ENVIRONMENTAL POLICY PAPER
Staff Level Review

Attached is the Environmental Policy Paper prepared by the Office of the Environmental Adviser, Central Projects Staff. A meeting will be held on the paper at 2:30 p.m., Friday, September 6, in Conference Room E1026.

The short notice for the meeting is due to the unavoidable absence of Mr. James A. Lee next week. In order to allow further time for reactions to the paper, comments may be sent in writing to the Environmental Adviser not later than close of business, September 16, 1974.

Frank Vibert
Secretary
Policy Review Committee

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I. SUMMARY AND CONCLUSIONS

1. International development assistance has historically addressed problems of the human environment -- its principal focus being the poverty, disease, hunger, and illiteracy associated with the lack of economic development. Worldwide concern, however, has steadily mounted over other aspects of environmental problems -- those which emerge as undesirable secondary effects of the very processes of development itself. As a result, the responsibility and procedures for addressing the potentially damaging environmental and related health/socio-cultural side effects of development schemes and projects have become the focus of increased concern for developing countries and for the institutions which provide development assistance.

2. The environmental problems and issues confronting both the developed and developing countries have been articulated and documented in considerable detail, owing, in great measure, to the historic 1972 United Nations Conference on the Human Environment in Stockholm. Developing countries assign the highest priority to finding solutions to their perceived environmental problems which they principally attribute to the lack of development. The industrialized developed countries meanwhile are becoming increasingly concerned and preoccupied with the environmental degradation that accompanies their economic growth. It is widely agreed, however, that virtually all nations share both classes of problems, the essential differences are in the mix and intensity.

3. Sharing in the concern of international development assistance for the threats and hazards posed to vital ecological systems, human health, and social well-being, the World Bank Group institutionalized systematic efforts to identify and prevent their occurrence in the development projects for which it makes loans. With the establishment in 1970 of an organizational "focus" for environmental matters, the Bank Group intensified its forward movement on a broad front to purposefully include the "environmental" dimension in all its development endeavors; and, to encourage, through its own actions and leadership, other development finance institutions and its members countries to minimize the disruptive side effects of development on the human environment. The impact of this policy has been felt far beyond that associated with the direct effects of its projects.

4. Its experiences to date have shown the wisdom of this policy and have given encouragement to those who on the one hand despaired that development and concern for the environment could find accommodation, and those on the other hand who feared their hopes for a way out of pervasive poverty through development would be dashed over the mounting concern for environmental degradation.
5. In its continuing efforts to help the world's two and three-quarter billion poor achieve a level of life in accord with fundamental human dignity, the Bank Group remains unalterably persuaded that such help is simply not possible without the continued economic growth of the developing nations -- and the developed nations as well. But -- not economic growth on the pattern of the past, however, wherein threats to the environment and the health and well-being of man are undeniable, but, rather, on patterns that strive to be in accord with the tolerances of the environment to the stress of development, as well as with the physiological thresholds that dictate man's status on the health-disease continuum.

6. Resolved that there can be no question whether the impact of economic growth on the environment must be respected, the Bank Group seeks to increase and expand its assistance to developing countries in ways minimally disruptive of the environment and maximally promising of an improved quality of life for the affected peoples.

7. To do this requires a continuation, improvement, and strengthening of its current policies and practices and, also, innovative initiatives designed to assist in the important tasks of environmental rehabilitation.

In summary, these are seen as follows:

(a) A continued strong emphasis on its earlier espoused mandate "... to review and evaluate every investment project from the standpoint of its potential effects on the environment."

(b) A continuation of its policy to assess such effects with conscious regard and attention to the setting of each investment project, applying such criteria and standards for the protection of environmental, health, and socio-cultural values as are seen to be best tailored to the affected milieu, and rejecting across-the-board application of fixed, common standards, except those applicable to highly toxic hazards demonstrated to be a threat to life processes.

(c) A continuation of its policy to provide guidelines for the consideration of the environmental dimensions in project formulation, and implementation, and to encourage their use not only with the Bank Group but also by other institutions, individuals, organizations, and governments, having responsibilities for economic development and its consequences.
(d) A furtherance of its earlier acceptance of environmental and human ecologic safeguards as constituting integral elements of development projects, and thus their eligibility for financing on equal terms with other long accepted and essential components of a "Bank-worthy" project.

(e) Extension of its requirements, when and where appropriate, that agreed-upon environmental and health safeguard measures, including their establishment and maintenance, be a condition of the loan, utilizing such instruments as are seen appropriate, and making it incumbent on the borrower and/or guarantor to adhere to such conditions.

(f) Initiation of support for projects seen by member countries as being of an "environmental" nature, designed to correct or otherwise improve conditions of the human environment prejudicial to health and social welfare, and/or threatening of the country's natural ambience and its resources.

(g) A furtherance of its efforts to provide technical advice and assistance on environmental matters upon request from its member countries.

In accomplishing the above, the Bank Group may wish to consider the following additional measures:

(a) The incorporation in its Country Economic and Sector Reports of salient information and data concerning the state of the human environment and including existent or planned legislation, institutions, regulations, standards, etc., useful in assessing the environmental implications of a country's development strategy.

(b) The provision in the Terms of Reference for consultants, engineering firms, contractors, etc., of appropriate references to the environmental dimensions so as to ensure their incorporation into designs, plans, feasibility studies, and other undertakings relating to the formulation and implementation of projects.

(c) The inclusion of environmental considerations within the purview of supervision missions, to ensure borrower compliance, if warranted, and to otherwise assess the effectiveness of the safeguard measures employed in carrying out the project.
(d) The provision of direct support, where appropriate, of research allied to the operational needs and requirements of the Bank Group as regards the environmental, health, and socio-cultural dimensions of its development assistance activities.

(e) A recognition of the environment-related training needs associated with Bank Group-financed projects, and provision for the support of such training within the framework of the loan. Further, a continuing appraisal of the problems and opportunities associated with environment/health curriculum development and the provision of training opportunities within member countries to meet perceived needs. An expansion and strengthening of the efforts by the Economic Development Institute (EDI) to incorporate the environmental dimensions within its courses and curricula.

(f) A continuation with the regional office and operational department of the primary responsibility for carrying out the Bank Group's policies and practices with regard to the environmental aspects of projects being financed. A continuation, also, of the close operational support provided by the Office of Environmental Affairs and its identification as the "focal point" within the Bank Group for liaison with the myriad of international, national, inter-governmental, and non-governmental organizations having responsibility for, or concern with, the environment.

(g) An increasing emphasis on improving the methodologies and techniques concerned with environmental economics and the analyses associated with the evaluation of projects exhibiting environment-related impacts.

(h) Examining and assessing the opportunities within national strategies for environmental improvement to fix responsibility for and equitably assess costs related to protection of environmental values. (Experience of the kind recently acquired in appraising a proposed national water pollution control project in Finland is especially valuable in this regard.) See attached annex.
NOTE: In awareness that every proposed solution for energy supply problems has environmental implications; and that, furthermore, a close correlation exists between economic growth and energy use in developing countries, the recent advent of an energy crisis on the world scene raises numerous questions relating to the environment and human well-being not specifically addressed in this paper. It is to be expected that in its current continuing efforts to deal with the energy situation, the Bank Group will give due consideration to these relationships.

Economic development, in large measure, has been made possible by the existence of energy resources and man's unique ingenuity for transforming them into usable forms of power -- to fuel the agricultural and industrial sectors, to light cities, to move people and goods, mechanize farms, and -- to give rise to pollution of the environment. Taken on a project-by-project basis, however, the energy/environment relationships do not suggest problems that require separate policy considerations; the Bank Group can be expected to continue its present efforts toward early identification and subsequent provision for the prevention or mitigation of potentially significant environmental problems associated with individual projects.

9. To reconcile its mandate to assist in the economic advance of the developing countries with its responsibility to protect and enhance the human environment, the Bank Group continues to be persuaded that it must:

. Encourage recognition that economic growth in the developing countries is essential if they are to deal with their human environmental problems; and to press vigorously for increasing concessional aid to levels targeted in the Second Development Decade.

. Act on the evidence that such economic growth, if properly planned, need not cause unacceptable environmental penalties.

. Actively assist developing countries in their choice of a pattern of economic growth yielding a combination of high economic gain with minimal environmental risk.

. Continue the momentum of its leadership in demonstrating that concern for the environment does not handicap the fundamental task of providing development assistance; but, on the contrary, enhances and accelerates that progress.
II. INTRODUCTION

10. Much of the effort to raise the standard of living in the developing countries involves a deliberate modification of the natural environment. Construction of roads, dams, airports, irrigation and sewerage systems, power plants and industrial facilities frequently result in the loss of ecological, health or socio-cultural values. Often this is because the consequences for the environment were not adequately considered at the project-planning stage or because information necessary to forecast the eventual impact on the environment was lacking or inadequate. And where adverse ecological consequences are forecast, effective steps to prevent or minimize the damage may sometimes not be taken because data on cost-effective safeguards or on economically competitive project alternatives are lacking or inadequate. Although the magnitudes of the loss in ecological and related values vary, there is a real cost to society over the long run.

11. To the extent that such losses occur, or go unmeasured, estimates of economic progress may be inflated. Often the remedial action must be taken at a later stage of a country's development, at a higher real price. Prudent planning and early preventive measures, such as pollution control or health safeguards, or a redesign or re-siting of the project, might have avoided the high cost of the subsequent remedial measures, or reduced it. It is important, therefore, that those involved with development projects -- planners, decision-makers, engineers, sources of finance, etc. -- keep in mind, from the earliest stages of the project cycle, the potential environmental implications, both positive and negative, of their development activity.

12. There have been repeated warnings, in recent years, that in many regions of the world, in both developed and developing countries, air, water, soil and other resources are deteriorating to an extent which threatens the quality of life and of the environment, perhaps even the future of human life. Such warnings have been sounded before. But their urgency has intensified: the consequences of continued cavalier use, or misuse, of natural resources, and of high rates of population growth, will be realized, not some time in the comfortably distant future, but soon. This was the message of the first (1972) United Nations Conference on the Human Environment, held in Stockholm.

13. The trend toward degradation of the biosphere is global in its dimensions and consequences; it can be reversed only through comparably widespread recognition of the danger and international cooperation in dealing with it. There are encouraging signs in both of these directions. Resolutions of the United Nations General Assembly in 1968, 1969 and 1970 underlined the importance of taking environmental factors into account in economic and social development planning. The International Strategy for
the Second United Nations Development Decade, adopted by acclamation in 1970, declares that "Governments will intensify national and international efforts to arrest the deterioration of the human environment and to take measures towards its improvement, and to promote activities that will help to maintain the ecological balance on which human survival depends."

11. The economic development which the developing countries are determined to achieve, and which the World Bank Group was established to support, will necessarily have an impact on the environment, on both its naturally occurring and its man-made elements. The developing countries are not, and should not be, required to choose between economic and social development, on the one hand, and the preservation of the environment, on the other. The question for them, and for the Bank Group is rather how to achieve economic progress with the least possible disruption of the environment and its ecological life-supporting systems.

III. ENVIRONMENT AND DEVELOPMENT

Definitions

15. It may be useful to begin consideration of the relationship of environment to development, and of the Bank Group's role and policies in relation to these, with some definitions. This is particularly true given the fact that, although the terms "environment" and "ecology" have received so much currency in recent years, there is no single universally accepted definition of either.

16. In this paper, "environment" is used to describe the total setting for economic development activity; it is not confined to the naturally occurring milieu (the ecological systems which surround the collectively support man, the biosphere), but extends to the socio-cultural milieu which man has created to facilitate adaptation to the demands and challenges of his naturally occurring surroundings.

17. "Ecology" is used to refer to the relationship between organisms and their environment, including most especially the man/environment relationship.

18. Environmental problems may be divided into three categories related to their magnitude: global, regional and local.

19. Global problems pertain to the biosphere; they affect all, or nearly all, countries. Into this category fall the most widely discussed and threatening problems, for example, those caused by persistent pesticide residues which find their way into the biosphere processes through the actions of wind, water and living carriers, with effects well beyond the country in which the pesticide was applied; the burning of fossil fuels, which affects the carbon dioxide
balance and the sulphur dioxide loading of the atmosphere, and the particulate content of the stratosphere; the pollution of the oceans from land sources, or from oil spillage or ship dumping on the high seas; and the man-induced or man-influences changes in global climatic patterns. Clearly the resolution of problems in this category calls for heroic measures of international cooperation.

20. Regional problems result from biophysical linkages among a group of countries which have little or no effect beyond the members of the group. A typical example is the effect of river basin development on riparian countries, up or down-stream.

21. Local problems are those whose effects are confined within the boundaries of a particular country, for example, the extirpation of a wildlife resource, the creation of an aesthetic blight, or the eutrophication of a lake from fertilizer runoff or discharge of domestic sewage.

Dimensions of Variation

22. Environmental problems in a given category may differ in their dimensions. For example, while a global problem may eventually result from the gradual build-up of carbon dioxide in the atmosphere over a long period, the effects of pervasive, persistent pesticides can be seen more immediately. Another variant, related to timing, is the degree of certainty. The greater the time span for the cause-effect relationship to be observed and understood, the greater the uncertainty as to its manifestation; whereas the continuation of presently observable consequences is far more certain.

23. Two other variables may be noted: magnitude and degree of reversibility. Magnitudes cannot easily be compared, because effects are of different types, occur in different places and affect different aspects of life systems. "Reversibility" concerns the possibility of returning an ecological system to its former state. For example, a lake in an advanced state of eutrophication is virtually irreversible; the extinction of a species is absolutely so. On the other hand, it is possible to end pollution from particulate matter in the smoke of an industrial plant, and to restore the ambient air quality.

24. The dimensions of time, certainty, magnitude, and degree of reversibility combine to produce the dimension of urgency. Where a problem to be dealt with poses an immediate, serious threat bordering on irreversibility -- such as a present threat of malaria affecting millions of persons -- it is seen as being more urgent than the possible, future, unknown effects to health arising out of the use of a pesticide to combat the malaria-carrying mosquito.

The Environment in Developing Countries

25. Developing countries have an obvious and vital stake in environmental problems which affect the biosphere, themselves, and their economic relations with the developed countries. The environmental problems of the developing
countries are essentially of two kinds. They are the problems associated with rural and urban poverty, characterized by poor housing, nutrition, water supply and sanitation, and by disease. Under these conditions of poverty, in which the biophysical environment often exhibits the ravages of long years of mismanagement (overgrazing, erosion, denuding of forests, surface water pollution, etc.), not merely the "quality" of life, but life itself, is endangered, for it is often very difficult or impossible for the environment to renew its life-supporting capabilities. The developing countries assign the highest priority to finding solutions to problems of this nature, associated with underdevelopment.

26. There are also the growing and serious problems which accompany the very process of development itself: Agricultural growth, for example, calls for construction of irrigation and drainage systems, clearing of forests, use of fertilizers and pesticides; new avenues for disease transmission will be created and new human settlement patterns established. All these developments have environmental and health implications. The process of industrialization will result in the release of pollutants, and in other environmental problems attendant on the extraction and processing of raw materials and the growth of urban trade centers. Urbanization is a serious and growing problem for many developing countries. In the absence of adequate land use planning, industrial pollution control, provision for water supplies and sewage disposal, and adequate housing, the population pressures that have produced unsatisfactory rural land use patterns impinge increasingly on the cities.

27. Economic development cannot proceed without exploitation of natural and human resources. As the pace of development accelerates, the associated hazards and threats to the environment and to human health become greater. The experience of the developed countries, in realizing immediate economic benefits only to become aware, later, of the greater and more lasting social costs attributable to application of new technology, should be kept in mind by the developing countries as they import the technology required for their own economic program. They will, presumably, wish to avoid, insofar as feasible, the development patterns which have led to the present environmental concerns of the industrialized countries.

The Environmental Debate

28. But while environmental concerns have of late been given a high priority in the developed countries of North America and Western Europe, they do not command the same attention in the Third World. This is understandable. Emphasis on the quality of life and the environment may well seem to be a luxury the developing countries cannot afford, preoccupied as they are with malnutrition, disease, high infant mortality, low life expectancy, high levels of illiteracy, unemployment and severely skewed distribution of per capita income, and with the widening gap between their material well-being and that of the developed countries. The difference in values, interest, priorities and capacities between developed and
developing countries is perhaps more marked in matters affecting the environment than in other areas. Developing countries prefer to give priority to projects and programs which promote economic growth; they assign relatively less importance to the need to protect the environment. If the dialogue between the haves and have-nots on such matters is to be productive, it must be based on a recognition that the viewpoints are different and that the solutions to, or ways of dealing with, the world's environmental problems must be complementary to and not at the expense of efforts to advance the economic and social development of the developing countries. 1/ The safeguarding and improvement of the environment should be one of the objectives of an economic development plan. While limitations on development capital are a serious constraint for many developing countries, and may lead to the assignment of a higher priority to other objectives, the fact is, as noted earlier in this paper, that preventive action may be taken now at a fraction of the future cost of remedial action, to the extent such action is still feasible.

29. There are encouraging signs of a growing awareness in the developing countries that "economic growth", narrowly defined, does not necessarily result in an improved quality of life. Concern for the environment and health is coming more and more to be viewed as an integral part of the development process. To an increasing extent development assistance agencies are being asked to help in assessing and combatting the degradation of water, soil and air attendant on industrialization, agricultural development, natural resource exploitation and water development projects. At a regional environmental seminar in Africa, one of a series of such seminars held in preparation for the 1972 Stockholm conference, some 30 countries adopted a resolution calling upon the governments of the region to give consideration to the environmental aspects of proposed development projects. While the resolution was motivated, in part, by concern that a failure to consider those aspects might lead to a reduction in external development assistance, it nevertheless appears that developing countries are increasingly willing to invest scarce resources to ensure that immediate development benefits are not offset by long-term environmental costs.

Development Assistance and Environmental Quality

30. Donor governments appreciate that developing countries regard the formulation of environmental goals as much a matter of national sovereignty as the formulation of economic and social policies generally. They recognize that programs and projects which contribute immediately to economic growth will, in most developing countries, receive a higher priority and be allocated a larger share of financial resources.

1/ For an in-depth treatment of these issues see Development and Environment, a report submitted by a panel of experts convened by the Secretary-General of the United Nations Conference on the Human Environment, Founex, Switzerland, June 4-12, 1971, and published by the Carnegie Endowment for International Peace in International Conciliation, No. 586, January 1972.
31. At the same time, mounting concern over the continuing deterioration of the environment on a global scale and awareness of the transnational environmental effects of development programs, especially at the regional level, are being coupled with pressures, both within and outside governments, to take positive steps to curb pollution and minimize or eliminate the damaging side effects of development. They are requiring donors to take a careful look at the costs and benefits of assistance in environmental terms, and at the alternative means available to minimize the one and maximize the other in the development projects they support. The United States Congress, for example, questioned whether U.S. aid should be made available for undertakings which would be criticized in the United States because of the associated environmental impact (e.g., use of certain pesticides, construction of industrial plants without effluent controls, etc.). The decision becomes more difficult where the proposed project will have undesirable environmental/health effects which will be felt outside the boundaries of the recipient country.

32. A difficult situation could be presented where a donor or development financing institution proposes, for example, that pollution controls should be incorporated into a project to protect the local, regional or global environment, but the prospective recipient disagrees, perhaps on the ground that standards which do not conform to its own development priorities or environmental circumstances are being imposed from abroad, and that this will increase project costs with an adverse effect on the country’s development plans. Developing countries reportedly have been worried that increasing donor concern over environmental matters could complicate and slow down the processing of development assistance projects and that the additional resources required to help pay for environmental safeguards will not be forthcoming.

33. Issues such as these are focusing attention on the responsibilities and activities of development assistance institutions. Within the past few years, some major development agencies have made substantial strides toward strengthened environmental responsibility, recognizing that development which ultimately degrades the human environment is neither a sound investment nor a humanitarian one. In most cases, what has been done is to incorporate consideration of environmental factors into agency project review procedures. There has been some examination of the policy issues involved, but no comprehensive policy statements have been forthcoming.

IV. THE WORLD BANK GROUP AND THE ENVIRONMENT

Environmental Guidelines

34. Before 1970, the Bank Group had no systematic procedure for identifying and examining the environmental effects of its activity. Moreover, in many instances, ways of identifying, preventing or mitigating adverse environmental consequences had not been devised. In his 1970
address to the U.N. Economic and Social Council (ECOSOC), Mr. McNamara, President of the World Bank Group, remarked that the problem facing development finance institutions was whether and how they might help the developing countries to avoid or mitigate some of the damage which economic development can do to the environment, without slowing the pace of economic progress. He noted that the costs resulting from adverse environmental change could be tremendous, and that a small investment in prevention would be worth many times what would later have to be spent to repair the damage. He announced to ECOSOC that a unit had been established in the Bank Group to determine, to the extent possible, what would be the environmental consequences of development projects being considered for financing, and said that the Bank Group proposed to work toward concepts which would make possible a consideration of environmental factors in development projects.

35. While this paper addresses the matters of Bank Group policy and activities with respect to the environmental/health implications of projects proposed to it for financing, it in no way describes the breadth of Bank Group involvement in international environment/health activities. These include, among others, technical advice and assistance to member countries; representation on international and inter-governmental bodies concerned with the environment; liaison with national and non-governmental agencies and organisations having environmental roles; and participation in conferences related to the foregoing. The very breadth of this involvement transcends the obvious participation by the Regional offices, and includes many of the Bank Group's organizational components, including mission offices. Even the Bank Group's own internal environment has been the object of studies and measures taken with regard to air pollution, solid wastes, occupational health and safety by the Administrative Services Department. But, remaining at the heart of these multi-faceted activities is that of ensuring to the best of its ability that projects financed by it do not pose an unacceptable threat to the environment and the public health.

36. The position of Environmental Adviser was established in 1970, with a strong mandate "... to review and evaluate every investment project from the standpoint of its potential effects on the environment." A set of staff guidelines was prepared for use in the formulation, appraisal and execution of projects. These were subsequently expanded, and in 1972, a handbook, Environmental, Health, and Human Ecologic Considerations in Economic Development Projects, was published. (A revised and further expanded edition of the Handbook will be made available in French and Spanish (as well as English)) in 1974. The Handbook has been widely distributed to other economic development agencies, governments, engineering, contracting and consulting firms, universities, etc.

Project Operations

37. Experience soon made it clear that the environmental/health dimensions of projects should be addressed at the formulation and design stages, rather than at the "eleventh hour", when changes or modifications prove difficult, if not impossible.
38. The Environmental Adviser (now Office of Environmental Affairs) instituted a procedure which has evolved as follows:

1. Operational department staff review with the Office projects under consideration for Bank or IFC financing with a view to identifying the likely environmental, health, and socio-cultural problems or opportunities associated with them;

2. Where indicated by the initial review, the Office of Environmental Affairs suggests what studies or investigations should be conducted to enable a better identification and understanding of the nature, dimensions, severity and timing of the problems likely to arise, to ensure that appropriate safeguarding or other, perhaps, enhancing measures can be taken. The Office designs the studies and advises on the disciplines needed to conduct them and the terms of reference;

3. When the studies are completed, the Office participates in the review and analysis of the data and information acquired and helps to work out appropriate safeguard measures. It participates in subsequent loan negotiations and, where appropriate, in the presentation to the Board;

4. The Regional Office and the Office of Environmental Affairs monitor the implementation of the project, to ascertain the inclusion and adequacy of the recommended safeguard measures, and to determine what future action may be required. This experience is also useful for subsequent assessment of the accuracy of the forecast of environmental/health consequences and helps to indicate the approaches which should be taken, should similar problems occur in other projects.

Experience With Environmental/Health Considerations

39. It should be kept in mind that during most of the period 1971 to the present, the solo post of Environmental Adviser was largely responsible for the broad range of environmental activities evolving within the Bank Group; hence, the limitation on project statistics as shown below in the results of a screening made of all Bank Group loans, IDA credits, and IFC investments, during the 30-month period July 1, 1971 - December 31, 1973.

The data presented reflect past project activities and show that the higher probability project-associated environmental/health concerns is to be found in the power, industrial and agricultural sectors.

(a) Of a total of 376 Bank Group loans and IDA credits reviewed for their environmental/health implications, 245 (65%) revealed "no apparent potential problems;" the same was true for 30 (51.6%) out of 58 IFC investments. There was considerable diversity among

1/ The expression implies that either no potential problems were apparent to the OEA or that other projects, seen as having a higher potential for more serious environmental/health implications were chosen because of staff and time constraints.
these 139 projects, as they included, for example, Bank Group loans to IFC, which in themselves have no identifiable environmental impact. Others include education, telecommunications, and, especially, population projects which have a large potential for positive environmental benefits, but do not ordinarily require an evaluation in the sense that projects in other sectors must undergo. These types of projects therefore are appropriately not included among the 159 projects that were acted upon.

(b) In a very small number of cases (4), representing about 1% of all loans and credits signed during the period, some other agency, such as the UNDP or WHO, had determined the need for safeguarding or remedial measures of some character and had taken the requisite action prior to Bank involvement. No IFC projects fell into this category.

(c) In 105 projects for which loans or credits were signed and in 26 IFC projects, the environmental problems identified could be handled adequately by Bank Group staff and the Environmental Office, without the need for outside expertise or special studies. The projects in this category accounted for 28% of the total of Bank or IDA projects screened, but for 80.2% of the Bank/IDA projects on which any action was taken. The 26 IFC projects in this category represented 45% of the IFC projects screened, and 93% of those on which action was taken, leading to the incorporation of appropriate environmental/health measures.

(d) The 22 Bank/IDA projects (including 9 power projects 1/, 6 agriculture 2/, and 3 industrial 3/) and 2 IFC projects (both industrial 4/), which were determined to require special studies by consultants, likewise led to the incorporation or safeguard measures as a condition of Bank/IDA or IFC financing. These represented 5.5% of the total number of Bank Group projects reviewed and 15.1% of the total requiring some action additional to an initial review.

1/ Loan/Credit Numbers 809, 829, 841, 874, 889, 919, 923, 296, 339
2/ Credit Numbers 393, 322, 282, 317, 277, 302
3/ Loan Numbers 787, 817, 934
4/ Investment Numbers 226, 258
The foregoing data, suggestive of the probability of environmental implications, are summarized in Tables 1 and 2, following.

### Table 1

**Numerical Distribution of Bank/IDA and IFC Projects by Categories of Actions Taken. Period 7/1/71-12/31/73**

<table>
<thead>
<tr>
<th>Category of Actions Taken</th>
<th>Bank Group/IDA</th>
<th>IFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>No problems apparent when reviewed</td>
<td>245</td>
<td>30</td>
</tr>
<tr>
<td>Problems handled by others prior to Bank Group involvement</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>In-house disposition</td>
<td>105</td>
<td>26</td>
</tr>
<tr>
<td>Consultants and Special Studies required</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Number of Projects</strong></td>
<td><strong>376</strong></td>
<td><strong>58</strong></td>
</tr>
</tbody>
</table>

### Table 2

**Numerical Subdivision of Bank/IDA and IFC Projects Reviewed and Acted On During The Period July 1, 1971-December 31, 1973**

<table>
<thead>
<tr>
<th>Bank Group/IDA / IFC</th>
<th>No. of Projects Signed &amp; Reviewed</th>
<th>No. of Projects Acted Upon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bank Group/IDA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>104</td>
<td>46</td>
</tr>
<tr>
<td>Industry</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Transportation</td>
<td>87</td>
<td>15</td>
</tr>
<tr>
<td>Tourism</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Water and Sewerage</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Power</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>Urban Projects</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Education</td>
<td>38</td>
<td>4</td>
</tr>
<tr>
<td>Multipurpose</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Others 1/</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td><strong>IFC</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Chemicals</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Iron and Steel</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mining</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Non-ferrous</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Petrochemicals</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pulp and Paper</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Textiles and Fibers</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Tourism</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Others 2/</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>131</strong></td>
<td><strong>159</strong></td>
</tr>
</tbody>
</table>

1/ Population & Nutrition, Loans to IFC, Technical Assistance, Engineering Loans, Development Programs & Export Expansion Lending, DFCs.
2/ Capital Markets, DFCs, Food Industries, General Manufacturing, Housing Financing, Industrial Equipment, Metal Fabricating.
The following examples are illustrative of some of the kinds of environmental/health/socio-cultural considerations which may be associated with conventional Bank Group projects.

a. Power

(i) Hydro-Power Projects involve the construction of a dam and the creation of an impoundment behind it. Problems associated with these activities include changes in the biochemical characteristics of the water downstream with its effect on fish populations. The dam may also act as a barrier to fish migration thereby preventing spawning unless a "ladder" arrangement facilitates their passage. The impoundment area, unless properly cleared of trees and vegetation, can become the site of undesirable water quality changes that preclude the establishment of a fishery, encourages aquatic weed infestation and algae blooms, and thereby threatens the power generating facility, and multiple uses of the man-made lake. Improper land use practices in the impoundment's watershed induces silitation while fertilizer/pesticide runoff can be detrimental to the food chains and developing biota in the impounded waters. The creation of new and/or increased habitats for disease vectors, and the opportunity for greater human/water contact raises the specter of new or increased health problems for the affected populace.

Hydro schemes often require the relocation and resettlement of people, villages, and urban centers from the proposed impoundment area. Many socio-cultural problems are thus raised which call for attention if the needs and requirements of such peoples are to receive adequate and humanitarian treatment.

Impoundments can also destroy important wildlife habitats, as can the operating regime wherein water level fluctuates over a wider range. Important historical, archeological, religious, and cultural sites can be obliterated.

The problems and opportunities associated with hydro-power schemes have been intensively studied and, if taken into account, their resolution and enhancement can be effectuated.

The Bank Group-financed Kidatu Hydroelectric Project in Tanzania is a case in point. This project, designed to meet coastal power requirements through 1980, consists of a regulating dam and an underground generating station on the Great Ruaha River, located several hundred miles west of Dar-es-Salaam. An environmental study of the project area was carried out by the borrower. Steps to prevent erosion during the construction and operations stages were strongly recommended. While the project was not expected to have an adverse impact on the environment and its biota, several health hazards were identified and plans made to control them. Unfortunately, however, the initial route selected for the transmission line traversed the Mikumi National Game Park and was destined to pass within view of a recently
constructed government-operated game lodge, near some of the best wildlife areas in the park. The Bank, in conjunction with the public utility, the borrower and park officials, reexamined the route and selected an alternative which not only preserved the park's scenic and aesthetic qualities but in the end proved cheaper to construct.

Another example of a successful attempt to reconcile wildlife and conservation interests with economic growth is the second stage of the Kafue Hydroelectric Project in Zambia. At a cost of $138 million, this project was designed to meet the requirements of the Central African Power Corporation's interconnected power system. It consists of a storage dam on the Kafue River and the installation of additional generating units at an existing downstream station. As part of a preinvestment study, an assessment was made of changes in ecology and land-use potential which would be induced on the Kafue Flats through construction of the dam. The report also evaluated potential environmental impacts, dealing with such matters as soil erosion and siltation, archaeology, agriculture, animal husbandry, wildlife, fisheries, aquatic nuisance plants and public health.

A Bank appraisal mission subsequently gave further consideration to the environmental implications. It concluded that by far the most significant impact of the project on the environment would be the elimination of the flooding of the Kafue Flats below the dam during dry years. The Kafue Flats, covering some 5,000 km², are the home of thousands of zebra, waterbuck, wildebeest and other plains animals. Under natural conditions, extensive flooding occurs each year and the annual cycle of the flood and its recession is responsible for much of the grazing upon which a large number of cattle and wildlife depend. These include some 90,000 lechwe, a species of small antelope unique to the project area, whose movements have been dictated largely by the grazing conditions provided for by the flood cycles, and whose future is a matter of concern to wildlife conservation groups the world over.

Because most of the incoming flood water will be storied in the reservoir, the extent and duration of flooding with regulation would be significantly reduced during low-flow years, compared with natural conditions. To compensate for the loss of natural flooding when the water is most needed, the dam was designed to allow reservoir storage of 750 Mm³ additional to that required for power discharges. This will permit discharge of 300 Mm³/s during the critical month of March in dry years. While this is less than the quantity which would occur naturally, it is still significant. Some reduction in the game population and in the number of cattle may be necessary to keep the herds in good condition, but the danger of extirpation or even extinction of yet another rare wildlife species will have been averted.
Other environmental measures incorporated into the project included a requirement that the contractor establish medical facilities to screen and treat workers, and the institution of modern sanitary arrangements for potable water supply and sewage disposal.

Covering an area of 22,500 km², the Kafue National Park is one of the largest game sanctuaries in the world; the loss of park area to the reservoir, being less than 1.5 percent, was therefore not a matter of serious concern to park management.

The dilemmas arising from differing views and value systems related to conservation versus necessary economic growth are numerous and of growing importance around the world.

The Kafue project illustrates a successful attempt made to resolve such important conflicting wildlife conservation development interests.

(ii) Thermal Power projects exhibit many of the problems characteristic of industrial schemes as they relate to air and water pollution. Of especial concern is the effect the thermally-elevated cooling waters will have on the biota of the water body into which they are discharged.

(iii) The problems associated with Transmission Lines have to do with scenery and tourism. The problems can be minimized or avoided if the proposed route is considered in terms of its relationship to these values. Use of herbicides along the right-of-way creates problems for the local flora and fauna.

As earlier stated, hydro-power projects (or series of projects constituting a scheme) often require the relocation and resettlement of people, villages, and even urban centers from the proposed reservoir area. Such man-made lakes have a profound influence not only on the bio-physical system, but also the socio-cultural systems of the affected basin. Relocation and resettlement constitute a traumatic psycho-social experience about which, unfortunately, little systematic research has been conducted. And, while this situation continues to prevail, increasingly planners are becoming aware of the need to deal systematically with resettlement during the initial feasibility studies, and utilizing the input of anthropologists, sociologists, and other behavioral scientists. Such systematic treatment is revealing that the stress of resettlement can be viewed as a multi-dimensional insult with psychological, physiological, and socio-cultural components. Physiological stress is best measured in terms of altered morbidity and mortality rates during the transition period. A priori there is
reason to expect higher rates following relocation, and hence increased physiological stress. Aside from the psychological stress (crises of cultural identity, grieving for "lost" home, uncertainty of security, etc.) of removal, the increased population density which has characterized most resettlement increases the risk of epidemic diseases. Socio-cultural stress can be inferred from the way in which people have reacted to the implementation of resettlement which, most often, is of a compulsory, government-ordered nature.

Recognition of these problems and the opportunity for minimizing them can be seen in a number of Bank Group-financed projects. In the case of the Accra/Tema Water Supply Project in Ghana, the resettlement of eight villages within the impoundment area with a population of about 2000 was preceded by a detailed socio-economic study, as part of the project feasibility studies. Detailed planning and supervision of the resettlement would be undertaken by the University of Kumasi. While not a hydro-power project, this project presented similar resettlement problems and opportunities, and would seem to have been handled in a model manner. In the case of the Quae Yai Hydro-electric Project in Thailand, 8000 inhabitants will be resettled out of a reservoir area, and presented classical psycho-socio-cultural problems of the type earlier described. In the environmental studies conducted during the feasibility stage, careful consideration was given to the resettlement sites, changes in occupation, life-styles, physical and social conditions, social services, etc., and these have formed the basis of a resettlement plan to be implemented by the borrower and government. Many other project examples exist such as the Sao Simao, Itumbiara and Paulo Alfonso Hydro-electric Projects in Brazil, wherein resettlement problems were presented and required incorporation as integral aspects of the projects' formulation and implementation.

b. Agriculture

Production of food and fibers requires large-scale manipulation of the naturally occurring environment, and gives rise to numerous ecological and human problems.

(i) Irrigation schemes are designed to provide a dependable, continuing supply of water to water-deficient areas, enabling additional lands to be brought under cultivation and often increasing the opportunity for perennial crop production. The problems of soil salinity and water-logging have long been recognized and addressed by the designers and operators of irrigation projects. But such projects may also result in infestation by undesirable aquatic plants and the creation of new or enlarged habitats for water-associated disease vectors, especially those snail species involved in transmission of Schistosomiasis. Irrigation canals, by increasing the opportunities for human contact with water, also increase the opportunities for transmission of water-borne disease.
The Upper Egypt Agricultural Drainage Project illustrates some of these problems. The construction of the High Dam at Aswan has allowed for perennial irrigation by stabilizing the flow of the Nile. Perennial irrigation has brought the groundwater table up to or just below the surface and, with it, salts which raise the salinity of the soil and of irrigation waters. As a consequence, land is going out of production and this situation will continue unless and until adequate drainage is provided, as is being done in this project.

The disease of Schistosomiasis (Bilharzia) affects millions of persons; WHO has described it as one of the major diseases of developing countries. It has long been prevalent in Egypt; it was known to the Pharaohs. Perennial irrigation has improved the habitat for the snail vector of the parasitic disease, and increased both its distribution and the chance for human reinfection (resulting in greater clinical severity of the disease). How to control the snail over large areas and arrest the clinical severity of the disease poses a formidable problem for Egypt's agricultural and public health authorities.

The Bank Group-financed drainage project in Upper Egypt provided an opportunity to study and deal with the problem. An internationally recognized Bilharzia expert, after a field survey, made recommendations for chemical control of the snails and treatment of infected individuals; these were incorporated into the project. The control effort is designed to fit into a national plan for tackling the environmental and clinical aspects of this important disease.

(ii) Forestry projects present problems associated with ensuring a sustained timber yield through regulation of annual allowable cuts, prescription of cutting cycles appropriate to the species harvested, reforestation of cut-over areas, prevention of erosion and fire, and maintenance of stream flows in the areas being harvested. Problems can also arise in connection with the scope and extent of enforcement of forestry laws and regulations, the competence of forest management institutions, and the award of lumbering concessions. The transport and industrial aspects of forestry projects may also require examination.

The Antalya Forest Utilization Project in Turkey is a recent case in point. This project, at an aggregated cost of $164.3 million, included a forestry development program, an integrated sawmill and pulp and paper mill, and forest industries feasibility studies. A large reforestation and afforestation program of 11,000 hectares per year was included in the forestry component, and modern forest management is expected to ensure sound silvicultural and cutting practices based on the principle of sustained yield and with due regard for erosion and fire control.
The integrated mill will analogously be designed and equipped in full consideration of environmental and health needs. Gaseous and liquid effluents will be minimized through maximum in-plant recycling and provisions made for advanced end-of-the-line treatment before final discharge.

The Antalya area is well known for its natural beauty, historical sites, and delightful climate. Consequently, it holds great promise from a touristic point of view and the development of a large pulp and paper plant would seem to be on a collision course with future development of tourism in the area. At an early stage, therefore, the inclusion of extensive environmental protection measures was recognized as a requisite for project implementation; and that such measures would have to include scenic considerations as well as careful architectural planning and landscaping in addition to advanced effluent treatment facilities. In particular, detailed studies were necessary to determine a site location compatible with conflicting interests.

The first study undertaken by the consultants recommended a site at the Mediterranean waterfront near the Manavgat River. Topographical constraints and scarcity of water put primary emphasis on eight possible plant sites along a 90 km belt of coastal land, and of these the Manavgat site was seen as offering the best balance between economic and ecological considerations. The premise that harmonious industrial and tourism development was possible in that area needed to be carefully examined by the Bank Group, when at each stage of the project's further development the Government became increasingly aware of the socio-economic benefits of the industrial plant.

The Turkish Government, however, did agree to a suggestion of the Bank group to review again the matter of plant location and established an inter-ministerial committee to conduct a detailed comparison of the site alternatives.

The least-cost site initially chosen was abandoned in favor of an off-beach location removed from areas of high tourism potential and at a greater distance from the coastal highway.

The problem of heavy truck traffic in the area will required further study and the Government intends to provide measures for improved handling of the increased vehicular traffic. Oceanographic studies will determine the exact location of the liquid effluent pipeline outfall into the sea which will minimize any future adverse impacts. Finally, zoning measures were agreed upon with the ministries involved to prohibit future encroachment from industrial development upon tourism, and vice versa.
The handling of the project by the Turkish authorities demonstrated an appreciation for and understanding of the perceived environmental problems.

In the case of the Antalya project, foresight, resulting in significant precautionary measures, would seem to have efficiently mitigated present and future problems.

(iii) Other types of projects in this sector present problems or opportunities peculiar to their nature and setting. In the case of marine Fishery projects, concern is evidenced for the stocks to be exploited, and the manner in which they will be harvested to ensure conformance to the concept of sustained yield. The institutional capacity for overseeing and regulating the harvesting of this resource, as well as conducting the necessary studies, investigations, and research is examined. Pollution with respect to its impact on the fisheris, especially estuarine and coastal stocks, is a matter of continuing concern. Fresh water fishery development schemes can be threatened by fertilizer and pesticide runoff, weed and algae infestation, and water-borne diseases.

(iv) Livestock projects require consideration of range conditions and carrying capacity, and the prevention of over-grazing. Livestock/wildlife competition, encroachment on game preserves, barriers to wildlife migration routes and the adequacy of water supplies are associated issues. In semi-arid areas, the potential for contributing to desertization, a phenomenon affecting large areas of the Sahel zone in Africa, must be taken into account.

(v) Rural Development projects may require consideration of health-care delivery and environmental sanitation. New water supplies need to be protected against surface and sub-surface contamination. The problems presented by small sub-projects -- impoundments, irrigated areas, fish ponds, etc. -- are local in character and can readily be handled, often on a self-help basis. Rural development projects under way or proposed in Malawi, Upper Volta and Mauritius, for example, have been examined for their environmental/health implication; and problems associated with erosion, soil conservation, afforestation, crop depredations, water-borne diseases and environmental sanitation have been identified, and provision made for appropriate remedial action.
(Continuing Para 41)

(vi) Pest Control activities may involve the use of toxic pesticides and herbicides, including their aerial application. Selecting chemicals which are the least harmful for non-target species and which do not become persistent and pervasive in the several ecological systems being affected is important. Of similar importance is ensuring that the formulation of pesticides is supervised to preclude using incorrect concentrations thereby posing a threat to applicators, the biota, and public health.

c. Industrial Projects

Few, if any, industrial projects are free of potentially troublesome environmental problems. Most common, as would be expected, are those associated with air and water pollution, solid wastes disposal, noise, in-plant industrial hygiene, plant siting, and subsequent related land use and settlement patterns. The capacity of the environment to withstand the injection of industrial wastes without serious undesirable consequences must be carefully considered. It is also important to identify specific pollutants, known to pose a demonstrable threat to human health or ecological systems (e.g., mercury, fluorine, arsenic, etc.) even in very low concentrations; their release must be prevented or carefully controlled and monitored.

Fortunately, the pollution resulting from industrial processes is susceptible to control. The degree of control appropriate will depend upon the environmental setting and the quality of the ambience to be achieved. Conditions in many developing countries permit more liberal effluent and emission standards than can be tolerated in the more highly industrialized countries. But it is important not to foreclose potentially important future resource options; hence, the need for projecting the cumulative consequences of industrial pollution.

An example of a Bank Group-financed industrial project posing a number of potentially serious problems is the MBR Iron Ore Project in Brazil. The project contemplated the exploitation of high-grade iron ore near Belo Horizonte and construction of a 640 km rail transportation line to an insular marine terminal on Sepetiba Bay, a recreational/tourist resource of great potential value.

An in-house examination by the Office of Environmental Affairs, in cooperation with the Industrial, Transportation, and Urban Projects Departments, revealed a number of potentially significant environmental problems at the mine site, along the rail line, and at the location of the terminal. It was decided to proceed with an on-site study, and a team of environmental consultants was engaged to identify likely problems and recommend preventive or mitigating measures. Partly as a result of the consultants' recommendations, arrangements were made for safe handling of the berthing ships' slops; an improved navigation system; a contingency plan for handling accidental oil spills; improved landscaping and rail trestle design; erosion and dust control; and solid waste handling and liquid waste treatment. At the mine site steps are being taken to prevent pollution of nearby surface waters, to stop erosion and to restore the landscape through plantings and contouring.
The rail line will pass through urban areas. The frequency of heavily loaded ore trains will create noise and safety problems. Although less than fully satisfactory solutions could be found, the undesirable consequences were accepted because of the overall importance of the project.

Sepetiba Bay, a largely, as yet, unspoiled estuary of great beauty, represents a recreational/tourism resource of great potential value. In addition, it has a significant shell and fin fishery, as well as a nursery ground for important coastal fish stocks. The fate of this estuary is uncertain in view of planned industrial activities along its shores. But, the joint concern shown by the Bank Group and the Borrower for the future of this area, has set an example. Another industrial project on this Bay, financed in part by the IFC, has received similar treatment of its environmental aspects to ensure its not representing a threat to the Bay's future resource options.

Examination of the plans for the Erdemir Steel Expansion Project in Turkey revealed that little or no provision had been made to control the liquid and gaseous effluents which would be released into the environment in relatively large quantities. Of particular concern was the possible effect of air pollution on public health and on livestock and vegetation in and around the project site. Further, the liquid wastes, containing toxic ingredients, were to be released directly into the offshore waters of the Black Sea, which already shows signs of increasingly heavy pollution. It was decided that an industrial pollution study should be made, and a team of industrial pollution control experts was engaged by the Bank Group. The team recommended controls to achieve reasonable standards governing the release of effluents in keeping with conditions peculiar to the project site. The sum of $5 million, representing 1.7% of total cost, was included in the project cost estimate for this purpose.

The Cuaonce Mining Project in Peru, a large copper mining and smelting operation for which IFC is providing slightly more than 2% of the total cost of $550 million, will involve the development of a new copper mine, installation of a concentrator, and expansion of smelting and supporting infrastructure facilities. The project, which will produce 186,000 tons of blister copper annually, is located in a sparsely inhabited largely semi-arid area of southern Peru immediately adjacent to the Pacific coast.

Examination revealed that effluents and emission created by the mining and smelting operations already being carried on at the project site would be doubled, causing 30 million tons of tailings to be discharged into the sea and 600,000 tons of sulfur oxides to be released into the air annually. Population centers and surrounding agriculture would be exposed to marked increases in air pollution. Experience during the prior 14 years of operation indicated that the pollution had on occasion reached as far as 60 km upwind from the smelter, with adverse effects on sugar cane and vegetable production.
In addition to problems attributable to the gaseous effluents, there was the question of the effect of tailings in the offshore waters; the waters are associated with the large-scale "upwelling phenomena" along the Peruvian coastline which gives rise to an abundance of phytoplankton, on which the anchovy feed. The annual anchovy catch has been estimated at about 10 million tons per year, making it the world's largest fishery in terms of weight of catch of a single species. The fishing grounds also sustain a large but fluctuating bird population (10-30 million) which includes the important guano-producing species (cormorant, piquero and alcatraz).

Because of the magnitude of the mining project, the limited availability of data and the potential environmental/health impact, and industrial/environmental pollution control expert was sent to the area. His report recognized the very significant economic/social benefits that Peru would realize from the proposed operations, and attempted to weigh these against the possible adverse environmental/health effects.

Ultimately the decision was to proceed with the project, when the borrower agreed to implement the Bank Group's recommendations on environmental/health safeguards. Qualified consultants, acceptable to IFC, will conduct studies on mine tailings disposal and air pollution. The project's sponsor has agreed to carry out its operations with due regard for the environmental, occupational health and safety, public health, and agricultural consequences attributable to the presence and operation of the mine, smelter and supporting or associated facilities. In particular, it will take whatever steps are agreed to be necessary to alter its present tailings disposal practices should this prove necessary, and will monitor air pollution in and around the smelter site to preclude any threat to the public health or to agricultural interests.

d. Other Bank Group Projects

(i) Environment/health requirements are usually taken into consideration in design and implementation of water and sewerage projects. Occasionally, it is necessary to examine the waters into which treated sewage will be discharged to ensure correct placement of the outfall and the adequacy of treatment. Data on currents, tidal action, flushing rates and fisheries resources are important in this connection.
The Sao Paulo Water and Sewerage Project in Brazil may be taken as an example of environmental problems being reduced by this type of project. Rapid urbanization has occurred nearly everywhere in Latin America; typically, Sao Paulo has tripled its population in the past two decades. Half of the houses in the metropolitan area have no water connection and two-thirds have no sewer connection. This leads to contamination of groundwater, and endangers environmental health. Moreover, industrial plants draw 70 percent of their water needs from polluted waterways and have little incentive to refrain from dumping waste waters into nearby rivers.

Two Bank loans ($22 million for water supply and $15 million for pollution control) are designed to expand bulk facilities for water distribution and sewage disposal. Altogether, projects costing a total of $750 million are planned for the 1970s. Two million city dwellers should be able to have piped water. The pollution control component, representing $82 million in construction costs by 1974, will be the first stage of a long-range program to free the rivers of 70 percent of their present load of solids and 45 percent of the biochemical pollutants.

(ii) Transport projects of all kinds can present environmental problems.

Highway projects may change surface water drainage patterns and lead to erosion; open new pathways for transmission of human and animal disease; lead to unregulated settlement along the route, and create aesthetic problems in areas with high tourism potential; adversely affect wildlife habitats; and pose safety problems for people and animals. Highway design engineers and contractors are, however, becoming increasingly aware of the problems posed for the physical environment, while development planners are becoming aware of the secondary impact of new roads. The problems presented by railways are similar to those posed by highways. The principal problem associated with airports is noise, which affects decisions concerning runway orientation, flight paths and aircraft schedules. Siting and land use zoning assume importance, as means of minimizing the undesirable consequences of congestion from development associated with or triggered by the airport.

Port development and inland waterway projects pose problems of dredging and the disposition of spoil material, the possible disruption of fish habitats, the potential for accidental oil spills, pollution of water, changes in sediment transport which may alter beaches and other land forms, undesirable urban development, marine accidents and solid wastes management.
Pipelines which are not properly sited can become a barrier to wildlife movement, create an aesthetic blight, constitute a hazard if ruptured by an earthquake and may encourage improper use of herbicides along the right-of-way.

(iii) Because Urban Centers in developing areas suffer from too rapid growth and the continuing impact of rural/urban migration, they are the focus of major problems concerned with air and water pollution, environmental sanitation, solid wastes management, congestion, noise, health care services, open spaces and recreational areas. While virtually every city exhibit all these problems, the mix and intensity varies, and solutions must be designed for the particular socio-economic-political milieu. A case in point is the Istanbul Urban Development Technical Assistance Project.

This centuries-old city has been, in later years, undergoing rapid, unplanned, and uncontrolled growth. The provision of urban services and amenities has not kept pace with growing demands. Installed water systems lack capacity to meet present demands and service is intermittent. Only one-third of the city is served by a water-borne waste disposal system. Contamination of surface and ground water eventually used for domestic purposes is widespread and was linked to a cholera outbreak in 1970. Storm sewers are lacking and standing water is a problem in areas of the city. Pollution of the Golden Horn has reached alarming proportions, while the Bosphorous and Sea of Marmara are grossly polluted from domestic and industrial wastes, and ships. Solid wastes management and disposal are inadequately handled, including open burning dumps, infested with vermin. Health services, particularly those serving the explosively growing squatters settlements are inadequate and insufficient, and ancillary health services (diagnostic laboratory, food inspection, etc.) are antiquated and insufficient as well. Compounding these urban environmental/health problems is the diffusion of responsibility for local administration among multiple agencies, and the diffused relationships existing between metropolitan, regional, and central government bureaucracies.

This project seeks, among other things, to work toward a correction of the deficiencies and builds upon its predecessor projects, Istanbul Urban Development and Water Supply. The project aims toward achieving comprehensiveness and coordination of the policies, plans, and programs among and between levels of government; and leading to the formulation and execution of a sound metropolitan development program. The quality of life as well as the quality of the environment in Istanbul and its environs is to be directly affected by the outcome of this project. The problems cited in Istanbul can be seen in many cities in the developing countries, and their solutions increasingly call for a multidisciplinary
approach to the many interlinkages that characterize the rapidly changing man-environment relationships in the urban setting. The UNDP has been called upon by the Turkish Government to assist in its development of a national environmental policy and to finance specific studies aimed to resolve pressing existing problems. The Bank Group has encouraged these moves, works in close cooperation with the UNDP, and stands ready to assist in financing suitable projects among those identified.

(iv) All Tourism projects are a potential scenic and aesthetic threat. Architectural design and proper utilization of the land/water areas being developed are critical, as is the continued prevention of pollution in water bodies associated with the project. The impact of the project on nearby urban areas, their peoples and cultures must be taken into consideration. Zoning and land-use planning are important. The Babin Kuk Tourism Project in Dubrovnik, Yugoslavia, comprised of nine hotels (2,500 rooms) plus services, shops, transportation and related infrastructure, is one of the largest tourist complexes in the world. A prime objective of the project's design was the preservation of the area's scenic beauty; the project was skillfully blended into the natural surroundings. Collection and treatment of human wastes posed a problem, particularly since Dubrovnik's sewage had to be taken into account. Marine biology and oceanographic studies were conducted to assure that beaches and offshore waters were protected against pollution from the tourist facility. The studies, carried out in cooperation with Yugoslavian biologists, fisheries specialists and hydrographic authorities, produced recommendations for the treatment of wastes and for locating the sewage outfall so as not to endanger public health, tourism and the marine biota. In addition, a modern urban sewage collection and treatment system is planned for Dubrovnik.

The problems associated with the potential incompatibility of industrial and tourism development were examined in the case of the Antalya Forest Utilization Project in Turkey (see p. 20).

(v) Additional Project Types. Such projects as those concerned with education, population and nutrition, and telecommunications rarely present environmental problems of any significance. The objectives and purposes of the population/nutrition projects are clearly consonant with reducing the impact of a burgeoning population on the environment and its resources, while at the same time improving the human condition.
Lessons Learned

42. Experience with the environmental dimension of development projects has been highly encouraging. Thanks in large measure to the preparatory work for the Stockholm Conference on the Human Environment, and to the Conference itself, developing countries have, by and large, responded positively to Bank Group initiatives. Indeed, it is not uncommon for developing countries to assume the initiative themselves, not only in anticipation of the Bank Group's requirements but in response to their own perception of the problems. Other development financing institutions are now taking an approach similar to that of the Bank Group. The activities of the United Nations Environment Programme can be expected to support and to encourage further efforts in this direction.

43. A growing number of countries are adopting environmental legislation and pollution standards, and setting up regulatory and enforcement agencies. The Bank Group now frequently receives requests for advice, consultation and technical assistance in the environmental field. Further evidence of a spin-off from the Bank Group's environmental activities has been the development of an ecological conscience in the private lending sector; financing institutions are incorporating environmental considerations into their operations.

44. Some environmentalists may say that the Bank Group is not doing enough, that it should conduct extensive preinvestment studies to assure that all alternatives have been considered before making its investment decisions. Others will appreciate, however, that a long delay in the provision of development assistance attributable to environmental considerations would not be acceptable to the developing countries; they are likely to reject all environmental considerations, in an effort to expedite the financing they seek.

45. The fact is that by and large the environmental critics of the Bank are becoming fewer, as the actions which the Bank Group has taken and the results achieved become known and understood. Among the international health community, critics of the Bank Group on the grounds that it paid little attention to the health implications of its projects have also now come to acknowledge with approval the initiatives put forth by it in recent years, and to applaud especially its spearheading of the Onchocerciasis Control Programme in West Africa and its concern with Schistosomiasis.

46. So far as concerns the Bank Group's own procedures, the emphasis on early consideration of a project's environmental dimensions has been fully justified by experience. Often the initially available data essential for an informed judgment and reasonable projections (e.g., on wind direction and frequency, temperature inversions, river flow, offshore currents, etc.) are insufficient; they may be entirely lacking. It takes time to put together the requisite information, to analyze it and to formulate recommendations. Moreover, timing becomes a critical factor when dealing with natural systems or the human organism, so it is highly desirable that problems be identified early, and that steps be taken to resolve them as the project cycle proceeds. If a project's environmental implications have not been thoroughly reviewed before the appraisal stage, the opportunity for any significant action will have been appreciably diminished.
It may prove easier to project a project's economic and financial rates of return than to forecast its direct and secondary effects on the environment. For example, to judge the risk of Schistosomiasis from an irrigation project it is necessary to make some assumptions concerning the manner in which natural systems will develop so as to provide a micro-environment congenial to the establishment and/or further distribution of the vector, a particular species of snail. In the absence of data from the project, site, judgments must be based upon observation and study of similar systems. The degree of risk and the related social costs must be weighed against the expected benefits from the project. If it does not seem likely that the incidence of the disease will be stimulated to any great extent by the project, or that it will become more widespread, it may be acceptable to take the risk and make no provision for any countervailing measures. On the other hand, if there is a strong likelihood that these undesirable health consequences will be realized, it will prove necessary to incorporate into the project measures for the control of the vector and treatment of afflicted individuals.

A hydro-power dam may cause the demise of riverine fish species by changing the character of the downstream aquatic environment by barring movement to upstream spawning grounds. The fishery may represent an important local source of food, or have considerable use for sporting purposes. It might well be possible to establish, in the impoundment, a fishery of equal or greater value. But if no consideration is given to the affected fishery resources in the preparation of the project, the result will be the loss of an existing resource without provision for replacement.

The risks to the environment and to health should be included among those to which consideration is given in the course of appraising a project's expected contribution to improvement in the human condition. The problems that arise in identifying and evaluating these risks and the remedial actions that may be possible are discussed in the next section.

Costs of Environmental Safeguards

When the Bank Group first determined to incorporate environmental protection measures in its lending operations, some concern was expressed about the cost of such measures and the burden that would be imposed on borrowers. Estimates ranged as high as 25-50% of total project cost, which would have been wholly unacceptable to the developing countries.

It is difficult to separate out those costs and benefits which are attributable exclusively to environmental measures, and in any event the quantification of those costs and benefits will depend largely on how the environmental dimension is defined. In the case of a sewerage treatment project the cost would be 100% under most definitions. As public health is a most important part of our environmental considerations, most water supply and sewerage projects fall in this category. In FY73, the aggregate total for such projects financed by the Bank amounted to $278.8 million in 9 countries.
The Bank Group's experience to date, however, when disregarding such projects, appears to be consistent with that of other aid agencies and suggests that those early estimates were much too high. The additional cost attributable to environment/health safeguards in "non-environmental" projects has ranged from 0-3% of total project cost, the high end of the range applying where precautionary measures were added on to projects already well advanced. Exact data on environmental expenditures are not easily furnished for several reasons.

52. Environmental measures are often productive, and it is questionable whether a project's environmental dimension gainfully should be separated out. Project components are all intimately related, as is the project itself to other projects, the external environment and the society at large. The Bank Group operates under a broad definition of what is environmental, and seeks to incorporate a project's internal environment and its public health and socio-cultural aspects in its evaluations. This mode of operation calls for improvement of human ecologic conditions frequently not conceived of as environmental, while at the same time attempting to circumvent or mitigate errors made through development on the patterns of the past. The idea that well-defined anti-pollution measures are to be added to a project at a cost is not seen as especially productive or desirable. Frequently this is still the only solution available for industry, but often, and more so in the future, pollution is, and will be, overcome through redesign, recirculation, product changes, etc., a style of planning and production in which steps taken specifically for reasons of environmental protection will be indistinguishable from, and a true part of the entire process. The Bank Group, furthermore, does not ordinarily separate out environmental expenditures as such on projects it finances; it frequently pays for part of studies undertaken and subsequently finances the foreign exchange component of a project, or parts thereof, alone or in cooperation with others. In other instances environmental expenditures relating to a project are financed from other sources entirely. Also, at the time of project appraisal only estimates are made of expenditures to be incurred regarding resettlement, cost of land at new locations, training, occupational health measures, medical facilities, water supply and sewerage, landscaping, studies on how best to minimize industrial pollution, and subsequent cost of treatment facilities and final disposal. Additional money may in time be transferred for these and related environmental purposes or vice versa, depending on progress made toward project realization.

53. It can be expected, however, that as economic development proceeds the cumulative impact of the environment/health-threatening effects will lead the developing countries themselves to adopt higher standards and impose tighter controls. This is already being done, for example, with respect
to urban industrial locations where air quality is deteriorating; the installation of controls on existing plants is being required and stricter regulations governing the operation of new plants have been promulgated. As the assimilative capacity of ecological systems in developing countries become severely strained, it will be necessary to employ additional measures and to strengthen existing measures; at the same time, the cost of these measures will be greater. Reports on air pollution in, for example, Sao Paulo, Ankara and Mexico City indicate that the requisite control measures will be both costly and technically difficult. In general, the cost of removing a pollutant from a waste stream is proportional to the amount already removed and this trend produces increasingly higher costs for additional incremental improvement. A zero discharge, often referred to as an appropriate goal for adequate industrial pollution control, does not, however, imply an astronomical cost, but instead a "closed" system wherein recycling is extensive and only non-problem waste, if any, is leaving the plant.

54. A further case in point illustrating the need to consider the assimilative capacity of ecological systems when evaluating the environmental impact of a project is to be seen in the Pan African Pulp and Paper Project on the Nzoia River in Kenya which flows into Lake Victoria. In considering the impact of an IFC-financed pulp and paper mill on the river, its downstream uses, and the Lake, the expected municipal and industrial development of the watershed needed also to be examined. The nature and degree of control over the effluent of the pulp and paper mill could only be gauged when its relationship to all other pollutants entering the river system was understood. This examination revealed the critical necessity for requiring a high level of treatment of the plant's effluent and at the same time encouraging the Government of Kenya to monitor the river's condition and plan further development with careful regard to cumulative threat to downstream uses posed by such development. If adequate control over the municipal, industrial, and agricultural wastes entering the river system is not maintained, the river's already precarious ecological integrity will be lost with disastrous consequences for important downstream uses.

55. Thus, while costs for environmental/health protection associated with individual projects remain an acceptably small part of the total investment, it should be stressed that increased development will contribute to the need for developing countries to assess the cumulative impact and the need for more stringent standards governing the design and execution of development schemes with resulting cost increases.

56. International surveys have been conducted in an effort to obtain information on the magnitude of the costs of national programs for environmental pollution control, particularly from industrial sources. Such projections of national costs as are currently available, however, are notoriously unreliable. Problems exist with respect to cost calculations
that assume only "end of pipe" treatment strategies will be adopted rather than internal process changes or product modifications; indirect costs that are inconsistently handled; a pattern of demand that are assumed to be constant.

57. The figures that are available, however, for some of the more advanced OECD countries suggest that for these countries, total investment plus operating costs might vary from one-half of a percent to about two and one-half percent of the GNP. The U.S. has undertaken perhaps the most extensive data collection effort with regard to cost estimates. Cumulative estimated total pollution control expenditures for the period 1972-1981 was published in the fourth annual report of the U.S. Council on Environmental Quality, 1973. They amounted to 27½ billion of 1972 dollars, or about 2.5 percent of the GNP during the same period. Any lower level of expenditures, it was stated, would likely result in even greater economic penalties as reflected in adverse environmental/health effects. The estimates covered air and water pollution, land reclamation, radiation and solid waste. No further details of estimates made on individual industries are furnished here. Marked variations exist in estimates made from year to year and the above percentages are included only to indicate the order of magnitudes for illustrative purposes.

58. In particular cases, a country's decision to impose environmental control measures on its producers may alter the terms of trade for the country's exports. This should be expected because different countries will face different costs even for the same level of environmental standards. Furthermore, the implicit tradeoff between a healthier, more amenable environment, and additional financial resources will be resolved differently by different countries. While data which would predict the magnitude of shifts in international terms of trade are not available, few independent experts feel that widespread dislocations should be expected. Rather, effects are more likely to be felt in individual industries, plant and/or localities. (See paras. 104, 105 where the subject of adjustment assistance is discussed).

Other Development Assistance Organizations

59. It was earlier mentioned (p. 33) that other development assistance agencies have incorporated environmental dimensions into their activities. It can fairly be said that the Bank Group's policy and practice has had some influences in this regard. The U.S. (AID) program, for example, has adopted environmental guidelines governing project formulation and implementation. Under the terms of the U.S. National Environmental Policy Act, which has been applied to U.S. (AID)-financed projects abroad, all such projects are subjected to an environmental impact appraisal, which considers the likely consequences and proposed how they can best be handled.
60. The Swedish International Development Authority (SIDA) has established a Secretariat for International Ecology, with responsibility for reviewing all projects for their environmental implications. The impact of this review has already been felt in several projects jointly financed by IBRD/SIDA.

61. The United Kingdom Overseas Development Administration (ODA) and the Canadian International Development Administration (CIDA) are also incorporating environmental assessments in their lending activities.

62. There are indications that development assistance agencies in Germany, France and Japan may adopt a similar policy.

63. In November 1972, the Bank Group organized a conference on development/environment issues and problems attended by officials from the principal development assistance agencies. The conference, which is expected to be repeated in 1975, revealed a growing sensitivity to environmental matters and a disposition to take account of these matters in the programs of the agencies.

64. The U.N. Environment Programme (UNEP) will be working closely with developing countries in identifying environment/development problems, and assisting them in preparing appropriate legislation and standards, institution-building, research and training. Through its information referral system, in which the Bank Group cooperates, the UNEP will be providing developing countries with information, data and advice on a broad range of environmental and related health matters, as well as on related development planning efforts.

V. COST-BENEFIT EVALUATION PROBLEMS AND NATIONAL ENVIRONMENTAL POLICIES

Project Considerations

65. As earlier pointed out, efforts are being made increasingly to include environmental considerations as integral parts of development strategy and action, and Bank Group operations. This raises difficult problems of evaluation as to the various costs and benefits involved in alternative ways of dealing with such environmental considerations. This section considers, first, the general criteria for making cost-benefit project decisions where a project involves significant environmental considerations; and, second, approaches to the formulation of national environmental policies. It attempts to identify the relevant principles involved, recognizing that both within the Bank Group and elsewhere, experience to date has shown quantification of the relevant tradeoffs to be an elusive goal.

66. In general, the methodologies and criteria applicable to projects with environmental aspects are similar to those applicable to other kinds of projects: the benefits (broadly considered) which could be expected to be realized from incremental environmental expenditures should be determined to be greater than those which flow from alternative uses of the resources.
involved. There are, however, uniquely troublesome aspects of measurement and quantification associated with environmental matters which make application of such a concept at present more of an art than a science. It is difficult to predict the extent and type of environmental change that will result from a particular activity. It is even more difficult to value a predicted change in cost-benefit terms.

67. When the extent and character of environmental change can be predicted, often existing markets will provide a measure of the monetary value of some of the effects, at least. For example, the value of fish protein gained or lost through a change in water quality, and the repair and maintenance costs for physical structures subject to air or water pollution, can usually be adequately measured in this way. But it is not possible to directly establish a market value for the health effects of a change in amounts of air-borne particulates or a change in drinking water quality. In such cases indirect methods must suffice; an attempt must be made to infer from the prices of things which do have a market value, the value placed upon things for which no market has been established.

68. This concept of cost-benefit evaluation has been termed the "willingness to pay" concept. For example, a Bank Group appraisal mission on a sewerage project in Brazil was able to quantify some of the aesthetic and health benefits associated with a clean-up of the river through measurements of increases in nearby land values. In principle, this is the concept that the Bank Group currently attempts to employ in projects, such as water supply and sewerage, with direct health and environmental consequences. While the concept presents measurement difficulties, it is in principle applicable to any project with environmental implications. Where markets fail or do not exist, an inference is drawn concerning the amount that individuals would be willing to pay were there a market. The measurement of willingness to pay should of course include the value of benefits which actually accrue to the individual, whether or not he is in fact charged with the cost of providing them.

69. Several factors with a special bearing on discussions of environmental matters, and which influence willingness to pay in particular instances, should be noted. First, willingness to pay for alternative items is a function of resource endowments, e.g., national wealth, and also of individual preferences and tastes. Consequently, different countries will make different choices as between environmental goods and other goods.

70. Second, willingness to pay will be to some extent a function of the options available within the area. For example, the value of cleaning a particular river or stream will depend upon the number of other clean bodies of water in close proximity and the extent to which they offer suitable alternative facilities. In an area with an abundance of clean water bodies, the marginal benefit of providing one more is likely to be substantially smaller than would be the case where there were very few water bodies or where most existing bodies were fouled.
71. A third factor affecting willingness to pay falls under heading of "non-user" benefits. Persons who are not and may never be users of a facility may nevertheless receive some benefit from the knowledge that the opportunity for use exists. In principle, that benefit should be measured by the sum of all such "non-user" beneficiaries' willingness to pay.

Approaches to Project Analysis

72. Least Cost. A "least-cost" analysis evaluates alternative proposals for achieving a particular environmental target, with the solution that achieves both the environmental (and productive) targets at least cost being selected. Least cost analyses are frequently used in power and other public utility projects where benefits are difficult to quantify. It is important in any such analysis to assess the sensitivity of costs to variations in the environmental target level, so that tradeoffs between levels of expenditure and the environmental quality obtained thereby can be evaluated. Although this approach provides only a partial analysis; if the proper sensitivity tests are made it can at least demonstrate, in physical and in cost terms, what are the relevant tradeoffs.

73. Switching Values. Another technique has been used in a few Bank projects which have environmental aspects, where some but not all benefits are quantifiable. It deserves wider attention. The approach involves providing an answer to the question "How large would the value of residual environmental benefits (those benefits not quantified) have to be to justify the project?" (The procedure is described in terms of benefits, rather than costs, because the valuation of benefits is likely to be more uncertain; costs may, however, be similarly treated.)

74. In using this approach, it is assumed that the cost stream, the discount rate and certain other benefits are known. One can thus solve for the unknown value of residual environmental benefits which would equalize the stream of total benefits and total cost at the given discount rate. Since benefits occurring in multiple years are involved, future-year residual benefits must be expressed as a function of first-year benefits.

75. When a value showing what the first-year benefit would have to be in order to justify the project is obtained, the decision whether to proceed with the project will depend on a judgment about the reasonableness of the result. The computed value of first-year benefits serves as a "switching value" for the decision. If a higher amount is ascribed to actual willingness to pay for these benefits, the project will be accepted; if willingness to pay is lower, it will be rejected. The greater the difference between the judgment concerning actual willingness and the computed value of first-year benefits, the greater can be the confidence with which a project is accepted or rejected. This kind of analysis is appropriate for gains or losses in recreation and aesthetic benefits, for example, the value of a man-day of recreation under the project being the unknown to be solved.
76. The "switching values" technique also has special relevance to problems involving the permanent loss of a unique natural or cultural asset. The fact of uniqueness will of itself make any kind of "market" pricing difficult, if not impossible. 1/

Use of Qualitative/Descriptive Analyses

77. If the environmental impact is significant, and all attempts at quantification fail, it will nevertheless often be possible to describe in qualitative terms the nature of the effects of alternative courses of action. A decision on project acceptability will typically be facilitated if, for example, in a project involving air pollution, a statement describing the benefits (or costs) of reducing (or increasing) the level of sulfur dioxide in a section of an industrial city accompanies the data on the quantifiable costs and benefits. The descriptive statement should attempt to characterize all aspects of the effects of the pollutants -- on sight, smell, taste, health, recreation, attitudes, animal and vegetative life, etc.

78. It is as important in a qualitative presentation as in a quantitative one to provide information in terms of incremental differences, i.e., to show the differences between the "with" or "without" cases, as well as the differences among project alternatives. Unfortunately, projects that produce only marginal changes may be harder to describe than projects with a large non-marginal impact.

National Environmental Policies

79. In lending for a project with significant environmental implications, the Bank Group often has an opportunity to influence the larger institutional framework within which decisions will be made. This has been the case with projects now in the preparatory stages in Finland, Yugoslavia and Turkey. It is useful, therefore, to consider the economic and social implications of alternative policy instruments available to governments. It should be kept in mind, however, that this is a new field in which views are still rapidly evolving and Bank Group staff experience is still fairly limited.

1/ A recent attempt at computing such switching values for a unique scenic canyon located in the United States made an assumption which is probably of wide general applicability: because the supply of substitute assets was fixed, the population and per capita income were increasing, and the income elasticity of demand for unique cultural or recreational assets was greater than for other goods, the price of the unique goods will increase, over time, relative to prices of other products.
80. Of the many national or regional strategies that have been proposed, most can be classified as involving regulations, subsidy or charges. These different approaches create different incentives and have different effects on resource allocation and on the distribution of the gains and losses resulting from governmental intervention.

81. Subsidies. The use of environmental resources can be effected by a program of subsidies. However, subsidies may give rise to certain practical difficulties, the nature of which depends on the basis of the subsidy. First, unless all productive investment is to be subsidized, the regulatory agency must isolate the costs incurred by enterprises for purely environmental purposes from those costs that would be incurred in any case in the interests of increasing production or improving efficiency. This will frequently be too complex for a regulatory agency to handle since an enterprise's least-cost response to regulatory requirements will often involve changes in internal processes which simultaneously result in usable or marketable outputs. This complexity is illustrated by information received during the preparation of a proposed project in Finland where it was estimated that it would cost as much as $100,000 simply to carry out a study of the net difference in cost to build a modern pulp and paper mill, with and without pollution control. As a result, in negotiating with authorities on the amount of the subsidy, the enterprises have all the advantages since only they have all the facts.

82. In consequence of the difficulty in separating out costs according to purpose, proposals involving subsidies tend to either encompass "productive" investment along with strictly pollution control investments and enterprises prefer investment toward "end-of-pipe" treatment facilities over internal process changes. The latter tendency occurs because while internal process treatment facility changes are often far superior to "add-on" treatment facilities, the latter can more easily be claimed to have been adopted exclusively for pollution control purposes.

83. Even if the level of subsidy could be related to actual reductions in effluents, rather than the cost of the preventive or ameliorative measures (i.e., payments to "clean" industries), other problems would arise. Subsidy payments would have to be adjusted as demand for a product changed over time, and to take account of obsolescence, modification and the introduction of new products; this would be extremely difficult to calculate and administer.

The policy instruments discussed in this section are in general limited in their applicability to the pervasive problem of residuals generation (i.e., the generation of waste products from productive facilities), rather than the quite different problem of the loss of a unique natural or cultural resource. Moreover, they are not directed at the question of highly toxic substances, such as mercury or fluorine, which can be dangerous even in minute quantities. Problems of unique resources and of toxic substances can more usefully be considered in the context of special studies.
84. Assuming that the costs of the appropriate environmental measures could be identified, a subsidy which met less than 100% of those costs would provide insufficient incentive, unless it was associated with, for example, a requirement that certain standards be met. On the other hand, if 100% of costs were reimbursed, a producer would have no incentive at all to determine which of the many possible approaches to effluent reduction is the most efficient.

85. With any kind of subsidy, optimal substitution by users of products that have different environmental effects will not take place, because the total payment for the use of products (including an income or other tax necessary to pay the subsidy) is not related to the social cost of the particular products consumed. Demand for and production of highly polluting products will be greater than optimal.

86. The difficulties cited refer only to questions of efficiency. There would also be the considerable problem of financing the enormous funds required, were subsidies to be a principal component of an environmental control strategy.

87. Regulation/Standards/Licenses. Environmental resources use may also be controlled through regulation; for example, through issuance of permits (e.g., allowing a given volume of effluent discharge per time period); establishment of minimum standards of quality; or specification of equipment to be employed in treatment.

88. The easiest kind of regulation to draw up and enforce is one which is uniformly applied. A national or regional requirement that all effluent be of specified quality is attractive from an administrative point of view. However, the inefficiencies associated with uniform regulations are substantial. Uniform effluent standards take no advantage of local absorptive or regenerative capacities, nor do they take into consideration the differences in marginal costs faced by different enterprises in adjusting the amount or quality of their effluents.

89. In addition, a system of uniform regulations and standards, by not allowing any flexibility in pollution control requirements, makes almost inevitable a complex and long-drawn-out system of appeals to avoid extreme inequities and inefficiencies (for example, where a particular enterprise's costs of control actually exceed the benefits to society of the effluent reduction). However, the process of appeals and litigation is usually self-defeating, since the industry always has the advantage in arguments about its costs and technology.
Individually Adjusted Standards. In view of the inefficiencies of uniform effluent standards, the adoption of effluent standards tailored to each enterprise is often proposed. In theory, a governmental body could appraise each enterprise and issue individualized regulations which would require the enterprise to reduce emissions to the point at which the marginal cost of an additional unit reduction among all enterprises is equalized and/or the desired level of total region-wide reduction is achieved. The administrative costs of obtaining the information required to institute such a system would, of course, be enormous. Furthermore, the potential for delays through appeals and litigation, which is a disadvantage of a uniform standards system, is even greater when individual standards are set for each enterprise.

Effluent Charges. Another technique is a system of effluent charges, under which a fee is levied on the use of publicly-owned environmental media for disposal of wastes. The amount of the fee is based on the total load of the harmful pollutant discharged. Where the data are less than complete and reliable, this approach may have certain advantages over those discussed above. For example, if a decision is taken to achieve a given level of reduction in effluent for some particular air-or-watershed, a unit effluent charge, at the proper level, will achieve the desired reduction at a lower total cost to the economy than a regulation calling for uniform reductions in levels of emissions or setting uniform quality standards. This is so because an effluent charge, unlike a uniform regulation, will induce the greatest reduction from those enterprises which can accomplish the reduction most efficiently. Self-interest in maximizing profits will lead each enterprise to invest in process changes or effluent treatment up to the point at which the cost of a unit reduction in effluent is equal to the amount of the charge. Producers with different cost curves will therefore respond differently. Uniform regulations, on the other hand, require a uniform response regardless of the cost to the individual enterprise.

International experience with effluent charge systems is limited. Several European countries, among them France, Holland, Czechoslovakia, Germany and the United Kingdom, which have employed license systems, have replaced or supplemented these systems with effluent charges or are considering doing so.

Because absorptive/regenerative capacities, and therefore the harm caused, will be different for different air shed or water basins, an effluent charge should be set on a regional basis. The level at which the charge is set is critical. In principle, the rate per unit of discharge should be equal to the estimated cost to society of an additional unit of pollutant discharged. Such an estimate would also have to be made to
rationalize a system of regulation. While determination of an ideal level of effluent charge may be beyond the current state of the art, several methods have been proposed for arriving at rough approximations of the proper charge.  

The question is whether an inexact level of effluent charge is more, or less, acceptable than an inexact standard. With the "wrong" level of charges, the level of effluent production will be higher or lower than the target. The reduction that is achieved, however, is achieved by means of the "least cost" procedure. Furthermore, the level of charges may be raised or reduced over time to bring results in line with the target. If a uniform standard is adopted, whatever the standard, it can be shown to be inefficient with respect to particular enterprises with differing marginal costs. Individually adjusted standards avoid the latter difficulty but, as noted above, the informational requirements and the administrative machinery necessary to set the individual standards and to avoid claims of discrimination may be overwhelming.

The conventional wisdom is that with an effluent standard, the target for environmental quality is sure to be met, even though inefficiencies are involved, while with effluent charges the results are uncertain. Experience, however, has convinced many observers that almost exactly the opposite is true. Reductions in industrial waste loads where even modest sewer charges have been imposed by municipalities have often been rapid and spectacular; on the other hand, regulatory processes are frequently not only time-consuming, but also quite uncertain in result.

A practical method for arriving at a rough estimate of the proper charge, using average, rather than marginal, considerations, might be as follows: First, an estimate is made of the total harm in a region being caused by a particular affluent, e.g., biochemical oxygen demand (BOD) or suspended solids in water, sulfates in air. Second, the total quantity in kilograms of the effluent currently being discharged by all sources into the air or watershed is determined. The damage estimate is then divided by the quantity to give an average cost that could be used as the effluent charge. Where more than one pollutant is involved a charge must, of course, be levied on each. In countries experimenting with such systems, formulas have been devised for computing the charges based upon a combination of different pollutants. There is an alternative, somewhat less desirable, approach, which does not require an estimate of social damages. If one of the goals of a national or regional program is a reduction by a certain percent of the amount of a harmful effluent, the amount of target reduction in kilograms could be estimated, and divided by the estimated total industry-wide cost of achieving the reduction. It may also be possible to obtain an independent estimate of the average per unit marginal cost of the target reduction across industries.
96. For very low levels of control, the appropriate remedies for a particular industry may be obvious both to the regulatory agency and to the industry. In such cases, there may be no great difference in result between a system of individually specified standards and a system of effluent charges. As the desired level of environmental improvement rises, however, marginal costs typically increase in a sharply non-linear fashion \(^1\) and the difference in results can be substantial.

97. One of the most detailed studies yet attempted for determining the cost of reducing pollution in a waterway was conducted almost a decade ago for the Delaware Estuary area of the United States. The study estimated costs of achieving a given level of reduction in water pollution through several different approaches, including uniform treatment standards and a unit effluent charge. It showed, among other things, that a program involving a uniform effluent standard resulted in costs from 70% to 100% higher than one involving a unit effluent charge, depending upon the specified quality level. (The difference in cost between the charge and the uniform standard was estimated at the time to be approximately $8 million annually for the higher quality level.)

98. The overall implementation strategy, whether regulation or effluent charge, must be augmented by other tools of public policy. The strategies discussed above apply chiefly to producers of goods, rather than to consumers. Moreover, they are directed at reducing future loads of pollutants, rather than improving already contaminated environments. Certain kinds of environmental activities, however, because of economies of scale, are most efficiently implemented through public initiative, often through "public utility" type organizations. Examples of such activities are urban sewerage, waste collection and treatment, and efforts to improve water bodies through artificial aeration, sludge removal or low flow augmentation.

**Equity Considerations**

99. Different forms of government intervention may have fundamentally different effects on the distribution of gains and losses from environmental improvement. Selection of the most appropriate strategy in terms of both efficiency and distributional implications can best be assured through a cost-benefit analysis which compares alternative strategies and takes account of the income position of those who gain and those who lose.

100. Under a system of charges, to the extent that the charges are reflected in a price increase, the additional costs are borne by the consumers of higher-polluting products; to the extent that producer costs increase,

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\(^1\) See Annex 5 of IBRD "Finland's Water Pollution Control Program; The Role of Economic Analysis", Public Utilities Department, PUN 8--February 20, 1974.
those producers most efficient in reducing pollution will suffer the least reduction in profits. Charges are also a source of additional public revenue available to compensate those damaged by emissions which are not reduced, and for investment in publicly-owned treatment facilities where economies of scale make these appropriate.

101. Adoption of a uniform regulation rather than an effluent charge will cause a shift in economic burden from those efficient producers most capable of making an incremental reduction in pollution to the inefficient producers least capable of doing so. The shift will generally be accompanied by higher total costs. Under a system of non-uniform regulations the distributional effects will depend upon the amount of information available to regulatory bodies (and to some extent upon the relative political or economic influence of particular enterprises).

102. A subsidy paid out of general tax revenues shifts the burden from the producers and consumers of polluting products to society as a whole.

103. A principle gaining increasing attention is that "the polluter pays". This principle, recently adopted by the OECD, is vague in application, but serves to bring to popular notice the economic concept that a producer forced to bear external costs imposed on others will adjust production activity to minimize such external consequences relative to overall profit levels. Different forms of governmental intervention can have different distributional implications and still be generally consistent with this principle, as is evident in the preceding comparison of the distributional effects of a system of uniform regulation and a system of effluent charges, under both of which "the polluter pays". A policy of subsidization out of general tax revenues would, however, appear to violate the prescription.

104. In some situations, the principle that the polluter pays may run counter to other social objectives. Where an important industry is forced out of business by newly-enacted environmental controls, society may wish, for equity considerations, to compensate those adversely affected. This kind of "adjustment assistance" is a relatively common type of governmental policy tool. Thus, to compensate for the economic impact of new environmental policies in economically depressed regions, some part of the adjustment costs may be borne out of general tax revenues. It is important, however, that such assistance be based upon demonstrated need, since distortions can result from across-the-board subsidies.

105. In assessing alternative strategies, whether or not adjustment assistance is actually provided, the social costs involved when factors of production are taken out of employment should be taken into account. The "lumpiness" of these social costs can, in fact, considerably complicate the problems of selection of the best strategy. In regions where pollution is caused by relatively few sources, and these few are important to the local economy, a curve relating total social costs to different levels of improvement in the environmental media could exhibit marked discontinuities. This would be the case where the strategy selected would force some of the important
enterprises out of production at a given level of environmental improvement. In such a situation, it would most likely be preferable to appraise separately the effects of the proposed program on each enterprise and to determine the impact of each enterprise's adjustment on the economy as a whole.

106. While no single national strategy is likely to be suitable in all contexts, a strategy of effluent charges based generally upon social damage caused and combined, where appropriate, with public works, commends itself from the standpoint of economic and institutional efficiency. Governments wishing Bank support in specifically environmental projects should therefore be encouraged to determine whether such an approach is appropriate for them. Where economic dislocations are likely to occur as a result of a change in domestic policies towards the environment, adjustment assistance based upon demonstrated need may be warranted. Such assistance would be preferable to across-the-board subsidies because of the distortions in investment to which the latter are likely to lead.

VI. IMPLICATIONS FOR BANK GROUP OPERATIONS

107. This chapter focuses on the Bank's policies and procedures in the light of its recent experiences in dealing with environmental questions.

Environmental Impact Assessment

108. Some development assistance organizations require that a formal assessment of the expected environmental impact be included in all project appraisal reports.

109. Given the Bank Group's comprehensive definition of "environment" and the wide variety in Bank Group activities, programs and projects, it would be impracticable for the Bank Group to institute such a requirement. The degree of importance or relevance of actually or potentially adverse environmental factors or effects will range across a very broad spectrum, from none or insignificant to highly critical. There is, in any event, a presumption that all projects under consideration, being intended to improve the human condition, will on balance have a beneficial impact on the environment as broadly conceived. Moreover, while a project's environmental, health and socio-cultural implications may be analyzed separately in an environmental impact statement, they are not in fact independent and separate elements of the project. The growing attention now being given to environmental/health impacts has simply enlarged the scope of project appraisal by focusing on a project dimension which, being difficult to quantify, has often been neglected in the past. It is important that adequate attention be given to activities which do have identifiable environmental implications, whether short or long-term, that an assessment be made of the significance of those implications and that, where warranted, they be fully analyzed.
The Bank Group should, therefore, adhere to its current policy of reviewing every investment project from the standpoint of the potential effects on the environment. It should encourage its member governments, both donors and recipients, to consider whether proposed projects have a potential for adverse environmental consequences, to arrange for further analysis and appropriate action where the nature and severity of those consequences warrant it, and to assure that project planning and execution takes due account of the results of that analysis. In this connection, the guidelines which the Bank Group has developed should be made available to governments, international organizations and individuals concerned with economic development.

Pre-investment Environmental Studies

In an increasing number of cases, the borrower finances environmental studies in much the same manner as it finances studies of other aspects of the project, a logical extension of the view that environmental, health and socio-cultural implications are as much a true dimension of a project as, e.g., the marketing aspects. Experience has shown, for example as noted earlier, that engineered changes in process design often produce results both superior to those obtained from end-of-the-line treatment and less costly. Process changes (often based on recycling) and new processes are constantly being developed to save resources and reduce treatment expenditures and disposal problems. An environmental study may also suggest selection of a different site, to avoid potential health hazards, reduce the likelihood of adverse impacts from effluents, avoid a conflict in resource use, etc.

Under certain circumstances, the Bank Group itself will carry out and analyze the results of such studies. Where the Bank Group will not be carrying out the study, borrowers often ask for its help and advice, for example in drawing up terms of reference, or in making arrangements to have the studies carried out at the borrower's expense. The Bank Group should normally encourage borrowers to finance and carry out environmental project preparation studies themselves. However, in view of the importance of assuring that such studies are undertaken, the Bank Group should also be prepared, in appropriate cases, to include the cost of such studies in the expenditures to be retroactively financed out of a subsequent project loan.

Additional Transfer of Resources for Environmental Protection Measures

The question of "who pays" for environmental protection measures in the developing countries has already arisen in international discussions and promised to be one of the more controversial aspects of the environment/development debate. A strong effort by the developing countries was launched in preparation for the U.N. environmental conference to establish the concept of a net additional amount of assistance from the developed countries, additive to the 0.7 percent of GNP target established for the Second Development Decade, to cover the added costs of environmentally sound
development projects. The Development Assistance Committee of OECD expressed its reservations concerning the concept of "additionality," as it has come to be called. It indicated that it considers it is unrealistic and misleading to accept the notion of an increase in the gross total of resources available for development assistance to cover environmental costs, but it has accepted the principle that the added costs of development projects necessitated by environmental protection measures are a legitimate part of the project cost structure and the amount of assistance provided to projects requiring such added factors should take these costs into account. In this latter sense, the notion of "additionality" is acceptable; in the former sense, it is not. Further the OECD (DAC) donor countries rejected the concept of "additionality," (attributable to incorporating environmental protection measures in development projects). They did agree, however, that should developing countries have "environmental projects" among their priority investments, donor countries should finance them (e.g., urban water and sewage, erosion control, forest management, etc.).

113. It is possible that with a separate U.N. Fund for the Environment established it might be anticipated that there will be some suggestion by the developing countries to use this fund as a source for augmenting other development assistance flows. In its present conception, however, the donors to the Fund have made it clear that it should not be considered as another source of assistance for development projects in developing countries, but rather, as a source of funding for activities which address global problems of environmental protection of concern to both the developed and developing countries; (e.g., global environmental monitoring systems, research projects, costs of developing international conventions and agreements on protection of the oceans and the atmosphere, etc.).

114. The Bank Group should maintain the policy which its management has taken to date in international discussions of the "additionality" issue, which has been to urge acceptance of the idea that added costs in specific projects or activities for environmental protection reasons should be taken into account and, where necessary, assistance to such projects increased to cover all or appropriate portions of such costs.

Loan Conditions

115. Given the Bank Group's concern that projects be "environmentally sound", question arises whether country performance in establishing and following a sound environmental policy should be a "condition" of Bank Group support.

116. The question of "conditions" or "strings" attached by donors has long been a contentious issue. The growing concern with environmental implications has added a new facet to the problem. Developing countries are worried that developing assistance agencies, reflecting the donors' viewpoint, will translate this concern into additional criteria of eligibility for support. This is closely linked to developing country fears that developed countries may agree on environmental standards for particular types of projects, insisting that these standards be met as a precondition to the provision of assistance.
117. Since the issue of "conditions" is not new, its resolution in respect of environmental issues should be arrived at by applying the policy which has been followed with respect to "conditions" relating to economic or technical feasibility, engineering adequacy, financial soundness, etc. Without mutual agreement and cooperation among the parties, a project or program is unlikely to be successful, or at least will not be so for very long. Unilateral attempts by one party to impose or force compliance with requirements, restrictions or conditions will not work and are likely to impair the relationship. This is not to say that conditions should never be imposed; it is as unrealistic to expect assistance agencies, bilateral or multilateral, to extend aid unconditionally as it is to expect a recipient to accept the directives of an external authority concerning matters it considers to be within its own prerogative. The solution is not to eschew "conditions," but rather to seek agreement on conditions which are sensible and satisfactory.

118. One of the most useful roles which the Bank Group could play in the environmental field would be to establish a dialogue on the subject with member countries. The most effective vehicle to this end would be project appraisal, where the Bank Group's own work could provide the example of a proper balancing of all relevant factors. Bank Group financing of industrial projects in countries whose national environmental policy permits other enterprises in the vicinity to operate without emission controls justifies examination of the need for policy changes. In many countries there are no laws, rules or regulations governing environmental matters; the Bank Group may, in these countries, encourage and advise on promulgation and implementation of appropriate legislation. Where environmental conditions have deteriorated significantly and are causing severe problems through their negative feedback upon man, they were seldom caused by any single enterprise or project. Air, land and water as recipient media must cope with cumulative impacts over time, and the Bank Group having information on national development plans, may be able to identify areas in which problems are likely to arise in the absence of precautionary measures and prudent planning. If donor and recipient cannot agree on terms and conditions relating to environmental factors, donors will have to decide whether to provide the assistance on the terms and conditions proposed.

**Common Environmental Standards**

119. Development assistance agencies recognize that developing countries want to give priority to programs and projects which will promote economic growth, and will assign less importance to the need to protect the environment and health. They also recognize that the choice of development goals, priorities and alternatives is the sovereign responsibility of each developing nation.
120. At the same time, there is growing concern over the continuing deterioration of the environment on a global scale, the transnational environmental effects of development programs, especially at the regional level, and pressure, both within and outside governments, for steps to curb the growth of pollution and to minimize or eliminate the damaging side effects of development. In consequence, donors are tending to take a careful look at costs and benefits in environmental terms, and at alternative ways of selecting and implementing the development projects they agree to support. When, as will happen, a developing country opts for sacrificing the environmental protection aspects of development activities in favor of greater, or less costly, immediate economic growth, development assistance agencies must decide whether to provide assistance to a project of the latter character.

121. It has been suggested in some quarters that the potential for conflict could be reduced if all development assistance agencies were to adopt common environmental standards or criteria which development projects must satisfy to qualify for assistance. Developing countries, however, see such an approach as an infringement of their right to set their own priorities and standards, a form of "environmental imperialism". And in development assistance agencies there is some opposition to the "standards" approach, on the ground that it may lead to insistence on impracticable and excessively costly solutions, and fail to take due account of the wide variety of circumstances and situations and the multiplicity of variables in project design and implementation.

122. Since each country decides for itself whether to allocate limited resources to environmental protection as against education, housing, etc., and, if so, in what amount, and since levels of income, costs, local environmental absorptive capacities, tastes and cultural values differ from country to country, decisions concerning the allocation of resources will also differ. Uniform international standards, therefore, are not in general appropriate (except perhaps to the extent that they can be demonstrated to be physiological minimum standards, i.e., international health standards). Developing countries, however, while rejecting the automaticity and rigidity of uniform standards, appear to regard "guidelines" of the Bank Group type, characterized by flexibility and adaptability, as acceptable. Understandably and commendably, they wish to participate in the formulation and application of any such guidelines, and they emphasize the need for consultation between donors and recipients on these matters.

123. At the same time, in addition to the objections, noted above, to the setting of standards and criteria for project appraisal, developing countries have expressed concern that the application of guidelines may lead to "bottlenecks" in the implementation of development projects, and, in addition, to involvement in irrelevant detail. Nevertheless, it seems highly probable that agreements setting international standards on hazardous and toxic material, and environmental agreements related to the oceans, will be worked out. Extensive research is under way to evaluate the extent of man's global impact on the earth's air mantle; these efforts may likewise lead to agreements on international standards.

124. The Bank Group does not now, and should not, encourage development of common environmental standards or criteria for support of development assistance projects or activities. But should international financial assistance organizations agree on "guidelines" or standards or should international agreement be reached in certain environmental areas, the Bank Group should assure that its project financing is consistent with their terms.

125. The Bank Group should also help to bring to the attention of its member governments information, guidelines, instructional materials, technical data, etc., on environmental impact analyses available from public and private organizations concerned with environmental affairs. In doing so, however, the Bank Group should make plain that it is not imposing on its members its own views about environmental protection or attempting to legislative environmental virtue.

Funding "Environmental" Projects

126. An important issue is whether the Bank should finance "environmental" projects (a term which can be applied to a great variety of projects, including air and water pollution control, control of erosion, solid wastes disposal, reforestation, and pest and disease vector control) or should merely concern itself with the environmental/health dimensions of traditional projects.

127. The economic and social returns of "environmental/health" projects can be quite substantial relative to other projects in a particular country. The Bank should consider lending for projects of this character where the project in question satisfies the Bank Group's other project criteria. Such a policy will not represent a significant change of position since there is already a long history of involvement in sectors with direct environmental/health consequences, such as water supply and sewerage, afforestation, etc.

Other Suggested Steps

128. Several additional steps can be taken by the Bank Group to help assure that all projects are environmentally sound.

129. Country economic and sector reports should, where appropriate, include a survey of environmental conditions, highlighting any which are particularly relevant to project selection, location and design. The survey should include reference to existing or pending legislation, institutions charged with environmental/health responsibilities, pollution standards, and other matters associated with environment and health.

130. Terms of reference for consultants, and project preparation guidelines, should emphasize the importance of considering environmental issues and of reaching a judgment as to whether additional analysis or action is warranted. It is particularly important that engineering consultants be made aware of the Bank Group's concern and that they be required to incorporate in project design measures to prevent or minimize adverse environmental/health problems.
131. The Bank Group should undertake or sponsor research (e.g., on the problems of cost-benefit analysis in the environmental field) which will facilitate appraisal of projects with an environmental impact or will be otherwise related to its operational requirements.

132. Having had three years of experience with environmental/health aspects in its lending program, the Bank Group is now in a position to "audit" these aspects in an increasing number of projects. The accuracy of environmental/health forecasts, the adequacy of the safeguard measures employed, and the consequences for the affected ecological systems and human health can usefully be assessed; the results can be drawn on in the design of similar projects in the future. While this assessment can be carried out for many projects by a supervision mission (perhaps with the addition of an appropriate expert), others will require a multidisciplinary examination. The Bank Group should continue to strengthen its capacity to review the environmental/health aspects of projects in the course of supervision missions; the mission reports should include an assessment of the extent to which environmental safeguards were taken and the appropriateness of the project's design; operations evaluation reports should similarly deal with environmental aspects. Studies of selected projects by multidisciplinary teams should also be undertaken.

133. The Bank Group should encourage, perhaps even require, staff members to take courses relevant to, or specifically designed for, operational needs. The Bank Group's EDI should emphasize environmental considerations to an even greater extent that it does at present.

Responsibility for Environment-Related Operational Work

134. Consideration has been given to the question whether a separate organizational entity should be established within the Bank Group to handle the increasing operational workload resulting from concern with the environment.

135. The conclusion reached is that this would be undesirable, both as regards projects in which the environmental aspect is only one of several, and as regards projects with specifically environmental objectives. With regard to the former, the initial stages of project design and location are the most critical from an environmental point of view. The Country Programs and existing Projects Departments clearly must retain principal responsibility for such matters. As for specifically environmental projects, neither the expected number of these nor the Bank Group's technical appraisal requirements is such as to suggest at this time the necessity of a separate organizational entity. The differing expertise that would be required for the varied kinds of environmental projects leads to the conclusion that they can best be handled either within existing departments or by ad hoc teams seconded from existing departments. The Office of Environmental Affairs should continue to provide overall guidance and assistance, and to serve as the focal point for liaison between the Bank Group and other international and national, governmental and non-governmental, agencies concerned with the environment.
REPORT ON ENVIRONMENTAL ASPECTS

OF BANK OPERATIONS

October 17, 1974

Office of Environmental Affairs
Projects Advisory Staff
Central Projects Staff

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APPENDIX: Economic Evaluation of National Environmental Policies and Projects
CHAPTER I

SUMMARY AND CONCLUSIONS

1.01 International development assistance has always attempted to address problems of the human environment -- its principal focus being the poverty, disease, hunger, and illiteracy associated with the lack of economic development. Worldwide concern, however, has steadily mounted over other aspects of environmental problems -- those which emerge as undesirable secondary effects of the very processes of development itself. These aspects of the problem were articulated and documented in considerable detail at the 1972 United Nations Conference on the Human Environment. The Stockholm deliberations led to the development of a U.N. Action Plan and to the establishment of the U.N. Environmental Fund for providing "financing for environmental programs envisaged in the Plan."

1.02 In 1970 the Bank Group established the Office of Environmental Affairs "...to review and evaluate every investment project from the standpoint of its potential effects on the environment." In the 30-month period between July 1, 1971 and December 31, 1973 the Bank has reviewed 434 loans and credits from the environmental viewpoint. Of these, 275 revealed "no apparent potential problems." For 135 projects, the environmental problems which were identified could be handled by the Bank staff; the remaining 24 projects required special studies by outside consultants.

1.03 The Bank has now accumulated considerable experience in dealing with environmental concerns. This report reviews the Bank's approach and the experience which has been gained. Among the main lessons derived from the Bank's experience are the following:

(a) Environmental problems have a cumulative impact. If remedial action is taken only at a later stage, its cost would be considerably higher.

(b) The Bank Group's experience to date suggests that the additional cost attributed to the environmental/health safeguards incorporated into projects has ranged from 0% to 3% of the total project cost. The high end of the range applied where precautionary measures were added to projects already well advanced. The additional costs were generally kept low by accepting flexible environmental standards in the developing countries appropriate to their current stage of development.
Concern with environment has resulted in progressive incorporation of environmental safeguards in technology. This is particularly so in industry, a sector in which environmental issues first attracted attention. Incorporation of environmental technology makes it difficult to separate environmental and non-environmental costs in the processes in which this development has occurred.

In the initial stages of the development of what may be called environmental technology, emphasis was on the treatment of waste matter. The Bank Group's experience has underscored the need to treat the environmental problem as a much more multifaceted one.

The project-by-project approach has pointed to a number of sector-specific environmental problems, and sectoral guidelines have been prepared that could help improve project designs with regard to their environmental impact.

In evaluating various costs and benefits involved in alternative ways of dealing with environmental considerations, the Bank's experience to date has shown quantification of the relevant trade-offs to be particularly difficult.

For the future, the Bank Group intends to continue its project-by-project approach. The lessons learnt so far provide helpful guidance for the course to be followed. In determining and dealing with the impact on environment of the projects financed by it, the Bank Group will adapt the standards of protection to the circumstances of the country and incorporate only those environmental measures that are considered essential in any particular case. Should international agreements be reached in certain environment areas, the Bank Group would ensure that its project financing is consistent with their terms. It will also help to bring to the attention of its member governments information, guidelines, instruction materials, technical data, etc., on environmental impact analyses available from public and private organizations concerned with environmental affairs. In those countries in which there are no adequate laws, rules or regulations governing environmental matters, the Bank Group may encourage and advise on promulgation and implementation of appropriate legislation.

The Bank Group should be prepared to consider lending for 'environmental' projects (a term which can be applied to a great variety of projects, including air and water pollution control, control of erosion, solid wastes disposal, reforestation and pest and disease vector control) where the project in question otherwise satisfies the Bank's normal project criteria.
CHAPTER II

INTRODUCTION

2.01 Much of the effort to raise the standard of living in the developing countries involves a deliberate modification of the natural environment. Construction of roads, dams, airports, irrigation and sewerage systems, power plants, and industrial facilities frequently results in ecological loss. Often this is because the consequences for the environment were not adequately considered at the project planning stage or because information necessary to forecast the eventual impact on the environment was lacking or inadequate. And where adverse ecological consequences are forecast, effective steps to prevent or minimize the damage may sometimes not be taken because data on cost-effective safeguards or on economically competitive project alternatives are lacking or inadequate. Although the magnitudes of the loss in ecological and related values vary, there is a real cost to society over the long run.

2.02 In recent years, there have been repeated warnings that in many regions of the world -- in both developed and developing countries -- air, water, soil, and other resources are deteriorating to an extent which threatens the quality of life and of the environment, perhaps even the future of human life. Such warnings have been sounded before, but their urgency has intensified.

2.03 The trend towards degradation of the biosphere is global in its dimensions and consequences; it can be reversed only through comparably widespread recognition of the danger and the need for international cooperation in dealing with it. There are encouraging signs in both of these directions. Resolutions of the United Nations General Assembly in 1968, 1969 and 1970 underlined the importance of taking environmental factors into account in economic and social development planning. The International Strategy for the Second United Nations Development Decade, adopted in 1970, declares that: "Governments will intensify national and international efforts to arrest the deterioration of the human environment and to take measures towards its improvement, and to promote activities that will help to maintain the ecological balance on which human survival depends." The first United Nations Conference on the Human Environment held in 1972 at Stockholm led to the development of a U.N. Action Plan and to establishment of the U.N. Environmental Fund for providing "financing for environmental programmes envisaged in the Plan."

2.04 Although 'environment' and 'ecology' have received so much currency in recent years, there is no single universally accepted definition of either. In this paper, environment is used to describe the total setting for economic development activity; it is not confined to the naturally occurring milieu
(the ecological systems which surround and collectively support man), but extends to the socio-cultural milieu which man has created to facilitate adaptation to the demands and challenges of his naturally occurring surroundings. 'Ecology' is used to refer to the relationship between organisms and their environment, including most especially the man/environment relationship.

2.05 Environmental problems may be divided into three categories related to their magnitude: global, regional and local. Global problems pertain to the biosphere; they affect all, or nearly all, countries. Into this category fall the most widely discussed and threatening problems; for example, those caused by persistent pesticide residues which find their way into the biosphere processes through the actions of wind, water and living carriers, with effects well beyond the country in which the pesticide was applied; the burning of fossil fuels, which affects the carbon dioxide balance and the sulphur dioxide loading of the atmosphere, and the particulate content of the stratosphere; the pollution of the oceans from land sources, or from oil spillage or ship dumping on the high seas; and the man-induced or man-influenced changes in global climatic patterns.

2.06 Regional problems result from biophysical linkages among a group of countries which have little or no effect beyond the members of the group. A typical example is the effect of river basin development on riparian countries, up- or down-stream.

2.07 Local problems are those whose effects are confined within the boundaries of a particular country, for example, the extirpation of a wildlife resource, the creation of an aesthetic blight, or the eutrophication of a lake from fertilizer runoff or discharge of domestic sewage.

2.08 Environmental problems in a given category may differ in their dimensions. For example, while a global problem may eventually result from the gradual build-up of carbon dioxide in the atmosphere over a long period, the effects of pervasive, persistent pesticides can be seen more immediately. Another variant, related to timing, is the degree of certainty. The greater the time-span for the cause/effect relationship to be observed and understood, the greater the uncertainty as to its manifestation; whereas the continuation of presently observable consequences is far more certain.

2.09 Two other variables may be noted: magnitude and degree of reversibility. Magnitude cannot easily be compared, because effects are of different types, occur in different places and affect different aspects of life systems. Reversibility concerns the possibility of returning an ecological system to its former state. For example, a lake in an advanced state of eutrophication is virtually irreversible; the extinction of a species is absolutely so. On the other hand, it is possible to end pollution from particulate matter in the smoke of an industrial plant, and to restore the ambient air quality. The dimensions of time, certainty, magnitude, and degree of reversibility combine to produce the dimension of urgency.
2.10 The environment problems of the developing countries can be divided into two categories. To the first belong the problems associated with poverty. Under conditions of poverty the biophysical environment often exhibits the ravages of long years of mismanagement (overgrazing, erosion, denuding of forests, surface water pollution, etc.). Not merely the 'quality' of life but life itself is endangered, for it is often very difficult and sometimes impossible for the environment to renew its life supporting capabilities. The developing countries assign the highest priority to finding solutions to problems of this nature. Here the principal concern is to correct the environment that has gone through a long period of deterioration.

2.11 The other set of problems accompanies the very process of development itself. Agricultural growth, for example, calls for construction of irrigation and drainage systems, clearing of forests, use of fertilizers and pesticides—all of which have environmental and health implications. Similarly, the process of industrialization could well result in the release of pollutants and in other environmental problems attendant on the extraction and processing of raw materials.

2.12 In summary, the developing countries are now beginning to be concerned with two different types of environmental problems. In the first, they have to alleviate poverty. In the other, they have to seek ways to prevent the deterioration in man's environment that has often been associated with development. The first task is immensely more difficult than the second. The second could also become difficult if the present concern for environment is not translated into action. The Bank Group is concerned with both aspects of the problem. Some other policy papers have addressed themselves to the problem of poverty. In this paper, we will be concerned mostly with the environmental problems that often arise with development unless precautionary measures are taken.

1/ The following policy papers have dealt with the Bank's approach to the problem of poverty: Bank Policy on Agricultural Credit (Report No. 436); Bank Policy on Land Reform (Report No. 440); and Population Policies and Economic Development (Report No. 481).
CHAPTER III

THE LESSONS FROM THE BANK'S EXPERIENCE

3.01 In recent years, some major development agencies have given concrete definition to what may be called environmental responsibility. They now recognize that development which ultimately degrades the human environment is not a sound investment. They have, accordingly, incorporated consideration of environmental factors into agency project review procedures.

A. Environmental Investigation of Projects

3.02 The Bank Group's involvement in environmental affairs started in earnest in 1970. In his 1970 address to the U.N. Economic and Social Council (ECOSOC), Mr. McNamara remarked that the problem facing development finance institutions was whether and how they might help the developing countries to avoid or mitigate some of the damage which economic development can do to the environment -- without slowing the pace of economic progress. He noted that the costs resulting from adverse environmental change could be tremendous, and that a small investment in prevention would be worth many times what would later have to be spent to repair the damage. He announced to ECOSOC that a unit had been established in the Bank Group to determine, to the extent possible, what would be the environmental consequences of development projects being considered for financing; and he said that the Bank Group proposed to work towards concepts which would make possible a consideration of environmental factors in development projects.

3.03 The position of Environmental Adviser was established in 1970 in the World Bank "...to review and evaluate every investment project from the standpoint of its potential effects on the environment." A set of staff guidelines was prepared for use in the formulation, appraisal and execution of projects. Experience soon made it clear that the environmental/health aspects of projects should be handled at the formulation and design stages, rather than at the "eleventh hour," when changes or modifications prove difficult if not impossible.

1/ While most of the discussion in this Chapter focuses on the experience of the Bank Group, some references will be made to the work of other donor agencies.

2/ These guidelines were subsequently expanded and in 1972 a handbook, Environmental, Health, and Human Ecologic Considerations in Economic Projects, was published. (A revised and further expanded edition of the handbook will be made available in French and Spanish as well as English in 1974.) The handbook has been widely distributed to other economic development agencies, governments, engineering, contracting and consulting firms, universities, etc.
3.04 The Environmental Adviser (now Office of Environmental Affairs) instituted a procedure which has evolved as follows:

(i) Operational staff review with the Office projects under consideration with a view to identifying the likely environmental, health, and socio-cultural problems or opportunities associated with them.

(ii) Where indicated by the initial review, the Office of Environmental Affairs suggests what studies or investigations should be conducted to enable a better identification and understanding of the nature, dimension, severity and timing of the problems likely to arise, to ensure that appropriate safeguarding measures can be taken. The Office designs the studies, advises on the disciplines needed to conduct them, and formulates the terms of reference of these studies.

(iii) When the studies are completed, the Office participates in the review and analysis of the data and information acquired and helps to work out appropriate safeguard measures. It participates where appropriate in subsequent loan negotiations and in the presentation to the Board.

(iv) The Regional Office and the Office of Environmental Affairs monitor the implementation of the project, to ascertain the inclusion and adequacy of the recommended safeguard measures, and to determine what future action may be required. This experience is also useful for subsequent assessment of the accuracy of the forecast of environmental/health consequences and helps to indicate the approaches which should be taken, should similar problems occur in other projects.

3.05 The data presented below are for the period July 1, 1971 to December 31, 1973 and give an indication of the nature and extent of the Bank's involvement in environmental matters.

(a) Of a total of 434 Bank Group loans and IDA credits reviewed, 275 (63%) revealed no apparent or potential environmental problems. There was considerable diversity among the projects investigated. They included projects in the sectors of industry, agriculture, education, health and telecommunications.

(b) In four cases representing about 1% of all loans and credits signed during the period, some other agency such as UNDP or WHO, had determined the need for safeguarding or remedial measures of some character and had taken appropriate action prior to Bank involvement.
(c) In the case of 135 projects, the environmental problems identified could be handled adequately by Bank Group staff and the Environmental Office without the need for outside expertise or special studies. The projects in this category accounted for 28% of the total of Bank or IDA projects screened, but for 80% of the Bank/IDA projects on which any action was taken.

(d) The 20 projects (including 9 in power, 6 in agriculture, and 5 in industry) which were found to require special studies by consultants, led to the incorporation of safeguard measures as a condition of lending. These represented about 5% of the total number of Bank Group projects reviewed and 15% of the total requiring some action additional to an initial review.

3.06 The foregoing data, suggestive of the probability of environmental implications, are summarized in Tables 1 and 2.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>ENVIRONMENTAL SCREENING OF BANK GROUP PROJECTS</th>
<th>(July 1, 1971 - December 31, 1973)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bank/IDA</td>
<td>IFC</td>
</tr>
<tr>
<td>No problems apparent when reviewed</td>
<td>245</td>
<td>30</td>
</tr>
<tr>
<td>Problems handled by others prior to Bank Group involvement</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>In-house disposition</td>
<td>107</td>
<td>26</td>
</tr>
<tr>
<td>Consultants and Special Studies required</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Total Number of Projects</td>
<td>376</td>
<td>58</td>
</tr>
</tbody>
</table>

1/ Loan/Credit Numbers: 809, 829, 841, 874, 889, 919, 923, 296 and 339.
2/ Credit Numbers: 393, 322, 282, 317, 277 and 302.
Table 2

BANK GROUP PROJECTS REVIEWED AND ACTED UPON FROM
JULY 1, 1971 TO DECEMBER 31, 1973

<table>
<thead>
<tr>
<th>Bank/IDA</th>
<th>Number of Projects Signed and Reviewed</th>
<th>Number of Projects Acted Upon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>104</td>
<td>46</td>
</tr>
<tr>
<td>Industry</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Transportation</td>
<td>87</td>
<td>15</td>
</tr>
<tr>
<td>Tourism</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Water and Sewerage</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Power</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>Urban Projects</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Education</td>
<td>38</td>
<td>4</td>
</tr>
<tr>
<td>Multi-purpose</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Others</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>376</strong></td>
<td><strong>131</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IFC</th>
<th>Number of Projects Signed and Reviewed</th>
<th>Number of Projects Acted Upon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Chemicals</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Iron and Steel</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Mining</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Motor Vehicles</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Non-Ferrous</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Petrochemicals</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pulp and Paper</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Textiles and Fibers</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Tourism</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Others</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sub-Total</strong></td>
<td><strong>58</strong></td>
<td><strong>28</strong></td>
</tr>
</tbody>
</table>

**Grand Total** | **434** | **159**
B. Lessons Learnt

3.07 The lessons from the Bank's experience are summarized in four sections dealing with (i) incremental costs, (ii) cumulative impact of the problem, (iii) linkages between different aspects of the problem, and (iv) sector-specificity of some environmental problems.

(i) Incremental Cost

3.08 When the Bank Group began to incorporate environmental protection measures in its lending operations, some concern was expressed about the cost of such measures and the burden that would be imposed on borrowers. Estimates ranged as high as 25-50% of total project cost, which would have been wholly unacceptable to the developing countries.

3.09 It is difficult to separate out those costs and benefits which are attributable exclusively to environmental measures, and in any event the quantification of those costs and benefits will depend largely on how the environmental dimension is defined. For example, in the case of a sewage treatment project the cost would be 100 percent. As public health is a most important part of our environmental considerations, most water supply and sewage projects will fall in this category. In FY73, the aggregate total for such projects financed by the Bank/IDA amounted to $278.8 million in nine countries. These projects aside, the Bank Group's experience to date appears to be consistent with that of other aid agencies and suggests that those early estimates were much too high. The additional cost attributable to environment/health safeguards in "non-environmental" projects has ranged from 0% to 3% of total project cost; the high end of the range applying where precautionary measures were added on to projects already well advanced.

3.10 The 0-3% range may not be operative in the future. This is for two reasons. First, what is now regarded as environmental expenditure may in the future get incorporated in the technology chosen for projects. In that case, it will not be possible to separate out environmental costs. Second, as economic development proceeds, the cumulative impact of the environment/health-threaten- ing effects will lead the developing countries to adopt higher standards and impose tighter controls. This is already being done in the case of urban industrial projects. Several developing countries now require installation of controls on existing plants, while stricter regulations governing the operation of new plants are being promulgated. As the assimilative capacity of ecological systems in developing countries becomes severely strained, it will be necessary to take additional measures and to strengthen existing ones. The cost of these measures will be greater and may exceed 3% of the total project costs.

3.11 Reports on air pollution in Sao Paulo, Ankara and Mexico City indicate that the requisite control measures will be both costly and technically difficult. In general, the cost of removing a pollutant from a waste stream is
proportional to the amount already removed and this trend produces increasingly higher costs for additional incremental improvement. We, therefore, expect the cost of adding environmental measures to industrial projects designed for cities such as Sao Paulo, Ankara and Mexico City to be greater than 3% of the cost of the project.

3.12 While costs for environmental/health protection associated with individual projects remain an acceptably small part of the total investment, it should be stressed that increased development will contribute to the need for developing countries to assess the cumulative impact on the environment and the need for more stringent standards governing the design and execution of development schemes with resulting cost increases.

3.13 Some international surveys have been conducted to estimate the costs of national programs for environmental pollution control. However, such projections of national costs as are currently available are not very reliable. These estimates (available from advanced industrial countries) suggest that total investment plus operating costs for clearing up a polluted environment and maintaining it at some suitable standard might vary from upward of one-half percent of the GNP. Perhaps the most extensive data collection effort with regard to cost estimates has been made in the U.S. Cumulative total pollution control expenditures for the period 1972-1981 were published in the fourth annual report of the U.S. Council on Environmental Quality, 1973. They were estimated to be $27.5 billion (1972 dollars), or about 2.5% of the GNP. Any lower level of expenditures, it was stated, would likely result in even greater economic penalties as reflected in adverse environmental/health effects. The estimates covered air and water pollution, land reclamation, radiation and solid waste. This means that by postponing action on environment, the developing countries can expect to incur very large expenditures in the not-too-distant future.

3.14 It is appropriate to mention here another type of cost that the adoption of environmental measures may well impose on the developing countries. Developing countries fear that imposition of environmental control measures on their producers may alter their terms of trade with the developed world. This may happen since different countries will not face the same costs for the same level of environmental standards. Furthermore, there will be differences in the resolution of the implicit trade-off between a healthier, more amenable environment and additional financial resources.

3.15 The Bank Group's approach has been to include in project financing those additional costs made necessary by the incorporation of environmental safeguards. Another difficult question arises with those projects in which benefits are not realized by the residents of the country in which the investment is being made. Wildlife preservation components fall in this category. For instance, the Kafue Hydroelectric Project in Zambia, in its original design, would have had a serious impact on the wildlife in the area. These include some 90,000 lechwe, a species
of small antelope unique to the project area, whose movements have been dictated largely by the grazing conditions provided for by the flood cycles and whose future is a matter of concern to wildlife conservation groups the world over. By interfering with these flood cycles, the dam would have provided a grave threat to this already endangered species. To compensate for the loss of natural flooding when the water is most needed, the dam was redesigned to allow additional reservoir storage. This will permit discharge of water needed by wildlife during the critical months of March and April in dry years.

(ii) Cumulative Impact of the Problem

3.16 As pointed out above, environmental problems have a cumulative impact. If remedial action is taken at a later stage of a country's development, costs incurred will be considerably higher. Prudent planning and early preventive measures would avoid or reduce the high cost of subsequent remedial measures. There are a number of examples from the Bank Group's experience in which action at the planning stage prevented the occurrence of a serious environmental problem.

3.17 Turkey's Antalya Forest Utilization Project (cost $164.3 million) is one case in point. The Antalya area is well known for its natural beauty, historical sites, and good climate. These factors make the area an attractive place for tourists. Setting up of a large pulp and paper plant would seem to conflict with the development of tourism in the area. At an early stage, therefore, the inclusion of extensive environmental protection measures was recognized as a requisite for project implementation. It was seen that such measures would have to include careful architectural planning, landscaping, and effluent treatment facilities. This meant that detailed studies were necessary to determine the location of a suitable site.

3.18 The first study undertaken by the consultants recommended a number of sites on the Mediterranean. Topographical constraints and scarcity of water limited choice to eight possible locations along a 90 km belt of coastal land, and of these the one near the Manavgat River was seen as offering the best balance between economic and ecological considerations. Locating the plant at this site promised harmonious industrial and tourism development. However, the Bank expressed reservations and the Government established an inter-ministerial committee to conduct a detailed comparison of various alternative sites. The least costly site initially chosen was abandoned in favor of some off-beach location removed from areas of high tourism potential and at a greater distance from the coastal highway.

3.19 With environmental concerns now incorporated in the site selection, some further investigations are being carried out. For instance, the problem of heavy truck traffic in the area requires further study and the Government intends to provide measures for improved handling of this traffic. Oceanographic studies are to determine the exact location of the liquid effluent pipeline outfall into the sea so as to minimize any future adverse impacts. Gassous and
liquid effluents will be minimized through maximum in-plant recycling and provisions made for advanced end-of-the-line treatment before final discharge. Finally, zoning measures are being worked out with the ministries involved to prohibit future encroachment from industrial development upon tourism and vice-versa.

3.20 Another example of the need to consider the assimilative capacity of ecological systems when evaluating the environmental impact of a project is to be found in the IFC-financed Pan African Pulp and Paper Project on the Nzoia River in Kenya which flows into Lake Victoria. The effluents carried by it, therefore, affect not only Kenya but also Uganda and Tanzania. In evaluating the environmental impact of this project, the impact of the downstream of the river and the lake, and the expected municipal and industrial development of the watershed needed to be examined. The nature and degree control over the effluent of the pulp and paper mill could only be gauged when its relationship to all other pollutants entering the river system was well understood. This examination revealed the critical necessity for requiring a high level of treatment of the plant's effluent and for encouraging the Government of Kenya to monitor the river's condition and plan further development with careful regard to cumulative threat to downstream uses. If adequate control over the municipal, industrial, and agricultural wastes entering the river system is not maintained, the river's already precarious ecological integrity will be lost with disastrous consequences for important downstream uses.

3.21 Brazil's MBR Iron Ore Project is another example of Bank Group-financed activity that, without adequate environmental planning, could have posed serious problems. The project contemplates the exploitation of high-grade iron ore near Belo Horizonte and construction of a 640 km rail transportation line to an insular marine terminal on Sepetiba Bay, a recreational/tourist resource of great potential value.

3.22 An examination of the project design revealed a number of potentially significant environmental problems at the mine site, along the rail line, and at the location of the terminal. It was decided to proceed with an on-site study, and a team of environmental consultants was engaged to identify likely problems and recommend preventive or mitigating measures. Partly as a result of the consultant's recommendations, arrangements were made for safe handling of the berthing ships' slops; an improved navigation system; a contingency plan for handling accidental oil spills; improved landscaping and rail trestle design; erosion and dust control; and solid waste handling and liquid waste treatment. At the mine site steps are being taken to prevent pollution of nearby surface waters, to stop erosion and to restore the landscape through plantings and contouring.

1/ Up until the writing of this report, final site selection for the project had not been made.
3.23 Sepetiba Bay, as yet a largely unspoiled estuary of great beauty, represents a recreational/tourism resource of great potential value. In addition, it has a significant shell and fin fishery, as well as a nursery ground for important coastal fish stocks. The fate of this estuary is uncertain in view of the planned industrial activities along its shores. But, the joint concern shown by the Bank Group and the borrower for the future of this area has set an example. Another industrial project on this bay, financed in part by the IFC, has received similar treatment of its environmental aspects to ensure it is not representing a threat to the bay's future resource options.

3.24 Turkey's Antalya project and Brazil's MBR Iron Ore project are, therefore, examples of investment activities that would have caused major environmental problems if no changes had been made in siting and design. This does not mean that these projects will not result in any environmental deterioration. For instance, the railway to the MBR mines passes through some fairly highly congested urban areas. The frequency of heavily loaded ore trains will create noise and safety problems. Since no fully satisfactory solution to the environmental problem could be found, these undesirable consequences were accepted. This, notwithstanding the redesigned project, will produce considerably less adverse environmental impact. All those features that would have produced a progressive deterioration in the environment have been eliminated from the project design.

(iii) Linkages Between Environmental Problems

3.25 In the initial stages of the development of what may be called environmental technology, the emphasis was on the threat of waste matter before it was introduced into the environment. Our experience with the impact on ecology of development projects has underscored the need to treat the environmental problem as a multifaceted one. The best examples of development leading to a wide range of environmental problems are to be found in the large urban areas of the developing countries. These centers suffer from too rapid growth and the continuing impact of rural/urban migration; they are the focus of major problems concerned with air and water pollution, environmental sanitation, solid waste management, congestion, noise, and lack of open spaces and recreational areas. Since the mix and intensity of these problems vary between cities, solutions must be designed for the particular socio-economic-political milieu. A case in point is the Istanbul Urban Development Technical Assistance Project.

3.26 This centuries-old city has been, in recent years, undergoing rapid, unplanned, and uncontrolled growth. The provision of urban services and amenities has not kept pace with growing demand. For instance, the water system lacks capacity to meet the present demand and service is intermittent. Only one-third of the city is served by a water-borne disposal system. Contamination of surface and ground water eventually used for domestic purposes is widespread and was linked to a cholera outbreak in 1970. Storm sewers are lacking and standing water is a
problem in several areas of the city. Pollution of the Golden Horn has reached alarming proportions, while the Bosphorous and Sea of Marmara are grossly polluted from domestic and industrial wastes. Solid wastes management and disposal are inadequately handled, including open burning dumps, infested with vermin. Health services, particularly those serving the rapidly growing squatter settlements are less than adequate and ancillary health services (diagnostic laboratory, food inspection, etc.) are antiquated. Diffusion of responsibility for local administration among multiple agencies, and between different layers of government (metropolitan, regional and central government bureaucracies) has compounded urban environmental health problems.

3.27 The Bank-financed project seeks to address itself to some of these environmental problems. It aims towards achieving comprehensive and coordinated policies, plans, and programs among and between levels of government leading to the formulation and execution of a sound metropolitan development program. The quality of life as well as the quality of the environment in Istanbul and its environs is to be directly affected by the outcome of this project. The problems being faced by Istanbul can be seen in many other cities of the developing world. The solution to these problems calls for a good understanding of the rapidly changing man-environment relationships in the urban setting. It is recognition of these linkages that has convinced the Turkish Government to seek assistance from a number of agencies. For instance, the UNDP has been called upon to help draft a national environmental policy while WHO is working on a comprehensive urban health program. The Bank has encouraged these moves, and is working in close cooperation with the UNDP and WHO. It stands ready to assist in financing suitable projects among those identified.

3.28 Large mining, industrial and irrigation projects provide other examples of the way development can produce a serious environmental imbalance. The Cuajone Mining Project in Peru, a large copper mining and smelting operation for which IFC is providing slightly more than 2% of the total cost of $550 million, will involve the development of a new copper mine, installation of a concentrator, and expansion of smelting and supporting infrastructure facilities. The project, which will produce 186,000 tons of blister copper annually, is located in a sparsely inhabited, largely semi-arid area of southern Peru immediately adjacent to the Pacific Coast.

3.29 Examination revealed that effluents and emission created by the mining and smelting operations already being carried on at the project site would be doubled, causing 30 million tons of tailings to be annually discharged into the sea and 60,000 tons of sulfur oxides to be released into the air. Population centers and surrounding agriculture would be exposed to marked increases in air pollution. Experience during the prior 14 years of operations indicated that the pollution had on occasion reached as far as 60 km upwind from the smelter, with adverse effects on sugarcane and vegetable production.
In addition to problems attributable to gaseous effluents, there was the question of the effect of tailings in the offshore waters. The waters are associated with the large-scale "upwelling phenomena" along the Peruvian coastline which give rise to an abundance of phytoplankton, on which the anchovy feed. The annual anchovy catch has been estimated at about 10 million tons per year, making it the world's largest fishery in terms of weight of catch of a single species. The fishing grounds also sustain a large but fluctuating bird population (10-30 million) which includes the important guano-producing species (cormorant, piquero and alcatraz). The project without adequate environment safeguards, therefore, could have a far reaching impact on Peruvian agriculture and fishing industries and on the health of the residents in nearby urban centers.

The magnitude of the mining project, the limited availability of data and the potential environmental/health impact, persuaded the Bank Group to engage an environmental pollution control expert. His report from the field, while recognizing the very significant economic/social benefits that Peru would realize from the proposed operations, weighed them against the adverse environmental/health effects. Based on these findings, the Bank Group persuaded the borrower to accept in principle the incorporation of a number of environmental safeguards in project design.

In particular, it will take whatever steps are agreed to be necessary to alter its present tailings disposal practices, should this prove necessary, and will monitor air pollution in and around the smelter site to preclude any threat to public health or to agricultural interests. Qualified consultants, acceptable to IFC, will conduct detailed studies on mine tailings disposal and air pollution.

In another case, examination of the plans for the Erdemir Steel Expansion Project in Turkey revealed that little or no provision had been made to control the liquid and gaseous effluents which would be released into the environment in relatively large quantities. Of particular concern was the possible effect of air pollution on public health and on livestock and vegetation in and around the project site. Further, the liquid wastes, containing toxic ingredients, were to be released directly into the offshore waters of the Black Sea, which already shows signs of heavy pollution. It was decided that an industrial pollution study should be made, and a team of industrial pollution control experts was engaged by the Bank Group. The team recommended controls to achieve reasonable standards governing the release of effluents in keeping with conditions peculiar to the project site. The sum of $5 million, representing 1.7% of total cost, was included in the project cost estimate for this purpose.

Irrigation projects may not only result in soil salinity and waterlogging, but they may also produce infestation by undesirable aquatic plants and the creation of new or enlarged habitats for water-associated disease vectors,
especially those snail species involved in transmission of schistosomiasis. Irrigation canals, by increasing the opportunities for human contact with water, also increase the opportunities for transmission of water-borne diseases.

3.35 The Upper Egypt Agricultural Drainage Project illustrates some of these problems. The construction of the High Dam at Aswan has allowed for perennial irrigation by stabilizing the flow of the Nile. Perennial irrigation has brought the groundwater table up to or just below the surface and, with it, salts which raise the salinity of the soil and of irrigation waters. As a consequence, land is going out of production and this situation will continue unless and until adequate drainage is provided, as is being done in this project.

3.36 The disease of schistosomiasis (bilharzia), long known to Egypt, affects millions of persons. WHO has described it as one of the major crippling diseases of developing countries. Perennial irrigation has improved the habitat for the snail vector of the parasitic disease, and increased both its distribution and the chance for human infection (resulting in greater clinical severity of the disease. How to control the snail over large areas and arrest the clinical severity of the disease poses a formidable problem for Egypt's agricultural and public health authorities.

3.37 The Bank Group-financed drainage project in Upper Egypt provided an opportunity to study and deal with the problem. An internationally recognized bilharzia expert, after a field survey, made recommendations for chemical control of the snails and treatment of infected individuals; these recommendations were incorporated into the project. The control effort is designed to fit into a national plan for tackling the environmental and clinical aspects of this disease.

3.38 Ecological problems also have psychological, physiological and socio-cultural components. Recognition of these problems and the opportunity for minimizing them can be seen in a number of Bank Group-financed projects. In the case of the Accra/Tema Water Supply Project in Ghana, the resettlement of eight villages within the impoundment area with a population of about 2,000 was preceded by a detailed socio-economic study, as part of the project's feasibility studies. Detailed planning and supervision of the resettlement would be undertaken by the University of Kumasi. While not a hydro-power project, this project presented similar resettlement problems and opportunities, and would seem to have been handled in a model manner. In the case of the Quae Yai Hydroelectric Project in Thailand, 8,000 inhabitants will be resettled out of a reservoir area, and presenting classical psycho-socio-cultural problems. In the environmental studies conducted during the feasibility stage, careful consideration was given to resettlement sites, changes in occupation, life-styles, physical and social conditions, social services, etc.; and these have formed the basis of a resettlement plan to be implemented by the borrower and the
Government. Many other project examples exist, such as the Sao Simao, Itumbiara and Paulo Alfonso Hydroelectric Projects in Brazil, wherein resettlement problems were presented and which required incorporation as integral aspects of the projects' formulations and implementations.

3.39 These illustrations from the Bank's experience in environmental work underscore the important point that remedial measures have to be spread over a number of sectors. As pointed out, often the secondary impact on environment can be much more serious than the primary. This means that in evaluating the environmental impact of the projects financed, the Bank Group should spread its net as wide as possible, calling in other international agencies in cases where the comparative advantage lies with them.

(iv) Sector-Specific Problems

3.40 In looking at environmental problems, the Bank Group has followed what may be described as the project approach. As indicated in Section B, the Office of Environmental Affairs first identified those projects that, for reasons of chosen technology or siting, had potential environmental problems, and then suggested changes that were deemed necessary in order to reduce their impact on the ecology. This project-by-project approach, notwithstanding the Bank's experience, shows that different sectors of the economy are each faced with their own specific set of problems. Some of the potential problems are described below.

3.41 Industry: Few if any industrial projects are free of potentially troublesome environmental problems. Most common, as would be expected, are those associated with air and water pollution, solid wastes disposal, noise, in-plant industrial hygiene, plant siting, and subsequent related land use and settlement patterns. The capacity of the environment to withstand the injection of industrial wastes without serious undesirable consequences must be carefully considered. It is also important to identify specific pollutants, known to pose a demonstrable threat to human health or ecological systems (e.g., mercury, fluorine, arsenic, etc.) even in very low concentrations; their release must be prevented or carefully controlled and monitored. Fortunately, the pollution resulting from industrial processes is susceptible to control. The degree of control appropriate will depend upon the environmental setting and the quality of the ambiance to be achieved. Conditions in many developing countries permit more liberal effluent and emission standards than can be tolerated in the more highly industrialized countries. But it is important not to foreclose potentially important future resource options; hence, the need for projecting the cumulative consequences of industrial pollution.

3.42 Power: Thermal power projects exhibit many of the problems characteristic of industrial schemes as they relate to air and water pollution. Of special concern is the effect the heated cooling waters will have on the biota of the water body into which they are discharged. The problems associated with transmission
lines have to do with scenery and tourism. The problems can be minimized or avoided if the proposed route is considered in relation to these values. Use of herbicides along the right-of-way creates problems for the local flora and fauna.

3.43 Forestry: Forestry projects present problems associated with ensuring a sustained timber yield through regulation of annual allowable cuts, prescription of cutting cycles appropriate to the species harvested, reforestation of cut-over areas, prevention of erosion and fire, and maintenance of stream flows in the areas being harvested. Problems can also arise in connection with the scope and extent of enforcement of forestry laws and regulations, the competence of forest management institutions, and the award of lumbering concessions. The transport and industrial aspects of forestry projects may also require examination.

3.44 Fishing: In marine fishing projects, problems concern the stocks to be exploited and the manner in which they will be harvested to ensure a sustained yield. This leads to examination of the institutional capacity for overseeing and regulating the harvesting of this resource, as well as for conducting the necessary investigations. Pollution with respect to its impact on the fisheries, especially estuarine and coastal stocks, is a matter of continuing concern. Fresh water fishery development schemes can be threatened by fertilizer and pesticide runoff, weed and algae infestation, and water-borne diseases.

3.45 Livestock: Livestock projects require consideration of range conditions and carrying capacity of the land in order to prevent over-grazing. Livestock/wildlife competition, encroachment on game preserves, barriers to wildlife migration routes and the adequacy of water supplies are associated issues. In semi-arid areas, the potential for contributing to desertization, a phenomenon affecting large areas of the Sahel zone in Africa, must be taken into account.

3.46 Rural Development: Rural Development projects may require consideration of health-care delivery and environmental sanitation. New water supplies need to be protected against surface and sub-surface contamination. The problems presented by small sub-projects -- impoundments, irrigated areas, fish ponds, etc. -- are local in character and can readily be handled, often on a self-help basis.

3.47 Transport: Highway projects may at times change surface water drainage patterns and lead to erosion. If not properly planned, they may open new pathways for transmission of human and animal disease; lead to unregulated settlement along the route and create aesthetic problems in areas with high-tourism potential; adversely affect wildlife habitats; and pose safety problems for people and animals. Highway design engineers and contractors are, however, becoming increasingly aware of the problems posed for the physical environment, while development planners are becoming aware of the secondary impact of new roads. The problems presented by railways are similar to those posed by highways. The principal problem associated with airports is noise, which affects decisions
concerning runway orientation, flight paths and aircraft schedules. Siting and land-use zoning assume importance, as means of minimizing the undesirable consequences of congestion from development associated with or triggered by the airport. Port development and inland waterway projects may pose problems of dredging and the disposition of spoil material, the possible disruption of fish habitats, the potential for accidental oil spills, pollution of water, changes in sediment transport which may alter beaches and other land forms, undesirable urban development, marine accidents and solid wastes management. Pipelines which are not properly sited can become a barrier to wildlife movement, create an aesthetic blight, constitute a hazard if ruptured by an earthquake and may encourage improper use of herbicides along the right-of-way.

3.48 Tourism: Tourism projects often constitute an aesthetic threat to the local scenery. Architectural design and proper utilization of the land/water areas being developed are critical as is the continued prevention of pollution in water bodies associated with the project. The impact of such projects on nearby urban areas and people and cultures should be taken into consideration.

3.49 The foregoing discussion suggests that it is possible to generalize from the project-by-approach that the Bank Group has followed to date. It is possible, for instance, to develop environmental guidelines that would be sector-specific. While this would not do away with the need for detailed project analysis, it would help the development agencies to focus attention on potential environmental problems. Awareness of problems associated with certain sectors can help to improve project design with regard to its environmental impact.
C. Guidelines for the Future

3.50 For the future, the Bank Group intends to continue its project-by-project approach. The lessons learnt so far provide helpful guidance for the course to be followed. In determining and dealing with the impact on environment of the projects financed, the Bank Group would adapt the standards of protection to the circumstances of the country and incorporate only those environmental measures that are considered essential. Should international agreement be reached in certain environment areas, the Bank Group would ensure that its project financing is consistent with their terms. It would also help to bring to the attention of its member governments information, guidelines, instruction materials, etc., on environmental impact analyses available from public and private organizations concerned with environmental affairs.

3.51 One of the most useful roles which the Bank Group can play in the environmental field would be to establish a dialogue on the subject with member countries. The most effective vehicle to this end is project appraisal, where the Bank Group's own work can provide the example of a proper balancing of all relevant factors. For example, Bank Group financing of industrial projects in countries whose national environmental policy permits other enterprises in the vicinity to operate without emission controls justifies examination of the need for policy changes.

3.52 In many countries there are no adequate laws, rules or regulations governing environmental matters; the Bank Group may, in these countries, encourage and advise on promulgation and implementation of appropriate legislation. Where environmental conditions have deteriorated significantly and are causing severe problems through their negative feedback upon man, they were seldom caused by any single enterprise or project. Air, land and water as recipient media must cope with cumulative impacts over time, and the Bank Group having information on national development plans, may be able to identify areas in which problems are likely to arise in the absence of precautionary measures and prudent planning.

3.53 The Bank Group should encourage its member governments, both donors and recipients, to consider whether proposed projects have a potential for adverse environmental consequences, to arrange for further analysis and appropriate action where the nature and severity of those consequences warrant it, and to assure that project planning and execution takes due account of the results of that analysis. In this connection, the guidelines which the Bank Group has developed should be made available to governments, international organizations and individuals concerned with economic development.

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1/ For a discussion of this see the Appendix on "Economic Evaluation of National Environmental Policies and Projects."
3.54 The Bank Group should be prepared to consider lending for "environmental" projects (a term which can be applied to a great variety of projects, including air and water pollution control, control of erosion, solid wastes disposal, reforestation and pest and disease vector control). The economic and social returns of "environmental/health" projects can be quite substantial relative to other projects in a particular country. Such projects should be considered for Bank lending provided they otherwise satisfy the Bank Group's normal project criteria. Such a policy will not represent a significant change of position since there is already a long history of involvement in sectors with direct environmental/health consequences, such as water supply and sewerage, afforestation, etc.

3.55 In summary, this paper proposes the continuation of the Bank's present approach towards environmental problems. The experience gained so far suggests that following this course, the Bank Group can expect to play an increasingly fruitful role in improving and/or helping to retard the deterioration of man's physical environment.
APPENDIX

ECONOMIC EVALUATION OF NATIONAL ENVIRONMENTAL POLICIES AND PROJECTS

Project Considerations

1. As pointed out in the text of the paper, efforts are increasingly being made to include environmental considerations as integral parts of development strategy and action. This raises difficult problems of evaluating the various costs and benefits of alternative ways of dealing with environmental considerations. This Appendix considers, first, the general criteria to be employed in cost-benefit analysis of projects involving significant environmental considerations; and, second, approaches to the formulation of national environmental policies. It attempts to identify the relevant principles involved, recognizing that both within the Bank Group and elsewhere, experience to date has shown quantification of both costs and benefits to be particularly difficult.

2. In principle, the methodologies and criteria applicable to projects with environmental aspects are similar to those applicable to other kinds of projects; the benefits (broadly considered) which could be expected to be realized from incremental environmental expenditures should be determined to be greater than those which flow from the best alternative use of the resources involved. There are, however, uniquely troublesome aspects of measurement and quantification associated with environmental matters which make application of such a concept at present more of an art than a science. It is difficult to predict the extent and type of environmental change that will result from a particular activity. It is even more difficult to value a predicted change in cost-benefit terms.

The Concept of "Willingness to Pay"

3. When the extent and character of environmental change can be predicted, existing markets will often provide a measure of the monetary value of some of the effects. For example, the value of fish protein gained or lost through a change in water quality, and the repair and maintenance costs for physical structures subject to air or water pollution, can usually be adequately measured in this way. But it is not possible to directly establish a market value for the health effects of a change in amounts of air-borne particulates or a change in drinking water quality. In such cases indirect methods must suffice; an attempt must be made to infer from the prices of things which do have a market value, the value placed upon things for which no market has been established. For example, a Bank Group appraisal mission on a sewerage project in Brazil estimated some of the aesthetic and health benefits associated with a clean-up of the river on the basis of a predicted increase in nearby land values.

4. This approach to cost-benefit evaluation is based on the "willingness to pay." In principle, this is the concept that the Bank Group currently attempts to employ in projects with direct health and environmental consequences. While the concept presents measurement difficulties, it is in principle applicable to
any project with environmental implications. Where markets fail or do not exist, an inference is drawn concerning the amount that individuals would be willing to pay were there a market. The measurement of willingness to pay should, of course, include the value of benefits which actually accrue to the individual, whether or not he is in fact charged with the cost of providing them.

5. Several factors with a special bearing on discussion of environmental matters, and which influence willingness to pay in particular instances, should be noted. Willingness to pay for alternative items is a function of resource endowment, e.g., national wealth, and also of individual preferences and tastes. Consequently, different countries will make different choices as between environmental goods and other goods.

6. Willingness to pay may also be a function of the options available within the area. For example, the value of cleaning a particular river or stream will depend upon the number of other clean bodies of water in close proximity and the extent to which they offer suitable alternative facilities. In an area with an abundance of clean water bodies, the marginal benefit of providing one more is likely to be substantially smaller than would be the case where there were very few water bodies or where most of them were fouled.

7. A third factor affecting willingness to pay falls under the heading of "non-user" benefits. Persons who are not and may never be users of a facility may nevertheless receive some benefit from the knowledge that the opportunity for use exists. In principle, that benefit should be measured by the sum of all such "non-user" beneficiaries' willingness to pay.

8. Finally, the use of willingness to pay as an indicator of a project's worth is limited to the extent that it is in part determined by the existing distribution of income. Thus it may be felt that the poor, who often suffer most from environmental pollution, should be protected by expenditures that exceed their capacity to pay.

Approaches to Project Analysis

9. Least Cost. A "least-cost" analysis evaluates alternative proposals for achieving a particular environmental target, with the solution that achieves both the environmental (and productive) targets at least cost being selected. It is important in any such analysis to assess the sensitivity of costs to variations in the environmental target level so that trade-offs between levels of expenditure and the environmental quality obtained thereby can be evaluated. Although this approach provides only a partial analysis, if the proper sensitivity tests are made, it can at least demonstrate, in physical and in cost terms, what are the relevant trade-offs. It is important to note that in this regard, the project analyst should be concerned with achievement of the least social cost, defined to include costs incurred not only by the pollution control
authority, but also by those who cause and by those who suffer from pollution. Achievement of the least social cost solution requires analysis of the financial and administrative approaches to pollution control as well as of the physical means of attaining environmental quality targets.

10. Where some but not all benefits are quantifiable, least cost analysis can usefully be supplemented by the "switching value" approach. This involves providing an answer to the question "How large would the value of residual environmental benefits (those benefits not quantified) have to be to justify the project?" In using this approach, it is assumed that the cost stream the discount rate and perhaps certain other benefits are known. One can thus solve for the unknown value of residual environmental benefits which would equalize the stream of total benefits and total cost at the given discount rate. Since benefits occurring in multiple years are involved, future-year residual benefits must be expressed as a function of first-year benefits.

11. After obtaining a value showing what the first-year benefit would have to be in order to justify the project, the decision whether to proceed will depend on a judgment about the reasonableness of the result. The computed value of first-year benefits serves as a "switching value" for the decision. If a higher amount is ascribed to actual willingness to pay for these benefits, the project will be accepted; if willingness to pay is lower, it will be rejected. The greater the difference between the judgment concerning actual willingness to pay and the computed value of first-year benefits, the greater can be the confidence with which a project is accepted or rejected.

12. The foregoing kind of analysis is appropriate for dealing with "intangible" gains or losses, including aesthetic values or recreational activities. It also has special relevance to problems involving the permanent loss of a unique natural or cultural asset, for the fact of uniqueness will of itself make any kind of "market" pricing difficult, if not impossible.

Use of Qualitative/Descriptive Analyses

13. If the environmental impact is significant, and all attempts to quantify it in monetary terms fail, it should be possible to describe in qualitative or numerical terms the nature of the effects of alternative courses of action. A decision on project acceptability will typically be facilitated if, for example, in a project involving air pollution, a statement describing the benefits (or costs) or reducing (or increasing) the level of sulfur dioxide in a section of an industrial city accompanies the data on the costs and benefits quantified in monetary terms. The descriptive statement should attempt to characterize all aspects of the effects of the pollutants -- in sight, smell, taste, health, recreation, attitudes, animal and vegetal life, etc.

14. It is as important in a qualitative presentation as in a quantitative one to provide information in terms of incremental differences, i.e., to show the differences between the "with" and "without" cases, as well as the differences among project alternatives. Unfortunately, projects that produce only marginal changes may be harder to analyze than projects with a large non-marginal impact.
National Environmental Policies

15. In lending for a project with significant environmental implications, the Bank Group often has an opportunity to influence the larger institutional framework within which decisions will be made. This has been the case with projects in the preparatory stages in Finland, Yugoslavia and Turkey. It is useful, therefore, to consider the economic and social implications of alternative policy instruments available to governments. It should be kept in mind, however, that this is a new field in which views are still rapidly evolving and Bank Group staff experience is still fairly limited.

16. Of the many national or regional strategies that have been proposed, most can be classified as involving subsidies, regulations or changes. These different approaches create different incentives and have different effects on resource allocation and on the distribution of the gains and losses resulting from governmental intervention.

17. Subsidies. Subsidies are often used to encourage parties responsible for environmental pollution to install pollution control equipment, or to compensate them for having to meet environmental quality standards. However, by the distortion of relative prices, subsidies can be expected to result in inefficient investment decisions. One problem that arises is that unless all productive investment is to be subsidized, the regulatory agency must isolate the costs incurred by enterprises for purely environmental purposes from those costs that would be incurred in any case in the interests of increasing production or improving efficiency. This will frequently be too complex for a regulatory agency to handle since an enterprise's least-cost response to regulatory requirements will often involve changes in internal processes which simultaneously result in usable or marketable outputs. This complexity is illustrated by information received during the preparation of a proposed project in Finland where it was estimated that it would cost as much as $100,000 simply to carry out a study of the net difference in cost to build a modern pulp and paper mill, with and without pollution control. As a result, in negotiating with authorities on the amount of the subsidy, the enterprises have all the advantages since only they have all the facts.

1/ The policy instruments discussed in this section are in general limited in their applicability to the pervasive problem of residuals generation (i.e., the generation of waste products from productive facilities) rather than the quite different problem of the loss of a unique natural or cultural resource. Moreover, they are not directed at the question of highly toxic substances, such as mercury or fluorine, which can be dangerous even in minute quantities. Problems of unique resources and of toxic substances can more usefully be considered in the context of special studies.

2/ A comprehensive discussion of the principles involved is to be found in IBRD, "Finland's Water Pollution Control Program: The Role of Economic Analysis," Public Utilities Department, PUB 8 - February 20, 1974.
18. Due to the difficulty of separating out costs according to purpose, firms causing pollution have an incentive to claim subsidy for investments that strictly speaking are not for pollution control purposes at all. Furthermore, enterprises may be encouraged to invest in "end of pipe" treatment facilities rather than to carry out a less expensive internal process change, because the former can more easily be demonstrated to be an anti-pollution device and therefore qualify for subsidy.

19. Inherent in the provision of subsidies, therefore, is not only the danger that the least social cost means of achieving environmental quality targets will fail to be selected, but also the strong possibility that decisions to invest in productive equipment will be similarly distorted. As with any kind of subsidy, the optimal rate of consumption of products that have different environmental effects will not take place, because the total payment for the use of products (including an income or other tax necessary to pay the subsidy) is not related to the social cost of the particular products consumed. In particular, the supply of highly polluting products will tend to be greater than optimal.

20. While the distorting effects of subsidies are well known, subsidization of investment in pollution control equipment is commonplace. This may possibly be justified on the grounds that it is necessary to obtain the cooperation of industry in achieving environmental goals. Usually, however, the argument is couched in terms of equity; the establishment of environmental standards may require firms to make quite considerable changes in processes that have been carried on for many years.

21. The foregoing may be an argument in favor of gradualism in enforcing pollution control regulations. It should not, however, be used to justify the continued use of across-the-board subsidies, that do not distinguish between industries on the basis of social need. Furthermore, the fact that enforcement of pollution control standards may make the difference between a firm remaining in business or closing down is not in itself an argument for subsidizing pollution control. For example, assistance to a firm that is the major employer in a community in order to keep it in business may be carried out more efficiently by a system of lump sum payments than by direct subsidization of pollution control equipment. It would, however, be unreasonable to expect a water pollution control authority to be able to exercise this kind of judgment.

22. Regulation Standards - Licenses. The use of environmental resources for the disposal of water may also be controlled through regulations; for example, through issuance of permits (e.g., allowing a given volume of effluent discharge per time period); establishment of minimum standards of quality; or specification of equipment to be employed in treatment.

23. The easiest kind of regulation to draw up and enforce is one which is uniformly applied. A national or regional requirement that all effluents be of a specified quality is attractive from an administrative point of view.
However, the inefficiencies associated with uniform regulations are substantial. Uniform effluent standards take no advantage of local absorptive or regenerative capacities or, therefore, of variations in the costs of pollution at different points; nor do they take into consideration the difference in marginal costs faced by different enterprises in adjusting the amount or quality of their effluents.

24. In addition, a system of uniform regulations and standards, by not allowing any flexibility in pollution control requirements, makes almost inevitable a complex and long drawn-out system of appeals to avoid extreme inequities and inefficiencies (for example, where a particular enterprise's costs of control actually exceed the benefits to society of the effluent reduction). However, the process of appeals and litigation is usually self-defeating, since the industry always has the advantage in arguments about its costs and technology.

25. Individually Adjusted Standards. In view of the inefficiencies of uniform effluent standards, the adoption of effluent standards tailored to each enterprise is often proposed. In theory, a governmental body could appraise each enterprise and issue individualized regulations which would require the enterprise to reduce emissions to the point at which the marginal cost of an additional unit reduction among all enterprises is equalized and/or the desired level of total region-wide reduction is achieved. The administrative costs of obtaining the information required to institute such a system would, of course, be enormous. Furthermore, the potential for delays through appeals and litigation, which is a disadvantage of a uniform standards system, is even greater when individual standards are set for each enterprise.

26. Effluent Charges. Another technique is a system of effluent charges, under which a fee is levied on the use of publicly-owned environmental media for disposal of wastes. The amount of the fee is based on the total load of the harmful pollutant discharged. Where the data are less than complete and reliable, this approach may have certain advantages over those discussed above. For example, if a decision is taken to achieve a given level of reduction in effluents for some particular air or watershed, a unit effluent charge, at the proper level, will achieve the desired reduction at a lower total cost to the economy than a regulation calling for uniform reductions in levels of emissions or setting uniform quality standards. This is so because an effluent charge, unlike a uniform regulation, will induce the greatest reduction from those enterprises which can accomplish the reduction most efficiently. Self-interest in maximizing profits will lead each enterprise to invest in process changes or effluent treatment up to the point at which the cost of a unit reduction in effluent is equal to the amount of the charge. Producers with different cost characteristics will, therefore, respond differently. Uniform regulations, on the other hand, require a uniform response regardless of the cost to the individual enterprise.
27. International experience with effluent charge systems is limited. Several European countries, among them France, Holland, Czechoslovakia, Germany and the United Kingdom, which have employed license systems, have replaced or supplemented these systems with effluent charges or are considering doing so.

28. Because absorptive/regenerative capacities, and, therefore, the harm cause, will be different for different air shed or water basins, an effluent charge should be set on a regional basis. The level at which the charge is set is critical. In principle, the rate per unit of discharge should be equal to the estimated cost to society of an additional unit of pollutant discharged. While the informational difficulties involved in achieving this result are immense, it should be noted that such an estimate would also have to be made to rationalize a system of regulation. While determination of an ideal level of effluent charge may be beyond the current state of the art, several methods have been proposed for arriving at rough approximations of the proper charge.\footnote{A practical method for arriving at a rough estimate of the proper charge might be as follows: First, an estimate is made of the total harm in a region being caused by a particular effluent, e.g., biochemical oxygen demand (BOD) or suspended solids in water, sulfates in air. Second, the total quantity in kilograms of the effluent currently being discharged by all sources into the air or watershed is determined. The damage estimate is then divided by the quantity to give an average cost that could be used as the effluent charge. Where more than one pollutant is involved a charge must, of course, be levied on each. In countries experimenting with such systems, formulas have been devised for computing the charges based upon a combination of different pollutants. There is an alternative, somewhat less desirable, approach, which does not require an estimate of social damages. If one of the goals of a national or regional program is a reduction by a certain percent of the amount of a harmful effluent, the amount of target reduction in kilograms could be estimated, and divided by the estimated total industry-wide cost of achieving the reduction. It may also be possible to obtain an independent estimate of the average per unit marginal cost of the target reduction across industries.}

29. The question is whether an inexact level of effluent charge is more, or less, acceptable than an inexact effluent standard. With the "wrong" level of charges, the level of effluent production will be higher or lower than the target. The reduction that is achieved, however, is achieved by means of the "least cost" procedure. Furthermore, the level of charges may be raised or reduced over time to bring results in line with the target. If a uniform standard is adopted, whatever the standard, it can be shown to be inefficient with respect to particular enterprises with differing marginal costs. Individually adjusted standards avoid the latter difficulty but, as noted above, the informational requirements and the administrative machinery necessary to set the individual standards and to avoid claims of discrimination may be overwhelming.
30. The conventional wisdom is that with an effluent standard, the target for environmental quality is sure to be met, even though inefficiencies are involved, while with effluent charges the results are uncertain. Experience, however, has convinced many observers that almost exactly the opposite is true. Reductions in industrial waste loads where even modest sewer charges have been imposed by municipalities have often been rapid and spectacular; on the other hand, regulatory processes are frequently not only time-consuming, but also quite uncertain in result.

31. Where environmental pollution is excessive, and the first steps at improvement are being taken, the appropriate remedies for a particular industry may be obvious both to the regulatory agency and to the industry. In such cases, there may be no great difference in result between a system of individually specified standards and a system of effluent charges. As the desired level of environmental improvement rises, however, marginal costs typically increase in a sharply non-linear fashion and the case for a rigorous system of charges becomes stronger.

32. Finally, an advantage of an effluent charges system is that it may be a source of funds for certain environmental improvement works that are most efficiently carried out by the public sector. In the water pollution field, for example, economies of scale may be reaped in collective treatment works, while artificial aeration, sludge removal and low-flow augmentation would normally best be carried out by a public authority.

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1/ See Annex 5 of IBRD, "Finland's Water Pollution Control Program: The Role of Economic Analysis," op cit. One of the most detailed studies yet attempted for determining the cost of reducing pollution in a waterway was conducted almost a decade ago in the Delaware Estuary area of the United States. The study estimated costs of achieving a given level of reduction in water pollution through several different approaches, including uniform treatment standards and a unit effluent charge. It showed, among other things, that a program involving a uniform effluent standard resulted in costs from 70% to 100% higher than one involving a unit effluent charge, depending upon the specified quality level. (The difference in cost between the charge and the uniform standard was estimated at the time to be approximately $8 million annually for the higher quality level.)
Environmental, Health, and Human Ecologic Considerations in Economic Development Projects

World Bank -- 1973
Environmental, Health, and Human Ecologic Considerations in Economic Development Projects

World Bank
Washington, D.C.
1973
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PREFACE
The quest by the developing nations of the world for higher standards of living often involves the deliberate modification of the natural environment to achieve economic objectives. However, such activities as the construction of roads, dams, airports, irrigation and sewage systems, powerplants and industrial facilities sometimes results in concomitant losses of ecological, health, or social/cultural values or all, and in the long run, increased costs to society. Such losses, which vary widely in magnitude, may result from the failure to adequately consider environmental consequences during project planning and design or from the lack of knowledge and information necessary to predict the eventual impact. Even if undesirable effects are forecast, information on cost-effective environmental safeguards may not be known or economically competitive project alternatives are often unavailable.

To the extent these losses occur, or go unmeasured, the level of development is inflated. Often the difference has to be paid at a higher price and at a later stage of development. Higher costs of future remedial action may be avoided by prudent planning and early preventive measures.

It is important, therefore, that all who are involved in a proposed project — planners, decision-makers, engineers, lending institutions — have as clear an understanding as possible of the potential positive and negative environmental consequences of development activity at an early stage of project planning. Based on such knowledge, it may be possible to avoid or mitigate undesirable effects, or promote positive consequences, by incorporating pollution control technologies, redesigning the project, or selecting another site. The identification and analysis of environmental considerations in all of these projects requires trained expertise at all levels.
In this connection several international organizations including Stockholm Conference participants have called for the creation or expansion of interdisciplinary training in environmental topics. Occasionally, education and training can be carried out on site in conjunction with development projects. But expertise in the environmental and human ecologic sciences is a unique problem in itself and deserves attention in accordance with the priority it deserves in planning future education programs.

The World Bank Group, together with other international development agencies, is presently using and developing improved detailed environmental considerations, suggested criteria and standards, and tolerance levels which should be taken into account during the planning and appraisal stages of development projects. These guidelines have been designed to provide further guidance to Bank staff in the detection, identification and measurement of environmental and related human ecologic effects. This guide sets forth environmental considerations for sixteen kinds of development projects (grouped in four chapters) typically financed by the World Bank Group and other international development institutions. Chapters I through IV outline these considerations, Chapter V summarizes existing environmental standards which have been developed throughout the world, and Chapter VI provides appropriate reference material and institutions corresponding to each chapter. In Chapter VII Institutional Resources are presented.

The considerations are organized around categories designed to (1) indicate general points of departure for analyzing the potential environmental consequences of proposed projects, (2) indicate types of expertise and information required to address in detail the environmental aspects of various projects, and (3) provide a framework for the development of procedures and guidelines for systematic review and consideration of environmental factors. The considerations in each of these chapters are organized around the following headings and subheadings.
A. ENVIRONMENT/RESOURCE LINKAGES

Ecosystem context
  ecosystem factors and function,
  *e.g.*, population carrying capacity
  and land use, pollution assimilative capacity

Amendments or alternatives
  technological choices
  recycling possibilities
  other external markets

B. PROJECT DESIGN AND CONSTRUCTION

Immediate protection of environmental values -
  consolidated construction plans to protect
  flora, fauna, and prevent erosion

Work force health-screening and periodic examination

C. OPERATIONS

Raw materials management
  Wastes management
  Maintenance of safeguards
  Monitoring for effects (and synergistics)
  Occupational health

D. SOCIO-CULTURAL FACTORS

Socio-cultural impact (preemption)
  Relocation of peoples

E. HEALTH IMPACTS

Control of disease vectors
  Health care services
  Introduction and/or redistribution of diseases

F. LONG-TERM CONSIDERATIONS

Unexpected events (catastrophies)
  Regional development context
The considerations identified herein are generalized for each class of project; in application, they should be individually tailored to respond to the unique physical, economic, and social conditions encountered in a particular project. For example, roads that are constructed in arid regions of the world clearly affect that environment differently than those through tropical rain forests. In some instances, individual environmental considerations may not be relevant to a specific project being planned or reviewed.

Comments and suggestions to improve these considerations are invited. Also welcome are appropriate published references and other sources of information and expertise which may assist organizations and individuals attempting to include environmental considerations in their development plans. These should be addressed to:

Office of Environmental Affairs
World Bank
1818 H Street, N.W.
Washington, D.C. 20433
I AGRICULTURE

1. Agricultural Development
2. Irrigation Systems
1. AGRICULTURAL DEVELOPMENT

A. Environment/Resource Linkages

- Is this a climax ecosystem (e.g., undisturbed tropical forest) or has it undergone earlier man-induced changes?
- If new water sources are to be tapped, what is known of their extent and replenishment?
- Will changes in population density and/or life-style brought about by the project be likely to create environmental/health/social problems?

B. Project Design and Construction

- Will the necessary measures to protect environment and health be incorporated in the design and construction of the project?
- How will sheet erosion or gully erosion resulting from the removal of trees and other vegetated cover be controlled?
- If ponds, canals, or other surface water bodies are involved, can a fishery be established?
- How will downstream water users be affected by the project, e.g., supply, pollution, pesticides, etc.?
- Will stored agricultural products be the target of insect and rodent pests? If so, what control measures will be taken?
- Will wildlife or fish populations and/or their migrations be affected? How will this be handled?
- Will pesticides and fertilizers be employed? If so, what steps will be taken to minimize their undesirable effects?
C. Operations

- How will the project be monitored to gauge its effects on the environment, human health and social welfare?
- Will extension sources be provided? Can they be used to detect and counteract any adverse effects should they arise?
- Will those responsible for on-going management and supervision of the project (if applicable) be on the alert for environmental problems? Do they know where to seek advice and assistance?

D. Socio-cultural Factors

- If the project involves settlement or relocation of peoples, has a plan for their removal and settlement been prepared and/or approved by, or benefited from review by, qualified social scientists?
- Will the peoples to be resettled be fully briefed and oriented to their new environmental setting and the changes to be expected, if any, in their life-styles, living arrangements and occupation?
- Will the affected peoples need to acquire new skills and techniques for successful adaptation? Does the project plan provide for the necessary education and training?
- Will the project also provide for training in the techniques of erosion control, water management, forest and range management, etc.?
- Will indigenous, primitive peoples be affected? What provisions will be made to assure their future?

E. Health Impacts

- Will agricultural disease problems result from this project? If so, how will they be handled?
• If the project involves colonizing new areas, will the settlers receive medical examination and treatment to control the introduction of new diseases?

• Will the settlers be informed of the health hazards to be expected, and of methods of control?

• Will a system of health care delivery be included in the project?

F. Long-Term Considerations

• Does the project preempt any future resource options either by its presence or operation?

• Will the project so alter the environment to preclude its future use for other activities, including other agricultural uses?

• Will water logging and/or soil salinity become a problem? Can the process of soil lateritization be expected and, if so, what will be its consequences?

• If large areas of indigenous vegetative cover is to be removed (e.g., tropical forests) can meso-scale climatic changes be expected?
2. IRRIGATION SYSTEMS

A. Environmental/Resource Linkages

- What will be the ecological consequences of changes in land-use patterns and population distribution? Will future resource uses be preempted?

- Will undesirable population-crowding occur as villages expand either to make way for, or take advantage of, the irrigated areas?

- What type of environmental planning is being done?

- Are major components of the ecosystem known? How will the project affect them?

- Will changes in population density upset ecological balances?

- What will be the impact of the project on the biota in the water system?

- Will the diversion of water to cultivated areas seriously degrade the capabilities of the original water system to support valuable biological species?

- Will important wildlife migration routes be permanently disrupted?

B. Design and Construction

- Has a consolidated construction plan for the development been prepared that takes into account ecological factors?

- Are road patterns, land excavations, fill sites, refuse disposal activities, etc., planned to minimize damage to the natural environment?
 What provisions have been made, if needed, for restoring borrow pits and other scarred sections of the construction area by filling, grading, and reseeding to prevent erosion?

Will precautions be taken to protect management and construction crews from introducing new diseases and/or redistributing endemic diseases?

C. Operations

Will water diversions be screened to prevent the destruction of fish?

What steps are being taken to preserve fish and wildlife resources in the area?

Will runoff water contain residues, such as pesticides and fertilizers, that contaminate downstream waters?

What are the sedimentation, salinity and erosion problems?

How will water logging and salt accumulation be controlled? Will serious aquatic weed problems arise?

How does the irrigation network interact with sources of drinking water?

Will irrigation permit the cultivation of new crops to which exogenous pests might be attracted?

What provision has been made for monitoring the effects of the development on the environment and on affected peoples?

D. Socio-cultural Factors

Will the introduction of water, new crops or population increases be detrimental to important social or cultural practices?

Will the construction or operation of the system adversely effect other agricultural, economic or commercial practices in the area?
Will construction of the system or new cultivation cause the relocation of people seeking new opportunities? If so, what steps will be taken to ensure orderly and productive resettlement?

E. Health Impacts

- To what extent will the project introduce new public health problems? Will health care services be included in the project?
- Will food, wastes, or water cycles aggravate sanitation and disease problems? Has provision been made for adequate environmental sanitation?
- Will changes in water velocities, temperatures and depth result in a more favorable environment for insect pests and disease-bearing organisms?
- Will changes in water patterns introduce disease-bearing organisms into previously unaffected areas?

F. Long-Term Considerations

- What undesirable long-range changes in population or the environment may accompany the irrigation system development?
- Will further related development projects planned for the future introduce new possibilities for adverse environmental effects?
II INDUSTRY

1. Fertilizer Plants
2. Iron and Steel Mills
3. Mining Operations
4. Petroleum and Petrochemical Industry
5. Pulp and Paper Mills
6. Smelting Plants
7. Textile Mills
8. Tourism
1. FERTILIZER PLANTS

A. Environmental/Resource Linkages

- What environmental factors will be considered in site selection and plant design?
- Are the character and major components of the site ecosystem known?
- Have hydrologic, geologic, seismologic and meteorologic studies been made to anticipate or minimize damage to the environment?
- Will consideration be given both to the direct effects of the plant on the site and also to secondary impacts resulting from associated urban and industrial activities?
- Does a comprehensive development plan link the project to related raw materials, by products and utilization, shipment and processing facilities?
- Have economical recycling schemes possible for future implementation been incorporated into project plans?

B. Project Design and Construction

- Have environmental and industrial pollution control experts been included in the planning and design of the project?
- Has a consolidated construction plan been formulated to take ecological factors into account?
- Will alternative sites or alternative orientations of the plant be considered in an effort to avoid or mitigate water and air quality degradation and solid wastes disposal?
- Does the project meet other plans for water resources use or development?

1-1
Will design features consider or incorporate adequate processes to prevent or mitigate air, water, and solid wastes pollution?

Have provisions been made for recovery or disposal of solid wastes?

Are road patterns, land excavations, fill sites, refuse disposal activities, etc., planned to minimize damage to the natural environment?

What provisions have been made for restoring borrow pits and other scarred sections of the construction area by filling, grading, and reseeding to prevent erosion?

C. Operations

How will raw materials and hazardous products be transported, handled and stored? Is there a potential for pollution and how will it be controlled?

Has an adequate safety plan been prepared to cope with releases of toxic materials due to accidental spillage or natural catastrophes?

Has provision been made to prevent toxic chemicals released by spills leakages, or ruptures from contaminating surface and ground waters?

Has an adequate monitoring system for plant effluents been proposed?

What standards are being used to govern the types and quantities of gaseous, liquid and solid wastes to be discharged into the atmosphere, soil and water?

Will such effluent limits be compatible with the laws, standards and regulations of the country or locality concerned?

What alternative methods of disposition have been considered?

Can the emission controls to be incorporated into plant design and operations be easily altered to meet more stringent requirements in the future?
Given different levels of plant investment, what additional safeguards and controls can be incorporated and how would each affect the emissions?

Are possible synergistic effects considered?

Will plant operators be trained in environmental protection?

What is the potential impact of plant operations on animal, plant, and human life and their interrelationships in the immediate vicinity, and downwind or downstream?

Will impacts change significantly with time?

D. Socio-cultural Factors

Will the location or production of the plant threaten to harm important cultural patterns or practices?

Will population shifts to or from the plant site overburden urban facilities or natural amenities?

Will the plant's presence or operation adversely effect any planned human settlements?

E. Health Impacts

Have health service measures for plant and community been incorporated into project planning? Has an adequate program of industrial hygiene, plant safety, and occupational health been provided?

F. Long-Term Considerations

Are there plans for plant expansion? Is the site adequate in all respects for such expansion?
2. IRON AND STEEL MILLS

A. Environment/Resource Linkages

- What environmental factors will be considered in site selection and plant design?
- Are the character and major components of the site ecosystem known?
- Will the plant's presence or operation preempt any other important use of the area; e.g., tourism?
- Has the impact of associated urban and industrial activities been considered?

B. Project Design and Construction

- Will alternate sites or alternative orientations of the plant be considered in an effort to mitigate downwind effects and/or water quality degradation?
- Is the project compatible with plans for water resources conservation?
- Will design features adequately consider the effect of plant effluents on air, soil and water, on human settlements, on agriculture, and on aquatic or marine resources?
- What effluent controls will be incorporated and are they adequate? What additional safeguards are possible given different levels of investment?
- Have acceptable procedures for the use and disposal of pickling liquors been developed?
- Have technologies for recycling by products and effluents been considered and will they be employed?
Does a comprehensive development plan link the project to raw materials, by-products use, shipment and processing facilities?

Has a consolidated construction plan been formulated to take ecological factors into account?

Are road patterns, land excavation, fill sites, etc., planned to minimize erosion?

Will construction minimize damage and disruption to local natural environmental systems and amenities?

What provisions are being made for reclaiming disposal dumps and for recycling residues?

Will health and safety measures for operators and construction crews be a component of project design and construction?

C. Operations

Will raw materials, particularly industrial chemicals, be handled and stored with safety features and mechanisms?

Have provisions been made to prevent toxic materials from entering water bodies in the event of an accident?

Will handling and packaging safety measures be incorporated on ship or barge transporters?

Is there an adequate safety plan to cope with accidents and accidental spillages?

Have the types and quantities of gaseous, liquid, and solid wastes under operating conditions been calculated?

How will plant emissions be monitored?

Will receiving media (air and water) be monitored?

Will plant effluents cause synergistic effects with other wastes to be found in the receiving waters?

What provisions will be made for training plant managers and operators in environmental protection?
● How will slag be handled?
● Where will pickling liquors be discharged after treatment?

D. Socio-Cultural Factors

● Will the production facilities attract large numbers of people and create serious urban problems?
● Have solutions to social disruptions attributable to the plant's presence or operations been considered?

E. Health Impacts

● Will the plant have adequate provisions for plant safety, industrial hygiene and occupational health?
● Will health care delivery systems be provided for workers and their families?
● Can these be made available to a wider segment of the local population?

F. Long-Term Considerations

● In the event of future plant construction in related industries or expansion in urbanization, are plant facilities adequate to accommodate possible changes without harmful environmental effects?
3. MINING OPERATIONS

A. Environmental/Resource Linkages

- Will the mining preclude other future use of the area or its resources?

- What environmental safeguards will be incorporated into mineral exploration and production agreements?

- Will environmental factors, including land-use patterns in the vicinity, be considered in the selection of technology, the location, scale and design of the operations?

- Have the impacts on fish, wildlife and vegetation been considered?

- To what extent will mining activities adversely effect local land-use; e.g., land subsidence, mine drainage, pollution of water courses, erosion, etc.?

B. Project Design and Construction

- What measures will be taken to prevent land subsidence in areas in which underground mining is carried out? Will erosion be a problem? Will reforestation be carried out? Will wash waters be clarified or recycled?

- Has a monitoring program been considered to detect changes in neighboring plant and animal life caused by mining operations?

- Will plans for mining activities consider environmental aspects of regional plans in relation to mining?

- Will a system of sequential land-use planning be developed for the site in order to retain its social and economic utility?
• Have hydrologic, geologic, seismologic and meteorologic studies of the site been made to anticipate and minimize damage?

• Will underground and/or surface water runoff patterns be adversely affected?

• Are there opportunities to economically reclaim or recycle wastes, to reduce effluent volume or to market by-products?

• Can production technology or design offer possibilities for recycling mining tailings?

• Does a comprehensive development plan link the project to environmental aspects of shipping and processing sites? Will the transport of the mined materials present environmental or human ecologic problems?

C. Operations

• Will mining operations be a source of land erosion and despoilation?

• Will strip mines be reclaimed and replanted?

• Have provisions been made to reclaim spoil dumps, tailing piles, etc.

• Will occupational health safeguards and service facilities for miner's lung disease, etc., be provided?

• Will noise associated with blasting and other mining operations have undesirable impacts on nearby human and wildlife populations?

• What measures will be taken to prevent water pollution from mine drainage directly or indirectly into water bodies?

• Will pollution controls be incorporated into processing operations to prevent the discharge of effluents into surface waters?

• Will irrigation or drinking water supplies be affected?
What are the specific effluents of concern and what are their most troublesome characteristics?

Will the discharge of effluents be compatible with other present and future uses of the receiving water, particularly during periods of minimum stream flow?

Will water and land biota be adversely affected from runoffs from spills and tailings?

What provisions have been made to prevent air pollution from coal fires and smouldering slag heaps?

Will processing operations incorporate controls to prevent release of toxic gases, fumes, and particulants?

Will access roads constitute a source of dust pollution?

What measures can be taken to reduce air pollution from mining operations smoke and dust?

What effect will drilling, dredging, or related exploratory operations have on the marine environment?

Have dredging disposal areas been chosen for minimum deleterious impact upon the biota?

What measures will be taken to prevent water pollution from tower or service boat discharges of oil, sewage, or toxic drilling mud?

Do the production systems include accident prevention equipment such as storm chokes and blowout preventors?

Will safety equipment be monitored regularly?

Has a contingency plan been prepared for coping with accidents such as spills?

D. Socio-cultural Factors

What provisions (housing, community services, etc.,) have been made for families that will be displaced by or attracted to the mining development?
● Will mining operations threaten important archeological deposits or cultural practices?

● Could mining operations bring about unwanted changes in local economic activity?

E. Health Impacts

● Will the mining development create health or sanitation problems?

● Is there an adequate program for employee safety and occupational health?

● Will settling ponds attract insect pests or create other potential disease problems?

● Have possible hazards to the health of people attracted to the project site been considered?

F. Long-Term Considerations

● Will mining attract large populations involving the provision of health services or urban infrastructure?

● Have the effects of possible associated future projects on land-use, water and air resources been taken into account?
4. PETROLEUM-PETROCHEMICAL INDUSTRY

A. Environment/Resource Linkages

- Will environmental considerations, including present human land-use patterns in the vicinity, be incorporated into the selection of technology, the location, scale and the design of the plant?

- Have hydrologic, geologic, seismologic, and meteorologic studies of the site been made to anticipate and minimize possible damage to humans, fish, and wildlife resources and vegetation?

- Does a comprehensive development plan link the project to environmental aspects of raw materials, by-products utilization, shipping and processing?

B. Project Design and Construction

- Have alternative sites or locations of the plant been considered in an effort to avoid or mitigate environmental degradation?

- What features for environmental protection will be incorporated in the design and operation?

- Is there a comprehensive construction plan that takes into account ecological factors?

- Are road patterns, land excavation, fill sites, refuse disposal activities, etc., planned to minimize damage to the natural environment?

- What provisions have been made for restoring sections of the construction area?

- Will construction personnel be exposed to unique local health problems, or will they introduce diseases?

4-1
C. Operations

- Do offloading and onloading methods of handling petroleum and chemical products incorporate human and environmental safeguards?

- What are the dangers of an explosion or spill of hazardous materials?

- Will contingency plans, including manpower and materials, be available to cope with accidents?

- Has adequate attention been given to the design and construction of safe storage facilities for hazardous materials and refinery products?

- Will floating-roof tanks be employed?

- What types and quantities of effluents or particulate emissions will the plant produce?

- Will the discharge of effluents and sludge into water bodies be compatible with other present and future uses of the receiving waters, particularly during periods of minimum stream flow?

- Will effluents enter into synergistic effects with other elements?

- Will effluents contain toxic materials?

- If effluents are to be discharged directly or indirectly into a water body, have studies been made of the physical and chemical properties of the receiving water, e.g., temperature, current patterns, dissolved oxygen, etc.?

- What effects will effluents have on water supply sources, algae growth and invertebrate and fish population?

- Will plant effluents and emissions be controlled and monitored?

- What control techniques will be employed to remove toxic materials from effluents?

- If solid wastes are produced, what disposition will be made of them?
Has the recycling of solid wastes been considered?

What provisions have been made for training plant operators in environmental protection?

Has pollution control equipment been planned?

Will odors be controlled?

D. Socio-cultural Factors

How and to what degree will the presence and operation of the plant alter the size and economic activities of the local population? Will urban problems be created or accentuated?

E. Health Impacts

Will the plant produce emissions that will directly or indirectly be detrimental to health?

Are new health problems likely to occur?

What measures have been taken to ensure a program of employee safety and occupational health?

Will plant employees and their families be provided with a system of health care?

F. Long-Term Considerations

How will future projects fit into the environmental context of present plant operations?

Is an expansion of facilities envisioned and, if so, how will it affect the environment?
5. PULP AND PAPER MILLS

A. Environment/Resource Linkages

- Do plans for plant location and construction take into account environmental criteria regarding surrounding land use, agricultural patterns, water use?

- Have hydrologic, geologic, seismologic and meteorologic studies of the site been conducted?

- What will be the potential impact of plant operations on water quality and on plant, animal and human life?

- Does a comprehensive development plan link the project to environmental aspects of raw materials, by-products utilization, shipping and processing sites?

- Are logging operations to be carried out on a sustained yield basis? Are good cutting practices to be followed? Are reforestation plans adequate?

B. Project Design and Construction

- Have alternative sites or locations of the plant been considered in an effort to avoid or mitigate water and air quality degradation?

- Is there a comprehensive construction plan for the project that takes into account ecological factors?

- Are road patterns, land excavations, fill sites, refuse disposal activities, etc., planned to minimize erosion and other damage to the natural environment?

- Will settling ponds create odors near surrounding urbanized areas?
Can a coupling of pulping and paper operations reduce waste water outflows?

What are the types and quantities of the waste to be discharged into the environment?

Will controls on air and water pollutants, including odors, be incorporated? Are they adequate in all respects?

Logging

What provisions are being made to minimize erosion and the siltation of water bodies as the result of logging operations?

Is there sufficient information about regional topography and soil types on which to base effective measures for controlling erosion and siltation?

Will the rate and pattern of cutting affect the region's ecology?

Will the logging be carried out in accordance with recognized forest management practices, including provision for cutting patterns and revegetation to retard erosion?

What effect will logging operations and the construction of access roads have on fish and wildlife resources and scenic values of the region?

C. Operations

How will chemical raw materials and wastes be handled and stored?

What will be the effects on the environment of storage tank ruptures, leakage or spillage during handling?

Is the process being used designed to recover chemicals and process heat?

Will plant effluents and environmental quality be monitored? Will logging operations be monitored to ensure good practices are employed?
Will operating personnel be trained in environmental protection?

D. Socio-cultural Factors

Will large scale logging operations affect human settlements and their economies?

What are the possible consequences of logging and/or pulp and paper production for the impacted communities?

Will logging bring on land-use changes in surrounding areas with significant impact on the residents of the region?

E. Health Impacts

Are endemic disease vectors well enough known for purposes of control in case the project inadvertently increases their influence?

Are health care facilities and services planned or in being, adequate to meet the increased demands during logging operations?

Is there an adequate program of industrial hygiene and occupational health for the pulp and paper plant?

F. Long-Term Considerations

Are there plans for eventual plant expansion or related industrial and residential construction?

Is the site adequate for such later expansion without harmful environmental effects?

Are the forest resources to be managed so as to assure a sustained yield and will not leave the area denuded of forest cover and otherwise impoverished?
6. SMELTING PLANTS

A. Environmental/Resource Linkages

- What environmental factors will be considered in site selection and plant design?
- Have hydrologic, geologic, seismologic and meteorologic studies been made to anticipate or minimize damage to the environment?
- Are the character and main components of the dominant ecosystem known?
- Do comprehensive development plans link natural resources to raw materials, by-product use, and shipment and processing facilities?
- Have alternative technologies leading to possible future recycling schemes or marketable by-products been considered in the plan?
- What is the potential impact of plant emissions on plant, animal and human ecology in the immediate vicinity and downwind or downstream?

B. Project Design and Construction

- Have alternative sites or orientations of the plant been considered in an effort to mitigate effects on air and water quality degradation?
- Does a comprehensive development plan exist which also considers environmental factors?
- Does the project consider possible environmental impacts on economically important local activities in agriculture, natural resources, conservation, etc.?
• Are road patterns, land excavations, and refuse disposal activities planned to minimize erosion and other damage to the natural environment?

• What provision is being made for reclaiming disposal dumps and restoring and reseeding scarred sections of the site?

• Will health and safety measures for operators and workers be made a component of project design and construction?

• Are the technologies and costs of abating present or future effluent levels known? Are the planned effluent controls adequate to prevent damage to the environment and human health?

C. Operations

• How will raw materials, particularly industrial chemicals, be handled and stored?

• Is there an adequate safety plan to cope with accidents?

• What are the types and quantities of the gaseous, liquid, and solid wastes which will result?

• What types of effluent controls will be incorporated and what additional safeguards are possible given different levels of plant investment?

• How will plant emissions be monitored?

• Will plant effluents cause synergistic effects with upstream or downstream effluents?

• What provision will be made for training plant managers and operators in environmental protection?

• To what degree will plant operations affect fish, wildlife, and vegetation in the surrounding area?

• Will acidic fumes affect downwind crops, forests, or urbanized areas (e.g., fluorides from aluminum smelting, sulfur oxides from non-ferrous metals smelting)?

• What disposition will be made of ashes and slag?
What effect will direct dumping or runoff from dumps have in degrading surface or subsurface water quality or flow patterns?

D. Socio-cultural Factors

- Will production activities impact on large numbers of people?
- Have solutions to social disruption from noise, air or water pollution been developed?
- Will worker housing be provided? If so, is it adequate in all respects to meet the socio-cultural needs of the affected people?

E. Health Impacts

- Have possible disease problems been considered?
- Are health care delivery systems for workers and their families provided as a part of the project? Is there an adequate program of industrial hygiene and occupational health?

F. Long-Term Considerations

- Are there future plans for plant construction or related industrial, residential and urban expansion?
- Are the site and facilities adequate to accommodate expansion without harmful environmental effects?
- Is the plant's presence and planned level of operations compatible with local and regional development plans?
7. TEXTILE MILLS

A. Environmental/Resource Linkages

- What environmental factors entered into the site selection for the plant?
- Is the plant linked to related raw materials, by-products utilization, transportation and processing centers via a coherent development plan and is it in keeping with regional land-use plans?
- Will upstream water users create problems for the plant's processing waters? Will the plant's effluents create problems for downstream users?
- Will other industrial plants or activities planned for the area create pollution problems; necessitating more stringent controls over waste effluents?

B. Project Design and Construction

- Were alternative sites and designs considered in an effort to minimize environmental pollution?
- Is the project compatible with water resource management plans?
- How will downstream water users be specifically affected by pollutants released from the plant.
- Were alternative industrial processes considered in an effort to recapture and/or recycle materials?
- Have methods for minimizing the generation of liquid and gaseous effluent been incorporated into the project design?
Does the process design and physical layout of the plant allow for future additional pollution control equipment or procedures to be installed or implemented with minimum difficulty?

Have aesthetic considerations been included in the architecture, landscaping, etc.?

Will land excavations, borrow pits, and other disturbed areas be graded, filled and reseeded?

C. Operations

- How will pollutant emissions be monitored?
- Will the effect of gaseous and liquid effluents on the air and receiving waters be monitored, thereby allowing for necessary adjustments in treatment?
- Will any components of the liquid effluent be particularly harmful to human health or aquatic life and thus require special treatment and monitoring before release?
- Will in-plant sanitation and safety hazards be continually monitored?
- How will solid wastes be handled? If sanitary landfill is used, has a proper site been selected and have operators been trained in proper operation?
- How will the plant's human wastes be treated?

D. Socio-cultural Factors

- Does the project provide for employee housing and related services? If so, are they adequate for the social and cultural needs of the workers?
- Will the plant's presence create any immediate or future urban problems (e.g., transportation, housing, education, health services, water supply and sewage)?
E. Health Impacts

- Is there an adequate program of industrial hygiene and occupational health?
- Will a health care delivery system be provided for workers and their families?

F. Long-Term Considerations

- Is the project compatible with proposals for future industrial development?
- Has the plant been designed so that any future expansion could be accomplished with minimum adverse impact to the environment?
- Will future industrial growth and its attendant pollution require more stringent and costly control of effluents?
A. Environmental/Resource Linkages

- What are expected environmental consequences of any changes in land-use patterns and population redistribution as a result of the project's presence and/or operation?
- Will the project cause an influx of people seeking employment possibilities? If so, what environmental/social problems are envisaged?
- Will the tourist population create conditions inimical to the preservation or management of important aspects of the natural environment?
- Will undesirable activities and facilities spring up around the project? How will this be handled?
- What guarantees are in force, such as land-use planning, zoning and other appropriate instruments, to ensure the preservation of tourism values in the future?

B. Project Design and Construction

- Is the project design totally compatible and in keeping with the natural environment? Does it harmonize and blend in with the scenery and character of the landscape?
- Are the unique attributes of the area recognized and observed in the project design?
- Will there be minimal disruption of the natural environment? When disruption is unavoidable, will proper steps be taken for restoration and replanting?
- Will odors, air pollution and/or waste discharges from nearby urban areas or industries present a problem?
C. Operations

- Will any facet of the project's operations contribute to environmental or social degradation?
- Is the design of the water supply and waste-treatment systems adequate in all respects?
- Where will the human wastes be discharged, and have alternatives been fully considered?
- If a marine outfall is contemplated, have the necessary marine biology and oceanographic studies been carried out to ensure protection of the marine biota and the coastline?
- Will insects pose a nuisance or health problem and how will they be controlled?
- Will food-handling facilities and employees be periodically inspected for sanitation and health problems?
- Are there any diseases endemic to the area (e.g., malaria) that call for special attention and control?
- Will billboards, neon signs, noise, etc., be controlled?
- Will jet aircraft pass over or near the site, causing noise problems?
- Will beaches be subjected to oil pollution from passing ships and/or human or industrial wastes?

D. Socio-cultural Factors

- Has the impact of the project and ancillary activities on the local culture and life styles been evaluated? Will the project prove detrimental to these values and thus in turn affect project success?
- Will the presence and operation of the project so constrain local residents to create social disharmony?
Will the project also attract local tourists or will they be denied access to heretofore used recreational opportunities?

If historical, religious, geologic, or archeological sites or artifacts constitute all or part of the tourist attraction, will their preservation and management be adequately handled?

E. Health Impacts

- Are existing health care facilities and personnel adequate to meet increased demands?
- Do these facilities and personnel meet acceptable standards for the tourist population being served?
- Are emergency facilities (fire, ambulance, rescue) adequate?

F. Long-Term Considerations

- What future projects are planned and how will they interact with the currently proposed project?
- Will tourism values continue to be important in the area, or is their future likely to be in doubt?
9. GUIDELINES FOR ESTIMATING INDUSTRIAL ENVIRONMENTAL IMPACT

The guidelines for including environmental considerations in project appraisals follow a progression of check points designed to accomplish two main purposes: (1) the prevention of deterioration of natural resources so that they can continue to provide the basis for further and sustained economic development and (2) the provision of adequate warning of the side effects of project development which may incur costs not identified in ordinary review procedures.

The first purpose, protection of the resource base for future development, aims to identify opportunities in project design which will facilitate the full utilization and renewal of resources where possible or the conversion of resource sites to alternate subsequent uses where renewal is not possible. The guidelines also seek avoidance of depletion and destruction in the sense of leaving areas with no future uses or in a condition to do harm to other related resources.

The second purpose, to call attention to undesirable side effects, aims to bring external effects or social costs not ordinarily calculated by the industry into the overall project evaluation. In this case, the rate of return to the industry and the economic return to society may be different so that the total expected costs have to be weighed against total expected benefits.

The structure of the information package which will accomplish these objectives has two main characteristics. Its first attribute is sufficient breadth of scope and time frame to identify the relevant context for project evaluation. Therefore, nine different steps are outlined in the guidelines; they serve to link the particular project firstly to the natural resource origin of the raw material to be handled.
and lastly to its final resting place in a disposal area. The steps are outlined below in detail, but their essential characteristic is that they call attention to the place of the project being appraised in the context of the cycle from extraction to disposition.

Within this scope, a second feature limits the concern of the analyst. To incorporate environmental considerations into the concerns of economics, the environment will have to be treated as an economic entity. That is, it will have to be demonstrated to have scarcity, priorities, and alternatives for action. Without an awareness of these three characteristics, environmental evaluation reduces to assertions which cannot be handled through economic analysis. Whether or not these economic characteristics of the environment are quantitatively expressed is not the only issue. Analysis can proceed as long as there is a sense of scarcity, priorities and alternatives.

Environmental considerations have often been excluded from economic analysis because they could not be handled with current analytical tools. We are still in early stages of the development of necessary concepts, and the criteria articulated above are minimally necessary to proceed. The state of the art of incorporating environmental criteria is not only complicated by conceptual difficulties, but also by an absence or relative paucity of both the data necessary to assess effects and the dynamic predictive models which employ the data. We are thus left with the need to make difficult judgments, for we must assess the risk of uncertainty of prediction as well as weigh the costs and benefits. The difficulty is compounded by the fact that many environmental judgments do not have to deal with the imperatives of survival, but with differences in values of substance and timing. Thus, poor men may value jobs more than aesthetics and may be willing to make short term gains now and hope to repair the damage later. The guidelines point the way to making these choices consciously, but they cannot make the choices themselves. They are guides rather than absolute prohibitions or assertions of certain fact.
The guidelines following represent an early step in the direction of building experience in environmental assessment. They will, of necessity, need to be subjected to critical review before their structure is more firmly set and they will have to be applied in particular cases to illustrate their meaning and to provide feedback on the conceptual design.
Environmental Guidelines

The following guidelines are applicable from the raw material phase of a project through the construction to the final disposal of the material produced. In this way they reflect the cyclical nature of investment along with expansions and spin-off plants. The definition of guideline steps with examples are:

1. **Natural Resource Linkage**: considerations from extraction or arrival in country to project under evaluation. [Naphtha Cracker]

2. **Process**: analysis of alternative possibilities for both unit operations and chemical conversions. [Copper Extraction]

3. **Site Assimilative Capacity**: present or baseline analysis of air, land and water carrying capacity to determine original conditions and project's effect. [Coal Mine]

4. **Waste Management**: analysis of all outputs including by-products, and wastes for treatment, reuse and assimilation. [Phosphate Fertilizer]

5. **Operation and Control**: maintenance and monitoring of project. (Monitoring includes the air, water, and land from both chemical and biological standpoints.) [Steel Mill]

6. **Social Aspects**: human relations in settlement patterns. [Cement Plant]

7. **Health Aspects**: safety and welfare of population affected by plant. [Sugar Refining]

8. **Final Resting Place**: recycling, reuse and assimilation of product and future products (return to natural resource linkage when possible). [Polyolefins]

Step 1. Natural Resource Linkage: This step includes environmental considerations from the original extraction of the ore or other resource to the time it enters the projected plant. If the material is an import the linkage may start with its arrival in the country. The natural resources would include (a) all organic material such as liquid, solid, and gas fossil fuels and other organics not used for fuel including crude oil; (b) all inorganic ores leading to the fields of fertilizer, ceramics and cements, and other basic chemicals; (c) all metallic ores whether complex or native metal; and (d) all primary and reusable materials including agricultural and marine products for food and industry.

An example of this linkage can be seen in a decision to fund a naphtha cracker to produce feedstock for polyethylene. The linkage would begin with the drilling of a well or with the arrival of the crude at the seaport, go through the refining process to separate the naphtha fraction by distillation, and then follow on to the actual building of the cracker, the project under consideration. The particular problems to be considered in this linkage would be oil spillage, oil storage and transportation, and the refinery operations. The refinery would produce a range of gases, liquids, and solids, of which the naphtha feedstock would be only a small part. Plans for the full range of waste materials should be formulated at the same time.

A sample cost calculation applicable to the extraction of materials through surface mining can be made for open pit uranium mining. The Mullen Corporation has, for example, prepared a system for restructuring the land based on a computer simulation of haul patterns for various pit designs.* This plan includes the layout of the pits and the revegetation of the land at costs ranging from $200 to $360 per acre.

Step 2. Process: This step includes the decisions on basic processes to be used in the projected plant, the source(s) of energy for power and heat, and the supply of air and water. The environmental aspects of any projected plant start with the decision to use a particular process. An environmentally sensitive decision includes a consideration of by-products and wastes and their abilities to be either reused or assimilated. The source of energy considers available materials in the area besides the traditional supplies, whether there be waste gases or liquids, or perhaps tree bark or other solids with potential heat content.

Air and water can be thought of as chemical inputs to the system, their purity after use to be considered as carefully as before use. To ensure more complete materials utilization, the raw materials in each step can be chosen from the possibilities in the area including by-products and wastes which might be available but often are excluded by a centralized designing source. The selection of the process or processes can be made from a collection of all these facts.

Copper extraction suggests an example of an environmentally sensitive decision. Although most copper is extracted from its ore by smelting and then electrolytic refining, there are alternatives. Depending on the particular ore to be processed, there are roast and leach techniques or just leaching itself. The leaching approach avoids the formation of sulfur dioxide and instead produces a waste liquor which can regenerate the leaching solution. This process can provide an alternative to the formation of sulfur dioxide and subsequent production of by-product sulfuric acid by extracting sulfur when this is a more convenient by-product.

A similar line of reasoning can be made for flash smelting. In this process the sulfur dioxide gas will be richer, thus allowing a more profitable operation of a by-product sulfuric acid plant for those cases where there is a sufficient acid market. Oxygen enrichment is another method of increasing the sulfur dioxide content of the off gas and thus increasing the sulfuric acid recovery or allowing the production
of liquid sulfur dioxide, another marketable chemical.

The decision to use one process instead of another is made by considering the by-products as well as the product. In this way, economic gains through reuse or resale of these wastes can be made greater and environmental degradation through waste disposal can be minimized.

By way of example, the Stearns-Roger Corporation has compared four processes of copper extraction: conventional smelting; flash smelting; roast, solvent extraction, electrowin; and roast, electrowin.* Each produces sulfur dioxide, but in varying concentrations. They compared these processes by analyzing operation costs and evaluating freight costs of by-product sulfuric acid, ore concentrates and copper in three geographic regions of the western U.S. There was a range of approximately $12/ton of copper in the four systems for each area: e.g., Arizona showed $83.81 for conventional smelting and $71.70 for roast, electrowin. This type of analysis in a given location can then maximize production of the main product and by-products thus paying for environmental waste control.

Step 3. Site Assimilative Capacity: The purpose of this guideline is to analyze and interpret a proposed site's natural resource characteristics for its ability to sustain an industrial project's environmental impact. It is assumed probable industrial project stresses on the bio-physical environment (scope of impact) will be delineated during the Step 2 project process guideline assessment. Environmental parameters relating to water, land and air should be inventoried and interpreted to identify those implicit and explicit characteristics indicative of project impact/stress on the fragility of the local ecosystem. Direct and indirect effects should be assessed within this guideline framework to ensure least cost in natural resource degradation to the local site as well as direct or indirect effects over time to the regional environment.

Site assimilative capacity should not necessarily be constrained only to the environmental impact of an industrial project. Local and regional natural resource characteristics should be assessed for land use assimilative capacity. Proposed settlement patterns generated by an industrial project should be compatible with the land and its related resource characteristics; e.g., basic infrastructure such as water supply, sewage and solid waste disposal, road layout and design, land stability for housing construction and other land use settlement criteria should be considered as part of the site assimilative capacity guideline.

The choice of site does not only imply constraints, but also opportunities. Through the application of density controls for land use, the costs of abatement technology might be eliminated where the assimilative capacity is not exceeded and standards can be maintained.

A proposed coal mining operation site will be used as an example of site assimilation guideline application. A major environmental pollution problem is created by acid mine drainage occurring when pyrites—iron sulfides usually found in coal deposits—are exposed to air and water. The pyrites—oxidized to sulfuric acid and ferrous sulfate—leach through natural drainage waters and trickle into streams creating major pollution problems. The sulfuric acid not neutralized by receiving waters destroys vegetation, fish and other water biota rendering streams useless for recreation, water and food supply. Therefore, attention should be given to the hydrographic character of groundwater movements and gradients in the vicinity of operations to determine the natural capacity to neutralize drainage waters. Where site conditions might lead to water pollution, alternative abatement tactics should be considered. The alternatives for coal mining include: (1) closing the mine to oxygen after use by filling with an inert substance such as sand or by sealing (This prevents the oxygen from entering in the first place and thus avoids oxidation.), (2) neutralizing the waste liquor after it is formed by means of lime or limestone, (3) treating and recycling the chemicals in the liquor. (There are several techniques for doing this, but they are expensive unless there is a ready market for the chemicals.)
Where a site cannot assimilate any new wastes without destroying desired water use, then a sample cost calculation for staying within the existing capacity can be shown by a water quality program. The Calgon Corporation has incorporated a baseline study such as would be needed for this step with a monitoring and treatment program for Steps 4 and 5 of these guidelines. This combined program can be used to show the costs for effluent control of the milling and mining industry by conducting a comprehensive water flow inventory, water quality study, and limnology study. The Calgon Corporation estimates a capital cost of $790,000 for a 1500 gpm installation with a treatment cost of 13¢ per thousand gallons.* This would provide an organized approach to Steps 3, 4, and 5 for this industry and include maximum recycling.

Step 4. Waste Management: The most important consideration in waste management is that the alternatives be planned to fit with the process or processes and the site. Emphasis can be placed on use of the materials whenever possible, and assimilation back to the natural ecosystem as a last resort. In this way treatment is not the complete pollution solution, rather it is a part of the solution in making the material(s) fit for reuse or for assimilation.

An example can be used for the mineral fluorapatite: CaF$_2$.3Ca$_3$(PO$_4$)$_2$. This material can be acidified to produce a phosphate fertilizer along with two by-products, a fluoride gas and calcium sulfate. The gas can be collected in various forms and sold as is or can be further processed into other marketable materials. The calcium sulfate, likewise, has markets as is, or on further treatment, in other forms.

The Bureau of Mines of the U.S. Department of the Interior has evaluated the comparative profitability of four processes for fluoride gas use: the production of calcium fluoride with silica recovery and without silica recovery and the production of hydrogen fluoride with

calcine recovery and without calcine recovery. Their work shows a profit before taxes in dollars per ton of fluosilicic acid processed ranging from $17.62 to $201.25 depending on the process chosen and the volume. *

Step 5. Operation and Control: The objective of this guideline is to develop and maintain a project administrative framework capable of monitoring a facility within constraints indicated by previous guidelines—especially the performance of process and control devices. As a minimum, staff structuring might include expertise in environmental engineering applicable to the proposed industrial project. Environmental functions include monitoring systems applicable to materials flow from raw material input to final product output to ensure that tolerances are maintained according to design specifications. In-house research and development might be considered to ensure project efficiency and conservation of materials. Data compilation over time can be analyzed to monitor deviation from baseline (starting) conditions and the approaching threat of exceeding thresholds of ecological carrying capacity. An environmental engineering staff can serve in evaluating a change in process technology or industrial project expansion. Where feasible, simulation models can be developed and projected effects analyzed for project efficiency and environmental impact. Project quality control criteria could then include an active assessment of accumulative effects of waste streams.

The wastes from a steel mill depend on the integrated or comprehensive character of the plant. The steps are (1) mining of ore, (2) furnace(s) for conversion of ore to pig iron, (3) furnace(s) for conversion of iron to steel, and (4) finishing of steel by rolling and pickling. They therefore include environmental problems from (1) mining—tailings and dust leading to air, water and land pollution, (2) converting—dusts and gases for air, and possibly water and land, solids for

land, (3) steel making--dusts, gases and solids, and (4) finishing--pickle liquor and oil wastes.

The monitoring would include both chemical and biological activities to identify trends away from the baseline study of the site. This operations group would also include maintenance, monitoring, education for safety and environmental problems, and possibly R and D for future work to assess the impact of expansion.

**Step 6. Social Aspects:** This step previews social implications for the environment generated by industrial project investments. Social aspects, especially of those industrial projects employing a large labor force, influence in-migration of populations thus affecting land use patterns.

Locational requirements attendant to the in-migration of a labor force and its families' impact on land use patterns should be evaluated in the light of available food, water, shelter and accessible transportation systems, based on localized institutions, mores and customs. Medical and other public services should be available or accessible.

The social implications of product output consider effects on local land use patterns, e.g., cement manufacturing's effect on localized construction or a fertilizer plant's influence on agricultural techniques and the attendant changes in social, economic and land use structures. The guideline can consider such broad issues as the desirability of labor intensive technologies to aid in fulfilling employment and income distribution goals. Consideration might also be given to the impact of population movements on rural life.

The impact of cement manufacturing illustrates the social aspects of guideline application. Cement plant location generally will be guided by limestone and other raw material supply, such as sand and clay. Appraisal includes an assessment of the location's ability to sustain human development pressures and attendant land use patterns adjacent to or accessible to the project site. Sufficient water for both cement plant use and human consumption are part of the criteria. Dust
collection control systems could be implemented, especially where a plant is co-located near population concentrations.

Guideline assessments should generally preview the land and its related resources, identifying the ability of the area to sustain development pressures generated by habitation patterns characteristic of local cultural preferences. Attention to these potential problems can lead to desirable social cohesion and minimal social disruption. The effects on the push-pull of urban-rural migrations need attention, for the instabilities of urban life can be aggravated by adding industries to cities where the fixed capital of the infrastructure cannot effectively handle increased population loads and the tax base can tolerate little or no expansion.

Cost calculations of social aspects might include many different aspects: some quantitative, such as the cost of the provision of adequate worker housing; some qualitative, such as cultural change induced by relocating families or social tensions induced by crowded conditions. The assessment of social costs is not a simple engineering assessment and needs to be done in the light of broader qualitative criteria than are traditionally considered in project appraisal. This broadening of the definition of environmental assessment leads to linking project design with overall economic development goals and may or may not be done at the project level. However, specific project design in terms of location and physical layout can be affected by the more qualitative judgments, and attention would be usefully paid to dealing with the social issues somewhere in the appraisal effort.

Step 7. Health Aspects: This step calls attention to the need to monitor and consider maintaining the health and welfare of project employees and local and regional populations adjacent to the project facility. In-house safety procedures can be designed through employee education and clear and concise management policy statements pertaining to operations. Job specifications can be communicated to ensure
efficiency and safety of operations. Product safety hazards, implicit and explicit, should be clearly defined for consumer protection, notably in export industries to countries with high environmental standards. Attention needs to be paid where chemicals, petro-chemicals, fertilizers and other products for consumer use with possible cumulative concentrations have effects on human health and welfare. Pollution vectors—water, land and air transport—should be closed or minimized where local and regional health is affected by the transport of disease.

Public health standards should be set and maintained through regional or local institutions based upon ecological, economic and human susceptibility criteria. Water quality, ambient air, sewage and other waste water, land use and other standards as they relate to human health, can be implemented with appropriate flexibility to prevent environmental conditions capable of sustaining the growth and cumulative concentrations of germs, viruses, particulate matter, toxic chemical emissions, haphazard land disposal of toxic wastes, etc. For instance, air quality criteria are affected where meteorological conditions are conducive to inversions, such as in river valleys which trap emissions with probable effects on human health and welfare; e.g., increased prevalence of chronic bronchitis and emphysema in adults, diminished pulmonary function, increased frequency of common colds and minor respiratory ailments.

A food processing plant, namely a sugar refinery, serves to illustrate some narrow health aspects of guideline application. There must be minimum delay in transporting freshly cut cane to the raw-sugar plants. Failure to process the cane in less than 24 hours after cutting causes loss by inversion into glucose and fructose. Raw-sugar plants and refineries are characterized by unit operations, primarily mechanical, and chemical conversions. The conversion of cane to raw-sugar crystals for bulk shipment to refineries primarily entails crushing, filtering and mixing—unit operations. Employee safety procedures can be enforced to
prevent personnel injury especially during the varied mechanical operations. Plant operations policy statements and safety criteria need to be set for refinery personnel considering the use of conveyors, presses, lime and other chemicals as well as extreme cooking temperatures, e.g., temperatures ranging from 1000 to 2000 F are common in refinery retort operations. Catwalks and other access facilities should be properly maintained at all times.

An attempt to quantify health aspects which simply assesses the economics of worker-days lost through absenteeism, or the costs of medical clinics to provide cures would miss the most important cost of human discomfort. An assessment of this cost would have to be traded off against the illnesses associated with non-productive economies having poor levels of health due to poverty. The net cost calculated on this basis would then be more inclusive, even though it was not associated with dollar value.

Step 8. Final Resting Place: This step is considered in the overall evaluation in a manner similar to the natural resource linkage, in order to complete the natural cycles. Everything ends up someplace, there is no such thing as ultimate disposal. The step can be as complicated as a mercury flow chart locating every gram of the metal, or it can be as general as a paper discussion showing the amount to be recycled into pulp, the amount to be saved, and the amount to be dumped. The step must be included, however, for every disposal technique has a cost associated with it. In some cases, the cost may be high because it is a non-degradable substance, or because it has an intermediary or final product which is toxic. All these costs require evaluation.

A plant producing poly vinyl chloride can serve as an example. This is a non-biodegradable material which is resistant to compaction and large amounts could not be handled in sanitary land fills or compost heaps. Alternative means of disposal such as salvage or high temperature incineration would have to be considered. Not only do the solid, liquid and gaseous wastes from the project itself have to be considered, but the
costs of disposal of the product after use should be included. In the case of polyvinyl chloride, it may necessitate a higher-priced method of disposal.

It is not possible to identify the range of dollar costs precisely because the cost of collection, the cost of the land for disposal and the capacity to recover valuables from generalized waste varies considerably according to the character of materials in an economy.

Step 9. Optimization: The analysis of costs of the various alternatives for protecting environmental values and for protecting natural resources will have to augment traditional costing procedures in order to accomplish overall optimum project design. The previous eight steps have called attention to information requirements which are reviewed in the last step. Choices of industrial processes or choices of techniques for mining and harvesting forest products will all be associated with different costs. There will be considerable variation from project to project in terms of amounts and kinds of costs, and the aim in this guideline is to establish concepts which guide the judgments to be rendered. Environmental cost analysis can be conceived as having two parts. The first deals with who bears the costs and the second deals with determining amounts of costs.

There is already a body of literature on who bears the costs and economists have made a convenient distinction between those internal costs borne by the firm, which may affect the financial rate of return, and those external costs absorbed by the society, which may affect the economic rate of return. Guidelines cannot determine who will bear the costs, for proper assignation of costs is dependent on circumstances which vary from society to society. However, the guidelines do need to consciously examine total costs to avoid overlooking the full range of requirements for project design and evaluation.

It would require a substantial theoretical treatment to examine the alternative modes of assessing costs, for environmental costing
techniques are not as well developed as other economic guidelines in operational memoranda. However, as a general rule, the information gathered in the first eight steps should suffice to bring to mind such factors as public health effects. For example, some of the costs of air pollution from sulfur dioxide levels which exceed the threshold of human tolerances can be noted in terms of man days lost from work as well as public health facilities to effect cures, as well as the qualitative judgment of the tolerability of respiratory illness.

For another example, the costs of river pollution, may be the cost of a water treatment plant downstream to render water potable, or the opportunity cost of using the ecological carrying capacity of the river for a more productive enterprise, or for public recreation, or for tourism or fishing. For another example, forest management techniques used in a pulp mill project might result in erosion and can severely limit the life of a downstream dam through siltation, causing earlier amortization than projected. Erosion can also deny a second use of the land such as agriculture or can deny possible multiple uses of the land which could help defray overhead costs. Forestry cutting procedures create opportunity costs in terms of later benefits to be derived such as satisfying a projected demand for construction materials for public housing.

In each case the costs can be identified from calling attention to the information from the guidelines. Whether these costs are borne by the project or by the society is a matter for discussion and negotiation in each case. It may often be the case that the social benefits from a project will outweigh the social costs so that the net judgment for the project is positive and the assignation of the costs is accepted by the society. Historically, this has often been true, but recent changes in public values and strategies of economic development require a reassessment of the position.

A framework for determining costs will evolve from experience. As was suggested in the introduction, before the environment can be
handled by the tools of economists, it must at least have the characteristics of scarcity, priorities, and alternatives. The guidelines have been designed to satisfy these needs with information bearing on each. Scarcity arises from the fact that environmental assets such as clean water and air, have a limited capacity to absorb materials before they change state. The change of state may be through destruction of water bodies due to excessive nutrients which support plant life in water. The cost may be aesthetic, such as the loss of a lake, or it can be directly economic for such water chokes intake filters and cooling mechanisms of machinery. The change of state is due to the scarcity of carrying capacity for pollutants which represent materials outside of natural cyclical patterns. Such scarcity is the reason why the guidelines have called attention to monitoring and standard setting in order to know how much room for assimilation of materials is left before adverse changes of state must be borne. This scarcity of assimilative or carrying capacity also has led to emphasis on recycling and efficient use of natural resources in Steps 1, 2, 3 and 8.

Nature is constantly changing state, with or without the intervention of man, but industrial activity can hasten these changes and can send them in unfavorable directions with resulting counterproductive costs. That is why priorities need to be established. Whether or not changes of natural state are tolerable depends on priorities in economic development strategy. Global survival may take first place and environmental damage which threatens man as a species would therefore be intolerable. However, the evidence that survival is at stake needs further development and anything less than that is a relative matter subject to ordering of priorities. Thus, whether or not developing countries want to repeat the public health costs borne by the developed countries is a matter of priorities and trade-offs. The guidelines will indicate what the costs are, but how they are weighed is a relative matter. Economic development includes a mixed set of goals and the values of the environment impinge on many of them.
In the sense that other non-economic decisions are taken as parameters by growth economists, the environment is no different than employment goals, or income distribution goals, or political stability. The qualitative mix of economic development priorities will just include one more element. This element will have to seek its place in the priority schemes of planners, for allocating assets for the future is their task.

To help determine the place of the priorities for environmental and resource protection, alternative solutions have to be sought. One of the major alternatives which may be open to project designers is time. One can mortgage the environmental future by destroying now and cleaning up later. This argument will have much currency in that it is the path which developed countries have taken. However, cost analysis will have to include some assessment of how much time is available before diseconomies set in and how much the cost of reversibility will be. In some cases reversibility will be so costly, or biologically impossible, that there will be no choice. The guidelines for site assimilative capacity in Step 3 include information on threshold values and the possibility of reversibility. The loss of a species is currently irreversible; however, whether or not the irreversibility is serious depends on how valuable that species is in a larger ecosystem and that is a matter of weighing priorities.

There are other alternatives besides time. Process selection as indicated in Step 2 is specifically designed to evaluate alternative methods of achieving the economic goals without incurring costs which must be paid, now or in the future. There are different techniques for foresting on slopes which will forestall erosion and avoid costs. Once again, however, whether or not the costs are deemed to be serious or are outweighed by the benefits, as indicated in pricing mechanisms is a matter of relative priorities which need to be articulated.
In sum, nature has scarcity built in. The free goods of air and water are no longer free when they reach a threshold condition which leads to a change of state and an inability to carry on previous functions. Assessing the meaning of scarcity is a matter of priorities and these priorities will indicate which alternatives are to be favored. Within this structure it is possible to deal with the environment with the tools of economics. Carrying capacity is a quantifiable concept and the space remaining between present and desired state is finite. Within the limits of our basic knowledge this measurable space can be assigned for partial uses. The function of planning is to assign these uses according to the priorities of development strategies. Whether the priorities include open space amenities for human settlements or whether the priorities call for maximum utilization now with renewal later are all part of the parameters in which the economics of the environment will work. The guidelines can indicate the consequences of choice but the acceptance or rejection of the consequences is a matter of policy which lies outside of the guidelines built to help in the ultimate policy decision. The diagram following (Figure 1) summarizes the ninth step, optimization in the procedure of guideline application from initial to modified project design.

Section Summary

The environmental guidelines for project appraisal include a broad array of concerns designed to assess costs leading to impairment of future productivity of a country's natural resource base and the side effects of investments. As indicated in the nine steps of analysis, the impact of investments on the human environment requires a systematic and integrated view of projects which links them to materials flow within production processes and throughout the economy and society. This widening of the scope of concern is justified because incremental change in particular cases has led to a broader impact.
Figure 1. OPTIMIZATION PROCEDURE

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Proceeding through the nine steps from natural resource linkage to optimization calls attention to the interrelation of choice of process with recycling and reuse potential, of plant location with urbanization issues, of waste management with process design, and other such connections which make the integrated project design sensitive to environmental needs.

There will be considerable variation of opportunity to make an integrated appraisal for there is variation in the degree and timing involvement by the economic development institution. There will be variation in economics, natural conditions, and interests in the issues addressed. Over time, it is increasingly likely that the full range of interests expressed here, and perhaps others, will play a significant role. The following outline of environmentally sensitive target areas in current industrial projects lending is intended to call attention to relevant factors. From the list of these factors a check list can be derived which is specifically tailored to particular projects and the environments of each country.
OUTLINE OF ENVIRONMENTALLY SENSITIVE TARGETS IN GUIDELINE STEPS

REFINERY

1. Natural Resource Linkage: Pipeline transport
   Tanker transport
   Storage facilities
   Oilspill safeguards

2. Process: Analysis of alternatives in both unit operations and chemical conversions to minimize: air, water and solid wastes; and noise and thermal pollutants
   Energy source selection

3. Site Assimilative Capacity: Hydrologic, geologic, seismologic and meteorologic studies to identify present conditions of land, air, water

4. Waste Management: Qualitative and quantitative identification of wastes
   Control technology for wastes
   Segregation of wastes for treatment, reuse, assimilation
   Thermal pollution control
   Sewerage

5. Operation and Control: Maintenance
   Monitoring of effluents
   Contingency plans
   Expansion plans

6. Social Aspects: Population needs
   Buffer zones
   Greenbelt areas
   Odor control

7. Health Aspects: Safety and health protection plans
   Lighting standards
   Noise evaluation

8. Final Resting Place: Disposition of product(s)
   Reuse potential

9. Optimization: Integration of choices within steps

Intra-Bank Communications: Area Programs
   Transportation
   Special Projects
   Tourism
   Utilities
1. Natural Resource Linkage: Logging with reforestation plan
   To minimize climatic changes, land erosion
   Debarking and Chipping
   Transport
   Storage
   To minimize pollutants

2. Process: Analysis of alternatives in both unit operations and
   chemical conversions to minimize: air, water and solid
   wastes; and noise and thermal pollutants
   Inclusion of chemical, semi-chemical, mechanical
   processes in analysis
   Energy sources including bark

3. Site Assimilative Capacity: Hydrologic, geologic, seismologic
   meteorologic studies to identify present
   conditions of land, air, water

4. Waste Management: Qualitative and quantitative identification of wastes
   Segregation of wastes for treatment, reuse, assimilation
   Control technology for wastes
   Sewerage

5. Operation and Control: Maintenance
   Monitoring of effluents
   Contingency plans
   Expansion plans

6. Social Aspects: Settlement of population
   Buffer zones
   Odor control

7. Health Aspects: Safety and health protection plans
   Noise evaluation

8. Final Resting Place: Disposition of pulp and paper goods
   Reuse potential
   Return to Natural Resource Linkage

9. Optimization: Integration of choices within steps

Intra-Bank Communications: Agriculture Special Projects
                        Area Programs Transportation
                        Utilities

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FERTILIZER PLANT

1. Natural Resource Linkage: Land reclamation plan
   - Mining operations
   - Beneficiation (ore enrichment)
   - Transport
   - Storage
   To minimize pollutants

2. Process: Analysis of alternatives in both unit operations and
   chemical conversions to minimize: air, water and
   solid wastes; and noise and thermal pollutants
   - Energy sources

3. Site Assimilative Capacity: Hydrologic, geologic, seismologic
   and meteorologic studies to identify
   present conditions of land, air
   and water, including noise and heat

4. Waste Management: Qualitative and quantitative identification
   of wastes
   - Segregation of wastes for treatment, reuse,
     assimilation
   - Control technology for wastes
   - Sewerage

5. Operation and Control: Maintenance
   - Monitoring of effluents
   - Contingency plans
   - Expansion plans

6. Social Aspects: Resettlement of population
   - Buffer zones
   - Greenbelt areas

7. Health Aspects: Safety and health plans
   - Noise evaluation

8. Final Resting Place: Disposition of product(s)

9. Optimization: Integration of choices within steps

Intra-Bank Communications: Agriculture
   - Transportation
   - Area Programs  Tourism
   - Special Projects  Utilities

9-24
SMELTER

1. Natural Resource Linkage: Land reclamation plan
   - Mining operations
   - Beneficiation (ore enrichment)
   - Transport
   - Storage
   To minimize pollutants

2. Process: Analysis of alternatives in both unit operations and
   chemical conversions to minimize: air, water, and
   solid wastes; and noise and thermal pollutants
   - Energy sources

3. Site Assimilative Capacity: Hydrologic, geologic, seismologic
   and meteorologic studies to identify
   present conditions of land, air and
   water

4. Waste Management: Qualitative and quantitative identification
   of wastes
   - Segregation of wastes for treatment, reuse,
     assimilation
   - Control technology for wastes
   - Sewerage

5. Operation and Control: Maintenance
   - Monitoring of effluents
   - Contingency plans
   - Expansion plans

6. Social Aspects: Resettlement of population
   - Buffer zones
   - Greenbelt areas

7. Health Aspects: Safety and health plans

8. Final Resting Place: Disposition of product(s)
   - Reuse potential
   - Return to Natural Resources Linkage

9. Optimization: Integration of choices within steps

Intra-Bank Communications: Agriculture
   - Transportation
   Area Programs
   - Tourism
   Special Projects
   - Utilities

9-25
III TRANSPORTATION

1. Airports
2. Ports and Harbors
3. Roads and Highways
1. AIRPORTS

A. Environmental/Resource Linkages

- How will airport construction or expansion and attendant operations affect local residents and plant and animal life of the area?
- To what extent will the natural habitat of valuable species of fish and wildlife be affected?
- How can any such losses be mitigated?
- What effects will the airport and related uses of adjacent land have on the water table in the area?
- How will regional water drainage patterns be affected?
- Will increased water runoff resulting from heavy rain or snow clog sewerage systems or drainage ditches?
- Will the disruption of natural water and drainage patterns complicate the operation of public water or sewer systems?

B. Project Design and Construction

- Are road patterns, land excavations, fill sites, refuse disposal activities, etc., planned to minimize damage to the natural environment?
- Will topsoil be stored for resspreading?
- What provisions have been made for restoring scarred sections of the construction area by filling, grading, and reseeding to prevent erosion?
- Can health levels of construction personnel be protected?
C. Operations

- What disposition will be made of airport wastes, including sewage, petroleum and solid wastes?
- If dumped into ground "sinks", will wastes percolate into wells or aquifers?
- Will surface disposal degrade streams, marshes, etc., due to leaching and runoff?
- Have monitoring criteria been established for key variables?
- How will waste disposal be monitored?
- What levels of noise can be expected from aircraft operations?
- How will this impact increase if the airport eventually expands?
- How can the disruptive effects of aircraft noise on local residents, schools, hospitals, offices, etc., be held to acceptable levels?

D. Socio-cultural Factors

- Will the management of historical, religious, geological, or archaeological sites and artifacts be provided for protection or preservation?
- What provisions have been made for resettlement in adequate housing of residents displaced by the development?
E. Health Impacts

- Will monitoring of and controls for possible foreign disease vectors be implemented?
- Has a plan for controlling the introduction of animal and plant diseases been prepared?
- Have plans been made for the management and control of airport sanitation?

F. Long-Term Considerations

- Even though not directly pre-emptive, is the airport likely to attract industry and housing to adjacent areas which possess unique and valuable ecological features?
- What impact would such developments have on the natural environment?
- What future projects have been planned for the area and how will they interact with environmental factors?
2. PORTS AND HARBORS

A. Environmental/Resource Linkages

- What modifications of the landscape, waterways, and offshore geology will result from the development?
- Will these changes adversely affect fish and wildlife resources? If so, what measures are planned to mitigate the impact?
- What impact will the changes have on existing or projected sewerage or waste-disposal systems?
- Will stagnant pools develop to trap pollutants?
- Will stream discharge patterns be adversely affected?
- Is the project part of a coherent plan for the development of the region?

B. Project Design and Construction

- What are the pre-development coastal or waterway sedimentation patterns?
- How will wave and current action be modified?
- Will the development interrupt sediment transport needed to replenish adjacent beach areas?
- Might induced tidal wash and currents cause beach and coastal erosion?
- If the development is on a river, what may the impact be on the upstream and downstream environment?
C. Operations

- What cargoes are likely to be handled and what are the potential dangers to the environment from deliberate or accidental spills or dumping?
- Have accident contingency plans been formulated?
- Are measures available to handle emergencies or accidents (spills, collisions, etc.)?
- What safeguards and contingency plans will be available to contain and clean up hazardous chemicals and oils, slops, or wastes of normal operations?
- To what extent will land-filling and dredging operations be necessary?
- How will dredged spoils be disposed of and with what ecological impacts?
- Will ships and industrial development create significant air pollution from stacks in view of prevailing winds?
- How will ship and harbor sewage and other effluents be handled?

D. Socio-cultural Factors

- What consideration has been given to providing adequate housing for the population increase that will accompany port development: to land use planning, zoning, etc.; for anticipated industrial development; and to essential community services such as sewage and transportation facilities?
Will port construction or operations adversely affect local cultural or economic values, such as scenic beauty, local fishing and other economic enterprises?

Have steps been taken to provide for possible population influxes?

Will historical, religious, archaeological, and geological artifacts be preserved?

E. Health Impacts

Will air or water pollution associated with the port adversely affect local workers or adjacent populations?

Will water supplies and sewage treatment facilities be adequate to meet increasing demands?

Will health care services be adjusted to fit new requirements?

Have plans been formulated for protecting humans, animals, and plants from the introduction of diseases and for controlling these diseases?

F. Long-Term Considerations

Have the environmental consequences of future area projects been considered in the design and operation of port facilities?
3. ROADS AND HIGHWAYS

A. Environmental/Resource Linkages

- Will environmental criteria be incorporated into the selection of the road or highway route?

- Are the character, quality, and major components of the affected ecosystems known?

- Will access provided by the road open unsettled or previously inaccessible areas to human, animal, or plant communities?

- Will the road's impact on agricultural, industrial, commercial, or other urban land-use patterns be considered?

- Does the project complement land-use patterns developed for urban or regional programs?

- Will the road have adverse effects on important domestic livestock, wildlife, or vegetation?

- Will wildlife migration routes be disturbed?

- Will squatter settlements along the highway route be controlled?

B. Design and Construction

- Is there a consolidated construction plan for the project that takes into account ecological factors?

- Are forest conservation principles being incorporated into design and construction activities in forested areas?

- Will natural drainage patterns be unnecessarily disturbed?
Do plans include provisions for preventing despoilment of the landscape and vegetation during construction?

Will clearing, grubbing, and burning be limited to the extent practicable?

Will the size and number of quarry, barrow, and disposal sites be controlled?

Will topsoil be stored for respreading?

Will soil stabilization measures be taken during construction to minimize damage, e.g., slope reseeding to prevent erosion by wind or water?

Do plans include provisions for preventing water pollution by spillage and runoff during construction or during use of roadway?

Will water impoundments create health hazards?

Will wastes from machinery, asphalt and concrete plants, construction camps and shops be controlled to prevent water pollution?

Will air pollution by smoke, fumes, and sprays originating from construction operations be a problem?

Will air pollution by dust from unsurfaced roads or construction operations have a deleterious effect on the environment or on human welfare?

Does the roadway traverse a scenic area. If so, are steps being taken to protect and/or enhance areas of aesthetic and tourist value?

If a large work force is to be assembled from various locations, is provision being made for a pre-employment medical screening and periodic examination of employees to prevent introduction of new diseases and/or further distribution of endemic diseases?

C. Operations

Will the road serve purposes other than transportation?
Will road shoulders and aprons provide space for strip urbanization or vendors?

Will heavy traffic produce congestion, pollution or noise with adverse consequences to surrounding human, animal or plant communities?

Will traffic preempt or disrupt use of agricultural land?

Will there be an adverse effect on habitat and migration of wildlife?

Will facilities be available to monitor circulation and impact of traffic and new access upon important elements of ecosystems - population settlements, migration patterns, diseases, surface water and erosion?

What will be the environmental effects of herbicides and pesticides if they are used?

**D. Socio-cultural Factors**

Will the roadway disrupt the existing cultures, or impact on archaeological sites or other unique resources?

Has provision been made for adequate living conditions for populations that are displaced by construction activity and for populations that are attracted to newly opened areas?

**E. Health Impacts**

Will the roadway and related construction activity open up new pathways for disease vectors affecting humans, plants, or animals (e.g., hoof and mouth disease).
F. Long-Term Considerations

- Has the project been examined for ecological and environmental effects in the context of local and regional plans for development?

- Have the effects of future highway or transport development on the ecology of the area been considered?
IV UTILITIES

1. Dams
2. Power Plants
3. Sewerage and Sewage Treatment Plants
1. Dams

A. Environmental/Resource Linkages

- Have alternatives to the dam been fully considered? Is the dam's presence and operation, including the impoundment, compatible with present or planned development of the region?
- Is it a multipurpose dam? If not, could it be made multipurpose through modification?
- Will important resources be lost or their use precluded because of the dam's presence or operation? Does the dam offer opportunities for enhancing the environment through planned modifications in design or operating regimes?
- Will new settlements and/or cultivation of reservoir slopes cause erosion and premature silting up of the impoundment?
- Will alteration of the water regime (e.g., seasonal flooding, etc.) have important environmental or human ecologic implications?
- Will aquatic weeds and the introduction or exasperation of diseases constitute formidable and costly problems?
- What is the nature and magnitude of the human resettlement problems? Are there adequate resources to carry it out in a manner minimally disruptive of the well-being of the affected peoples?
- Will new public health problems arise as a result of the project?
- Will important historic, religious, archaeological, or geological sites be inundated?
- Will the operation of the dam effect the interests of nation(s) downstream and has it been consulted?
B. Design and Construction

- Will the design allow for the movement of important migratory fish populations?
- Will the dam construction activities be carried out in a manner that will minimize erosion and other damage to the environment?
- Are road patterns, land excavations, fill sites, and refuse disposal activities consistent with good environmental protection practices?
- Will land in construction areas be restored by filling, grading, reseeding and reforested to prevent erosion and erase scars?
- Will trees and vegetation be removed from the impoundment area to minimize the introduction of aquatic weeds and to improve the habitat for an exploitable fishery?
- Will control of disease vectors be carried out during the construction period?

C. Operations

- Can the operating regime be made to benefit fish and wildlife resources wherever possible?
- How fast will siltation occur and how can it best be handled?
- How will aquatic weeds be controlled?
- Will there be undesirable interactions between the altered surface water patterns and underground aquifers and their recharge?
- What physical and biological alterations can be expected to take place in downstream, estuarine, and ultimate discharge areas?
Can changes in water salinity be expected and how will this be handled?

Will new settlements and cultivated areas contribute sediment and pollutants to the impoundment, including fertilizer and pesticide runoff? How will this be controlled?

Will land use planning, zoning, and other measures be employed to protect the watershed area from practices and activities detrimental to the project?

Will important wildlife forms be salvaged and re-located?

D. Socio-cultural Factors

What will be the human ecological consequences of changes in land use and economic activities, population redistribution, influx of migrants, and changes in life styles and traditional living patterns?

Have resettlement plans had the benefit of social scientists and anthropologists? Are such plans in keeping with the socio-cultural needs of the affected peoples? Will the new settlements have adequate provisions for sanitation, disease control, and health care services?

Will measures be taken to control squatting on riparian lands and undesirable crowding around the periphery?

Will religious and historic sites and artifacts important to local peoples be salvaged and preserved?

E. Health Impacts

What types of health problems will arise and how will they be controlled?

Will the work force, including families, be given a pre-employment medical screening to prevent the introduction of new diseases? Will they receive periodic examinations to detect diseases and parasitism, and to receive clinical treatment? Will arrangements be made with local health authorities to control venereal disease and enforce environmental sanitation standards?
F. Long-Term Considerations

- Will contingency resources be available to cope with unforeseen or unexpected environmental and health problems?

- Will any provision be made for follow-up studies of the environmental and human ecologic consequences of the project?
2. POWER PLANTS
(FOSSIL FUELED, NUCLEAR FUELED AND HYDROELECTRIC)

A. Environmental/Resource Linkages

- What site selection criteria will be used?
- Will they include environmental considerations such as effects on air and water quality, and the resulting impact on residents of the area, fish, wildlife and vegetation?
- Will alternative sites and alternative orientation of the plant be considered in order to minimize adverse environmental impacts?
- Does the site correspond to other local or regional development and land-use plans?
- Have the environmental consequences of power transmission and fuel storage been considered in site selection?

B. Project Design and Construction

- Will the power plant construction activities be carried out in a manner that will minimize damage to the natural environment?
- Is there a consolidated construction plan that takes into account spatial planning and ecological factors?
- Are road patterns, land-excavations, fill sites and refuse-disposal activities consistent with good environmental protection practices?
- Will land in construction areas be restored by filling, grading and reseeding to prevent erosion?
Will air pollution be a problem and, if so, how will it be controlled?

How vulnerable is the power plant to surface subsidence, earthquakes, tornadoes, and other catastrophes?

What is the extent and impact of the environmental degradation which could be expected in the event of such catastrophes?

What steps are planned to avoid soil erosion and the silting of streams as transmission facilities and access roads are constructed?

C. Operations

What disposition will be made of solid and liquid residues (e.g., ashes, nuclear wastes)?

How will fuel be stored?

Are low-sulphur fuels available for fossil plants?

Have alternative fuel schedules been developed?

Does the disposal or storage method include adequate cassetting or neutralization to minimize the danger of soil or water pollution?

What steps are planned to contain and reclaim ash dumps to avoid pollution of surface and ground water by acid-laden runoff?

If waste disposal into water bodies is planned, what will be the effects on aquatic life?

To what degree will tidal action and currents dilute plant effluents?

What provision will be made for controlling the release of radioactive waste material into water bodies?

If additional units are constructed, what will the total load of radioactive waste materials be?

Is the makeup of the plant's gaseous emissions known in terms of chemistry and volume?
What downwind environmental effects can be anticipated with respect to humans, crops, forests, and wildlife?

How can such effects be minimized?

Will emissions control equipment be installed? If so, is the level of control adequate?

What impact will thermal effluents have on the receiving waters?

What temperature increase can be anticipated and how will this affect indigenous biota?

Is there sufficient water motion in the receiving bodies to dissipate heat effectively?

Has the use of cooling towers or ponds been sufficiently explored?

What is the probability of producing undesirable fog conditions through the dissipation of waste heat?

What impact will the impoundment for a hydroelectric plant have in terms of the destruction of agricultural and forest lands and habitats for fish and wildlife?

What measures are planned to mitigate the loss of natural habitats for fish and wildlife?

To what degree will archaeological and scenic values be affected?

How will the reservoir and downstream flow affect water quality parameters such as temperature, dissolved oxygen, nutrients, nitrogen concentration, hydrogen sulfide, and color? (See also environmental considerations for dam construction.)

D. Socio-cultural Factors

Will construction or operation of the plan adversely affect agricultural, economic or commercial practices in the area such as farming or access ways in a reservoir impoundment area?
Will plant construction cause displacement of peoples because of flooding, required rights-of-way or because of new opportunities?

Will plant effluent adversely affect agriculture, aquaculture, or related practices?

E. Health Impacts

What new public health problems may arise from the project?

Will changes in water velocities, temperatures, and depth result in a more favorable environment for disease-bearing organisms?

Will the changes in water patterns introduce disease-bearing organisms into previously unaffected areas?

Will long-term exposure to gaseous emissions prove a significant health problem?

Are contingency resources available to deal with unexpected problems of health maintenance or disease control? In the case of nuclear power plants is there a contingency plan for dealing with emergency health problems and accidents in the event of an emergency?

F. Long-Term Considerations

What provision has been made for industrial development associated with the power plant?

What impact due to increased immigration will that activity have on the environment?
3. SEWERAGE AND SEWAGE TREATMENT

A. Environment/Resource Linkages

- Will site selection and choice of available technology include environmental considerations such as effects on water quality and resulting impact on residents of the area, fish, wildlife and vegetation?
- Will alternative sites and alternative orientations on the selected site be considered?
- Have potential recycling schemes to use water for irrigation or industrial cooling purposes or sludge for fertilizer been considered in the project?
- Has the plant been designed to serve as a regional resource with thought given to expansion?

B. Project Design and Construction

- Will the project provide a system for domestic and industrial wastes separate from that for storm water? If separate systems are provided, what provision has been made for storm water drainage? If combined, what effects can be anticipated if the system overloads?
- Can the system be economically designed to accommodate or eliminate overloading problems, perhaps with storage or pumping or by separating the sewage and storm water components?
- Will the sewer system create new health problems by transporting and concentrating wastes at new locations?
- What effects will the sewage system have on water supply sources?
Is there a consolidated construction plan for the plant that takes into account urban plans as well as ecological factors?

Are road patterns, land excavations, fill sites, refuse disposal, etc., planned to minimize damage to the natural environment?

What provisions have been made for restoring scarred sections of the construction area by filling, grading, and reseeding to prevent erosion?

C. Operations

Will gases, odors, insects, and disease vectors be a problem?

What types of waste treatment equipment, (e.g., incinerators or digesters) are proposed that might cause air pollution problems?

Are adequate air pollution controls provided?

What type of sewage will the plant process - domestic, industrial, mixed? What percentage of the waste in each category will be processed and how effective will the treatment be for each type?

What type of toxic materials can be expected in raw sewage inputs, e.g., heavy metals, oils, hydrocarbons, other chemical compounds?

Will the plant be designed to remove toxic materials?

What sewage ordinances are provided to protect the system and personnel from explosives and other dangerous material?

What provisions have been made for the effective monitoring of plant effluents?

What are the present and projected uses of the waterways into which the project effluent will be discharged?

Will the level of treatment provided be compatible with the present and projected uses of the receiving waters?
Will sewage outfalls create additive or synergistic effects?

What effect will the effluent have on the dissolved oxygen regimen of the receiving waters?

What effects will the effluent have on the aquatic biota in the vicinity of the plant and downstream?

Have seasonal variations in water flow and temperature and water levels been considered?

Is thermal pollution of the waterway an associated problem?

What provisions have been made for training and professional, technical and operating manpower in the environmental aspects of the system operation?

What types of maintenance will be required? Will funds be available?

Is jurisdictional responsibility clearly established to ensure the operation of the system in a manner that will protect or enhance the environment?

D. Socio-cultural Factors

Has the site for the sewage treatment plant been selected to minimize impact on important cultural assets or on land use and economic activities of local residents?

E. Health Impacts

How will waterborne diseases and vectors be controlled?

What effect will the location of outfalls have on domestic and agricultural uses of the water courses?

Will the effluent be satisfactorily disinfected?

What provision has been made for the disposal of sludge in a manner that will not adversely affect public health and welfare or the environment?
F. Long-Term Considerations

Is the project designed so that future plant expansion can be accomplished in a manner consistent with the protection of the environment?
V  STANDARDS
V. STANDARDS

There is growing evidence that man's unrestrained and undirected manipulation of the natural world at today's expanding geometric rate can only bring disaster. Either we reduce the scale of our intervention, or we manage it so the cumulative impact is tolerable, even beneficial to man and society.*

In an effort to provide effective management of the environment, many countries of the world have implemented procedures for maintaining environmental quality. Two approaches have been employed. The first approach places a limit on the amount of a contaminant that an activity or facility of a given size can emit. The second approach restricts the level of the ambient concentration of a contaminant. Of the two approaches the latter, or quality standard, is the least enforceable. However, the former or emission standard, while easier to enforce, represents an insufficient condition in itself for preserving environmental quality. Only full consideration of both standards is adequate to protect and maintain environmental quality. The following discussion considers existing standards for both air and water quality. It is reproduced with permission of the publisher, McGraw-Hill Book Company, New York City, from Chapter 4 of the reference text Industrial Pollution Control Handbook edited by H. F. Lund, Copyright (c) 1971. The chapter is entitled Air and Water Pollution Quality Standards, Part 1: Air Pollution Standards by Arthur C. Stern; Part 2: Water Quality Criteria and Standards for Industrial Effluents by Robert M. Santaniello.

* Maurice Strong, Secretary-General, United Nations Conference on the Human Environment.
Part 1: Air Pollution Standards

An air quality standard says, "The concentration of a pollutant in the atmosphere at the point of measurement shall not be greater than some specified amount."

An emission standard says, "The amount of a pollutant emitted from a specific source shall not be greater than some specified amount." The amount may be expressed as a concentration in the effluent gases or as a total amount regardless of concentration in the effluent gases.

In general an air quality standard is developed by formally or informally considering air quality criteria, which are compilations of effects associated with various concentrations and durations of exposure of pollutants, plus other factors, such as cost and technological feasibility of emission control, and social questions.

An air quality standard is generally not enforceable as such. Standards which attribute to a source the decrease in air quality at the boundary of the land surrounding the source, and limit the emission from the source on this basis, are emission standards, even though stated in terms of air quality. Air quality is brought to the air quality standard by the enforcement of emission standards, by land use planning and zoning standards, and by limitations on minimum stack height and fuel composition.

Although land use planning and zoning standards will not be further discussed in this chapter, they are useful means of air pollution control. Included in this category are standards relating to streets, roads, parks, open space, transportation, structures, etc.
AIR QUALITY STANDARDS
United States

In the United States the Clean Air Act requires that the Secretary of Health, Education and Welfare designate air quality control regions, which may be intra- or interstate, and that the individual states adopt air quality standards for each air quality control region so designated by the Secretary. When a state fails to adopt an air quality standard for a designated air quality control region within the prescribed time interval after receipt from the Secretary of Health, Education and Welfare of air quality criteria for a pollutant and documentation of the control technology applicable thereto, or adopts a standard or a plan for its implementation which the Secretary finds to be inadequate, the Secretary may propose the standard for the designated air quality control region in the state. When a state finds the standard proposed by the Secretary unacceptable, approval or modification of the standard is then recommended to the Secretary by a board composed of five or more persons appointed by the Secretary, after such board has held appropriate hearings.

Although no state is required to adopt an air quality standard for any pollutant for which the Secretary has not yet issued air quality criteria and documentation of applicable control technology or for any area of the state not designated by the Secretary as an air quality control region, there is no prohibition in the act which would prevent a state from adopting air quality standards for substances on which the Secretary had not yet so acted and for areas of the state not so designated. There is, however, the presumption in the law that an air quality standard for a pollutant, adopted by a state, as applicable to the state as a whole, or to an area of the state including all or part of a designated air quality control region, prior to its receipt from the Secretary of air quality criteria and documentation of applicable
control technology for that pollutant, must be submitted to the Secretary for his approval within the prescribed time period after the Secretary has made such issuance.

As of the effective date of the latest amendments to the Clean Air Act, Nov. 21, 1967, the Secretary had previously (March, 1967) published air quality criteria for only one class of pollutants - the sulfur oxides. The law required that this document be reevaluated before formal issuance to the states. The air quality standards which have been adopted by the several States to date are given in Tables 1A, 1B, and 1C.

U.S.S.R.

In the U.S.S.R., air quality standards are promulgated by the Federal Ministry of Public Health on the basis of recommendations made to it by a permanent expert committee which also has the responsibility for seeing to it that the research necessary for the development of recommendations is undertaken in appropriate institutes. In general, U.S.S.R. air quality standards represent the lowest pollutant concentrations at which a response to a standardized battery of tests was evoked in man or in test animals. There is an a priori assumption that such a response is adverse and therefore is to be avoided. This procedure and philosophy lead to air quality standards considerably lower than in other countries where (1) a larger number of criteria are considered than in the U.S.S.R. and (2) the definition of an adverse response differs. U.S.S.R. air quality standards are for 24-hr. and instantaneous exposure, the latter generally interpreted as the shortest averaging time of the air sampling and analysis techniques utilized, which, for most substances, is about 20 min. (Table 2). An important feature of the U.S.S.R. standards are the rules for the combined effect of several pollutants. Some of the other eastern European member states of the Council for Mutual Economic Aid make official use of these U.S.S.R. air quality standards.
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*8 hr average time value not to be exceeded more than 15% of the time in a year.
1 hr average time value not to be exceeded more than 1% of the time in a year.
* St. Louis metropolitan area.
* Not to be exceeded over twice a year.
* Not to be exceeded more than twice in any 5 consecutive days.
* Not to be exceeded more than 1% of the time in any 3 months.
* 95th percentile (annual basis).
* Geometric mean (50th percentile) (annual basis).
* Not to be exceeded over 1 day in any 3-month period.
* Not to be exceeded more than once in any 90 days.
* Not to be exceeded more than once in any 4 days.
* Not to be exceeded more than once in any 8 hr.
* Not to be exceeded more than once in any 4 consecutive days.
* Not to be exceeded more than 1 hr in any 4 consecutive days.
* Not to be exceeded more than 1% of the time in any year in certain specified geographic regions.
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<td></td>
<td>Pennsylvania</td>
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<td></td>
<td>0.005</td>
<td>30 days</td>
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<tr>
<td>Sulfates:</td>
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<td>0.01</td>
<td></td>
<td>0.004</td>
<td>1 year</td>
<td></td>
</tr>
<tr>
<td>(as H₂SO₄)</td>
<td>Missouri</td>
<td>0.004</td>
<td></td>
<td>0.004</td>
<td>1 year</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Montana</td>
<td>0.012</td>
<td></td>
<td>0.004</td>
<td>1 year</td>
<td></td>
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<tr>
<td>Sulfuric acid</td>
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<td>0.012</td>
<td></td>
<td>0.012</td>
<td>30 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Montana</td>
<td>0.03</td>
<td></td>
<td>0.004</td>
<td>1 year</td>
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<td>0.012</td>
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<td>0.075</td>
<td></td>
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<td></td>
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<td>All</td>
<td>0.15</td>
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<td>0.12</td>
<td></td>
<td>0.04</td>
<td>30 days</td>
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<tr>
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<td>Oregon:</td>
<td>Industrial</td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>0.2</td>
<td></td>
<td></td>
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<tr>
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<td>Pennsylvania:</td>
<td>0.25</td>
<td></td>
<td>0.15</td>
<td></td>
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<td></td>
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<td>0.025</td>
<td></td>
<td>0.025</td>
<td>16 min</td>
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</tr>
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<td></td>
<td>South Carolina</td>
<td>0.025</td>
<td></td>
<td>0.025</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Texas:</td>
<td>Residential</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td>Industrial</td>
<td>0.15</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* At any point beyond the property on which the source thereof is located.
* Above normal background concentration.
* Tentative.
* St. Louis metropolitan area.
* Not to be exceeded over 1 percent of the time.
* Not more than once in any 90 days.
* Not more than twice in any 48 hr.
* This value appears elsewhere as the hourly average not to be exceeded over 1 percent of the time.
* Not to be exceeded more than 1 percent of the days in a year.
* The regulations are intended as a rate, and consequently 24 hr, 1 hr, or 1 min averaging time can be used.
* Based on results from geographically uniformly spaced sampling stations.
* From a source near ground level other than a flue.
* Not to be exceeded more than 10 percent of the days in a month.
* Vacant, range, or agricultural land, except within 100 ft of a residence.
* Geometric mean (50th percentile) (annual basis).
* 95th percentile (annual basis).
TABLE 1C  State Air Quality Standards for Deposited Particulate Matter (U.S.A.)

<table>
<thead>
<tr>
<th>State</th>
<th>Area</th>
<th>Tons/sq mi/month</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Missouri</td>
<td>Nonindustrial</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heavy industrial</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Montana</td>
<td>Residential</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heavy industrial</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Oregon</td>
<td>Residential-commercial</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Virginia</td>
<td>Residential-commercial</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>Any</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Air basin</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emission standard</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mg/sq cm/month</th>
</tr>
</thead>
</table>

* In St. Louis metropolitan area, 3 months average above 5 tons/sq mi/month background.
* Includes 5 tons/sq mi/month background.
* Above normal background concentration.
* Not to be exceeded as the average of three successive sampling periods.
* Based on results from geographically uniformly spaced sampling stations.
* At any point beyond the property on which the source thereof is located.

Poland

The air quality standards officially adopted in Poland are listed in Table 3.

West Germany

In West Germany there are both official (Table 4) and quasi-official (Table 5) air quality standards. The quasi-official standards are those adopted by the Kommission Reinhaltung der Luft (Clean Air Commission) of the Verein Deutscher Ingenieure (VDI—German Society of Engineers), which comprises task groups representing industry, government, and academic institutions.

Other Countries

Several other countries and provinces other than those listed above have adopted air quality standards (e.g., Czechoslovakia, Table 6, and Ontario, Table 7). Other countries have adopted standards for just one or two pollutants—particularly sulfur dioxide (Table 8). In many of the world's nations, the situation is analogous to that in the United
# TABLE 2  U.S.S.R. Air Quality Standards

<table>
<thead>
<tr>
<th>Substance</th>
<th>Single exposure (approx 20-min averaging time)</th>
<th>24-hr averaging time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>0.2</td>
<td>0.08</td>
</tr>
<tr>
<td>Acetic anhydride</td>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Acetone</td>
<td>0.35</td>
<td>0.15</td>
</tr>
<tr>
<td>Acetophenone</td>
<td>0.003</td>
<td>0.0006</td>
</tr>
<tr>
<td>Acrolein</td>
<td>0.3</td>
<td>0.12</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0.2</td>
<td>0.28</td>
</tr>
<tr>
<td>Amyl acetate</td>
<td>0.1</td>
<td>0.019</td>
</tr>
<tr>
<td>Amyl alcohol</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Aniline</td>
<td>0.05</td>
<td>0.013</td>
</tr>
<tr>
<td>Arsenic (as As)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Butane</td>
<td>200</td>
<td>85</td>
</tr>
<tr>
<td>Butanol</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Butyl acetate (-n)</td>
<td>0.1</td>
<td>0.021</td>
</tr>
<tr>
<td>Butylene</td>
<td>3</td>
<td>1.3</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>0.015</td>
<td>0.004</td>
</tr>
<tr>
<td>Caprolactum</td>
<td>0.05</td>
<td>0.013</td>
</tr>
<tr>
<td>Carbylic acid</td>
<td>0.01</td>
<td>0.002</td>
</tr>
<tr>
<td>Carbon black (soot)</td>
<td>0.15</td>
<td>0.05</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.1</td>
<td>0.033</td>
</tr>
<tr>
<td>Chloroaniline (-p)</td>
<td>0.04</td>
<td>0.008</td>
</tr>
<tr>
<td>Chlorobenzene</td>
<td>0.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Chloroprene</td>
<td>0.1</td>
<td>0.028</td>
</tr>
<tr>
<td>Chlorophenyl isocyanate (-m)</td>
<td>0.005</td>
<td>0.001</td>
</tr>
<tr>
<td>Chlorophenyl isocyanate (-p)</td>
<td>0.0015</td>
<td>0.0002</td>
</tr>
<tr>
<td>Chromium, hexavalent (as CrO)</td>
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</tr>
<tr>
<td>Cyclohexanol</td>
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<td>0.015</td>
</tr>
<tr>
<td>Cyclohexanone</td>
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<td>0.008</td>
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<td>Dichloroethane</td>
<td>3</td>
<td>0.75</td>
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<tr>
<td>2,3-dichloro 1,4-naphthaquinone</td>
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<td>0.05</td>
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<tr>
<td>Diethylamine</td>
<td>0.05</td>
<td>0.02</td>
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<tr>
<td>Diketene</td>
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<td>0.002</td>
</tr>
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<td>Dimethoxyline</td>
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<td>0.001</td>
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<tr>
<td>Dimethylamine</td>
<td>0.7</td>
<td>0.18</td>
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<tr>
<td>Dimethyl disulfide</td>
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<td>0.01</td>
</tr>
<tr>
<td>Dimethyl formamide</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>Dimethyl sulfide</td>
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<td>0.03</td>
</tr>
<tr>
<td>Dinkr (diphenyl + its oxides)</td>
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<td>0.0015</td>
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<td>0.05</td>
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<td>2.5</td>
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<td>0.029</td>
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<td>2.3</td>
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<td>Ethylene oxide</td>
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<td>Substance</td>
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<td>24-hr averaging time</td>
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<tr>
<td>----------------------------------------------------</td>
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<tr>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
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<td>0.006</td>
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<td>Hydrochloric acid (as HCl)</td>
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<td>Isopropyl benzene hydroperoxide</td>
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<td>0.001</td>
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<td>Methyl mercaptan</td>
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<td>0.01</td>
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<td>Methyl parathion</td>
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<td>Naphthaquinone (α)</td>
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<td>0.001</td>
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<td>Nitric acid (as HNO₃)</td>
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<tr>
<td>Nitric acid (as H⁺)</td>
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<td>Phenol</td>
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<td>1.6</td>
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<td>Pyridine</td>
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<tr>
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<tr>
<td>Sulfuric acid (as H⁺)</td>
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<td></td>
</tr>
<tr>
<td>Sulfuric acid (as H₂SO₄)</td>
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</tr>
<tr>
<td>Suspended particulate matter (dust)</td>
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</tr>
<tr>
<td>Thiophene</td>
<td>0.6</td>
<td>0.17</td>
</tr>
<tr>
<td>Toluene</td>
<td>0.6</td>
<td>0.15</td>
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<tr>
<td>Toluene di-isocyanate</td>
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<td>0.0071</td>
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<tr>
<td>Tributyl phosphate</td>
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<td></td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>4</td>
<td>0.67</td>
</tr>
<tr>
<td>Valeric acid (α)</td>
<td>0.03</td>
<td>0.008</td>
</tr>
<tr>
<td>Vanadium pentoxide</td>
<td>0.2</td>
<td>0.06</td>
</tr>
<tr>
<td>Vinyl acetate</td>
<td>0.2</td>
<td>0.05</td>
</tr>
</tbody>
</table>
### TABLE 3  Polish Air Quality Standards

<table>
<thead>
<tr>
<th>Substance</th>
<th>Single exposure</th>
<th>24-hr averaging time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20-min averaging time</td>
<td>24-hr averaging time</td>
</tr>
<tr>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
</tr>
<tr>
<td>Carbon disulfide*</td>
<td>0.045</td>
<td>0.015</td>
</tr>
<tr>
<td>Carbon monoxide†</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>Gasoline†</td>
<td>2.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Hydrogen sulfide*</td>
<td>0.06</td>
<td>0.04</td>
</tr>
<tr>
<td>Hydrogen sulfide†</td>
<td>0.008</td>
<td>0.005</td>
</tr>
<tr>
<td>Nitrogen oxides*</td>
<td>0.6</td>
<td>0.33</td>
</tr>
<tr>
<td>Nitrogen oxides†</td>
<td>0.15</td>
<td>0.08</td>
</tr>
<tr>
<td>Sulfur dioxide*</td>
<td>0.9</td>
<td>0.35</td>
</tr>
<tr>
<td>Sulfur dioxide†</td>
<td>0.25</td>
<td>0.1</td>
</tr>
<tr>
<td>Sulfuric acid*</td>
<td>0.3</td>
<td>....</td>
</tr>
<tr>
<td>Sulfuric acid†</td>
<td>0.15</td>
<td>....</td>
</tr>
<tr>
<td>Suspended particulate matter (dust)*</td>
<td>0.6</td>
<td>....</td>
</tr>
<tr>
<td>Suspension particulate matter (dust)†</td>
<td>0.2</td>
<td>....</td>
</tr>
</tbody>
</table>

**NOTE:** There are also deposited particulate matter standards of 250 tons/sq km/year* and 40 tons/sq km/year† and 6.5 tons/sq km/month.  
* For protected areas.  
† For specially protected areas.

### TABLE 4  Federal Republic of Germany Air Quality Standards

<table>
<thead>
<tr>
<th>Substance</th>
<th>30-min averaging time</th>
<th>Long-term exposure</th>
<th>Not to be exceeded more than once in any 8 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.3</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.15</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>1</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>0.4</td>
<td>0.15</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**NOTE:** There are also deposited particulate matter standards (in g/sq m/month) of 0.65 and 1.3 for general and industrial areas, respectively, and for the average of 12-month averages of 0.42 and 0.85, respectively.
### Evolution of Industrial Pollution Control

#### TABLE 5 VDI (German Engineering Society) Air Quality Standards

<table>
<thead>
<tr>
<th>Substance</th>
<th>Long-term exposure</th>
<th>Not to be exceeded more than once in any 4 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Acetone</td>
<td>120</td>
<td>50</td>
</tr>
<tr>
<td>Acrolein</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Amyl acetate</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Amyl alcohol</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Aniline</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Benzene</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Butanol</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Butyl acetate</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Chloroform</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Cresol</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Dichloroethane</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>65</td>
<td>20</td>
</tr>
<tr>
<td>Dimethyl ether</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Dimethylylamine</td>
<td>0.025</td>
<td>0.003</td>
</tr>
<tr>
<td>Dimethylaniline</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>Ethanol</td>
<td>75</td>
<td>20</td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>Furfural</td>
<td>0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>Gasoline</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>Higher alkyl benzenes</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Methyl alcohol</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Methyl acetate</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Methyl ethyl ketone</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Methyl isobutyl ketone</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Nitrobenzene</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Nitroethane</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Nitroethane chloride</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td>0.3</td>
<td>0.05</td>
</tr>
<tr>
<td>Perchloroethylene</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>Phosgene</td>
<td>0.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Propanol</td>
<td>50</td>
<td>20</td>
</tr>
<tr>
<td>Pyridine</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Tetrahydrofuran</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Toluene</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Toluene bisulfite-nitrate</td>
<td>0.007</td>
<td>0.001</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Tetrachloroethylene</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>Triethylamine</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>Turpentine</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Vinyl acetate</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Xylene</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Hydrochloric acid (as HCl)</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Nitric acid</td>
<td>1.3</td>
<td>0.5</td>
</tr>
</tbody>
</table>
States; i.e., enabling or authorizing legislation has been but recently adopted and the resulting air quality standards are, as of this writing, being developed, but have not yet been promulgated.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Single exposure (approx 30-min averaging time)</th>
<th>24-hr averaging time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
</tr>
<tr>
<td>Ammonia</td>
<td>0.3</td>
<td>0.42</td>
</tr>
<tr>
<td>Arsenic (as As)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>2.4</td>
<td>0.75</td>
</tr>
<tr>
<td>Carbon black (soot)</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>0.1</td>
<td>0.33</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.05</td>
<td>0.033</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Fluorides (inorganic, gaseous)</td>
<td>0.01</td>
<td>0.005</td>
</tr>
<tr>
<td>Hydrochloric acid (as H+)</td>
<td>0.008</td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead (as Pb)†</td>
<td>0.01</td>
<td>0.10</td>
</tr>
<tr>
<td>Manganese (as MnO₂)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitric acid (as H+)</td>
<td>0.3</td>
<td>0.075</td>
</tr>
<tr>
<td>Nitrogen oxides (as NO₂)</td>
<td>0.5</td>
<td>0.19</td>
</tr>
<tr>
<td>Phenol</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Suspended particulate matter (dust)</td>
<td>0.5</td>
<td>0.15</td>
</tr>
</tbody>
</table>

*Also its inorganic compounds, except arsine.
†Also its compounds, except tetraethyl lead.

**EMISSION STANDARDS**

**United States**

The Clean Air Act authorizes the promulgation of federal emission standards for motor vehicle exhaust. It does not authorize the setting of federal emission standards for any other class of source. The Act requires that within a specified time after the states submit state air quality standards to the Secretary of Health, Education and Welfare for his approval, they must indicate the means by which these air quality
**Evolution of Industrial Pollution Control**

**TABLE 7 Ontario (Canada) Air Quality Standards**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Single exposure (30-min averaging time)*</th>
<th>24-hr averaging time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/cu m stp</td>
<td>ppm</td>
</tr>
<tr>
<td>Ammonia</td>
<td>3.5</td>
<td>5</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.00001</td>
<td></td>
</tr>
<tr>
<td>Calcium oxide (lime)</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>0.45</td>
<td>0.15</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>5.5</td>
<td>5</td>
</tr>
<tr>
<td>Chlorine</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Fluorides (as HF):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial—commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential—rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial—commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential—rural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen chloride</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Lead (as Pb)</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxidant (by KI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial—commercial</td>
<td>0.78</td>
<td>0.3</td>
</tr>
<tr>
<td>Residential—rural</td>
<td>0.78</td>
<td>0.3</td>
</tr>
<tr>
<td>suspended particulate matter (dust):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial—commercial</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Residential—rural</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>66</td>
<td>60</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>0.36</td>
<td>0.2</td>
</tr>
<tr>
<td>Oxidant (by KI)‡</td>
<td>0.3</td>
<td>0.15</td>
</tr>
</tbody>
</table>

| Sulfur dioxide                   |             |     |             |     |
| Industrial—commercial            | 1.04        | 0.4 | 0.13        | 0.05|
| Residential—rural                | 0.65        | 0.25| 0.05        | 0.02|

| suspension particulate matter (dust): | | | | |
| Industrial—commercial | 1.11        | | 0.05        |
| Residential—rural      | 0.06        | |             |

**NOTE:** There are also deposited particulate matter standards (in tons/sq mile/month) of 20 and 40 for residential-rural and industrial-commercial areas, respectively; for the average of 13 and 25, respectively; and a single-exposure* value of 15.

* Maximum ground level concentration from a single source measured on the centerline downwind from the stack.

† 90 percent of 24-hr samplings.

‡ 90 percent of samplings in 1 month must be less than 0.07 ppm.

§ Geometric mean.
standards are to be enforced by the state and its subordinate jurisdictions. Although the law does not say so, in so many words, the most obvious means of implementation will have to be the adoption of state and local emission standards, the enforcement of which should achieve the air quality standard adopted.

**TABLE 8  Air Quality Standards for Sulfur Dioxide in Other Countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Single exposure (approx 30-min averaging time)</th>
<th>24-hr averaging time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/cu m stp ppm</td>
<td>mg/cu m stp ppm</td>
</tr>
<tr>
<td>The Netherlands* (avg over 1 yr)</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>a.</td>
<td>0.68</td>
<td>0.20</td>
</tr>
<tr>
<td>b.</td>
<td>0.65</td>
<td>0.25</td>
</tr>
<tr>
<td>Rumania</td>
<td>0.75</td>
<td>0.3</td>
</tr>
<tr>
<td>Sweden*</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Switzerland: Mar. 1-Oct. 31*</td>
<td>....</td>
<td>....</td>
</tr>
<tr>
<td>Switzerland: Nov. 1-Feb. 28/29*</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Valois Canton*</td>
<td>....</td>
<td>....</td>
</tr>
</tbody>
</table>

* Proposed standard (not yet adopted).
† Not to be exceeded more than 2 percent of the time.
‡ 24-hr mean not to be exceeded more than once in any 30 days; 30-min mean not to be exceeded more than 1 percent of the time in any 30 days. Also a monthly standard of 0.05 ppm (0.13 mg/cu m).
§ Single exposures standard not to be exceeded more than once in any 2 hr.

There is no prohibition in the Act of states and their jurisdictions having, in their regulations, emission standards (whether adequate or inadequate) for pollutants and processes for which no state air quality standard has been adopted; nor for areas of the state outside designated air quality control regions; nor for having in their regulations both air quality and emission standards (whether adequate or inadequate) for pollutants for which the Secretary has not yet sent to the states air quality criteria and documentation on applicable control technology. However, it appears implicit in the Clean Air Act
that, for those pollutants for which the Secretary has issued air quality criteria and documentation of applicable control technology, the state and its jurisdiction cannot have in their regulations emission standards applicable to designated air quality control regions which are inadequate to achieve within these regions the air quality standards approved by the Secretary for the state. It would therefore seem that emission standards now on the books which are inadequate for this purpose will have to be changed. Tables 9 and 10 list state and local emission standards presently existent in the United States.

In addition to the standards listed in these two tables, a number of American jurisdictions have adopted emission standards for total solid particulate pollutants in effluent air or gases from sources in general, and from combustion sources in particular. A wide variety of units have been used to specify these standards. When converted to the common units of mg/cu m stp (in the case of combustion gases, adjusted to either 12 percent CO\textsubscript{2}, 50 percent excess air, or 6 percent O\textsubscript{2}), the standards for sources in general range from 120 to 1,210 mg/cu m and those for combustion sources from 690 to 3,150 mg/cu m. Of the latter, 60 percent are at the value of 1,030 mg/cu m, and 25 percent are less than that value. The most recent trend is for values lower than 840 mg/cu m.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Jurisdiction</th>
<th>Source of emission</th>
<th>Original units</th>
<th>mg/cu in</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>stp</td>
<td></td>
</tr>
<tr>
<td>Carbonylso........</td>
<td>Bay Area APCD</td>
<td>Incineration</td>
<td>ppm</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Fluorine...........</td>
<td>Florida</td>
<td>Incineration</td>
<td>0.4 lb/ton PbOx</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrocarbonsa</td>
<td>Bay Area APCD</td>
<td>Incineration</td>
<td>ppm</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Nitrogen oxides...</td>
<td>California</td>
<td>Automobiles</td>
<td>ppm</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>Organic compounds</td>
<td>Bay Area APCD</td>
<td>As hexane</td>
<td>ppm</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>As total carbon</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive compounds</td>
<td>Bay Area APCD</td>
<td>Heated or baked</td>
<td>20 lb/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unheated</td>
<td>40 lb/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Los Angeles APCD</td>
<td>Dispose or evaporate</td>
<td>1.5 gal/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide....</td>
<td>Bay Area APCD</td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dade County, Fla.</td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eugene, Ore.</td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Los Angeles APCD</td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Missouri</td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>1,300</td>
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<td></td>
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<td></td>
<td></td>
<td>500</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>2.3 lb/million</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>2.0 lb/million</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>0.4 lb/million</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>10,000</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>4,000</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>39,000</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ppm</td>
<td>5,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfuric acid.....</td>
<td>Bay Area APCD</td>
<td>Acid mfg. from S</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pyrites</td>
<td>0.08 grain/cu ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acid mfg. from</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>other materials</td>
<td>0.3 grain/cu ft</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Missouri</td>
<td>mg/cu m</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>New Jersey</td>
<td>mg/cu m</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>mg/cu m</td>
<td>350</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* As formaldehyde.
+ Corrected to 5 percent O2 in the flue gas.
+ Average for specified test cycle.
+ Where less than 5 percent by volume of the organic compounds is "reactive" or "reactive" compound emissions are reduced at least 85 percent, these limits do not apply. There are other exemptions in Regulation 3.
+ Except where there is 85 percent or more solvent removal from effluent.
+ As defined by Rule 66 of Los Angeles APCD.
+ St. Louis metropolitan area.
+ Different dates of applicability for installations larger and smaller than 2,000,000,000 Btu/hr.
+ Not applicable with under 3,000 cfm of gas, and 50 lb/hr SO2 emission or 100 lb/hr instantaneous emission rate.
<table>
<thead>
<tr>
<th>Source of emission</th>
<th>Jurisdiction or code</th>
<th>Standard—original units</th>
<th>mg/cu m atp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incineration of refuse</td>
<td>Allegheny County, Pa.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Bay Area APCD</td>
<td>0.2 grain/cu ft</td>
<td>460*</td>
</tr>
<tr>
<td></td>
<td>Cleveland, Ohio</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
<tr>
<td></td>
<td>Cincinnati, Ohio</td>
<td>0.4 lb/1,000 lb gas</td>
<td>490*</td>
</tr>
<tr>
<td></td>
<td>Dearborn, Mich.</td>
<td>0.3 grain/cu ft at 500°F</td>
<td>1,280*</td>
</tr>
<tr>
<td>Florida</td>
<td>New York, N.Y.</td>
<td>0.2 grain/cu ft</td>
<td>460*</td>
</tr>
<tr>
<td></td>
<td>Delaware</td>
<td>0.65 lb/million Btu</td>
<td>790*</td>
</tr>
<tr>
<td></td>
<td>Montgomery County, Md.</td>
<td>0.75 lb/million Btu</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prince Georges County, Md.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td></td>
<td>Rockville, Md.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td></td>
<td>Delaware</td>
<td>0.6 lb/1,000 lb gas</td>
<td>790*</td>
</tr>
<tr>
<td></td>
<td>Prince Georges County, Md.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td></td>
<td>Rockville, Md.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Less than 200 lb/hr</td>
<td>Delaware</td>
<td>0.6 lb/1,000 lb gas</td>
<td>790*</td>
</tr>
<tr>
<td></td>
<td>Prince Georges County, Md.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td></td>
<td>Rockville, Md.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Less than 1,000 lb/hr</td>
<td>Illinois</td>
<td>0.25 grain/cu ft</td>
<td>885*</td>
</tr>
<tr>
<td>1,000 lb/hr and more</td>
<td>Illinois</td>
<td>0.2 grain/cu ft</td>
<td>460*</td>
</tr>
<tr>
<td>Up to 10,000 lb/hr</td>
<td>Philadelphia, Pa.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240*</td>
</tr>
<tr>
<td>Over 10,000 lb/hr</td>
<td>Philadelphia, Pa.</td>
<td>0.6 lb/1,000 lb gas</td>
<td>790*</td>
</tr>
<tr>
<td>Municipal</td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Industrial, less than 900 lb/hr</td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Industrial, more than 900 lb/hr</td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Residential, less than 200 lb/hr</td>
<td>Michigan</td>
<td>0.6 lb/1,000 lb gas</td>
<td>790*</td>
</tr>
<tr>
<td>Residential, more than 200 lb/hr</td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Asphaltic concrete plants</td>
<td>Florida</td>
<td>0.3 grain/cu ft</td>
<td>850*</td>
</tr>
<tr>
<td>Stationary</td>
<td>Wayne County, Mich.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>240*</td>
</tr>
<tr>
<td>Portable</td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>101-150 tons/hr</td>
<td>Michigan</td>
<td>0.6 lb/1,000 lb gas</td>
<td>740*</td>
</tr>
<tr>
<td>151-200 tons/hr</td>
<td>Michigan</td>
<td>0.5 lb/1,000 lb gas</td>
<td>430*</td>
</tr>
<tr>
<td>Over 200 tons/hr</td>
<td>Michigan</td>
<td>0.5 lb/1,000 lb gas</td>
<td>430*</td>
</tr>
<tr>
<td>Cement, grinding, crushing, etc.</td>
<td>Michigan</td>
<td>0.15 lb/1,000 lb gas</td>
<td>190*</td>
</tr>
<tr>
<td>Cement, clinker coolers</td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Concrete (wet)</td>
<td>Illinois</td>
<td>0.75 grain/cu ft</td>
<td>1,732*</td>
</tr>
<tr>
<td>Kilns, cement</td>
<td>0.1 grain/cu ft</td>
<td>230*</td>
<td></td>
</tr>
<tr>
<td>Lime</td>
<td>Michigan</td>
<td>0.25 lb/1,000 lb gas</td>
<td>310*</td>
</tr>
<tr>
<td>Design</td>
<td>Michigan</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240*</td>
</tr>
<tr>
<td>Operation</td>
<td>Wayne County, Mich.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240*</td>
</tr>
<tr>
<td>Metallurgical processes; Ferrous:</td>
<td>Wayne County, Mich.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370*</td>
</tr>
<tr>
<td>Bessemer converters</td>
<td>Allegheny County, Pa.</td>
<td>0.65 lb/1,000 lb gas</td>
<td>790*</td>
</tr>
<tr>
<td>Blast furnace gas, bled</td>
<td>Allegheny County, Pa.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240*</td>
</tr>
<tr>
<td></td>
<td>Detroit, Mich.</td>
<td>0.5 lb/1,000 lb gas</td>
<td>610*</td>
</tr>
<tr>
<td></td>
<td>Illinois</td>
<td>0.1 grain/cu ft</td>
<td>230*</td>
</tr>
<tr>
<td>Blast furnace gas, burned</td>
<td>Wayne County, Mich.</td>
<td>0.5 lb/1,000 lb gas</td>
<td>430*</td>
</tr>
<tr>
<td></td>
<td>Detroit, Mich.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>430*</td>
</tr>
<tr>
<td></td>
<td>Illinois</td>
<td>0.5 grain/cu ft</td>
<td>112*</td>
</tr>
<tr>
<td></td>
<td>Wayne County, Mich.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240*</td>
</tr>
<tr>
<td></td>
<td>Chicago, Ill.</td>
<td>0.35 grain/cu ft</td>
<td>800*</td>
</tr>
<tr>
<td></td>
<td>Cleveland, Ohio</td>
<td>0.5 lb/1,000 lb gas</td>
<td>610*</td>
</tr>
<tr>
<td></td>
<td>Allegheny County, Pa.</td>
<td>0.5 lb/1,000 lb gas</td>
<td>610*</td>
</tr>
<tr>
<td></td>
<td>Allegheny County, Pa.</td>
<td>0.65 lb/1,000 lb gas</td>
<td>790*</td>
</tr>
<tr>
<td></td>
<td>Michigan</td>
<td>0.4 grain/cu ft</td>
<td>920*</td>
</tr>
<tr>
<td>Source of emission</td>
<td>Jurisdiction or code</td>
<td>Standard—original units</td>
<td>mg/cu m stp</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Metallurgical processes:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferrous:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cupolas (continued):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jobbing, operation</td>
<td>Detroit and Wayne Counties, Mich.</td>
<td>0.4 lb/1,000 lb gas</td>
<td>490\textsuperscript{4}</td>
</tr>
<tr>
<td></td>
<td>Michigan</td>
<td>0.4 lb/1,000 lb gas</td>
<td>490\textsuperscript{4}</td>
</tr>
<tr>
<td>Production, operation</td>
<td>Detroit and Wayne Counties, Mich.</td>
<td>0.25 lb/1,000 lb gas</td>
<td>310\textsuperscript{4}</td>
</tr>
<tr>
<td>0-10 tons/hr.</td>
<td>Michigan</td>
<td>0.4 lb/1,000 lb gas</td>
<td>490</td>
</tr>
<tr>
<td>11-20 tons/hr.</td>
<td>Michigan</td>
<td>0.25 lb/1,000 lb gas</td>
<td>310</td>
</tr>
<tr>
<td>21 and over tons/hr.</td>
<td>Michigan</td>
<td>0.1 lb/1,000 lb gas</td>
<td>120</td>
</tr>
<tr>
<td>Production-design</td>
<td>Detroit and Wayne Counties, Mich.</td>
<td>0.1 lb/1,000 lb gas</td>
<td>120\textsuperscript{4}</td>
</tr>
<tr>
<td>Furnaces:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric, basic oxygen, and open hearth</td>
<td>Allegheny County, Pa.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
<tr>
<td>Operation</td>
<td>Cleveland, Ohio</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
<tr>
<td>Design</td>
<td>Detroit and Wayne Counties, Mich.</td>
<td>0.1 lb/1,000 lb gas</td>
<td>120\textsuperscript{4}</td>
</tr>
<tr>
<td></td>
<td>Michigan</td>
<td>0.1 lb/1,000 lb gas</td>
<td>120</td>
</tr>
<tr>
<td>Heating and reheating</td>
<td>Allegheny County, Pa.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370</td>
</tr>
<tr>
<td></td>
<td>Michigan</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370</td>
</tr>
<tr>
<td></td>
<td>Detroit and Wayne Counties, Mich.</td>
<td>0.3 lb/1,000 lb gas</td>
<td>370\textsuperscript{4}</td>
</tr>
<tr>
<td>Sintering plants:</td>
<td>Allegheny County, Pa.</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
<tr>
<td>Operation</td>
<td>Cleveland, Ohio</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
<tr>
<td>Design</td>
<td>Detroit and Wayne Counties, Mich.</td>
<td>0.1 lb/1,000 lb gas</td>
<td>120\textsuperscript{4}</td>
</tr>
<tr>
<td></td>
<td>Michigan</td>
<td>0.1 lb/1,000 lb gas</td>
<td>120</td>
</tr>
<tr>
<td>Nonferrous:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furnace or smelter, general</td>
<td>Cleveland, Ohio</td>
<td>0.2 lb/1,000 lb gas</td>
<td>240</td>
</tr>
</tbody>
</table>

\* Adjusted to 6 percent O₂, 12 percent CO₂, or 50 percent excess air.
\* Maximum emission, 250 lb/hr.
\* St. Louis and Washington metropolitan area.
\* In Detroit and Wayne County, Mich., less water vapor from wet collector, if employed.
\* Does not apply to domestic incinerators having less than 5 cu ft storage capacity.
\* Except for portable plants with fewer than three inhabited residences within 1 mile.
\* In remote locations, if no water is available and emission limit of 0.3 lb/1,000 lb gas cannot otherwise be satisfied, plant may be located in 1 mile radius of uninhabited buffer zone.
\* Up to 15,000 bbl/day kiln capacity. Special regulations for over 15,000 bbl/day total plant kiln capacity.
\* Also supplemental regulations.
\* Or 99.5 percent collector removal efficiency.
\* Rotary kilns must have 98.5 percent weight collection efficiency, if more restrictive.
\* Future date of applicability.
\* Or 95 percent collector removal efficiency.
\textsuperscript{4} Or 99.7 percent collector removal efficiency.
\textsuperscript{5} Or 85 percent collector removal efficiency.
\textsuperscript{6} Or 98.5 percent weight collection efficiency, if more restrictive.
\textsuperscript{7} Or 95 percent weight collection efficiency, if more restrictive.
Smoke emission standards (Table 11) limit such emissions, in terms of smoke density on the Ringelmann scale, which varies as follows:

<table>
<thead>
<tr>
<th>Scale Number</th>
<th>Percent Blackness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>

Although there are no federal emission standards universally applicable in the United States for other than motor vehicles (Table 12), there are standards adopted by the federal government for application solely to federal installations (Table 13).

Great Britain

In Great Britain, no air quality standards have been adopted. However, under the provisions of the Alkali Act, a number of emission standards have been adopted (Tables 14 and 15).

Federal Republic of Germany

In addition to the air quality standards adopted officially and by the VDI Kommission Reinhaltung der Luft previously referred to, there are also both official and quasi-official (VDI) emission standards in the Federal Republic of Germany (Tables 16 and 16).

Japan

The Japanese have adopted several emission standards (Table 18).
### TABLE 11 Smoke Emission Standards (U.S.A.)

<table>
<thead>
<tr>
<th>Emission greater than this Ringelmann number prohibited*</th>
<th>Date of enactment</th>
<th>Status as of end of 1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>61 (−1)</td>
<td>(−2)</td>
</tr>
<tr>
<td>2</td>
<td>14 13</td>
<td>57</td>
</tr>
<tr>
<td>1</td>
<td>0 0</td>
<td>0</td>
</tr>
<tr>
<td>Total (net)</td>
<td>75 12</td>
<td>55</td>
</tr>
</tbody>
</table>

*Except in some cases, for special circumstances such as soot blowing or starting cold fires.

### TABLE 12 Federal* Emission Standards for Motor Vehicles (U.S.A.)

<table>
<thead>
<tr>
<th>Substance</th>
<th>Original units</th>
<th>mg/cu m stp</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over 140 cu in. displacement.</td>
<td>1.5 % by vol</td>
<td>16,500</td>
<td>15,000</td>
</tr>
<tr>
<td>100-140 cu in. displacement.</td>
<td>2 % by vol</td>
<td>22,000</td>
<td>20,000</td>
</tr>
<tr>
<td>50-100 cu in. displacement.</td>
<td>2.3 % by vol</td>
<td>25,500</td>
<td>23,000</td>
</tr>
<tr>
<td>Hydrocarbons:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crankcase.</td>
<td>None permitted</td>
<td></td>
<td>275</td>
</tr>
<tr>
<td>Over 140 cu in. displacement.</td>
<td>ppm</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>100-140 cu in. displacement.</td>
<td>ppm</td>
<td>410</td>
<td></td>
</tr>
<tr>
<td>50-100 cu in. displacement.</td>
<td>ppm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Also California.

### TABLE 13 Federal Emission Standards for Federal Installations (U.S.A.)

<table>
<thead>
<tr>
<th>Source of emission</th>
<th>Original units</th>
<th>mg/cu m stp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incineration of refuse:</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
</tr>
<tr>
<td>Less than 200 lb/hr*</td>
<td>0.3 grain/cu ft</td>
<td>690</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel burning installations:</td>
<td>0.35 lb/million Btu heat input</td>
<td>...</td>
</tr>
<tr>
<td>In New York, N.Y.</td>
<td></td>
<td>...</td>
</tr>
<tr>
<td>In Philadelphia</td>
<td>0.05 lb/million Btu heat input</td>
<td>...</td>
</tr>
<tr>
<td>In Chicago</td>
<td>0.05 lb/million Btu heat input</td>
<td>...</td>
</tr>
</tbody>
</table>

*Adjusted to 12 percent CO₂.
<table>
<thead>
<tr>
<th>Substance</th>
<th>Source of emission</th>
<th>Original units</th>
<th>stp</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>Less than 5,000 cfm</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Antimony&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>More than 5,000 cfm</td>
<td>0.02 grain/cu ft</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Arsenic&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Less than 5,000 cfm</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Arsenic&lt;sup&gt;b&lt;/sup&gt;</td>
<td>More than 5,000 cfm</td>
<td>0.02 grain/cu ft</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Cadmium&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Max 30 lb/100 hr</td>
<td>0.017 grain/cu ft</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Chlorine&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen chloride</td>
<td>Alkali (salt cake) works</td>
<td>0.2 grain/cu ft</td>
<td>460 328</td>
<td></td>
</tr>
<tr>
<td>Hydrogen chloride</td>
<td>Hydrochloric acid works</td>
<td>0.2 grain/cu ft</td>
<td>460 328</td>
<td></td>
</tr>
<tr>
<td>Hydrogen fluoride</td>
<td></td>
<td>0.1 grain/cu ft</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Up to 3,000 cfm of exhaust gas</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Lead&lt;sup&gt;f&lt;/sup&gt;</td>
<td>3,000-10,000 cfm of exhaust gas</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Lead&lt;sup&gt;g&lt;/sup&gt;</td>
<td>10,000-140,000 cfm of exhaust gas</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Lead&lt;sup&gt;h&lt;/sup&gt;</td>
<td>Over 140,000 cfm of exhaust gas</td>
<td>0.005 grain/cu ft</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous&lt;sup&gt;i&lt;/sup&gt;</td>
<td>Superphosphate fertilizer manufacture</td>
<td>0.1 grain/cu ft</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>Nitrogen oxides&lt;sup&gt;f&lt;/sup&gt;</td>
<td>Nitric acid plants</td>
<td>1 grain/cu ft</td>
<td>2,300 1,280</td>
<td></td>
</tr>
<tr>
<td>Nitrogen oxides&lt;sup&gt;f&lt;/sup&gt;</td>
<td>Nitric acid plants</td>
<td>2 grains/cu ft</td>
<td>4,600 2,560</td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Chamber sulfuric acid plants</td>
<td>4 grains/cu ft (as SO&lt;sub&gt;3&lt;/sub&gt;)</td>
<td>9,200</td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Sulfuric acid concentration</td>
<td>1.5 grains/cu ft (as SO&lt;sub&gt;3&lt;/sub&gt;)</td>
<td>3,450</td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Contact sulfuric acid plants, sulfur burning</td>
<td>2% of the sulfur burned</td>
<td>9,200</td>
<td></td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>Contact sulfuric acid plants other than sulfur burning</td>
<td>4 grains/cu ft (as SO&lt;sub&gt;3&lt;/sub&gt;)</td>
<td>9,200</td>
<td></td>
</tr>
<tr>
<td>Total solid particulate matter</td>
<td>Greater than 10 microns</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td>Total solid particulate matter</td>
<td>Less than 10 microns</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Also compounds of the element.
<sup>b</sup> As the trioxide.
<sup>c</sup> As the element.
<sup>d</sup> As SO<sub>3</sub> equivalent in original units.
<sup>e</sup> 100 lb/week mass emission limit.
<sup>f</sup> 400 lb/week mass emission limit.
<sup>g</sup> 1,000 lb/week mass emission limit.
<sup>h</sup> Or efficiency of condensation of acid gases greater than 99 percent.
### TABLE 15 British Emission Standards for Particulate Matter from Specific Processes

<table>
<thead>
<tr>
<th>Source of Emission</th>
<th>Original units</th>
<th>mg/cu m stp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast furnace gas, bled:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integrated works</td>
<td>0.2 grain/cu ft</td>
<td>400</td>
</tr>
<tr>
<td>Merchant furnaces</td>
<td>0.5 grain/cu ft</td>
<td>1,150</td>
</tr>
<tr>
<td>Cement, grinding and crushing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New plants</td>
<td>0.1 grain/cu ft</td>
<td>230</td>
</tr>
<tr>
<td>Existing plants</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
</tr>
<tr>
<td>Kilns:*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Up to 1,500 tons/day clinker</td>
<td>0.2 grain/cu ft</td>
<td>400</td>
</tr>
<tr>
<td>1,500–3,000 tons/day clinker</td>
<td>Sliding scale from 0.2 to 0.1</td>
<td></td>
</tr>
<tr>
<td>3,000 and over tons/day clinker</td>
<td>0.1 grain/cu ft</td>
<td>230</td>
</tr>
<tr>
<td>Rock crushing, dust handling</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
</tr>
<tr>
<td>Cupolas, hot blast:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grit and dust†</td>
<td>0.2 grain/cu ft</td>
<td>400</td>
</tr>
<tr>
<td>Fume‡</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
</tr>
<tr>
<td>Electric generating plants:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
</tr>
<tr>
<td>New‡</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
</tr>
<tr>
<td>Furnaces, steel, all oxygen refining processes producing fume†</td>
<td>0.05 grain/cu ft</td>
<td>115</td>
</tr>
<tr>
<td>Nonfume processes‡</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
</tr>
<tr>
<td>Sintering plants</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
</tr>
</tbody>
</table>

* Older kilns, up to 0.5 grain/cu ft.
† Grit and dust, over 10 microns; fume, less than 10 microns.
‡ New 2,000- to 4,000-Mw plants must have 99.3 percent fly ash removal efficiency after 12 months’ operation.

### TABLE 16 Federal Republic of Germany Emission Standards for Particulate Matter from Specific Processes

<table>
<thead>
<tr>
<th>Source of Emissions</th>
<th>mg/cu m stp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast furnace gas:</td>
<td></td>
</tr>
<tr>
<td>Bled</td>
<td>20</td>
</tr>
<tr>
<td>Burned</td>
<td>50</td>
</tr>
<tr>
<td>Cement grinding and crushing</td>
<td>150</td>
</tr>
<tr>
<td>Copper smelting</td>
<td>500</td>
</tr>
<tr>
<td>Incineration of refuse:</td>
<td></td>
</tr>
<tr>
<td>Less than 20 tons/day</td>
<td>200*</td>
</tr>
<tr>
<td>More than 20 tons/day</td>
<td>150*</td>
</tr>
<tr>
<td>Lead smelting:</td>
<td></td>
</tr>
<tr>
<td>Reducing furnaces</td>
<td>400</td>
</tr>
<tr>
<td>Refining furnaces</td>
<td>200</td>
</tr>
<tr>
<td>Slag blowing</td>
<td>100</td>
</tr>
<tr>
<td>Oxygen-using steelmaking furnaces</td>
<td>150‡</td>
</tr>
<tr>
<td>Sintering plants:</td>
<td></td>
</tr>
<tr>
<td>Continuous operation</td>
<td>150</td>
</tr>
<tr>
<td>Special cases‡</td>
<td>300‡</td>
</tr>
<tr>
<td>Zine smelting:</td>
<td></td>
</tr>
<tr>
<td>Distillation process</td>
<td>200</td>
</tr>
<tr>
<td>Electrothermic process</td>
<td>100</td>
</tr>
<tr>
<td>Rotary process</td>
<td>500</td>
</tr>
<tr>
<td>Stationary retorts</td>
<td>400</td>
</tr>
<tr>
<td>Miscellaneous§</td>
<td>150</td>
</tr>
</tbody>
</table>

* Adjusted to 7 percent CO2.
† Particles smaller than 10 microns.
‡ Where, for instance, raw material is to be used in the form of fine dust and the applicant is able to show that, although the present state of technical development does not permit keeping within the 150 mg/cu m limit, no objectionable effects need be feared in the neighborhood.
§ Exhaust from screening, crushing, or filling plants and from other similar sources of emission.
<table>
<thead>
<tr>
<th>Standard No.</th>
<th>Source of emission</th>
<th>mg/cu m stp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2094</td>
<td>Cement kilns; cement grinding and crushing</td>
<td>150</td>
</tr>
<tr>
<td>2095</td>
<td>Sintering plants</td>
<td>300</td>
</tr>
<tr>
<td>2096</td>
<td>Blast furnace gas, burned</td>
<td>50</td>
</tr>
<tr>
<td>2101</td>
<td>Coke-crushing and screening</td>
<td>150</td>
</tr>
<tr>
<td>2102</td>
<td>Primary copper smelting, refining, reverberatory and shaft furnaces</td>
<td>300</td>
</tr>
<tr>
<td>2103</td>
<td>Secondary copper smelting, blast and refining furnaces and converters</td>
<td>300</td>
</tr>
<tr>
<td>2112</td>
<td>Oxygen-using steelmaking furnaces</td>
<td>150</td>
</tr>
<tr>
<td>2284</td>
<td>Zinc smelting:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distillation process</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Electrothermic process</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Rotary process</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Stationary retorts</td>
<td>400</td>
</tr>
<tr>
<td>2285</td>
<td>Lead smelting:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reducing furnaces</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>Refining furnaces</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Slag blowing</td>
<td>100</td>
</tr>
<tr>
<td>2286</td>
<td>Aluminum reduction:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alumina calcining</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Alumina grinding</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Primary reduction</td>
<td>100</td>
</tr>
<tr>
<td>2287</td>
<td>Copper smelting:</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>Hydrometallurgical:&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cobalt calcination</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Inhibition plant</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Roasting plant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zinc calcination with scrubbing</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>Zinc calcination with hydroelectric dust extraction</td>
<td>500&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>2292</td>
<td>Coal briquetting</td>
<td>300&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>2293</td>
<td>Coal preparation plants</td>
<td>300&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>2301</td>
<td>Incineration of refuse:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 20 tons/day</td>
<td>200&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>More than 20 tons/day</td>
<td>150&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>2441</td>
<td>Aluminum reduction, secondary recovery furnaces</td>
<td>300&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Particles smaller than 10 microns.

<sup>b</sup> Recovery after chloridizing roasting.

<sup>c</sup> Output over 30 tons/day of zinc.

<sup>d</sup> Limit for industrial exhaust ventilating system effluent, 150 mg/cu m.

<sup>e</sup> Adjusted to 7 percent CO₂.

<sup>f</sup> Total dust emission not to exceed 1 percent of aluminum production.
### TABLE 18
Japanese Emission Standards for Particulate Matter from Specific Processes

<table>
<thead>
<tr>
<th>Source of Emission</th>
<th>mg/cu m stp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cupolas</td>
<td>200</td>
</tr>
<tr>
<td>Electric generating plants:</td>
<td></td>
</tr>
<tr>
<td>Water wall</td>
<td>1,000</td>
</tr>
<tr>
<td>Other</td>
<td>1,200</td>
</tr>
<tr>
<td>Furnaces:</td>
<td></td>
</tr>
<tr>
<td>Blast</td>
<td>500</td>
</tr>
<tr>
<td>Calcining</td>
<td>100</td>
</tr>
<tr>
<td>Electric</td>
<td>900</td>
</tr>
<tr>
<td>Gas generating</td>
<td>1,000</td>
</tr>
<tr>
<td>Glass melting, tank</td>
<td>700</td>
</tr>
<tr>
<td>Metal heating</td>
<td>700</td>
</tr>
<tr>
<td>Metal refining</td>
<td>700</td>
</tr>
<tr>
<td>Open hearth</td>
<td>600</td>
</tr>
<tr>
<td>Oxygen-using</td>
<td>1,000</td>
</tr>
<tr>
<td>Petroleum refinery</td>
<td>700</td>
</tr>
<tr>
<td>Reactor*</td>
<td>1,200</td>
</tr>
<tr>
<td>Reverseratory</td>
<td>700</td>
</tr>
<tr>
<td>Other</td>
<td>1,000</td>
</tr>
<tr>
<td>Incineration of refuse</td>
<td>700</td>
</tr>
<tr>
<td>Kilns:</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>600</td>
</tr>
<tr>
<td>Calcining</td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>700</td>
</tr>
<tr>
<td>Other than continuous</td>
<td>2,000</td>
</tr>
<tr>
<td>Drying</td>
<td>1,200</td>
</tr>
<tr>
<td>Lime</td>
<td>1,500</td>
</tr>
<tr>
<td>Sintering plants</td>
<td>1,000</td>
</tr>
</tbody>
</table>

* Including direct burning carbon black furnaces.

### TABLE 19
Czechoslovak Emission Standards for Specific Pollutants

<table>
<thead>
<tr>
<th>Substance</th>
<th>kg/hr*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrolein</td>
<td>3</td>
</tr>
<tr>
<td>Ammonia</td>
<td>3</td>
</tr>
<tr>
<td>Arsenic (inorganic compounds, except arsine)</td>
<td>0.03</td>
</tr>
<tr>
<td>Benzene</td>
<td>24</td>
</tr>
<tr>
<td>Carbon black (amorphous carbon)</td>
<td>1.5</td>
</tr>
<tr>
<td>Carbon disulfide</td>
<td>0.3</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>0.1</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1</td>
</tr>
<tr>
<td>Fluorine (gaseous inorganic compounds)</td>
<td>0.3</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.5</td>
</tr>
<tr>
<td>Hydrochloric acid (as hydrogen ion)</td>
<td>0.1</td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>0.08</td>
</tr>
<tr>
<td>Lead (except tetraethyl lead)</td>
<td>0.007</td>
</tr>
<tr>
<td>Manganese (as MnO2)</td>
<td>0.1</td>
</tr>
<tr>
<td>Mercury (metallic)</td>
<td>0.003</td>
</tr>
<tr>
<td>Nitric acid (as hydrogen ion)</td>
<td>0.1</td>
</tr>
<tr>
<td>Nitrogen oxides (as NOx)</td>
<td>3</td>
</tr>
<tr>
<td>Phenol</td>
<td>3</td>
</tr>
<tr>
<td>Sulfuric acid (as hydrogen ion)</td>
<td>0.1</td>
</tr>
<tr>
<td>Total solid particulate matter†</td>
<td>5</td>
</tr>
</tbody>
</table>

* Emission rate above which it is necessary to submit a report to the government; where discharge is for less than 1 hr, there is a proportionate reduction in emission permissible without such reporting.
† Maximum SiO₂ content 20 percent.
Other Countries

In the U.S.S.R. and the other eastern European member states of the Council for Mutual Economic Aid, there has been a tendency until now to rely solely on air quality standards and not to adopt official emission standards. Czechoslovakia is an exception (Table 19). A few of the countries other than those already discussed (Tables 20 and 21) have adopted emission standards for specific pollutants. A more widespread coverage may be expected in the future.

<table>
<thead>
<tr>
<th>Substance</th>
<th>Source of emission</th>
<th>Original units</th>
<th>mg/cu m stp</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>As the element</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>As the trioxide</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>As the element</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td>As the element</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Hydrogen fluoride</td>
<td></td>
<td>0.05 grain/cu ft</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulfide</td>
<td>ppm</td>
<td>7.5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>As the element</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>As the element</td>
<td>0.01 grain/cu ft</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>Nitric acid plants</td>
<td>1 grain/cu ft</td>
<td>2,300</td>
<td>1,280</td>
</tr>
<tr>
<td>Sulfur dioxide*</td>
<td>Metallurgical plant SO₂ recovery</td>
<td>2 grains/cu ft</td>
<td>4,600</td>
<td>2,560</td>
</tr>
<tr>
<td>Sulfuric acid</td>
<td>Sulfuric acid manufacture</td>
<td>3 grains/cu ft</td>
<td>6,900</td>
<td>2,650</td>
</tr>
<tr>
<td></td>
<td>Total solid particulate matter greater than 10 microns</td>
<td>0.2 grain/cu ft</td>
<td>460</td>
<td></td>
</tr>
</tbody>
</table>

* New South Wales only.
† Or efficiency of condensation of acid gases greater than 99 percent.

<table>
<thead>
<tr>
<th>Country</th>
<th>Source of emission</th>
<th>Original units</th>
<th>mg/cu m stp</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium.......</td>
<td>Lead and zinc smelting</td>
<td>1 part/1,000 parts</td>
<td>2,600</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>Combustion:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 1 million kcal/hr</td>
<td>1 g/1,000 kcal</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>More than 1 million kcal/hr</td>
<td>4 g/1,000 kcal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paris, France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
STACK HEIGHT STANDARDS

The principal other type of air pollution standard is that which requires certain minimum stack heights.

FUEL STANDARDS

Emission standards limiting the emission of sulfur dioxide and smoke can be complied with by controls on either process or fuel. However, some jurisdictions have chosen to limit directly the sulfur content of fuel or the volatile matter content of coal that may be burned in the jurisdiction.
Part 2: Water Quality Criteria and Standards for Industrial Effluents

This year, approximately fifty thousand billion gallons of water will be fed into United States industrial plants and power generating facilities. Much of this water must first be treated in order to qualify it for the intended application. Such treatment may be quite simple or relatively complex but in most cases is amply justified by engineering or economic facts of life. Not every gallon reentering the free water domain as effluent matches its quality as an influent. A considerable quantity of effluent fails to meet quality requirements, still ill-defined, but nonetheless real, needed to prevent pollution. This pollution may be grossly evident as oil slick, foam, floating debris, or marked turbidity. It may, on the other hand, be manifest only in diminution or alteration of aquatic life, altered taste, or high concentrations of relatively nontoxic chemicals. Naturally, attention is directed most at those losses of water quality in which the industrial effluents are rendered unfit for their intended use as water for public consumption; maintenance of fish and wildlife; agriculture; recreation; or as influent, after standard treatment, in a downstream manufacturing facility.

Generally applicable control criteria and standards have been difficult to establish because of the variability of plant location, water sources, and processes and the practical need for controls. Agreement among even the foremost authorities in the field has been difficult to achieve.

The federal government has acted through the Federal Water Pollution Control Act as amended by the Water Quality Act of 1965 to initiate the establishment of standards and criteria for water pollution control.
Under the terms of the act such controls were to originate at the state level whenever possible. Only in those cases in which the states did not specify criteria and standards in time to meet the June 30, 1968, deadline was the government to take it upon itself to establish "permissible" and "desirable" criteria. These criteria have recently been proposed by the National Technical Advisory Committee on Water Quality Criteria, reporting to the Federal Water Pollution Control Administration.

Industry must now take a hard look at these criteria in an effort to find the most effective and expeditious manner in which to comply. In its own best interests, industry should remain alert to the possibility that criteria* have been established which cannot be met practically and for which justification may not be entirely clear. However, in reviewing these criteria, it must be kept in mind that pollution problems require a 100-year bookkeeping outlook rather than the more customary 3- to 5-year payout. Because this long-range view is necessary, the problem is one which cannot be borne by industry alone. Society as a whole must carry its share of this responsibility.

The pollutant capability of a manufacturing facility or power generating station effluent is a function of the nature of that effluent and of the intended use of the body of water which receives it. That is, industrial pollution may be quantitated in each instance in terms of the way in which an effluent affects the evaluated use of the receiving body of water. For example, waters used downstream for cattle farming may safely contain up to 1 g/l of SO$_4^{--}$. If these same waters were to be used also as public waters, the recommended upper limit for SO$_4^{--}$

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* There has recently been considerable controversy concerning the interpretation by the FWPCA and Mr. Udall that water supplies in any of the categories covered under the Act may not be subjected to any form of degradation, even if such degradation yields a water quality above that permitted under the criteria and standards suggested by the Committee on Water Quality Criteria.
is 0.25 g/l. A logical analysis preliminary to the establishment of water pollution control standards can be based upon the division of water sources into major end uses. The FWPCA Committee divides water end uses into five major categories. These are (1) public supply, (2) recreation and aesthetic value, (3) preservation of fish and wildlife, (4) agricultural use, and (5) industrial use.

The intended end use of water determines the degree of pollution permissible by certain specific constituents or characteristics. The concentration at which the designation "pollutant" is earned varies for each constituent from relatively high levels to any detectable quantity.

Pollutants directly attributable to industrial processes may be categorized as physical, chemical, and radioactive. Current criteria and standards for pollution control, based upon the recommendations of the Committee on Water Quality Criteria acting through its subcommittees, may be described by breaking down these large categories of pollutants into their major individual constituents.

PHYSICAL POLLUTANTS

Color

The presence of color in water may not necessarily be due to waste discharge from upstream facilities. Color in many instances is added to the watercourse because of the presence of decaying vegetation and bacteria.

Among the industries which commonly contribute to water color are the pulp and paper, textile, petrochemical, and chemical industries.

In general, the standards for color in waters designated for recreation and aesthetic use are not specified other than to contain the recommendation that surface waters should be free from all substances attributable to discharges or waste which produce objectionable color.
This includes waters classified as primary contact* waters and those designated for secondary contact such as boating and fishing.

The criterion now designated as "permissible criterion" for color in waters used for public water supply is 75 color units (platinum cobalt—standard). A value less than 10 color units is the recommended "desirable criterion." The criterion for color, as for other pollutants, of public water supplies is, in many cases, established on the basis of water quality attained by specific standard treatment methods. The water under evaluation is not to have been treated more vigorously than by coagulation employing 50 ppm alum, ferric sulfate, or copperas with alkali addition as necessary but without the use of coagulant aids or activated carbon; 6 hr. of sedimentation; rapid sand filtration at 3 gal/sq ft/min; and disinfection with chlorine.

Colors which result from dyes and from other industrial and processing sources cannot be measured by the platinum cobalt test standard. They should be present only in concentrations which can be removed by the standard water treatment plant. In addition to color removals obtained through processes for treatment of other waste constituents, removals are obtained by standard chemical precipitation methods with associated absorption by the precipitant of flocculant. Carbon adsorption can be applied to the more difficult color removal problems.

Waters designated for maintenance of fish, other aquatic life, and wildlife require color standards. This is required because 10 percent of the light striking the surface of a body of water must arrive at the bottom of any photosynthetic zone in which it is desired to maintain adequate dissolved oxygen concentrations. Color in excess of 50 units may limit photosynthesis and by reducing dissolved oxygen levels.

*Primary contact recreation is defined as that recreational use in which there is such intimate contact with the water that ingestion of significant amounts is probable. Secondary contact recreation refers to the use of water in which significant ingestion is unlikely.
disturb the balance between aquatic life form.

In the case of marine and estuary waters, color additions should be limited to those which have been shown conclusively not to be deleterious to aquatic life.

For agricultural waters, it has been recommended that color not exceed 15 color units on the basis that such excess becomes aesthetically objectionable although it may not represent a health hazard.

Table 22 lists, among other constituents, allowable color concentrations for point of use waters in the power generating, textile, paper, petrochemical, and chemical, food, and cement industries. These values then are tolerable levels after recommended water treatment. Success in achieving these values with only the basic treatment system depends largely on the nature of upstream effluents, if any.

Temperature

In some instances, the most economic solution to a thermal pollution problem is more effective utilization of heat in the process systems or better heat recovery by higher-efficiency heat exchangers. For the thermal pollution problem associated with large volumes of waste cooling water and minimal temperature difference, the application of cooling towers and recirculation of cooling water through the system is a most practical answer.

It is recommended that for primary contact recreation waters, water temperature should not exceed 85°F (30°C), except where higher temperatures are caused by natural phenomena. It has been found that prolonged exposure to waters warmer than 85°F may produce undesirable physiological effects.

For public water supplies it is again recommended that water temperature not exceed 85°F and that there not be more than a 5°F water temperature increase or variations greater than 1°F/hr above
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Power generation</th>
<th>Textile</th>
<th>Pulp and paper</th>
<th>Chemical process</th>
<th>Petroleum</th>
<th>Food</th>
<th>Soft drink</th>
<th>Cement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardness (CaCO₃)</td>
<td>0-20*</td>
<td>25</td>
<td>100</td>
<td>250-900</td>
<td>350</td>
<td>250</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>pH, units</td>
<td>8-10*</td>
<td>2.5-10.5†</td>
<td>6-10</td>
<td>6.2-8.7</td>
<td>6-9</td>
<td>6.5-8.5</td>
<td>†</td>
<td>†</td>
</tr>
<tr>
<td>Calcium, mg/l</td>
<td>0</td>
<td></td>
<td>20</td>
<td>60-100</td>
<td>75</td>
<td>100</td>
<td>100</td>
<td>250</td>
</tr>
<tr>
<td>Chlorides, mg/l</td>
<td>No problem</td>
<td></td>
<td>200-1,000</td>
<td>500</td>
<td>300</td>
<td>250</td>
<td>500</td>
<td>250</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.01-0.3</td>
<td></td>
<td></td>
<td></td>
<td>0.01-0.2</td>
<td>0.2</td>
<td>0.05</td>
<td>0.5</td>
</tr>
<tr>
<td>Iron, mg/l</td>
<td>0.01-1*</td>
<td>0.1-0.3</td>
<td>0.1-0.3</td>
<td>1</td>
<td>0.2</td>
<td>0.3</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Color units</td>
<td>No problem</td>
<td>5</td>
<td>10-30</td>
<td>20</td>
<td>No problem</td>
<td>5</td>
<td>10</td>
<td>No problem</td>
</tr>
<tr>
<td>Alkaline (CaCO₃)</td>
<td>40-140</td>
<td>5</td>
<td>10</td>
<td>125-200</td>
<td>250</td>
<td>85</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Suspended solids</td>
<td>0-10</td>
<td>5</td>
<td>10</td>
<td>5-30</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>500</td>
</tr>
</tbody>
</table>

* A function of boiler pressure.
† Depending upon operation (sizing, bleaching, scouring, etc.).
‡ Controlled by treatment for other constituents.
that caused by ambient conditions. Any water temperature change adversely affecting the aquatic life, taste, odor, or chemistry of the water is to be avoided. Likewise any variation which adversely affects water treatment facilities or which decreases the acceptance of water for drinking or cooling purposes is to be avoided.

For waters in which a well-rounded population of warm and cold water fishes is to be preserved, it is recommended that heat not be added to a body of water at any time in amounts greater than that which will raise the temperature of the water flowing at the minimum daily gpm more than 5°F. For certain surface water zones in lakes this recommended temperature rise should not exceed 3°F. These increases should be calculated on the monthly average of maximum daily temperatures.

In general, cooling water should not be pumped from the constant temperature zone near the bottom of a lake to be discharged into the same body. Discharge of a heated effluent into this zone is not recommended. Normal daily and seasonal temperature variations present before the addition of artificially provided heat should be maintained. Table 23 lists the currently recommended maximum temperatures compatible with spawning and growth requirements for various fish species.

Preservation of marine and estuarine organisms requires that there not be more than a 4°F rise in temperature associated with the addition of heat of artificial origin to coastal and estuarine waters during the months September through May. There should not be more than a 1.5°F rise during the summer months.

Temperature variations are not considered critical in waters destined for agricultural use, except in those cases where large quantities of water are used for hydro-cooling farm products.
Odor and Taste

In general, odor in water is due to the presence of dissolved gases, such as hydrogen sulfide, and the presence of volatile organic compounds. When the threshold odor value exceeds three units, based on n-butyl alcohol calibration tests, it is generally considered objectionable. The criterion for water quality with respect to odor is simply that it not be objectionable.

Taste is an important factor in that it may be a direct indication of the presence of dissolved inorganic salts of iron, zinc, manganese, copper, sodium, potassium, et al. Certain inorganic and organic constituents may taint fish and other marine organisms, imparting characteristic tastes. The hydrocarbons, phenolic compounds, sodium pentachlorophenate, coal tar wastes, and the wastes from sewage, coal coking, kraft paper, and petroleum processes among others may contribute to the production of objectionable tastes in water or aquatic life. Chlorophenol, for example, has been found to produce an unpleasant taste in fish at concentrations of only 0.0001 mg/l.

Copper concentrations of 0.019 mg/l seem quickly to impart a green color and characteristic unpleasant taste to oysters. These organisms seem to have special capacity to absorb, store, and concentrate certain metals and nonmetals, demonstrated dramatically by the so-called superiodized oysters produced in France before World War II.

Taste and odor in water supplies may also result from natural phenomena such as decaying vegetation, algae, or bacterial slime. As in the case of color removal, taste and odor may also be removed through processes for treatment or control of other waste constituents. Processes employed for taste and odor removal are coagulation, carbon adsorption, aeration, and oxidation with chlorine or other oxidizing agents.
Turbidity

In most cases turbidity is caused by suspended clay or silt, dispersed organics, and microorganisms.

The desirable criterion for public water supplies is that there be virtually no turbidity, that is, that there be low levels and that it not be objectionable. Moreover, the basic water treatment plant must be able to remove it adequately, continuously, and at reasonable cost. Since water treatment plants for turbidity removal are designed for the specific application, increases or fluctuations in turbidity loading above the capacity of the plant are considered excessive.

The common operations employed for the removal of turbidity are coagulation or flocculation, sedimentation, and filtration.

Methods used for measuring turbidity customarily may not adequately measure characteristics harmful to a public water supply. Since water with a given turbidity may coagulate more rapidly than one with less turbidity with or without the addition of coagulation aids, the establishment of turbidity criteria in terms of standard units has not been possible.

For waters designated for aquatic life preservation, turbidities due to the discharge of waste should not exceed 50 Jackson units* in warm water streams or 10 Jackson units in cold water streams.

Turbidities in warm water lakes should not exceed 25 Jackson units, and cold water lake turbidity should not exceed 10 units. For agricultural waters, it should not exceed 5 units, mainly on the basis of aesthetics.

CHEMICAL POLLUTANTS

pH

Control of effluent pH obviously requires adjustment of the hydrogen or hydroxyl ion concentrations. This can be effected by the addition of

*Based on the Jackson candle turbidimeter, commonly read with a direct reading colorimeter calibrated in Jackson units.
alkalies or acids as required. Adjustment of the hydrogen or hydroxyl ion can also be accomplished by the indirect application of acids and bases through use of ion exchange systems operated on a hydrogen or hydroxide cycle. Fixed bed or continuous systems may be used. Continuous systems, when applicable, offer higher efficiencies.

For primary contact recreation waters, it is recommended that the pH be in the range 6.5 to 8.3, in no case falling below 5 or rising above 9. Such criteria are based largely upon the physiology of the human eye and specifically upon the buffering capacity of tears.

For public water supplies the permissible criterion is 6.0 to 8.5.

Waters in which aquatic life is to be maintained should not be exposed to a pH below 6.0 or above 9.0. In the case of saline waters, materials which alter the pH by more than 0.1 unit should not be introduced. At no time in this case should the pH be less than 6.7 or greater than 8.5. It has been noted that aquatic plants of greatest value as waterfowl foods grow optimally in waters in which the pH ranges from 7.0 to 9.2.

Agricultural waters are by and large immune to nondrastic changes in pH, tolerating values between 4.5 and 9.0.

Alkalinity

Any of the standard techniques for neutralization may be used for control of alkalinity.

Alkalinity in public water supplies should be sufficient to cause effective floc formation but not high enough to be toxic or to produce a corrosive or encrusting water.

Alkalinity is determined by the relative amounts of bicarbonate, carbonate, and hydroxide ions. It is also related to pH and calcium content. In general alkalinity should not be less than 30 mg/l, based
upon 500 mg/l dissolved solids and a pH range of 6.0 to 8.5. Values higher than 400 to 500 mg/l are considered too high for public water supplies, except when normal for the water source. Since processing control is impaired by frequent variations from normal values, such variations should be minimized.

In order to maintain the proper chemical balance for preservation of aquatic life, it is recommended that no highly dissociated materials be added to water supply in quantities sufficient to induce pH changes above or below the range of 6.0 to 9.0. In order to protect the carbonate buffering system, acid should not be added in quantities which lower the total alkalinity below 20 mg/l, expressed as CaCO₃. Some weakly ionized materials may exert their prime effect upon aquatic life not in terms of pH changes but as the result of the formation of toxic substances. For example, such weakly dissociated compounds as HCN, HC10, and H₂S may be toxic because the anion formed or the undissociated molecule itself is harmful.

Total Dissolved Solids

Removal of total dissolved solids (TDS) from waste waters per se is one of the more difficult and, in many cases, more expensive waste treatment procedures. Where high total dissolved solids are associated with the heavy metals or hardness, reduction may be accomplished by precipitation operations. Where the total dissolved solids are present as sodium or potassium compounds, total dissolved solids reduction may require distillation or ion exchange and then an effective method for disposal of the ion exchange regenerant wastes.

Deep-well disposal of brines from oil field operations is common. Most often TDS disposal requires controlled discharge to the receiving body.

It is recommended that total dissolved solids not exceed 500 mg/l for public water supplies. High values for TDS may exert adverse economic effects and harmful physiological effects, primarily osmotic,
and may impart taste or odor. High levels of sulfate and chloride are often associated with corrosion of water system components.

In general, it may be said that the concentration of dissolved materials in natural fresh waters may be somewhat below the optimum levels for preservation and promotion in aquatic life. Thus, it may be that the addition of dissolved solids to a water supply benefits aquatic life in the receiving body. However, there exist upper tolerable limits beyond which osmotic effects cause dehydration of tissue cells.

It is recommended that for maintenance of fauna, total dissolved materials in a watercourse not exceed 50 millimoles, equivalent to 1.5 g/l of NaCl. Such a recommendation assumes that the dissolved constituents are fundamentally innocuous. In those cases in which there is toxicity associated with any constituent, the level must be lowered accordingly. Further, it is recommended that total dissolved materials not exceed more than one-third the concentration normal for that water source. This latter prohibition is based upon the fact that aquatic life food sources, such as diatoms, may be more sensitive to dissolved materials than the organisms they feed. Destruction of the food source may then result not only in kill-off of desirable organisms but in the overgrowth of nuisances.

For marine waters, it is recommended that industrial effluents not alter the salinity of the water strata more than ± 10 percent of the natural variation.

TDS levels in water destined for agricultural uses may be as high as 2,000 to 4,000 mg/l when carefully used for tolerant plants in permeable soil. Usually, concentrations below 500 mg/l are preferred since there are few detrimental effects at this level.

Ammonia

Ammonia is a by-product of many industrial processes. It is produced in greatest quantity by the distillation of coal for the production
of gas, coke, and compounds used in the manufacture of chemicals for the textile and chemical process industries. For the most part ammonia recovery processes are employed in these operations, but often the level of ammonia in the process effluent rises to 1.0 mg/l as \( \text{NH}_3 \). The waste products are principally free ammonia cyanide, and thiocyanate salts and a variety of aromatic compounds.

Past practice for ammonia removal from waste effluents has been by stripping or lime addition to decompose ammonia salts followed by stripping. Ammonia is effectively reduced by biological treatment. Lesser concentrations may be discharged to a secondary treatment plant where ammonia is consumed in the biological process. In cases where the nutrient balance is not favorable, it may be necessary to supplement phosphorus for effective ammonia reduction.

The permissible criterion for ammonia levels has been established as 0.5 mg/l in waters designated as public water supplies. The desirable criterion is less than 0.01 mg/l. Excessive ammonia requires higher feed of chlorine for effective disinfection.

Aquatic life exposed to levels of 1 mg/l may suffocate because of the significantly reduced oxygen combining capacity of blood. For preservation of aquatic life, ammonia pollution must be evaluated in terms of the most sensitive organism in receiving waters considered to be of economic or ecologic importance. It is necessary to determine the life stage in which this most sensitive organism is most vulnerable to ammonia and then to use an application factor* of 1/20 for tests carried out on this reference organism in order to determine the safe concentration.

* The ratio of the safe concentration of a given pollutant under prescribed conditions to the 96-hr median tolerance limit (\( \text{TL}_m \)) is called the application factor for that pollutant. It permits rapid calculation of the safe concentration, having determined the 96-hr \( \text{TL}_m \). The 96-hr \( \text{TL}_m \) is that concentration of the pollutant which is lethal for 50 percent of the test organisms exposed to it for 96 hr. \( \text{TL}_m \) should not be confused with the safe limit.
Arsenic

Arsenic pollution is often associated with the manufacture or use of herbicides and pesticides. It may be a by-product of mining operations.

Where arsenic is present as a pollutant with heavy metals, treatment by precipitation of the heavy metals will lead to a reduction of approximately 90 percent of the initial arsenic. The mechanism is not well understood but may be due to precipitation of arsenic as a complex with the heavy metal ions.

The permissible criterion for presence of arsenic in public water supplies is 0.05 mg/l. The desirable criterion is complete absence. The basic treatment plant exerts little or no effect upon the concentration of arsenic in influent waters.

Arsenic hydride and the trioxide are especially toxic. Arsenate acts by tying up active sites in cellular substituents. The situation is not always so clear-cut. For while arsenic is a notorious poison, arsenical "dips" have been used recently for livestock and arsenic compounds in low dosages are added to poultry feed as coccidiostatics. Sodium arsenate, when present in livestock water supplies at levels of 5 mg/l functions in some unknown way to reduce the toxicity of selenium in those same waters. A tolerance level of 1 mg/l has been established for irrigation waters.

Toxic doses or arsenic vary widely with the animal species, as indicated in Table 24.

The tissues of many organisms accumulate arsenic. Its harmful effects may therefore be delayed when the water concentration is low--but are lethal nonetheless.

Barium

The permissible criterion for barium in public waters is 1.0 mg/l.
Barium may exert its detrimental physiological effect by forming a barium sulfate precipitate, thus effectively diminishing sulfate ion concentration below body requirements.

Boron

Industrially, boron pollution occurs as the result of the manufacture or use of synthetic boranes. Boron may be present naturally in concentrations as high as 15 mg/l, particularly in the Western United States. The permissible criterion for public water supply is 1.0 mg/l. Ideally, it should be absent.

Boron is toxic for many organisms in concentrations as low as 1 mg/l, while other organisms tolerate levels above 15 mg/l. Boron is an essential plant nutrient in concentrations up to 0.5 mg/l. On the other hand irrigation waters containing more than 0.5 mg/l have caused destruction of such sensitive crops as apples, citrus fruits, and nuts. Generally, water containing more than 4 mg/l of boron is unsatisfactory for all crops.

Boric acid concentrations up to 2,500 mg/l are tolerated by many organisms, although inhibition of growth has been noted.

Cadmium

Cadmium is used widely by industry in the production of copper, lead, silver, and aluminum alloys. It also is used in metal finishing, ceramic manufacture, and photography and is a by-product of nuclear reactor operation. Salts of cadmium are used as insecticides and as antiparasatic agents.

Cadmium may be removed from waste water by precipitation as the metal hydroxide. Recovery of the metal by ion exchange can be economically attractive in some instances.

The permissible criterion for cadmium in public water supplies is 0.01 mg/l. Cadmium is especially dangerous, since it may combine synergistically with other toxic substances. Its principal effect upon aquatic life is the inhibition of bivalve shell production in mollusks.
Cadmium has been reported in concentrations as high as 3.2 mg/l in the waters off Long Island, New York. Such concentrations are the result of electroplating, textile, and chemical process operations.

Cadmium toxicity has been implicated in serious cardiovascular diseases in man. Therefore, based upon current knowledge, agricultural waters should not contain more than 0.005 mg/l in order to prevent cumulative toxicity in crops headed for market.

Chloride

Chloride and sulfate wastes are more closely associated with high total dissolved solids, and control of chloride waste is accomplished in much the same way as control of total dissolved solids.

It is recommended that chloride concentration not exceed 250 mg/l and that ideally it be less than 25 mg/l.

High chloride concentrations may result from oil field operations or from industrial effluents associated with papermaking, galvanizing, and water conditioning. Fortunately, this ion is not toxic in less than extreme concentrations and so does not present a major pollution problem.

Chromium

Chromium compounds may be present in industrial wastes from a wide variety of processes including tanning, electroplating, and cooling tower effluents.

Chromium wastes lend themselves to chromate recovery as commonly practiced in the metal plating industry. For final disposal, chromium is precipitated as the metal hydroxide after reduction of chromium to the trivalent state. Another less common practice is precipitation of chromium by addition of soluble barium salts.

For public water supplies chromium in the hexavalent form should not exceed 0.05 mg/l and preferably should be absent entirely.
The toxicity of chromium varies with pH, temperature, the organism exposed and the valence form. In any given form, toxicity may vary with the presence of other compounds.

For agricultural waters, tolerances of chromic and chromate ions varies with the plant species. More sensitive plants are adversely affected by concentrations of 5 mg/l.

Copper

Control of copper wastes and iron, lead, manganese, and zinc wastes is most commonly effected by precipitation as the metal hydroxides. Precipitation is usually effected at a pH between 7 and 9.

Public water supplies may tolerate as a permissible criterion 1.0 mg/l. A desirable criterion of virtual absence has been expressed. In general, excess copper is highly toxic to algae, sea plants, and invertebrates but is only moderately toxic to mammals. The relationships between concentrations of different heavy metals in a water supply are extremely important in the determination of ultimate copper toxicity. Positive and negative synergistic effects make necessary the individual evaluation of each situation.

Kills of 35 to 100 percent of primitive fresh water plant forms were obtained with copper concentrations as low as 0.5 mg/l. Concentrations of copper above 0.1 mg/l were found to be toxic for oysters. Lobsters transferred to tanks lined with copper, after living in aluminum, stainless steel, and iron tanks for 2 months, died within a day.

For agricultural waters, it appears that copper toxicities are more feed related than water related. It should be noted, however, that copper toxicities have been observed at copper concentrations as low as 0.1 mg/l in plant nutrient waters. Table 25 lists maximum safe concentrations for some trace ions.
### TABLE 23 Maximum Recommended Temperatures for Development of Various Fishes

<table>
<thead>
<tr>
<th>Max temp, °F</th>
<th>Spawning and/or egg development</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>Lake trout, walleye, northern pike, Atlantic salmon</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Salmon, trout</td>
<td></td>
</tr>
<tr>
<td>68</td>
<td>Perch, smallmouth bass</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>Largemouth and other bass</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Catfish, shad</td>
<td></td>
</tr>
<tr>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 24 Relative Resistance of Some Animal Species to Arsenic Intoxication

<table>
<thead>
<tr>
<th>Animal</th>
<th>Index of Resistance to the Toxic Effects of Arsenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry</td>
<td>1</td>
</tr>
<tr>
<td>Dogs</td>
<td>2</td>
</tr>
<tr>
<td>Swine</td>
<td>10</td>
</tr>
<tr>
<td>Sheep, goats, horses</td>
<td>200</td>
</tr>
<tr>
<td>Cattle</td>
<td>300</td>
</tr>
</tbody>
</table>

### TABLE 25 Maximum Safe Concentrations for Trace Ions

<table>
<thead>
<tr>
<th>Trace Ion</th>
<th>Allowable Concentration in Farmstead Waters, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>0.05†</td>
</tr>
<tr>
<td>Barium</td>
<td>1.00</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.01†</td>
</tr>
<tr>
<td>Chromium (Cr**)</td>
<td>0.05†</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0*</td>
</tr>
<tr>
<td>Cyanides</td>
<td>0.20</td>
</tr>
<tr>
<td>Iron</td>
<td>0.30*</td>
</tr>
<tr>
<td>Lead</td>
<td>0.05†</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.05*</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.01†</td>
</tr>
<tr>
<td>Silver</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc</td>
<td>5.0*</td>
</tr>
</tbody>
</table>

* Recommended limits.
† Also the maximum allowable concentration in farm animals' water supplies.
Iron

The permissible criterion for iron in the filterable form for public water use is 0.3 mg/l. Again, as with the pollutants described above, the defined water treatment plant is relatively ineffective for iron removal.

In general, iron is one of the less toxic pollutants. Criteria for waters designated for the preservation of aquatic species do not specifically define upper limits for iron. Statements on standards relating to the use of iron bearing waters for agriculture are confined either to the lack of available data or the assertion that iron is not likely to be a problem.

Lead

A permissible criterion of 0.05 mg/l and complete absence as a desirable criterion are the FWPCA's Committee on Water Quality Criteria recommendations for public waters. Lead may arise as a contaminant of groundwaters both from natural sources and in the form of various industrial and mining effluents. A major problem with lead pollution is that the element is a cumulative poison. There is considerable variation in the toxicity of lead, depending upon the form of the element. Drinking water supplies for animals should not contain concentrations of lead exceeding 0.5 mg/l. For irrigation waters an upper limit of 5 mg/l is proposed.

Manganese

A permissible criterion of 0.05 mg/l has been proposed for public water supplies. In general, toxicity data on manganese for aquatic life and agricultural waters are not readily available. Cattle fed up to 600 mg/kg for 20 to 45 days suffered no serious effects.
Phosphorus

Unnaturally high phosphorus concentrations may be the result of animal and plant processing or fertilizer and chemical manufacturing operations.

The ultimate effect of high phosphorus effluents depends upon a highly complex set of factors which have made establishment of generally acceptable limits impossible.

However, it can be said generally that total phosphorus concentrations above 50 mg/l contribute to the overgrowth of objectionable plant forms.

When the concentration of complex phosphates is greater than 100 mg/l, coagulation processes may be adversely affected. Another effect of high phosphorus is that it may bring about oxygen depletion in a body of water. This results from the requirement for 160 mg of O₂ to oxidize completely 1 mg of phosphorus from an organic source.

Selenium

Selenium, when present with heavy metals in a waste stream, will be removed in much the same way as arsenic is removed in heavy metal precipitation.

It is recommended that the value 0.01 mg/l be established as the permissible criterion for the presence of selenium in public water supplies. As a desirable criterion complete absence is recommended.

Selenium is toxic for animals when it accumulates in tissue at the level of 5 mg/kg. On the other hand, it is an essential trace mineral and is commonly fed in quantities sufficient to cause accumulations of 1 to 2 mg/kg.

The tolerance limits for selenium should be based upon animal toxicity rather than toxicity in plants. It is not uncommon for plants
to accumulate concentrations of selenium well above the levels toxic for animals if irrigating waters permit these accumulations. It has been suggested, therefore, that the concentration of selenium in waters used for irrigation not exceed 0.05 mg/l.

Uranyl ion

The permissible criterion for uranyl ion is 5 mg/l. Preferably, it should be absent. The standard for uranyl ion (UO$_2$$^-$) is drawn on the basis of its chemical properties rather than on the basis of its radioactivity. The ion is of concern in public water supplies because of the possibility of renal damage.

Taste and color appear in water at a level of 10 mg/l—a level considerably lower than the concentration at which physiological damage is manifested. The standard of 5 mg/l is established rather arbitrarily at one-half that at which taste and color appear, providing a considerable safety margin.

Zink

Zinc bearing effluents may be the result of primary metal and chemical process operations, among others.

It is recommended that zinc be present in public water supplies in concentrations no higher than 5 mg/l. Ideally, it would be virtually absent.

A complex relationship exists between zinc concentration, dissolved oxygen, pH, temperature, and calcium and magnesium concentrations. Prediction of toxicities has been less than reliable, and controlled studies on separate effects have been little documented.

For any given sensitive organism, a concentration of 1/100 of the 96-hr TL$_{50}$ is considered a safe level.

Zinc is normally found in seawaters at a concentration of 0.01 mg/l.
Marine life may contain zinc in concentrations up to 1,500 mg/l. It has been determined, however, that levels of 10 mg/l cause a 50 percent inactivation of photosynthesis in certain kelp.

A variety of fresh water plants tested manifested toxic symptoms at concentrations of 10 mg/l. For this reason a tolerance limit of 5 mg/l is proposed for irrigation waters.

Nitrates and Nitrites

The permissible criterion for nitrates and nitrites (determined as N) in public water supplies is 10 mg/l. It is desirable that they be virtually absent. Nitrite is included in this recommendation because it reacts with the oxygen-carrying pigment in blood, hemoglobin, to produce a compound which is a less effective oxygen transporter and may produce serious physiological effects.

Conversion of nitrates to nitrites in the stomachs of ruminant animals may produce this effect (at levels above 2,800 mg/l of nitrate). High nitrate concentration may also favor the growth of undesirable plants.

Sulfate and Sulfide

Sulfides and their oxidation products, sulfates, are found in water as the result of natural processes and as the by-product of oil refinery, tannery, pulp and paper mill, textile mill, chemical plant, and gas manufacturing operations.

The recommended permissible criterion is not more than 250 mg/l of sulfate in public water supplies. Recommended desirable criterion is less than 50 mg/l.

Concentrations in the range of less than 1.0 to 25.0 mg/l of sulfides may be lethal in 1 to 3 days to a variety of fresh water fishes.

Sulfate levels of 2,000 mg/l have been found to cause progressive weakening and death in cattle.
ORGANIC CHEMICALS

Carbon Chloroform Extract (CCE)

Current recommendations subject to change with additional low-flow rate data are that 0.15 mg/l be regarded as the permissible criterion for the presence of organic materials, as determined by carbon chloroform extraction. New analytical techniques indicate that the 0.2 mg/l level specified in "Drinking Water Standards"* as determined by older, less reliable methods is actually 0.15 mg/l as determined by newer techniques.

In general, CCE determinations are considered too complex for application to farmstead water supplies. Instead, an estimate of the CCE may be based upon values in nearby municipalities using the same or smaller water sources.

Methylene Blue Active Substances

The permissible criterion for methylene blue active substances is 0.5 mg/l. They should be virtually absent.

Cyanide

The cyanides, represented by hydrocyanic acid and its salts, are important and ubiquitous industrial chemicals. They are extremely toxic, especially at low pH. It is thought that cyanide acts by inhibiting the phosphorylative oxidation reactions which permit cellular respiration.

Many lower animals and fishes seem to be able to convert cyanide to thiocyanate ion, which does not inhibit respiratory enzyme activity. Cyanide compounds formed by the reaction of CN⁻ with heavy metals may be even more toxic substances. For these reasons control of cyanide in

industrial effluents is extremely important.

As with many of the water constituents described previously, cyanide ion is unaffected by the basic water treatment plant.

Cyanide removal from industrial effluents is commonly affected by the stagewise application of lime and chlorine, which progressively oxidizes cyanides to cyanates and then to carbon dioxide and nitrogen. In many European operations this process goes no further than the cyanide to cyanate conversion.

A permissible criterion of 0.20 mg/l and a desirable criterion of complete absence from public waters are the recommendations of the FWPCA Water Quality Committee.

It is recommended that for preservation of aquatic life, cyanide be determined by the flow-through bioassay method with particular attention paid to standardization of dissolved oxygen, temperature, and pH.

Oil and Grease

Oil and grease pollution may be the result of bilge and ballast water; refinery and industrial plant wastes resulting from the lubrication of machinery; rolling mills; gasoline filling stations; and fat manufacture or processing.

Oil and grease should be absent from industrial effluents — virtually absent as a permissible criterion and completely absent preferably. The specification of the subcommittee that no oils or greases be present in water supplies is based upon the troublesome taste and odor problems associated with even minute quantities in a water supply. Moreover, even very small quantities produce scum lines on water treatment facilities, swimming pools, retention basins, reservoirs, and other containers.

An oil slick is just barely visible at concentration of approximately 25 gal/sq mile. When the oil concentration is 50 gal/sq mile, an oil film three-millionths of an inch thick is visible as a silvery surface sheen.
Oils coat the gill filaments of fish, producing suffocation in low concentration. Some crude oils contain a water soluble fraction which is highly toxic to fish life. Oil and greases may, moreover, coat and destroy algae, plankton, and bottom dwelling organisms. Oil films may interfere with reaeration and photosynthesis and destroy aquatic insect life. Crayfish weighing 35 to 38 g die in oil concentrations of 5 to 50 mg/l within 18 to 60 hr. Similar lethalities exist for other small marine organisms.

Oil is especially destructive to water birds and other aquatic life species. Its deleterious effects range from inhibition of egg laying and hatching to the destruction of water impermeable compounds normal to plumage and fur.

The effects of oil pollution have recently been tested extensively as the result of oil tanker wreckings. The literature is now replete with data on the toxicities, color, taste, and synergistic effects of oil pollution.

Pesticides and Herbicides

The permissible and desirable criteria for the presence of pesticides and herbicides in public water supply vary with the specific compounds and are shown in Table 26.

**BIOCHEMICAL OXYGEN DEMAND**

Biochemical oxygen demand (BOD) is a measure of the dissolved oxygen in a water supply needed to depose organic materials in a measured time and at a constant temperature. Adequate dissolved oxygen is a principal requisite for maintenance of aquatic life. It is also a factor in the corrosivity, septicity, and photosynthetic activity of a water supply.

To determine BOD, uptake from an independent supply is measured over
TABLE 26  Current Criteria for the Presence of Some Pesticides and Herbicides in Public Water Supplies

<table>
<thead>
<tr>
<th>Compound</th>
<th>Permissible criteria, mg/l</th>
<th>Desirable criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene (Aldrin)</td>
<td>0.017</td>
<td>Absent</td>
</tr>
<tr>
<td>1,2,4,5,6,7,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane (chlordane)</td>
<td>0.003</td>
<td>Absent</td>
</tr>
<tr>
<td>1,1,1-trichloro-2,2-bis (parachlorophenyl) ethane (DDT)</td>
<td>0.042</td>
<td>Absent</td>
</tr>
<tr>
<td>1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-endo-exo-octahydro-1,4,5,8-dimethanonaphthalene (Dieldrin)</td>
<td>0.017</td>
<td>Absent</td>
</tr>
<tr>
<td>Same as above except endo-end (Endrin)</td>
<td>0.001</td>
<td>Absent</td>
</tr>
<tr>
<td>1,2,3,4,5,6-hexachlorocyclohexane (Lindane)</td>
<td>0.050</td>
<td>Absent</td>
</tr>
<tr>
<td>1( or 3a),4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindane (Heptachlor)</td>
<td>0.018</td>
<td>Absent</td>
</tr>
<tr>
<td>1,1,1-trichloro-2,2-bis (paramethoxyphenyl) ethane (Methoxychlor)</td>
<td>0.035</td>
<td>Absent</td>
</tr>
<tr>
<td>Organic phosphates plus carbamates*</td>
<td>0.1</td>
<td>Absent</td>
</tr>
<tr>
<td>2,4-D plus 2,4,5-T plus 2,4,5-TP (herbicides)</td>
<td>0.1</td>
<td>Absent</td>
</tr>
</tbody>
</table>

Subject to expert toxicological evaluation. The specified concentrations are those deemed not to be harmful if ingested over extensive periods.
* Certain compounds or mixtures may require even lower concentrations.

TABLE 27  BODs of Typical Industrial Wastes

<table>
<thead>
<tr>
<th>Industry</th>
<th>Production unit</th>
<th>BOD, mg/l per production unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat packing</td>
<td>One hog</td>
<td>1,048</td>
</tr>
<tr>
<td>Dairy</td>
<td>1,000 lb raw milk</td>
<td>570</td>
</tr>
<tr>
<td>Beet sugar process water</td>
<td>Ton of raw beets</td>
<td>1,250</td>
</tr>
<tr>
<td>Brewery</td>
<td>bbl of beer</td>
<td>1,000</td>
</tr>
<tr>
<td>Paper mill (drinking)</td>
<td>Ton of paper</td>
<td>300</td>
</tr>
<tr>
<td>Pulp mill (sulfite)</td>
<td>Ton of pulp</td>
<td>443</td>
</tr>
<tr>
<td>Tanning (vegetable)</td>
<td>100 lb of hides</td>
<td>1,200</td>
</tr>
<tr>
<td>Laundry</td>
<td>100 lb of clothes</td>
<td>320</td>
</tr>
<tr>
<td>Oil refinery</td>
<td>bbl crude</td>
<td>20</td>
</tr>
</tbody>
</table>
a 5-day period in a system maintained at 20°C. At the end of the test the total amount of oxygen consumed is a measure of the requirements of the system over and above those supplied by the dissolved oxygen in the water source.

Chemical oxygen demand (COD) is a part of BOD and may be determined independently in a test requiring only the use of an oxidizing agent, potassium dichromate, and a sample of the receiving water. BOD determination is an important index of industrial pollution when organic material is deposited as an industrial waste in a receiving stream. In fact, organic material is the single largest constituent of industrial waste.

The principal factors in a waste stream with high BOD are (1) carbonaceous organic material normally degraded by aerobic microorganisms and the main, if not the only, oxygen-demanding constituent of sewage; (2) oxidizable nitrogen in organic or inorganic forms; (3) certain chemical reducing compounds such as ferrous iron, sulfite, and sulfides.

Major problems may arise when high BOD industrial effluents enter municipal sewage plants. Clogging or corrosion of the sewer system, hydraulic overloading of the equipment, or overloading of the grit chambers, screens, or comminutors are just a few of the attendant problems. Industrial wastes may reduce the efficiency of settling tanks and of solids removal. They may produce scum problems associated with high oil and grease content. In addition to problems which have a mechanical origin, certain toxic industrial wastes destroy microbiological populations required to degrade sewage.

The permissible criterion for dissolved oxygen in public water supplies is that it be greater than or equal to 4 as a monthly mean with near saturation as a desirable criterion. The average BOD of domestic sewage is approximately 100 to 300 mg/l, and sewage streams receiving industrial wastes should not have BODs greater than 100 mg/l if overloading of the system is to be avoided.
Table 27 lists BODs of typical industrial wastes based upon arbitrarily chosen units of production for each industry.

INTERNATIONAL WATER QUALITY CRITERIA AND STANDARDS

French Legislation

Drinking water standards French legislation establishes the maximum permissible concentrations of specific water constituents as indicated in Table 28.

Color in water must not exceed 20 units (platinum-cobalt colorimetric scale) and turbidity must not exceed 15 drops of a 1/1,000 alcohol solution of gum mastic, under normal operating conditions. The code permits turbidity up to 30 drops of mastic in 50 mm of optically clear water, for limited periods of time.

Suspended solids may not exceed 0.1 unit on the Baudrey clogging capacity test. In this test a water sample is passed through a fine fabric filter 1 sq. cm in area under a constant head of 10 cm. The volume of water passing through the element is collected until the water no longer emerges in a steady stream but flows discontinuously. At this point clogging capacity and, thus, an index of suspended solids may be derived from standard curves.

The total mineral content of any water for drinking may not exceed 2 g/l, and water must be free from any unpleasant smell or taste.

Under a more recent amendment, additional criteria have been established specifying low nitrate content, noncorrosivity, and sulfates below the level at which components of the water distribution network would be affected.

Total hardness should be less than 30 French degrees (300 ppm), preferably 12 to 15 French degrees (135 ppm). Drinking water must in no circumstances contain more than 2 mg/l of phosphorus pentoxide.
<table>
<thead>
<tr>
<th>Constituent</th>
<th>Maximum Permissible Concentration, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (as Pb)</td>
<td>0.1</td>
</tr>
<tr>
<td>Selenium (as Se)</td>
<td>0.05</td>
</tr>
<tr>
<td>Fluorides (as F)</td>
<td>1.0</td>
</tr>
<tr>
<td>Arsenic (as As)</td>
<td>0.05</td>
</tr>
<tr>
<td>Chromium (as Cr⁺⁺)</td>
<td>Undetectable</td>
</tr>
<tr>
<td>Cyanides</td>
<td>Undetectable</td>
</tr>
<tr>
<td>Copper (as Cu)</td>
<td>1.0</td>
</tr>
<tr>
<td>Iron (as Fe)</td>
<td>0.2</td>
</tr>
<tr>
<td>Magnesium (as Mn)</td>
<td>0.1</td>
</tr>
<tr>
<td>Zinc (as Zn)</td>
<td>5.0</td>
</tr>
<tr>
<td>Phenolics</td>
<td>Nil</td>
</tr>
<tr>
<td>Magnesium (as Mg)</td>
<td>250</td>
</tr>
<tr>
<td>Chlorides (as Cl)</td>
<td>250</td>
</tr>
<tr>
<td>Sulfates (as SO₄)</td>
<td>250</td>
</tr>
<tr>
<td>Nitrates:</td>
<td>2-5</td>
</tr>
<tr>
<td>(As N)</td>
<td>9-22</td>
</tr>
<tr>
<td>* From French legislation.</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 29 World Health Organization Standards for Portable Water**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (as Pb)</td>
<td>Max 0.1 mg/l</td>
</tr>
<tr>
<td>Selenium (as Se)</td>
<td>Max 0.05 mg/l</td>
</tr>
<tr>
<td>Arsenic (as As)</td>
<td>Max 0.2 mg/l</td>
</tr>
<tr>
<td>Chromium (as Cr⁺⁺)</td>
<td>Max 0.05 mg/l</td>
</tr>
<tr>
<td>Cyanide (as CN⁻⁻)</td>
<td>Max 0.01 mg/l</td>
</tr>
<tr>
<td>Total solids</td>
<td>Max 500 mg/l</td>
</tr>
<tr>
<td>Color</td>
<td>5 units</td>
</tr>
<tr>
<td>Turbidity</td>
<td>5 units</td>
</tr>
<tr>
<td>Taste</td>
<td>Unobjectionable</td>
</tr>
<tr>
<td>Odor</td>
<td>Unobjectionable</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Max 0.3 mg/l</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Max 0.1 mg/l</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Max 1.0 mg/l</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Max 5.0 mg/l</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Max 75 mg/l</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Max 50 mg/l</td>
</tr>
<tr>
<td>Sulfate (SO₄)</td>
<td>Max 200 mg/l</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>Max 200 mg/l</td>
</tr>
<tr>
<td>pH</td>
<td>7.0-8.5</td>
</tr>
<tr>
<td>(Mg + Na)SO₄</td>
<td>Max 500 mg/l</td>
</tr>
<tr>
<td>Phenolics</td>
<td>Max 0.001 mg/l</td>
</tr>
<tr>
<td>α emitters</td>
<td>Max 10⁻⁴ c/ml</td>
</tr>
</tbody>
</table>
French law states generally that any discharge or effluent entering a watercourse directly or indirectly and thereby harming or destroying fish or their sources of food may bring civil penalties including fines up to 5,000 French francs and terms of imprisonment up to 5 years.

Trade wastes The following regulations have been established regarding the preliminary disposal techniques for trade wastes in general. All effluents must be neutralized to a pH value between 5.5 and 8.5. When lime neutralization is employed, the upper limit may be 9.5.

The effluent must be reduced to a temperature not exceeding 30°C (86°F).

Discharges of cyclic or hydroxylated compounds or their halogen derivatives are prohibited.

Any discharge which contributes to the appearance of abnormal odor, taste, or color for water to be used as public supplies is likewise prohibited. An industrial effluent may not contain any product likely to emit toxic or inflammable gases or vapors. The effluent may not contain floating material or substances which may be destructive to fishes or their food.

World Health Organization Standards and Criteria

The standards represent, in general, the consensus of world opinion. The maximum allowable concentrations and permissible criteria are described in Table 29 for the principal pollutant characteristics or constituents of water.

United Kingdom Recommendations for Water Quality

In England and Wales there are more than 800 authorities or joint bodies acting to prescribe water standards — each under obligation to ensure that water sources remain unpolluted in the individual localities.
When pollution occurs, they are charged with the responsibility for tracking it down and eliminating the source.

Published British standards are especially concerned with bacterial contamination and do not speak specifically of industrial pollutants other than to specify generally that continuous analysis of water sources, surface waters particularly, is necessary in order to control pollution.
VI REFERENCES
VI. RESOURCE REFERENCES

These references indicate additional information available regarding the impact of various development projects on the environment. There is a reference section for each of the preceding technical sections, plus a general interest section. The titles were included here to present many aspects of each subject area, rather than to provide exhaustive coverage of any one. Where possible, the country of publication, and the language of the original are indicated for each entry, with titles transliterated where necessary.

The references were culled from many sources, certain of which would be of particular value for research. *Air Pollution Technical Information Center (APTIC) Abstracts* are prepared by the U. S. Environmental Protection Agency's Office of Air Programs and provide exhaustive indexing of international literature pertaining to air pollution. *Water Pollution Abstracts*, a similar publication issued monthly by Her Majesty's Stationery Office, London, includes multinational articles and reports on water pollution and related subjects. The International Solid Waste and Public Cleansing Association (Internationale Vereinigung für Abfallbeseitigung und Stadtereinigung) publishes materials on solid waste handling. Information on these materials may be obtained from The Sekretariat: Eidg. Anstalt für Wasserversorgung, Abwasserreinigung und Gewasserschutz, Physikstrasse 5, Zurich 7/44, Switzerland.

Many of the reports included here are available from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Virginia, U.S.A. Where NTIS accession numbers were known, they were included. However, other documents may appear on the NTIS index which are not so indicated here. Most of these documents are sold for three dollars in paper copy, and ninety-five cents in microfiche.

Other sources of information include the various governmental offices charged with the protection and control of natural resources, and particularly the international organizations such as the Food and Agriculture Organization (Rome), the Organization for Economic Cooperation and Development (Paris), and the World Health Organization (Geneva). Publication lists of these and other organizations are included in the general references section. Addresses of the principal international agencies concerned with environment and health can be found in Chapter VII, INSTITUTIONAL RESOURCES.
1. AGRICULTURE

1. Agricultural Development

General


Emissions and Control


Impact


2. Irrigation Systems

General


Emissions and Control


**Impact**


2. INDUSTRY

1. Fertilizer Plants

General


Emissions and Control


Tennessee Valley Authority, Bibliography No. 1042 - Pollution from Fertilizer Manufacturing Plants. T.V.A. Division of Chemical Control.

Impact


2. Iron and Steel Mills

General


Emissions and Control


Impact


3. Mining Operations

General


Emissions and Control


Impact


4. Petroleum and Petrochemical Industries

General


Emissions and Control


Impact


5. Pulp and Paper Mills

General


Emissions and Control


Impact


6. Smelting Plants

General


Emissions and Control


Impact


7. Textile Mills

General


Emissions and Control


Impact


Hernberg, Sven; Mowe, Gunnar; Virkola, Pertti; Partanen, Timo and Nordman, Claes-Henrik, "Magnesium and Zinc Values of Erythrocytes and Plasma for Workers Exposed to Carbon Disulphide," *Work Environmental Health,* (Helsinki), Vol. 6, No. 2, 9-13, 1969.


Offhaus, K., "The Zinc Content in Waste Waters from the Synthetic Fibres Industry and its Toxicity," (German), *Wasser und Abwasser Forschung,* No. 1, 7-21, 1968.

8. Tourism

General


Emissions and Control


Impact


3. TRANSPORTATION

1. Airports

General


Emissions and Control


Impact


2. Ports and Harbors

General


Emissions and Control

Battelle Memorial Institute, *Study of Equipment and Methods for Removing Oil from Harbor Waters*. Columbus, Ohio: Battelle Memorial Institute.


Impact


3. Roads and Highways

General


Emissions and Control


Impact


4. UTILITIES

1. Dams

General


Emissions and Control


Impact


2. Power Plants

General


Emissions and Control


Kriz, Milan and Vejvoda, Josef, "Laboratory Study of the Optimum Additive for Desulphurization of Flue Gases from Power Plants," (Czech), Sbornik Praci UVP (Usta Vyskum Vyusiti Paliv), (Prague), No. 19, 3-30, 1968.


Impact


3. Sewerage and Sewage Treatment Plants

General


Emissions and Control


Impact


5. STANDARDS


6. PUBLIC HEALTH


7. GENERAL

Bibliographies


Other


VII INSTITUTIONS
VII. INSTITUTIONAL RESOURCES

UNESCO
United National Educational (Includes IOC/Intergovernmental Oceanographic Commission/) Scientific and Cultural Organization
Place de Fontenoy
Paris VIIe, France
1, rue Miollis
Paris XVe, France
Telephone: 566-57-57

UN/REC
UN Regional Economic Commissions:
ECE
Economic Commission for Europe
Palais des Nations
Geneva, Switzerland
Telephone: 33-10-00

ECAFE
Economic Commission for Asia and the Far East
Sala Santitham
Rajadamnern Avenue
Bangkok, Thailand
Telephone: 813544

ECLA
Economic Commission for Latin America
Edificio Naciones Unidas
Avenida Dag Hammarskjöld 3030
Vitacura
Santiago, Chile
Telephone: 485051
485061
485071
ECA  Economic Commission for Africa  
P. O. Box 3001  
Addis Ababa  
Ethiopia  
Telephone: 47200

UNESOB  U. N. Economic Social Office in Beirut  (Beirut)  
P. O. Box 4656  
Beirut, Lebanon

ECOSOC  Economic and Social Council  
United Nations  
New York, N. Y.

WHO  World Health Organization  
1211 Geneva 27  
Switzerland  
Telephone: 34-60-61

WMO  World Meteorological Organization  
41 Avenue Giuseppe-Motta  
Geneva, Switzerland  
Telephone: 34-64-00

FAO  Food and Agriculture Organization of the United Nations  
Via delle Terme di Caracalla  
Rome, Italy  
Telephone: 5797

IMCO  Inter-Governmental Maritime Consultative Organization  
101-104 Piccadilly  
London, WIV OAE  
England  
Telephone: 01-499-9040
ICAO  International Civil Aviation Organization  
International Aviation Building  
1080 University Street  
Montreal 101  
Canada  
Telephone: 866-2551

IAEA  International Atomic Energy Agency  
Kaerntnerring 11  
A-1010 Vienna I  
Austria  
Telephone: Vienna 52-45-11

OECD  Organization for Economic Cooperation and Development  
2 rue André Pascal  
75116 Paris, France