--	--
Lutsk	100	5	1	40	--	--
Lviv	200	50	3	70	--	--
Makiivka	300	30	2	110	--	3
Mariiupil	200	20	2	50	70	13

Table 7: Air Quality Measurements in Residential Areas 1990, HydroMet (selected components) Annual Mean Values in $\mu g/m^3$

City	Dust	SO_2	CO (mg/m^3)	NO_2	NH_3	H_2S
Melitopol	300	50	1	70	--	--
Mykolaiv	100	10	3	60	--	--
Nykopil	300	120	2	30	--	--
Odessa	300	50	2	10	3	--
Poltava	200	10	3	40	--	--
Rivne	100	5	3	40	40	--
Rubizhne	100	20	2	30	70	--
Svetlovdsk	1000	50	--	--	--	--
Siverskodonetsk	100	20	2	40	7	--
Sevastopil	200	70	3	30	--	--
Symferopil	400	80	3	30	--	--
Sloviansk	100	40	3	50	--	4
Sumy	300	10	1	50	30	--
Kharkiv	200	10	2	40	10	2
Kherson	300	20	2	50	--	2
Cherkasy	200	40	1	60	--	4
Chernivtsi	100	0	0.4	40	--	--
Shostka	100	20	1	50	--	--
Yalta	100	30	2	80	--	--

ANNEX 3: OVERVIEW OF POLLUTION PROBLEMS IN SELECTED OBLASTS, CITIES AND PLANTS

CONTENTS

DONETSK OBLAST

1. Donetsk Oblast (with neighboring Luhansk Oblast) is the center of coal mining activities in the country, and the site of numerous metallurgical and chemical plants. The oblast has a population of 5.35 million, and it is the most densely populated in the country; 90 percent of the population is urban. Table 1 provides a snapshot of the largest air polluters in the oblast. Many of these same industries are also sources of water pollution..

Table 1: List of Enterprises Leading in Air Pollution in the Donetsk Oblast, 1990

Enterprise	Gross Emissions (thousands of tons)	
	1986	1990
POWER STATIONS		
Uglegorsk	248.4	158.5
Starobenivsk	239.1	206.8
Kurahovsk	212.8	198.1
Sloviansk	118.3	56.9
Mironovsk	96.8	71.9
Zuevsk	35.1	65.7
Kramatorsk	4.8	2.4
METALLURGY PLANTS		
"Illych" M·riiupil (metallurgical)	526.8	396.0
"Azovstal" Mariiupil (metallurgical)	231.7	183.7
Makiivka (metallurgical)	191.3	168.8
Yenakiieve (metallurgical)	91.3	98.1
Donetsk (metallurgical)	16.5	11.6
Makiivka (tube-casting)	63.6	58.8
Avdiivka (coke-chemical)	84.3	56.5
Horlivka (coke-chemical)	17.1	12.4
Kostiantynivka (zinc)	6.9	10.3
Mikitivskiy (mercury)	2.9	2.6
CHEMICAL INDUSTRY PLANTS		
"Himprom" Sloviansk	21.3	19.8
"Stirol" Horlivka	9.8	6.8
COAL INDUSTRY		
"DONETSKUGOL"	125.7	107.9

2. A more specific breakdown of air pollutants from several metallurgical plants in Donetsk Oblast is shown in Table 2.

TABLE 2: INDUSTRIAL AIR EMISSIONS FROM THE METALLURGICAL INDUSTRIES IN DONETSK AREA (1991 DATA)						
GENERAL POLLUTANTS						
tons/year	DUST	SO_2	NOx	CO	Other Pollutants	TOTAL
DONETSK	3,200	898	1,200	6,300	n.a.	11,598
YENAKIIEVE	12,200	2,600	2,800	75,100	n.a.	92,700
MAKIIVKA	27,600	5,400	4,500	109,500	500	147,500
UKRZINC (KOSTIANTYNIVKA)	502	6,595	78	1,951	374	9,500
TOTAL	43,502	15,493	192,851	192,851	874	261,298
BENZO-A-PYRENE[1] (Kg\yr)						
UKRZINC			108			

3. Air pollution is also generated by the coal industry itself and the still-significant use of coal by households. About 60 percent of the population now use natural gas; the remainder use coal. The oblast is dotted with unsightly terracones of coal waste, some of which are slowly burning; others have been terraced and planted to reduce slides and improve their appearance. The oblast has other serious waste management problems (with solid and hazardous waste apparently undifferentiated) and is looking for solutions (see section beginning at para. 59).

Coal Mining in Donetsk Oblast

4. In Donetsk Oblast alone, there are about 300,000 underground coal miners. Coal miners represent a significant occupational risk group. Fatal injuries among coal miners in this oblast are common. Between 1986 and 1990, there were a total of 985 fatal injuries at work, an average of 197 per year--or about 2 deaths for every 3 million tons of coal mined (see Table 3). Stated in other terms, 1 of each 1,500 coal miners dies each year as a result of an occupational injury. Serious and other non-fatal injuries accounted for at least another 15,000 injuries a year from 1986 through 1989. In 1990, the reported data for non-fatal injuries among coal miners in Donetsk Oblast almost doubled, probably reflecting a more accurate accounting of the actual number of non-fatal injuries.

1/ BENZO-A-PYRENE (tracer of toxic and hazardous components)

5. Dust diseases of the lung are frequent in coal miners. There are an estimated 35,000 current cases of coal worker's pneumoconiosis and/or chronic dust bronchitis in the oblast. Between 1987 and 1991, there was an annual average of 22 new cases of pneumoconiosis per 10,000 worker-years, together with 14 cases of vibration-associated disorders, and 4 cases of chronic dust bronchitis. The average annual rates for this period obscure, however, sharp increases in the occurrence of all these disorders, starting in 1989.

6. Underground coal miners who work strenuously in a hot environment have increased rates of heart attack, which has been attributed by researchers to hot microclimates in the mines (often with temperatures at 35 degrees C) and arduous physical work. The rate of sudden death among coal miners in Donetsk Oblast is 170 per 100,000 per year (a total of 510 sudden deaths a year among the 300,000 coal miners in the oblast), as compared with a rate of 120 per 100,000 per year among the rest of the population.

7. In Ukraine, many coal mines have vertical shafts. Rates of occupational disease and injury are higher in mines with vertical shafts than those with horizontal shafts. Coal dust levels are said to average 90-150 mg/m^3 in the horizontal shafts and about 400-500 mg/m^3 in the vertical shafts. In addition, there have been documented instances of chemicals, such as chlorobenzene, formaldehyde, and cyanides, directly leaking into mines with vertical shafts from factories that sit atop or near the top of the mine shafts. In one incident, three mine workers died in Horlivka when chlorobenzene from a factory above the mine leaked into a vertical mine shaft over a period of several weeks.

Table 3: Fatal Injuries Among Coal Miners, by Cause, Donetsk Oblast, 1986-1990

	Number	Percent
All Fatal Injuries	*985*	*100%*
Underground, total	961	98%
Roof cave-ins	325	33%
Transport inside mine	241	24%
Dust and gas explosions	98	10%
Falls	38	4%
Mine collapses	38	4%
Lack of air/poisoning	20	2%
Explosions with raw materials	18	2%
Other	183	19%
At Surface	24	2%

Source: Center for Labor and Trauma Prophylaxis, Ministry of Health, Donetsk

Table 4: Non-Fatal Injuries Among Coal Miners, Donetsk Oblast, 1986-1990

Year	All non-fatal injuries	Serious non-fatal injuries
1986	16,269	580
1987	16,216	224
1988	15,969	506
1989	19,627	440
1990	29,889	NA

Source: Center for Labor Hygiene and Trauma Prophylaxis, Ministry of Health, Donetsk

Table 5: Reported Incidence of Occupational Diseases, Donetsk Oblast, 1987-1991

Category of Occupational Disease	Number of Cases (by year)						Mean Annual Rate per 10,000 worker-years
	1987	1988	1989	1990	1991	Total	
Pneumoconiosis	152	233	541	859	962	2,747	22
Chronic dust bronchitis	28	48	97	143	140	456	4
Vibration-associated disorders	83	78	123	91	145	520	14
Other	80	39	100	386	188	793	5
Total	343	398	861	1,479	1,435	4,516	45

Source: Ministry of Health, Donetsk

Table 6: Incidence Rates of Occupational Diseases (per 10,000) in Coal Miners Working in Horizontal and Vertical Mines, 1986-1988

Category of occupational disease	Horizontal Mines	Vertical mines	Partly horizontal/ partly vertical mines
Total	7.4	26.0	20.6
Pneumoconiosis	4.1	7.3	17.6
Chronic dust bronchitis	1.6	1.9	1.7
Vibration-associated disorders	1.3	20.2	0.3
Hearing impairment	0.6	1.6	0.1
Bursitis	0.2	3.7	NA

Source: Center for Labor Hygiene and Trauma Prophylaxis, Ministry of Health, Donetsk

Donetsk City and Surrounding Communities

8. Donetsk City has a population of 1.12 million, but there are several other industrial communities nearby: Horlivka, Makiivka and Yenakiieve; they are all part of one airshed. The largest industrial sources are the iron and steel plants in Donetsk, Makiivka and Yenakiieve. With emissions over 100,000 tons annually, they are major contributors to dust and SO_2 concentrations measured in the area, with the Makiivka and Yenakiieve plants being much larger polluters than the Donetsk plant (see Table 2). The Donetsk steel plant is located within the city of Donetsk, which means its impact could be significant; however, the plant is small and cleaner than most surveyed in Ukraine, and it no longer has a sinter plant. Similarly, the coking plant in Donetsk is relatively well controlled by Ukrainian standards. In the visit, no leaking doors were observed, and hoods captured much of the charged emissions. The area's air pollution does not appear to be as heavily influenced by this coking plant as those in the other urban areas surveyed. Table 7 gives the results of ambient monitoring in the airshed. As can be seen, the particulate levels are extremely high.

Table 7: Donetsk Area, 1991 Average Ambient Measurements (mg/m^3)

Pollutant	Ukrainian Allowable Concentration	Donetsk	Makiivka	Horlivka
Total Particulate	.15 (24 hour)	.5	.3	.4
SO_2	.05 (24 hour)	.029	.05	.057
CO	3 (24 hour)	2	2	4
NO_2	.04 (24 hour)	.08	.11	.15
NO	.06 (24 hour)	.06		
H_2S	.008 (20 minutes)	.028	.003	.025
Phenol	.003 (24 hour)	.005		
NH_3	.04 (24 hour)	.08		
CS_2	.005 (24 hour)	.004		

As noted in the body of the report the accuracy of these figures is questionable due to the ambient monitoring techniques used. However, they may give a crude indication of relative pollution problems.

9. **Donetsk Steel Plant**. This small plant is located in the city of Donetsk. It produces 1.3 million tons of iron and 1.4 million tons of steel annually. The plant has rather unique features. It is partly integrated-- with 2 blast furnaces, 6 open hearth furnaces, 2 continuous casting shops and an electric arc furnace (EAF) workshop with 2 furnaces. Half of the steel is produced from scrap in the EAF shop; the OHF use a mixture of pig iron (70 percent) produced at the plant and scrap iron (30 percent). The sinter plant has been shut down. Half of production of pig iron is sold outside the works. The rolling mills are common to both open hearth and EAF parts of the plant.

10. The two continuous casters process about 40 percent of the steel produced and rolled into sheets. The remaining 60 percent of OH steel is produced in the form of blooms, which are reheated in walking beam furnaces prior to rolling. The EAF do not have continuous casters. Reheat furnaces are fired with natural gas with no heat recovery. Blast furnace gas is cleaned, collected and used as a fuel in the plant; other fuels used are: coke oven gas (from a nearby coke plant), natural gas and fuel oil. Coal is added to the tuyeres of the blast furnace to reduce coke consumption.

11. The plant is kept quite clean, and emissions appear lower than in other steel plants visited. Pressure from the city appears to have influenced the shutdown of the sinter plant and the attention to housekeeping.

12. Plant staff are currently looking at EOF technology (energy optimizing furnace) to replace the six 142-ton OH furnaces by a single 70-ton EOF. The economics would have to be reviewed carefully for such a major investment (roughly US$80 million per unit), taking into consideration the longer term viability of this plant. Plant managers are interested in receiving assistance in financial planning to evaluate possible future investments.

13. **Mikitivskiy Plant (Horlivka).** A facility of special concern is the Mikitivskiy mining and mercury manufacturing complex. This plant was rebuilt in 1968 and produces 400 tons of mercury per year. The plant is situated on a hill within the Donetsk airshed. Total mercury emissions from the complex are high--8,000 pounds per year. The current pollution control system (sulfi· sorbent injection system) needs to be replaced with a more efficient mercury removal system. I-stallation of this technology may be difficult, though, because of the massive air flows used in the manufacturing process. The financial condition and competitiveness of the plant are unknown.

14. The current USEPA emission standard for a mercury ore processing facility similar to the Mikitivskiy complex would be a maximum of 50.7 lbs/day (2,300 grams/day) for a theoretical maximum emission level of 1,850 lbs/year. In practice, emissions would be well below 1,850 lbs/year because of the impossibility of actually emitting at the legal limit 365 days per year. This USEPA standard is also very old (1974) and may, in fact, not reflect currently available control technology.

15. **Makiivka Steel Plant.** This is a very old plant, sitting adjacent to a community of about 500,000 people. The plant produces only long products with OH furnaces; the most modern part is its rolling mills (for long products). It is one of the most "fearsome" looking in terms of air pollution. The plant also appears to have serious waste management problems. Managers are currently testing a new 250 ton OHF in place of two 500 ton furnaces. Four of its sinter plants (out of six) are being shut down due to pressure from MEP and local authorities. MEP has requested a rapid abatement of air pollutants--from 147,500 tpa in 1991 to 50,000 tpa in 1995. Existing pollution control equipment includes: sinter plants (some cyclones); blast furnaces (equipment for top gas; no equipment for casting bay fumes treatment); and no equipment for mixers, cast iron machines and OHF. Materials handling and waste management at the plant appear poor. The plant's future is uncertain, though, on economic grounds, not just environmental. Also, near the plant and the community of Makiivka are a series of underground coal mines.

16. **Yenakiieve Steel Plant.** The town of Yenakiieve has a population of about 210,000, of which 110,000 are reportedly workers; there are also neighboring villages. The town is dominated by

the steel plant. There is concern about unemployment over the next five years as coal mines in the area close. Other employment includes a cement plant and food processing industries. The town leaders are looking for other activities to create employment.

17. The steel plant was originally established in 1898 but rebuilt in the period 1949-51. It employs 12,000 people. It includes: a sinter shop (4 machines); a blast furnace shop (4 furnaces of 1,033-1,386 m^3 of capacity); a converter shop (with 3 BOF of 130 tons each); rolling mills; and shops for lime production and refractory products. Plant production is primarily long products for shipbuilding and billets (intermediate products) for other rolling mills. Production in 1991 was: 2.4 million tons of sinter; 2.5 million tons of pig iron; 2.5 million tons of raw steel; and 1.5 million tons of finished products. Today production is down by about 20 percent. Exports are only 200,000 tpa. Plant management wants to invest in upgrading rolled stock to meet world market needs. They also want to invest in 4 continuous casting machines and 2 plate beds (1 for cold rolled plate for the auto industry, which is not produced in Ukraine now).

18. The biggest air polluters in the plant compound are the sinter plant, lime plant (where bag filters do not appear to be working well), the blast furnace (where ESPs are in bad condition), and the converters. Housekeeping is generally poor, especially in the sinter plant. Hydromet only has one stationary monitoring post to cover plant operations.

19. Water pollution is also serious. About 11 million m^3 p.a. of partially treated water goes into the river nearby (Bolavin River); the water contains oil and suspended metals. There is some primary treatment via a settlement pond. About 450,000 tpa of sludge from the iron production and blast furnace, plus 80,000 tpa from the roller shops, are disposed of outside the plant. The reservoir holding the sludge is critically filled. Management speculated that the plant may be shut down because of the waste problem.

20. **Avdiivka Coke and Chemical Plant**. This plant appears to be the largest in Europe, capable of producing 7-10 million tpa of coke. Currently, it produces over 5 million tons of coke, 400,000 tons of tars, 50,000 tons of ammonium sulfate, 400 tons of phenols and 80,000 tons of assorted organic specialty chemicals. It treats about 250,000 tons of tar residues p.a. The plant appears to be one of the cleaner and more modern facilities in the domestic industry. Managers hope to reconstruct some units in order to produce higher value-added products, which would have better export potential. They need outside investment to modernize and replace older equipment.

21. The plant badly needs to reduce its gas flaring, currently at 250 million m^3 p. a. It also should reduce the hazardous waste it generates (60,000 tpa). All water effluents are biologically treated by mixing with domestic sewage. The effluent BOD is down to 6 mg/l after treatment, due to very long retention times in sewage treatment.

Kostiantynivka (formerly Konstantinovka) and Ukrzinc, its Zinc/Secondary Lead Smelter

22. Kostiantynivka is a town with 108,000 inhabitants, located approximately 50 km north of the city of Donetsk. In the center of the town, in a valley that is approximately 70-80 meters deep and 6-7 km wide, are located a lead and zinc smelter (with a 180-meter smokestack), a chemical plant, and a metallurgical plant. The smelter accounts for 33 percent of estimated gross air pollutants in the

town; the chemical/fertilizer plant, 15 percent; and the metallurgical plant, 15 percent. The smelter is considered the most serious because of heavy metal emissions.

23. The zinc/secondary lead smelter, built in 1930, is very large and based on the old sinter route with furnaces to refine the lead. In the past, it received vehicle batteries from various parts of the FSU, reclaimed the lead, and sent it to Russia for production of new batteries. Production capacities are 32,000 tpa of zinc and 19,000 tpa of lead. The plant is now operating at about one-third of capacity because of shortages of raw materials. Zinc ore is not produced in Ukraine, and its sources from the FSU have dropped dramatically. Despite its heavy production in the past, no investment for modernization or repair has been made at the smelter for the past 20 years. This plant is outdated compared to plants in Russia (reportedly 7 plants) which generally have much better technologies.

24. Sixteen hundred workers (600 of whom are women) work at the smelter. (Some women are restricted from certain jobs because of health risks.). The management of the smelter claims that there have been few cases of lead poisoning among workers in recent years--only 15 cases in the 1985-1990 period. Although annual physical examinations are performed on all workers at the smelter, modern blood lead testing is not undertaken. Despite the small number of reports of lead poisoning among workers, data from the Kostiantynivka San Epi station of the Ministry of Health document high levels of inorganic lead in the breathing zone of workers in several different parts of the smelter's operation.

25. The plant has dust/heavy metal control (via bag filters) but the level of performance is not satisfactory. Just to provide some comparison in regard to pollution control, estimated emissions of zinc and lead at the plant are 29 kg/ton and 1.7 kg/ton respectively; typical emissions of lead in western Europe would be 0.3-0.5 kg/ton; "best available technology" in the world offers emissions of 0.1 kg/ton. SO_2 recovery at the plant is about 80 percent; in western Europe, it is 95 percent. In regard to water pollution, zinc and lead in effluents are estimated at 322 mg/liter and 18 mg/liter respectively. The normal standard in western Europe would be 2 mg/liter and 0.5 mg/liter respectively. Staff at the San Epi station estimate that about 15,000 people live within 1 km of the smelter, chemical plant, or metallurgical plant. The San Epi station has found high levels of lead in ambient air and soil near the smelter.[2] Many of the town's residents (23 percent of whom are children 14 years old or younger) could be seriously exposed to lead and experiencing significant adverse health effects. Of most concern is irreversible brain damage to young children.

26. This is a case of a plant unlikely to survive over the longer term as market forces come into play. It also appears to be a major health hazard. These two considerations combined make this a plant which should be an early candidate for evaluation for possible shutdown.

Mariiupil

27. Mariiupil (which traces its origins to a small Greek settlement centuries ago) is a community of about 530,000 people on the Azov Sea; its population increases substantially with the influx of tourists in summer. Summer tourists formerly averaged about 300,000 but frequent beach closures and danger of disease reduced this number to about 50,000 last year.

2/ The soil lead concentrations are difficult to interpret because it is not known at what layer they were taken.

28. Mariiupil's landscape is dominated by the two major steel plants (Illycha and Azovstal) and the associated coking facility. These enterprises are major employers in the city, which as a whole boasts about 50 other, generally smaller enterprises in its jurisdiction. One of the steel plants, Azovstal, and an adjacent merchant coke oven are located in the center of the city. The city of Mariiupil is reminiscent of former steeltowns such as Pittsburgh in the US. City officials are concerned about a recent health study which suggests a relationship between health problems in Mariiupil (increased miscarriages and birth defects) and local pollution.[3]

29. The city is anxious to develop alternative industries and wants to consider ways to rationalize the two steel plants and the coke oven to minimize the impact on the city's population. To this end, they have developed a city plan which develops several scenarios for future economic development, restructuring of the metallurgical plants, and pollution abatement. The city could use technical assistance in further planning economic diversification.

30. Production from the two iron and steel plants for 1991 in millions of tons of products was as follows:

	Iron	Steel	Rolled Products
Illycha	6.8	6.8	6.0
Azovstal	5.8	6.0	4.5

See Annex 4 for more information on steel plants.

31. The two iron and steel plants and the coking plant dominate the air pollution situation in the city, generating 97 percent of all the air pollution from stationary sources. Table 8 shows a breakdown of principal air pollutants from these plants. The city's other smaller industrial concerns contribute only about 18 thousand tons in total.

32. The impact of these emissions may be seen by examining the Table 9 on ambient concentrations of air pollution in the city.

3/ The study by Dr. Antipinko of the Institute of Hygiene, Ministry of Health, needs further review and corroboration. The study may not have been properly controlled. However, its results are interesting and worthy of follow up.

Table 8: INDUSTRIAL AIR EMISSIONS IN THE CITY OF MARIIUPIL (1991 DATA)						
GENERAL POLLUTANTS						
tons/year	DUST	SO_2	NOx	CO	Other Pollutants	TOTAL
ILLYCHA	51,800	34,600	27,200	260,810	400	374,800
AZOVSTAL	22,600	12,300	13,800	103,900	300	152,900
COKE OVEN PLANT	1,900	2,440	610	8,120	2,250[a]	15,320
TOTAL	76,300	49,340	41,610	372,820	2,950	543,020

BENZO-A-PYRENE (Kg/yr)		
	1990	1991
COKE OVEN PLANT	59	47

Table 9: Mariiupil--Average Concentrations of Selected Pollutants (mg/m³)

Pollutant	Ukrainian Allowable Concentration	1988	1989	1990	1991
Particulate	.15 (24 hour)		.2	.2	.3
SO_2	.05 (24 hour)	.02	.02	.02	.02
NO_2	.04 (24 hour)	.04	.04	.05	.04
NO	.06 (24 hour)	.03	.03	.03	.02
H_2S	.008 (20 minutes)	.002	.004	.005	.007
Phenol	.003 (24 hour)	.004	.004	.005	.005
NH_3	.04 (24 hour)	.07	.09	.07	.08
Hyd. Fluoride	.005 (24 hour)	.012	.013	.018	.017

33. As noted in the body of the report, the accuracy of these figures is questionable due to the ambient air monitoring techniques used. However, they give some indication of relative air pollution problems. The particulate, NO_2, phenol, and ammonia concentrations stand out as pollutants of particular concern. In addition, emissions of hydrogen fluoride, benzo-a-pyrene, formaldehyde, and heavy metals (such as lead, cadmium, nickel, and chromium), associated with steel mill dust, are suspected to be quite high and should be closely monitored in the future. Any plan to deal with air

pollution in this city must concentrate on the three major polluters: the two steel mills and the coke plant. Ironically, the local MEP branch has only five inspectors for the entire municipality.

34. **Illycha Plant**. Built in 1936, Illycha is the largest producer of flat products (plate, hot and odd rolled sheets and strips) and is considered the most modern plant in Ukraine with 40 percent of its crude steel production coming from oxygen converters (BOF), some continuous casting, and a new rolling mill for flat products. It produces steel pipe for the oil and gas industries. Illycha employs 31,000 people and stretches for about 15 km along the edge of the city.

35. The plant includes: a sinter plant (twelve 85 m^2 strands); a blast furnace shop (5 blast furnaces of 8087 m^3 capacity); an open hearth shop (3 open hearth furnaces with a capacity of 900 tons each and 3 with capacities of 650 tons); an oxygen converter shop (3 converters of 160 tons each); 1 continuous casting shop, another under construction; a 1150 slab rolling mill; "1700", "3000" and "4500" thick sheet rolling mill; a cold rolling mill; and power supply shop (27 boilers of different capacity). Two stage venturi scrubbers are installed on the BOF; the OHF have no controls.

36. The plant accounts for 2/3 of pollutant emissions in the area; however, it is not in the center of town, as is Azovstal, and therefore may contribute less to ambient concentrations of pollutants affecting the population directly. Reportedly, 32,800 people reside in the so-called sanitary zone surrounding the plant, however.

37. More than 30 years of waste disposal at the plant have concentrated solid and liquid hazardous wastes in impoundments that were not designed or engineered to store hazardous material. Examples of hazardous materials stored on site include 3 million tons of solid waste from steel production, containing 65 percent Fe^2O^3, 10.7 percent FeO, 1 percent MnO and 1.2 percent Zn. Some steelmaking sludge is recycled in the sinter plant despite its high zinc content (5 percent). Liquid wastes are impounded in two holding ponds (400 m x 400 m each) that have been seeping sulfuric acid and organic chemicals for years.

38. Cooling water abstractions are made from the Kalmius River at the rate of 100 million m^3 per annum. Rinse waters from the rolling mills are discharged at the rate of 150 m^3 per hour into 2 lagoons of 600,000 and 300,000 m^3 capacity respectively. These lagoons are now overloaded and it is estimated that there is only sufficient capacity for 2 further years of operation at present rates of steel production. Effluents from the sinter plant are treated in a wastewater treatment plant providing sedimentation with oil skimming. Effluent from this passes to a lagoon of 800,000 m^3 capacity before overflow to the Kalmius River. The oil removed by flotation is recycled in the heating processes in the steelworks.

39 **Azovstal Plant**. Located on the Azov Sea, Azovstal is the second largest employer in Mariiupil with 25,000 employees and is located in the center of town. It manufactures long and flat products. About 10-12 percent of production is exported, but plant management hopes to increase this level. The plant includes: a sinter shop (2 lines, the rest previously closed); a blast furnace shop (6 blast furnaces with total volume of 9217 m^3); an open hearth shop (with 12 tilting furnaces, each 450 tons of capacity); an oxygen converter shop (2 converters of 350 ton capacity); 5 continuous casting machines (3 in operation during visit); a cogging "1170" mill; a rail and structural steel mill; a heavy merchant rolling mill; "3600" thick sheet rolling mill; a shop manufacturing rail fastenings; and a ball rolling section. Ancillary shops include: a lime production shop; a slag utilization shop;

and two boiler plants (10 boilers altogether). Most of the equipment is old, received from the US under "lend-lease" during World War II. It needs hard currency to modernize.

40. Environmental problems are directly related to the plant's operating with old equipment. It is the second largest air polluter in the city in terms of gross emissions, but its impact is probably more significant because of its location. Pollution control equipment at the plant includes: sinter plant (venturi scrubber); blast furnace (dust catcher and venturi scrubber); open hearth furnaces (no equipment). Conditions within the workshops of the plant are poor--with heavy fugitive dust. About 700 people reside in its sanitary zone. The plant has stockpiled 2 million tons of flue dust containing about 5 percent zinc at the sea's edge. Unless the flue dust is utilized someway and reprocessed, the waste may have to be disposed of into the sea.

41. Water for cooling purposes is abstracted from the sea by four pumping stations at the rate of 80,000 m^3 per hour. There are 11 separate wastewater discharges into the sea. These include cooling water, effluent from gas scrubbers, and slag production. Some other discharges flow to a lagoon of 300,000 m^3 capacity, constructed on the shoreline. A pumping station is under construction as part of the lagoon installation, and when this is complete it will enable water to be recycled back to the steel production processes. Wastewater from the gas scrubbers, which are produced at the rate of 22,000 m^3 per hour contains up to 3,000 mg/l of suspended solids, are discharged to a lagoon of 1,600,000 m^3 capacity.

42. **Mariiupil Coke & Chemical Plant**. The plant produced 2.7 million tons of coke in 1991 (down from 3.56 million tons in 1990). It supplies Azovstal with coke and also some coke oven gas (about 1 million m^3).[4] Its batteries are generally old (40 years old) with serious door leakages; six of the seven batteries need to be replaced urgently. The one new battery (built two years ago) looks much older than it is because of poor maintenance. A visit to the coke plant revealed poor environmental controls in place and a high level of air pollution obviously present. There were over 20 percent leaking doors, even on the newest coke oven battery. Only the newest battery at the Mariiupil facility has a hood to capture coke charge or discharge emissions and it is undersized. In contrast, all batteries in the United States must have hoods which capture emissions from charging operations. Immediate action is needed to reduce door leakages, improve charging and pushing, and raise the level of housekeeping generally. This study recommends investigating whether or not the hood over the new battery could be extended to improve emission reduction. Indeed, the municipal council has indicated interest in shutting down this plant because of its pollution and location in the city.

43. The general maintenance and control of fugitive dust was very poor. As with most coking plants, the level of the sulfur in the coke used as an input was very high (1.7 - 1.8 percent). The coke oven gas is not sufficiently desulfurized (its H_2S content is 3.2 g/m^3). However, the pollutant of primary concern at the coking plant is benzo(a)pyrene. Nearly 1400 people still live in the sanitary zone of the coke plant.

44. Concentrated phenolic wastes from the coke plant have been deposited in a lagoon some 20 km from the plant. Leachate from this lagoon has contaminated borehole water supplies which served

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4/ Most of the coke for the Illycha plant is transported from 100 km away. Illycha cannot receive any of the coke oven gas because of the lack of a pipeline (10 km).

a nearby small town, and these water supplies are no longer usable. The company has had to make available alternative supplies of water from the Mariiupil system. However, these alternative supplies are insufficient particularly during summer months, and the town has re-commenced abstractions from the boreholes, albeit on a limited scale. Clearly, there is a very serious public health risk associated with the use of this borehole water, and urgent steps are needed to provide an alternative supply to the town while steps are taken to remove the contamination from the lagoon. An appraisal is needed to evaluate and cost options for preventing leachate contaminating the borehole water supplies of the adjacent town. The appraisal should also make recommendations for providing alternative water supplies to the town to make up the deficiency of supply from Mariiupil.

45. **City Water Supply**. Raw water for drinking water supplies in Mariiupil is taken from several sources, primarily from the Siverskodonets River (permitted for withdrawals up to 300,000 m^3/day). Another surface water source, during wetter years, is a nearby surface reservoir. Groundwater was described as too highly mineralized for ultimate use as drinking water. A shortfall of 100,000 m^3/day of water was reported. The city's water supply treatment facility was designed to treat 300,000 m^3/day; supplies were described as often running less than this capacity (230 - 240,000 m^3/day). Changes in the channel of the Siverskodonets River have been planned which could increase safe withdrawals; however, expansion of treatment capacity would then be necessary.

46. The quality of drinking water in Mariiupil may create health risks. The raw water is of extremely bad quality (from the Siverskodonets River) and the treatment plant is operating inadequately. The operators are forced to add more chlorine than the regulations require, and still 6 percent of samples of processed water contains coliform bacteria with the frequency of coliform increasing to 15 percent for the samples taken from household taps. Drinking water in Mariiupil is chlorinated prior to distribution; however, distribution system problems, including supply interruptions and wastewater infiltration, reportedly lead to contamination of the water delivered at the tap. Residual chlorine levels are seldom measured at the tap; residual chlorine levels leaving the treatment plant were reported in the range of 1.2 to 1.5 mg/l. Coliform testing is performed once daily at the tap and once hourly as water leaves the treatment plant.

47. Drinking water was identified by local officials as a possible source of waterborne diseases observed in Mariiupil, together with surface overflows of raw sewage affecting beaches during the bathing season. The rate of enteric and other waterborne diseases reportedly rises two and a half times during summer months. The central city has 2-3 km of sand beaches all heavily polluted from outlets of sewage mixed with storm water and accidental - but frequent - sewage overflows. The bacterial contamination of the beaches are monitored by the sanitary control twice a week by sampling at 4 sites. This has resulted beach closures practically every year. Salmonella contamination is found on the beaches near direct sewage outfalls. Cholera embryos are regularly found in the Kalchic River, running through the city. One incident of cholera was reported in 1991. Reportedly, the whole stretch of the beach between Mariiupil and the Don mouth is polluted. To the west, the water quality improves; 100 km to the west of Mariiupil the water can be classified as good.

48. Many interruptions of reliable drinking water supply occur daily, either involving sharp reductions in pressure or total interruption of flow; officials estimate that between 100 and 150 breaks in supply occur each day, due to failures in the distribution system. Problems with maintaining the system are due to a highly corrosive water supply as well as the quality of materials and construction. Little or no metering is done, either at the supply side or the consumer side. Frequent interruptions

also reportedly result in excessive demands on the system, due to the common practice of filling bathtubs, pots and other containers in homes whenever water begins flowing properly.

49. **Municipal Wastewater Treatment.** While much of Mariiupil is sewered, a number of serious problems exist with the integrity and coverage of the collection system. Unsewered areas, pumping and collection system failures, and frequent surcharging all contribute to chronic water quality problems. Corrosive soil conditions and problems with materials and construction lead to frequent failures of collector sewers, especially the many force mains made necessary by the topography of the city. Mariiupil is located on the edge of the Black Sea at a place where numerous valleys are cut into the level farmland which lies several hundred feet above the sea. This configuration has led to the need for numerous force mains and pumping stations. In addition, the steeper slopes of the valleys were developed in an unplanned manner, with many of the illegal homes built there relying on failing septic tanks and drain fields, privies or direct discharge of wastewater. These valleys eventually receive garbage, urban stormwater, overflowing sewage from the failing collection system, raw wastewater discharges and septic field leakage from both the unplanned areas lining the valleys and several other spontaneous housing concentrations on the margin of the city. Officials described eleven stormwater outfalls, some with water quality poorer than raw municipal wastewater.

50. The Mariiupil wastewater treatment plant utilizes primary sedimentation and activated sludge; plans for tertiary treatment were reported. Chlorination is not operated at times; problems with supplies were reported. Sludge is currently stockpiled, although officials hoped to begin using this on agricultural fields if pathogens and metals are found to be low enough. Capacity at the plant was described as adequate, however capacity was reported to be insufficient to treat projected flows from the city's proposed deep tunnel interceptor. Influent concentrations of BOD5 were reported to be 180 mg/l with an effluent BOD5 of 8.2 mg/l. Influent concentrations of COD5 were reported to be 239 mg/l with an effluent COD5 of 13.7 mg/l. Influent concentrations of SS were reported to be 245 mg/l with an effluent SS of 12.4 mg/l.

51. At the time of the visit, rotary skimming was not operating on the sedimentation tanks being used; gassing was observed in both the sedimentation tanks and clarifiers, indicating insufficiently frequent de-sludging of these tanks. Aeration in the activated sludge chambers appeared to be spotty, with large areas not being thoroughly aerated; failure of tiles used in the aeration system was reported to be the reason for this condition.

52. **The Local Vodokanal.** The Mariiupil office of Vodokanal and the city's Department of Community Services are responsible for water and sewerage services. Cities in Ukraine bear responsibility for repair and maintenance of most infrastructure including the portion of inter-oblast highways passing through the city and water and sewer facilities. Until recently, financing was provided from the national (Soviet) budget for most new infrastructure.

53. Most industrial enterprises are metered for water use and most residences are not. The ongoing privatization of houses and apartments is generating a demand for residential meters, since actual water use is usually less than the norms used to compute charges in the absence of meters. Demand for meters is reportedly high, but the supply is poor. The water also reportedly has a corrosive pH and high levels of calcium and magnesium, limiting the useful life of meters.

Table 10: Charges for Water in Mariiupil (Ukrainian krb/m^3)		
	Drinking Water Charges	Wastewater Treatment
General Population	2	2
Industries	75	20

54. In contrast with these rates, local costs for providing drinking water were estimated at 75 krb per cubic meter. No estimate was provided for the local costs of wastewater collection and treatment. The city must gain oblast approval for changing the fees charged for drinking water and wastewater collection and treatment.

55. A study is needed to revamp water and wastewater charges and to review management of water and sewerage systems, suggesting ways to streamline and identifying staffing and training needs. The Mariiupil wastewater treatment plant employs 140 people, with an anticipated expansion to 250 employees when planned tertiary treatment is installed.

Proposed Studies Under the Black Sea Program

Water and wastewater treatment problems, as well as waste management, will be considered as part of the "urgent investment portfolio" of the Black Sea Program. A feasibility study will consider ways to lower water demand through leakage reduction, public education and pricing (including a possible tourist tax) and will evaluate alternative sources of water supply. The study will also address the overall alternatives available for managing the serious problems with wastewater collection and stormwater management, including the city's proposals for either a deep tunnel or a separate stormwater system and other options such as rehabilitation, improved operational efficiency and upgraded maintenance and materials. Finally, the study will evaluate the overall scheme for collection of wastewater, including sunk costs, and determine for various projected time horizons, the most cost-effective combination of programs to resolve the most serious contamination and public health issues. The intent is to identify immediate versus longer-term investment needs in the water supply and wastewater systems of Mariiupil.

In the area of municipal and industrial solid waste, the study will review the characteristics of the solid waste stream (makeup, mass and volume, temporal variability, etc), review current disposal options and proposals and recommend a scheme or schemes to address this problem. Options will include sanitary landfills, rubble fills, incineration, source reduction, toxic waste pollution prevention, and other techniques.

56. **Municipal Finance**. When asked about funding for municipal water problems, Mariiupil officials explained that the city has very limited financial resources, and that funding from the Ukrainian national government for infrastructure investments is not sufficient. The city

representatives suggested the city's steel industry and the Ukrainian government together should provide the needed funds. The steel mills could contribute more, since the mills have the ability to pay. In fact, a municipal tax has been levied recently on employees of one of the Mariiupil steel mills, although the legality of this tax is now under challenge. The city also suggested that, as a major industrial center, Mariiupil generates significant tax revenue for the Ukrainian government. The city maintains that too little of the taxes from Mariiupil are returned to the local government, given the serious problems with public health and the Azov Sea's environment. In 1992, spending and aid by the national government in Kiev reportedly returned just 17 percent of total taxes collected from enterprises and the public in Mariiupil.

57. **Other Concerns**. The dredging and dumping of dredged material along the coastal area of Mariiupil have negative impacts on the costal zone and the marine ecosystems. The main dumping site is at 5 m depth, not far from recreation and fish reproduction areas. Oil pollution from the city is not reckoned to be a major problem. Only small volumes of oil are discharged in the sea. The total load of oil products to the Sea of Azov is estimated to be 3000 tons per year, of which the Don carries 1200 tons. The concentration in the Mariiupil coast area is about 0.4 mg/l at a distance of 250-500 m from the main discharge points.

58. **Solid Waste**. Several existing open dumps or landfills serving Mariiupil are nearing capacity. Available land for municipal solid waste disposal sites is in very short supply within the boundaries of the city, and acquiring some part of the surrounding farmland would be difficult. The solution suggested by local officials is incineration using either Western European or CIS technologies. They believe that building and operating a sanitary landfill is not realistically within the city's means.

Hazardous and Solid Waste Disposal in Donetsk Oblast

59. The state engineering consultancy, Kievprojekt of Kiev, has prepared a scheme for incineration of hazardous and solid wastes throughout Donetsk Oblast. The proposed incinerator is a very advanced high temperature plant which includes technology for pelletizing furnace ash and coating the pelletized ash with molten glass produced in a parallel furnace. The glass coating apparently facilitates the disposal of the otherwise toxic ash in landfills or on construction sites. The incinerators in this instance are to be operated using natural gas as fuel in a temperature range of 1600°C to 2760°C. The scheme for toxic, hazardous and solid waste disposal has been drawn up by dividing Donetsk Oblast into five sub-regions. Sites for incinerators have been identified in four of the five sub-regions at Slaviansk, Horlivka, Donetsk and Mariiupil. The sub-region of Torozsky is to utilize the incinerator planned for Donetsk. The four incinerator installations will be provided as a phased construction program commencing initially with the scheme for Mariiupil on the south coast of the Azov Sea.

60. The estimated annual production of wastes in the sub-regions is as follows:

Sloviansk	256,000 tons
Horlivka	350,000 tons
Donetsk (incl. Torozsky)	180,000 tons
Mariiupil	112,000 tons

In the inland areas of the Mariiupil sub-region, municipal (domestic) solid waste is generally disposed of in landfills. Along the coastal strip, however, landfill sites are no longer available and, due to the increased production of municipal solid waste from tourists, there is an increasingly urgent need to provide alternative facilities for disposal. The city of Mariiupil has therefore been given priority in the phased program for the incinerator installations.

61. There are no overall estimates available for the total construction costs of each installation, or foı the operating costs. The incinerators are designed as modular units each unit having an operating capacity of 50,000 tons per annum. At 1991 prices each modular incinerator unit has a cost of $10m. The estimated costs for provision and installation of the proposed number of units at each location are:

Slaviansk	$50m	(5 units)
Horlivka	$70m	(7 units)
Donetsk	$40m	(4 units)
Mariiupil	$20m	(2 units)

These sums do not represent total scheme costs since civil works, site infrastructure costs, etc. are not included.

62. From the appraisal of the proposals undertaken in Donetsk and Mariiupil, it is apparent that insufficient consideration has been given to the following aspects:

- It is unlikely that four toxic waste incinerators could be justified for one oblast; there has been no financial analysis of this investment.

- In the case of the scheme for Mariiupil it is proposed to use the incinerator plant partly for the disposal of municipal refuse. There appears to have been insufficient thought given to the need to differentiate between the different classes of waste (toxic, hazardous, municipal) and the use of the most appropriate and economic means for disposal.

- The proposed incinerators will incorporate very advanced technology which is not appropriate to the present standards of operation and maintenance available in the Ukraine.

- The financing of the proposals does not appear to have been considered in sufficient detail, bearing in mind that total capital costs will probably be in excess of $200 million. There is no financing plan available to show the overall capital and operating cost of the individual schemes or the corresponding requirements for revenue raising to finance capital and operational charges.

- Independently prepared environmental impact assessments are essential before any decisions can be taken on the proposals for the individual incinerator installations.

63. It is recommended that an external consultant undertake a detailed review and financial analysis of the proposals, using the data available, working in collaboration with Kievprojekt or another locally appointed consultant. The assignment should include developing a strategy and a

master plan for the future disposal of all toxic, hazardous and municipal solid waste in the oblast to include recommendations on the following:

(i) a control policy for the disposal of wastes, site licensing, environmental protection, etc.;

(ii) identification of optimal approaches for waste disposal throughout the oblast, i.e. landfill sites, incineration, etc. and a financing plan, which estimates capital and operating costs as well as revenues from the investments;

(iii) recommendations for an operational management structure for administration of the waste disposal strategy;

(iv) finally, and very importantly, a review of opportunities for waste minimization in key industries.

ZAPORIZHZHIA OBLAST

64. Zaporizhzhia Oblast has a population of 2.1 million, 78 percent of which is urban. Industrial output in this oblast is reportedly third after Kiev and Kharkiv. The oblast has a lot of agricultural activities as well.

City of Zaporizhzhia

65. The population of the city is 875,000 and it is home to 130 major industries (altogether, some 1,100 industrial plants) many of which are located in a 60 km^2 industrial zone (district no. 2), and are sources of both air and water quality problems. A nuclear power plant operates some 40 miles away. The MEP branch was set up in January 1989; its inspection team comprises about 70 people.

66. **Air Quality.** Total annual emissions loading is estimated at 231,000 tons from industry, another 110,000 tons from transport. Ambient air concentrations and toxic pollutants are considered the priority, followed by water quality problems. The maximum reading for particulates recently was 0.65 mg/m^3. About 15 plants are responsible for 95 percent of air pollution. Those mentioned were: various emissions from the sintering plant at the steel mill; fluorides from the aluminum smelter; chlorides from titanium and manganese enterprises; and BAP (benzo-a-pyrene) from coking and electrode plants. Most obvious air polluters are two major metallurgical plants: Zaporozhstahl and Zaporizhzhia Integrated Aluminum Smelter. These two plants contribute about 60 percent of the total air pollution in the area. But there are many other plants of concern, because of the nature of their emissions, notably the merchant coke oven in the middle of the city and an electrode plant.

67. The sanitary zones around the plants have over 20,000 people residing in them. Some 75,000 people reside in areas outside the sanitary zone but within an adjacent part of the city. Health studies have shown a large number of people in close proximity of the plants have been experiencing health problems associated with air pollution (respiratory illness, skin rashes, and eye irritation), perhaps 50 percent higher than other districts of the city.

68. The following tables provide data on air quality in Zaporizhzhia.

Table 11: Zaporizhzhia--Average Concentration of Selected Pollutants (mg/m^3)					
Pollutant	Ukrainian Allowable Concentration	1988	1989	1990	1991
Particulate (24 hour)	.15	.20	.20	.30	.30
SO_2 (24 hour)	.05	.04	.04	.02	.026
NO_2 (24 hour)	.04	.10	.10	.09	.09
NO (24 hour)	.06	.05	.04	.04	.05
H_2S (20 minute)	.008	.027	.023	.027	.020
Phenol (24 hour)	.003	.005	.007	.007	.006
HF (24 hour)	.005	.003	.005	.003	.003
HcL (24 hour)	.20	---	.17	.15	.12

Table 12: Seven Leading Industrial Sources of Ambient Air Pollution, by Annual Amount of Emissions, City of Zaporizhzhia (1990)

Industrial Source	Annual Emissions (in metric tons)
Zaporizhzhia steel	150,998
Aluminum Plant	27,478
Abrasives plant	13,892
Carbon electrode plant	13,230
Electrometallurgy	11,385
Iron alloy plant	11,017
Coke plant	6,219

Source: San Epi Station, Zaporizhzhia, Ministry of Health

Table 13: Leading Ambient Air Pollutants from Industrial Sources, by Annual Amount Emitted, City of Zaporizhzhia

Air Pollutant	Annual Amount Emitted (in metric tons)
Carbon monoxide	153,894
Dust	59,329
Sulfur dioxide	23,759
Nitrogen dioxide	14,014
Silica dust	3,893
Hydrogen chloride	1,408
Hydrocarbons	1,153
Toluene	1,141
Manganese	976
Fluoride compounds	778
Xylene	739
Hydrogen sulfide	478

Source: San Epi Station, Zaporizhzhia, Ministry of Health

Table 14: Breakdown of Air Pollution from Selected Plants in Zaporizhzhia (1991 Data)

CLASSICAL POLLUTANTS

tons/year	DUST	SO_2	NOx	CO	Other Pollutants	TOTAL
ZAPOROZHSTAL	17,500	12,800	8,200	88,200	100	126,800
DNEPROSPETSSTAL	5,788	335	471	3,534	63	10,191
COKE OVEN	400	2,700	360	1,300	220	4,980
ELECTRODE PLANT	1,865	185	-	4,221	1,651	7,922
DNIEPER ALUMINUM	9,242	1,083	706	5,320	325	16,676
TOTAL	34,795	17,103	9,737	102,575	2,359	166,569

FLUOR (HF and FLUORIDES)

tons/year	HF	FLUORIDES (DUST)
DNIEPR ALUMINUM	218 2.4 kg/t Al	415 4.6 kg/t Al

BENZO-A-PYRENE (kg/yr)

COKE OVENS	54
ELECTRODE PLANT	356
TOTAL	410

69. **Zaporozhstal**. This iron and steel works was built in 1933 and rebuilt after the war. According to a briefing by the interim director, "60 percent of the plant is depreciated, and a lot of reconstruction is needed." The plant operates open nearth furnaces only; managers want to install BOF, but lack the funding to do so. Capacity is 5 million tons raw steel; in 1991, 3.6 million tons were produced (down from 3.8-3.9 million in 1990). Total employment in actual steel production is 17,000, but the plant claims it actually needs 2,000 more. There is a shortage of workers because wages are low at the plant, and there are other industries apparently paying more and better located near residential areas (eg. motor and machinery plants). Pig iron capacity is 4.5 million, but output is only 3 million; some scrap is used. The plant sells some pig iron to Japan, Yugoslavia and Bulgaria. Production in 1992 was said to be down because of lack of coal (due to the miners' strike in Donbass).

70. The biggest culprit in regard to air pollution is the sintering plant which spews brown smoke. Dust control (a wet venturi scrubber system) is not very effective (a wide range of 80-98 percent was cited); it looked as if dust controls were not operating during the study visit. The blast furnace and OH furnaces also have venturi scrubbers; the mixers have bag filters. An estimated 103 million m^3 of industrial wastewater are partially treated at a sludge pond managed by the steel plant (including 70 million m^3 from the steel plant).

71. **Zaporizhzhia Aluminum Smelter.** The aluminum smelter was built in the 1930's (reportedly the largest in Europe at the time) and rebuilt following the war; the plant uses the Soderberg technology dating back to the 1950s, producing alumina, primary aluminum, and commercial silumin (silicone alum). It currently produces only 98,000 tpa with practically no pure aluminum production; the bulk of production is of aluminum silica alloys. Managers cited two processes used: traditional electrolysis and in-plant recovery of oxides "cum" addition of different alloys. Management has ambitious ideas for rehabilitation of the plant, but no funds to do it.

72. From estimates made available during the study, its energy efficiency and pollution control performance are much lower than the most advanced technology (eg. "pre-baked" technology, which is actually older but has been refined and improved over the years), but more importantly they are lower than what is achieved at other plants in Europe based on the Soderberg technology.[5] Aluminum production is energy intensive; hence, an important aspect of competitiveness is how energy efficient a plant is. No information was available to the study team with regard to overall energy efficiency of the plant. The Soderberg technology generally requires 17.5 kWh/kg alumina; the pre-baked technology is less than 14 kWh/kg alumina.

73. Of most concern are two pollutants emitted at the plant: fluorines and tars. The emissions of fluorides, in the form of hydrogen fluoride, are estimated at 2.2-3.2 kg/ton alumina. Emissions in Europe and the US are 0.5-1.5 kg/ton. "Best available technology" can bring emissions down to 0.3 kg/ton. There are also tar emissions from the electrolysis process in the plant which are a serious problem because they are carcinogenic (emissions in a plant like this can be higher than those in coke ovens).

5/ Three western European countries still use the Soderberg technology: Norway, Sweden and Spain. Norway in particular intends to continue using its plants, but in so doing is trying to improve associated pollution control systems.

74. Pollution control equipment includes: alumina production (ESPs); aluminum electrolysis (venturi scrubbers); and silumin production (sleeve filter and wet scrubber). The degree of containment of all pollutants in the Zaporizhzhia plant is probably about 50 percent, compared to Soderberg based plants in western Europe which achieve 70-80 percent. Also, fugitive emissions in the plant are high; they could be reduced by better control of furnaces, maintenance and housekeeping.

75. Complete revamping of this plant would cost in the order of US$ 1 billion, an expensive proposition. Installing good pollution control equipment in this plant would cost in the order of US$20-25 million. Pollution control, though, would also bring some commercial benefits--recovery of aluminum fluorides, the raw material--which could bring returns to part of the investment (in Sweden, the payback period was 3.5 years for an improved pollution control system which recovered the raw material). Whether such an investment would be sensible or not depends on a more careful analysis of equipment and options in this plant, as well as its underlying competitiveness, in view of the poor world market for aluminum at the moment. The plant has over 4,000 employees.

Zaporizhzhia Coke Oven Plant

76. This plant is located in the city of Zaporizhzhia (in the city's industrial district, which is close to areas where people live and work). It produced 2.74 million tons and 2.12 million tons of coke in 1990 and 1991. It has four coke oven batteries; a special battery for heating tar and producing a special molten tar-coke for the Zaporizhzhia electrode plant; and a byproduct plant. The plant employs 2,500 workers.

77. Officially, the four batteries are equipped with charging and pushing fume collectors, but these were not seen. Door leakages were high (about 40% on the pushing side; emissions of dust also occur during charging and pushing). There are seven small hoods for collecting door leakages on the first seven furnaces which produce coke tar. Dry and wet cyclones are used for coke oven gas purification. Coke oven gas is partly desulfurized, but the gas still has too high a sulfur content. Total emissions were 5,500 tpa in 1990 and close to 5,000 tpa in 1991; BAP emissions were 74 and 54 kg/year respectively.

78. Phenols in the wastewater reportedly are substantially reduced before discharge. The plant's general water circuit is common with other plants in the industrial district.

79. The situation at this plant is somewhat paradoxical. General housekeeping is very good (cleaning of roads, tanks and buildings and efforts to landscape the premises). But the coke oven batteries themselves and tar production in the plant present serious environmental hazards in a plant located in the middle of the city.

80. **Zaporizhzhia Electrode Plant.** This plant produces about 15,000 tpa of electrodes. The plant is the only producer of electrodes in Ukraine; it has some 3,500 employees. The plant uses bag filters and ESP for particulate control. What is shocking, though, is the high level of benzo-a-pyrene emissions (356 kg/yr).

81. **Alchevsk car assembly plant.** This factory manufactures light passenger vehicles. The wastewater streams are derived from metal working and finishing and include a galvanizing plant,

metal plating shops and paint shops. The wastewater stream from the galvanizing plant is treated within the car assembly works. The treatment process is based upon precipitation of the metallic salts with lime. Settle sludge is dewatered by hydraulic presses and the sludge is then sent to a treatment plant in Kiev for the extraction of zinc and nickel.

82. The other industrial waste streams and the domestic wastewater from the factory are gravitated to a comprehensive wastewater treatment plant located near the factory. Treated effluent from the wastewater treatment plant is all recycled back to the factory. The sludges from the wastewater treatment process are mechanically dewatered by vacuum filtration and are tipped in the factory's own landfill site about 20 km from Zaporizhzhia. This plant is doing a good job in wastewater recycling and treatment.

83. One problem may be the wastes containing hexavelant chromium; they are treated by addition of domestic wastewater in hermetically sealed tanks to reduce the chromium to trivalent state before being discharged to the sewerage system for further treatment at the municipal authority's wastewater treatment plant. Although it is claimed that the method adopted for chromium reduction is effective, it is extremely doubtful that the bacteria in domestic wastewater, in anaerobic conditions, are able to produce the required treatment, and it is quite possible that highly toxic hexavelant chromium is being discharged to the municipal wastewater treatment plant.

84. **Water Quality Management.** In regard to water resources, water consumption by both industry and public utilities is 546 million tpa, most of which is recycled through closed water circuitry. The city has some 30 treatment stations, but they are inadequate. About 57 million m^3 of untreated water (municipal waste) goes into the river. The river is reportedly polluted with increasing ammonium salts, cyanides, suspended particles, phenols and heavy metals.[6] In 1989, the city stopped giving licenses to industries without treatment facilities. In 1991, there were 5,000 violations; 200 heads of enterprises were fined. Investment priorities to address water pollution were cited: (i) expansion of sludge pond and further treatment; (ii) expansion of sewerage network and biological treatment (38 sewerage pumping stations exist but facilities are inadequate); and (iii) installation of proper instruments to measure pollutants. Also mentioned were problems with irrigation, causing increased salinization of rivers feeding into the Dnieper.

85. **Municipal Wastewater Treatment.** Zaporizhzhia is served by a wastewater treatment plant on each bank of the Dnieper River. The plant on the left bank has a treatment capacity for 175,000 m^3/day, but receives an inflow of 350,000 m^3/day. Only 200,000 m^3/day is passed through the treatment plant, the remaining 150,000 m^3/day discharges direct to the river without treatment. When the ongoing extensions to this plant are completed, it will have a treatment capacity of 430,000 m^3/day. Completion of the extensions was intended in 1994, but lack of financing is causing delays. The right bank treatment plant has a capacity for 110,000 m^3/day, and present inflow is 100,000 m^3/day. However, plans for the city envisage most development on the right bank; it is forecast that, by the year 1995, a treatment capacity of 200,000 m^3/day will be required. Design work for the required extensions to the plant have just started.

6/ Mentioned briefly were a couple of measurements: soluble oxygen = 6 mg/liter; and BOD = 1.42 mg/liter.

86. Both treatment plants incorporate preliminary screening and grit removal followed by primary sedimentation and biological treatment utilizing the diffused air activated sludge process. To meet the requirements of the sanitary service of the municipality the effluents from both plants are chlorinated with 3 mg/l chlorine before being discharged to the Dnieper River.

87. In March 1991, MEP and MOH set new standards for the quality of effluents discharged from the two treatment plants. The new standards included an unreasonably strict BOD limit of 3 mg/l compared to a previous limit of 15 mg/l and a suspended solids limit of 5.25 mg/l compared to a previous limit of 15 mg/l, forcing the plants to consider the construction of expensive tertiary treatment systems. At the plant on the left bank, drum filters and rapid gravity sand filters, together with a new chlorination station, are now under construction as part of the plant extensions, but at the right bank plant planning work for the tertiary treatment system has not yet commenced. This is an example of overly strict standards pushing individual plants into planning investments which may not make sense at this time because of severe resource constraints and other priorities.

88. Both treatment plants have serious operational problems in the treatment and disposal of sludge. Previous attempts at mechanical de-watering of sludge using Soviet-built centrifuges have not met with success as the mechanical equipment has lasted only two years. At present sludge is pumped from the plant to lagoons where it de-waters by a combination of surface evaporation and gravity. The drainage water is returned to the plant for treatment. Some of the air-dried sludge is used for agricultural purposes, but over the years considerable quantities have accumulated. For example, at the left bank plant there is an accumulation of 150,000 tons of air dried sludge and, similarly at the right bank plant, there is 30,000 tons. There is a need at both plants to develop an integrated policy for the treatment and disposal of sludge. Although anaerobic digestion is used for treatment and stabilization of the sludge at the left bank plant, it was noted that natural gas was being used for heating; methane from the digestion process, which could be utilized, was being vented to the atmosphere. Clearly the inefficiencies in the design and operation of the digestion plants needs to be remedied.

89. The following capital investments are needed to meet the future operational needs of both the right bank and left bank plants:

i) completion of the extensions to the left bank plant to increase treatment capacity from 175,000 m^3/day to 350,000 m^3/day;

ii) extensions to the right bank works to increase treatment capacity from 110,000 m^3/day to 200,000 m^3/day;

iii) construction of an integrated scheme for both plants for the treatment and disposal of sludge. Such a scheme should include consideration of anaerobic digestion plants built to the latest standards of technology; mechanical sludge de-watering using either centrifuges or filter belt presses and disposal of the dried sludge either by tipping in a landfill, agricultural use (if the sludge is not contaminated with toxic metal), or incineration, probably with one incinerator to serve both treatment plants.

90. **Municipal Drinking Water Treatment.** The city is served by two water treatment plants, one on each bank of the Dnieper River. Raw water is abstracted from the river. The total average

daily volume of water going into the supply is 550,000 m^3, of which 450,000 m^3/day is supplied to the urban areas on the left bank and 100,000 m^3/day is supplied to the right bank. The right bank treatment plant has sufficient capacity to meet demand, but there is a shortfall of 80,000 m^3/day in meeting the demand on the left bank, although some of the deficit is met occasionally by transferring some water from the right bank treatment plant. Generally, however, it is necessary to interrupt supplies to distribution zones on a scheduled basis to overcome the shortage of supply on the left bank.

91. Raw water is treated by prechlorination; coagulation and settlement followed by filtration by rapid gravity sand filters. The backwash cycle of the filters does not include an air scour so that the efficiency of cleaning is reduced. Consequently, the quantities of water used for backwashing are high and the water is discharged to the river without any treatment. It is estimated that 19 million m^3 of water per year are discharged in this way, and since it causes pollution in the river, fines are applied by the authorities. Managers of the Vodokanal responsible for the Zaporizhzhia water supply believe that some of the shortfall of 80,000 m^3/day could be made up by the introduction of a leakage control scheme. At present, little effort is made to either quantify or to bring under control leakage from the distribution system. Estimates of leakage of the order of 25 percent are reported, but Vodokanal managers believe the figure could be as high as 35 percent. Due to the absence of sufficient distribution zone meters of the automatic logging type, there is virtually no data available to make a reasonable estimate of losses by leakage.

92. To secure the future efficient operation of water treatment and supply the following schemes requiring capital investment and technical assistance are recommended:

i) extensions to the left bank treatment plant to provide an additional 80,000 m^3/day;

ii) improvements at both treatment plants to the filtration installations including treatment of backwash water to reduce pollution into the river;

iii) technical assistance in establishing and operating a comprehensive leakage control scheme including installation of distribution zone metering.

93. **Water and Sewerage Tariffs.** Rates for water and sewerage are shown below for different categories of users:

Rates for Water and Sewerage by User		
	Water	**Sewerage**
General population	10.0	6.0
Local government agencies	33.9	32.9
Other communal services	271.2	164.5
Industry	627.0	575.9
Agriculture	322.0	164.5

Precautions in Zaporizhzhia after Chernobyl

Following the Chernobyl nuclear power station accident in April 1986, additional treatment facilities were installed at both the left bank and right bank treatment plants. The installations comprise additional settlement tanks followed by filtration plant utilizing clay, chalk or fine granulated carbon as a filter medium. So far it has not been found necessary to operate the additional treatment facilities for the purposes of removing radioactive contamination. Daily checks are now made on the levels of radioactivity, and it is reported that total beta activity is in the range 12-16 picocuries per liter, compared to the WHO recommended maximum for drinking water of 30 picocuries per liter. Prior to the Chernobyl accident the level of total beta activity was checked on water samples at 10 day intervals and was recorded in the range 1.2 to 1.6 picocuries per liter. While there has been a 10 fold increase in the level of total beta activity following Chernobyl, this is still well within the proposed maximum for drinking water recommended by WHO.

Berdyansk

94. Industrial use of water accounts for 36,000 m^3/day out of a total consumption of 60,000 m^3/day. The industries supplied include grease manufacture, cable manufacture, machine building and electronics.

95. **Municipal Water Supply**. Due to a shortage of water resources there are supply interruptions in the city. The supply interruptions are also sometimes attributable to a lack of filtration capacity at the water treatment plant. A scheme is in progress for increasing supplies to the city from the Dnieper River. The civil works for this scheme are 40-50 percent completed, but progress is at present suspended due to lack of financial resources for the purchase of pumping plant.

96. It is reported that leakage levels in the distribution system are in the range 5-20 percent but there is no data available to confirm this estimate. It is quite possible that leakage levels could be appreciably greater than the estimates suggest.

97. **Municipal Wastewater Treatment.** Reportedly, only 60 percent of the city's properties is served by the sewage network. There are also drainage problems in the city due to the lack of a surface water sewage system. The wastewater treatment plant has a capacity of 120,000 m^3/day, but the plant is in need of reconstruction. A project is in the design stage which would increase treatment capacity to 200,000 m^3/day, but an agreement has not yet been reached on the type of treatment to be adopted. The reconstruction and extension is to be financed by the electronics industry in the city, but funds are not presently available.

98. A preparation study is required to examine the following investment requirements.

i) The water supply scheme, which has been partly constructed. (The study should include a review of the scheme and make an appraisal of the existing water treatment plant, paying particular attention to the filtration installations. In addition, the study should look closely at industrial water consumption; in view of the high level of industrial usage an assessment should be made of the potential for economy by recycling.)

ii) The scheme for reconstruction and extension of the wastewater treatment plant.

iii) Extension of the sewage network to increase the availability of main sewers substantially above the present level of 60 percent.

iv) Solution of the problems of surface water sewage including the need for a separate network.

DNIPROPETROVSK OBLAST

99. Dnipropetrovsk Oblast has a population of 3.9 million, 84 percent of which is urban. It is second to Donetsk oblast in terms of population density. Industrial activities include metallurgical industries, defense industries, and iron, coal and uranium production. The oblast has three "hot spots" in terms of industrial pollution: the city of Dnipropetrovsk, Dniprodzerzhinsk about 30 km away, and Kryvyi Rih, the center of the iron ore producing district and home to the largest steel plant in the country.

100. There are 568 major enterprises in the oblast, which, according to the MEP branch, equates to 61,000 stacks of which about 25,000 have controls. Ambient concentrations in 1991 were cited as 4-14 times standards for pollutants such as BAP (benzo-a-pyrene), particulates and ammonia.[7] The "quiet industries"--military plants (which until recently were difficult to inspect)--are most worrisome, along with galvanic/electroplating plants. Other industries of concern are the chemical and metallurgical industries.

City of Dnipropetrovsk

101. Dnipropetrovsk is the third largest city in Ukraine (1.19 million) and the center of a major industrial region. The city is home to a major missile manufacturing plant, the Dneprovsky steel plant, various electroplating and galvanic plants, food processing plants, and an aged heat and power plant.

102. **Municipal Wastewater Treatment.** There are three wastewater treatment plants serving the city. On the left bank of the Dnieper River there are two plants, one which has a treatment capacity of 60,000 m^3/day and is receiving 130,000 m^3/day and the other having a treatment capacity of 45,000 m^3/day and receiving 60,000 m^3/day. The plant on the right bank has a treatment capacity for 330,000 m^3/day but extensions are needed to provide for a capacity of 720,000 m^3/day by the year 2015.

103. The sewerage networks serving the treatment plants are separate but the municipal authority are concerned at the levels of pollution of surface water run-off in the urban areas and are now proposing a new, combined, network of sewers to take both foul and surface water flows. If these proposals are to proceed it will be necessary to make arrangements at the treatment plants for significant increases in hydraulic load. The treatment plant on the right bank provides for inlet screens and grit channels followed by primary sedimentation and biological treatment using a diffused air activated sludge process. In the past the plant has been able to meet the river water quality standards that have been set. However, these standards have recently been reviewed by the Ministry of Environment and the level of treatment does not meet the stricter standard now applied.

7/ Please note the authorities were not distinguishing clearly between annual average and maximum, short duration concentrations. "Photocalorimetric" measurements are taken by rather old equipment by Hydromet. Stations near principal population centers were cited as follows: 8 in Dnipropetrovsk, 4 in Dniprodzerzhinsk, and 5 in Kryvyi Rih.

104. There are operational problems at all three plants with the treatment and disposal of sludge. At the plant on the right bank, liquid sludge is pumped for settlement to an area of lagoons extending to 140 ha; of this area only 11 ha remains for future use. Problems are also experienced with industrial wastewater discharges to the sewerage network. The monitoring and control of industrial discharges is dependant on spot sampling undertaken manually during normal working hours. It is known however, that many polluting discharges of industrial wastewater are being made to the sewerage network at night-time and the introduction of 24-hour samplers is essential if these discharges are to be brought under control.

105. If the effluent discharges from the wastewater treatment plants serving the city of Dnipropetrovsk are to meet the river water quality standards required in the Dnieper River, then the following capital investment schemes will need to be undertaken:

i) a scheme of extensions to the right bank plant to increase treatment capacity from 330,000 m^3/day to 720,000 m^3/day;

ii) schemes of extensions to the two plants on the left bank to provide respective increases from 60,000 to 130,000 m^3/day and 45,000-60,000 m^3/day; and

iii) an integrated scheme for all three treatment plants to provide for the treatment and disposal of sludge. (Such an integrated scheme should be investigated on the lines of providing for sludge digestion followed by mechanical sludge de-watering at each plant with the disposal of de-watered sludge either in a landfill or, alternatively, by the provision of a centralized sludge incinerator to serve all three treatment plants.)

106. **Municipal Drinking Water Treatment**. Dnipropetrovsk is supplied with water from the following sources:

i) Lomovskaya water treatment plant on the left bank of the Dnieper River;

ii) Kaydak water treatment plant on the right bank of the river;

iii) borehole sources on the left bank of the river; and

iv) limited raw water supplies from the Dniprodzerzhinsk reservoir.

107. The treatment plants at Lomovskaya and Kaydak both abstract raw water from the Dnieper River. The total supply to the city is on the order of 720,000 m^3/day. The largest source is the Kaydak treatment plant which supplies about 580,000 m^3/day. The Lomovskaya plant treats 110,000 m^3/day and supplies 20,000 m^3/day to the town of Novo Moskovsk, 25 km away. The balance of the supplies of 30,000 m^3/day are obtained from the borehole sources. Water supplies from the plant at Kaydak to that part of the town on the right bank of the Dnieper River are adequate, but future planned residential development on the left bank will require extensions to the Lomovskaya plant. Proposals for these extensions are only at outline stage but are planned for construction as two phases each of 100,000 m^3/day capacity.

108. The water treatment process comprises prechlorination, with a dose rate of 6-9 mg/l; coagulation with aluminum sulphate; filtration with rapid gravity sand filters followed by secondary chlorination to maintain a chlorine residual in the water distribution system. As with the treatment plants at Kryvyi Rih, there is no provision for clarification of the raw water following the aluminum sulphate coagulation. The efficiency of the filters could be significantly increased with the introduction of clarifiers into the treatment process. In order to meet planned residential growth on the left bank of the city, capital investment is required for the two phases of extensions planned for Lomovskaya treatment plant. In addition, capital investments to improve the efficiency of filtration at both Lomovskaya and Kaydak are highly desirable.

Dniprodzerzhinsk

109. This city of 300,000 has 30 large enterprises dedicated primarily to metallurgical (steel plant and 2 coke plants) and chemical production (fertilizers, polystyrene, ammonia and different acids).

110. **Coke ovens.** The older coke plant visited was founded in 1932; the plant has 3 batteries, 45 furnaces and employs 4,500 people. Capacity is 1.5-1.6 million tons, but it is only currently producing 300,000 tons of coke because two of the batteries are under reconstruction. One battery is completely rebuilt ("steamless charging"). The biggest pollution problem remains the emissions from operating the batteries. Gas cleaning equipment for hydrogen sulfide is used. The coke oven gas is used in industry. Chemicals produced at the plant are ammonium sulfide, benzoil and resins. Water pollution from such processing can be a serious problem, but the plant engineer indicated that they now reuse much of the water, though some pollutant indicators are not up to standards. The plant has been fined in the past, but fines were "not large." The other coking plant in Dniprodzerzhinsk is slightly younger, but has some of the same problems; its capacity is 2.5 million tons of coke.

111. **Dzerzhinsky Steel Works.** The massive steel plant dominates this city. It produces cast iron and rolling steel. The capacity is 4 million tons; there are 8 open hearth furnaces (240-450 tons per charge)--and 2 basic oxygen furnaces (BOF; 250 tons per charge). Plant data provided was as follows: coke consumption--6,0000 tpd; sinter--12,000 tpd; cast iron--9,000 tpd; open hearth production--4,000 tpd; BOF production--7,000 tpd. The intent of managers and civic leaders is to renovate the steel plant, but funds are unavailable; they are looking for foreign partners. Over the next 5 years they want to expand BOF production and incorporate continuous casting. Eventually, they hope to shut down the open hearth furnaces and modernize the sintering plant. An estimated US$500 million is needed.

112. The steel plant causes an estimated 80 percent of ambient pollution in the city (total emission loading cited as close to 220,000 tons p.a.). The worst emissions come from the sintering plant, part of which was shut down recently because of the severe pollution. A visit inside the plant was eye-opening; floors caked with soot and mud from the sintering process; workers' faces covered with soot (some were wearing masks, others not); and debris everywhere.

113. **Azot Chemical Plant**. The factory produces ammonia and nitrate fertilizers; caustic soda, detergents and plastics including polystyrene and pvc resin. The wastewaters from the treatment processes at the factory, which amount to some 30,000,000 m^3 per annum, are generally discharged, without treatment, direct into the Dnieper River. Only the effluent from the urea production plant receives any treatment. This is discharged to the municipal wastewater treatment plant at the rate of

18,000 m^3/day, with 50,000 m^3/day of treated water being recycled from the municipal wastewater treatment plant to the factory (see below). Proposals have been drawn up to construct a wastewater treatment plant to treat the industrial flows from the industrial complex. At present there are seven untreated effluent discharge points from the factory; these will be combined to provide three discharges of treated effluent. A proportion of the flow will be recycled; part will be used for irrigation of agricultural land and the remainder will be discharged to the Dnieper River. The necessary finance for construction of the plant is reportedly available, but the management at the Azot plant wish to have an independent technical appraisal before proceeding. It seeks technical assistance to make an appraisal of the existing proposal and to introduce some Western technology into the proposal.

114. **Municipal Wastewater Treatment.** The city is served by two wastewater treatment plants, one on each bank of the Dnieper River. The plant on the right bank treats flows from 250,000 people and has a designed treatment capacity of 90,000 m^3/day but presently receives flows in the order of 150,000 - 160,000 m^3/day. The sewage system is separate i.e. there is a separate system for draining surface water flows, highway drainage, etc. The treatment system comprises screening and grit removal followed by primary settlement for sludge removal. Biological treatment is by an activated sludge plant. Effluent from this plant is further treated in rapid gravity sand filters and is then chlorinated, following which up to 100,000 m^3/day is used to irrigate grassland areas located 12 km from the plant.

115. A number of industrial wastewater flows are treated at the plant, the most significant being a flow of 18,000 m^3/day from the AZOT plant. A flow of 50,000 m^3/day of effluent from the treatment plant is recycled for use in the AZOT complex. Sludge from the plant is pumped a distance of 4 km for settlement in a complex of 38 lagoons. Since the plant was brought into operation in 1978, nine of these lagoons have been filled. Sludge digestion tanks were constructed with the plant, but these have never been brought into use.

116. To provide for future efficient operation of the plant, capital schemes should be considered for the following aspects:

i) plant extensions to increase treatment capacity from the present 90,000 m^3/day to 160,000 m^3/day; and

ii) treatment and disposal of the sludge to include thickening, stabilization by anaerobic digestion, mechanical de-watering by either centrifuging or by filter belt presses, an appraisal of disposal options including landfill sites and incineration, appraisal of possible utilization of methane from the digestion process for power generation on the treatment plant. Although it appears that there is still adequate lagoon capacity available for the sludge from the plant, this method of disposal cannot be considered to be an acceptable long-term solution.

Kryvyi Rih

117. While the Kryvyi Rih iron ore basin (Krivbass) encompasses only a small land area (1500 km^2), it has a large concentration of industrial enterprises. Located among residential developments are 17 iron ore mines, 5 ore-enriching mills, metallurgical plants, cement mills, and a lead factory.

Estimated air pollutant emissions over Kryvyi Rih are close to 900,000 tons. Each year there is an effluent of 60 million cubic meters of highly mineralized water. Over 5 billion cubic meters of waste from ore-enriching combines have accumulated in waste dumps and tailing storage sites.

118. Kryvyi Rih is dominated by one of the largest, if not the largest, iron and steel plant in the world; it is the largest plant in the former Soviet Union. In addition to the plant itself, a coking plant and a number of agglomeration plants nearby are major sources of air pollution. The next largest source is the city cement plant. There are a total of 103 air pollution sources in the city but the remaining sources contribute only a small proportion. Table 11 gives an estimate of the emissions from the major sources.

Table 15: 1991 Emissions from the City of Kryvyi Rih* (tons/year)

Facility	Total	Particulates	Total Gaseous including CO	SO_2	NO_x
Norokrivoy Rih Agglomeration Plant	269,540	20,854	248,686	9,303	3,507
Southern Agglomeration Plant	266,903	21,979	244,924	7,237	2,915
Inguletsk Agglomeration Plant	4,791	2,687	2,104	554	352
Central Agglomeration Plant	18,854	11,233	7,621	978	515
Northern Agglomeration Plant	35,957	22,002	13,954	7,653	2,260
Krivorozstal Iron and Steel Works	238,842	53,416	185,426	21,817	11,095
Coke and Chemical Plant	24,448	4,135	20,313	10,413	1,002
Total for City of Kryvyi Rih	887,806	154,098	733,707	---	---

* These totals do not include mobile source emissions.

119. In the city of Kryvyi Rih more than half of the adult population is employed in industry, with over 25 percent in mining and metallurgical enterprises. Workers are continuously exposed to occupational hazards such as inorganic dusts and chemical substances. The latter include carbon oxides, sulfur and nitrogen compounds, hydrogen sulfide, phenols, benzols, naphthalene, pyridine ammonia, and others. Many of these are emitted by a coke chemical plant and metallurgical plant. Table 16 provides information on ambient concentrations.

Table 16: Kryvyi Rih--Average Concentration of Selected Pollutants (mg/m^3)					
Pollutant	Ukrainian Allowable Concentration	1988	1989	1990	1991
Particulate	.15 (24 hour)	.4	.4	.4	.4
SO_2	.05 (24 hour)	.03	.04	.03	.062
NO_2	.04 (24 hour)	.08	.08	.08	.12
NO	.06 (24 hour)	.04	.04	.05	.05
H_2S	.008 (20 minute)	.038	.042	.058	.055
Phenol	.003 (24 hour)	.004	.004	.004	.006
NH_3	.04 (24 hour)	.09	.14	.12	.14
Note: As noted in the body of the report, the accuracy of these figures is questionable due to the ambient air monitoring techniques used. However, they may give some indication of relative air pollution problems.					

120. The particulate concentrations stand out as being very high, especially as they are average readings, not maximum levels. These levels do not account for the higher concentrations which are undoubtedly found in the sanitary zone in the vicinity of the iron and steel plant. There are 1,000 people living in this sanitary zone.

121. Kryvyi Rih is a very good candidate for establishing an emergency action program to reduce emissions during high episode periods. Such a program would be a part of a broader air quality management program recommended in the body of the report. San-Epi conducts a form of an emergency action plan now using mobile monitoring units. This program could be considerable strengthened by the adoption of recommendations in Annex 8.

122. **Krivorozhstal Plant.** Krivorozhstal is one of the world's largest plants and a major producer of non-flat products (rebar, bar, wire rod, heavy and light sections), primarily used in construction. It has 33,000 employees and covers an area of 2,200 ha. In 1991, it produced 9.2 million tons of iron, 10 million tons of steel, and 7 million tons of rolled products. It is a major producer of rebars, bars, wire rod, heavy and light rolled sections. Production data is provided below.

Table 17: Krivorozhstal--Production (million tons)				
	Sinter	Pig Iron	Raw Steel	Rolled Products
1989	4.1	11.8	12.9	8.7
1990	3.7	11.8	12.3	8.5
1991	2.5	9.2	10.0	7.5
1992 (estimated)	3.5	9.1	8.5	6.6
Products: Long and flat products Exports: 2.5 million tons (billets) in 1991.				

123. In every workshop of this massive plant there are opportunities to reduce both individual sources of emissions and fugitive emissions. The plant has 8 relatively small blast furnaces (working volumes of 1,316 and 2000 m^3) and one large, more modern blast furnace (working volume of 5000 m^3). A program of cleaning all the small blast furnaces is in progress. Pollution control equipment includes: blast furnaces (ESP and venturi scrubbers); BOF (venturi scrubbers); OHF (cyclones and venturi scrubbers); sinter plant (cyclone); lime and refractory plants (ESP and bag filters). This equipment, however, is not performing adequately. Heavy stack emissions are seen throughout the plant.

124. The plant's sinter workshop, commissioned in 1951, is in terrible condition, and its emissions are very high (representing one-third of total emissions from the plant). The six sinter strands (62.5 m^2) use high iron content waste and sludge from steel production as inputs, which creates high fugitive emissions and affects the efficiency of the process. Management wants to invest in a new sinter charge preparation plant, but would give no specifics about the proposed process during the visit. Clearly some immediate action needs to be taken to improve the worker environment.

125. The steel plant discharges 13 separate wastewater streams to a 14 km long canal running through the complex. The canal also receives wastewater streams from the coke plant and the iron ore mine. Overflow water from the canal passes through two settlement/storage lagoons before discharge to the Ingulecs River. These lagoons, which are operated in series, have capacities of 960,000 m^3 (primary lagoon) and 800,000 m^3 (secondary lagoon). The average daily flow of wastewater entering the lagoons is in the region of 340,000 m^3/day, of which 110,000 m^3/day is recycled through the steel plant for use as cooling water and rinse water. The discharge of polluted wastewater to the Ingulecs River is therefore of the order of 230,000 m^3/day.

126. At the site of the storage/settlement lagoons is a pressure filtration plant comprising 18 steel pressure filters with polystyrene bead media. It is understood that this was provided for the removal of oil contaminants from the water being recycled so that the water could be used as boiler feed water and for cooling and rinsing. However, the recycled water has been found to be highly mineralized with total dissolved solids on the order of 1200 mg/l and is not suitable for boiler use without demineralization. The pressure filtration plant is therefore only occasionally brought into use when oil contamination of the recycled water exceeds 5 mg/l and suspended solids are in excess of 30 mg/l. This usually occurs after periods of heavy rainfall.

127. Proposals have been drawn up for biological treatment of part of the effluent from the lagoons to reduce pollution in the Ingulecs River. The scheme envisages adapting the existing primary and secondary lagoons for use as aeration and secondary settlement tanks in an activated sludge plant. A third lagoon will be constructed to provide tertiary treatment for the effluent from the activated sludge treatment stage. It is estimated that treatment can be provided for 110,000 m^3/day, i.e. approximately 50 percent of the effluent present discharged to the Ingulecs River with an effluent standard of 4 mg/l BOD and 15 mg/l of suspended solids. The estimated cost of the biological treatment plant at 1991 prices was 5,000,000 rubles.

128. **Kryvyi Rih Coke/Chemical Plant.** This is a large plant producing over 4 million tons. It has highly visible door leakages, and six of the twelve batteries at the plant require replacement. Housekeeping generally is very poor. The plant represents a serious hazard to workers.

129. There are two wastewater discharges associated with the coke production process: effluents from the primary gas plant and phenol discharges. The wastewater stream from the primary gas plant contains ammonia in concentration up to 500 mg/l. Most of the effluent is pre-treated in a wastewater treatment plant and is recycled as quenching water for the coke production plant, but a proportion of the effluent, up to 2,000 m^3/day, is discharged to the municipal authority's sewerage network. The treatment process includes primary settlement, phosphoric acid addition and biological treatment using a bubble type aeration system for activated sludge treatment.

130. The wastewater stream from the phenol discharge is not pre-treated and is used as quenching water in the coke production plant. Use of the untreated phenol waste stream creates high levels of ammonia; investment in biological treatment of this waste is considered a priority.

131. **Norokrivoy Rih Agglomeration Plant.** One of the major problems at the Norokrivoy Rih Agglomeration Plant is all solid dust waste from the iron and steel plant is recycled back into this agglomeration plant. This can result in a build-up of very fine particulate matter which clogs the cyclone treatment systems. Three million tons of waste is recycled back to this plant. The emissions during periods of malfunction have been over 900 mg/m_3 of emissions. Frequent maintenance is needed to ensure proper operation.

132. **Kryvyi Rih Iron Ore Mine.** The mine produces iron ore for the nearby steel plant. Water from the mining operations which is produced at the rate of 83,000,000 m^3 per annum contains chloride in concentrations up to 250 mg/l. Total dissolved solids in the mine water vary within the range 10 to 100 grams per liter. Abstraction of the mine water is handled by a series of five pumping stations which pump to an elevated complex of 6 settlement lagoons having a total storage capacity of 260,000,000 m^3. Water is recirculated from the lagoons for ore washing at the rate of 24,000,000 m^3 per annum. Occasionally, the pumping stations are not able to pump all the water from the mine and polluted water then finds its way to the Ingulecs River through the 14 km long canal serving the steelworks. Leakage from the storage lagoons is also believed to be the cause of pollution in subterranean water. The mine only has consent to discharge up to 5,000,000 m^3 per annum of filtered water to the canal, but exceptions are made should an emergency arise in the ore washing plant or if a breakdown occurs at the pumping plant.

133. Taking account of the very large volume of mine water the costs of introducing a scheme for removing chlorides and total dissolved solids would be prohibitive. However, management at the

mine is preparing a scheme to treat the water at the rate of 600 m^3 per hour based upon a treatment process to be used in the mining areas of Katowice in Poland.

134. **Hazardous Waste and Radon.** Mining products in the Krivbass include considerable quantities of radionuclides which can be found in waste dumps, building materials, ash from electric power plants, ore tailings, and other materials. Many waste products, in the form of specially prepared building materials, are used in residential buildings, although all are not checked for radioactivity. In some buildings the concentration of radon exceeds the acceptable amount for residential rooms by 2 to 3 orders of magnitude. This is due to both contamination of building materials and ground radon discharge. Radon and radon daughters are found in the iron ore mines, which is not surprising considering the proximity to the uranium mines in Zhovti Vody.

135. **Kryvyi Rih Cement Factory.** The cement factory in Kryvyi Rih is, very much like those in other countries, a very dusty place. The Kryvyi Rih plant uses ESPs on the rotary kilns, small fabric filters on the cement silos, and some enclosures on materials handling processes. The ESPs have varying levels of effectiveness. The newer installations were functioning well enough, resulting in stack opacity levels (visible emissions) in the range of 5-10 percent (which is up to US standards). The older ESPs were clearly having problems, since stack opacities exceeded 30-40 percent It was unclear whether the ESPs were overloaded or simply malfunctioning. The plant engineer blamed the trouble on the fact that one of the older rotary kilns was down for repairs.

136. The baghouse system controlling the venting of the main cement silo was not working very well. There was considerable evidence of cement dust deposition all over the plant property, giving the impression that this baghouse problem is ongoing. (Frankly, the expert visiting the plant for this study had never seen a poorer result from a baghouse.) The plant engineer estimated that the filters themselves are replaced every two to three weeks, which seems excessive. Either they are using an unsuitable fabric, or the system may be grossly undersized.

137. Many of the materials conveying systems were fully enclosed to prevent fugitive dust, and the plant systems so endowed were performing well. On the other hand, some of the transfer systems were open on top, and it was easy to observe dust emissions due to the mildly strong wind that day. Such problems were more typical of the "waste" handling systems--the cooled clinker and furnace fines transfer systems. At the "back end" of the plant there was a large, partially enclosed space for handling the cooled clinkers, furnace fines, and one or two other "waste products" of the cement making process. Some of these materials are reused in the process, which is fine, but there is a fugitive dust problem at that location.

138. The plant would benefit from technical assistance in the operation of its baghouses, particularly at the cement silo vent. The plant may also benefit from technical assistance in the operation of its older ESPs, since there may be a design flaw or technique to improve performance. Immediate efforts can be made by the plant itself in terms of managing most of the remaining fugitive dust problem. These efforts should be concentrated at the "back end" of the process, at the point where certain "waste" by-products are temporarily stored prior to reuse. These wastes, which include cooled clinkers and furnace fines, are stockpiled in a large building which is completely open to the wind at one end and perhaps at the other as well; even erecting a simple screen would be effective in sheltering the stockpiles from the wind. The conveying systems for the cooled clinkers and especially the furnace fines must be completely enclosed.

139. A relatively simple change to operating practices would be of great benefit in the transfer of furnace fines within the stockpile enclosure. The technique used was identical to that used for cooled clinkers, which is to say that a large clamshell scoops up a full load of solid material, is raised about 7 meters above the floor, and then moved to the proper location within the stockpile enclosure and dumped onto the proper pile. This works well enough for cooled clinkers because they are 2-3 cm in diameter and not very friable, but to dump several hundred kilograms of fine dust from a height of 7 meters is a disaster in terms of dust generation. If instead the scoop of fine dust would be lowered to a height just above its destination pile and then dumped, fugitive dust would be reduced.

140. **Municipal Drinking Water.** Kryvyi Rih is supplied with drinking water from two treatment plants. The Karachung treatment plant has a capacity of 250,000 m^3/day and abstracts its raw water from the Karachung reservoir. The reservoir, which is fed by the Inhulets River, has a total volume of 308,000,000 m^3. At Radushansko, there is a second treatment plant with a capacity of 700,000 m^3/day to supply 800,000 people. Treatment at both plants comprises pre-chlorination, coagulation using aluminum sulphate, followed by rapid gravity sand filtration and secondary chlorination to provide a chlorine residual in the distribution system. There are no sedimentation tanks prior to the filters, and it is apparent that the efficiency of the filters could be increased if sedimentation tanks or clarifiers were introduced. In addition, there are no provisions for treatment of the filter backwash water. Consequently, the river is polluted when discharges of filter backwash water are made.

141. To meet the anticipated increase in demand due to the growth of population of the city there are proposals for the construction of a third water treatment plant at Iskrovskoe. This plant will have a treatment capacity of 400,000 m^3/day and will be designed to supply a population of 200,000. Design work for this scheme has not yet commenced.

142. **Health Issues.** The level of occupational illness in Kryvyi Rih is 20 times greater than the mean in Ukraine. A further increase in occupational illness is expected in the next 8 to 10 years due, in part, to an increase in understudied conditions such as silicotuberculosis. Working conditions are especially poor and difficult among "hot shop" laborers (blast furnace, open hearth furnace, converter). Occupational morbidity is 12 percent higher in hot shops than in shops with normal microclimates.

143. The incidence of cancer (unadjusted incidence per 100,000/year) has been steadily increasing in Kryvyi Rih. This temporal increase in the incidence of cancer in Kryvyi Rih compared to Ukraine is presented in Table 18.

144. Kryvyi Rih has also experienced an increase in morbidity from disease other than cancer. In the last 10 years, there has been a 60 percent increase in hypertension, 75 percent increase in diabetes, and a 60 percent increase in stomach and other gastrointestinal ulcers. For every 1,000 children of primary and pre-school age, there are 1,600 to 1,700 registered illnesses, 70 percent of which are related to broncho-pulmonary pathology. Although birth rates in the city of Kryvyi Rih have dropped by 22.4 percent within the last 20 years (1970-1989), infant mortality has increased by 11.6 percent in the last 10 years. For every 10,000 newborns, 30 have serious genetic damage.

145. **Note:** These disturbing data about the environmental and occupational health hazards and rates of morbidity and mortality in Kryvyi Rih come from a report by a Ukrainian health authority,

Dr. Mykola Slinchenko of the Kryvyi Rih Institute of Industrial Hygiene and Occupational Diseases[8] (reviewed and summarized in this study by Dr. Hryhorczuk of the University of Illinois). Dr. Slinchenko unfortunately does not reference these data, and we cannot be assured of their accuracy. The increases in morbidity and mortality rates which he presents are not age adjusted. If the data are correct, then Kryvyi Rih is clearly a "hot spot" of environmental and occupational illness in Ukraine.

Table 18: Cancer Morbidity Rates per 100,000 Residents, Kryvyi Rih

Year	Morbidity Rate per 100,000	% Increase from 1975	Ukraine
1970	166.0	--	--
1975	190.0	--	220.2
1980	250.0	31.5	233.7
1981	248.0	30.5	244.1
1982	269.2	41.6	252.0
1983	269.5	41.8	259.2
1984	287.0	51.0	267.1
1985	294.2	54.8	275.2
1986	301.7	58.7	282.6
1987	314.7	65.6	292.6
1988	320.0	68.4	297.8
1989	328.6	72.9	298.0
1990	334.6	76.1	301.2

8/ Dr. Slinchenko's paper, entitled "The Silent Chernobyl of Kryvyi Rih" was presented at a meeting of the World Ukrainian Medical Association in Kharkiv, August 1992.

LUHANSK OBLAST

146. Luhansk Oblast has a population of 2.87 million, 87 percent of which is urban. Industrial activities are dominated by coal mining and various chemical industries. Coal mining is centered in the southern part of the oblast, while the chemical industries are centered in the western part of the oblast, north of Luhansk, in what is called the Lysychansk-Rubizhne area. Table 19 shows the major sources of water pollution in that region.

Table 19: Major Sources of Water Pollution in the Lysychansk-Rubizhne Area of Luhansk Oblast (1991)

Enterprise	City	Effluent quantity ('000 m^3 per year)
Paint/Dye factory "Krasitel"	Rubizhne	40,800.0
Chemical factory "Lissoda"	Lysychansk	24,700.0
Oil processing factory	Lysychansk	135.0
Radio technology factory	Siverskodonetsk	926.0
Factory "Impuls"	Siverskodonetsk	48.0
Resistor factory	Siverskodonetsk	21.0
Chemical factory "Zarya"	Rubizhne	14,300.0
Pulp/Paper Combine	Rubizhne	68.0
Glass factory	Lysychansk	1.1
Fertilizer factory "Azot"	Siverskodonetsk	111,700.0

Source: Ministry of Environmental Protection, Ukraine (1992).

Coal Mining Activities

147. There are over 120 coal mines in the oblast, mining primarily anthracite. Nine of these are in and around the city of Luhansk. A visit to one of these mines during the study showed conditions to be very poor for workers. A major part of this problem was lack of attention to removal of old equipment and debris, and to safety procedures in the mines.

148. The city of Luhansk itself has a population of 520,000 and obtains its water supplies mainly from borehole sources into a chalk aquifer. Mine waters which have total dissolved solids in the region of 3,000 mg per liter are pumped into the Siverskodonets River at the rate of 300,000,000 m^3 per annum, causing significant pollution of the river. The bathing beaches on the Azov sea were closed for the first time in 1992, due to pollution, and bathing in the Siverskodonets River has been banned since 1988. The river is also used to supply irrigation water for agriculture in the surrounding region.

149. Treatment of the mine waters to remove dissolved solids would be prohibitively expensive on the scale that is required. As an alternative, further consideration should be given to disposing of the mine water by groundwater recharge. A detailed hydrological study should be undertaken to determine the feasibility of such a proposal that will not cause pollution of the aquifer used for drinking water supplies and will not exacerbate the flow of water into the mines. Technical assistance for a hydrological feasibility study in the sub-region is needed.

Svetlovdsk

150. This town is surrounded by 18 operating underground mines which drain the water table, resulting in a severe shortage of drinking water. Fresh water is supplied to the town for only 3 hours a day. Mine waters have become contaminated with chloride and sulfate salts. This is a classical mine dewatering/water desalinization problem. The town also has very high ambient air pollution--no doubt from coal burning for mining activities as well as household use.

Siverskodonetsk

151. **"AZOT" Fertilizer & Chemicals Combine.** The AZOT combine saw its first production in 1951. The plant occupies a 1400 acre site at the edge of the city Siverskodonetsk. The city has approximately 150,000 inhabitants and is heavily dependent for its economic well-being on AZOT. The combine employs nearly 17,000 people. The city is literally a "company town" since AZOT supports directly much of its social infrastructure.

152. AZOT produces over 100 chemicals, including ammonia, fertilizers (urea, ammonium sulfate, ammonium nitrate, aqueous ammonia), methanol, formaldehyde, organic acids (acetic, sebacic and adipic), caprolactam, acetylene, vinylacetylene and its derivatives, polyethylene, and some catalysts. Annual tonnages of the principal chemicals are shown in Table 20.

Table 20: Annual Production of Principal Chemicals at the AZOT Combine.

Chemical	Metric Tons/Year
Ammonia	900,000
Fertilizers*	300,000
Methanol	600,000
Polyethylene	200,000
Acetic acid	100,000

*As 100% nitrogen

153. The Azot plant represents about 16 percent of ammonia production capacity in Ukraine. It apparently accounts for the major portion of polyethylene production (representing over 34 percent of total 1990 production of the former USSR). Methanol production is also at world scale (over 20 percent of total 1990 production of the former USSR). About 10 percent of total nitrogen fertilizer production in Ukraine occurs at AZOT. In addition to these bulk chemicals, the plant produces

consumer-oriented products: various cleansers, paints, gardening fertilizers and pesticides, as well as plastic molded products of several types.

154. The estimated value of all products produced at AZOT was about Rb. 550 million in 1989. At current world chemical prices, the value probably approaches US $1 billion (approximately 7 percent of the total value of the annual chemical production of Ukraine). Consumer-oriented products represent about 10 percent of the total value. Total investment in facilities at AZOT is estimated to be over Rb. 1 billion, of which about 11 percent is invested in various environmental cleanup processes. Both the production statistics and economic figures show how important this enterprise is to the economy of Ukraine.

155. State of the Enterprise and its Prospects. The economic disruptions in the country have affected plant operations in significant ways. The supply of major raw materials has been disrupted, as have been markets for plant output. It also appears that some of the process trains either were not running or were running at significantly reduced capacities, perhaps because of inadequate natural gas supplies or other raw materials. The plant expects that it will need to find new markets for some chemical products normally destined for other ex-Soviet republics.

156. Azot's technologies are a combination of Soviet and Western processes, some licensed from the West and built by Japanese or European contractors. Some facilities, such as the ammonia complex, represent the best the West was offering 10-15 years ago. There have been some marginal improvements in energy efficiency of the process since then, particularly in the reformer energy designs. This is probably true also for some of the other process trains. The primary energy efficiency gains, however, will likely come from tightening and improving overall utility system operations, where most of the energy waste occurs.

157. The overall facilities showed signs of poor maintenance and little new investment during the past decade. Many older process units need updating and replacing. The plant is large and complex and includes many different processes, reflecting diverse and complex product slates. Modernization investments need to wait until a new business plan is developed which takes into consideration changing market conditions. There is an obvious need for a detailed strategic business study by knowledgeable Western experts in combination with AZOT's management, addressing new market realities and assisting in finding foreign partners willing to invest in modernization. Given the economic importance of this enterprise to Ukraine and the value of some of its bulk chemicals for both domestic and foreign markets, the prospects for Azot's survival are good, albeit in a much changed form.

158. Human resources. The technical staff at the enterprise seems to be highly qualified and dedicated. However, the total number of employees is much higher than in comparable Western enterprises. Part of this may be related to the large social infrastructure that the enterprise is responsible for both at the plant and in the city. There is danger of losing highly qualified people because of the disrupted economic situation. In some cases, technical employees are finding it more lucrative to move to a plot of land and grow vegetables than to remain working for inadequate wages. Wages have not kept up with inflation. Market prices for consumer goods in the region seem to be set by the high wages paid coal miners (about 10 times that of an average chemical industry worker). Management is doing its best to survive under terribly disrupted economic conditions and is partially successful in establishing ties with new partners and obtaining needed raw materials through a barter

system. In the longer run, management will need to be introduced to modern strategies and financial planning practices.

159. Energy use. Natural gas is the primary raw material and energy source at the plant. Reportedly, nearly 3 million metric tpa of natural gas are required at the plant. An estimated 30 percent is needed as feedstock for ammonia and methanol production. Additional natural gas is also used for other chemical processes, but in smaller quantities. These requirements still leave a large amount of the annual gas requirement unaccounted for. Some of it is undoubtedly used for energy production (mainly steam). However, given the fact that electricity to the plant is supplied by the city power station, the quoted figure for natural gas use seems high.

160. No statistics were made available for energy efficiency at the plant. However, during a plant tour it was clear that energy efficiency must be very low--utility and process line insulation was missing in many places, steam lines showed many leaks, water cooling towers were in a poor state of maintenance and seemed to work very inefficiently. An energy efficiency audit is an important priority for the plant, along with development of a realistic business plan.

161. Environmental aspects. The enterprise estimates air emissions at approximately 8000 metric tons per year. The breakdown of these emissions is shown in Table 21.

Table 21: Principal Air Emissions at AZOT

Emission	000 tons/year
Carbon monoxide	2700
Nitrogen oxides	1500
Particulates	1000
Ammonia	1000
Sulfuric acid	30
Sulfur dioxide	23

Source: AZOT

These estimates appear low. They are probably estimates based on assumed values for losses from various process units rather than monitored, measured values.

162. The enterprise estimates nearly 19,000 metric tons per year of solid wastes go to storage ponds. A little over 13,000 metric tons of these solids are various process and water treatment sludges (6,000 tons of which is waste biological sludge), slags and other solids. The rest comes from washing railroad cars before loading with products. The enterprise has established a railroad car washing business which receives cars from other enterprises. Because of tightening emissions standards, this business seems to be unwanted now.

163. Fees for emissions are established by the local and national authorities. These fees are based on agreed annual emission estimates of various pollutants. Additionally, fines are levied for emissions that exceed allowed quantities. AZOT paid Rb 2 million in emissions fees in 1991 and

expected to pay Rb 5 million in 1992. It did not pay any fines in 1991, and does not expect to pay fines in 1992.

164. Wastewater Treatment. Nearly 300,000 m^3/day of wastewater is sent to the Siverskodonets River. It is claimed that of this water, 84 percent water that was used for cooling purposes and which has undergone biological treatment. The quality of wastewater is claimed to meet most of the established regulations, except for total dissolved solids. Total dissolved salt content in the water is about 1460 mg/l, of which 375 mg/l are chlorides and 330 mg/l are sulfides. COD and BOD of the wastewater average 5.2 and 37 mg/l of oxygen. The total dissolved solids are about 19 mg/l. Wastewater from the city of Siverskodonetsk and the Azot chemical manufacturing plant is treated in one plant which is owned and operated by the Azot enterprise.

165. Problems are encountered at the treating facility from various heavy metals that come with the city wastewater, apparently from the defense-related electronics assembly facilities that are in the city. All the effluent from the treatment plant is recycled for use in the factory.

166. The wastewater treatment plant has three waste treatment streams totalling 140,000 m^3/day:

i) domestic wastewater from the factory complex which is mixed with effluent from cleaning of tanks on rail cars. Total volume: 40,000 m^3/day.

ii) industrial wastewater from the manufacturing processes at the factory. This waste stream includes flows from acetate and ammonium sulphate production, methanol production, acids and complex salts. Total volume: 40,000 m^3/day.

iii) municipal wastewater from the city of Siverskodonetsk totalling 60,000 m^3/day.

167. The treatment plant has a capacity of 200,000 m^3/day, but during periods of heavy rainfall there is hydraulic overloading as a result of surface water entering the sewage system. The elimination of this overloading will require the installation of storm tanks so that high rates of inflow can be adjusted to the available hydraulic capacity of the plant.

168. The treatment processes comprise grit removal, primary sedimentation, and biological treatment using the activated sludge process. All the effluent is passed through rapid gravity sand filters before being recycled through the industrial complex. Problems are being experienced with the backwashing of the sand filters, and it is apparent that improved technology, including the introduction of air scour, is required to improve the performance of this part of the treatment plant.

169. The sludges derived from the treatment of the wastewater streams from the factory domestic inflow and the municipal inflow (i.e., streams (i) and (iii) above) are de-watered by vacuum filters. The de-watered sludge is tipped on the treatment plant site, but the availability of tipping space for the future is becoming an operational problem. Flocculents are not used in the vacuum filtration plant; although the plant was designed to treat 40 tons/day, it can treat only 16 tons/day. Present production of sludge from the two waste streams amount to 24 tons/day; it is therefore necessary to pump 8 tons/day of liquid sludge to two settlement lagoons adjacent to the treatment plant. The lagoons, which have a total volume of 1,050,000 m^3, also take sludge pumped from the industrial treatment plant. The supernatant water from the lagoons is recycled to the industrial plant after

treatment, but it is estimated that there is only 2 to 3 years' capacity available in the lagoons at the present rate of sludge pumping.

170. The following schemes of capital investment are required if the operational problems of sludge treatment and disposal and hydraulic overloading of the wastewater treatment plant are to be overcome:

i) construction of storm water balancing tanks;

ii) improvements to the existing vacuum filtration sludge de-watering plant by the installation of sludge thickening tanks before the filters and by the introduction of flocculation chemicals to improve the performance of the vacuum filters;

iii) provision of additional mechanical sludge de-watering equipment to treat the sludge from the industrial wastewater stream;

iv) provision of an incineration plant to dispose of all de-watered sludges; and

v) a scheme of improvements to the mechanical plant of the rapid gravity sand filters to increase their effectiveness.

171. In addition, it would also be appropriate to investigate the feasibility of treating the sludge in a heated digestion plant, including utilization of the methane gas for power generation at the plant.

Rubizhne

172. **"Krasitel" Dyes and Chemicals Combine.** Krasitel was founded in 1915 as a joint German/Russian company for the manufacture of dyes. The enterprise has since grown into a world class organic synthesis complex with a very wide product slate. It produces wet dyes for cotton, dyes for synthetics, pigments for polymer materials, and dyestuffs for pharmaceutical products. There are nearly 500 different production facilities at the site. The plant is located on a 640-ha site contiguous to the city of Rubizhne and employs approximately 10,000 people. The plant is nearly self-sufficient and has a large infrastructure. It has extensive maintenance and equipment fabrication facilities, allowing it to construct less complex equipment on site. It also self-generates all of its power and steam needs.

173. The surrounding community infrastructure is supported by the plant. For example, municipal city water from Rubizhne, as well as from the adjacent town of Kremennoye, is treated at the plant's biological facility. Much of the communal infrastructure of the surrounding area is directly supported by the enterprise.

174. Chemical output. The plant produces a wide assortment of chemicals from small quantities of reagent grade chemicals to bulk quantities of raw and intermediate chemicals. In addition, there is extensive production of dyes of various types and smaller quantities of pigments. No production data was obtained as it was considered confidential. Nevertheless, output varies from hundreds of kilograms per month for some chemicals, to thousands of tons per month for others.

175. Among the dyes that are produced are cotton dyes (wet solutions) and dispersed dyes for synthetic fibers. Carbazole chemistry was mentioned as a basis for producing some of the dyes. This may imply that anthracene oils from coal tars are still used as feedstock for dye manufacture, posing a potential health hazard for the workers at the site. The quantities of dyes that are produced must be very large. A production figure of 20,000 tons per year was given for Beta-naphthol. Beta-naphthol, occurring in coal tars, is an intermediate used in the manufacture of dyes.

176. Additionally, various plasticizers and saturated and unsaturated resins are made. There is also significant production of phthalic and maleic anhydrides, probably used for resin and plasticizer manufacture at the plant and for sale outside. The plant also manufactures a series of organic acids, including formic, benzoic and salicylic acids. The first is used as a textile conditioner and as an intermediate chemical, while the latter two, among other applications (including aspirin from salicylic acid), are used in dye manufacture.

177. State of the Enterprise and its Prospects. The plant is going through very uncertain economic times. Output is falling, raw material supply sources and market outlets are disrupted, lack of capital and rising prices are all causing great difficulties. The plant badly needs renovation and maintenance and some of the production units appear to be shut down.[9] However, in spite of this there appears to be a sense of normalcy.

178. The prospects for survival of Krasitel are high, even though undoubtedly much needs to be done to readjust product output to meet new market conditions. This will require strategic planning, management retraining, and large capital outlays. Some pragmatic steps are already being taken at the plant. Plant management has shifted some production to consumer goods, necessitated by a nearly 30 percent drop in market demand for their bulk and intermediate chemicals. In addition, joint ventures and sales agreements are being pursued in the West. There is also significant domestic and foreign trade still taking place and new foreign ties and contracts are being pursued, giving the plant badly needed income.

179. Energy Use. Because of the small amount of time spent at the plant, only some general observations can be made. The plant occupies a large area and facilities are dispersed over large distances, requiring long utility system pipe runs. Steam and heat losses must be very high considering the apparent poor state of maintenance and aging equipment. All of the electricity needs at the plant (60 to 70 MW) are met by a power station that also produces steam. Undoubtedly there are significant gains that could be made in energy use at the plant. Merely to install good insulation, and to improve operating and maintenance practices could reduce energy losses by at least 10 percent.

180. Environmental Aspects. There are two potential sources of air pollution at the plant. The first is the utility boilers; the second is the solid waste combustion furnace. The first is probably insignificant, since only natural gas is combusted in utility boilers. But the second, the solid waste combustion furnace, could be a significant source of pollution because nearly 5,000 tons/day of solids are reportedly handled by the furnace. The question regarding what solids were burned in the furnace was unanswered. It is unclear where such large amounts of solids could come from, unless they are various tars and pitches left from coke tar processing. In that case, the furnace could be a significant

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9/ The latest plant was installed in 1980 (phthalic and maleic anhydride units), and no new construction has taken place during the last 5 years.

source of polycyclic aromatics and other hazardous materials if combustion is not efficient. This potential source of air emissions needs further investigation.

181. Various chemical leaks may also be a significant source of air pollution. Carbon monoxide, for example, is manufactured on site. Other hazardous chemicals may leak and be airborne as dust or aerosols. However, no emission estimates were made available to the team, and these levels are difficult to estimate.

182. Wastewater from the industrial processes, together with municipal wastewater from the city of Rubizhne and from the nearby town of Kremenhoye, is treated in two biological treatment plants. The first is designed to handle 6 to 7 tons/day of organics, while the second is designed to handle 24-26 tons/day of organics. Treatment Plant No. 1 treats 60,000 m^3/day, most of which is municipal wastewater. The treatment process comprises primary sedimentation, biological treatment by activated sludge, followed by rapid gravity sand filtration and disinfection of the effluent by ozonation. Treatment Plant No. 2 treats 10,000 m^3/day of industrial process water. The treatment process includes preliminary treatment, primary sedimentation, biological treatment in a 2-stage activated sludge plant, followed by rapid gravity sand filtration and disinfection by ozonation. The effluents from both plants are discharged to the Siverskodonets River. Effluent standards are re-negotiated annually between factory management and MEP and MOH. The standard of effluent produced by both treatment plants is within the required standards set for maintenance of river water quality.

183. Sludge from both the plants is dried in open lagoons and then deposited on grass areas around the treatment plants. If demineralization of the effluents from both treatment plants is introduced, it will be possible to introduce recycling and substantially reduce the demand for potable water to the factory. At the same time, it will be possible to eliminate the discharge of effluent to the river. The feasibility of introducing a scheme of demineralization of the effluents should therefore be investigated.

Lysychansk

184. **Lysychansk Soda Works.** This plant was founded over 100 years ago. Parts of the plant still retain the old 500 volt utility system. It was destroyed during WWII, and parts of it carted away to Germany. After the war, the Soviets brought some of the equipment back from Germany and reconstructed the plant on the old model. Some of the equipment dates back to the beginning of the enterprise and is being constantly patched up. The soda factory is undergoing long-term reconstruction in phases; over half of the factory has been rebuilt over the last 10 years. Reconstruction has now halted because of lack of funds. Apparently, much of the specialized replacement equipment used to come East Germany; this equipment has now become unaffordable.

185. The plant produces sodium carbonate (soda ash) and its related products (sodium bicarbonate, ammonium chloride, calcium chloride, and others). The old Solvay process is used, which reacts calcium carbonate (limestone) with sodium chloride (common salt). Calcium carbonate is mined at open pits 18 kilometers away and is brought in by an elevated cable car system. Sodium chloride in solution is mined 40 kilometers away and the saturated brine is pipelined to the plant.

186. In contrast, in the US and several other countries, soda ash is produced by mining and processing naturally occurring minerals (principally trona), which is easier and more energy efficient to process and thus cheaper to produce.

187. The principal products produced by the plant and their quantities are shown below.

Table 22: Annual Production of Principal Chemicals at the Lysychansk Soda Works

Chemical	1,000 metric tons/year
Sodium carbonate	400
Calcium chloride	250
Sodium bicarbonate	53
Ammonium chloride	48
Reagent grade chemicals	4

188. This plant is reportedly the only plant in the FSU that is producing laboratory (reagent) grades of the chemicals mentioned above, although how important this is in monetary terms is questionable. In addition, finished products, mainly soda ash-based cleansers, are produced and packaged for sale to consumers and the military.

189. The products are reported to be generally of acceptable grade, except that of the calcium chloride.[10] The principal products exported are soda ash and calcium chloride. Calcium chloride is sold as a 37 percent aqueous solution for shipping (vs. hydrates, a higher concentration product shipped in dry form, which command a higher price). An additional problem is lack of proper packaging, making the product appear shabby when compared to its competition when exported. Most of the exports are to the former USSR republics and to Hungary, Bulgaria, and Sweden. Plant staff feel that if the packaging problems could be solved, more product could be exported.

190. State of the enterprise and its prospects. Although the plant operation seems inefficient and would have long since been shut down in the West, current operating costs must be low enough to be able to attract foreign customers for its products. Of course, low operating costs are attributed to inadequate cost accounting at the plant or to government subsidy of the operation. Because the plant is energy intensive, and its main raw material, ammonia, is also energy intensive, the cost of production is likely to rise with the increased cost of natural gas. In addition, the large capital investments that are needed for reconstruction of the facility and to bring it into compliance with modern environmental, health and safety standards could make the enterprise uneconomic.

191. The plant output of chemicals does not appear to be significant in the context of world trade but is significant in the Ukrainian market. Although it would be an obvious candidate for closure from the economic point of view, its products may be critical for other local enterprises, such as glass manufacturers, soap and detergent makers and as raw materials for other chemical manufacturers. It is clear, however, that the enterprise is a very unlikely candidate for joint ventures with Western

10/ Calcium chloride is a byproduct of the Solvay process and is recovered from the so-called "distiller" waste.

companies. A rough estimate of the value of plant annual output, at current world market prices, approaches US$ 200 million.

192. Energy use. The overall energy usage at the enterprise must be high because of the cable car system that brings the limestone to the plant and the pumping costs for the brine. Also, heat must be supplied to the process in at least three steps: the lime kilns, the rotary calciners, and the ammonia still.

193. Environmental aspects. An unusually high level of annual carbon monoxide emissions (27,000 tpa) was quoted for the plant. The quantity is over ten times that which could be related to the process itself and/or attributed to the poor combustion of fuels. If this figure is not an error, then it warrants further investigation. Other air pollutant quantities where not given. However, ammonia could be smelled at the plant and at the wastewater storage ponds. Ammonia losses, from the process and also from wastewater to the air, must be high. In addition, heavy chemical dust is evident all over the plant site, sometimes completely covering large areas of the ground. Chemical dust losses are evident at all dry steps of the process and at the waste water storage sites. This dust is also airborne during product loading of railroad cars via open loading chutes.

194. The hot lime, from the lime kiln, is transported in an underground open tunnel to slakers. Workers in this pit are exposed to high levels of airborne lime. The only breathing protection evident around the kiln is an occasional person wearing what appears to be a rag or a handkerchief tied around the nose and the mouth. Such protection is totally inadequate and must cause high levels of respiratory problems. The plant environmental engineer admitted that this is unacceptable and that the work is also particularly unbearable in the summer when high ambient temperatures, combined with the process heat, raise the temperatures to limits of endurance. *It is obvious that dust control and appropriate breathing protection should be given highest priority at the plant.*

195. Another potential airborne hazard at the plant is mercury. Apparently, there was an old chlor-alkali electrolytic process at the plant in the past that used mercury cells. This was abandoned some years back and dismantled. When construction of new process equipment began at the site of the old mercury cells, large pools of mercury, sometimes permeating the ground were discovered. To eliminate the potential mercury hazard, the old site was covered with concrete, apparently without great effort to clean up all of the mercury except that which was obvious. The only ambient air monitoring equipment that was installed is not sensitive enough to measure ambient air mercury concentrations. There is an obvious need for such analytical instruments to protect worker health. In addition, a medical test program should be begun for workers near this site to check for potential mercury poisoning. Since there are no records available about how mercury was handled at the plant, the whole plant site should be checked carefully for presence of mercury spills.

196. The factory operates a wastewater treatment plant for itself and for another factory nearby. As the treatment plant has a capacity of 10,000 m^3/day but only receives a flow of 7,000 m^3/day, there are no difficulties in meeting the effluent standards. Municipal wastewater from the city of Lysychansk is treated in a separate wastewater treatment plant operated by the Vodokanal authority.

197. The industrial wastewater stream from the factory is of the order of 4,000,000 m^3 per annum. It contains high concentrations of calcium chloride (90 grams per liter) and sodium chloride (50 grams per liter). The waste is strongly alkaline (pH over 10). In addition, there are occasional discharges

of wash water from the purification of the lime kiln. This water contains carbon dioxide, alkali carbons, flue dust, etc. The wastewaters are pumped to an elevated area of land adjacent to the factory where there is a complex of 4 large open lagoons. Lagoons 3 and 4 are currently in use, although lagoon 3 is nearly full. The flow is initially pumped to lagoon No 4 which has a capacity of 6,000,000 m^3. This lagoon is lined with polyethylene and clay. The overflow from the lagoon is then pumped to lagoon No 3 (capacity 3,500,000 m^3) which is also lined and which acts as a storage/clarifier basin. Clarified effluent passes from this lagoon through three outlet pipes to the Siverskodonets River. The discharge is regulated by MEP and is only permitted when the level of river flow is sufficient to provide adequate dilution to the lagoon effluent.

198. Last year when the flow in the Siverskodonets River was depleted over a long period, it became necessary to pump water from a canal at a cost of Rb. 7,000,000 (for the energy used), to dilute the effluent from the clarifier lagoon before it could be discharged to the river. Treatment of the wastewater streams from the factory to remove chloride and dissolved salts on the scale that would be required would be prohibitive. The only practical form of treatment is that presently adopted in lagoons. However, it should be possible to effect improvements; an audit of water usage within the factory is warranted, with a view to determining the extent to which it is possible to economize on process water and recycle water from one process stream for use as lower grade water in another process stream. A study of the complex of lagoons is also needed, with the object of establishing long-term provision of storage and settlement lagoon capacity for the effluent before discharge to the river.

199. The immediate problem at the plant, in regard to water treating, is to find ways to reduce process effluents, either through increased recycling of the water or recovery of solids from the effluents. The main problems are that recycled water needs to be clean enough to prevent equipment plugging and corrosion, and solids recovery is a complex, expensive task that requires new processes that might pay for themselves through recovered product sales.

200. An additional potential health hazard at the site are several hundred private vegetable gardens that have been planted over the now abandoned and revegetated first disposal pond. Apparently an agricultural expert has been at the site and found unacceptable levels of chemicals in the soil and in vegetation. These chemicals are apparently leaching up through to the top soil. Plant management is reluctant to evict these gardeners from the site. This is another area that calls for attention.

201. Recommendations for short term actions to reduce pollution at this plant are summarized below:

- Amelioration of chemical dust at the soda plant is of immediate concern for the health of plant workers. Also, immediate attention should be given to providing adequate respiratory protective gear to workers that are most affected by lime and other dust at the plant.

- Ambient air mercury measuring instruments need to be provided to the soda works, and a medical testing program setup for checking workers exposure to potential mercury poisoning.

- The potential contamination of vegetables at the old disposal site gardens needs to be investigated further.

- Steps need to be taken to provide adequately protected new storage facilities for new and old process wastes to prevent further contamination of underground waters.

ODESSA OBLAST

202. Odessa Oblast has a population of 2.6 million, of which 88 percent is urban. The oblast also includes the Ukrainian part of the Danube Delta (described in Annex 6).

City of Odessa

203. Odessa is a large city with 1.1 million people, situated at the northwestern corner of the Black Sea, close to the mouth of the Dosiestio River. Its port city of Ilichevsk (population 300,000) is located about 20 km to the south, on a natural harbor. The city has a wide variety of large and medium-sized industries, including an aging oil refinery, chemical machine building, food processing plants, port and other transport facilities, and various light industries. The country's high pressure ammonia pipeline terminates at Odessa where there are storage facilities for later transhipment.[11]

204. The city also has a variety of cultural attractions, including a magnificent opera house. Tourism in the region is significant, especially in the string of small towns immediately north and south of the city, as well as in Odessa itself, although exact figures are not available.

205. The coastal zone of Ilichevsk is heavily polluted from domestic sewage. Several city beaches have been closed the entire season in the last three years, and in 1993 all but two were closed for most of the summer. The average level of pollution measured has been 23,000 coliforms/ml in the port lagoon and on the beaches; in August 1992, 200,000 coliforms/ml were found in a sample. Salmonella and cholera embryos are regularly found in the sewage, and there was cholera in the city last year.

206. **Municipal Wastewater Treatment.** The city of Odessa is served by two wastewater treatment plants known as northern and southern plants; 85 percent of the population is served by the two plants. The northern plant has a treatment capacity of 400,000 m^3/day from a population of 700,000 and provides conventional mechanical and biological treatment using an activated sludge process. There are proposals for increasing the treatment capacity by 200,000 m^3/day, but these proposals have been delayed until recently due to difficulties in acquiring the necessary land.

207. The southern plant at present provides only mechanical treatment (i.e screening, grit removal and primary sedimentation) for an average daily flow of the order of 150,000 to 160,000 m^3/day from a population of 400,000. A scheme of extensions is now under construction to provide biological treatment using a diffused air activated sludge process and to increase the total treatment capacity to 200,000 m^3/day. This scheme was to be completed by the end of 1992, but is delayed because of insufficient funding.

208. There are industrial wastewater discharges to the sewerage networks of both plants. At the northern works, industrial discharges come from truck manufacture, vehicle repairs, machinery and ferrous and non-ferrous castings. The industrial discharges to the southern works are mainly food processing, fish processing, breweries and electronics.

11/ Parallel natural gas pipelines pass through the region also.

209. The effluent standards applied to the northern plant are BOD 12 mg/l and suspended solids 12 mg/l, which the plant usually meets. At the time of the site visit, the plant was producing an effluent well within a standard of 20 mg/l BOD and 30 mg/l of suspended solids. At present, effluent from this works is discharged into the sea through an outfall of only 300 m length. Work is in progress to extend this to 4 km length, but present standards apparently require that the outfall length should be 10 km from the shoreline. Finance is not available at present for extending the outfall to 10 km. During summer months, for protection of the bathing beaches, the effluent is diverted from the sea outfall by pumping into the adjacent estuary (Koolyanic River) to obtain dilution with river water before discharge it to the sea.

210. Problems in the treatment and disposal of sludge are experienced at the northern works. A previously constructed digestion plant was abandoned some years ago due to problems in its operation. A new digestion plant is now being constructed, but during the site visit there was no construction activity at the site, and it was apparent that completion of these works would be drawn out due to lack of adequate funds. Sludge is currently di- sed of in lagoons, and there is an urgent need for a mechanical dewatering plant. Proposals for the use of centrifuges have been drawn up, but further progress cannot be made until funding is available.

211. The sewerage networks for each plant have separate systems for foul and surface water flows. However, the trunk sewers leading to the plants are combined and receive the connections from the surface water sewerage networks. Consequently, during periods of heavy rainfall, the volume of flow to the treatment plants is exceptional, and overflows of sewage-polluted storm water are discharged directly to the sea. This occurs on an average of about 6 to 10 times each year, and clearly there is a serious health hazard to the bathing beaches in the vicinity.

212. At the southern plant, effluent from the plant is discharged through a sea outfall 2.5 km long into a water depth of 19 m. A chlorination installation is available to treat the effluent but this is only introduced during summer months when pollution of bathing beaches is detected by MOH. Sludge at the southern plant is treated by heated digestion and is then mechanically de-watered in centrifuges. Sludges from both plants are tested for toxic metal concentrations by the University in Odessa and by sanitary service of the Municipal authority. Some of the sludge from the southern plant is used in agriculture for application to grassland.

213. Within the Poselok Kotovsky district of the city, there are serious problems of surging of the sewerage system, with resultant overflows of untreated wastewater directly into the sea. The sewerage flooding occurs on an average of 2 to 3 times each year and affects 400,000 people residing in this sector of the city. It has been necessary to interrupt water supplies into the area for periods of up to 3 days in order to attempt to combat the wastewater flooding.

214. At the southern side of the city, problems are experienced with a pumping station at the resort area of Arcadia. When power cuts occur, there is an overflow at the pumping station which results in untreated wastewater being discharged directly to the sea via the stormwater sewerage network. Proposals have been drawn up for a 10 km long gravity sewer to be constructed in a tunnel which will eliminate four intermediate pumping stations. The estimated cost of these proposals is Rb 3.7 billion at 1993 prices.

215. To provide an adequate level of protection to the bathing beaches in the vicinity of the sea outfalls from the two plants, consideration needs to be given to the following capital schemes:

i) The early construction of a 200,000 m^3/day extension to the northern plant.

ii) The provision of tanks at both plants to minimize the overflow of storm sewerage during heavy rainfall.

iii) Treatment for the disinfection of the effluent from both plants.

216. **Municipal Water Supply.** The Dniester water treatment plant serving Odessa lies adjacent to the Dniester River approximately 40 km to the northwest of the city. The plant has a treatment capacity of 1 million m^3/day and supplies water to a total population of 2 million. The installation comprises pre-chlorination and flocculation/sedimentation followed by rapid gravity filtration and chiorine adjustment before the water enters the supply system. Treated water is stored in service reservoirs which have a total capacity of 55,000 m^3. There are 7 pumping mains from the plant to Odessa with an intermediate booster pumping station 14 km from the city. In addition to supplying the city the plant provides supplies to various towns and villages including : Ilichevsk; Yuzhniy with the port of Ovidiopol; Belgorod - Dnestrovsk; Belyaevka; Teplodar; and Kardina-Bugaz.

217. It is reported that the capacity of the treatment plant needs to be increased to provide 1.6 million m^3 of water/day to meet both present and future anticipated levels of demand. The standards of treatment also need to be improved to overcome problems of pollution in the raw water taken from the Dniester. Leakage levels in the distribution system are not known but from information available on the bulk metered volumes put into supply and the total of metered quantities recorded as supplied to consumers, there is an 18 percent discrepancy. However, it is unlikely that this data represents the true level of leakage in the system.

218. **Water and Sewerage Tariffs**. The most recent water and sewerage rates are shown below:

Rates for Water and Sewerage by Sector		
	Water	**Sewerage**
General population	10.0	6.0
Other communal services	39.0	--
Local government agencies	336.0	185.5
Industry	1480.0	899.2
Cooperative enterprise	373.7	222.2

They indicate the heavy cross subsidization of other sectors, particularly households by industry.

219. **Oil Contamination Problems at the Port of Odessa.** At Odessa's harbor, the oil jetties do not have modern facilities for cleaning accidental oil spills. There are very small tanks for receiving oil contaminated ballast water and no facilities for cleaning ballast water. As a result, tanker calling at Odessa often discharge their ballast waters into the open sea (without declaring this to authorities). There have also been accidental oil spills from ships from time to time.

Proposal for a Water Management Plan Under the Black Sea Program

A comprehensive study is required for the greater region of Odessa to appraise the existing installations of municipal water supplies, wastewater treatment and sewerage so that a master plan can be drawn up. The preparation study will need to address the following issues:

i) Extensions and improvements at the Dniester water treatment plant.

ii) Appraisal of the water distribution network with an emphasis on leakage losses.

iii) Review of the two wastewater treatment plants serving the city with recommendations on the level of treatment, safe disposal of the effluents, and an efficient means for the treatment and disposal of sludge.

iv) A complete appraisal of the foul and surface water sewerage systems in the city, probably including analysis by mathematical modelling to identify causes of such problems and to make recommendations for the most effective means for eliminating them.

220. The port has a wastewater treatment plant to provide treatment for the effluents arising from cleaning of ships' ballast tanks. The plant comprises sedimentation tanks followed by a dissolved air flotation (DAF) unit for removing oil contaminants. The DAF unit does not have the benefit of flocculent addition, and its operating efficiency is therefore impaired. Sludge from the sedimentation tanks, in liquid form, is deposited in lagoons, but it is reported that these are now 80 percent full and investigations into a solution to the future problem of sludge disposal are now required. In addition, a surface water sewer outfall into the port, from the city center of Odessa, is contaminated with oil from urban run-off. Technical assistance is needed to experiment with, and to provide, polyelectrolyte flocculents to improve the operational efficiency of the DAF unit used in the treatment of the effluent from the ballast tanks of vessels. A capital investment scheme is also required to provide mechanical dewatering equipment for the sludges from the ballast water treatment installation. Technical assistance could be provided in the preparation of a feasibility study to install an oil interceptor on surface water sewer outfalls discharging into the port.

221. The Government of Ukraine has decided to invest in oil storage capacity of about 8 million tons at a location near the Odessa port (Yuzhny) with the purpose of expanding Odessa's role as an import terminal, thus assuring an alternate source of petroleum imports vis a vis traditional suppliers in the FSU. Various ancillary investments will also be needed (eg. modernization of existing oil jetties to receive larger tankers and a product pipeline network connecting Odessa and the center of the country). MEP is planning to undertake an environmental impact assessment of the oil storage investment, although this evaluation may need to be broadened to cover other related investments.

222. In parallel, with the planned investments mentioned above, the municipal authorities of Odessa requested and received support from the national government and Parliament for a broader evaluation of oil pollution problems in Odessa's harbor area (related to both commercial and military

harbor operations) and development of a management plan. This is an important step, as oil pollution prevention has been inadequate in the harbor, and the local community, through local NGOs, has expressed concern about the existing and possibly future problems if Odessa's role as an oil terminal expands.

KHERSON OBLAST

City of Kherson

223. **Water Supply.** Kherson, which has a resident population of 420,000, is supplied with 1,450,000 m^3 of water/day from a series of 143 shallow boreholes. The quality of water abstracted is gradually declining and traces of oil which are believed to have seeped from ground contamination at the oil refinery, have been detected in increasing concentrations. Construction has commenced on a scheme to abstract and treat water from the Dnieper River but it is believed that this scheme is not very far advanced. A hydrogeological survey has indicated that there is a significant source of good quality borehole water on the left bank of the Dnieper, but so far proposals have not been drawn up for developing this source. Leakage levels in the distribution system are estimated by the Vodokanal authority to be of the order of 15 percent, but there is no reliable data available, and the municipality believes that leakage losses are considerably greater than this.

224. **Wastewater Treatment.** The city has a wastewater treatment plant (constructed in 1964) which provides full treatment for a flow of 100,000 m^3/day. From Kherson and the surrounding area, the sewerage system discharges an average daily flow of 180,000 m^3/day. Reconstruction of the wastewater treatment plant is now being completed, and it is claimed that treatment capacity of 250,000 m^3/day will then be available. The next stage of development of the wastewater treatment plant involves the construction of a tertiary treatment plant. Initially this was intended to be based upon sand filtration but the proposals are now founded upon the use of a fixed film system incorporating plastic hair mat modules which have been observed in use at other wastewater treatment plants in the former Soviet Union. At present the effluents from the biological treatment stage of the wastewater plant receive tertiary treatment through 3 oxidation ponds. Effluent BOD concentrations in the range of 15-25 mg/l are reported but there are siltation problems with these lagoons and it is claimed that effluent quality is deteriorating progressively. Introducing a new tertiary stage of treatment at the plant *does not seem justified* when the effluent BOD concentrations from the biological stage of treatment are reported to be as low as 9-12 mg/l.

225. Sludge from the plant is dewatered by gravity settlement in lagoons and is then disposed of into the farmlands. A project for mechanical dewatering of sludge using vacuum filters has been drawn up but no progress has been made with construction of this plant. The treatment plant includes a chlorination unit but this has not been in operation since 1982 due to the difficulty in obtaining chlorine supplies owing to lack of funds.

226. The city's sewerage network serves only 60 percent of the city. The system includes 13 pumping stations; at two of these stations (No. 6 and No. 12), the rising mains are the cause of pollution problems. When blockages or bursts occur, it is not possible to effect repairs without discharging untreated wastewater into the Dnieper River. Proposals have already been made for duplication of the rising mains from these two stations.

227. At the oil terminal, which is a part of the Kherson port complex, there is a wastewater treatment plant for treatment of ballast waters and other polluting run-off in the terminal area. The plant has flotation tanks for the separation of oil, but these are apparently in need of reconstruction and the plant is reported to be a source of pollution to the Dnieper.

228. The city of Kherson would benefit from a careful study of the following:

i) The extent of pollution of existing ground water supplies and the options for providing alternative sources of water if this proves to be necessary.

ii) The condition of all existing sewage pumping mains where recommendations for the rehabilitation is necessary.

iii) The wastewater treatment plant at the oil terminal with recommendations for the refurbishment or reconstruction of this plant.

Tsiurupinsk

229. The paper and pulp mill at Tsiurupinsk was originally established in the area to process high quality reeds from beds in the Dnieper River. However, due to river regulation on the Dnieper, the quality of reeds deteriorated, and the pulp mill has now switched to production from timber obtained from Russia. Plantations of poplar are now being developed in the area to enable future pulp production to be obtained from local timber supplies.

230. The plant produces 34,000 tons of pulp per annum, of which 18,000 tons is sold overseas. It also produces 10,000 tpa of filter paper. The plant currently relies on a chlorine bleaching process, but as part of a joint venture investment, it is planning to invest in a more modern non-chlorine process. It has also arranged foreign commercial financing for the investment, in part secured by a government guarantee. The loan is expected to be repaid from the future cash flow of the enterprise. The foreign investor also commissioned an environmental audit of the enterprise as part of its business evaluation.

231. The factory has its own wastewater treatment plant that has a treatment capacity of 100,000 m^3/day. At present it receives only 50,000 m^3/day, of which 15,000 m^3/day is municipal wastewater from the adjacent town. The treatment plant comprises of mechanical treatment and an activated sludge biological treatment stage, followed by oxidation ponds before effluent discharges into the river. From an influent wastewater strength of 120-140 mg/l of BOD and suspended solids, the final effluent produced is in the order of 3.0 mg/l BOD and suspended solid. Despite its good operation, it paid pollution fees of Rb 3 million last year for discharging suspended solids and organic chlorine components. The planned new process will completely eliminate discharges of chlor-organic compounds.

232. The wastewater treatment plant is maintained in good structural and mechanical condition, and the site visit indicates that it is obviously operated in a professional manner. The installation could be considered as a useful model for a demonstration activity in industrial wastewater treatment for other industrial enterprises in Ukraine.

THE CRIMEA

Sevastopil (including Balaclava)

233. **Municipal Water Supply.** Water supplies for both Sevastopil and Balaclava are obtained from surface sources (Dnieper channel) and shallow artesian wells. The total quantity of water supply averages 210,000 m^3/day. Both surface waters and borehole waters are reportedly polluted, though recently eight new boreholes have been drilled, four of these when tested were found to be affected by organic pollution. The municipality believes that the water supply problem of Sevastopil and Balaclava still require a long-term solution. An appraisal of the existing water supply installations in Sevastopil and Balaclava with the object of rationalizing existing supply sources and identifying new sources is necessary. The appraisal should closely look at leakage levels in the distribution system, which the municipality believes are high.

234. **Municipal Wastewater Treatment.** At Sevastopil there are two wastewater treatment works. The northern works provides only mechanical treatment, i.e. preliminary treatment and primary sedimentation with a small amount of biological treatment. The southern works, which presently receives a flow of 120,000 m^3/day is designed to treat only 49,000 m^3/day. This works provides only preliminary treatment (grit removal and screening) followed by primary settlement. The outfall is through a pipeline extending 1 km offshore into 100 m depth of water. However, the diffuser at the end of the outfall is blocked. Consequently, there is inadequate dispersion of the settled sewage discharged from the pipe. A new biological treatment stage has been under construction for the last 15 years, but it is still less than 50 percent complete.

235. Sludge is treated by digestion, but operational problems are being experienced with the installation, and only one of the two digestion tanks is now in use. Following digestion, the sludge is pumped to lagoons, and after dewatering by settlement it is disposed of on farmland.

236. The sewerage system in Sevastopil is overloaded during times of heavy rainfall and there are reported to be 12 locations where overflows of untreated wastewater are directed into the sea. At one such overflow point (Pumping Station No. 1), it is reported that a continuous discharge amounting to 8,000 m^3/day occurs.

237. At Balaclava, which has a population of 40,000, there is no wastewater treatment plant to serve the existing sewerage network. Untreated sewage is discharged at the rate of 20,000 m^3/day through a 40 m long outfall, into a 40 m depth of water. Due to tidal conditions and the position of the outfall, the harbor at Balaclava is affected by pollution from this discharge. A scheme for a tunnel sewer to convey wastewater from Balaclava to Sevastopil has been investigated, but it is evident that the per capita cost of such a proposal will be expensive.

238. **Solid Waste.** From 1985, the city of Sevastopil has operated a solid waste incinerator. However the capacity of this installation is hindered by the lack of equipment to control flue stack emissions.

Yalta

239. **Municipal Wastewater Treatment.** The Yakos wastewater treatment plant serving the city of Yalta provides for a total population of 100,000. The plant gives full treatment to an average daily flow of 60,000 m^3 and provides screening, grit removal, primary sedimentation and biological treatment using an activated sludge system with diffused air aeration. Sludge is mechanically dewatered by an installation of centrifuges, and semi-dried sludge is disposed of into the farmland. Sludge vacuum filters that were installed some years ago have never been brought into use due to operational and mechanical problems.

240. The wastewater treatment plant is sited on a narrow strip of land between cliffs and the edge of the sea. The biological treatment plant is currently being extended to increase treatment capacity to 80,000 m^3/day to accommodate flow increases during the tourist season. Financing has not been made available to complete the installation of the aeration equipment for this extension. Problems are experienced with the existing aeration plant in the removal and treatment of surplus activated sludge, and it is understood that 20,000 m^3 of surplus activated sludge are discharged per week directly into the sea.

241. The sea outfall is a 6.2 km long pipe terminating in 90 m depth of water. The pipe is a steel main constructed 12 years ago and is suffering from corrosion. There are a number of leaks, the nearest being only 1 km away from the shoreline. A contract for the inspection and repair of the outfall has been placed, but it is believed that the first 1 km needs complete replacement. An allocation of Rb 200 million has been made by the central government for refurbishment of the outfall.

242. Sewage is pumped into the wastewater treatment plant through a number of pumping stations on the sewerage network. Problems are experienced from time to time due to power failures at the pumping stations and also during periods of high rainfall, when surcharging of the sewerage system occurs. It is understood that under exceptional rainfall conditions, the inlet works of the wastewater treatment plant become inundated and sewage flooding occurs on the site.

243. Subject to a technical review of proposals in a preparation study, the following investment requirements have been identified as a result of the site visit:

i) Provision of diesel powered stand-by generation plant at the key sewage pumping stations on the sewerage network.

ii) Appraisal of machinery requirements for completion of the activated sludge plant extensions for which the civil works have already been completed. This appraisal should include a detailed review of the means of removal and treatment of surplus activated sludge from the final settling tanks.

iii) An appraisal of the condition of the existing sea outfall with an assessment of its future life span. This appraisal should include a review of requirements for replacement of the outfall at a future date.

Armyansk

244. The "Titan" plant at Armyansk is now trying to address its environmental problems. The plant operates on the sulphate route for the dissolution of its titanium ore, an older process. It generates large amounts of contaminated acid. A very large, shallow salt lagoon--43 km^2--is used as a dump for the waste (which is mixed with dilute process streams and heavy metals); about 52 million m^2 of waste have accumulated. The plant is now seeking international assistance to deal with the waste; the solution will include separating the waste streams and neutralizing the waste acid.

LVIVSKA OBLAST

City of Lviv

245. The city of Lviv, with a population of about 800,000,[12] is located on the watershed between the Dniester and Vistula river basins. The main industries in the city are: mechanical, electronic and food industries (dairy, abattoir and meat processing, yeast factory, brewery and poultry processing). The total quantity of wastewater is about 45 million m^3/year. Poor water management and an antiquated delivery system limits the availability of water for domestic use to several hours in the morning and in the evening. The Poltava River, which flows through the middle of the city (beneath the city's Opera House), directly receives residential sewage and industrial waste in the old part of the town, without any kind of pretreatment; mean BOD5 of the raw wastewater is unexpectedly high because of the huge discharge from industries. The newer parts of the city are served by a separate sewer system and a wastewater treatment plant with a capacity of 500,000 m^3/day. The technology applied is activated sludge with fine bubble aeration. The plant is fed by a pumping station, with by-pass overflow to the river. There is very simple sludge treatment generally; excess sludge is dried in sludge lagoons, but it reportedly contains too much heavy metal residue for agricultural use.

Other Areas

246. The principal sources of environmental problems are: the industrial complex "Sirka" (sulfur), petroleum refining/petrochemical plants, and the local coal mining area. Lviv Oblast is the home of the Drohobych petroleum refinery, which has the capacity to process 3.3 million tons of crude oil p.a., altogether producing 3.23 million tons of products, the largest being fuel and heating oil. Drohobych, along with the refinery at Odessa, needs a complete replacement of main processing facilities, and because of needed downsizing in the industry as a whole, it is likely to face stiff competition from other, larger and more modern refineries in the country. Typical environmental problems include: insufficient facilities and lack of modern technology for removing oil and other pollutants, particularly phenolic compounds, from the plant's wastewater; excess fuel use; leakages of oil and gas during processing, generating high fugitive air emissions, particularly in the worker environment; and disposal of oil-contaminated solid wastes and sludge in open areas. Hydrocarbons have seeped into the soil, and there is evidence of groundwater contamination. The refinery is located along the Tishmenitia River, a tributary of the Dniester River, which serves as a drinking water source for various communities.

247. Elemental sulfur is mined from open pits or recovered in-situ from near-surface deposits in Yavoriv and Novij Rozdil districts. These plants supply sulfuric acid plants throughout Ukraine. Several large open pits remain unreclaimed and contribute to air and water pollution in the Yavoriv area. In-situ sulfur recovery operations are impinging upon residential areas and are affecting surface water quality. Local authorities are considering evacuation of several population centers in the vicinity of the sulfur operations.

248. There are 12 coal mines in the oblast, part of the Lviv-Volga coal basin. They are located near the towns of Czerwonograd and Nowowolynsk, which are the sites of various other small

12 About 120,000 people come each day to work in Lviv from satellite towns.

industries as well. The drainage water from the mines is reportedly collected in ponds and reused without discharge to the river. The main problem in the area seems to be insufficient wastewater treatment at various towns.

IVANO-FRANKIVSKA OBLAST

249. This oblast is half covered in forests and unique to the area are problems associated with an active lumber industry. Poor land management and outdated lumber harvesting techniques have led to serious sedimentation problems in the otherwise pristine mountain streams. The area has enormous tourist potential (it is the site of the 53,000 hectare Carpathian National Nature Park) but lacks the infrastructure to deal with a tourist industry. The oblast is also has several chemical manufacturing sites, an oil refinery complex and several large military bases. The Ministry for Environmental Protection estimates industrial discharges of wastewater to be about 180 million cubic meters per year, of which 46 million m^3 is polluted. Discharges include 3.3 million tons of suspended material, 96,000 tons of salt, 1,600 tons of nitrogen, 79 tons of oil hydrocarbons, and lesser amounts of phenols and inorganic chemicals. About 50,000 tons of toxic waste are impounded in the territory of the oblast.

250. There are two coal-fired power generating stations, in the towns of Burschyn and Kalush. The stations utilize high sulfur coal. Together, they emit 230,000 tons of SO_2 each year.

251. Health officials claim the primary sources of pollution in the oblast are;

i) The chlorvinyl plant in Kalush, which produces polyvinyl chloride;

ii) The "Barva" plant in the city of Ivano-Frankivska, which is engaged in light organic synthesis;

iii) The power plant at Burshtyn (classified as one of the top 30 air polluters in the country, based on gross emissions).

252. The chlorvinyl plant in Kalush has a mixture of modern (Western European) and old technology. The modern part of the plant is in excellent condition. Plant managers are reluctant to show outsiders the older parts of the plant. A local NGO is concerned about the plant.

253. Barva employs 3,000 workers and manufactures over 100 chemical products, including specialty dyes, polymer additives and intermediates. The facilities are modern, clean and impressive, according to an expert who visited the plant during the study. About 70 percent of production goes to Russia, 20 percent stays in Ivano-Frankivsk and Ukraine, and 10 percent is exported to Western Europe for US dollars. The same leather dye chemical product that brings 700 rubles/kg from Russia can be sold to Germany for 7 US$/kg, and so there are hopes to increase exports to Western Europe. Western currency is reportedly being utilized to purchase pollution control equipment.

CHERNIVTSKA OBLAST

City of Chernivtsi

254. The primary environmental health problem in the Chernivtska Oblast has been the mysterious outbreak of thallium-like illness in Chernivtsi in 1988. This outbreak was investigated by the Soviet Ministry of Health, Ukrainian Ministry of Health, World Health Organization and, most recently, the University of Illinois. In the summer and fall of 1988, 165 children in Chernivtsi were affected with an unusual illness characterized by upper respiratory symptoms, central nervous system symptoms, and alopecia (hair loss). One hundred and ten of these children had total diffuse rather than patchy alopecia. Among these 110 children, 89 percent had upper respiratory symptoms, 60 percent had sleep disturbances, 58 percent had behavioral abnormalities, and 19 percent had hallucinations. There were no deaths, and all of the children with total alopecia had eventual regrowth of their hair. The cases ranged in age from less than 1 to 14 years with 30 percent age 1-2 years, 21 percent age 2-3 years, and 17 percent age 3-4 years. The cases clustered geographically in the older part of the city. Nail thallium levels were elevated in 8 affected children compared to controls, but bioassays were negative in most of the other cases. Epidemiologic investigations did not find any associations between the illness and diet, source of water, medications, or radiation.

255. A commission appointed by the Soviet Ministry of Health concluded that the illness was most likely caused by micro-doses of thallium in combination with the effects of other metals such as aluminum and boron. The source of thallium was speculated to be the illicit use of organic thallium anti-knock compounds in gasoline. In its efforts to halt the outbreak, the city of Chernivtsi banned automobile traffic in the old city, temporarily closed several factories, and prohibited leaf burning. In late fall of 1988, the military initiated a massive campaign to hose down the streets and roofs of the city to wash away potential contaminants. These clean-up efforts, however, failed to placate the public, and by November most parents had taken their children and fled the city.

256. In the spring of 1989, WHO sent a team to Chernivtsi to assist in the investigation of the outbreak. Over the course of one week, they examined every fifth affected child and reviewed the results of clinical and environmental studies conducted by the Soviets to date. They concluded that the illness was not caused by thallium for two reasons: i) bioassays did not detect thallium in the majority of the affected children; and ii) peripheral neuropathy, which is one of the cardinal features of thallium poisoning, was present in less than 5 percent of the children. While they could not identify a specific causative agent, they agreed that this was most likely a chemical illness.

257. On June 13 and 14, 1990, the USSR. Ministry of Health, USSR Academy of Science, UkrSSR Ministry of Public Health, Chernivtsi Department of Public Health, and the Chernivtsi Scientific Research Institute of Toxicometry hosted the All-Union Scientific and Practical Conference for Medico-Ecologic Problems of Health Protection of Maternity and Childhood. The conference attempted to convene all of the researchers who had participated in the investigation of this outbreak and achieve a consensus as to the etiology. While the cause was again not determined, most participants agreed that this was a chemical illness caused by air pollutants.

258. Several additional theories have been advanced as to the cause of this outbreak. A mycologist in Tashkent believed that the illness was caused by a new fungus which she christened "zalmonella." The U.S. Center for Disease Control reviewed slides and cultures of the suspect fungus and identified it at Paecomycetes Variotti, a common soil saprophyte which they felt was unlikely to be the cause of the outbreak. Another theory, which is believed by many residents of Chernivtsi, is that a military convoy passing through the city in July 1988 was involved in a transportation accident with a resultant spill of SS-20 rocket fuel. Another theory holds that military plants in the city, which produce semiconductors, burned their industrial wastes in the cities brick kilns, releasing thallium and other metals into the environment. Yet another theory holds that an industrial accident at a chemical plant in Romania (approximately 50 km from Chernivtsi) released a cloud of identified pollutants which landed on the city.

259. There have been no new cases of this "toxic alopecia syndrome" since November 1988. The incidence of patchy alopecia, however, has climbed approximately 5 fold. Many residents believe that this patchy alopecia is the result of continued exposure to toxins, though at lower concentrations than in 1988. These new cases have not been reviewed by outside alopecia experts. Moreover, scalp biopsies, which would aid in the diagnosis of this patchy alopecia, have not been performed. Another explanation for this rise in incidence of patchy alopecia is increased case-finding.

260. In November 1990, several doctors from the University of Illinois visited Chernivtsi to conduct an assessment of air quality over the city. The study revealed that levels of pollutants in Chernivtsi were much higher than in large urban cities in the US. The University of Illinois team was accompanied by scientists from Finland, who conducted a soil survey for thallium and lead using a portable X-ray diffraction unit. Soil sampling did not identify localized hot spots of lead or thallium.

261. While the outbreak of toxic alopecia syndrome appears to be over, residents of Chernivtsi continue to be concerned about the high rates of patchy alopecia and the possibility of continued exposure to pollutants. The University of Illinois, together with the University of Toronto, is proposing that samples of affected children and controls be examined by U.S. alopecia experts in preparation for a case-control study of this outbreak. Dr. Prodanchuk at the Institute of Medical and Ecologic Problems in Chernivtsi has obtained support from the Ukrainian government to conduct a long-term prospective study of ecologic determinants of health of the entire pediatric population of Chernivtsi.

CITY OF KIEV

262. **Municipal Drinking Water Treatment.** The city of Kiev is supplied with drinking water from two water treatment plants (Dnieper and Dyesna), and a network of some 350 boreholes. The boreholes are between 160 m and 350 m deep into the chalk aquifer and are operated conjunctively with the two water treatment plants. The Dnieper treatment plant, which abstracts water from the right bank of the Dnieper River below the Kiev Reservoir, has a capacity of 600,000 m^3/day and treats at present 400,000 m^3/day. The Dyesna plant abstracts water from the left bank of the Dyesna River just above its confluence with the Dnieper River. The plant has a capacity of 1,100,000 m^3/day and treats at present 850,000 m^3/day.

263. Total water supply into Kiev averages 1,500,000 m^3/day of which 250,000 m^3/day is derived from borehole sources. The water treatment process at both plants comprises screening at the intake; pre-chlorination; coagulation using aluminum sulphate followed by rapid gravity sand filtration and secondary chlorination to provide a chlorine residual of 0.5 mg/l in the distribution system. The quality of raw water abstracted, particularly from the Dyesna River, is poor due to pollution from untreated sewage and poor quality sewage effluents upstream and it is necessary to prechlorinate at dosage rates of 6 to 7 mg/l.

Measures in Response to Chernobyl

Following the Chernobyl nuclear power station accident in April 1986, emergency measures were taken to maintain water supplies to Kiev in the event of radioactive contamination of the Dnieper river water. A floating intake pumping station was constructed on the Dyesna River and twin pumping mains laid to the Dnieper water treatment plant so that raw water supplies from the Dyesna River could be made available if required. This pumping station has been maintained in operational readiness, although to date it has not been found necessary to bring it into use. Daily checks are made on the level of radioactivity in the raw water supplies from the Dnieper and the Dyesna River. The gross beta activity in the raw water is of the order of 16 picocuries per liter and beta radiation from strontium 90 is less than 0.1 picocuries per liter. By comparison with WHO maximum level for gross beta activity in drinking water of 30 picocuries per liter, the presently recorded levels in the Dnieper raw water are satisfactory. However, the supply authority is concerned in the event of a flood occurring in the region of Chernobyl which could lead to significant and very rapid increases in the level of radioactivity. The floating pumping station on the Dyesna is therefore maintained in a state of readiness but for the longer term the supply authority have proposals for the construction of a raw water intake on the right bank of the Dyesna to supply the Dnieper treatment plant.

264. At both treatment plants, improvements are required to the air scour equipment of the filter installations to improve the efficiency of backwashing. There are also operational problems due to the lack of treatment capacity for the backwash water. The backwash effluent from the filters at present discharges directly back into the river and is a significant source of pollution of the river

water. The two treatment plants operating conjunctively with the borehole abstractions provide an adequate level of supply for the city, and measures have been taken to provide security of supplies in the event of contamination of the Dnieper water from a flood in the Chernobyl region. However, capital investment schemes are required at both plants, to provide for the treatment of the filter backwash water. These schemes will alleviate pollution of the river water and reduce abstraction since the treated backwash water can be recycled through the plant.

265. **Municipal Wastewater Treatment.** The city of Kiev is served by one wastewater treatment plant located on the left bank of the Dnieper River. The plant treats a present flow of 1,700,000 m^3/day from a contributing population of 3,200,000 people. Extensions are presently under construction, and at the end of 1992 the treatment capacity will be increased to 1,800,000 m^3/day. The sewage system is separate. The sewerage network on the left bank of the river drains by gravity to the plant through a 3.0 m diameter trunk sewer, and the flows from the urban areas on the right bank are pumped across to the inlet. The treatment system comprises inlet grit channels and primary sedimentation followed by activated sludge biological treatment using a diffused air system. Screening of the wastewater is undertaken at pumping stations on the sewerage network. Following secondary settlement, effluent is discharged to the Dnieper River by a 10 km long channel. The final effluent is not chlorinated. The plant achieves a standard of effluent within that set by MOH, MEP and the Kiev municipal sanitary service.

266. Primary sludge and surplus activated sludge are treated by an anaerobic digestion system operated at a temperature of 54°C with a retention time of 4 to 5 days. Up to 1988 the sludge was used in agriculture and the plant effluent was used for irrigating 26,000 ha of agricultural land. Since January 1989 however, MOH and the Kiev municipal sanitary service have decided that toxic metal levels exceed State Standards, and agricultural use of the sludge and the effluent is no longer permitted. The disposal of liquid digested sludge, which amounts to 11,000 m^3/day, is now a major problem in the operation of the plant. At present the sludge is pumped 10 km to lagoons but the storage capacity is becoming limited. It is evident that a scheme is required for the treatment and disposal of sludge from the plant. In preparation of a scheme, the following aspects of treatment should be given consideration:

i) Thickening of liquid sludges both before and after the digestion process so that the efficiency of the existing digestion plant can be increased.

ii) Mechanical de-watering of digested sludge using either belt type presses or centrifuges to produce a semi-solid sludge cake.

iii) Disposal of the sludge by either depositing in an engineered landfill or by incineration. The possibility of combining incinerator plant with the city's refuse incinerator on the adjacent site, should be appraised.

iv) The economics of introducing a power generating installation on the plant to utilize methane gas from the sludge digestion installation.

267. **Kiev: Dnieper-Darnitsa Chemical Plant.**[13] The facilities at the chemical plant include an old chloroalkali plant that relies on very outdated technology. The chloroalkali plant utilizes elemental mercury in its galvanic cells. Mercury can escape into the environment from several operations in the plant. Both the galvanic cells in the plant, as well as the demercurization building where equipment is decontaminated, are potential sources for mercury emissions into the air and into the subsurface. The chloroalkali plant had a water treatment plant recently installed to remove mercury from the plant effluent. Prior to water treatment, mercury contaminated effluent was probably discharged directly into the stream flowing past the industrial facility.

268. Although no satisfactory material balance has been performed on the mercury that is utilized in plant operations, discussion with plant personnel suggested several tons of mercury is lost yearly during plant operations. Most of this unaccounted mercury may be lost as emissions to the atmosphere. In the past, some of the unaccounted mercury probably was discharged as effluent to the stream.

269. Most of the mercury discharged in the Dnieper-Darnitsa industrial area, may have entered the hydrological regime in previous years, perhaps when effluent discharges were not treated. The mercury in the hydrological drainage was probably deposited as elemental mercury or as mercury salts which are reacting in the bottom sediments of the stream and the man-made lakes and forming toxic methyl-mercury compounds.

270. Preliminary geochemical surveys of the area surrounding the complex that were conducted by the State Committee on Geology, revealed anomalous concentrations of mercury in near-surface soils adjacent to the complex, and in bottom sediments from a stream flowing past the facility. The stream eventually enters the Dnieper River through a series of man-made lakes several miles from the complex. Reported concentrations of 15 milligrams of mercury per kilogram of soil exceeded by at least one order of magnitude the concentration of mercury that would be reasonably expected in natural, uncontaminated soil material. The elevated concentrations from the preliminary survey implicated a man-made source.

271. To obtain a more accurate analysis of the level of contamination, selected samples from the survey were requested for duplicate analyses. These samples were delivered to Core Laboratories in Denver, Colorado, and were reanalyzed using EPA approved procedures. The results of these duplicate analyses are presented in Table 23, where mercury results from Core Laboratories are compared with the original results of the survey. The duplicate analysis reported much high mercury concentrations than previously reported in soil and sediment samples downgradient of the industrial complex. The discrepancy is most likely related to the presence of methyl-mercury compounds in the soil and sediment that were not accurately measured with 1960s analytical instrumentation.

13 This plant is situated on the east bank of the Dnieper River in the Dnipro-Darnitsa industrial complex, situated in the center of a residential area within the city limits of Kiev.

Table 23: Analysis of Mercury Concentrations in Soil			
Sample No.	**Location**	**Mercury Concentration, in mg/kg**	
		"Servukgeologia" Results[1]	**Core Lab Results[2]**
202	Background soil east of industrial complex	0.19	0.21
309	Soil north of industrial complex, adjacent to recreational area	0.84	0.93
105	Stream sediment adjacent to industrial complex, upgradient to discharge point	0.5	15.0
120	Stream sediment, about one mile downgradient of discharge point	15.0	400.0
128	Stream sediment, about two miles downgradient of discharge point	2.0	16.2
155	Bank sample from man-made lake near outlet to Dnipro River	3.0	135.0

1/ Using gold-foil mercury analyzer
2/ Using EPA Method 245 (Cold Vapor)

272. Mercury levels in samples of the stream's bottom sediments reached concentration of 400 milligrams per kilogram. This level of mercury is at least 400 times higher than what would be reasonable in natural, non-contaminated soil or sediment material. Moreover, the analyses suggest that the bulk of mercury is in the most toxic, methyl-mercury form. The environmental situation is aggravated by the location of the industrial complex, in the heart of a residential/recreational area, and that surface water downgradient to the site is used for fishing and recreation. No water analyses were available from the stream, or from the man-made lakes built to receive stream flow and regulate the flow into the Dnieper River.

273. In 1992, bioassay of the fish population downgradient of the site were performed by the Ukraine Ministry of Health. Results of the preliminary bioassays indicated that the mercury concentration in fish caught several miles below the industrial complex were 30 times greater than in fish caught above the industrial complex. The results of the bioassay triggered a prohibition, issued by local authorities, on downstream fishing in the man-made lakes.

274. The short-term solution to the problem is to limit the exposure of people to heavy metals and organic contaminants that are accumulating in the bottom-sediments of the lake near the industrial complex, Lake Nizhniy Telbyn. Exposure can be controlled best by managing access into the area and restricting all recreational use of the lake. Monitoring of mercury levels in fish from the lake should also be undertaken. Water samples should be analyzed for a complete suite of inorganic and organic parameters in order to establish present water quality in the lake.

275. Most of the heavy metals (excluding mercury) reported in the bottom-sediments of the lake are probably fixed geochemically by the silts and fines of the lake. They are unlikely to pose an immediate threat to human health and safety, unless the bottom sediments are disturbed and put in suspension.

Ukrstement

276. This plant produces 500,000 tpa (1991) of corrugated roofing insulation board. It has 820 employees.

277. Housekeeping in the general plant area appears satisfactory except for the unsecured presence of exposed asbestos. Workers wear no breathing protection. Steam from the paper machines should be collected by side vents, which pull the steam into ducts where it can be condensed and then recycled or sewered. In general, the use of this composite material should be discontinued because of the health hazard associated with asbestos. This is true not only for plant workers and people living in the area but there is concern for the deterioration of these insulation boards installed in buildings around the country. The boards are not very sturdy and their decomposition over time will, in aggregate, release considerable asbestos particles in the air.

ANNEX 4: DATA ON THE STEEL AND CHEMICAL INDUSTRIES

TABLE 1: STEEL PLANT CAPACITY (MILLION TONS)			
PLANT	PRODUCT		
	PIG IRON	RAW STEEL	ROLLED PRODUCTS
KRYVYI RIH	14.6	13.9	8.41 (LONG & FLAT)
AZOVSTAHL	5.9	7.0	4.65 (FLAT)
ILLYCHA	5.6	7.3	6.7 (FLAT, TUBES)
ALCHEVSK	5.7	4.5	3.2
DNIPRODZERZHINSK	5.4	6.0	4.0
ZAPORIZHZHIA	4.1	4.8	2.4 (FLAT PROD)
MAKIIVKA	3.3	4.05	3.4 (LONG)
YENAKIIEVE	3.1	3.1	1.5 (RAILS, TUBES)
DNIPROPETROVSK	2.4	1.9	2.55
DONETSK	1.27	1.8	1.9
KRAMATORSK	0.93	6.4	0.69
DNIPROSPETSSTAL (electric arc only; in Zaporizhzhia)	-	1.4	0.6

TABLE 2: MAJOR PLANTS AND PRODUCTION, 1991 (MILLION TONS PER YEAR)				
PLANTS	LOCATION	IRON	RAW STEEL	ROLLED
KRIVOROZHSTAL	Kryvyi Rih	9.2	10.0	7.0
AZOVSTAL	Mariiupil	6.0	6.0	4.5
ILLYCHA	Mariiupil	4.2	5.5	4.7
DZERZHINSKY	Dniprodzerzhinsk	4.6	5.3	3.6
ZAPOROZHSTAL	Zaporizhzhia	4.5	4.5	3.5
MAKEYEVKA	near Donetsk	2.8	3.5	2.7
YENAKIIEVE	near Donetsk	2.8	3.0	2.3
DONETSK	Donetsk	1.3	0.7	0.5

TABLE 3: INTEGRATED IRON AND STEEL PLANTS: 1991 PRODUCTION DATA									
	SINTER PLANTS			BLAST FURNACES		OPEN HEARTH FURNACES		BASIC OXYGEN FURNACES	
INTEGRATED PLANTS (VISITED)	Number of strands	Total area m²	Sinter production million t/yr (1991)	Number of furnaces	Pig iron production million t/yr (1991)	Number of O.H.F.	Raw steel production million t/yr (1991)	Number of B.O.F.	Raw steel production million t/yr (1991)
DONETSK	-	-	-	2	1.3	8[1]	0.7	-	-
YENAKIIEVE	4	250	2.4	4	2.8	-	-	3	3.0
MAKIIVKA	6[2]	375	5.0	4	2.8	11[3]	3.5	-	-
AZOVSTAL	2	125	1.7	6	6.0	11	2.9	2	3.1
ILLYCHA	12	1,020	9.9	5	4.2	6	3.1	3	2.4
ZAPOROZHSTAL	6	375	5.6	5	4.5	10	4.5	-	-
KRIVOROZHSTAL	6	375	2.5	9[4]	9.2	6	4.3	10	5.7
TOTAL	36	2,520	27.1	35	30.8	52	19.0	18	14.2

1/ DONETSK: in 1992, only six open hearth furnaces are in operation.

2/ MAKIIVKA: in 1992, only two sinter strands are in operation.

3/ MAKIIVKA: in 1992, two 500 tons open hearth furnaces have been replaced by a new 250 tons furnace.

4/ KRIVOROZHSTAL: in 1992, due to lack of raw materials, three blast furnaces are stopped.

TABLE 4: PRODUCTION HISTORY		
A/ STEEL INDUSTRY (plants visited)	STEEL PRODUCTION million tons / year	
	1989	1991
DONETSK	1.6	1.4
YENAKIIEVE	2.9	3.0
MAKIIVKA	3.7	3.5
AZOVSTAL	7.0	6.0
ILLYCHA	6.3	5.5
ZAPORIZHZHIA	4.2	4.5
KRYVYI RIH	12.9	10.0
DNIPROSPETSSTAL	1.2	1.0
TOTAL	38.6	33.9

B/ ALUMINUM PLANT (ZAPORIZHZHIA)	PRODUCTION tons / year	
	1990	1991
ALUMINA	207.639	200.000
ALUMINUM	94.619	90.850
SILUMIN	21.620	21.845

C/ COKE OVEN PLANTS	PRODUCTION million tons / year	
	1990	1991
COKE	33.7	28.2

TABLE 5: BASIC DATA ON STEEL PLANTS VISITED

PLANT	SHOP	TECHNOLOGY	PRODUCTION (1)	EMISSIONS (TONS)			
				DUST Tons	SO_2	NOx	CO
DONETSK	IRON-MAKING	2 BLAST FURNACES	1.3 mn tons				
	STEEL MAKING	6 OHF x 142 tons	0.7 mn tons				
		2 EAF x 100 tons	0.7 mn tons				
	CASTING	2 CC (OHF)	0.7 mn tons				
	ROLLING MILLS	1 for Medium Plate	"na"				
		5, for long Products					
	TOTAL			3972	885	3669	2850
YENAKIIEVE	SINTER PLANT	5 x 62.5 M²	3 mn tons sinter				
	IRON MAKING	4 BLAST FURNACES	2.8 mn tons				
	STEEL MAKING	3 BOF x 130 tons	3 mn tons				
	CASTING	No Cont. Casting	3 mn tons				
	ROLLING MILLS	5, for Long Products	2 mn tons				
	TOTAL			16000	6750	2900	71650
MAKIIVKA	SINTER PLANT	2 x 435 M²	5 mn tons sinter	5000	3000	1300	70000
	IRON MAKING	4 BLAST FURNACES	2.8 mn tons	11800	400	100	31600
	STEEL MAKING	3 OHF x 250 tons	3.5 mn tons total	11200		2800	14400
		6 OHF x 500 tons					
	CASTING	No Cont. Casting					
	ROLLING MILLS	7, for Long Products	2.8 mn. tons laminate	1100	600	400	5900
	TOTAL			29100	4000	4600	121,900
AZOVSTAL	SINTER PLANT	2 x 62 M²	1.7 mn tons	1855	903	607	47733
	IRON MAKING	6 BLAST FURNACES	6.0 mn tons	6046	761	806	30578
	STEEL MAKING	11 OHF x 400 tons	2.9 mn tons	7313	856	8413	1588
		2 BOF x 350 tons	3.1 mn tons	2354	11	124	17274
	CASTING	5 Cont. Casting		583	8		
	ROLLING MILLS	6, for Long Products		891	2549	1413	2125
	POWER PLANT			858	7158	2013	427
	LIME PLANT			1711	26	373	2171
	ANCILLARY			585	75	9	1897
	TOTAL			22196	12337	13758	103793
ILLYCHA	SINTER PLANT	12 x 85 M²	9.9 mn tons	37296	28689	7176	213730
	IRON MAKING	5 BLAST FURNACES	4.2 mn tons	?	?	?	?
	STEEL MAKING	1 OHF x 650 tons	3.1 mn tons in total	5321	2116	14747	14971
		3 OFH x 900 tons					
		3 BOF x 175 tons	2.4 mn tons	2114	?	?	?
	CASTING	No Cont. Casting					
	ROLLING MILLS	7, for Flat Products	5.7 mn tons	6056	?	?	24317
	POWER PLANT			7785	3820	?	?
	TOTAL			58572	34625	27185	260773

TABLE 6: BASIC DATA ON STEEL PLANTS VISITED							
PLANT	SHOP	TECHNOLOGY	PRODUCTION (1)	EMISSIONS (TONS)			
				DUST	SO_2	NOx	CO
ZAPOROZHSTAL	SINTER	6 x 62.5 M^2	5.6 mn tons	5540	7790	1530	72430
	IRON-MAKING	5 BLAST FURNACES	4.5 mn tons	12410	4060	430	14910
	STEEL-MAKING	2 Tandem x 142 tons					
		1 x 250 tons OHF	4.5 mn tons in total	1910	310	3880	7590
		6 x 500 tons OHF					
	CASTING	No. Cont. Casting					
	ROLLING MILLS	8, for Flat Products	3.3	?	?	?	?
	POWER PLANT			?	2510	1260	?
	TOTAL			20890	15050	8310	95080
KRYVYI RIH	SINTER PLANT	6 x 62.5 M^2	3.7 mn tons sinter	9439	?	?	?
	IRON-MAKING	9 BLAST FURNACES	11.8 mn tons	16792	?	?	?
		(1 x 9000 ton/day)					
	STEEL MAKING	4 OHF x 650 tons					
		2 Tandem (1 x 270 tons)					
		(1 x 306 tons)		9453	?	?	?
		4 BOF x 50 tons	12.3 mn tons in total	8329	?	?	?
		6 BOF x 160 tons		3330	?	?	?
	CASTING	No. Cont. Casting					
	ROLLING MILLS	1, for Flat Products	8.5 mn tons	14942	?	?	?
		12, for Long Products		6035	?	?	?
	POWER PLANT			19102	?	?	?
	LIME PLANT			1318	?	?	?
	ANCILLARY						
	TOTAL			61592	32688	14548	18853 0

Notes:
1. Production data are for 1990 and emissions data are for the same year.
2. OHF = OPEN HEARTH FURNACE; EAF = ELECTRIC ARC FURNACE; CC = CONTINUOUS CASTING.
3. BOF = BASIC OXYGEN FURNACE.
4. Where data are not available, a ? has been inserted.

TABLE 7: UKRAINIAN INTEGRATED IRON AND STEEL PLANTS				
INTEGRATED PLANTS	SINTER PLANTS Annual capacity mill.t (sinter)/yr	BLAST FURNACE Annual Capacity mill.t (pig iron)/yr	OPEN HEARTH FURNACE Annual capacity mill.t (raw steel)/yr	BASIC OXYGEN FURNACES Annual capacity mill.t (raw steel)/yr
DONETSK	-	1.1	1.0	-
YENAKIIEVE	3.0	3.1	-	3.3
MAKIIVKA	1.2	3.7	4.4	-
AZOVSTAL	1.6	5.7	3.4	3.5
ILLYCHA	12.0	5.7	3.9	2.8
ZAPOROZHSTAL	5.2	4.6	5.0	-
KRIVOROZHSTAL	4.2	13.6	5.0	6.5
DZERZHINSKY	4.1	5.6	3.6	2.2
ALCHEVSK	5.4	6.3	4.1	-
KRAMATORSK	-	1.0	-	-
DNIPROPETROVSK	-	2.2	0.6	1.2
KOSTIANTYNIVKA	-	0.4	-	-
TOTAL	36.7	53.0	31.0	19.5

TABLE 8: INTEGRATED IRON AND STEEL PLANTS: AIR POLLUTANT EMISSIONS (1991 DATA)						
INTEGRATED PLANTS	Raw steel production million tons/year	AIR POLLUTANTS EMISSION (thousands tons / year)				
		DUST	SO_2	NOx	CO	TOTAL (4 pollutants)
DONETSK	0.7	3.2	0.9	1.2	6.3	11.6
YENAKIIEVE	3.0	12.2	2.6	2.8	75.1	92.7
MAKIIVKA	3.5	27.6	5.4	4.5	109.5	147.0
AZOVSTAL	6.0	22.6	12.3	13.8	103.9	152.6
ILLYCHA	5.5	51.8	34.6	27.2	260.8	374.4
ZAPOROZHSTAL	4.5	17.5	12.8	8.2	88.2	126.7
KRIVOROZHSTAL	10.0	53.4	21.8	11.1	150.5	236.8
DZERZHINSKY	n.a.	34.4	27.1	12.9	144.7	219.1
ALCHEVSK	n.a.	28.7	11.9	9.4	86.3	136.3
KRAMATORSK	n.a.	0.6	0.1	0.7	3.2	4.6
DNIPROPETROVSK	n.a.	14.8	3.0	2.7	13.8	34.3
KOSTIANTYNIVKA	n.a.	1.1	0.1	0.2	1.3	2.7
TOTAL	-	267.9	136.2	94.7	1,043.6	1,538.8

* DONETSK also has an electric arc furnace steelmaking shop.

TABLE 9: INTEGRATED IRON AND STEEL PLANTS: SPECIFIC AIR POLLUTANT EMISSIONS COMPARISON BETWEEN UKRAINIAN AVERAGE AND WESTERN REFERENCE

	UKRAINIAN AVERAGE			WESTERN REFERENCE		
	DUST	SO_2	NOx	DUST	SO_2	NOx
SINTER PLANT kg/t sinter	1.7	1.3	0.5	0.6	1.3	0.9
BLAST FURNACES kg/t pig iron	2.7	0.4	0.1	0.4	0.09	0.04
OPEN HEARTH FURNACES kg/raw steel	2.0	0.3	2.3	NO REFERENCE		
BASIC OXYGEN FURNACES kg/t raw steel	0.85	-	-	0.3	0.01	0.03
ROLLING MILLS kg/t rolled steel	0.6	0.3	0.2	0.07	0.2	0.16
OTHER PLANTS (power plant, lime plant and ancillaries) kg/t raw steel	1.1	0.8	0.4	0.4	0.2	0.1

TABLE 10: INTEGRATED IRON AND STEEL PLANTS: WATER CONSUMPTION AND WATER POLLUTANTS EMISSION (1991 DATA)											
INTEGRATED PLANTS (VISITED)	**Raw steel production million ton / year**	**Water consumption *thousands* m^3**	**WATER POLLUTANTS EMISSIONS** (tons / year)								
			BOD	SS	Dissolved Components	Oil	Cl^-	SO_4^{--}	$N(NH_4^+$	Fe
YENAKIIEVE	3.0	1.164	12.2	22.3	1.405	0.2	262	530	0.21	0.27
AZOVSTAL	6.0	219.917	266.0	2.599.0	6.196	-	4.398	1.199	239.9	-
ILLYCHA	5.5	50.264	156.3	431.3	93.320	29.6	19.160	28.569	191.6	16.7
ZAPOROZHSTAL	4.5	96.032	-	2.307.6	80.772	49.9	8.108	41.367	482.9	75.3
KRIVOROZHSTAL	10.0	83.003	166.0	962.80	147.330	448.7	-	-	487.2	54.0
TOTAL (5 integrated plants)	29.0	450.380	600.5 (4 plants)	6.323	329.023	528.4 (4 plants)	31.928	71.665 (4 plants)	1.401.8	146.3 (4 plants)

TABLE 11: UKRAINIAN COKE OVEN PLANTS	
PLANTS	COKE OVEN BATTERIES 1991 coke production millions tons coke / year
MARIIUPIL	2.734
ZAPORIZHZHIA	2.117
KRYVYI RIH	4.339
AVDIIVKA	5.187
HORLIVKA	0.986
YENAKIIEVE	0.768
DONETSK	1.776
IASINOVSKA	2.422
MAKIIVKA	0.594
BAZNEVSKA	1.901
DNIPRODZERZHINSK	0.968
DNIPROPETROVSK	0.936
ALCHEVSK	3.220
KADIIVKA	0.229
TOTAL	28.177

TABLE 12: COKE OVEN PLANTS: ORGANIC COMPOUND EMISSIONS				
COKE OVEN PLANTS	TOTAL HYDROCARBONS		BENZO-A-PYRENE	
	tons / year	kg / t coke	kg / year	mg / t coke
MARIIUPIL	1.000	0.4	47	17
ZAPORIZHZHIA	20	0.01	54	26
KRYVYI RIH (1990)	3.300	0.6	8	2
AVDIIVKA	2.470	0.5	226	44
HORLIVKA	240	0.2	81	82
YENAKIIEVE	500	0.7	24	31
DONETSK	500	0.3	1.6	1
IASINOVSKA	1.000	0.4	9	4
MAKIIVKA	17	0.03	2	3
BAZNEVSKA	800	0.4	2	1
DNIPRODZERZHINSK	700	0.7	6	6
DNIPROPETROVSK	810	0.9	1	1
ALCHEVSK	700	0.2	54	17
KADIIVKA	90	0.4	9	39
TOTAL	12.147	-	524.6	-
AVERAGE	-	0.4	-	19.6

TABLE 13: CAPITAL INVESTMENT PLANS FOR SURVEYED PLANTS IN THE IRON AND STEEL INDUSTRY

(i) DONETSK IRON AND STEEL WORKS

- OPEN HEARTH FURNACES REPLACEMENT (US $125 millions)
  - an EOF (Energy Optimizing Furnace): 80 t capacity, 0.7 million t/yr
  - ladle metallurgy
  - continuous casting machine
- ELECTRIC ARC FURNACES MODERNIZATION OR RECONSTRUCTION
- BLAST FURNACES SHUT DOWN

(ii) YENAKIIEVE IRON AND STEEL WORKS

- 250 MM CONTINUOUS WIRE ROD MILL MODERNIZATION ($130 million)
- FOUR CONTINUOUS CASTING MACHINES (US $400 millions)
  - two machines for casting square billets
  - two machines for casting slats (for a future production of flat products)

(iii) MAKIIVKA IRON AND STEEL WORKS

- 150 MM CONTINUOUS WIRE ROD MILL MODERNIZATION: (US $80 millions)
- 350 MM ASSORTMENT MILL MODERNIZATION: (US $60 millions)
- CLOSING OF LAST SINTER STRANDS
- MODIFICATION OF THE RUNNERS OF PIG IRON IN BLAST FURNACES CAST HOUSE
- EVENTUAL GENERALIZATION OF A NEW STEELMAKING PROCESS (WHICH IS STUDIED IN MAKIIVKA FOR A FEW MONTHS)
- INSTALLATION OF A LADLE METALLURGY UNIT
- NEW ELECTRIC ARC FURNACES STEELMAKING SHOP: (US $300 millions)
  - electric arc furnaces
  - continuous casting
  - hot slab rolling mill
  - cold coil rolling mill
- BLAST FURNACE COMPUTERIZATION

New slag treatment unit (US $ 12 - 32 millions)

(iv) <u>AZOVSTAL IRON STEEL WORKS</u>

- HEAVY PLATE MILL HEATING FURNACE MODERNIZATION OR REPLACEMENT
- RAIL MILL MODERNIZATION
- HEAVY PLATE MILL MODERNIZATION
- ELEVEN OPEN HEARTH FURNACES SHUT DOWN AND REPLACEMENT BY THREE BASIC OXYGEN CONVERTERS (16,000 - 18,000 roubles / annual tons)
- PROGRESSIVE REPLACEMENT OF TEN BOILERS (500 millions rubles, 1991)

(v) <u>ILLYCHA IRON AND STEEL WORKS</u>

- TWO-LINES CONTINUOUS CASTING MACHINES
  - a first machine is being erected
  - a second machine is possible in a few years
- SIX LAST OPEN HEARTH FURNACES SHUT DOWN

(vi) <u>ZAPOROSZHSTAL IRON AND STEEL WORKS</u>

- OPEN HEARTH FURNACES SHUT DOWN (INCLUDING TANDEM FURNACES) AND REPLACEMENT BY BASIC OXYGEN CONVERTERS
- SIX LAST OPEN HEARTH FURNACES SHUT DOWN

(vii) <u>DNEPROSPETSSTAL ELECTRIC STEEL WORKS</u>

- STEELMAKING SHOP #2 MODERNIZATION
  - replacement of the last 30 tons electric arc furnaces by a new 50 tons electric arc furnace
  - secondary fumes collection and cleaning equipments
- STEELMAKING SHOP # 3 TRANSFORMATION (US $140 millions)
  - replacement of the existing electric arc furnaces by two Danielli 70 tons electric arc furnaces (1 million)
  - ladle metallurgy
  - continuous casting
  - primary and secondary fumes collection and cleaning equipments

(viii) <u>KRIVOROZHSTAL INTEGRATED IRON AND STEEL WORKS</u>

- SINTER PLANT SHUT DOWN AND CREATION OF A NEW CHARGE PREPARATION COMPLEX (260 millions roubles 1989)
    - Present sinter plant recycles solid of the plant
- OPEN HEARTH FURNACES SHUT DOWN
- BASIC OXYGEN CONVERTERS # 1 SHOP SHUT DOWN
- NEW BASIC OXYGEN CONVERTERS TO BE INSTALLED NEAR # 9 BLAST FURNACE (at 2.5 km of the city, 640 millions roubles 1989)
- THREE BLOOMING MILLS SHUT DOWN
- NEW CONTINUOUS CASTING MACHINES
- LONG PRODUCTS ROLLING MILLS REVAMPING (US $100 millions)
- NEW HOT STRIP MILL (US $600 millions)
    - Reorientation of steel production from long products to flat products
    - 3 millions tons / year
- SEVEN YEARS ECOLOGICAL PROGRAM (2,000 millions roubles, 1992)

TABLE 14: ESTIMATED COST OF VARIOUS PROCESS CHANGES OR POLLUTION CONTROL INVESTMENTS					
PLANT	INVESTMENT	INVESTMENT	ABATEMENT OF:		
		ESTIMATE COST $ million	DUST tons / year	Total Pollutants tons / year	Benzo-a-pyrene kg / year
1. DONETSK	OPEN HEARTH FURNACES SHUT DOWN	-	-	-	-
	REPLACEMENT BY AN EOF STEELMAKING SHOP (0.7 million t raw steel/yr)	50	1,500	10,000	-
2. UKRZINC (Kostiantynivka)	PLANT SHUT DOWN (very obsolete plant without any possible future)	-	500	9,500	108
3. YENAKIIEVE	NEW DEDUSTING EQUIPMENT OF SINTER PLANT	20	3,000	3,000	-
	BETTER COLLECTION AND DEDUSTING OF BLAST FURNACE TOP GAS	12	8,000	42,000	-
			(as MAKIIVKA)		
4. MAKIIVKA	SINTER PLANT SHUT DOWN (There were 6 strands of which 4 have been closed in February 1992) or	-	5,000	79,000	-
	NEW DEDUSTING EQUIPMENT OF 2 REMAINING SINTER STRANDS	10	1,500	1,500	-
	BETTER COLLECTION AND DEDUSTING OF BLAST FURNACE TOP GAS	12	8,000	42,000	-
	NEW DEDUSTING EQUIPMENT OF OPEN HEARTH FURNACES (Primary gas cleaning)	10	7,000	7,000	-
5. AZOVSTAL (Mariiupil)	SINTER PLANT SHUT DOWN or	-	1,600	50,900	-
	NEW DEDUSTING EQUIPMENT OF 2 SINTER STRANDS	10	1,500	1,500	-
	BETTER COLLECTION AND DEDUSTING OF BLAST FURNACE TOP GAS	18	4,600	34,000	-
	NEW DEDUSTING EQUIPMENT OF OPEN HEARTH FURNACES	9	2,400	3,500	-

TABLE 14: EST. COST OF VARIOUS PROCESS CHANGES OR POLLUTION CONTROL INVESTMENTS

6. **ILLYCHA** (Mariiupil)	SINTER PLANT SHUT DOWN or	-	30,500	280,000	-
	NEW DEDUSTING EQUIPMENT OF 12 SINTER STRANDS	60	27,000	27,000	-
	NEW DEDUSTING EQUIPMENT OF OPEN HEARTH FURNACES (Primary gas cleaning)	50	4,000	4,000	-
7. **MARIIUPIL COKE OVEN PLANT**	SIX OLD BATTERIES SHUT DOWN	-	1,400	11,000	35
	MODERNIZATION OF THE NEW BATTERY	15	200	200	8
	NEW SECOND BATTERY (after six old batteries shut down)	50 (for information)	-	-	-
	COKE OVEN GAS DESULFURIZATION	40	-	- SO2 directly + 2400 SO2 in Azovstal	-
8. **ZAPORZHSTAL**	SINTER PLANT SHUT DOWN or	-	5,500	87,000	-
	NEW DEDUSTING EQUIPMENT OF 6 SINTER STRANDS	30	4,500	4,500	-
	BETTER COLLECTION AND DEDUSTING OF BLAST FURNACE TOP GAS	15	11,000	25,000	-
	NEW DEDUSTING EQUIPMENT OF OPEN HEARTH FURNACES (secondary fumes cleaning)	10	1,500	1,500	-
9. **ZAPORIZHZHIA ELECTRODE PLANT**	PLANT SHUT DOWN or	-	1,900	7,900	356
	PLANT RECONSTRUCTION AND MOVE	n.a.	-	-	-
10. **DNEPROSPETSSAL** (Zaporizhzhia)	NEW EAF STEELMAKING SHOP (#3) (Order under signature)	50 (130 with ladle metallurgy and continuous casting)	4,500	4,500	-
11. **DNIEPR-ALUMINUM WORKS** (Zaporizhzhia)	MODERNIZATION OF ELECTROLYSIS SHOP (Replacement of Sodeberg electrodes)	150-200	5,500	5,600 (HF emission could be reduced from 218t to about 100t)	-

TABLE 14: EST. COST OF VARIOUS PROCESS OR POLLUTION CONTROL INVESTMENTS

12. ZAPORIZHZHIA COKE OVEN PLANT	DOOR CLEANING EQUIPMENT (mechanical scraper or water electrodes)	4	-	-	40
	NEW CHARGING AND PUSHING DEDUSTING EQUIPMENT	30	300	300	-
	COKE OVEN GAS DESULPHURIZATION	0	-	2,500 SO_2 directly +2500 SO2 in Zaporozhstal	-
13. KRYVYI RIH COKE OVEN PLANT	DOOR CLEANING EQUIPMENT (mechanical scraper or water injection)	10	-	-	8
	NEW CHARGING AND PUSHING EQUIPMENT	70	3,000	3,000	-
	COKE OVEN GAS DESULFURIZATION	100	-	14,000 SO_2 directly +14,000 SO2 in Rivorozhstal	-
14. KRIVOROZHSTAL	SINTER PLANT SHUT DOWN (it is very obsolete) and REPLACEMENT BY A NEW CHARGE PREPARATION COMPLEX	150	9,000	50,000 (CO reduction thanks to a better sinter plant control)	-
	BETTER COLLECTION AND DEDUSTING OF BLAST FURNACE TOP GAS	20	13,000	13,000	-
	OPEN HEARTH FURNACES SHUT DOWN	-	9,400	49,700	-
	NEW DEDUSTING EQUIPMENT OF LIME PLANT	-	11,000	11,000	-

TABLE 15: COMPARATIVE STATISTICS FOR THE CHEMICAL INDUSTRIES OF THE REPUBLICS OF FORMER USSR

COUNTRY	OUTPUT $ BILLION	# OF PLANTS	EMPLOYMENT
Russia	55	600	980,000
Ukraine	15	208	300,000
Belarus	5	47	100,000
Transcaucasus	3	93	66,000
Kazakhstan	2.6	39	83,000
Baltics	2	46	52,000
Central Asia[a]	2	57	60,000
Moldova	0.2	17	4,000
Totals	85	107	1,645,000

a/ Excluding Kazakhstan

TABLE 16: PRODUCTION BY THE CHEMICAL INDUSTRIES IN UKRAINE, USSR AND THE UNITED STATES IN 1985.

CHEMICAL	100 METRIC TONS/YEAR		
	UKRAINE	USSR	US
Sulfuric acid	4,125	29,372	36,188
Caustic soda	500	3,323	9,808
Soda ash	1,161	5,098	7,721
Fertilizers			
Nitrogen	3,197	15,815	11,000
Phosphorous[1]	1,573	10,013	35,048
Potassium[2]	304	11,300	1,963
Plastics			
Polyethylene & Polypropylene	172	1,190	9,387
Styrene polymers & copolymers	128	465	2,801
Vinyl resins & copolymers	117	455	3,157
Other plastics[3]	302	2,890	6,856
Synthetic fibers			
Cellulosic	60	605	253
Synthetic	105	789	3,430

[1] As P_2O_5 [2] As K_2O [3] Including fiber feedstocks

(Data in this table to be updated)

TABLE 17: AMMONIA PRODUCTION FACILITIES IN UKRAINE			
LOCATION	(METRIC TONS)		
	UNITS	UNIT CAPACITY	TOTAL ANNUAL PRODUCTION
Cherkassy	3	220,000	660,000
	1	400,000	400,000
	1	450,000	450,000
Rivne	1	220,000	220,000
	1	475,000	475,000
Siverskodonetsk (AZOT)	2	450,000	900,000
Dniprodzerzhinsk	1	450,000	450,000
(Dnipropetrovsk oblast)	1	500,000	500,000
Horlivka (Donetsk oblast)	2	450,000	900,000
Yuzhniy (Odessa)	2	450,000	900,000
Total Production			5,855,000

ANNEX 5: DATA ON THE ELECTRIC POWER INDUSTRY AND RESULTS OF PLANT VISITS

Table 1: Estimates of Emissions From Thermal Power Sector

Pollutant	Fuel	Uncontrolled Emission Factor (lb/ton fuel)	Estimated Emissions[a]			
			1990		1991	
			US tons	Metric tons	US tons	Metric tons
Dust	Coal	380[b]	838,000	760,000	735,000	665,000
	Mazut	3.45	62,000	56,000	42,000	38,095
	Natural Gas	0.005 lb/MBTU	--	--	--	--
	TOTAL		900,000	816,000	775,000	703,000
SO_2	Coal (2.5% S)	87.5[c]	1,930,000	1,750,000	1,785,000	1,619,000
	Mazut (2.4% S)	95.6	859,000	779,000	580,000	526,000
	Natural Gas	0.0006 lb/MBTU	--	--	--	--
	TOTAL		2,789,000	2,529,000	2,365,000	2,145,000
NOx	Coal	1.25 lb/MBTU	496,000	450,000	458,000	416,145
	Mazut	0.58 lb/MBTU	182,000	165,000	122,815	111,000
	Natural Gas	0.65 lb/MBTU	378,592	343,395	344,175	312,177
	TOTAL	2.48 lb/MBTU	1,056,592	958,395	924,990	839,322

a/ Based on updated energy data for 1990 and 1991. Efficiency of particulate controls on coal-fired plants is assumed to be 90%.
b/ 10 x Ash content
c/ 35 x S content

Survey of Plants

1. Four major thermal power plants were surveyed during this study as representative of environmental problems in coal-fired thermal plants. They are described in Table 1. Individual recommendation for each plant follow.

Table 2: Thermal Power Plants Surveyed in This Study

Plant	Capacity on coal	Capacity on oil	Capacity on gas	Coal use 1990 (million tons)	Remarks
Kurakhovskaya[a]	1460 MW	(same)	(same)	3.5	3 fuel capability
Starobeshevskaya[a]	2000 MW	(same)	--	7.0	2 fuel capability
Zaporozhskaya[b]	1200 MW	2400 MW	(same as capacity on oil)	3.0	2400 MW (gas/oil)
Krivorozhskaya[c]	3000 MW	(same)	(same)	9.0	3 fuel capability

a/ Donestk Oblast
b/ Zaporizhzhia Oblast
c/ Dnipropetrovsk Oblast

Kurakhovskaya Power Plant

2. The Kurakhovskaya Power Plant is located in the Donbass region of southeastern Ukraine, about 40 km due west of the city of Donetsk. The station's installed capacity is nominally 1460 MW_e, which is achieved with seven identical 210 MW pulverized coal-fired units. The boilers are balanced draft, dry bottom units with opposed wall firing. There are two rows with four burners each on the front and rear walls, and the furnace is partitioned down the middle for its full height. According to official documents, the plant burns local coal washery wastes and slurry (from the Donetsk coal mines). The plant director stated that Kurakhovskaya Power Plant burns all coal types other than anthracite.

3. Kurakhovskaya Power Plant's chief engineer stated that the maximum steam production of each 210 MW boiler is 670 (metric) tons per hour. This converts to 7019 pounds steam per hour per megawatt, which is less than the average value of 8000 lbs/hr/MW in the U.S., meaning that the Kurakhovskaya power-producing units are at least as efficient as typical U.S. pulverized coal systems. The chief engineer also indicated that the heat rate of each of these boilers is 2038 kcal/kW-hr, which converts to 8087 BTU/kW-hr. When one considers that heat rates of 9500 - 10,000 BTU/kW-hr are common in the U.S. for existing pulverized coal-fired units of this vintage (1970's), it appears that more heat is necessary to produce a unit of electricity here in the U.S. than in Ukraine. One cannot comment any further without

knowing how accurate the Ukrainian measurement methods are relative to the American measurement methods.

4. While the Kurakhovskaya Power Plant may be doing very well with energy efficiency, there are certainly improvements to be made in the environmental performance of the power station. It should be stated first, however, that the two stacks in use at this power station are 250 meters tall, while the boiler building height is about 65 meters. Thus, the dispersion of pollutants emitted from these stacks is very wide (because the stack heights far exceed "good engineering practice") and should not produce a local air quality problem. On the other hand, this plant emits about 100,000 metric tons of sulfur dioxide annually and could contribute significantly to downwind sulfuric acid precipitation.

5. From the point of view of air pollution control, much could be done at the Kurakhovskaya Power Plant. The station has functioning electrostatic precipitators (ESPs), but all of them could work better. The two techniques to consider in the short term are flue gas conditioning and comprehensive fuel acquisition, both forms of fly ash management. Otherwise, more up-to-date ESPs (or ESP rebuilds to modern standards) are required to bring the level of particulate control up to world standards.

6. By coincidence, Kurakhovskaya Power Plant is now ready to replace its first set of ESPs (each of the plant's seven identical boilers has an ESP). Between 1970 and 1975, one or two power production units were built per year, with the first operation in 1972. Therefore, it is not surprising that these 20-year old ESPs are ready for retirement. What is somewhat surprising is that these ESPs, which are apparently 6-field units, are not collecting more than 90-95 percent of the inlet particulate loading. Perhaps the ESPs are undersized, or perhaps the years of burning marginally suitable coals have affected the control system. In contrast, modern ESPs easily collect more than 99 percent of the inlet particulate loading. The extra 4-9 percent may not sound like much, but at this plant it would make the difference between 50-60 percent opacity (visible emissions) and 15-20 percent opacity. Another way to state this difference is that the second scenario would satisfy new source standards in the U.S., whereas the first situation would represent non-compliance, even with regulations for existing sources in the U.S.

7. Flue gas conditioning involves changing the chemistry of the flue gases prior to entering the ESP so that the fly ash particles may be more effectively electrostatically charged. The better the charge, the greater the rate of particle collection. Ammonia and sulfur trioxide (SO_3) are common flue gas conditioning agents. In the US, SO_3 injection has been successfully used by the electric power industry for some time as a relatively low-cost technique to enhance the performance of an existing ESP.

8. The physical and chemical properties of coal ash play a significant role in the ultimate performance of both the boiler and the electrostatic precipitator. Fly ash resistivity, for example, has a direct bearing on the ability of the fly ash to accept an electrostatic charge. Therefore, this fuel property directly relates to the ability of the ESP to collect fly ash particles from the flue gases. As such, it is essential for Kurakhovskaya Power Plant to decide for itself just what coals to accept at the plant for burning, as a technique for complying with particulate emissions control regulations if for no other reason.

9. The Director of Kurakhovskaya described the present system of coal selection and acquisition as a mixture of old (i.e., Soviet) and new ideas. Under the Soviet scheme, a central coal board selected the fuels for all of the power plants, trying to match coal type and furnace type appropriately. That Kurakhovskaya still rarely burns design (or even suitable) coal is a testament to the failure of the old ways as applied to power production. The mix of fuels coming to Kurakhovskaya includes coal wastes as well as coals ranging from bituminous to lignite. The ash content of these fuels has ranged from 30

to 60 percent; the lignite was the low sulfur fuel. The Kurakhovskaya Power Plant is now developing a market-based approach to acquiring fuels for the plant, considering such factors as coal properties as well as transportation and purchase costs.

10. Kurakhovskaya Power Plant burns 3.5 million (metric) tons of Donets Basin coal per year. In addition, this facility burns 7.5 million (metric) tons of heavy oil and 8.7 million (metric) tons of natural gas annually. The plant reports its emissions as follows:

Table 2

Pollutant	Facility Limit (tons per year)	Actual Emissions (tons, Jan-Jun)
Particulates	63,842.8	25,880.1
Sulfur Dioxide	157,386.1	54,284.1
Nitrogen Dioxide	19,686.3	6245.3
Carbon Monoxide	133.8	66.9
Hydrocarbons	39.2	19.6
Carbon in Flyash	19.9	9.9
H_2SO_4 Mist	$2.8x10^{-5}$	$1.3x10^{-5}$
Vanadium Pentoxide	4.1	2.1
Mn + MnO	$8.6x10^{-3}$	$4.3x10^{-3}$
Hydrogen Fluoride	$3.4x10^{-3}$	$1.7x10^{-3}$
Chromium Dioxide	$2.0x10^{-3}$	$9.9x10^{-4}$

Recommendations for Kurakhovskaya Power Plant

(i) Portable Combustion Analyzers

Portable combustion analyzers are very useful devices to have available to power engineers. Not only do these analyzers facilitate boiler operational adjustments to improve combustion efficiency, but the analyzers also enable boilers to be fine-tuned from an emissions point of view. For estimation purposes, a suitable analyzer has a capital cost of $6000 (1992 USD). To give meaningful results, these devices must be periodically calibrated and otherwise maintained in good working order. Assuming that the equipment vendor was located somewhere in Eastern Europe, an annual budget of $600 should be sufficient for operation and maintenance.

(ii) Evaluation of Fuel Purchasing Strategies

Kurakhovskaya Power Plant needs to assume control over its fuel acquisition as quickly as possible. It would not be surprising if part of the plant ESPs' poor performance can be directly attributed to fly ash resistivity. If Kurakhovskaya management were to decide for themselves which fuels were to be burned at the plant, they would be able to specify coals which would satisfy various plant operational needs including top-notch ESP performance. The boilers themselves also have operational needs related to coal properties, so again it is wise for the plant to take control of this very important element of plant management. Kurakhovskaya Power Plant should investigate fuel blending strategies to find a mix of Ukrainian coals and coal wastes which would be suitable from an operational point of view yet cost competitive with the existing fuel supply.

Kurakhovskaya Power Plant would benefit from technical assistance in the form of a person or persons knowledgeable about fuel purchasing strategies to work directly with Kurakhovskaya Power Plant personnel, who would then be responsible for implementing such strategies over the medium term.

(iii) ESP Performance Audit

With the imminent retirement of the one or two oldest ESPs at Kurakhovskaya Power Plant, there is an excellent opportunity to upgrade the dust control systems on these 20-year old boilers. In addition, the somewhat newer ESPs are all candidates for upgrading to world performance standards. None of the ESPs at Kurakhovskaya Power Plant appeared to be working as well as they should in terms of resultant stack opacity.

Kurakhovskaya Power Plant would benefit from receiving technical assistance in the form of a person or persons knowledgeable about ESP troubleshooting strategies to work directly with Kurakhovskaya Power Plant personnel who would then be responsible for maintaining and operating the upgraded ESPs over the long term.

(iv) Fuel Sulfur Removal Techniques

Ukrainian technology exists which removes, by magnetic separation, pyritic sulfur from coals. This sulfur removal technology is of great interest to Kurakhovskaya Power Plant, according to the Director, and the plant would very much like to participate in demonstrating the technology. It was not possible to see the technology, so it is impossible to evaluate its viability. But it could well be worth pursuing. The plant should be encouraged to do so. The Kurakhovskaya Power Plant may want to seek funding for research and development of techniques to remove sulfur from Ukrainian coals.

(v) Development (by Plant) of Boiler Start-up and Shutdown Plans

If Kurakhovskaya Power Plant writes and implements detailed plans for boiler start-up and shutdown with the intent of minimizing emissions during those periods of operation, the plant should realize an immediate improvement in the day to day visible emissions from the stacks. The details of minimizing emissions are best developed by the plant itself.

(vi) Development (by Plant) of Malfunction Prevention and Abatement Plan

If Kurakhovskaya Power Plant writes and implements detailed plans for preventing boiler and air pollution control system malfunctions, the plant should realize an immediate improvement in the likelihood of day to day compliance with visible emissions standards at the stacks. The details of system operation and maintenance resulting in stable long-term performance are best developed by the plant itself. A good example of a system to evaluate is a pollution control system, such as the ESP on each unit at Kurakhovskaya Power Plant. If something were to go wrong with the ESP, the immediate environmental impacts would be increased particulate and visible emissions from the stack associated with that ESP.

(vii) Two Continuous Opacity Monitors (one per stack)

Over the longer term, installation of opacity monitors would be useful. Stack monitoring is an expensive but reliable method of demonstrating compliance with pollutant emission restrictions. Opacity (visible emissions) is monitored essentially as a surrogate parameter for dust emissions. Stacks equipped with continuous opacity monitors therefore enable plant and regulatory personnel to judge dust control effectiveness over the long term. For estimation purposes, each continuous opacity monitor has a capital cost of $250.000 (1992 USD). To properly operate, maintain and calibrate these units, one should budget $25,000 annually. This is a longer term recommendation, because of the cost.

Dispersion Modeling of a Typical Ukrainian Power Plant

11. The Kurakhovskaya Power Plant was used as an example to demonstrate the use of a screening model for air dispersion analysis. The two stacks in use at this power station are 250 meters tall, while the boiler building height is about 65 meters. The stack exit diameter is approximately 6.25 meters, and the stack gas exit temperature is estimated to be 350 °F. For three boilers operating, the stack flow rate is estimated to be 2100 cubic meters per second.

12. Using the USEPA emission factor for particulate emissions from a dry bottom pulverized coal boiler firing bituminous or subbituminous coal (10A, where A is the percent ash in the coal), the maximum particulate emissions from one of the two stacks at Kurakhovskaya Power Plant (assuming three 210 MW boilers are operating simultaneously) are approximately 1345.0 grams per second assuming 95 percent control by the ESPs.

13. However, the plant typically operates at about 50 percent of capacity due to the reserve system capacity. For example, Kurakhovskaya reports that its particulate emissions during January through June, 1992 were 25,880.1 metric tons. Annualized, this emission rate is 51,760.2 metric tons per year, or 5.9087 metric tons per hour, which is equivalent to 1641.3 grams per second.

14. Since the second stack has identical parameters, we may simply use the facility-wide particulate emission rate and model the emissions as though they were all emitted from one stack.

15. The results from the SCREEN2 dispersion model are presented on the next pages. We predict that the maximum ground-level particulate concentration resulting from the maximum operation of Kurakhovskaya is 338.6 micrograms per cubic meter (1-hour maximum). On a 24-hour average basis, this is 135.4 micrograms per cubic meter (ug/$m^{3)}$.

16. Background particulate concentrations in rural Wisconsin (and, presumably, in rural Ukraine, where the power plant is located) are on the order of 70 micrograms per cubic meter (24-hour average). The total predicted ground-level concentration resulting from the typical operation of Kurakhovskaya is 205.4 ug/m^3. This value exceeds the American national ambient air quality standard of 150 ug/m^3 (24-hour basis), which is equivalent to the Ukrainian standard. The results also tell us that this maximum concentration occurs 1531 meters downwind of the stack.

17. We may use the particulate modeling results to estimate concentrations of SO_2 and NO_x resulting from the normal operation of Kurakhovskaya Power Plant. Since the dispersion model is linear in emission rate, we may simply ratio emission rates and solve for the unknown concentration. For SO_2, we use the USEPA emission factor (35 S pounds per ton of (subbituminous) coal fired, where S is the weight percent of sulfur in the coal). For Kurakhovskaya, we assume a typical sulfur content of 2.7 percent, so that the plant SO_2 emissions are 11,823.4 grams per second. In this case, the emissions are uncontrolled. The maximum ground-level concentration of SO_2 (1-hour average) during normal operation is thus

$$\frac{11{,}823.4 \text{ g } SO_2\text{ /s}}{1{,}641.3 \text{ g PM /s}} \times 338.6 \text{ ug/m}^3 = 2439.2 \text{ ug/m}^3$$

18. For NO_x, we estimate the emissions at 1.25 pounds per million BTU from Electric Power Research Institute data for wall-fired utility boilers. For the six operating (at any one time) 210 MW boilers at Kurakhovskaya Power Plant, the typical heat input rate in English units is 8,072 million BTU per hour (MMBTU/hr). Thus, the maximum NO_x emission rate is 10,090.3 pounds per hour, or 1271.4 grams per second. Applying the above principles, the maximum ground-level concentration of NO_x (1-hour average) during normal operation is thus

$$\frac{1{,}271.4 \text{ g } NO_x\text{ /s}}{1{,}641.3 \text{ g PM /s}} \times 338.6 \text{ ug/m}^3 = 262.3 \text{ ug/m}^3$$

19. The 24-hour average SO_2 concentration impact is 975.7 ug/m^3, and the annual average NO_x concentration impact is 104.9 ug/m^3. Background concentrations for SO_2 and NO_x in rural Wisconsin are approximately 222 ug/m^3 and 7 ug/m^3, respectively. The total predicted concentrations are therefore 1198 ug SO_2 /m^3 and 112 ug NO_x /m^3. These values are higher than the corresponding national ambient air quality standards in America of 365 ug SO_2 /m^3 (24-hour) and 100 ug NO_x /m^3 (annual), and higher than the corresponding Ukrainian standards (50 ug/m^3 and 40 ug/m^3, which is actually on a 24-hour average basis).

20. In conclusion, this screening analysis (a more sophisticated analysis requires more detailed local meteorological information) shows that the very large (by American standards) emissions of particulates, sulfur dioxide, and nitrogen oxides from Kurakhovskaya Power Plant result in ground-level pollutant concentrations which would not meet ambient air quality standards either in America or in Ukraine. However, these ground-level impacts are based on very general assumptions about the local meteorological conditions. What these results suggest is that proper location of ambient air quality monitors near Ukrainian thermal power plants may occasionally record exceedances of ambient air quality standards. Moreover, the large SO_2 and NO_x loadings to the atmosphere may be significant in terms of long-range transport and acid rain formation.

Starobeshevskaya Power Plant

21. The Starobeshevskaya Power Plant is located in the Donbass region of southeastern Ukraine, about 35 km southeast of the city of Donetsk. The station's installed capacity is nominally 2000 MW_e, which is achieved with ten virtually identical 200 MW pulverized coal-fired units. The boilers are balanced draft, wet bottom units with wall firing. There are four cells (groups) with three burners each, and the furnace is equipped with over-burner injection of coal mill surplus. Among wall-fired units, the cell burners have the highest nitrogen oxides (NO_x) emissions.

22. According to the Director, the plant principally burns local coal (anthracite) wastes, but other Ukrainian coals can be burned. The design fuel was 16-18 percent ash, 6010 kcal/kg (10,815 BTU/lb) heating value anthracite. However, after 1970, the quality of the fuel burned at Starobeshevskaya gradually declined. From 1982, the plant has burned a 40 percent ash, 3500 kcal/kg (6298 BTU/lb) anthracite waste. The fuel sulfur content varies from about 0.8 percent to 2.5 percent, with the sulfur normally being below 1 percent.

23. The plant's director stated that maximum steam production of each 200 MW boiler is 640 (metric) tons per hour. This converts to 7056 pounds steam per hour per megawatt, which is less than the average value of 8000 lbs/hr/MW in the U.S., meaning that Starobeshevskaya's power-producing units are at least as efficient as typical U.S. pulverized coal systems. The director also stated that the heat rate of each of these boilers is 2800 kcal/kW-hr, which converts to 11,110 BTU/kW-hr. When one considers that heat rates of 9500 - 10,000 BTU/kW-hr are common in the U.S. for existing pulverized coal-fired units of this vintage (1970's), one concludes that the Starobeshevskaya boilers are below average in thermal efficiency.

24. There are certainly improvements to be made in the environmental performance of the power station. Two of the four stacks in use at this power station have good engineering practice (GEP) stack height, while the remaining two stacks just barely reach, if at all, GEP stack height. In addition, the plant is located in the Kalmius River valley, surrounded by significantly rolling terrain. Thus, the dispersion of pollutants emitted from these stacks, especially the shorter ones, may not be particularly effective due to the effects of the terrain elevations relative to the stack release heights. Moreover, this plant emits about 125,000 metric tons of sulfur dioxide annually and could contribute significantly to downwind sulfuric acid precipitation.

25. From the point of view of air pollution control, much could be done at the Starobeshevskaya Power Plant. The station has functioning venturi scrubbers, but all of them could be made to work considerably better. Also, at present, only plain water is used as the scrubbing medium, so that only dust is controlled. The most obvious technique to consider in the short term is adding a sorbent, such as limestone, to the scrubbing medium to control sulfur dioxide (SO_2) emissions in addition to dust. Limestone is widely used in wet scrubbers in the West because it is highly reactive with SO_2 and it is reasonably inexpensive. The costs of limestone scrubbing are generally in the range of $200-300 per ton of SO_2 controlled. More to the point, Ukraine has vast reserves of limestone located at or near the coal fields, making limestone a very attractive alternative indeed. Otherwise, more up-to-date scrubbers (or scrubber rebuilds to modern standards) are required to bring even the level of particulate control up to world standards. And of course new scrubbers can be designed to control both SO_2 and NO_x in addition to dust.

26. Starobeshevskaya Power Plant is ready to replace its first set of scrubbers (each of the plant's ten identical boilers has a scrubber). Between 1961 and 1967, one or two power production units were built per year, with the first operation in 1968. The scrubbers were upgraded in the early 1970's to include a venturi section. Therefore, it is not surprising that these 20-year old scrubbers (already once reconstructed) are now ready for retirement. These wet scrubbers should be replaced as soon as budget allows; none of them seems to be very effective at controlling air pollution. There are a number of very effective units now available in the West which would significantly upgrade the level of air pollution control at the plant.

27. Under the former Soviet scheme, a central coal board selected the fuels for all power plants, trying to match coal type and furnace type appropriately. Starobeshevskaya still rarely burns design (or even suitable) coal. The mix of fuels coming to the plant includes local anthracite coal wastes as well as anthracite coals from around Ukraine. The ash content of these fuels is generally about 40 percent; the volatile matter content, of course, is very small, as it is with all anthracite.

28. This dependence on anthracite (without higher volatile matter coals blended into a fuel mixture) means that the Starobeshevskaya boilers are extremely difficult to ignite and have problems with sustaining combustion. To be able to operate their boilers (in order to generate steam), Starobeshevskaya must soak the anthracite with heavy oil in order to provide enough volatile matter in the furnace to initiate and sustain combustion. The plant director stated that as much as 40 percent of the boilers heat input must be derived from heavy oil. So this dependence on anthracite effectively translates into a dependence on heavy oil.

29. The Starobeshevskaya Power Plant is now developing a market-based approach to acquiring fuels for the plant, considering such factors as coal properties as well as transportation and purchase costs. To date, they have found that coal purchase prices are dominating the decision. Through 1990, they could buy coal for 18 rubles per ton. Now, coal they receive is priced at 2500 rubles per ton.

30. Starobeshevskaya Power Plant reports its emissions as follows:

Pollutant	Facility Limit (tons per year)	Actual Emissions (tons, Jan-June)
Particulates	89,379.7	38,856.5
Sulfur Dioxide	131,825.9	69,099.6
Nitrogen Dioxide	23,108.4	11,145.7

Recommendations for Starobeshevskaya Power Plant

(i) Portable Combustion Analyzer

Portable combustion analyzers are useful devices to have available to power engineers. Not only do they facilitate boiler operational adjustments to improve combustion efficiency, but they also enable boilers to be fine-tuned from an emissions point of view. For estimation purposes, a suitable analyzer has a capital cost of $6000 (1992 USD). To give meaningful results, these devices must be periodically calibrated and otherwise maintained in good working order. Assuming that the equipment vendor were to set up shop somewhere in Eastern Europe, an annual budget of $600 should be sufficient for operation and maintenance.

(ii) Evaluation of Fuel Purchasing Strategies

This facility, more than any other visited in Ukraine, needs to assume control over its fuel acquisition process as quickly as possible. The Starobeshevskaya boilers have critical operational needs related to coal volatile matter content because of the preponderance of anthracite burned at the plant. The large amount of residual (heavy) oil burned at this plant to make up for the lack of volatile matter in anthracite probably leads to excessive particulate emissions during startup conditions (which occurs every day for every boiler). Also, the plant director stated that in 1992 the average sulfur content of coal was 1.4 percent, whereas the average oil sulfur content was 2.4 percent.

Starobeshevskaya Power Plant should investigate fuel blending strategies to find a mix of Ukrainian coals and coal wastes which would be suitable from an operational point of view, yet cost competitive with the existing fuel supply. This plant may even be able to eliminate its use of heavy oil by burning a suitable coal blend instead. Starobeshevskaya Power Plant would benefit from technical assistance in the form of a person or persons knowledgeable about fuel purchasing strategies to work directly with plant personnel responsible for implementing such strategies over the long term.

(iii) Scrubber Performance Audit

With the imminent retirement of the one or two oldest scrubbers at Starobeshevskaya Power Plant, there is an excellent opportunity to upgrade the dust control systems on these 20-year old boilers. In addition, the somewhat newer scrubbers are all candidates for upgrading to world performance standards. None of the scrubbers are working as well as they should be in terms of resultant stack opacity. The plant would benefit from technical assistance in the form of a person or persons knowledgeable about wet scrubber troubleshooting strategies to work directly with Starobeshevskaya Power Plant personnel who would then be responsible for maintaining and operating the upgraded scrubbers over the long term.

(iv) Development (by Plant) of Boiler Startup and Shutdown Plans

If the plant writes and implements detailed plans for boiler startup and shutdown with the intent of minimizing emissions during those periods of operation, the plant should realize an immediate improvement in the day to day visible emissions from the stacks. No one understands a plant's operation better than its operators, so the details of minimizing emissions are best developed by the plant itself.

(v) Development (by Plant) of Malfunction Prevention and Abatement Plan

Similarly, the plant should write and implement detailed plans for preventing boiler and air pollution control system malfunctions. The details of system operation and maintenance resulting in stable long-term performance are best developed by the plant itself.

All power plants involve mechanical processes which can affect air pollution emissions. Anything which affects the delivery of fuel to the boiler, for example, must be working properly to avoid boiler upset conditions. In Wisconsin, all power plants must develop and then implement a comprehensive plan to address potentially excessive air pollution emissions resulting from the failure of some portion of the power generation system.

A good example of a system to evaluate is a pollution control system, such as the venturi scrubber on each unit at Starobeshevskaya Power Plant. If something were to go wrong with the scrubber, the immediate environmental impacts would be increased particulate and visible emissions from the stack associated with that scrubber.

(vi) Over Long Term (when budget allows): Four Continuous Opacity Monitors (one per stack)

Stack monitoring is an expensive but reliable method of demonstrating compliance with pollutant emission restrictions. Opacity (visible emissions) is monitored essentially as a surrogate parameter for dust emissions. Stacks equipped with continuous opacity monitors therefore enable plant and regulatory personnel to judge dust control effectiveness over the long term. For estimation purposes, each continuous opacity monitor has a capital cost of $250,000 (1992 USD). To properly operate, maintain and calibrate these units, one should budget $25,000 annually.

(vii) Demonstration of Fluidized Bed Combustion Technology

The Director of Starobeshevskaya Power Plant stated that the plant's boilers should have been replaced some time ago, that the age of the boilers is about double the original projected life. While the plant recognizes the need for a complete reconstruction of all of the boilers' heating surfaces, they may be better off simply retiring the units one by one and replacing as many as possible, perhaps with fluidized bed combustion (FBC) technology. Starobeshevskaya Power Plant is located in a region with vast coal and limestone reserves. FBC can handle a wide variety of coal types and grades, and substantial SO_2 reduction may be easily achieved at the bed. However, there are problems in regard to waste generated by FBC. Therefore, a careful comparison of technology options would be required.

Zaporizhskaya Power Plant

31. The Zaporizhskaya Power Plant is located on the shore of the Kakhovka Water Reservoir in southern Ukraine, about 70 km southwest of the city of Zaporizhzhia in a small town called Blahovishchenka. The station's installed capacity is nominally 3600 MW_e, which is achieved with four identical 300 MW pulverized coal-fired units and three identical natural gas/residual (heavy) fuel oil-fired 800 MW units. The four coal-fired boilers are vented through one stack, and the three gas/oil-fired units are vented through the plant's other stack.

32. The coal-fired boilers are balanced draft, dry bottom units with opposed wall firing. There is a single row with four burners each on the front and rear walls. According to official documents, the plant burns local "gas coal", with a design heating value of 5000 kcal/kg (8998 BTU/lb). The plant director stated that the plant typically burns coal with a heating value of 4000 kcal/kg (7198 BTU/lb) and a sulfur content varying between 2.0 - 3.5 percent. The ash content of the coals burned at Zaporozhskaya varies from 30-50 percent, with perhaps 36 percent being the average. The saving grace of this coal is that it is a high (37 percent) volatile matter bituminous coal, so that it burns well in the furnace. Unfortunately, the plant experiences some slagging problems related to burner location.

33. The gas/oil-fired boilers are also opposed wall-firing units. In these units, there are three tiers (rows) with six burners each on the front and rear walls, for a total of 36 burners in the furnace. Since one of these units was down for a regular maintenance outage when I visited the plant, I seized the opportunity to climb inside the furnace to have a look around. This 800 MW unit with 36 burners is really steam production on a grand scale. Incidentally, it seemed to me that the restorative work on the heating surfaces was very well done. According to official documents, the plant burns "high sulfur" fuel oil, with a heating value of 9330 kcal/kg (16,790 BTU/lb). The document does not state what "high sulfur" means for the oil.

34. All of the boilers at Zaporozhskaya Power Plant are dispatched in a cycling mode. That is, the boilers run at peak operation during high-demand times of day, like in the evening, but are backed off considerably over night. So the coal-fired boilers cycle between 70 MW at night and 300 MW during the day. The gas/oil-fired boilers cycle between 300 MW at night and 800 MW during the day.

35. Official documents describe the maximum steam production of each 300 MW coal-fired boiler as 950 (metric) tons per hour. This converts to 6983 pounds steam per hour per megawatt, which is less than the average value of 8000 lbs/hr/MW in the U.S., meaning that the Zaporozhskaya power-producing units are at least as efficient as typical U.S. pulverized coal systems. These documents also state that the maximum steam production of each 800 MW gas/oil-fired boiler is 2650 (metric) tons per hour. This converts to 7304 pounds steam per hour per megawatt, which is less than the average value of 8000 lbs/hr/MW in the U.S., meaning that these Zaporozhskaya power-producing units are at least as efficient as typical U.S. systems.

36. While the Zaporozhskaya Power Plant may be doing very well with energy efficiency, there are improvements to be made in environmental performance. It should first be noted, however, that the two stacks in use at this station are each 320 meters tall, while the associated boiler building height is about 70-80 meters. Thus, the dispersion of pollutants emitted from these stacks is very wide because the stack heights far exceed "good engineering practice" and should not produce a local air quality problem. On the other hand, this plant emits about 206,000 metric tons of sulfur dioxide annually and could contribute significantly to downwind sulfuric acid precipitation. As a matter of fact, the director stated that Zaporozhskaya Power Plant participated in an experiment involving cosmonauts - the plant turned off its ESPs for a while and the cosmonauts observed (from above) the fate of the plume. The result was that the plume was still discernable at a distance of 120 kilometers downwind of the power plant!

37. The electrostatic precipitators (ESPs) have regular maintenance outages generally coinciding with boiler outages. A technician makes daily observations of ESP performance, with the shift head reporting to the chief engineer about ESP performance. Records of ESP performance are kept with the T-R (transformer-rectifier) sets which always seem to be typically located underneath the precipitators themselves.

38. Once every ten days a monitoring van comes out to Zaporozhskaya and drives around to all of the ambient monitoring sites around the plant. Stack measurements are generally not made, but the control system inlet and outlet are tested. With this latter information, Zaporozhskaya Power Plant is able to calibrate emission factors for their boilers.

39. From the point of view of air pollution control, much could be done at the plant. The station has functioning electrostatic precipitators (ESPs), but all of them could work better. The two techniques to consider in the short term are flue gas conditioning and comprehensive fuel acquisition, both forms of fly ash management. Otherwise, more up-to-date ESPs (or ESP rebuilds to modern standards) would be necessary to bring the level of particulate control up to world standards.

40. Zaporozhskaya Power Plant has already replaced one of its original ESPs (each of the plant's four identical coal-fired boilers has an ESP). In 1972 the coal-fired boilers were put in service; between 1975 and 1977 the three gas/oil boilers came on line. Therefore, it is not surprising that these 20-year old ESPs are ready for retirement. What is somewhat surprising is that these ESPs, which are apparently 3-field units, have been tested and show 98.4 - 98.5 percent control of the inlet particulate loading. Independent observation of stack plume opacity suggested that the coal-burning boiler stack, which serves all 1200 MW of the plant's capacity on coal, was not meeting a visible emissions standard of 40 percent. In contrast, modern ESPs easily collect more than 99 percent of the inlet particulate loading and don't let the stack opacity exceed 20 percent.

41. The present system of coal selection and acquisition is a mixture of partly old and mostly new ideas. Zaporizhskaya now writes contract specifications for coal purchases, complete with monetary penalty clauses for off-specification fuels delivered to the plant. And yet, the mix of fuels coming to Zaporizhskaya includes coals with ash content ranging from 30 to 50 percent and sulfur content ranging from 2.0 to 3.5 percent. To check on coal quality, Zaporizhskaya tests, essentially according to ASTM standards, the as-received coal for ash, heating value, sulfur, moisture, and volatile matter, as they should. On the other hand, trace elements such as sodium are not evaluated. The problem appears to be that no mine is producing the coal that Zaporizhskaya would like to be burning.

42. On a quarterly basis, the plant has been renting a portable combustion analyzer of German make for stack measurements. There appear to be no Ukrainian manufacturers of portable combustion analyzers. The power plant's emissions are reported as follows:

Pollutant	Actual Emissions (tons per year)	Actual Emissions (mg/Nm^3, measured)
Particulates	18.000	--
Sulfur Dioxide	206,000	3000-5000
Nitrogen Dioxide	48,800	700-800
Carbon Monoxide	--	10-15

43. On its own, Zaporizhskaya Power Plant has been working since the early 1970's to reduce NO_x emissions from their gas/oil boilers. Zaporizhskaya has used three techniques: low excess air operation, burners out of service, and low NO_x burners. Zaporizhskaya has been able to reduce the stoichiometric

(fuel:air) ratio to 1.025 - 1.03; 1.02 reduced NO_x, but high temperature corrosion of the lower furnace resulted which meant that 1.02 was too low for the furnace. The lowest of the three rows of burners was made to operate with a stoichiometric ratio of 0.8 - 0.9 (by cutting back on the fuel feed while the windbox provided a fixed amount of combustion air). At lower loads, such as 450-500 MW, the highest row of burners was completely turned off (i.e., out of service). And the burners themselves were modified by the power engineers at Zaporizhskaya Power Plant to be lower NO_x emitters. The best reduction was 18-20 percent; 15 percent was a more typical result. These results are quite impressive when one considers how little help the power engineers at Zaporizhskaya Power Plant apparently have had from other researchers.

Recommendations for Zaporizhskaya Power Plant

(i) Portable Combustion Analyzers

Portable combustion analyzers are very useful devices to have available to power engineers. Not only do these analyzers facilitate boiler operational adjustments to improve combustion efficiency, but the analyzers also enable boilers to be fine-tuned from an emissions point of view. For estimation purposes, a suitable analyzer has a capital cost of $6000 (1992 USD). To give meaningful results, these devices must be periodically calibrated and otherwise maintained in good working order. Assuming that the equipment vendor were to set up shop somewhere in Eastern Europe, an annual budget of $600 should be sufficient for operation and maintenance.

(ii) ESP Performance Audit

With the retirement of the oldest ESPs at Zaporizhskaya Power Plant, there is an excellent opportunity to upgrade the dust control systems on these 20-year old boilers. In addition, the somewhat newer ESPs are all candidates for upgrading to world performance standards. None of the ESPs at Zaporizhskaya Power Plant appeared to be working as well as ESPs on coal-fired boilers should be working (in terms of resultant stack opacity).

The plant would benefit from technical assistance in the form of a person or persons knowledgeable of ESP troubleshooting strategies to work directly with personnel who would be responsible for maintaining and operating the upgraded ESPs over the long term. The assistance would probably comprise a 1 person-week.

(iii) Development of a Suitable Coal Blend

Zaporizhskaya Power Plant personnel should experiment with a blend of various available coals into a fuel which will burn effectively in the boilers in terms of thermal efficiency and reduced emissions. Rather than being tied to the properties of a single fuel, a suitable coal blend would allow continued use of local poor quality coals while potentially reducing emissions and improving plant efficiency.

(iv) Optimization of Burner Tilt and Yaw Angles

Clearly the next step for Zaporizhskaya Power Plant to take in the development of its NO_x reduction program is to provide the opportunity for its low NO_x burners to tilt side to side and up and down. When burners can be individually "aimed" in this way, additional NO_x reductions can be achieved from additional combustion staging within the furnace. The Zaporozhskaya Power Plant personnel are so knowledgeable already about the NO_x emissions from their furnaces that they seem to be excellent candidates for further research. Such support would benefit both the plant in terms of lower NO_x emissions as well as observers from the outside who want to learn more about reducing NO_x emissions from utility boilers.

(v) Burners Out of Service (BOOS) for Coal-Fired Furnace

The same technique that Zaporizhskaya Power Plant has applied to its gas/oil boilers can be applied to coal-fired boilers. While the coal-fired boilers at this plant have only a single row of burners, if the burners were capable of tilting up and down and side to side, ;this technique may be successful at Zaporozhskaya. If successful, it would be an important technology demonstration for Ukraine.

(vi) Development (by Plant) of Boiler Startup and Shutdown Plans

If Zaporizhskaya Power Plant writes and implements detailed plans for boiler startup and shutdown with the intent of minimizing emissions during those periods of operation, the plant should realize an immediate improvement in the day to day visible emissions from the stacks. The details of minimizing emissions are best developed by the plant itself.

(vii) Development (by Plant) of Malfunction Prevention and Abatement Plan

The plant should write and implement detailed plans for preventing boiler and air pollution control system malfunctions. This could improve day to day compliance with visible emissions standards at the stacks. The details of system operation and maintenance resulting in stable long-term performance are best developed by the plant itself. A good example of a system to evaluate is a pollution control system, such as the ESP on each unit at Zaporizhskaya Power Plant. If something were to go wrong with the ESP, the immediate environmental impacts would be increased particulate and visible emissions from the stack associated with that ESP.

(viii) Two Continuous Opacity Monitors (one per stack)

Over the longer term, acquisition of opacity monitors would be useful. Stack monitoring is an expensive but reliable method of demonstrating compliance with pollutant emission restrictions. Opacity (visible emissions) is monitored essentially as a surrogate parameter for dust emissions. Stacks equipped with continuous opacity monitors therefore enable plant and regulatory personnel to judge dust control effectiveness over the long term.

For estimation purposes, each continuous opacity monitor has a capital cost of $250,000 (1992 USD). To properly operate, maintain and calibrate these units, one should budget $25,000 annually.

Krivorozhskaya Power Plant

44. The Krivorozhskaya Power Plant is located in southern Ukraine, about 50 km due south of the city of Kryvyi Rih. The station's installed capacity is nominally 3000 MW_e, which is achieved with ten identical 300 MW pulverized coal-fired units. Two boilers, each equipped with two electrostatic precipitators (ESPs), are vented through each of the five stacks. The height of one stack is 180 meters, while the four other stacks are each 250 meters high.

45. The coal-fired boilers are balanced draft, wet bottom units with opposed wall firing. For the four oldest boilers, of the "Podolsk" design, there are two rows with six burners each on the front and rear walls; the furnace is partitioned down the middle for its full height. The six youngest boilers, of the "Taganrog" design, have six burners altogether: a row of three on front and rear walls: again the furnace is partitioned. According to the plant director, the plant burns local (from the Donetsk coal mines) "poor" coal, with design heating values of 4800 kcal/kg (8998 BTU/lb) for the older boilers and 6000 kcal/kg (10,797 BTU/lb) for the newer boilers. The director stated that the plant generally burns one type of coal throughout the plant, typically with a heating value of 5200 kcal/kg (9358 BTU/lb), an as-received moisture content of 9-12 percent, and a sulfur content varying between 2.0 -2.7 percent. The ash content of the coals burned at Krivorozhskaya varies from 17 (i.e., design) to 40 percent, with perhaps 32 percent being the average.

46. All of the boilers at the plant are dispatched in a cycling mode. That is, the boilers run at peak operation during the high-demand times of day, which are 7-11 in the morning and 7-10 in the evening, but are backed off to warm standby over night. Krivorozhskaya likes to operate during the peak hours so that one boiler is kept at half capacity while the others operate at capacity. The dispatch hierarchy is for the shift chief to dispatch each boiler at the plant, the Dneproenergo Production Power Engineering Association to control the dispatch of the various power stations in the region, and a national office to control the dispatching of all Ukrainian power plants.

47. Official documents describe the maximum steam production of each 300 MW coal-fired boiler as 950 (metric) tons per hour. This converts to 6983 pounds steam per hour per megawatt, which is less than the average value of 8000 lbs/hr/MW in the U.S., meaning that the Krivorozhskaya power-producing units are at least as efficient as typical U.S. pulverized coal systems. All ten of the boilers at Krivorozhskaya are apparently identical to the four coal-fired boilers at Zaporozhskaya. This is indicative of the high level of standardization in Soviet-style power production.

48. While the Krivorozhskaya Power Plant may be doing very well with energy efficiency, there are improvements to be made in the environmental performance. Four of the stacks in use at this station are each 250 meters tall, and the fifth is 180 meters high. Since the boiler building height is about 60 meters, the dispersion of pollutants emitted from these stacks is very wide (the stack heights far exceed "good engineering practice") and should not produce a local air quality problem. On the other hand, this plant emits about 277,000 metric tons of sulfur dioxide annually and could contribute significantly to downwind sulfuric acid precipitation.

49. The electrostatic precipitators (ESPs) have regular maintenance outages generally coinciding with boiler outages. A technician makes daily observations of ESP performance, with the shift head reporting to the chief engineer about ESP performance. Records of ESP performance are kept with the T-R (transformer-rectifier) sets which are typically located underneath the precipitators themselves. Major ESP maintenance activities are performed by an outside contractor.

50. Over the years, especially the last ten, Krivorozhskaya Power Plant has made some modifications to the ESPs resulting in improved performance. The initial (i.e., design) dust collection efficiency was 94.5 percent; following modification, the efficiency became 96.5 percent. Still, this level of performance is not up to world standards, as the stack's visible emissions (40 to 50 percent) demonstrate. Apparently, six years ago the plant and the State Committee for Ecology (the forerunner to MEP) had agreed that the Krivorozhskaya ESPs must be replaced. The only thing that has been done to implement that plan is a pending order for the latest ESP design from the Ukrainian Institute of Energy Projects in Donetsk.

51. Ironically, the existing Krivorozhskaya ESPs represent the Institute's first design. The precipitator plates are "S" shaped with a spacing of 180 millimeters (7.1 inches). The approach velocity is 2.3 meters per second and the electrode height is 7.5 meters. There are four fields altogether in the device, but the particulate control simply isn't good enough for environmental compliance. Krivorozhskaya Power Plant's Environmental Department has measured pollutant concentrations with ambient monitors, across the control devices, and at the stack, and they know that the ESPs are not adequate.

52. For better dust control, the two techniques to consider in the short term are flue gas conditioning and comprehensive fuel acquisition, both forms of fly ash management. Otherwise, more up-to-date ESPs (or ESP rebuilds to modern standards) are required to bring the level of particulate control up to world standards.

53. Krivorozhskaya now writes contract specifications for coal purchases, complete with monetary penalty clauses for off-specification fuels delivered to the plant. And yet, the mix of fuels coming to Krivorozhskaya includes coals with volatile matter content up to 20 percent, even though the coal burned in these boilers must have no more than 12 percent volatile matter. To check on coal quality, Krivorozhskaya tests, essentially according to ASTM standards, the as-received coal for ash, heating value, sulfur, moisture, and volatile matter, as they should. On the other hand, trace elements such as sodium are not evaluated.

54. Krivorozhskaya Power Plant burns 7.3 - 9.9 million (metric) tons of Donets Basin coal per year. In addition, this facility burns, on a heat basis, 12 percent heavy oil and 12 percent natural gas annually. The plant reports its emissions as follows (NA means "not available"):

Pollutant Emissions	Facility Limit (tons per year)	Actual (tons per year)
Particulates	NA	96,000
Sulfur Dioxide	NA	277,000
Nitrogen Dioxide	NA	50,000

Recommendations for Krivorozhskaya Power Plant

(i) Portable Combustion Analyzers

Portable combustion analyzers are very useful devices to have available to power engineers. Not only do these analyzers facilitate boiler operational adjustments to improve combustion efficiency, but the analyzers also enable boilers to be fine-tuned from an emissions point of view. For estimation purposes, a suitable analyzer has a capital cost of $6000 (1992 USD). To give meaningful results, these devices must be periodically calibrated and otherwise maintained in good working order. Assuming that the equipment vendor were to set up shop somewhere in Eastern Europe, an annual budget of $600 should be sufficient for operation and maintenance.

(ii) ESP Performance Audit

With the imminent retirement of several of the oldest ESPs at Krivorozhskaya Power Plant, there is an excellent opportunity to upgrade the dust control systems on these 25-year old boilers. In addition, the somewhat newer ESPs are all candidates for upgrading to world performance standards. None of the ESPs at Krivorozhskaya Power Plant appeared to be working as well as they should in terms of resultant stack opacity.

The Krivorozhskaya Power Plant would benefit from technical assistance in the form of a person or persons knowledgeable of ESP troubleshooting strategies to work directly with Krivorozhskaya Power Plant personnel who would then be responsible for maintaining and operating the upgraded ESPs over the long term.

(iii) Develop a Suitable Coal Blend

The plant personnel should experiment with a blend of various available coals into a fuel which will burn effectively in the boilers in terms of thermal efficiency and reduced emissions. Rather than being tied to the properties of a single fuel, a suitable coal blend would allow continued use of local poor quality coals while potentially reducing emissions and improving plant efficiency.

(iv) Development (by Plant) of Boiler Startup and Shutdown Plans

Krivorozhskaya Power Plant should write and implement detailed plans for boiler startup and shutdown with the intent of minimizing emissions during those periods of operation. Details of minimizing emissions are best developed by the plant itself.

(v) Development (by Plant) of Malfunction Prevention and Abatement Plan

The Krivorozhskaya Power Plant should write and implement detailed plans for preventing boiler and air pollution control system malfunctions, to improve compliance with visible emissions standards at the stacks. Details of system operation and maintenance resulting in stable long-term performance are best developed by the plant itself. All power plants involve mechanical processes which can affect air pollution emissions. Anything which affects the delivery of fuel to the boiler, for example, must be working properly to avoid boiler upset conditions. A good example of a system to evaluate is a pollution control system, such as the ESP on each unit at Krivorozhskaya Power Plant. If something were to go wrong with the ESP, the immediate environmental impacts would be increased particulate and visible emissions from the stack associated with that ESP.

(vi) Five Continuous Opacity Monitors (one per stack)

Over the longer term, opacity monitors would be useful. Stack monitoring is an expensive but reliable method of demonstrating compliance with pollutant emission restrictions. Opacity (visible emissions) is monitored essentially as a surrogate parameter for dust emissions. Stacks equipped with continuous opacity monitors therefore enable plant and regulatory personnel to judge dust control effectiveness over the long term. For estimation purposes, each continuous opacity monitor has a capital cost of $250,000 (1992 USD). To properly operate, maintain and calibrate these units, one should budget $25,000 annually. This is a longer term investment, when the budget allows it

(vii) Opportunities for Demonstration Projects in SO_x INO_x Control

The plant's Environmental Department has been busy developing and evaluating strategies to address SO_x and NO_x emissions. With respect to SO_2 reductions, Krivorozhskaya plans to inject a lime slurry into the flue gas duct to achieve perhaps 85 percent removal of sulfur dioxide and make gypsum from the recovered wastes. For NO_x, the plant wants to phase in SNCR in the form of ammonia injection, since low-NO_x burners for coal-fired furnaces are not available in Ukraine or the former Soviet Union.

To implement these strategies, Krivorozhskaya Power Plant has considered three alternatives: complete and immediate replacement of all of the air pollution control equipment at the plant, including the installation of the new technologies; construction of a brand new 300 MW boiler with all new pollution control equipment for dust, SO_2, and NO_x; reconstruction of four boilers to be equipped with new pollution control systems, in combination with the sequential replacement of the remaining six boilers with new boilers equipped with new pollution control systems. Krivorozhskaya prefers the third option and plans to send a formal proposal to the MEP by year's end to seek approval to begin reconstruction; the plant believes that all of the boilers are nearing the end of their useful life.

Before a final decision on such investments is taken, it will be important to consider whether indeed expensive sulfur or NO_x control on power plants is a priority for pollution control in the country. That determination must consider whether emissions from power plants are significant contributors to local ambient pollution or not. If not, then the priority should be to send scarce resources first on those sources contributing to ambient pollution with its local health impact. Nevertheless, it would be useful to go ahead with some demonstration projects to acquaint Ukrainian engineers with these technologies.

(a) Selective Non-Catalytic Reduction (Urea Injection)

The power engineers at Krivorozhskaya Power Plant have expressed an interest in applying a selective non-catalytic reduction (SNCR) technology to one or more of their existing coal-fired boilers. They have investigated the ammonia-based process. Instead, they should seriously consider the urea-based system. Urea has several advantages over ammonia from a handling point of view, and the urea-based system has been shown to be significantly more flexible than the ammonia-based system in terms of the range of flue gas temperatures for effective operation.

The urea technology can reduce up to 60 percent of flue gas NO_x resulting from coal combustion. A wall-fired pulverized coal boiler at Wisconsin Electric's Valley Power Plant in Milwaukee recently completed a successful demonstration of this SNCR technology, and several coal-fired boilers in Germany have successfully applied urea injection as well.

The capital costs of SNCR are estimated to be $10-12 (1992 USD) per kilowatt of generating capacity. The annualized operation and maintenance (O&M) costs are estimated to be $400 (1992 USD) per ton of NO_x removed. For one 300 MW boiler at Krivorozhskaya Power Plant, this would mean $3 - 3.6 million in capital cost plus $1.2 million annually for O&M. A 60 percent reduction from one existing boiler would amount to about 3000 tons of nitrogen oxides.

(b) Duct Sorbent Injection for Sulfur Dioxide Emissions Control

The power engineers at Krivorozhskaya Power Plant have also expressed an interest in applying a scrubbing technology to one or more of their existing coal-fired boilers to achieve 85 percent SO_2 removal. They have investigated using a lime slurry for this purpose. Dry limestone duct injection has been successfully applied in the U.S. when more modest reductions (e.g., 50 percent) are appropriate. Some technical assistance from abroad would probably be useful, especially for the dry sorbent injection strategy. This plant is a good candidate for this technology since its Environmental Department has demonstrated an ability to be both innovative and aggressive in terms of reducing emissions from their boilers. The successful application of dry sorbent injection for SO_2 control would be very important for Ukraine because it is very cost-effective and since so many of the fuels burned at the thermal power plants are relatively high in sulfur.

Perhaps two person-weeks of technical assistance would be sufficient to enable Krivorozhskaya Power Plant to apply limestone injection to reduce SO_2 emissions. The costs of this technology would be very similar to those of SNCR, both in terms of capital cost and O&M.

(c) Demonstration of Fluidized Bed Combustion Technology

Several times during the visit to Krivorozhskaya Power Plant the Director stated that it is time to begin plant reconstruction, that the boilers are "nearing the end of their useful life". After all, the first units were designed in 1960 and commissioned in 1965. This plant, is an excellent candidate for new boiler technology to replace at least one of the out-of-date boilers now ready for retirement.

Fluidized Bed Combustion (FBC) might be an option to replace one or more of the existing Krivorozhskaya boilers because this technology can handle a wide variety of coal types and grades, and because substantial SO_2 reduction may be easily achieved at the bed. In this way, Krivorozhskaya could continue to burn the local coals in an environmentally acceptable manner. Krivorozhskaya's use of FBC would also represent a demonstration of a new technology for Ukraine, a country with vast reserves of coal and limestone and a tendency to assign low-grade fuels to the power plants. A major concern with FBC, though, is the waste it generates. This would have to be considered in comparing options for the future.

ANNEX 6: PROTECTED AREAS: DESCRIPTIONS AND RELATED INFORMATION

A. Danube Delta--Ukrainian Part

1. The Ukrainian part of the Danube Delta (some 225,000 ha) is located in the southwest part of the Odessa oblast. The major part of the delta area is in Kiliya raion. The largest of the three branches of the Danube flowing through the delta is the Kiliya, with 70 percent of the total flow; it serves as the border between Ukraine and Romania. The delta region encompasses a large number of large and small islands, marshes, a maze of tributaries and canals, lakes rich with aquatic plants, and a mosaic of forests, grasslands and dunes in the wetland area. Islands in the Danube Delta are very low, with marshes and reed beds. Within the last 10-20 years, a new generation of islands has been formed (Kuban islands), and in the Black Sea, some new islands called Kuril islands are still emerging.

2. Annual precipitation is 370-380 mm; humidity is 75-80 percent. Evaporation is about 900 mm per year. The cold period lasts 120 days and the warm period (average daily temperature above 5 c) 245 days. The average temperature in July is 23 C, the maximum 39 C; in January, it is -5 to -1 C, the minimum -15 C. Snow may fall at the end of December and stay on the ground for 20-30 days. There are two major flood periods -- one in spring-summer and another in autumn. When the water level is high, up to 95 percent of the delta may be covered by water. The interior part of the delta accumulates annually up to 2.23 million m_3 of water. Most of the lakes in the delta have fresh water and low salinity. Some of them are used as a part of the Danube-Dniester irrigation system. Lake Sasyk has been transformed into a reservoir for fresh water for irrigation, although it is not operating as effectively as planned.

3. Four major types of soils are common in the Danube delta area: marshy soils (the major type); peat bogs; peat-marshy soils; and soda saline peat bogs. Vegetation in the Danube Delta area is very diverse. In a relatively small territory there are six major types of vegetation complexes. Grassy cattail-reeds constitute the majority of the Danube Delta vegetation types.

The Reserved Area and its Management

4. The Ukrainian natural reserve "Dunayskie Plavni" (Danube's wetlands) is located in the Danube "avandelta", near Vilkovo. The area is the youngest part of the Delta, formed perhaps 150-200 years ago, and is changing rapidly as new islands and land formations develop from accumulations of silt. It is an area considered one of the richest in wildlife in Europe. The total area of the Dunayskie Plavni reserve is only 14,851 ha along the Black Sea coast, including 9,251 ha of land and 5,600 of water.[1] The reserve

1/ In contrast, the Romanian biosphere reserve in the Danube Delta is over 591,000ha.

was formed by a decree of the Ukrainian Council of Ministries on April 23, 1981. It had previously been a branch of the Black Sea reserve.

5. **Flora and Fauna.** Flora of the Dunayskie Plavni (DP) reserve consists of 563 plants, or about 11.4 percent of Ukrainian flora. There are some unique flora complexes in this area, formed by Hippophae rhamnoides L., which on the territory of the DP reserve constitute probably the biggest area of the whole Danube Delta. There are some other rare species on the territory of the reserve such as Trapa natans L., Nymphaes alva, salvinia natans L., Orchis palytris, Leucojunt aestivuns.

6. Fauna of the DP consists of more than 5,000 species. Birds nesting on the territory of the DP consist of 67 species, while about 225 species are observed on this territory during the year. This factor was one of the major reasons for the creation of the Dunayskie Plavni reserve. At present, some of the rare species are the pygmy cormorant and the red-breasted goose. The Danube Delta contains most of the world population of these two endangered species. It also has more than 50 percent of the palearctic breeding population of the common pelican and about 5 percent of the world's dwindling number of Dalmatian pelicans.

7. Mammals of the Danube Delta are represented by 25 species, including otter, mink, little ermine, wild cat, fox and hare. Ichtyofauna is represented by 92 species, belonging to 32 families. There is strong evidence that some of the species are in significant decline due to pollution and overfishing. For example, beluga (white sturgeon) in the past typically weighed about 500 kg, while today they average no more than 200 kg.

8. **Management.** The Reserve Authority, operating out of the town of Vilkovo, has a total of 15 people working in the reserve including 6 scientific researchers, 4 guards and 5 administrative employees. Its budget in 1989 was 88,700 rubles. The Reserve Authority has control only over the land, not over the water because of historical water rights of Vilkova fisherman (see para. 12). The currently protected area is presently unpopulated except for some summer cottages, although some of the inhabitants of Vilkovo have established small orchards and vegetable gardens in the area, and there is some cattle grazing. The Reserve Authority is currently operating as a small research body, with little in the way of a management function.

9. The intention of MEP is to transfer the reserve authority to the direct jurisdiction of the Ministry and eventually to declare a much larger area of the delta a National Park (140,000 ha), divided into a highly protected area, a buffer zone, and a larger protected area for which a management plan would be prepared. The proposed national park would be a part of a biosphere reserve which would include wetlands of Danube and Prut and such lakes as Katlabuh, Kagul, Kartal, Kugurluy, Yalpug and Kitay, with the total territory of about 250,000 ha. But this project is unlikely to be realized in the near future because of scarce resources. There are some moderate proposals to enlarge the present territory of the reserve to 30,000 ha and make it one territory with different zones.

Population, Industry and Agriculture in the Kiliya Raion

10. The area of the Kiliya raion is 1,400 km^2 with a population of 68,500 people, including rural population of 32,000. Population density is 48.9 persons per km^2. In Vilkovo, agriculture is the principal economic activity. There are 11 collective farms, 3 fisherman collective farms, and 5 state farms which have titles for 69,600 ha of arable land, including 60,000 ha of irrigated land. Rice plantations cover 5,500 ha. There are 20 enterprises in the Kiliya region which provide employment for about 14,400 people.

11. Kiliya is an administrative center of the raion, located on the left bank of the Danube with a population of 25,500 people. There are 14 industrial enterprises in Kiliya, 8 construction companies and 5 transportation facilities. The biggest and most important of these enterprises is the Kiliya port and ship repair factory. The Kiliya port is able to work with all major types of ships, cargo and passenger, sea - and river-going. It is the location also of one of the biggest collective fish farms in the area, involved in fishing in the Danube river, the Delta and Kitay lake. This enterprise combines fish breeding and fish ponds with some food processing. It is considered to be the major opponent of enforcement of a totally protected regime in the Danube Delta area, especially in the Dunayskie Plavni reserve.

12. Vilkovo is the second town in population (10,500). It is situated in the delta on hundreds of small island. After the Russian-Turkish war of 1878, the people of Vilkovo were granted rights to all waters in the Kiliya branch and small farms between islands in the delta for fishing free of charge and in perpetuity. There are now about 450 fisherman in the Vilkovo collective fish farm. These fishermen claim that enforcement of a strict regime of nature reserve will significantly decrease their catches and their losses will exceed krb 60 million. They have steadily increased their fishing in the Delta area which, in the judgement of some experts, has created overfishing problems. This collective farm provided information to the authorities in Kiev which shows that in 1986 they caught 400 tons of herring, 6 tons of sturgeon and 500 tons of other species, indicating a nearly twofold drop in catch in ten years. Fishermen are still conducting intensive fishing on the territory of the DP reserve. The reserve authority estimates that intensive fishing (year round with 177 boats and 4 permanent warehouses on the islands of the delta) creates the biggest threat to birds and fishes of the reserve territory.

13. Another major threat to the delta ecosystem is intensive irrigation. Based in Vilkovo, enterprises belonging to the Danube-Dniester irrigation trust are responsible for digging a 14 km long canal from the Danube to Lake Sasysk through the very rich Zebryanskie Plavni, cutting it into two parts. There is also a fish producing plant, a ship repair factory, and a special enterprise responsible for producing nets for fishermen. The local population in Vilkovo uses islands in the delta for small scale orchards, vegetables, vineyards and cattle breeding. Some of the cattle are brought to the islands and left there during spring and summer and slaughtered on the islands in the fall. These animals are brought to the islands without authorization from the DP reserve authority and can move from unprotected territories to protected ones because there are no fences between them.

Organizations involved in Monitoring the Ukraine Danube Delta Area

14. State Inspection on the Black Sea Protection enforces the Law on Environmental Protection of Ukraine and has the authority to stop all activities which are illegal. However with very scare resources and lack of equipment, it is very difficult to do so in practice.

15. The Danube Delta and the Danube itself have been investigated by the following institutions:

(i) **Institute of Hydrobiology** conducts research on hydrology, biology and pollution, especially dealing with irrigation. It previously had a stationary base in Vilkovo which was transferred to the DP reserve.

(ii) **Institute of Biology of the Southern Seas** has been responsible for the reserve. Its scientists have conducted various studies and collected materials on flora and fauna. The Institute was one of the initiators of the "national park" concept.

(iii) **Hydromet** monitors water quality at some points on a daily basis, others weekly, and still others seasonally.

(iv) **The Institute of Botany and Zoology of the Academy of Sciences of Ukraine (Kiev)** is responsible for flora and fauna surveys of the DD.

(v) **The Southern Center of the Academy of Science in Odessa**, through its local institutes and some branches of Kiev institutes, provides assistance in expeditions and local facilities.

(vi) **Odessa University, Kiev University and University of Chernovtsy** are also working in this zone, undertaking soil and landscape research, geology, climate and hydrology research.

(vii) **Some NGOs, like the Institute of Geoinformatics**, also participate in related research, sometimes in cooperation with the Ukrainian center of the Ecology of the Sea, which previously was responsible for research in the Black Sea.

(viii) **Ukrainian Center of the Ecology of the Sea**, now under the umbrella of the Ministry for Environmental Protection, together with the Kharkov Water Research Institute, was involved in US-USSR activity on environment and was one of the leaders in setting water pollution standards for the former Soviet Union.

B. Description of Selected Other Ukrainian Reserves

16. Information for the short reserve descriptions that follow has come from translation of short descriptions published for each reserve. A more detailed description can be found in a volume of the six volume Zapovedniki SSSR series (Zapovedniki Ukrainy i Moldavii 1987 edited by Sokolov V.E. and Syroeckovskii E.E. "Mysl" publishers Moskva). This publication details for each reserve:

- the history of survey and establishment
- the physical geography
- ecosystem characteristics

- flora and fauna with special attention to rare species
- monitoring and research activities.

Askanya-Nova

17. The Askanya-Nova reserve, located in the Chaplinsky region of the Kherson area, is the oldest reserve in Ukraine. It was set up at the end of the 19th century by the former owner of the F.E.Falts-Fein estate. He managed the establishment of a botanical garden and zoo, and the steppe area aimed for economic activities. In 1919 Askanya-Nova was proclaimed a people's reserve park; in 1921 it was designated as the first state reserve in Ukraine; and in December 1984, according to the resolution of the UNESCO Coordination Council, it was assigned the status of biosphere reserve. The total area of the reserve is 33,307 ha, which includes a strictly protected reserve nucleus (virgin steppe) of 11,954 ha.

18. The reserve is the natural standard of dry steppe. It ensures the conservation and studies of the unique virgin feather-grass steppe area with dominating turf cereals, various sedges, and wormwoods. The reserve protects more than 450 species of upper plants, including 50 endemics, and more that 8,000 species of fauna, specific for genuine feather-grass steppes. The territory of the Great Chapel Hearth of the reserve houses 50 species of animals from all over the world.

Rastochya

19. The Rastochya reserve of 2,085 hectare is located in the forest-steppe biogeographic region. It is part of the watershed of the Black and Baltic Sea basins and is situated on the spurs of the podol'skaya upland. Characteristically flat-topped hills in the reserve, from 380-390 m, are cut by river valleys with a system of post-glacial lakes. This small reserve contains a sample of all basic forest types of Ukraine. It is at the northeast boundary of the European beech and silver fir forests as well as the southeast boundary of the pine forests. Soil type varies greatly, from very poor to transitional and limited areas of fertile loams.

20. A research center is active there. Part of the research activity involves researchers invited from educational and research institute, in Lviv and Kiev as well as research undertaken by contract. Many research activities are designed to provide practical training of senior students of biological, geographical and forestry institutes. The inventory of flora and fauna is the first phase of research and, as in all the reserves, yearly annals of nature are prepared. Studies are underway for the 26 Red Book species held in the reserve, such as: the forest lily, butterfly orchid, spotted orchid, snowdrop, stiff club moss and common lambseccory. Of note is the white tailed eagle and a breeding site is located on the reserve. Black storks are also found in the reserve.

21. The protected zone adjacent to the reserve holds the Ivano-Frankivsk training forestry farm, the Shklo forestry area, and artificial ponds of the Lviv regional fish factory operate. The forests are designated as type 1 forests with strict limitations on economic activities. The reserve also functions as an ecological education center and a museum has been created. It presents the specific features of the reserve and region and to some extent the whole protected area system. Unlike a national park, access to the reserve is for staff only and outside research activity is strictly controlled.

Ukraine Steppe Reserve

22. The Ukrainian Steppe reserve of 2,755 hectares is composed of four discrete areas. One of these, the Khomutovsky steppe, is the largest integral site of fescue-stipa steppe in Europe. Taken together with the Lugansky and Askanya Nova reserves, these areas are significant in preserving a representative sample of plants and animals of the steppe. There are more than 900 species of the higher vascular plants in the Ukraine Steppe reserves, 40 of which are seldom found outside the reserves and 20 are recorded in the Red Data Book. Examples include centaiurea taliev, white pseudolamellar centaurea, alpian woodsia, spear leaf witch grass, bare yarrow, Schrenk tulip, granite tulip, narrow-leaved peony and 6 species of spear grass. The reserves contain the habitat of dozens of rare species of mammal, fish and waterfowl. Five of these species are included in the Red book including the steppe viper, eared hedgehog and marbled polecat. During transmigration the steppe eagle and the war eagle can be observed in the reserves.

23. Two of the four areas, the Khommutsky steppe and Kamenny mogilly, occupying only 1500 hectares, include 60 percent of the plants recorded for the northern Azov area. These areas also contain many species endemic to the Azov zone including feather grass, rough spear grass, "deceitful" spear grass, Azov spear grass, Azov kleistogena, Azov bluesem, Azov star of Bethlehem and eight species of fern, two of which are relics and are most often found in forest zones.

24. Research is the principal activity at the reserve. Researchers located at the reserve, and in cooperation with several institutes of the Academy of Sciences, have published extensively. One significant program (on the comparative ecology of the structure and functional relations of the abiotic and biotic components of the steppe ecosystem) resulted in many publications including "Soil and Biogeocoenotic Studies in the Azov Region" (1975, 1976,1978).

Yalta Mountain Reserve

25. The Yalta reserve comprises 14,584 hectares. A large part is covered by Crimean pine forests which are only found in the southern mountain lands of Crimea. The flora of the reserve include 65 percent of all species growing in mountain Crimea: species from a number of rare forest ecosystems, such as high juniper and Sudak, and 1,363 species of vascular plants. 256 species of medicinal plants are found here, as well as Red Book species such as European yew, narrow leaved peony, Crimean peony, red cephalanther, small spotted orchid and narrow-leaved saffron. The reserve forests are part of the watershed which supplies the numerous resorts and populated areas of the resort region of Bolshaya Yalta.

26. The fauna of the reserve is diverse. The 274 species include 30 species of mammal, 113 birds, 11 species of reptiles, 4 amphibians and 19 species of Lepidoptera. The Red Book lists 7 species of mammal which are present in the reserve. These include water shrew, greater horse shoe bat, Geoffrey's notch eared bat, Natterer's red grey bat, common barbastelle, lesser noctule and Kuhl's pipistrelle. Five bird species are also present and are Red Book-listed.

Lugansky

27. The Lugansky reserve (1,575 ha) comprises three different landscapes. The Stanichno-Luganskoye area (494 ha) is located in the alluvial plain of the Severskodonets River and contains seven flood plain lakes. The forest is typical steppe-oak with broadleaves, and terraces above the bottom land contain pine species. Mixed oak groves alternate with alder scrubs, poplar groves and osier beds and flood plain meadows. Altogether, 631 higher plant species from 81 families are found in this part of the reserve.

28. The Streltsovskaya steppe landscape (494 ha) is located in the Melovsky region. No natural forests are to be found here, and the vegetation cover is represented mainly by cereals such as feather grasses, sheeps fescue etc. There are 556 species belonging to 59 families; this part of the steppe is habitat to grey hare, urchin, fox weasel and wild boar. The Provalsjaya steppe (587 ha) is located in the Sverdlovsky district. Besides steppe it contains ravine forests. There area 729 higher plant species with several relic and endemic species.

29. Taken as a whole the reserve areas contain 15 Red Book species and 83 of 232 species recommended for sanctuary preservation of the southeastern flora of Ukraine. The current decrease in the water available for the Donets floodplain has caused a dramatic modification of habitat for many species. Otters, European mink and raccoon dogs are therefore limited to the reserve. One important endemic species is the European baboc. The main activity undertaken at the reserve is research by both reserve personnel and from the institutes of the Academy of Science.

Kardazsky

30. The reserve is located in the southeastern end of the Crimean peninsular in the Sudak district and has an area of 2877 hectare, 72 percent of which is dry land. The Jurassic geology of the area results in a unique combination of fauna and flora. Over 1,040 plant species grow in this area and many of these are relict, endemic or rare. These include the Greek juniper, wig-tree, Shrenk tulip and turkterebinth pistache. The reserves fauna include 12 species of amphibians and reptiles, 157 species of birds and 29 species of mammals. Some 10 species of fauna present in this reserve are listed in the Red Book.

31. The waters included in the Karadag reserve contain 160 marine plant species or about 60 percent of the number of species found in the Black Sea. 70 species of fish, 9 species of coral snake, 140 species of Crustacea, 92 annelids and 81 species of mollusks make this part of the reserve biologically significant.

Polessky

32. The reserve is located close to large scale land reclamation carried out in the decade form 1960. It is a representative sample of the forest-bog complexes which were previously much more extensive in the region. The 20,100 hectare reserve is characterized by lichen pine forests on poorer soils, birch forests and by mixed forests and flood plain oak groves. 86 percent of the area is forest but this interspersed with bog communities (oligotrophic, mesotrophic and eutrophic).

33. Polessky reserve plays an important role in the preservation of the regions gene pool. There are 603 species of vascular plants 11 of which are listed in the Red Book. The fauna is diverse with rare species such as the black stork, 140 species of birds, 30 species of mammals, 8 species of amphibian and

7 species of reptiles. Research in the reserve is mainly aimed at studying the effects on the ecosystems by land use changes outside the reserve which markedly affects the water regime.

Cape Martyan

34. This small reserve of 240 hectares includes the rocky cape and an equal area of sea. The vegetation can be described as a Mediterranean relict and is typical of the coastal zone of the dry subtropical region. The nature protection department of the nearby Nikitsky Botanical Garden manages the reserve. The reserve contains 500 species of higher vascular plants (about 20 percent of Crimean flora) and 200 species of fish. 40 species of flora and fauna are included in the Red Data Book. Personnel of the reserve are active in developing a network of reserves adjacent to Cape Martyan and to date 1,550 hectares has been reserved as natural monument, botanical reserve or landscape reserve.

Black Sea Biosphere Reserve

35. The Black Sea Biosphere Reserve located in southern Ukraine has a core protected area of 57,000 hectare. The reserve plays an important part in the conservation of ornithological fauna, and part of the reserve has been nominated by the government as an internationally significant wetland site according to the requirements of the Ramsar Agreement. The reserve covers dry land forest steppe and coastal areas, the islands of Tendra, Orlov, Smaleniy, Babin, Dolgiy, Krugliy, and Konsky and part of the Djarylagatchsky and Yagorlitsky bays of the Black Sea (see description under RAMSAR sites).

36. Dramatic changes have taken place over the sixty years of the existence of the reserve. For example the population of black headed gulls was only 18,916 in 1935 and in 1983 this rose to 360,000 pairs. The common eider, ringdove, blackbird are now found in the reserve. The plant and animal life of the reserve is very rich. There are more than 700 species of higher plants, some 70 species of fish and 44 species of mammal. The reserve has a museum which is visited by 3,000 people every year.

Carpathians Biosphere Reserve

37. The Ukrainian Carpathians preserve some unique Central European areas of beech and spruce forests which are of great significance for studying the development history of the East Carpathians vegetation. The first reserve of beech and fir-beech forests was created in 1932 on the Stuciza mountain slopes. Since that time the reserve has been enlarged to 2,952 ha and included in the Ukrainian Carpathians Biosphere Reserve (CBR). The CBR was created in 1991 with a total area of 38,930 ha which is subdivided into a reserve zone (21,879 ha), a buffer zone (8,949 ha), and a nature management zone (8,071 ha). The reserve zone includes the Stuzica scenic reserve, and four separately located forest areas. These areas are the Khust forest, the Uglya-Shyroky Lug forest, the Chernogirs'ky forest and the Maramorosky forest.

38. The Stuzica Reserve is located on the border with Slovakia and Poland at a range of between 770 to 1269 m (ASL). Flora of the reserve forest includes over 500 species of vascular plants many of which are rare, such as: Atropa belladonna, Arnica montana, Astrantia major, Helleborus purpurascens, Streptopus amplexifolius, and Telekia speciosa. In this region the beech is characterized by high vitality and has a wide altitudinal range (500-1260m). The sub-alpine meadows occupy small areas with the most

typical species being Nardetum strictae and Vaccinetum myrtillae. The most typical representatives of the fauna are Felis sylvestris, Coronella austrialis, Elaphe longissima, Apatura iris and Rosalia alpina.

39. The Khust Reserve Massif is a small area of forest (256 ha) is the largest European locality for the narrow leaved narcissus. The forest is at 180-200m ASL. In addition to the narcissus there are many other rare plants in particular: Dactylorhiza majalis, Erythronium dens-canis, Gladiolus imbricatus, Iris sibirica, Orchis laxiflora, Potentilla alba and Leucojum vernum. The typical fauna representatives include: Iphiclites podalirius, Eudia pavonia, Papilio machaon, and Proserpinus proserpina.

40. The Uglya-Shyroky Luf Massif (10,350 ha) is located at elevations ranging from 400 to 1280m on the Polonya ridge. The beech forest extends to 1280 m. Although the majority of the ridge is flysch, a limestone ridge is contiguous with the flysch on the south side. This limestone ridge results in specific flora and fauna associated with caves in the karst system. The forest contains about 550 species of vascular plants. The notable species associated with the limestone include Taxus baccata, Juniperus sabina (unique in Ukraine) and Quercus petrea. Herbaceous plants also represented here include Erythronium dens-canis, Cortusa mattioli, Iris graminea, Sedum hispanicum, Coronilla varia, Jovibarba pressiana, Corallorhiza trifida and Orchis morio. Significant fauna species include Thymallus thymallus, Salamandra salamandra, Ciconia nigra, Faleo preregrinus, Bubo bubo, Srix uralensis, Dendrocopos leucotos, Rhinolophus hipposideros, Myotis emarginatus, Barbastella, Meles meles, Aglia tau and Endronius versicolor.

41. The Chornogirsky Reserve Forest lies on the Chornogorsky ridge at elevations from 800m to 2061m. It has seven identifiable plant profiles associated with elevation. These are (from the bottom) Fagetum sylvaticum, Acereto pseudoplatani-Fagetum (fragmentary association), Piceeto-Abieto-Fagetum, Fageto-Abieto-Piceetum, Piceeto-Abietis and elfin woodland with pinus mugo, Duscheka viridis and Juniperus sibirica. The forest flora numbers more than 700 species of particular note are Saussurea alpina, Polygonum viviparum, Senecio carpaticus, Gentiana punctata, G. acaulis, Aconitum nanum, Pulmonaria filarszhyana, Leontodon croceus and Rhodendron kotschyi. Spruce is the dominant forest type (Piceetum oxalidosum, P. myrtillosium, P. polytrichosium). The sub alpine level of plants widely represents climatic communities such as Mugeta, Duschekieta viridae, Junipereta sibirica. As far as rare communities are concerned it is worth mentioning Rhodoretum kotschyi, Salicetum herbacea, Doronicetum capatici, Juncetum trifidi and Caricetum sempervirentis.

42. Fauna comprise many rare and commercially valuable species such as Triturus montandoni, T. alpestris, Circus cianeus, Aquila chrysaetos, Tetraeo urogallus, Glaucidium passerinum, Prunella collaris, Sorex alpinus, Chionomys nivalis and Callimorpha dominulla.

43. The Maramorosky Reserve Massif has a total area of 3,970 ha with well defined glacier cirques at the higher elevations. The slopes of the cirques are covered with thickets of Pinus mugo and Duschekia viridus. The geology includes schists, gneiss and marble-like limestone of the Jurassic period which determines the vegetation and to some extent the fauna. The flora is noted for such species as Campanula carniolica, Cardaminopsis neglecta and Anemone narcissiflora. The herbaceous sub alpine level can display a number of rare species such as Gentiana lutea, G.punctata, Sempervivum montanum, Anthemis carpatica and Poa deyli. The forest fauna shows a number of peculiar features as well. Present are Tetrao urogallus, Bubo bubo, Neomys anomalus, Mustela lutreola, Lutra lutra, Felis sylvestris, Lynx lynx and Lucanus cervus.

44. Surrounding each of the reserves are buffer zones which decrease the impact of human induced activity on the protected areas by restricting the extent and nature of some uses. As a result of a recent agreement between Ministers of Environment for Ukraine, Poland and Slovakia, plans are underway to develop a tri-national biosphere reserve. This international reserve would include expansion of the Stuciza reserve and the creation of a national park. The table below indicates the preliminary areas in Ukraine identified for the international reserve. Considerable investigation and preparation is required to make the proposal a reality.

Proposed Eastern Carpathians Tri-National Biosphere Reserve

Country	Reserve	Area (ha)
Ukraine	Stuzice National Park (presently 2,000 ha)	14,300
Slovakia	Vychodne Karpaty - protected landscape park (future national park)	40,601
Poland	Sau River Valley Landscape Park Cisna-wetlina Landscape Park Bieszcardy National Park	35,635 46,025 27,065
	TOTAL:	**163,626**

C. Wetlands Formerly Registered Under RAMSAR

45. Internationally important wetlands in Ukraine were identified and accepted with the USSR becoming a Contracting Party to the RAMSAR convention in 1976. Ukraine has yet to become a signatory to the convention. Set out below are descriptions of the areas previously accepted as RAMSAR wetlands. It is understood that even though the Ukraine Government has not entered into the convention, that for al intents and purposes the management of the areas is still consistent with their international significance.

Sivash Bay

46. The Sivash bay Ramsar site is situated between Genichesk and the north-east coats of the Crimea peninsula on the sea of Azov, Kherson district. An area of 45,700 ha is included, 22,400 ha of which is water. It was designated as a Ramsar site in 1976. The bay is largely isolated from the sea of Azov by the Astrabatskaya Strelka. The shallow saltwater bay (up to 3m in depth) has an indented shoreline and contains several spits and islands, some originally part of the mainland. The water level fluctuates according to the prevailing wind which exposes the shallows. These shallows become subject to intense evaporation in summer, followed by wind erosion. The generally salt and windswept coastal area is covered with a holophytic sword. The site includes two alluvial islands on which desert/holophytic steppe scrub and halophilous meadow vegetation predominate. High salinity confines the aquatic flora and fauna

to salt tolerant species. Their high productivity under the eutrophic conditions forms a valuable food source for birds.

47. This wetland is of international importance for nesting, molting and migrating birds. Numerous ducks (*Anatidae*) and waders (*Charadriiformes*) migrate through the area including shelduck *Tadorana tadorna* (2-10,000) and ruff *Philomachus pugnax*. There are 17,000 nesting birds of 20 species including shelduck, great black-headed gull *Larus ichthyaetus*, Mediterranean gull *L. melanocephalus*, herring gull *L. argentatus*, sandwich tern *Sterna sandvicensis*, little tern *S. albifrons* and caspian tern *S. caspia*. It is one of the principal molting sites in the former USSR for mute swan *Cygnus olor* (3-4,000) and shelduck (2-3,000).

Karkinitski Bay

48. Karkinitski bay is situated in the northwest of the Crimea peninsula opposite Sivash Bay, in the Crimean District. It has an area of 37,000 ha and was designated a Ramsar site in 1976. Most of the site comprises water less than 8 m deep to the north of the islands, and there is an extensive shallow coastal area (0.8-1.0 m). The coastline is indented with a number of small bays and several spits and islands within the main saltwater Karkinitski Bay including the Lebiaji Islands 100 ha (of great ecological interest). Several small islands are formed by shellfish colonies and the hinterland is mountainous. The vegetation is typical of the steppe bordering the Black Sea. Coastal vegetation in the bay is predominantly reedbeds of *Phragmites communis* with halophytes and grasses on sandy salty soil. These are vast water-meadows of aquatic plants such as stonewarts *Charophyta* spp. and eelgrass *Zostera marina*, with a rich zoobenthos. The vegetation of the islands consists of halophytes, steppe vegetation and reeds.

49. The bay is important for waterfowl in all seasons including up to 100,000 ducks (*Anatidae*) and waders (*Charadriiformes*) which pass through the area on their spring and autumn migrations. Spring flocks are dominated by whooper swan *Cygnus cygnus*, mute swan *C.olor*, greylag goose *Anser anser* and white fronted goose *A. albifrons*. Autumn flocks are dominated by ruff *Philomachus pugnax* and sandpipers *Calidris* spp. The islands are the site of a large seabird breeding colonies including herring gull *Larus argentatus* (65-68,000 pairs), Mediterranean gull *L. melanocephalus* (4-5,00 pairs) gull-billed tern *Sterna nilotica* (8-9,000 pairs), Caspian tern *S. caspia* (2-400 pairs), common tern *S. hirundo* (2-300 pairs), shelduck *Tadorna tadorna* (50 pairs) and red-breasted merganser *Mergus serrator* (50 pairs). There are specially protected colonies along the shore of little egret *Egretta garzetta* (50 pairs), great white egret *E. alba* (50 pairs), gray heron *Ardea cinerea* (100-150 pairs), squacco heron *Ardeola ralloides* (60 pairs) and glossy ibis *Plegadis falcinellus*. The bay is one of the most important summer molting grounds for non-breeding mute swan *Cygnus olor* (3-5,000). Over 50,000 birds winter in the area including whooper swan, sea ducks, freshwater ducks, coot *Fulica atra* and gulls.

50. The importance of the wetlands around the Dnieper delta are shown in the harvest of about a quarter million waterfowl. The viability of this resource is threatened because of pollution, irrigation withdrawals, and the five large dams on the Dnieper. Changes in the estuarine water and salinity balance, eutrophication from the rice irrigation and fertilization, have resulted in alteration of the benthic communities in the bays with losses in such critical macrophytes as the seagrasses of the genus Zostera which are critical, and in the case of some geese, biologically essential food sources.

Intertidal Areas of the Dounai, Yagorliski and Tendrovski Bays

51. The designated wetlands comprise several separate areas: the intertidal areas of the Dounai, detailed previously in the description of the Danube Delta; and the Yagorlitski and Tendrovski Bays (113,000 ha) 50-60 km south-west of Kherson in Nikolayev and Kherson districts. In the two bays, two extensive shallow water lagoons (up to 6m deep) are separated from the Black Sea by narrow sandy spits and small islands. The vegetation of the low coasts and islands is characterized by brackish and salt water associations with a predominance of saltwort *Salsola soda* and marshgrass *Puccinella* spp. On the steep sloping island shores, kelp lies among sparse reedbeds of *Phragmites communis*. Behind the shore, there is usually a strip of brackish marsh. Shallow water vegetation is characterized by large meadows of eelgrass *Zostera* sp. with tassel pondweed *Ruppia spiralis* and stoneworts *Charophyta*. The waters also support abundant benthos and fish including the small genus *Cottus*.

D. Selected Summary Data on Reserves and Species

Table 1: Reserves and Parks of Ukraine, January 1991

	Area (ha)	Agency Responsible	Annual Expenditure source (,000 krb) Total	State	Other	Employees Res/ Tech	Guards	Total
RESERVES								
1. Askanya Nova	11,312	Institute of Agricultural Research	1,089	980	109		21	162
2. Dinsakiye plavni (Danube Delta)	14,851	Academy of Science	74 5	37	0 5	6	5	15
3. Kanovsky	2,027	Min. High Education	270	220	50	14	14	76
4. Kardazsky	2,874	Academy Science	230	180	5	24	13	
5. Carpathians	19,899	Ministry of Forestry	458	-	458	17	51	133
6. Lugansky	1,608	Academy of Science	43		-	1	12	18
7. Cape Martyan	240	Academy of Agriculture	14.1	8.5	5.6	6	3	9
8. Polessky	20,104	Ministry of Forestry	199	157	42	3	22	67
9. Medobari	10,455	Ministry of Forestry	112	83	29	2	38	116
10. Rastochya	2,085	Min. High Education	219	206	13	12	16	56
11. Ukraine Steppe	2,755	Academy of Science	87	69	18	4	8	32
12. Chernomorsky (Black Sea)	57,048	Academy of Science	239	229	10	9	17	68
13. Yaltinsky	14,523	Ministry of Forestry	442	350	92	1	56	142
14. Dneprovsko-Drilsky	3,766	Ministry of Forestry	155		-	12	17	40
15. Crimea	44,175	Ministry of Forestry	540	420	120	5	85	153
NATIONAL PARKS								
1. Carpathians	50,303	Ministry of Forestry	1,167	-	1,167	4	134	436
2. Sinevir	40,400	Ministry of Forestry	455	-	455		82	364
3. Shatsky	32,430	Ministry of Forestry	428	405	23	2	45	106
BIOSPHERE RESERVES								
1. Askanya-Nova	33,307	Institute of Agricultural Research	Information not available					
2. Carpathians (nominated)	38,930	Awaiting detail	"					
3. Chernomorsky (Black Sea)	87,348	Academy of Science of Ukraine	"					

Table 2: Species Numbers in Protected Areas[a]

AREA	SPECIES PROTECTED		
	Mammals	Birds	Plants
RESERVES			
1. Askanya Nova	57	213	1,729
2. Dinsakiye plavni (Danube Delta)	22	212	563
3. Kanovsky	49	240	832
4. Kardazsky	42	200	1,100
5. Carpathians	50	141	898
6. Lugansky	43	151	1,037
7. Cape Martyan	288	146	500
8. Polessky	39	174	604
9. Medobari			
10. Poztochya	33	117	793
11. Ukraine Steppe	30	129	926
12. Chernomorsky (Black Sea)	44	300	624
13. Yaltinsky	33	91	1,363
14. Dneprovsko-Drilsky	16	15	11
15. Crimea	37	250	1,180
NATIONAL PARKS			
1. Carpathians	50	110	1,100
2. Sinevir			
3. Shatsky	30	219	825

a/ Adapted from Environmental Status Report Vol 3: USSR, IUCN East European Program, 1990.

Table 3: Lowland Grassland Types in Protected Areas[a]

NAME	Indicator Species	Grassland Type
1. Shatsky	Grus grus	
2. Lugansky	Anthus campestris Otis tarda G. grus Falco vespertinus Asio flammeus	Salt steppe
3. Ukrainian Steppe	Anthropoides virgo Melanochorypha calandra Circus macrourus F. vespertinus Sturnus roseus	Virgin steppe/Hay meadow
4. Sivash Saliv & Azovskoye More (Ramsar site)	A. virgo O. tarda	Virgin steppe/Hay meadow/grazed land
5. Askanya-Nova	A. virgo Tetrax Oenanthe Burhinus oecidemus	Virgin steppe (1500 ha)
6. Yagorlytski & Tendrovski Zalivy (Ramsar site)	A. virgo O. tarda T. tetrax Glareola pratincola Glareola nordmanni	Secondary steppe/Salt steppe
7. Kradag, Sudag	Falco sherrug	Meadow

a/ Adapted from: Table 11, Lowland Grasslands of Central and Eastern Europe, IUCN 1991.

Note: Not all of the above areas are included in nature reserves, for example the significant areas associated with the RAMSAR sites of Sivash Bay. Such areas carry a less strictly protected reserve classification. Information on the distribution of most animal species or plant associations of Eastern Europe is extremely limited; it is only on avifaunal distributions that widespread information is available. Bird species have therefore been used as indicators of the presence and type of grassland, and breeding species are shown. The information should be treated with caution as it is biased towards rarer or more noteworthy species.

Table 4: 1991 Game Population and Harvest Figures[a]

SPECIES	National		Lviv		Kherson	
	Pop	Kill	Pop	Kill	Pop	Kill
Moose	14,796	1,380				5
Red/spotted deer	24,925	1,083	2,240	86		2,731
Boar	59,800	7,354	3,050	555		1,593
Roe deer	172,300	7,390	9,300	404		2,488
Squirrel	60,000	0				600
Hare	1,960,000	351,000				161,000
Marten	33,000	28				
Fox	83,000					2,806
Muskrat	52,000					1,139
Mink/Ermine	1,310					
Beaver	7,600					
Wolf	1,450	563	57	37		
Bear	590	1 rogue				
Partridge						9,129
Ducks	4,100,000	1,552,000				236,000
Geese	239,000	21,000				20,000,000

a/ An account of aggregated numbers of game animals for the country, and the number harvested is given for 1991. These data are contrasted with figures from two oblasts in different parts of the country to convey some notion of the regional differences and variation to be found. The official error is +or- 10 percent, although an official in the Ministry for Environmental Protection noted that error is probably 20-30 percent. Note that the absence of a number does not imply that the animal was not taken, but rather that the data were not collected. Some interesting questions emerge, such as the absence of partridge from the national accounts, the heavy wolf take in Lviv Oblast, the presence of moose in the southern areas of Kherson, etc.

E. Geographic Information Systems (GIS)

52. GIS use spatial data which are displayed as "themes" (forest cover, pollution damage, threatened habitat, etc.) to analyze and display the solution to a spatial land management problem. GIS analysis can include, for example, the least cost siting of a logging road, areas of highest return on habitat development activities, dispersion of pollutants, etc. Such data are usually acquired through remote sensing of the environment from a platform such as a satellite, or aircraft. The aerial photographs or images of digital information transmitted from a satellite are then "processed" manually or statistically to make them meaningful for aiding the achievement of the goals of the project. Perhaps the greatest failures of GIS technology lie not in the technology but in the failure of the resource scientists familiar with the area of interest to review the image (ground truthing), and work with the computer scientist who provides the image and does the initial processing. Lack of precise communication at this point can lead to an expensive but useless product, whose categories are meaningless in terms of real habitat or forest types.

53. Forestry applications of GIS are increasingly common. Forest inventory, infrastructure, wildlife habitat, geotechnically suitable sites for extraction activities, and other themes can be overlaid. Likewise, the least expensive environmentally acceptable travelsheds can be spread over a compartment, silvicultural treatments allocated, and other analyses performed of use to foresters. Graphic output can include hard copy maps or digital files.

54. Other environmental applications of GIS, of particular use in the conservation of biological diversity, are emerging. One common problem is in inventorying valuable resources such as endangered species. Often they are fugitive, furtive, and their ranges are not fully known. One application of GIS involved assessing the impact (of roads) on a poorly located species (very similar to the black grouse). Field studies were conducted on twenty habitat variables, such as vegetation type, and distance from water, at the few known population sites. Statistical analyses revealed that only four of the environmental features contributed to the presence of the bird on its mating display grounds - the critical environmental requirement in its annual cycle. These four map variables were overlaid and the priority areas for habitat preservation were predicted over the whole forest. Furthermore, forest succession and encroachment due to effective fire control efforts were predicted, and the habitat losses due to the loss of mating grounds were also predicted for twenty years.

55. GIS was used to predict the impacts of poaching in a rich wildlife area, due to the siting of a mine nearby. Surveys revealed that people would travel up to two hours to recreate. A "travelshed" of two hours on three different grades of roads and trails was created by the GIS. The travelshed was overlain on key habitat and revealed that only 3 percent of the area described by drawing a circle of two hours travel at 80 kph (the traditional method) needed to be patrolled. The GIS analysis produced an efficient focus of effort and savings of project money.

System Selection

56. The acquisition of GIS will, to a degree, lock the user into the hardware and software system selected. It must be able to satisfy the requirements of the user while being adaptable to future needs and compatible with the systems of related users (and sources of data), such as national mapping agencies, and other resource agencies. Two key steps in determining needs are: inventorying the activities and

systems of other parts of government; and conducting a workload analysis. They lay the groundwork for making appropriate choices which will have a long-lasting effect. Specifically, the analyses should cover the following: current uses of spatial information; project future uses; and assessment of those uses which can be replaced by GIS. Specific questions include: how many maps are used for how long? how many users? are uses centralized or distributed? how many maps are created by the different uses? how many overlays? The answers will reveal system requirements, the supporting infrastructural requirements, and staff needs. The product will be a 5-year implementation plan with annual costs and proposed phasing.

57. The final contract for the system should include the training necessary before operations can be productive. Potential vendors will provide considerable ad hoc planning advice. It should be stressed that although the process will take several months and an initial expenditure, the savings from upfront planning should be considerable. Moreover, the entire process must be closely supervised by knowledgeable resource scientists and users (biologists and foresters), not only the providers (vendors and programmers). However, a well-planned GIS is a proven and essential tool in the kit of today's resource planners and managers. Use of GIS-aided impact assessment in analysis by the of the U.S. Forest Service has resulted in an estimated 75 percent saving of time and money over traditional manual methods.

Training

58. The system will not work without trained user/operators. There is no magic to acquiring the necessary skills, however, it is particularly useful if the users become operators; for example, the scientist will not always want to rely on a computer operator, who may be uninformed about the technical demands and logic of the biologist or environmental engineer, meteorologist, etc. There are several excellent centers which have the range of new equipment and the relevant resource scientists, who have taught novices how to use GIS. A working knowledge will take about 2 to 3 months of training. A complete facility will take about a year of working on actual projects. At least one of the trainees (there should always be more than one trained) should be good at dealing with the hardware and software maintenance and updating for the lab at the institution.

F. Requirements Under the Convention on Biological Diversity

59. The main provisions of the Convention call for the following actions:

- development of measures for conservation and sustainable use, including national strategies, plans and programs, and integration into relevant sectoral and cross-sectoral plans, programs or policies;

- identification and monitoring of processes and activities with adverse impacts;

- in-situ conservation through a variety of activities: establishment of protected areas; protection of ecosystems and habitats; appropriate management practices, legislation and financial support; ex-situ conservation through a variety of means to complement in-situ conservation;

- adoption of economically and socially sound incentives;

- establishment and maintenance of programs for research and training in conservation and sustainable use, as well as promotion of public education and awareness;

- introduction of appropriate procedures for environmental impact assessment and measures for minimizing adverse impacts;

- stipulation of conditions regulating a variety of aspects, including: access to genetic resources; access to and transfer of technology; exchange of information; technical and scientific cooperation; the handling of biotechnology and distribution of its benefits; financial resources and mechanisms; relationship to other Conventions.

ANNEX 7: OVERVIEW OF WATER QUALITY MONITORING

Surface Water Quality Monitoring

1. **Ambient water quality monitoring**. Monitoring of ambient water quality data is insufficiently target-oriented and inefficient. It consists of various systems originally designed for purposes other than developing baseline information for pollution control, planning and policy development. The number of different monitoring systems in operation and the lack of coordination among the agencies and institutions involved, has created a situation where some water bodies and sites are doubly monitored while others are not covered at all. There is not a good system of reporting to the environmental or health authorities when alarming water quality situations are observed. Better coordination and cooperation would make it easier to respond both to control requirements and strategic planning needs.

2. **Hydromet** works through a network of 244 hydrochemical "posts" of observation, covering 144 rivers, 7 lakes and 15 water reservoirs. The network was originally designed to study the natural water quality situation in the country. Consequently, the best coverage of sampling stations is in the Carpathian and Crimean mountains; the analyses focus on general chemical parameters like inorganic salts and minerals.

3. There are 4 categories of observation posts on the rivers:

(i) One station in the Donbass region with daily sampling of temperature, oxygen and conductivity.

(ii) Four stations in Kiev, Zhytomyr, Kirovohrad, and Donetsk, which are sampled every 10 days. In addition to the above mentioned parameters, Ph, suspended solids and organic material (BOD_5) are measured. Some other parameters such as chloride, ammonium, formaldehyde and phenol are measured dependent on the specific problem situation at the site.

(iii) 34 stations, most of them in oblast centers, are sampled every month. Detergents, chromium (Cr_6), asphalt, and mercury are measured in addition to the parameters mentioned above.

(iv) The rest, about 200 stations, are sampled 7 times per year according to phases in the hydrological regime of the river (peak flow, low flow, before flooding, before freezing etc.). About 50 parameters, mostly natural components like calcium, magnesium, sodium, potassium, kalium, sulphate and hydrocarbonate, are determined. In particular cases, some of the pollutant indicators mentioned above, together with some micropollutants such as pesticides and heavy metals are also monitored.

The monitoring in the reservoirs and lakes is similar to the river stations of category (iv), but the samples are taken only 4 times a year, on a seasonal basis.

4. The monitoring serves general information functions, but some linkage to environmental control and warning has been made. If the analysis shows figures more than 10 times the environmental standard, or the level of oxygen is below 3 mg/l in summer and 2 mg/l in winter, Hydromet will

immediately inform the MEP and the local municipal authorities. The same holds for samples with an unpleasant smell or oil film.

5. The **San-Epi stations** under the Ministry of Health carry out rather extensive water quality monitoring for purposes of assessing ambient water quality and control and providing guidance for water usage. This is reflected in the importance of microbiological parameters in the list of standards and in the monitoring program. Monitoring of ambient water quality is done infrequently. The oblast station in Dnipropetrovsk, for example,samples 58 stations 4 times per year. The number of parameters covered by the monitoring program vary with the administrative level:

(i) The local (city and district) stations have an analytic program for raw water and drinking water control, including assessment of general water quality conditions in the drinking water reservoirs. They also check the microbiological conditions at bathing beaches. The sampling and analytic program is designed to reflect local problems and conditions;

(ii) The oblast stations carry out more comprehensive studies of the quality of drinking water sources and water bodies used for recreational purposes. They are generally better equipped than the local stations and analyze for a greater number of parameters which partially overlap the local monitoring programs; and

(iii) The central San-Epi bureau conducts special studies, further strategic monitoring and general quality control of the regional and local monitoring activities.

6. The local offices of the **Ministry for Environmental Protection** do not conduct regular ambient water quality monitoring in rivers and lakes. The only information on general water quality collected regularly by the MEP is from samples taken 500 m upstream from registered discharge points. This is used to help determine the "allowable dilution" of discharges (e.g. MAD). Ambient quality figures used for assessing background water quality (for purposes of running the dispersion model) are normally provided by Hydromet. As mentioned above, though, the Hydromet monitoring network is not particularly well designed for evaluating pollution problems. For example, the Inhulets river, which receives considerable discharges of wastewaters from Kryvyi Rih, is insufficiently monitored.

7. Many institutes and organizations have been involved in monitoring activities and studies in the Black Sea. The Ministry for Environmental Protection has set up a unit for **State Inspection on Black Sea Protection**, with duties similar to the local and regional MEP offices. This unit, in cooperation with the Ukrainian Center of the Ecology of the Black Sea, carries out water quality monitoring and pollution control in the Ukrainian sector of the Black Sea. Also, the regional network of the Ministry of Health monitors some of the coastal areas, in particular aimed at water quality of the beaches.

8. Some of the institutes under the auspices of the **Academy of Science** have programs for water quality assessment and registration. The Institute of Hydrobiology, for instance, does regular studies of the algae composition and eutrophication development in the Dnieper reservoirs. However, the purpose of these studies is primarily research and ad hoc needs; access to this data for management purposes has proven limited. The scientific institutes have also shown interest in the design and development of monitoring systems; an automatic water quality monitoring system has been proposed by the Academy. There are also some regional and local initiatives from the scientific community for introducing some

rather ambitious automatic monitoring systems, for instance in Kryvyi Rih, but none has moved beyond the planning stage as yet.

9. **Recommendations for Changes.** Almost all monitoring is at present focused on raditional physical and chemical analysis of the water itself. This method makes it difficult to detect the level of exposure to micropollutants, such as heavy metals, pesticides, and chlorinated hydrocarbons, which are dangerous even in very low concentrations. Such pollutants, which it is suspected are commonly present in Ukrainian water bodies, should be monitored by analyzing biological indicators and sediment samples. Many of the micropollutants concentrate in the tissue of water organisms such as stationary fish, mussels, water mosses etc. and can be analyzed from such samples. Similarly, such persistent toxic elements settle in the bottom sediment of lakes, reservoirs and slow flowing river stretches.

The following steps are recommended:

(i) The structure of the water quality monitoring system should be reshaped in order to focus more on pollution control and environmental planning. A revised system--defining the network of sampling stations, sampling frequency, parameters monitored at each particular point, level of automatization, etc.--needs to be designed with a view to cost-effectiveness. The new system should try to coordinate the needs and purposes of all the existing water monitoring systems, at least with regard to ambient water quality monitoring. It might be possible to organize the new system using Hydromet's existing network.

(ii) The monitoring system should be expanded to include biological indicators. Simple ecological surveys should be carried out in the receiving waters in order to monitor general trends in the ecosystem and water quality development. Biological material and sediment samples should be collected on a regular basis for analysis of inorganic and organic micropollutants. Testing for specific synthetic organic chemicals, especially solvents, pesticides, etc., should be expanded.

(iii) The control monitoring and inspection should include other locations along with the "official discharge point". This can help in tracking deliberate permit violations and to discover unknown discharges and non point pollution leakage. Control monitoring should also be done closer to the processes themselves and to the source of water pollution.

(iv) Some non-fixed station monitoring activities should be included. Detailed synoptic studies of water bodies of particular interest should be prepared and repeated after some years in order to make a more detailed assessment of ecological development. Such studies would be characterized by short term surveys of high sampling density and analytic detail.

10. **Discharge monitoring and control.** Monitoring of discharges from pollutant point sources and at wastewater and drinking water treatment plants serves specific control purposes and seems in general to be set up in a rational manner. These monitoring activities could be made more effective, however, in particular by addressing the lack of equipment, transport facilities, etc.

11. Most of the data on effluent water volume and quality are collected by enterprises that are defined as "end" wastewater dischargers. These are the industrial enterprises, municipal sewage treatment plants, etc. that have a permit with MEP for the discharge of wastewater. These enterprises take samples at the outlet--in some cases every day--and analyze for all the parameters mentioned in the permits. The data are primarily kept in hard copy logs on site and reported as annual loading figures to the MEP. Detailed data may be available on request to the inspectors representing the MEP. These "end" dischargers may also collect and treat water from other enterprises. Most common is the delivery of industrial wastewater to the municipal sewage treatment plant, but some industrial units also receive wastewater from neighboring enterprises. In such cases, the delivering unit monitors the volume and quality of the delivered water, and the receiving unit controls measurements for the purpose of cost sharing for treatment, fees and fines.

12. The control monitoring of the registered "end" dischargers is done by the MEP at local and oblast level. This control serves as a check on the data produced by the enterprises. Such control monitoring is done at the same sites as monitored by the enterprise, i.e., the outlet point(s) defined in the permit. In addition, background data are some times collected by sampling 500 m upstream and 500 m downstream of the discharge point. The number of controls per year is in general low, 4-6 times per year seems to be the average, mainly due to capacity problems. Control monitoring is done both with and without informing the enterprise beforehand. However, surprise controls may be difficult to arrange since the controllers are often dependent on the enterprise for transport to the monitoring site.

13. The local and regional San-Epi Stations control the water supply treatment plants and their distribution systems, based on the same principles used by MEP in its control of municipal and industrial wastewater dischargers. Routine monitoring of the characteristics of the intake water at the water supply treatment plants and quality control of the treated water delivered to consumers are the responsibility of the municipal water supply organizations. However, their compliance with the standards is controlled by the local and oblast San-Epi Stations by reviewing their books and by taking water samples for control analysis. Based on the findings of the analyses, the San-Epi stations can instruct the municipal authorities to take protective action, such as advertising warnings, closure of beaches, etc. as necessary. In severe cases, such as the recent cholera episodes, the police and army have been employed to enforce bathing prohibitions.

Groundwater Monitoring

14. The assessment of groundwater resources is mainly the responsibility of the State Committee on Geology. The committee has 7200 stations for groundwater monitoring, primarily for assessments of groundwater levels (availability) and some assessment of natural geochemistry. The central Donbass, Kryvyi Rih, Dnieper and Odessa areas are priority areas for monitoring. Within these areas, 120 testing plots are established and operated together with the MEP, Ministry of Chernobyl and the Academy of Science. Data from the Ministry of Municipalities provide additional input for analysis. Subsets of the monitoring network have been used, for example, to assess the extent of agricultural chemical contamination. The Committee has its own laboratory, as well as use of facilities at the Institute of Toxicology for some analyses. There are major gaps in data on local groundwater quality, reflecting the widespread lack of requirements for monitoring landfills, waste impoundments, and industrial sites. In addition, the absence of advanced analytical laboratory equipment has prevented obtaining even rough information on site-specific or area-wide contamination from specific toxic organic constituents within such contaminate categories as pesticides and chlorinated solvents.

15. Groundwater resources may provide a useful complement to surface waters for drinking water supply. Expansion of aquifer-specific and problem-specific monitoring is, therefore, needed. The following steps are recommended:

(i) Special attention should be given to monitoring the microbiological quality of rural wells.

(ii) Monitoring of groundwater quality in the most promising aquifers should be carried out to assess the capability of the resource to augment or substitute for surface water supplies in some areas.

(iii) Requirements for monitoring of landfills, impoundments, and other local contamination sources should be put in place.

(iv) Requirements for proper well construction and abandonment should be examined for completeness.

Water Quality Analyses and Laboratory Organization

16. There are a series of laboratories involved in the analysis of water quality parameters. Each enterprise and unit registered as wastewater dischargers or water suppliers has its own lab. The same is true for the control inspectorates and agencies at all administrative levels. General monitoring and research institutions also often have networks of regional and local laboratories in addition to a central one. Most of these laboratories are equipped with outdated hardware lacking the ability to detect low concentrations. The range of parameters they can analyze is limited to traditional inorganic elements and gross organic indicators.

17. Most of the samples collected at the Hydromet stations are analyzed in one of their ten regional laboratories. Some of these are part of the regional Hydromet organization and others belong to the oblast administration. It was claimed that these laboratories carry out complete chemical analyses of the relevant water quality parameters. However, from their reports it is clear that only a fraction of the parameters mentioned in the list of Water Quality Standards are analyzed. A review of one of their publications also indicated that the detection limits for some parameters, i.e., heavy metals, are rather low and that the figures presented for other parameters, i.e., nitrogen, have been systematically underestimated. The central Hydromet laboratory in Kiev has the responsibility for quality control of their laboratory network. In addition, this laboratory carries out some more advanced analysis and special studies. However, the general capacity of the central Hydromet laboratory makes it unable to exercise its quality control functions in a satisfactory manner.

18. Due to the special focus of the San-Epi Stations on human health, microbiological parameters have been given priority. Station representatives stated that their laboratory network had the ability to measure almost all parameters of interest, with the exception of dioxin. Compared with the overwhelming list of parameters included in the Drinking Water Quality Standards, however, it is obvious that only a fraction of these are monitored and analyzed on a regular basis.

19. The **Ministry for Environmental Protection** has its own system of laboratories. Again, it is a network with local laboratories in some cities and districts, laboratories linked to the oblast Environmental

Protection Agencies and central laboratories in Kiev. In addition, there are specialized laboratories in some of the research institutes affiliated with the Ministry. The quality of the results produced at present are difficult to assess. However, some of the analytic figures of Dnieper River water, provided to the team from different sources, showed striking discrepancies. This may be the result of equipment error or improper laboratory management and procedures, either of which indicate lack of quality control. The following steps are recommended:

(i) At least one center should be developed to conduct high quality specialized micropollutant analysis, including dioxin, on a regular high capacity basis.

(ii) The upgrading of at least one water laboratory per oblast should have priority over investing in stations for automatic monitoring or mobile labs.

(iii) Technical assistance, training and equipment should be provided. A possible joint Ukraine and foreign sampling and analysis mission on the Dnieper should be investigated. This could serve as an input in the establishment of a baseline for the Dnieper Commission work, as a quality test of the local laboratories, and as training in modern equipment use and sampling techniques. In addition it could serve as a neutral assessment of the health risk connected with using the Dnieper as a drinking water source.

ANNEX 8: MANAGEMENT OF COMPLEX AIR QUALITY PROBLEMS

Introduction

1. The development of procedures for dealing with complex air quality problems involves a number of participants including different levels of government, industrial polluters, mobile sources of pollution, small nonindustrial pollution sources such as home heating and consumer product users, and the general public who is affected by the pollution. Complex air quality problems are those which result from a combination of emissions, not just one or two distinct sources. The procedures for dealing with these problems have become somewhat standardized in many areas of the world such as the United States and Western Europe. This paper will describe this basic approach.

Ambient Air Quality Standards

2. The first step in the process of air quality control is to define conditions under which unacceptable air quality conditions exist. This is done for a localized area by defining ambient air quality standards. These standards should be designed based on observed adverse health or other environmental effects. The standards are normally expressed as a concentration of the contaminant over a set period of time. For example, the United States and the World Health Organization (WHO) have defined SO_2 standards for two time periods, 24-hours and annually. For the 24-hour period. the acceptable concentrations are very dissimilar between the two agencies. The acceptable concentration for the WHO is .125 milligrams per cubic meter (mg/m^3) while the USA uses .365 mg/m^3. The annual concentrations are not as dissimilar with the WHO using .050 mg/m^3 and the USA .080 mg/m^3. There is no single right number, and standards should be selected based on the best information available and upon the particular needs of the nation making this determination.

3. The ambient standards are normally established at the national or federal level and provide a minimum acceptable level of air quality which should be attained throughout the nation. Individual republics or states may elect to establish air quality standards more stringent than the minimum set at the federal level. For example, the state of California has an SO_2 standard which is nearly three times more restrictive than the 24-hour standard applicable at the Federal Level. This state standard is very close to the standard recommended by WHO.

Ambient Air Quality Monitoring

4. The next step in the program is to establish a comprehensive monitoring system to measure the concentrations of the air pollutants for which ambient air quality standards have been established. There are generally two strategies for locating the monitors which are employed by the agencies responsible for the monitoring. They are:

(i) General exposure monitors which are located based on general guidelines, which are designed to ensure that the monitors are located in typical areas where large numbers of people are concentrated. These areas are normally in urban centers and would reflect the possible exposure from a large number of sources, including mobile sources as well as stationary sources.

(ii) High incidence monitors which are located by modeling the areas near large sources of the pollution of interest. The monitor is located at or near the spot at which the model predicts the highest concentration of that particular pollutant.

5. The typical monitoring system normally has a mix of these two types of monitors. If the area in which the monitoring is being conducted is not expected to exceed the standard for a particular pollutant, the number of monitors may be reduced, and only a limited number of each type of monitors may be maintained.

Air Quality Management Plans

6. The development of a plan is undertaken via a number of steps. They include:

(i) An analysis of the possible contributing sources to the violation of the ambient air quality standards. This analysis includes;

(a) Development of a comprehensive emission inventory of all possible sources which could be contributing to the violation of the standard.

(b) Modeling of the sources based on the inventory to determine the relative contribution of the sources based on actual and potential emission levels for each of the sources.

(ii) An analysis of the potential pollution reduction actions which may be feasible for the sources which are determined to be significant contributors to the violation of the standards. Included in this analysis would be the cost of the pollution reduction actions in order to identify the most cost effective approaches,

(iii) Public involvement in the planning process, which should include all of the affected sources of pollution and other affected interested groups. This public involvement is essential to determine the adequacy of the analysis conducted to this point and the political acceptability of a particular control strategy, and as a mechanism to bring about an understanding of the actions which will be required as a part of implementing the plan.

(iv) Allocation of control requirements among the significant sources of pollution identified in the analysis. These clean up requirements may differ significantly between different types of sources. Some sources may be regulated as a category and may not have site specific requirements. For example, residential home heating may be regulated as a category where the use of coal may be prohibited throughout the region regardless of a particular home's contribution to the measured violations of the standard. Some of the sources may have a site specific emission limit which is needed to correct a predicted violation of the ambient standard at a particular critical location. Site specific limits are especially common to correct SO_2 violations in a localized area. Categorical limits are more common for regional pollutants such as Ozone (O_3). However, both types are normally used to correct complex air quality problems.

(v) Establishment of the time frames for attaining the ambient air quality standards. This is an essential step in the development of the plan. Depending upon the severity of the violations and the actions needed to correct the problem, the time frames may vary widely. For example, the ozone standard in the United States has extremely variable requirements in air quality management plans. In areas where the violations of the standard are not severe, the plan must be implemented and the standard achieved within 3 years. On the other hand the Los Angeles area has been given 20 years to develop and implement its plan because the ozone problem is extremely bad. For Los Angeles the types of pollution control measures which will be required are very expensive and technology forcing. It may include changes in life style which will take long periods of time to implement.

Development of Regulations to Implement
the Air Quality Management Plan

7. The clean up requirements which are contained in the Air Quality Management Plan must be established in specific rules and regulations. These rules and regulations may be general such as those pertaining to home heating or they may be specific to particular industrial categories or even specific industries.

8. A primary tool for establishing the specific emission control requirements is a permitting program for the significant stationary sources of air pollution. The permit is in effect a license to emit certain amounts of pollution. It also contains important compliance demonstration requirements. For example, it indicates the type of compliance testing which must be undertaken and the frequency of that testing. It also contains the reporting requirements which the source is subject to. It is a clear statement of what is expected of that source of air pollution. If any changes are made at that source of air pollution, it must be reflected in the permit so that the emission control requirements are up to date.

9. For other sources of air pollution such as automobiles or consumer products or very small sources there would not be a comprehensive permit program, but compliance requirements may be included in general regulations. It is then the responsibility of the air quality management agency to inform the regulated community of the requirements which are imposed on their actions.

Compliance/Enforcement Actions

10. The air quality management agency will be responsible for determining compliance with the requirements which are contained in the permits and the general regulations which are developed in response to the air quality management plan. These activities include inspecting the regulated sources, conducting stack tests, or witnessing stack tests, examining records of production and operation. Large sources of pollution are inspected more frequently than smaller sources. Response to complaints is also often an effective method of identifying sources which are operating out of control.

11. For mobile sources of pollution, the agency or a cooperating agency may operate an inspection program which tests the emissions from the vehicles which are regulated. If a vehicle fails the test, it would be required to go to a service station to have the pollution control equipment repaired or for the vehicle to improve its combustion characteristics.

12. When violations of the emission standards are determined, there should be a process of enforcement is aimed at accomplishing two primary objectives. The first is to ensure that prompt corrective action is taken to bring the offending source back into compliance with the emission standards. The second is to provide for a penalty which is commensurate with the severity of the violation and

ensures that the offending source has not profited from the act of violating the standard. In the most extreme cases, criminal penalties may be assessed against individuals who knowingly and willfully violate the regulations in a serious manner. If the enforcement actions are swift and effective the maintenance of a healthful environment may be accomplished.

13. In summary, the process of dealing with complex air quality problems is time consuming and resource intensive. The program cannot be fully implemented in a very short period of time. It takes adequate legislative authority, ample staff and technical resources and the support of the general public which the program is designed to protect.

The Emergency Action Plan

14. The purpose of the emergency action plan is twofold. One, to inform the public when unhealthy air conditions exist so citizens can take actions which will limit their exposure to the air pollutants. Two, to establish a procedure to reduce the level of the air pollutants of concern in the affected areas. Administration of this program should be a joint, coordinated effort by the staff of the Ministry for Environmental Protection, the Ministry of Health, and the Hydromet.

Episode Stage Criteria

15. The program should contain three episode states: "1-Alert", "2-Warning", and "3-Emergency". The stages represent the increasing severity of health effects on the population with the alert level having the least severe effects, followed by the warning, then the emergency level. A declaration of an episode occurs when the monitored concentration exceeds the level for that stage and meteorological conditions are expected to remain favorable for elevated levels of that air contaminant for the next 24-hours. Five air contaminants are included in this program; particulate matter, sulfur dioxide, carbon monoxide, ozone, and nitrogen dioxide, with a special category for the product of particulate matter and sulfur dioxide.

The Pollutant Standards Index

16. The Pollutant Standards Index is used to convey to the public the current air quality conditions in their area (see Table 2). This index has been found to be useful to the public and something they can more readily understand than a concentration value for an air contaminant. The index reflects the ambient air quality standard and three episode levels. It provides a general description of air quality (e.g., good, unhealthful, hazardous) based on the ambient concentration, in addition to providing general health effects information and precautionary advice about limiting outdoor activities.

17. The program should be aimed at significant sources, those capable of emitting 500 pounds (227 kilograms) per day of any of the air contaminants in the episode program. Owners and operators of these sources are required to prepare Emergency Action Control Plans designed to reduce or eliminate emissions. These plans must be implemented when an episode is declared and must remain in effect until the episode is cancelled. The plans are progressive in nature in that they become more restrictive of facility operation as air quality worsens.

- Alert Level / First stage where control actions must begin
- Warning Level - Conditions continue to worsen and additional measures are required.

- Emergency Level / Most stringent measures needed including curtailing operation of all manufacturing and commercial facilities.

18. The owner or operator of a facility must submit an Emergency Action Control Plan to the protection authority for review and approval. The plan must specify for each emission point and each episode stage:

- Amount of reduction of contaminants possible;
- Time required to achieve the reductions;
- The manner in which the reductions will be achieved.

19. The plan must be kept at the facility for the protection authority to review and brief summaries of the actions needed must be posted at locations in the facility where those actions will be implemented.

20. It is expected that, at the Alert Level, a 10 percent to 40 percent reduction in emissions should be achieved. At Warning and Emergency Levels a 40 percent to 100 percent reduction would be expected.

21. As an example, at a coal or oil-fired electric power generating facility it would be expected that the following actions would be taken to reduce sulfur dioxide emissions under episode conditions in the area of the plant.

Alert Achieve substantial reduction by using fuels with lowest available sulfur content and diverting electrical generation to facilities outside the alert area.

Warning Maximum reduction by switching to fuel with lowest available sulfur content and diverting electrical generation to facilities outside the warning area. At the Emergency Level the requirement would be the same.

22. The plan itself would provide the specifics, including the opportunities for fuel switching and ability to divert power generation tc other stations.

Critical Elements of an Episode Program

23. For an episode program to function well, communication and a clear understanding of authority is essential. The roles of all government agencies must be clear. It is critical to identify who has the authority to declare an episode, who is responsible for notification of the public and affected air pollution sources and who has the inspection powers to insure reductions are being achieved. The specific roles of the Ministry for Environmental Protection, the Ministry of Health, and Hydromet should be carefully spelled out. Also, the role of municipal officials should also be identified.

Table 1
Recommended Episode Stage Criteria
for Air Contaminants*

Air Contaminants	Sampling Period	Averaging Period	Episode Stage		
			Alert	Warning	Emergency
Particulate Matter	24-hours	block average	375 ug/m^3	625 ug/m^3	875 ug/m^3
Sulfur Dioxide	1-hour	Any hour	1,870 ug/m^3 (0.70 ppm)	3,730 ug/m^3 (1.40 ppm)	4,990 ug/m^3 (1.90 ppm
	24-hours	Continuous running average	800 ug/m^3 (0.30 ppm)	1,600 ug/m^3 (0.60 ppm)	2,100 ug/m^3 (0.80 ppm)
Product of Particulate Matter and Sulfur Dioxide	24-hours	block average	65,000 ug/m^3	261,000 ug/m^3	393,000 ug/m^3
Carbon Monoxide	8-hours	Continuous running average	17 mg/m^3 (15 ppm)	34 mg/m^3 (30 ppm)	46 mg/m^3 (40 ppm)
Ozone (for volatile organic compounds	1-hour	Any hour	0.20 ppm (400 ug/m^3)	0.40 ppm (800 ug/m^3)	0.50 ppm (1,000 ug/m^3)
Nitrogen Dioxide	1-hour	Any hour	1,130 ug/m^3 (0.60 ppm)	2,260 ug/m^3 (1.20 ppm)	3,000 ug/m^3 (1.60 ppm)

*These criteria were developed by the United States Environmental Protection Agency.

Table 2
The Pollutant Standards Index*

Pollutant Standards Index Value	Description	Episode Level	General Health Effects and Cautionary Statement
0-50	Good		
51-100	Moderate		
101-300	Unhealthful to very unhealthful	Alert	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the health population. Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity at higher levels in this episode level. Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease with widespread symptoms in the healthy population. Elderly people and those with existing heart or lung disease should stay indoors and reduce physical activity.
301-400	Hazardous	Warning	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in health persons. Elderly people and those with existing heart or lung diseases should stay indoors and avoid physical exertion. The general population should avoid outdoor activity.
401-Above	Hazardous	Emergency	Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal active. All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion and avoid traffic.

*This index was developed by the United States Environmental Protection Agency

ANNEX 9: SELECTED INFORMATION ON US AND EC STANDARDS

US AMBIENT AIR QUALITY STANDARDS (NAAQS) IN EFFECT IN 1990.

Pollutant	Primary (health related)		Secondary (welfare related)	
	Averaging Time	Standard Level Concentration[a]	Averaging Time	Standard Level Concentration[a]
PM-10	Annual Arithmetic Mean[b]	50 $\mu g/m^3$		Same as Primary
	24-hour[b]	150 $\mu g/m^3$		Same as Primary
SO_2	Annual Arithmetic Mean	(0.03 ppm) 80 $\mu g/m^3$	3-hour[c]	1300 $\mu g/m^3$ (0.50 ppm)
	24-hour[c]	(0.14 ppm) 365 $\mu g/m^3$		
CO	8-hour[c]	9 ppm (10 mg/m^3)		No Secondary Standard
	1-hour[c]	35 ppm (40 mg/m^3)		No Secondary Standard
NO_2	Annual Arithmetic Mean	0.053 ppm (100 $\mu g/m^3$)		Same as Primary
O_3	Maximum Daily 1-hour Average[d]	0.12 ppm (235 $\mu g/m^3$)		Same as Primary
Pb	Maximum Quarterly Average	1.5 $\mu g/m^3$		Same as Primary

a/ Parenthetical value in an approximately equivalent concentration.

b/ New PM standards were promulgated in 1987, using PM-10 (particles less than 10μ in diameter) as the new indicator pollutant. The annual standard is attained when the expected annual arithmetic mean concentration is less than or equal to 50 $\mu g/m^3$; the 24-hour standard is attained when the expected number of days per calendar year above 150 $\mu g/m^3$ is equal to or less than 1; as determined according to Appendix K of the PM NAAQS.

c/ Not to be exceeded more than once per year.

d/ The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is equal to or less than 1, as determined according to Appendix H of the Ozone NAAQS.

Site Characterization Programs for Air Quality Regulation in the US

A site characterization program would include one of two approaches:

Approach #1

Emissions profiles, using updated factors, would be developed for key pollutants from each enterprise in the region. An emissions profile, as defined here, is not simply the rate of pollution per hour from an operation, but rather typical emissions patterns from each point and fugitive source over the normal yearly operation of the enterprise. A basin-wide urban airshed modeling effort would then be conducted to determine potential region-wide ambient loading. This involves using Gaussian dispersion models and combining results to determine potential concentrations throughout the region. Dispersion modeling should also be utilized to determine localized health impacts (near the plant) for those pollutants where deposition is likely to occur within a relatively short distance from the plant.

Approach #2

An alternative and possibly less costly approach would be to employ receptor modeling based on the "chemical mass balance" model. The receptor modeling approach is a recent advance in air quality evaluation. It is based on the composition of ambient and source influenced air samples to provide a quantitative evaluation of source emissions measured at a receptor location.

Whichever approach is used, model results should be verified through updated monitoring. The specific degree to which each industry contributes to the total loading of the region and to any localized impact should be tabulated and incorporated into the plan for the region. Finally, there should be a concentrated effort to enhance the ability to forecast local meteorological conditions in order to predict peak pollutant concentrations. It is possible that much of the threat is due to exposure to short term peak concentrations which may be significantly mitigated through an effective forecasting and episode management program.

The source emission profiles and tabulation of relative contributions describe the extent to which each source (including transportation and residential sectors) contributes to the overall pollutant loading in the region. For each emission point within the enterprise, the costs of control would be calculated and tabulated; a cross reference table would be created that links these two tabulations. A least cost path could then be calculated. For general pollutants, one will need to determine the overall reduction in pollutant loading needed in the basin. Each enterprise could then be required to achieve an overall annual reduction in the plant's emissions which would be defined in the facility permit. The enterprises would have the ability to locate and secure the most cost effective reduction available to them.

E.C. NORMS FOR METALLURGICAL PLANTS (mg / m³) FROM TA LUFT UNLESS OTHERWISE NOTED					
PLANTS	DUST	NOx (as NO_2)	SO_2 (as S)	CO	Others (as specified)
COKING PLANTS					
Coal crushing station	10* when flow > 0.9 kg/h				
Coal drying, preheating	100				
Coke screening station	50				
Coal charging	25				P.A.H. 0.1 when >0.5 kg/h
Pushing	5 g/t coke				
Coke dry quenching	20				
H_2O quenching	50				
Battery chimney	10	500	800	200	
SINTER PLANTS	400				
BLAST FURNACES	20				
OXYGEN CONVERTERS				1000	
ELECTRIC ARC FURNACES	20				Fluorine (as HF) 1 mg/m³
MILL (based on 5% excess O_2)		0.5 if 200°C 0.7 if 450°C			
ALUMINUM	20		800 if >5 kg/h		Chlorine 3 Organic Compounds (as C) 50
LEAD	10		800 if >5 kg/h		Organic compounds 50
ZINC	20		800 if >5 g/h		Organic compounds 50

* Netherlands