TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT IN INDUSTRY

4-25 August 1991, Tampere, Finland

Lecture notes

Organized by Tampere University of Technology/Institute of Water and Environmental Engineering (TUT/IWEE)

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Training Course on Environmental Management in Industry was financed by United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO) and Ministry of Trade and Industry, Finland.

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COURSE PROGRAMME FOR AUGUST 4-25, 1991

Venue: Tampere University of Technology, Department of Civil Engineering, 2nd floor, room RG 203

Sunday, 4 August

16.02	Arrival in Riihimäki Bus to Tampere Accommodation, Hotel Victoria
19.30	Dinner

Monday, 5 August

9.00	Departure from Hotel Victoria

OPENING SESSION, Chairman Matti Viitasaari

10.00	Welcome to Tampere University of Technology (TUT) Rector Timo Lepistö
10.15	Finnish developing aid by Minister Toimi Kankaanniemi, Ministry for Foreign Affairs
10.45	Finland's environmental policy by Tuija Talsi, Ministry of the Environment
11.15	Finland's commercial and industrial activities by Pertti Valtonen, Ministry of Trade and Industry (paper missing)
11.45	Lunch
13.00	Challenges of sustainable development by Dr Wimala Ponniah, UNEP
14.15	Coffee
14.30	Practical arrangements during Training Course
15.30	Departure to Hotel Victoria
17.00	Departure from Hotel Victoria
17.30- 22.30	Sauna evening

Tuesday, 6 August

7.40	Departure from Hotel Victoria, city bus no. 20

ENVIRONMENTAL IMPACT ASSESSMENT (EIA), Chairman Sirpa Sandelin

8.30	Introduction to EIA by Pekka Salminen, Diskurssi Ltd.
10.15	Coffee
10.30	FINNIDA's and international financiers' EIA policy by Kari Silfverberg, FINNIDA

12.00	Lunch
13.00	Case: EIA in industrial mill by Pentti Väänänen, Soil and Water Ltd.
14.00	Coffee
14.15	Case: EIA in power plant projects by Hannu Härkönen, Imatran Voima Ltd.
15.15	Case: Discharge of industrial wastewaters into municipal sewer system by Simo Isoaho, TUT
15.45- 16.15	Discussion

Wednesday, 7 August

8.20	Departure from Hotel Victoria, city bus no. 20

SEMINAR ON COUNTRY REPORTS, Chairman Simo Isoaho

9.00	Presentations by course participants
10.15	Coffee
10.30	Continued ...
12.00	Lunch
13.00	Continued ...
14.00	Coffee
14.15- 16.00	Continued ...

Thursday, 8 August

8.20	Departure from Hotel Victoria, city bus no. 20

SEMINAR ON COUNTRY REPORTS, Chairman Simo Isoaho

9.00	Presentations by course participants
10.15	Coffee
10.30	Continued ...
12.00	Lunch
12.45	Tour at TUT
13.30	Continued ...
14.00	Coffee
14.15- 16.00	Discussion

Friday, 9 August

FIELD VISIT, guided by Simo Isoaho

8.30	Departure from Hotel Victoria Visits to Viinikanlahti and Rahola wastewater treatment plants in Tampere
12.00	Lunch

13.00 Departure from TUT
Visit to hazardous wastes reception and treatment centre in Tampere
17.00 Arrival at Hotel Victoria

Saturday, 10 August

Free programme

Sunday, 11 August

Free programme

13.00 Departure from Hotel Victoria
Tampere city tour, guided by Simo Isoaho
15.30 Arrival at Hotel Victoria

Monday, 12 August

8.20 Departure from Hotel Victoria, city bus no. 20

INFORMATION SEARCH, Chairman Arja-Riitta Haarala

9.00 Introduction to information sources
by Arja-Riitta Haarala, TUT
10.00 Coffee
10.15 Principles of subject search: manual, CD-ROM and on-line techniques
by Arja-Riitta Haarala, TUT
11.00 Demonstrations
by Arja-Riitta Haarala and Leena Huiku, TUT
12.00 Lunch
13.00 Exercises on information search
by Arja Riitta Haarala mand Sirpa Sandelin, TUT
14.45 Coffee
15.00-15.30 Discussion

Tuesday, 13 August

8.20 Departure from Hotel Victoria, city bus no. 20

ADMINISTRATION AND ECONOMY, Chairman Sirpa Sandelin

9.00 Public relations
by Håkan Nylund, Economical Information Bureau
9.45 Coffee

10.00	Negotiations with authorities by Emilie Enckell-Sarkola, National Board of Waters and the Environment
10.45	Planning of industrial investments by Jari Paranko, TUT
12.00	Lunch
13.00	Economic comparative methods by Olli Niemi, Tampere Science Park (paper missing)
14.30	Coffee
14.45	Case: Cost-benefit analysis of pulp and paper mill by Jouko Peltokangas, TUT
16.00- 16.30	Discussion

Wednesday, 14 August

7.40	Departure from Hotel Victoria, city bus no. 20

HAZARD ANALYSIS AND RISK ASSESSMENT, Chairman Veikko Rouhiainen

8.45	Presentation of VTT/Safety Engineering Laboratory and VTT/Electrical and Automation Engineering Laboratory by Jouko Suokas, Safety Engineering Laboratory
9.00	What is safety and risk analysis- safety analysis process and short presentation of methods by Veikko Rouhiainen, Safety Engineering Laboratory
9.45	Coffee
10.00	Potential problem analysis by Markku Reunanen, Safety Engineering Laboratory
11.00	HAZOP and work safety analysis by Veikko Rouhiainen, Safety Engineering Laboratory
12.00	Lunch
13.00	Case: Management of accidental releases in pulp plant by Raija Koivisto, Safety Engineering Laboratory
13.45	Coffee
14.00	Failure mode and effects analysis, effect of maintenance on the systems safety, maintenance effects analysis and life cycle cost analysis by Helena Mälkki, Electrical and Automation Engineering Laboratory
14.45	Break
15.00	Failure mode ... Continued ...
15.30- 16.00	Discussion

Thursday, 15 August

8.20 Departure from Hotel Victoria, city bus no. 20

HAZARD ANALYSIS AND RISK ASSESSMENT, Chairman Veikko Rouhiainen

9.00 Analysis of operational experiences
by Urho Pulkkinen, Electrical and Automation Engineering Laboratory
9.45 Coffee
10.00 Analysis of human factors and organizational safety
by Pekka Pyy, Electrical and Automation Engineering Laboratory
11.00 Consequence analysis in chemical risk assessment
by Rhea Kakko, Safety Engineering Laboratory
12.00 Lunch
13.00 Principles of quantitative risk assessment
by Urho Pulkkinen, Electrical and Automation Engineering Laboratory
13.45 Coffee
14.00 Management of risk analysis projects
by Jouko Suokas, Safety Engineering Laboratory
14.45 Break
15.00 Importance of safety analysis in risk management-benefits obtained with safety analysis
by Jouko Suokas, Safety Engineering Laboratory
15.45-16.00 Discussion

Friday, 16 August

7.40 Departure from Hotel Victoria, city bus no. 20

IN-MILL MANAGEMENT, Chairman Simo Isoaho

8.30 Mill characteristics
by Simo Isoaho, TUT
9.00 In-mill characterization of emissions and waste sources
* Wastewaters
by Pertti Keskitalo, Air-Ix Consulting Engineers
9.45 Coffee
10.00 * Air pollution
by Hannu Mattila, Air-Ix Consulting Engineers
10.45 * Wastes
by Pentti Rantala, Air-Ix Consulting Engineers
11.30 Lunch
12.30 Planning of industrial wastewater treatment
by Pertti Keskitalo, Air-Ix Consulting Engineers
13.30 Consulting aid
by Pentti Rantala, Air-Ix Consulting Engineers
14.15 Coffee

14.30	Staff training by Sirpa Sandelin, TUT
15.15- 16.00	Discussion

Saturday, 17 August

Free programme

Sunday, 18 August

SIGHT SEEING TOUR TO HÄMEENLINNA, guided by Sirpa Sandelin

10.00	Departure from Hotel Victoria
11.15	Hämeenlinna castle
13.00	Lunch, Hotel Aulanko
14.00	Tour in Hämeenlinna City
15.30	Iittala Glass Ware Centre
17.00	Arrival in Tampere

Monday, 19 August

FIELD VISIT, guided by Sirpa Sandelin

8.00	Departure from Hotel Victoria
9.30	Friitala Ltd., Ulvila - leather industry
11.30	Lunch
13.30	Raision Tehtaat Ltd., Kokemäki - food industry
16.00	Arrival in Tampere
17.00	Presentation of UNIDO by Ranko Vujacic

Tuesday, 20 August

FIELD VISIT, guided by Simo Isoaho

8.00	Departure from Hotel Victoria
10.00	Oras Ltd., Rauma - metal plating industry
11.30	Lunch
13.00	United Paper Mills Ltd., Rauma Pulp - pulp mill
15.00	Teollisuuden Voima Ltd. Industrial Power Company, Olkiluoto - nuclear power plant
19.00	Arrival in Tampere

Wednesday, 21 August

FIELD VISIT, guided by Simo Isoaho

8.00	Departure from Hotel Victoria
10.00	United Papermills Ltd., Kaipola - pulp and paper mill, deinking plant
12.00	Lunch
14.00	VTT/Compustion and Thermal Engineering Laboratory, Jyväskylä
16.00	University of Jyväskylä/Institute for Environmental Research
20.00	Arrival in Tampere

Thursday, 22 August

FIELD VISIT, guided by Sirpa Sandelin

10.00	Departure from Hotel Victoria
12.00	Lunch
13.00	Hazardous waste treatment plant, Riihimäki
18.00	Arrival in Tampere

Friday, 23 August

FIELD VISIT, guided by Simo Isoaho

8.00	Departure from Hotel Victoria
9.00	Sahalahti wastewater treatment plant
11.30	Lunch (at TUT)
14.00	Lielahti Power Plant, Tampere
16.30	Arrival at Hotel Victoria
18.45	Departure from Hotel Victoria
19.00	Farewell dinner (at Tampere Hall)

Saturday, 24 August

Free programme

12.00	Lunch
14.00- 18.00	Final discussions and closing ceremonies (at TUT)

Sunday, 25 August

Free programme

13.00	Lunch (at Hotel Victoria)
16.30	Departure from Hotel Victoria to Riihimäki
18.56	Departure to Moscow

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Training Course on Environmental Management in Industry

Opening speech by Rector Timo Lepistö, Tampere University of Technology.

5 August, 1991

Mr Minister, dear ladies and gentlemen,

Today we are facing challenges which could not have been imagined two or three decades ago. The exploitation of natural resources, mainly unrenewable ones has expanded. Urbanization and the growth of population has accelerated. International trade takes an increasingly important role in national and world economics and dominates international policy. After the Second World War this development exploded into exponential growth.

Consequently environmental disturbances are main issues of common global concern. One reason why they were not seen so important in the past is that there was a lack of appropriate research methods coupled with a lack of ecological research. Also, environmental problems were considered as local ones. We lived as if the natural resources were a bottomless well. Now we are facing the fact that this is not true. In this connection I would like to refer the report "Our Common Future" prepared by The World Commission on Environment and Development that gives us a thorough summary of the consequences how industrialization has affected our environmental living conditions.

In Finland we have recently made progress for instance in municipal and industrial wastewater treatment and air pollution control. I hope that during your visit here in Tampere you will have an opportunity to become acquainted with these technologies.

Recently Tampere University of Technology decided to expand its efforts in environmental engineering. We have established a program leading to the degree of Master of Science in Environmental Engineering for Finnish students. In addition, all students in future will be required to attend lectures on the basic principles of ecology and environmental engineering. Also, for many years now we have already been offering special courses in wastewater treatment and waste management in the Department of Civil Engineering.

Over the past ten years our University has been cooperating with developing countries. In this connection Tampere University of Technology has delivered every second year since 1979 a Postgraduate Course in Water

Supply and Sanitation. This eighteen-month Master's course is specialized in the conditions of developing countries. At present we also have a six-year course in municipal technology for Namibian students, leading to the degree of Bachelor of Science. These are a few examples of our activities to increase the understanding of environmental questions. These activities are mainly financed by the Finnish Ministry of Foreign Affairs.

Distinguished participants and guests,

I hope that this seminar will be rewarding and successful and that you will have some time to get acquainted with Finland and Tampere.

I wish you warmly welcome to Finland and to Tampere University of Technology.

MR. TOIMI KANKAANNIEMI
Minister of Development Cooperation

Training course on environmental management in industry, Tampere, Finland
August 5, 1991

Distinguished participants,

I am very pleased to welcome you all to Finland. I would like to give a short overview of the main objectives and basic principles of the Finnish development cooperation specifically from the point of view of environmental protection and care.

The Finnish international development cooperation experienced a period of dramatic growth during the 1980s. The disbursements of development aid increased from 412 million Finnish marks in 1980 to about 3,4 billion marks in 1990. The objective was to attain the quantitative target set by the United Nations of utilizing 0,7 per cent of the GNP to development cooperation activities.

The steep growth trend of the 1980s is now over and a reverse trend slowly emerges due to the considerable economic constraints the Finnish economy is facing as well as due to the international economic situation. Quantitative growth having come to an end the Finnish development cooperation policy faces new qualitative challenges. We are now to strive to allocate the funds available in a clearly focused way and we must ensure that the new projects that are started are planned with care and improved professionalism. Some of the assessments and studies recently carried out point out that the project planning and implementation has not always succeeded in the best possible way during the years of rapid growth of 1980s. The results aimed at by applying the principles of sustainable development were not attained to the extent desired.

The challenges of qualitatively improving development assistance are significant. Special attention in Finnish development cooperation has lately been given to the environmental impact and environmental protection objectives as well as to measures aiming at improving the

situation of women in our development assistance projects. Finland is strongly committed to the efforts of furthering the principles of sustainable development as defined in 1987 by the World Commission on Environment and Development (WCED), so called Brundtland Commission. These principles have an important influence on wider and wider range of economic and cultural sectors of international development cooperation.

It is now realized better than ever before that important changes of global scale are required in structures of production, consumption and international trade to preserve the vital conditions of future generations. The starting-point for economic and developmental activity must be thrifty and rational utilization of natural resources, minimization of adverse effects on environment, increase in social justice and improvement of living conditions of the poorest population groups. Within the framework of the international cooperation, development cooperation should have the role of an innovative frontline-runner and a think-tank for new and improved solutions.

It is, however, important to keep in mind that the possibilities for development assistance to resolve the huge problems in front of us are limited. In the 1990s purposeful action and collaboration are required in all sectors and fora of international cooperation.

An important milestone in the near future in measures towards attaining sustainable development will be the United Nations Conference on Environment and Development, UNCED, to be held in Brazil in 1992. On its agenda are among other issues international conventions on climatic protection and deceleration of climatic change as well as conventions on protection of forests and biodiversity.

As an established basic principle in the Finnish development cooperation about 60 per cent of the aid appropriations are utilized for bilateral development projects and approximately 40 per cent channelled through United Nations organizations and agencies, development banks and other international organizations.

Around 60 per cent of the bilateral grant aid is directed to the least developed countries. The main recipient countries of the Finnish bilateral assistance are Egypt, Kenya, Tanzania, Zambia, Mocambique and Namibia in Africa, Sri Lanka, Nepal, Bangladesh and Vietnam in Asia, and Nicaragua and Peru in Latin America.

In addition to country programme cooperation an important form of cooperation is regional programmes, especially in the Southern African Development Coordination Conference (SADCC) area in Southern Africa, South-East Asia and Central America. Our development cooperation with so called middle-income developing countries consists of concessional credits and pre-mixed credits. The beneficiaries of the credit schemes have in the last few years been China, Thailand, Indonesia, Mexico and Argentina.

Already during several years the Finnish bilateral development assistance has been equally divided between three major sectors of activity: agriculture and forestry, social development and basic services (basic health care services, education, water development etc.) and development of economic infrastructure (energy development, transportation and industrial development).

Alongside development cooperation new forms of international environmental cooperation are emerging with the Soviet Union and countries of Eastern Europe. The administration of this cooperation is delegated to the Ministry of Environment, whose representative will surely report more in detail on its objectives and modes of action. I would only like to mention that among other projects collaboration projects are under preparation with the Soviet Union in Kuola Peninsula for diminishing important sulfur emissions from the nickel smelteries of the area by modernization of the production processess and equipment, and with both Soviet Union and Poland to improve the programmes of protection of The Baltic Sea and construction of waste water plants.

Before concluding I would like to touch upon the role, objectives and principles of environmental protection in the Finnish development cooperation.

The sustainable use of natural resources and the control of negative environmental impact are seen as the overall guideline for action.

On the global level the main channels and mechanisms in our development cooperation for environment protection are the United Nations Environment Programme, UNEP, the World Conservation Union, IUCN as well as the global environment funds GEF (Global Environment Facility) and the Ozone Protection Fund of the Montreal Protocol. Finnish total annual contribution to these organizations and programmes amounts to nearly 100 million Finnish marks.

The Global Environment Facility is administered together by UNEP, the World Bank and the United Nations Development Programme, UNDP. It has been recently established to finance development projects for controlling global level environmental hazards: climatic change, ozone depletion and accelerated narrowing of biodiversity.

The Ozone Fund aims at assisting the developing countries in developing new technology to substitute those chemicals (so called CFC substances) used in productive processes that destroy stratospheric ozone layer. The fund was established through an initiative by Finland.

In our bilateral development assistance the objective of environmental protection is taken into account through two established measures:

1. Improvement of planning and implementation of all projects in order to prevent or minimize any negative environmental impact. The most important practical measure to ensure this is that of applying Environmental Impact Assessment (EIA) in all project planning. A detailed Guideline for EIA is now being implemented since August 1989. (This will be elaborated tomorrow.)

2. The implementation of environment protection projects is the second practical mode of action to reach the objective. The list of environment protection projects includes most of the forestry projects, erosion control and soil conservation projects, waste management and sanitation projects, industrial environmental

protection projects, projects of institutional support to environmental management as well as projects dealing with establishing of nature conservation reserves and their management.

Such projects are either planned or under way at the moment in Tanzania, Zambia, Mocambique, Namibia, Nepal and Nicaragua. In addition regional programmes are planned in SADCC area and in Central America. The most important project that includes strictly environment protection activities is that of the Amani Rainforest protection project in the Usambara Mountains in Tanzania.

Industrial environment protection projects are being undertaken or prepared in Tanzania (reduction and purification of emissions and effluents of saw mills, cardboard and chipboard mills and phosphate mines), in Zambia (support to the environment control administration), and Central America (support to the environment control administration and waste water treatment and control). Projects to be financed through concessional credits are prepared for waste water treatment plants in China.

In addition to the above mentioned 'pure' environmental protection projects the number of environmental control components and integrated by-projects are increased across the programmes of all sectors. The total share of the environmental protection projects or project components of all appropriations is at the level of 150 million Finnish marks annually. (Formal classification of 'environmental components' has not yet been developed internationally. The interpretation of different organizations vary somewhat.)

Although there has been a clear and strong trend in the Finnish development cooperation to increase input in environment protection and care a very important matter needs to be underlined: that is that the priorities and views of the recipient authorities are as important in directing funds - if not more important - as are the views of Finnida.

In many of the main recipient countries of the Finnish development cooperation the governmental authorities do not give sufficient importance to the environmental concerns. Often the main aim is to increase production as quickly as possible, sometimes also against sustainable utilization of natural resources and protection of environment. Fortunately the signs of changes in attitudes are already visible.

I hope your visit to Finland is a success and will prove beneficial to you. I also hope that this course will provide you with the necessary tools for tackling the important tasks ahead of you.

UNEP/UNIDO/UNEPCOM/TTKK
Training Course on Environmental Management in Industry
4-24.8.1991, Tampere, Finland.

OPENING SESSION
AUGUST 5, 1991

Tuija Talsi
Senior Advisor
Ministry of the Environment

FINLAND'S ENVIRONMENTAL POLICIES

Mr Chairman,
Distinguished Participants and Colleagues,

It is a great honour for me to speak here on behalf of the Finnish Ministry of the Environment and it is also very rewarding to speak about Finnish environmental policies to such an interested and accomplished audience.

First of all, I should like thank the organizers and sponsors of the Training Course, for their efforts in arranging the course and offering all us the opportunity to learn more about environmental management in industry.

The Ministry of the Environment finds this kind of training courses extremely important and valuable and we are happy to see that one is again being organized in Finland. Training and scientific co-operation are of utmost importance

in promoting environmental protection both on a national and international level and we believe this is one of the ways in which Finland may contribute to the global efforts to combat environmental problems.

Nevertheless, I believe that the new information you will have during this course cannot always be used unmodified in the circumstance prevailing in your own countries. It is clear that no information can be used and put into practice as such, unless it is first assessed carefully and then adapted to the new conditions and environments. It is only through this kind of adaptation process that information becomes true knowledge that can be fully utilized and developed even further.

Since environmental degradation in many parts of the world has gone far beyond our control, we need truly new ideas and innovative thinking in order succeed in regaining this control. Many of the old ways of thinking may have to be reassessd and even set aside if we are to solve the immense environmental problems we are facing today. And even this is not quite enough - what we need most is action - action and co-operation by all individuals, whether laymen or professionals as you yourselves, and by all nations, both developing and developed, to achieve our common goal.

Mr Chairman,
Dear Colleagues,

I shall now turn to the environmental policies of Finland. I intend to tell you first a little about our national policies and the development of environmental protection over the years, and then go on to give you a brief account of our international policies and Finland's role in the international efforts to combat environmental degradation.

ational Environmental Policies of Finland

Environmental protection may be said to have fairly long traditions in Finland. However, the traditional approach in Finland as in many other industrialized countries was to see environmental protection as the conservation of nature. For example, the Finnish Nature Conservation Act was promulgated as early as 1923, and under this act several nature reserves have been established.

However, the adverse environmental effects of industry began to be felt severely in Finland during the 1960s and it was during this decade that concern for environmental pollution among the public and the Finnish administration was fully awakened.

It is quite understandable that in a country like Finland, with thousands of lakes and smallish rivers and with a strong pulp and paper industry and its heavy discharge loads into waters, attention was first given to water pollution control. The Finnish Water Act was promulgated in 1961, and the National Board of Waters, with the task i.a. of supervizing the Water Act and studying our water courses, was established in 1970.

As a consequence of these legislative and administrative measures and the investments by industry and communities in water pollution control, the discharges of many pollutants into Finnish watercourses has decreased markedly since the early 1970s. Nevertheless there is still a lot to be done, since agriculture now seems to have become the largest source of pollutants, such. phospohorus, nitrogen and pesticides, in our water courses.

During the 1970s environmental administration and legislation began to be developed in earnest: for example, the Waste Management Act was promulgated in 1979 and the Air Pollution Control Act in 1982. The Ministry of the Environment was not established until 1983, so that we are, in

fact, less than 10 years of age. Quite a lot has been accomplished in the field of environmental protection during the late 1980s, which owes a great deal not only to the establishment of the Ministry, but to the generally favaourable attitudes towards environmental protection that prevailed in the late period.
At the moment, the focus of our national environmental policies has shifted slightly away from water pollution control and it is felt that the most severe problems we are facing today are connected with air pollution, especially acidification, due mostly to emissions of sulphur and nitrogen oxides, and the global climate change. In addition, the large amounts of wastes, especially hazardous wastes, and the use of a growing number of chemicals pose a threat to the Finnish environment and we still have many problems to tackle in these fields.

Due to the Air Pollution Control Act and the international treaty signed on the reduction of sulphur emissions, investments have been made in new process and purification technologies, especially by the industry and energy sectors. As a consequence, Finland has managed to reduce its sulphur emissions by approximately 50 % since 1980 and we are examining possibilities to reduce them even further. Nevertheless, as our nitrogen oxide emissions, which are mainly due to traffic, are still on the increase and as acid deposition, often due to emissions from other European countries are still substantial, the problem of acidification has by no means been completely solved in Finland.

However, the most important development in Finnish environmental policies during the late 1980s has been the understanding that environmental protection cannot be seen as being composed of different sectors, i.e. air or water pollution control or waste management, but that the environment must be taken into account as a whole. Nor can environmental policies work in isolation, or as a separate sector in society; instead, environmental concerns must be taken into account and integrated into all sectors of our economic and social life.

In this regard, I must stress the importance of the Report of the World Commission of Environment and Development (WCED), issued in 1987, where the notion of "sustainable development" was introduced and described. The Report has had an enormous impact on Finnish national environmental policies: in 1990, the Government gave a Report to the Finnish Parliament on Finland's aims and efforts to achieve sustainable development.

Thus environmental protection and sustainable development have reached the highest political and decision-making levels in Finland and the Government is committed to promote sustainable development both nationally and internationally.

International environmental policies

The notion of sustainable development has brought us directly into Finland's aims and priorities in international environmental co-operation. We have already heard the excellent and most interesting account of Finnish development aid by HE the Minister for Development Aid, Mr Toimi Kankaanniemi. As concerns of environment and development are often inseparable, it is clear that that development aid and co-operation has a vital role to play in Finnish international environmental policies.

Global change, or the global degradation of the environment, has brought environmental issues to the top of political agenda in Finland as well as in many other countries. The most serious global threats we are facing are connected with air pollution, the depletion of the ozone layer and climate change and the pollution of freshwaters, groundwaters, coastal areas and seas as well as the generation of hazardous wastes and the use of chemicals. Desertification and loss of forests and arable land threaten the viability of many areas or even entire countries. The loss of biodiversity, i.e. the extinction of valuable flora and fauna

and the impoverishment of their genetic bases, is yet another serious problem we have to tackle.

It seems to us that the reasons behind these problems often lie in the wasteful and short-sighted utilization of natural resources and the use of polluting technologies that has taken place mostly in the industrialized countries. On the other hand, in the developing countries poverty and population growth often force people to use natural resources in an unsustainable and environmentally unsound manner.

We must break this vicious circle of wasteful use and over-exploitation, nurtured both by wealth and by poverty, in order to preserve our environment for the future generations. No country can do this alone or in isolation - it is absolutely vital that we all work together.

Finland has over the years been in the vanguard of those countries that understand the importance of international environmental co-operation and we have also recognized the interdepence of the environment on the one hand and development on the other. For example, we already participated in the preparations of the first UN Conference on the Environment in Stockholm 1972.

Global co-operation: international conventions

When turning to the concrete steps made in international environmental co-operation, important landmarks include the 1974 Convention on the Protection of the Baltic Sea and the 1979 Convention on Transboundary Air Pollution and its Protocols on the reduction of emission of sulphur compounds (1985) and nitrogen oxides (1988). The Vienna Convention (1985) and the Montreal Protocol (1987) on substances that deplete the ozone layer are two other extremely important examples of what can be achieved through international co-operation.

Finland's active role in the international context is illustrated by the fact that Finland has had a major role in

achieving all the above-mentioned conventions; three of them were agreed in Helsinki and four were reached under Finnish chairmanship. In addition, the recent ECE Convention on Environmental Impact Assessment in a Transboundary Context was also signed in Finland in February 1991.

Global co-operation: the UN system and the UNCED

On the whole, Finland attaches great importance to the UN system in combatting and solving global environmental problems. For example, we have supported the activities of the UNEP since its establishment and, despite our fairly small size and limited resources, we have become one of the largest donors of UNEP. We find that UNEP has done very fruitful work over the years especially as regards the developing countries and we believe that the role and resources of UNEP should be strengthened.

You may be well familiar with the so-called UNCED-process - that is, the preparations for the large UN Conference on Environment and Development to be held in Brazil in June 1992. We feel that is extremely important that the Conference should try to tackle and solve many of the severe environment and development problems; the Conference is, among other things, expected to discuss and make decisions and plans for the future on the extremely important issues of transfer of technology and financing of environmental protection, and several other issues such as the protection of seas and coastal areas, freshwaters, combatting desertification and soil degradation, to name just a few.

Moreover, two international treaties are currently being negotiated that will hopefully be signed at the Conference. These future conventions touch upon two very grave problems we are facing, namely the climate change and the loss of biodiversity. Both these topics are immensely broad and they include a number of serious and extremely difficult questions. Finland will work hard in the negotiations so that we should have the Conventions ready for signing in

Brazil next year and we will make initiatives so as to bring closer the views of the negotiating parties.

We understand that the developing countries cannot be expected to combat their national, let alone the global environmental problems without any assistance from the developed countries. Both financial and technical assistance must be given. The fund under the Montreal protocol was certainly a step forward, but it may not be able to serve as a model on all occasions. The World Bank, UNEP and UNDP have recently created the Global Environmental Facility (GEF), with the purpose of supporting an integrated approach to meeting both environment and development objectives. Finland supports the GEF and it has agreed to fund it by 20 mill. SDR for the initial period of 1991-1993.

Mr Chairman,
Dear colleagues,

I have been dwelling on the global international co-operation and the UN efforts for quite a long time, but we must not forget our regional co-operation with the rest of Europe nor the close co-operation we have with our neighbouring countries, especially the other Nordic countries (Denmark, Sweden and Norway) and the Soviet Union.

Regional Co-operation : Europe

Finland finds the multilateral environmental co-operation within the UN Economic Council for Europe (ECE) extremely important and we are also pleased to see that the Conference on Security and Cooperation in Europe (CSCE) has also acquired a higher profile in the environmental field. Both these organizations are attended by all European countries which makes them important and potentially efficient fora for regional environmental co-operation in Europe.

Finland also participates actively in the work of the Organization for Economic Co-operation and Development (OECD),

the co-operative body of the wealthy industrialized nations. As the OECD countries use up by far the greatest part of the world's natural resources, they also bear a responsibility for many of the global environmental problems. Thus the OECD is in a position to promote sustainable development and it also has the means and tools for assessing the links between economic and environmental development and to search cost-effective means of solving environment and development problems.

Naturally, the so-called European integration and the outcome of the negotiations between the European Communities (EC) and the European Free Trade Area (EFTA), of which Finland is a member, are also of great interest for Finland. We have a high standard of environmental protection in several areas and we should not relax these standards due to the integration process. We also feel that the expected growth of production and the environmental implications of economic integration in Europe should be assessed and the problems minimized.

Regional Co-operation: the Baltic Sea and the Arctic Region

Being one of the Baltic States and a country for which the well-being of our common inland sea, the Baltic, is of extreme importance, the protection of the Baltic Sea is one of the high priority areas in Finnish international co-operation. Finland will again promote a strengthening of the status, as well as the resources, of the Baltic Sea Commission. We will also try to see to that the goals of a declaration made by Contracting Parties in 1988, namely to halve their discharges into the Baltic by the year 1995, will be achieved.

The Finnish proposal for the promotion of sustainable development and sustainable use of natural resources in the Arctic regions received positive feedback from the countries concerned, i.e. the other three Nordic countries (Norway, Denmark and Sweden), Canada, the USA and the

USSR. A ministerial meeting held in Rovaniemi, Finland, in June 1991 was very succesful and a progressive Declaration was signed.

Regional co-operation: Eastern and Central Europe

Co-operation with Eastern and Central Europe is of course extremely important for Finland since the emissions of these countries often affect our environment as well. Therefore our previous Government prepared in 1990 a specific programme for co-operation with the countries of Eastern and Central Europe.

In this programme, which is being carried out by the Ministry for Foreign Affairs, M. of Trade and Industry and the M. of the Environment, the main emphasis is on sustainable economic growth, environmental protection, education and training. Priority is given to co-operation with Poland and the Soviet Union and, as regards environmental co-operation of the latter, areas neighbouring Finland, i.e the Kola Peninsula, the Karelia and Leningrad areas and Estonia, are focussed on.

An agreement on a programme for combatting transboundary air pollution between Finland and the Soviet Union was signed in Helsinki in 1989 during the visit of President Gorbachev. The first concrete step was taken with an agreement on the reconstruction of two nickel plants in the Kola Region with the intoduction of Finnish process technologies. Other Nordic countries, i.e. Norway and Sweden, would also participate in this construction work.

Co-operation with the other areas of Soviet Union (i.e Leningrad and Karelia areas, and Estonia) has got under way this year with a specific programme called the "East European Project" that was established at the Ministry of the Environment. The Project has funds from which grants and so-called "soft loans", i.e. loans with interest subsidies, can be given to joint projects between Finnish and Soviet companies or authorities.

In this Project, priority is given to undertakings that concern the reduction of sulphur emissions and the renewal of energy plants, the reduction of other industrial emissions, the construction of treatment plants for community waste waters and the treatment and management of hazardous wastes.

In addition to actual reconstruction of industry and tranfer of technology, the Eastern European Project also includes training of experts and the development of methods for monitoring the state of the environment and for supervision of emissions.

Regional co-operation: Nordic countries

Last but not least I should like to mention Nordic co-operation, which has long been very important for us in developing our own environmental policies and in exchanging views on environmental issues with countries that are in many ways similar us.

Although Nordic co-operation is important in itself, allowing us all to gain more information and more efficiency in our national efforts, its true strength shows itself especially in the global context. With these small, like-minded countries Finland's views often gain more weight and we can thus promote the goals of sustainable development and environmental protection more efficiently in the international fora.

Thus, with the Nordic co-operation we have come to realize in a very concrete manner how, in co-operation with our neighbours, we can often reach far better results than if we should all try to struggle along on our own.

Mr Chairman ,
Dear Colleagues,

with these words on Nordic co-operation I shall conclude my presentation of Finnish environmental policies. I am afraid that I have more or less exhausted you with facts and statements, many of which may have been known to you and others that you may never even have heard of.

However, I do hope you have got at least an idea of Finnish priorities in our national and international environmental policies and that some of the views presented here may encourage you to work more efficiently and with more enthusiasm to protect the environment in both your own countries and internationally.

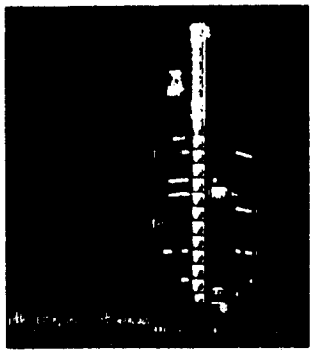
Once again, I wish to thank the organizers and especially you, Mr Chariman, for allowing me to take up so much our valuable time.

And finally, I wish you all a most successful seminar and fruitful training course and hope you will truly benefit from this course. Neverthless, these weeks you spend in Finland should not all be spent work and drudgery - I do hope you will also get an opportunity to enjoy the Finnish environment as well.

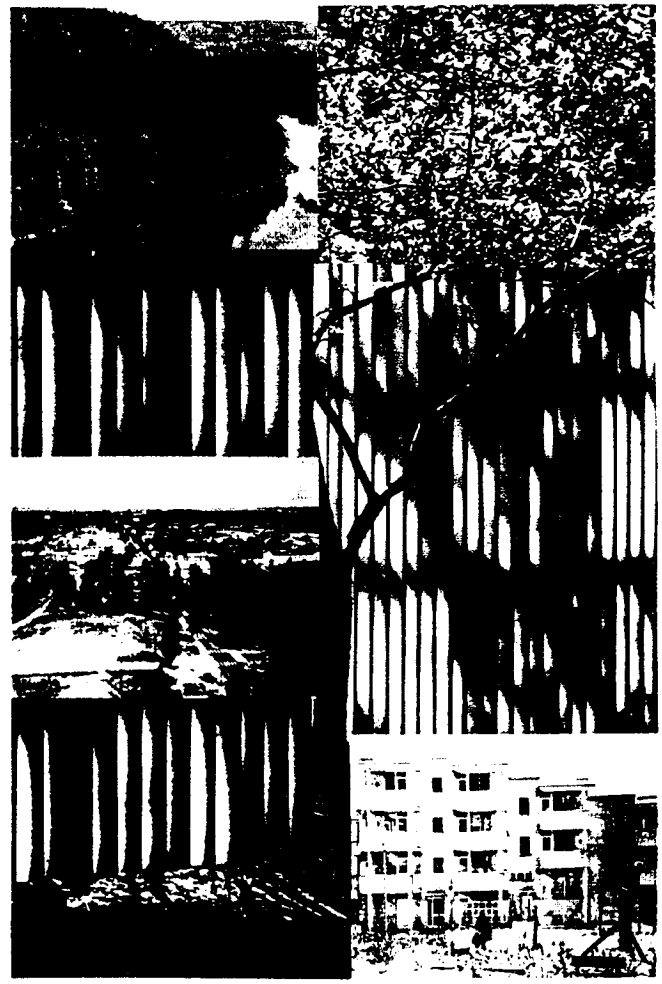
On behalf of the Ministry of the Environment, I wish you all welcome to this training course and, of course, welcome to Finland.

Thank you very much.

Ministry of the Environment Finland



Ministry of the Environment Finland



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Objectives and functions

The Ministry of the Environment is working for sustainable development and to ensure a healthy and safe environment, a harmonious blend of natural and man-made elements. The work is broad in scope, encompassing environmental protection, nature conservation and development of human settlements.

All these fields require comprehensive planning, co-ordination and management. Development of legislation and allocation of funds are the main means of guidance and control. Research, data compilation and information services support the Ministry in its administrative functions.

A good living environment with clean air, water, and soil is not only a national concern but also a matter of global importance. The Ministry co-operates bilaterally with neighbouring countries and multilaterally on a global scale.

All human endeavour – industry, agriculture, forestry, energy production and communications – has an impact on the environment. To minimize this impact, the Ministry consults and works with many bodies in both the public and the private sector.

Many specialized activities are performed in collaboration with the National Board of Waters and the Environment and the National Housing Board, both of which are subordinate to the Ministry. The support given by the Ministry to regional and local authorities helps them bear increasing responsibility for the environment in their respective areas.

Three Advisory Councils and several other Advisory Boards work under the auspices of the Ministry.

The Ministry was created in 1983 and now has some 250 employees in its four departments.

Environmental protection and nature conservation

Environmental protection and nature conservation are essential to maintain an acceptable balance between the human race and nature. Only the preservation of natural ecosystems with all their diversity, productivity and beauty will ensure that a safe, healthy and pleasant living environment remains for us all. This requires that environmental considerations and impact assessment be included in all economic and social planning.

The particular fields in which the *Environmental Protection Department* works are:

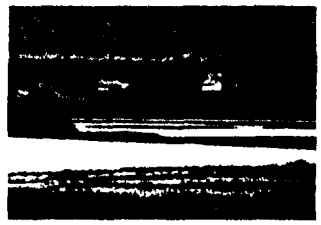
- developing environmental monitoring and data systems
- environmental economics
- nature conservation and landscape protection
- matters pertaining to outdoor recreation
- controlling the environmental impacts of off-road traffic
- waste management and recycling
- preventing harmful effects of chemicals on the environment
- air pollution control
- noise abatement
- water management and the utilization and protection of water resources
- protection of the marine environment and prevention of oil pollution

Physical planning and building

Physical planning and building means reconciling different land use interests with the aim of promoting people's material, cultural and social well-being. The planning system is multilevel and based on a close dialogue between local and central government authorities. Environmental goals are mainly expressed in terms of flexible norms, and their tangible implications for regional and local physical plans are determined more specifically within democratic decision-making processes on the municipal and joint-authority levels.

The Physical Planning and Building Department is mainly concerned with:

- guiding and monitoring physical planning and building,
- sanctioning regional plans, master plans and nationally important detailed plans
- guiding the work of the municipal building inspectorates
- protecting and maintaining the architectural environment
- stipulating building regulations and guidelines and granting type approval for building materials and components
- developing information systems for planning and building



Important tasks in relation to building include improving the ratio between costs and quality, the flexibility of systems and enhancing the safety, health and durability aspects of buildings and building materials. The development of new means and methods are prominently to the fore in promoting the protection and maintenance of the architectural environment. A question of topical importance in the development of the planning process is that of strengthening local autonomy by delegating power of decision and improving the flow of information concerning the substance and process of planning.

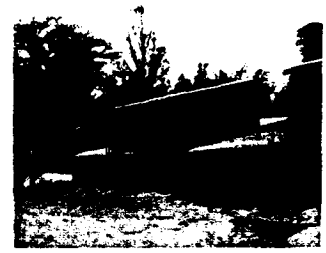
Housing

Finnish housing policies are under continuous review both in Parliament and within the administration. The definition of lines of action for successful implementation of Government housing policies includes both the preparation of legislation and the development of administrative procedures. Current housing programmes and those planned for the future are another important area of work.

Five-year Housing Policy Programmes are drafted by the Ministry of the Environment and promulgated every two years by the Council of State. They set forth the goals of Government housing policy and the measures proposed for achieving them. Each programme is a comprehensive document covering all fields of Government activity with a bearing on housing and housing developments.

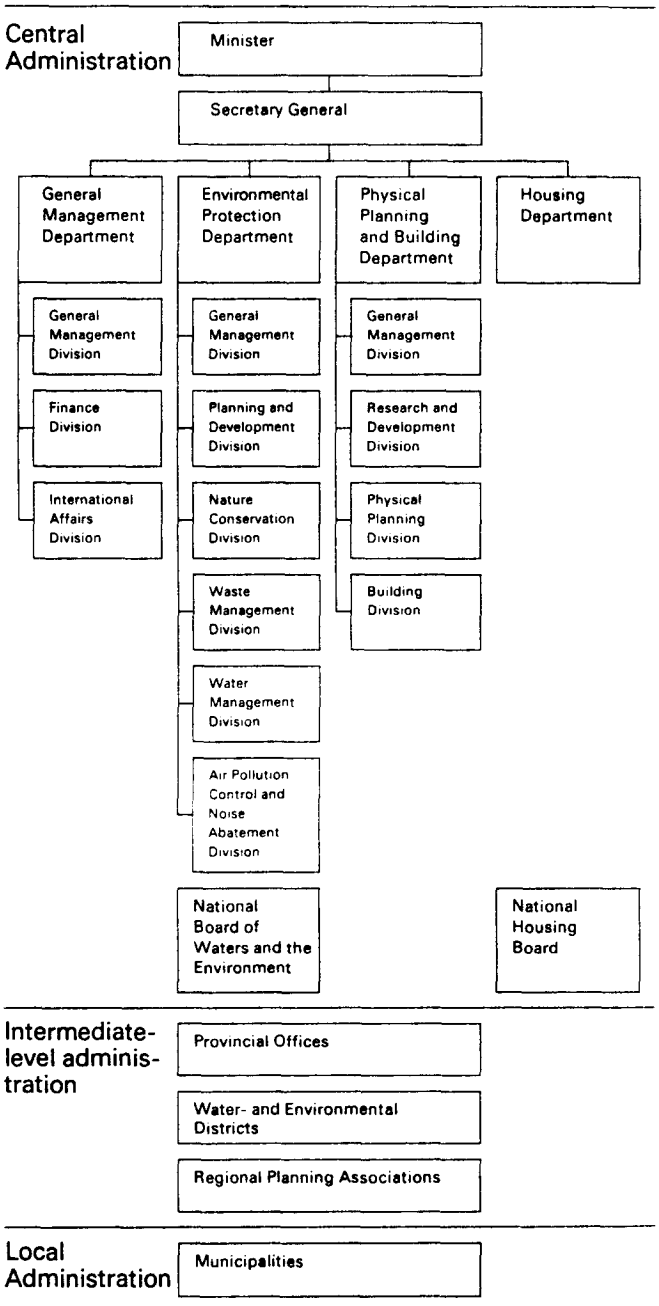
The *Housing Department* is especially in charge of

- Government loans and interest subsidies for new construction, repair and acquisition of dwellings;
- housing allowances;
- measures concerning rent policy; and
- development and co-ordination of housing research.



The *National Housing Board* is responsible for the actual implementation of housing support measures, such as granting Government loans.

Organization



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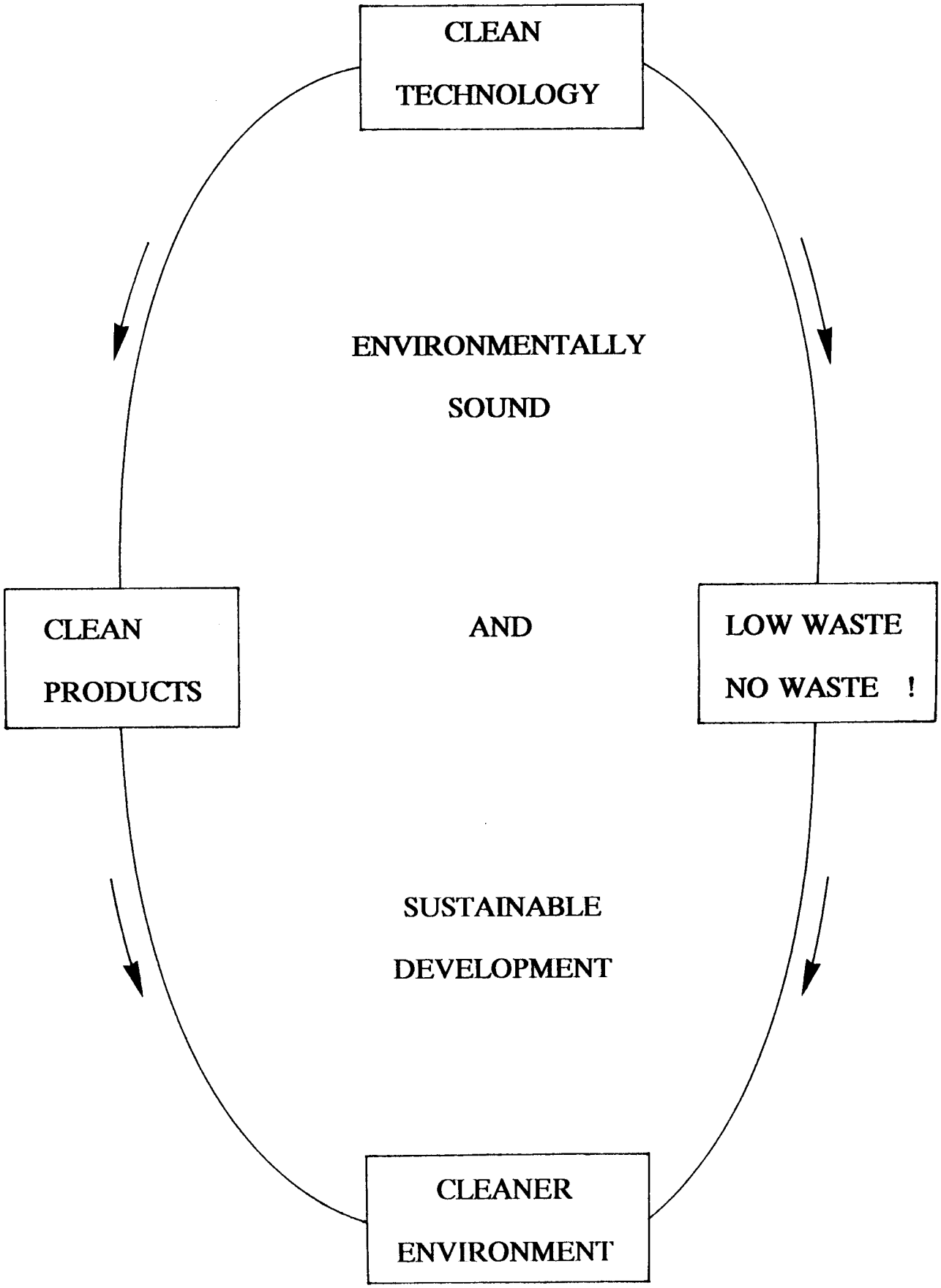
TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT IN INDUSTRY

Challenges of sustainable development

by Dr Wimala Ponniah, UNEP

5.8.1991


CLEAN
TECHNOLOGY
ENVIRONMENTALLY
SOUND
CLEAN
PRODUCTS
AND
LOW WASTE
NO WASTE !
SUSTAINABLE
DEVELOPMENT
CLEANER
ENVIRONMENT

UNEP/IEO'S CLEAN PRODUCTION PROGRAMME comprises:

- the International Cleaner Production Clearing-house (ICPIC), a computer-based information exchange based on the US Pollution Prevention Information Clearing-house;

- Industrial Sector Working Group in tanning, textiles, halogenated solvents & electroplating industries providing data to ICPIC;

- a government policies & strategies working group to collaborate with the OECD; and

- the Cleaner Production newsletter.

UNEP/IEO'S APELL - a process for responding to technological accidents.

The IEO has also established a global emergency response package for preventing or handling industrial accidents at the local level.

This Programme, the Awareness & Preparedness for Emergencies at the local level or APELL was established following devastating industrial accidents in Mexico, Bhopal & Basel.

Both the ICPIC & APELL were the result of fruitful cooperation between industry & government.

Examples of successful & mutually beneficial collaborative efforts between industry and governments in the face of environmental challenges:

- action to protect the ozone layer was only possible because industry was closely involved from the outset;

- action being taken by industry to reduce, treat & safely dispose of hazardous wastes;

- industry has also been instrumental in helping the world prepare for climate change by devoting substantial funds to research programmes. Due to the technological development of industry & cooperation between industry & government, cost-effective technologies are now commercially available & which could substantially cut greenhouse gas emissions in all countries;

- fruitful cooperation between industry & IEO in the establishment of ICPIC.

Present indicators of environmental decline include the following:

(1) **In the developing world:**

- shrinking forests
- accelerated soil erosion
- expanding deserts
- increased water shortages
- degradation of marine coastal areas and their resources
- declining fish stocks
- disappearance of plant & animal species

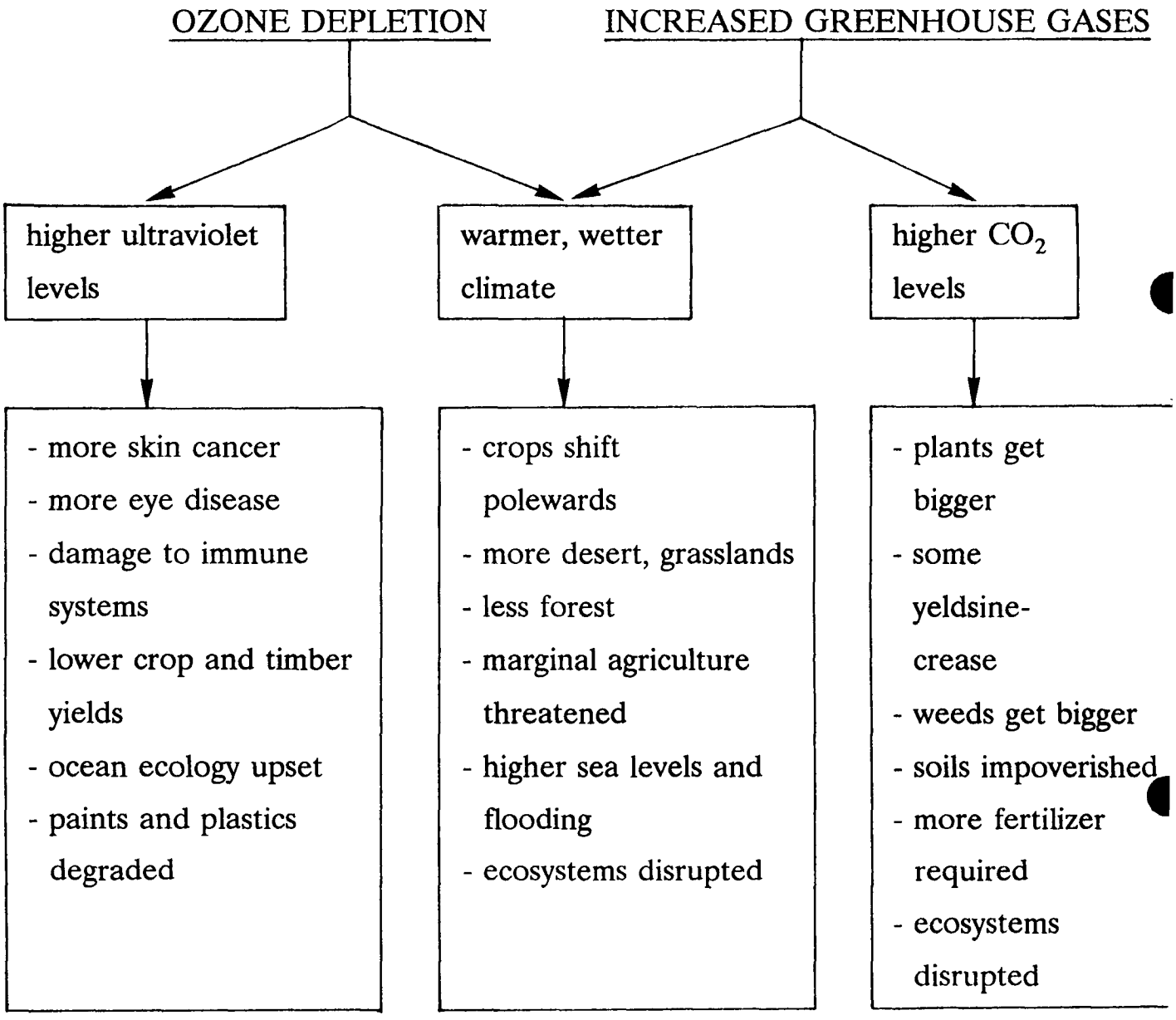
(2) **At the global level:**

- increased air, water & hazardous waste pollution despite some gains in the developed world

- thining of the ozone layer which protects us from dangerous ultra-violet radiation

- increase in the earth's temperature posing frightening prospects of sea-level rise, agricultural disruption & changes in rainfall patterns

SOCIAL EFFECTS OF DAMAGING THE ATMOSPHERE.



Definition of SUSTAINABLE DEVELOPMENT

Sustainable development is defined in the common future and in the environmental perpective as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

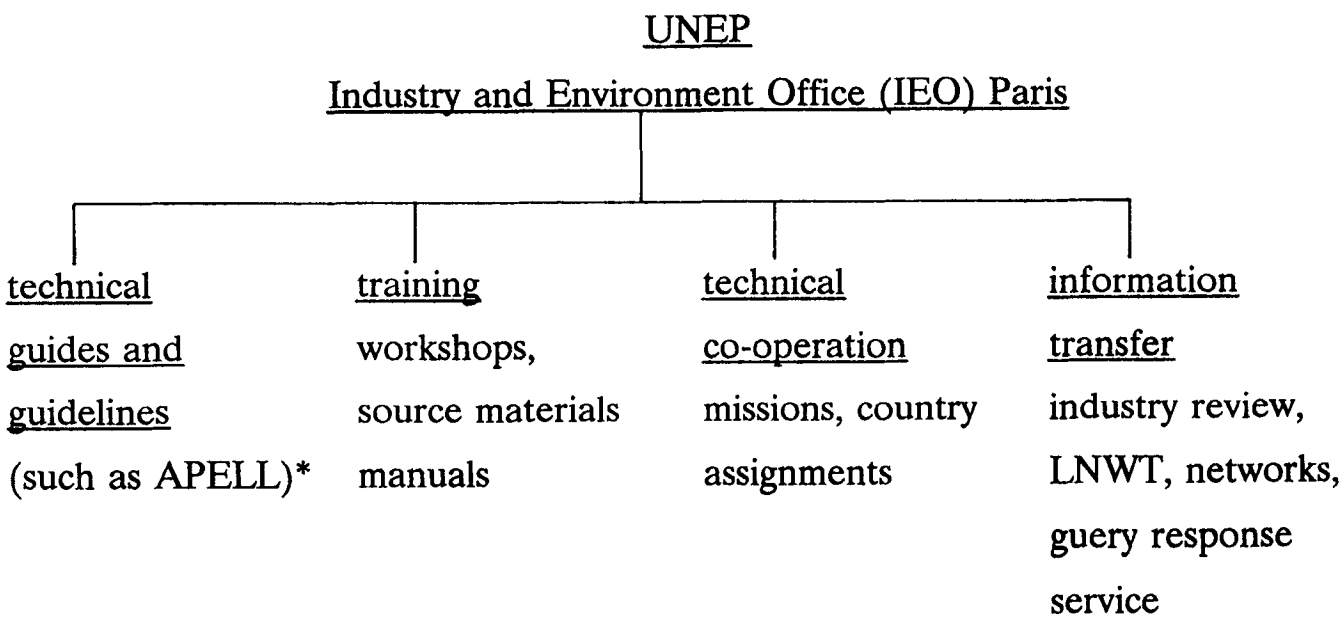
Our **main task** therefore is to:

- radically lower pollution levels
- drastically increase soil & forestry conservation
- instigate strong measures to protect our planet's biological diversity which is being diminished at the rate of 100 species a day
- minimize hazardons wastes
- step up action to protect our already depleted ozone layer, and
- pave the way to address probably the greatest ecological threat ever to face humanity - that of climate change & global warming

Objectives of the UNEP Industry and Environment Office (UNEP/IEO)

The IEO seeks to promote sustainable industrial development by:

- encouraging the incorporation of environmental criteria in industrial development;
- facilitating the implementation of principles and procedures for environmental protection;
- promoting the use of safe, low-or non-waste technologies; and
- stimulating the exchange of information and experience throughout the world.



* Handbook on Awareness & Preparedness for Emergencies at Local Level: A Process for Responding to Technological Accidents.

Environmental Perspective to the Year 2000 and Beyond

PHOTO UNEP

Dr. Mostafa K. Tolba,
Executive Director of the
United Nations Environment Programme
(UNEP)

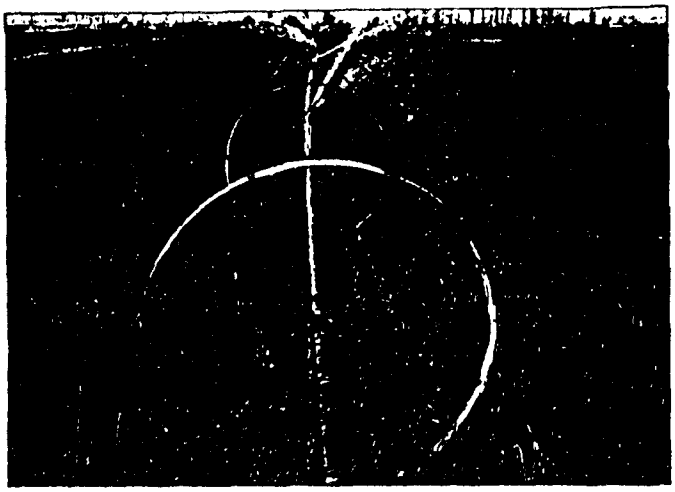
In December 1987 the United Nations General Assembly adopted a document as a broad framework to guide national action and international co-operation for environmentally sound development. It is called the Environmental Perspective to the Year 2000 and Beyond. It was prepared by Governments themselves in response to their recognition that, despite growing scientific and popular awareness of environmental issues, the environment has deteriorated for the majority of humanity, undermining its wellbeing and prospects of social and economic betterment. Ways and means have to be found to transform the growing commitment, in principle, to protecting and improving the environment into needed economic, social and political actions.

The Perspective analyses present environment and development trends, examines environmental issues in their relationship to challenges of social and economic development, sets out goals for environmentally sound and sustainable development, and calls upon Governments, international organizations, industry, financial institutions and non-governmental bodies to take specific actions to achieve those goals. It is guided by the recognition that environmental resources are the life-blood of socio-economic development, and that the state of the environment is a vital aspect of human wellbeing everywhere. While advocating programmes and measures to tackle existing environmental problems, The Perspective calls for an anticipatory and preventive approach to environmental management, to integrate environmental considerations in all action for development. It invites coordinated planning, direction and control of policies and activities of sectoral activities (e.g. industry, agriculture, energy, health, human settlements trade), and for greater inter-governmental collaboration to harmonize long term and short term objectives.

The Environmental Perspective was prepared and approved by the Governing Council of the United Nations Environment Programme, before its adoption by the General Assembly. In its preparation, the Council received the benefit of eminent technical and scientific advice in the form of the report of the World Commission on Environment and Development headed by Dr. (Mrs) Gro Harlem Brundtland, Prime Minister of Norway. There were also direct contributions by Governments and international organizations. The Commission's report has been published under the title of "Our Common Future".

It is UNEP's hope that this illustrated edition of the Environmental Perspective will improve access of policymakers, planners, administrators, diplomats, NGOs, scholars, activists, media and citizens everywhere to this vital document. It embodies a political consensus, based on global solidarity, on measures to improve the human condition. I believe it provides a practical basis not merely for direct action for environmental improvement, but for the design and implementation of national and international policies and programmes to reconcile social, economic and environmental objectives in development. It should also help build bridges between countries, between interest groups, between disciplines, between politicians and administrators, and indeed between the present and the future, so as to make "sustainable development" a reality.

MOSTAFA K. TOLBA
Executive Director, UNEP



UNEP PHOTO LIBRARY

D. Industry

D.1 Issue and Outlook

36. **Issue**: Industrial development brings obvious benefits, but it frequently entails damage to the environment and to human health. The main negative impacts are: wasteful use and depletion of scarce natural resources; air, water and soil pollution; congestion, noise and squalor; accumulation of hazardous wastes; and accidents with significant environmental consequences. Industrialization patterns and the consequent exploitation of natural resources and environmental degradation have been markedly unbalanced. The prospect for accelerated, yet environmentally sound world industrial development, are slim in the absence of concerted international action.

37. **Outlook**: Although some efforts to deal with environmental problems of industry have been made, negative impacts will grow in magnitude if not addressed methodically now. A promising trend is the steadily growing awareness of industrial environmental risks throughout the world. While this awareness increasingly informs and influences public policy, environmental knowledge remains as yet markedly uneven. In the absence of mechanisms for its unhindered sharing, Governments and industry may import hazardous materials and allow establishment of processes discarded elsewhere. Inadequate knowledge at the grassroots level of changes in the environment, and of their causes as well as economic implications, impedes participation of the concerned people in decision-making on siting of industrial plants and choice of industrial technology.

38. Natural resources have been used wastefully in industry. Recently, a number of countries have made significant progress in developing and adopting low-waste and clean industrial technologies and in recovering as well as recycling scarce industrial raw materials. New materials and processing technologies have been able to save raw materials and energy resources, and reduce environmental stress. Nevertheless, in many countries resource-intensive processes persist in the absence of suitable policies and access to proper technology.

39. Uncontrolled industrial practices have led to unacceptably high levels of harmful or toxic substances in the air, pollution of rivers, lakes, coastal waters and soil, destruction of forests, and accumulation of carbon dioxide and other greenhouse gases which threaten to cause climatic changes, including a global warming of the atmosphere. Sea levels may rise considerably as a result. Industrial production and emission of chlorofluorocarbons threaten a significant depletion of the ozone layer, leading to increased ultraviolet radiation.

40. Recently, there has been an increase in the seriousness of industrial accidents, particularly in the chemicals industry. Even in the developed countries the preparedness to meet such contingencies has been inadequate. Also, frameworks for international co-operation in such situations have been lacking. A crucial problem has been the lack of timely warning and of full sharing of information on the nature and magnitude of the hazards at local and regional levels.

41. With industrial growth and spread, the transport, storage and disposal of chemical, toxic and radioactive wastes will pose an increasingly serious challenge. The "Polluter Pays Principle" has been applied with good results in some countries; but in many others it is still not applied at all, so that the source of environmental damage is often unaccountable for the harm caused. In the pursuit of rapid industrialization, some polluting industries may be relocated from other countries. As many developing countries do not possess technical or institutional capability to analyse or monitor environmental implications of industrial processes, products or wastes, they are vulnerable to industrial environmental damage.

42. Many developed countries have successfully applied technology, policies and institutional and legislative frameworks to deal with industrial pollution. Several have succeeded in innovating or applying low-waste or clean technologies. The UNEP Industry and Environment Office has produced publications with extensive and detailed information on environmentally-sound technologies in specific industries. Thus, although environmental hazards of industrial processes, products and wastes, persist, there is available considerable experience, expertise and technology to prevent industrial accidents and to implement environmentally responsible practices.

43. Technical innovation has opened up promising opportunities for achieving mutually supportive economic and environmental objectives. Properly-guided technology can transform patterns of industrialization and improve the international division of labour. Innovation in micro-electronics and opto-electronics has revolutionized information and communications industries and can lead to geographical dispersal of industry. These innovations hold promise for developing countries suffering from the twin

WHO PHOTO: JEAN MOHR

problems of excessive industrial concentration in urban areas and relative neglect of rural areas.

44. In the decades ahead, the developing countries will depend considerably more on industry, including processing of their own raw materials, for incomes and employment. In contrast, in some developed countries, the pattern of industry is changing in the direction of knowledge-intensive, energy-saving, and materials-saving activities. Moreover, leisure and service industries have begun to play a significant part in this change.

45. Countries have been coming together to forge agreements on preventive measures to contain global, regional and transfrontier environmental impacts of industrial products and processes. Examples of this encouraging trend include conventions and protocols for the control of land-based sources of marine pollution in frameworks of various Regional Seas Programmes, Vienna Convention to Protect the Ozone Layer and the evolving international consensus on the control of emission of chlorofluorocarbons; the 1979 Convention on Long Range Transboundary Air Pollution and its Cooperative Programme for the Monitoring and Evaluation of Long-range Transmission of Air Pollutants in Europe (EMEP), and the UNEP-sponsored 1985 Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes. Such international co-operation can extend in many areas of industrial environmental management and geographical regions. Moreover, industry itself, following the 1985 World Industry Conference on Environmental Management convened by UNEP is becoming increasingly ready to undertake environmental responsibilities.

D.2 Goal and Recommended Action

46. **Goal** — Sustained improvements in levels of living in all countries, especially the developing ones, through industrial development which prevents or minimizes environmental damage and risks.

47. Recommended Action:

(a) Governments should implement policies to assist the

transition of economies from wasteful use of natural resources and raw materials, and dependence on their exports, to environmentally sound industrial development. National efforts in planning and implementing

environmentally sound industrial policies should be intensified. Governments should introduce incentive schemes to help establish facilities for recovery and recycling of scarce raw materials. The transfer of industrial technology and skills from developed to developing countries to arrest environmental degradation associated with industry should be internationally supported. UNDP, UNEP, ECE and UNIDO should intensify efforts in this direction;

(b) Governments should introduce programmes to monitor (i) air, soil, fresh water and coastal pollution from industrial emissions and effluents, and (ii) hazardous industrial activities, where such programmes do not already exist;

(c) Governments should provide for environmental standards, and their enforcement, and fiscal and other incentives to industry for the retro-fitting of equipment for pollution control. They should also ensure penalties for non-compliance, in conformity with the "Polluter Pays Principle". International organizations should co-operate with governments in establishing global or regional standards;

(d) Governments should require periodic reports by industries on measures implemented to protect and improve the environment, especially those industries involving high environmental and health risks;

(e) Industrial enterprises should carry out environmental impact and social cost-benefit analyses prior to the siting and design of industrial plants. Governments should ensure that such analyses are carried out and made public. Governmental policies should facilitate location of industries to relieve urban congestion and encourage rural development. Industries which use each others' products and wastes should be located near each other;

(f) Governments and industrial enterprises should be receptive to the views of citizen groups, community associations, labour organizations and professional and scientific bodies in arriving at, and implementing, the decisions on industrial siting, design and technologies to meet the environmental, economic and social needs of the people;

(g) Chambers of commerce and federations of industry should collaborate actively in implementing emission standards and pollution control measures. They should establish mechanisms to bridge the gap in environmental management knowledge and capabilities among their members. Such co-operation should also be encouraged among small-scale producers;

(h) Transnational corporations (TNCs) should comply with the host country's environmental legislation, while respecting similar legislation of the home country. Legislation could include requirements for public environmental audits of the activities of TNCs and local enterprises. In accordance with proposed international codes of conduct, the TNCs should establish progressively in the host countries the skills and technological capabilities needed for environmentally sound management of industry, even in the absence of legislation on desirable environmental standards;

(i) International industrial collaboration should be subjected to environmental impact assessments just like national industry;

(j) Countries, especially developing countries, should, as a matter of urgency, design and implement research, training and manpower-planning programmes to strengthen the management of hazardous industrial processes and wastes;

(k) International organizations, including UNDP, UNIDO, WHO, FAO, WMO and ILO, and intergovernmental organizations such as the OECD and the CMEA should ensure that their programmes will progressively strengthen the capacities of the developing countries in designing and implementing industrial operations along environmentally sound lines. They should also assist in establishing or strengthening information services on environmental and health implications of industrial processes, products and wastes. In addition access of the developing countries to information and data on environmentally-benign technologies should be promoted, including risk management techniques;

(l) International co-operation for the monitoring of the accumulation of carbon dioxide and other "greenhouse" gases and of their impacts on climate and sea levels must be strengthened to encompass both the conclusion of international agreements and the formulation of industrial strategies to mitigate the environmental, economic, and social impacts of potential changes. Intergovernmental negotiations, following upon the Framework Convention on the Ozone Layer, should lead to agreements on the reduction of ozone-depleting substances;

(m) Existing legal and technical activities of United

Nations organizations, especially UNEP, in closer co-operation with regional organizations, should progressively establish international agreements and monitoring mechanisms: (i) to deal with spills and other industrial accidents, particularly chemical; (ii) to control the transportation, storage, management and disposal of hazardous industrial wastes; and (iii) to settle disputes involving damages and claims for compensation. United Nations and regional organizations should encourage Governments to extend the "Polluter Pays Principle" to transboundary problems;

(n) UNEP's International Register for Potentially Toxic Chemicals (IRPTC) programme should maintain and improve its assistance to governments in assessing whether producing, marketing, distributing or disposing of any industrial substances, including chemicals and wastes, are potentially damaging to health and environment.

E. Health and Human Settlements

E.1 Issue and Outlook

48. **Issue**: Despite considerable advances in dealing with problems of health and human settlements, the environmental basis for further improving the situation is deteriorating. Inadequate shelter and basic amenities, rural underdevelopment, over-crowded cities and urban decay, lack of access to clean water, poor sanitation and other environmental deficiencies continue to cause widespread disease and death, ill-health and intolerable living conditions in many parts of the world. Poverty, malnutrition, and ignorance compound these problems.

49. **Outlook**: Human ability to prevent disease has grown greatly over the last few decades mainly owing to scientific achievements and better access to sanitation, clean water and safe waste disposal. In many developed countries better living conditions have helped prevent disease and enhance average life expectations. In the developing countries, however, achievements have lagged behind what is technically feasible.

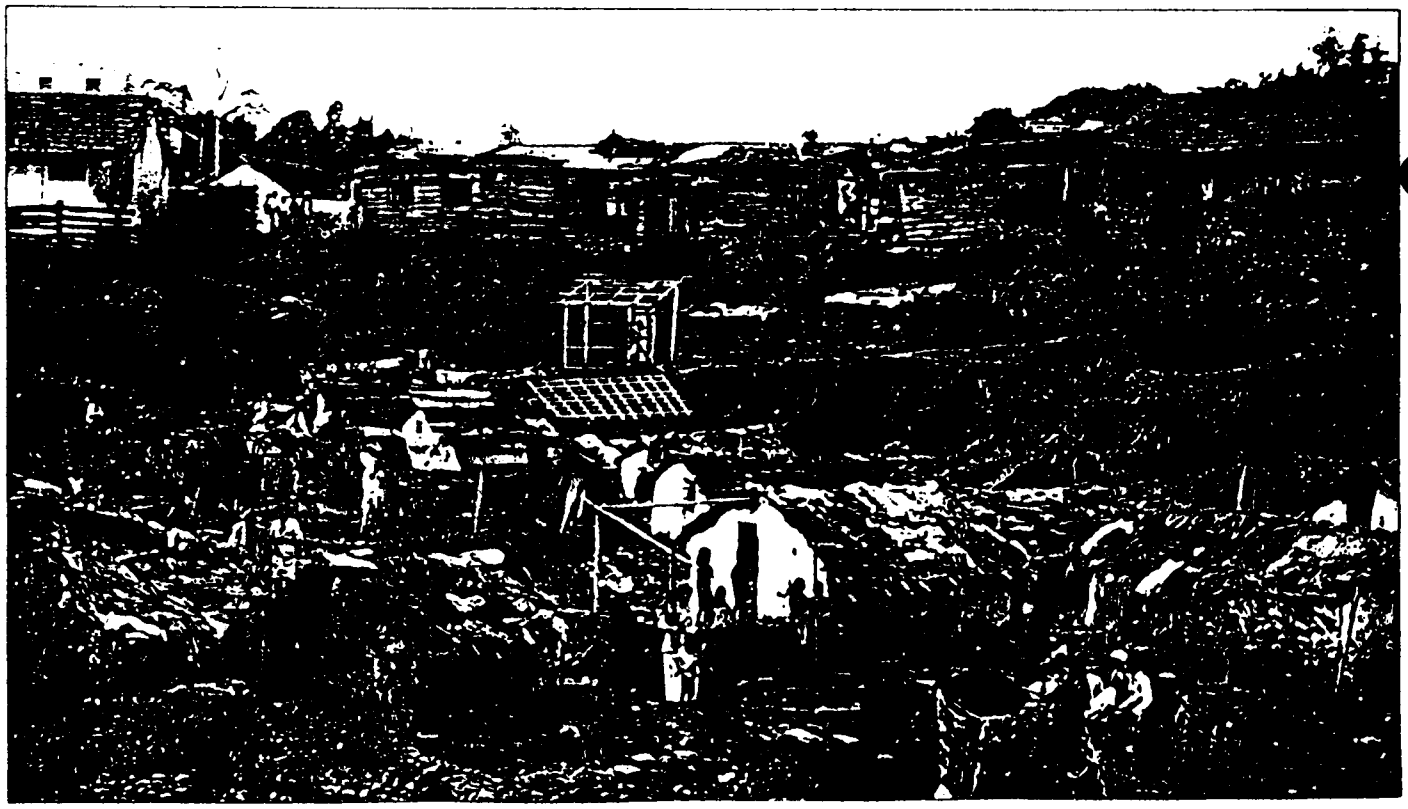


PHOTO: UNICEF

SUSTAINABLE DEVELOPMENT

A Guide to
Our Common Future
The Report Of The World Commission on Environment And Development

Prepared By
Gregory G. Lebel and Hal Kane

THE GLOBAL TOMORROW COALITION
Washington, D.C.

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the original book

Our Common Future

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SUSTAINABLE DEVELOPMENT
A Guide to
Our Common Future

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A center insert provides guidelines for testimony at the Public Hearing organized by the Global Tomorrow Coalition on action and policy implications of the WCED report, to take place on November 1-2, 1989, in Los Angeles, California.

CHAPTER SEVEN | INDUSTRY: NEW CHALLENGES

Today, the world manufactures seven times as many goods and produces three times as many minerals as it did in 1950. Manufacturing has an impact on the natural resource base through the entire cycle of raw materials exploration and extraction, transformation into products, energy consumption, waste generation, and the use and disposal of products by consumers. Industrial growth is occurring most rapidly in developing countries, and these industries tend to be pollution- and resource-intensive. To deal with resulting energy and resource depletion, pollution, hazardous waste, and industrial accidents, governments in developing countries will have to strengthen their environmental and resource management capabilities substantially. At the same time, developing countries must maintain industrial growth. Growing populations and high proportions of young people in the Third World increase the labor force, and agriculture alone cannot absorb them. To provide this growing work force with jobs, and with products and services, industry must grow with the population.

THE NEED FOR NEW POLICY MEASURES

The solution is for industry to grow more efficient as it grows larger, to generate less pollution and waste, and to minimize adverse impacts on human health and the environment.

Air and water have traditionally been regarded as "free goods," but they are not. The economic and environmental costs of their contamination are not encountered until the capacity of the environment to absorb that contamination has been exceeded. After that point, they cannot be avoided. The economic and environmental costs must be paid, whether by transferring them directly to the community in the form of damage costs to human health, property, and ecosystems, or through clean-up payments by the corporation.

Regulations to control the impacts of industrial activity across national boundaries and on the international commons are also needed. The responsibility for safety, the liability for compensation for damage, and the right of access to remedial measures of each country should be maintained.

CHEMICALS

One of the most dynamic sectors of most economies is the chemical industry. The benefits of chemical products range from increased life expectancy to expanded economic opportunity. But the environmental impact of chemicals and chemical products is severe, and that impact can counteract the long-term prospects for health and economic opportunity that chemicals create.

Chemicals represent about ten percent of the total value of world trade. Some 70,000 to 80,000 chemicals are now in world markets. Every year, 1,000 to 2,000 new chemicals enter the commercial market, many without adequate prior testing or evaluation of effects. A U.S. National Research Council sample found that complete health hazard evaluations were available for only ten percent of pesticides and eighteen percent of drugs in the United States. Toxicity data existed for only about twenty percent of the chemicals used in commercial products and processes inventoried under the Toxic Substances Control Act.

But this situation is changing as the governments of developed countries move gradually from a system of post-market testing of new chemicals to one of pre-market testing. By 1986, more than 500 chemicals and chemical products had been banned or restricted in the countries where they were manufactured. In addition, an unknown number of chemicals are withdrawn from testing every year in light of control agency concerns, or are never submitted to control agencies for clearance for distribution.

Chemical control agencies of developed countries, in an increasingly interdependent and effective system, share test results and notify each other of new restrictions on chemicals. A ban or restriction in one country is often quickly followed by a review and action in other countries.

Alarmingly, however, some chemicals banned in industrial countries are exported for use in Third World countries. Those Third World countries are often not notified of the bans. Recently, some industrial countries have required a one-time notification to Third World countries of bans and restrictions. But the governments of most developing countries have no institutions to receive notifications and no capacity to assess the information.

Third World countries also have no way to control trade in chemicals effectively once the chemicals have been restricted. And they do not have the infrastructure to assess risks associated with chemical use, so it is difficult for them to make informed decisions. In view of the seriousness of this situation, the Commission recommends that all governments, particularly those of the major chemical-producing countries, should:

- exclude new chemicals from international markets until their health and environmental impacts are assessed;
- reinforce efforts to obtain international agreement on the selection of chemicals for priority testing, on procedures for their assessment, and on international sharing of the tasks;
- strictly regulate the export of chemicals not authorized for domestic sale; and
- ensure prior notification and information exchange with chemical-importing countries, and support the establishment of units in existing regional organizations to receive and assess information, and to advise governments regarding risks and benefits.

Consumer awareness should be increased. Governments should encourage establishment of consumer information centers on chemical products and strengthen international networks of information exchange, assessment, and data banks now evolving in the United Nations and elsewhere. Another essential step is the adoption and enforcement of regulations on the packaging and labelling of chemicals whose use may be harmful, to ensure that clear directions are provided in local languages. Consumer unions and other nongovernmental organizations should take the lead in collecting and distributing comparative risk information on ingredients in products such as cleaning agents and pesticides.

The chemical producer and user industries should bear the responsibility for ensuring (and the liability for not ensuring) that their products meet the highest standards of safety, have the fewest adverse side effects on health and the environment, and are handled with appropriate care by workers and users. This will require the full disclosure of information about the properties and production processes of chemical substances and their comparative risks, not only to regulatory authorities but to workers, consumers, and residents of communities in which chemical industries operate.

HAZARDOUS WASTES

Industrialized countries generate about ninety percent of the world's hazardous wastes. Clean-up is expensive, with some estimates putting the cost in the United States at as much as $100 billion per year (1986 dollars).

In all countries, waste management suffers from a variety of problems. For instance, frequent and heavy rains in the developing countries of the tropics leach wastes into the soils under landfills or even cause them to overflow. With little or no pretreatment, this can contaminate water supplies or expose local people directly to the unsanitary wastes. Dangers of this sort point out the need for land use planning in developing countries, and the urgent need to actually implement and enforce such plans. The overriding policy objective must be to reduce the amount of waste generated and to transform an increasing amount through recycling into resources for use.

Small and poor countries are especially vulnerable to offshore dumping. An international agreement currently under development by OECD is to be based on three important principles: equally strict controls on shipments of hazardous waste to all countries; prior notification to and consent from the country of final destination; and a guarantee of existence of adequate disposal facilities in the recipient country. The United Nations Environment Programme has drawn up extensive draft guidelines, but there is no effective mechanism to monitor and control hazardous waste trade and dumping.

INDUSTRIAL ACCIDENTS

The U.S. Environmental Protection Agency found that an average of five accidents of varying severity occurred every day at U.S. plants between 1980 and 1985. Recent accidents in Mexico City, Bhopal, Chernobyl, and Basel were of such a large scale that they raised worldwide concern about industrial disasters. To deal with industrial accidents, national capabilities and the framework for bilateral and regional cooperation must be strengthened. National and local governments should:

- survey hazardous industrial operations and enforce regulations on safe operation and on the transport, handling, and disposal of hazardous materials;
- encourage industries that have high pollution or accident potential to locate away from population centers, through land use policies and regional development plans;
- ensure that plant workers are provided with full information about the products and technologies they handle, and are given training in safe operational procedures and emergency preparedness;
- involve local governments and residents in major siting decisions and emergency preparedness planning;
- notify each other of the location and essential characteristics of existing hazardous installations that could threaten other countries;
- prepare contingency plans covering potential accidents in those installations;
- provide prompt notification, full information, and mutual assistance in case of accidents; and
- establish liability and compensation standards for any damage caused by transfrontier pollution.

Governments, international organizations, and industry should promote development of risk assessment methods, establish data banks on assessments, and make them easily accessible to all countries.

Opportunities exist today for much-needed improvement in energy efficiency and raw materials conservation. Concerns that environmental measures are too costly have proven unfounded. A 1984 survey by the OECD in a number of industrial countries concluded that expenditures on environmental measures over the past two decades had a positive short-term effect on growth and employment. Further, benefits such as improved health both for people and for ecosystems have been significant and have usually exceeded costs.

Pollution control has become a thriving branch of industry in several industrialized countries. Industries that developed pollution control equipment, detoxification and waste disposal technology, measurement instruments, and monitoring systems have found new opportunities for investment, sales, and exports. A growing market for pollution control systems, equipment, and services is expected worldwide.

Transnational corporations have a special responsibility for protection of resources and the environment. They are repositories of scarce technical skills that the industries of Third World countries do not have. Transnationals should take the lead in adopting the highest safety and health protection standards and in assuming responsibility for safe plant and process design and for staff training. Transnationals should also institute environmental and safety audits of their plants measured against standards of their home countries. These audits and follow-up actions should be made available for review by governments and other interested parties.

But there are limits to what society can expect industry to do voluntarily. Regulations imposing uniform performance standards are essential to ensure that industry makes the investments necessary to reduce pollution and waste and to facilitate equitable competition in the international market.

CHAPTER EIGHT | URBAN PRESSURES

Between 1950 and 1985, the number of people living in cities almost tripled, and growth has been fastest in the cities of the developing world. By 1980, nearly one in three citizens of developing countries lived in an urban center, and those populations will continue to grow. Current rates are without historic precedent, and few Third World governments can provide land, services, sanitation, schools, transport, and clean water to such growing populations. Facing economic hardship and uncertainty, those countries are already hard put to meet the needs of even their present populations. As a result, illegal settlements spring up, marked by primitive facilities, overcrowding, and rampant disease in an unhealthy environment.

Poor people usually build these settlements on land ill-suited for human habitation: floodplain, dusty deserts, hills subject to landslide, or next to polluting industries. They choose these sites because the land's low commercial value means they have a chance of avoiding eviction. Their homes and buildings are decrepit. The essential infrastructure of the area is often in an advanced state of decay. Public transport is overcrowded and overused. There are no adequate ways to dispose of human wastes hygienically. Water supply systems leak and sewage seeps into drinking water. Often, the poor residents have no piped water, storm drainage, or roads. Even in a relatively small city, just one or two factories dumping wastes into a nearby river can contaminate everyone's drinking, washing, and cooking water.

A growing number of the urban poor suffer from acute respiratory diseases, tuberculosis, intestinal parasites, and diseases linked to poor sanitation and contaminated drinking water, like dysentery, hepatitis, and typhoid. These diseases are usually endemic and a major cause of illness and death, especially among children. In parts of many cities, poor people can expect to see one in four of their children die of serious malnutrition before the age of five, or one adult in two suffering with intestinal worms or serious respiratory infections.

Uncontrolled urban expansion makes housing, roads, water supply, sewers, and public services prohibitively expensive. Unguided growth sometimes encroaches on

TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT IN INDUSTRY

Tampere, August 1991

INTRODUCTION TO ENVIRONMENTAL IMPACT ASSESSMENT

6 August
Pekka Salminen, Diskurssi Oy

Environmental Impact Assessment

* is a planning and decision-making tool
* is a process (not a single study or report) which:
  - begins at the early stages of planning
  - is tightly integrated to the whole planning process
  - identifies, predicts and describes comprehensively the likely consequences of alternative decisions thus leading to better informed, more responsible and fair decision-making
  - increases accountability by making the basis of decisions transparent and by facilitating public participation and debate
  - promotes environmental protection by enabling minimization of disadvantages and maximization of positive impacts
  - facilitates resolution of environmental disputes and conflicts
  - reduces expensive delays and conflicts in later stages ("prevention is cheaper than cure")
  - facilitates interagency communication and coordination
  - promotes environmental research and education
* originated in USA in 1969 (National Environmental Policy Act)
* originated from the critique on "conventional" Cost-Benefit Analysis
* is now applied in numerous countries and states in e.g. Canada, EC, many less industrialized countries, and by several development aid agencies
* combines a scientific analysis of impacts and an administrational procedure for bringing this analysis to bear on political decisions
* consists of a sequence of steps and activities

An Example of a Planning Process

Problem analysis

↓

Definition of objectives

↓

Identification of alternatives

↓

Impact analysis

↓

Comparison/Evaluation of alternatives

↓

Decision / Selection of the "desired"alternative

↓

Guidance of action / Final design

↓

Implementation

↓

Monitoring

Some Essential Characteristics of Developmental/ Environmental Problems and Impacts

The developmental/environmental problems and impacts are:

1. Complex, multidisciplinary, multisectoral

- The number and variability of influencing factors (ecological, social, cultural, technical and economic) is great and they are intermingled and interactive; indirect (secondary, tertiary, etc.) are common.
- No sigle discipline, either technical, economic, or ecological, and no sigle agency is able to solve the broblems on its own; cooperation and teamwork between representatives of different disciplines and administrative agencies is necessary.
- Peacemeal, incremental approach does not work; a holistic approach is needed.

2. Multidimensional and often extended beyond the actors involved in market transactions

- Monetary as well as non-monetary factors and impacts are involved.
- Monetization of (non-traded) environmental values is not possible nor desirable.
- To reduce complexity to one dimension (money, utility, points, etc.) = to lose relevance (and misleading).

3. Involving resources and values which are often unique or very rare (irreversible)

- Loss of future options
- Extinction of species; the habitats and culture of indigenous peoples, etc.

4. Having a specific spatial extension and distribution

- Often far-reaching impacts, which are not limited to a single municipality, county, or country (e.g. global impacts).
- Affect different areas, ecosystems and social systems differently.

5. Often cumulative and synergistic

- Many small (insignificant) impacts and projects may together make significant impacts.
- The synergistic impact may be bigger than the "sum" of the individual impacts.

6. Having a specific temporary extension and distribution

- Different impacts in different phases of project.
- Short-term vs. long-term impacts.
- Frequency of impacts.
- Dynamic nature of ecosystems and social systems should be taken into account.

7. Involving uncertainty and risk

- Can be reduced only partly by scientific research efforts.
- Probability?
- Perception of risk -> significance, acceptability (value judgement).

8. Involving conflicts between different ideologies, values and interests in the society

- Different ethical and ideological starting points, world views, human-nature relatioships, ethnic origins, cultures, social status, occupations, educational backgrounds, vested interests, etc.
- Different opinions on e.g. the situation, problems, causes of problems, desired means of solving problems, goals and objectives (of development), desired environmental conditions.
- Unequal distribution of "negative" and "positive" impacts.
- Unequal rights and possibilities to control and use natural resources.
- Conflict between present and future generations?!

Phases and Activities of an EIA Process

I. Preparatory Phase

A. "Screening"

- Is EIA process needed? Are significant impacts likely to be caused?
- Positive lists (+ project thresholds)
- Negative lists
- Sensitive area criteria
- Preliminary assessment based on readily available information

B. "Scoping"

- Aims at an early, preliminary clarification and agreement on:
  - the "problem" (problem analysis)
  - objectives and purpose of planning
  - planning and decision-making situation
  - purpose of the assessment
  - alternatives to be considered
  - impacts to be considered (identification -> scoping; ecolocical, social, health, cultural, physical, economic, etc.; checklists, flow diagrams, matrices, etc. may help, see annexes)
  - study area and time scale of the assessment
  - data requirements
  - desired composition of the assessment team (experts)
  - assessment methodology
  - interest groups, participants (interest analysis; participation analysis)
  - objectives and methods of participation
  - procedures
  - timetable
  - budget
  - reporting, communication, publicity

- Usually leads to Guidelines or Terms of reference for the detailed assessment

- Avoids:

  - unnecessary data collection
  - unnecessary costs
  - unhelpful reports
  - conflicts and delays in later stages

- Contributors to scoping:

  - Proponent ("developer")
  - Competent / Licencing authorities
  - Other authorities
  - EIA review agency (e.g. "EIA panel" or "EIA commission")
  - Local community, various interest groups, non-governmental organizations, etc.
  - Research institutions, universities, libraries
  - Consultants

II. Studies and Preparation of the EIA Report

C. Baseline studies

- The existing environmental conditions are studied, based on the factors determined in the scoping phase
- Form the basis for impact predictions and monitoring

D. Prediction of impacts

- Various methods available (mathematical modelling, simulation models, photomontages, expert judgement, etc.)
- E.g. magnitude, geographical extension, time, duration, frequency, probability, social distribution (affected groups and interests), reversibility/irreversibility, synergistic and cumulative impacts, risks, uncertainties and lack of knowledge should be explicitly considered

E. Interpretation of impacts

- Significance? Acceptability? Is mitigation needed?
- These are mostly value judgements -> participation is important !
- Pre-set criteria such as laws, regulations and standards may be available

F. Identification and planning of mitigation measures

- Environmental protection technology; alternative processes, fuels, sites, routes, design, phasing, compensation

G. Comparison / Evaluation of alternatives

- The "final" information basis for decision-making
- Two categories of evaluation methods: aggregative and disaggregative; they are based on different philosophical and theoretical principles
- Compare e.g. "conventional" Cost-Benefit Analysis and "disaggregative EIA approach"

H. Planning of a monitoring programme

- The practical arrangements and responsibilities should be agreed upon and documented
- Notice the continuum: baseline studies - predictions - monitoring

I. Documentation (draft EIA report)

- See an example of EIA report contents (annex)
- Non-technical summary!
- Communication and publicity!

III. Review Phase

J. Review by the authorities and the review agency

K. Review by general public and various interest groups

L. Amendments and further studies, if necessary

M. Approval of the EIA report (and the whole information basis)

IV. Decision-Making Phase

V. Post-Decision Phase

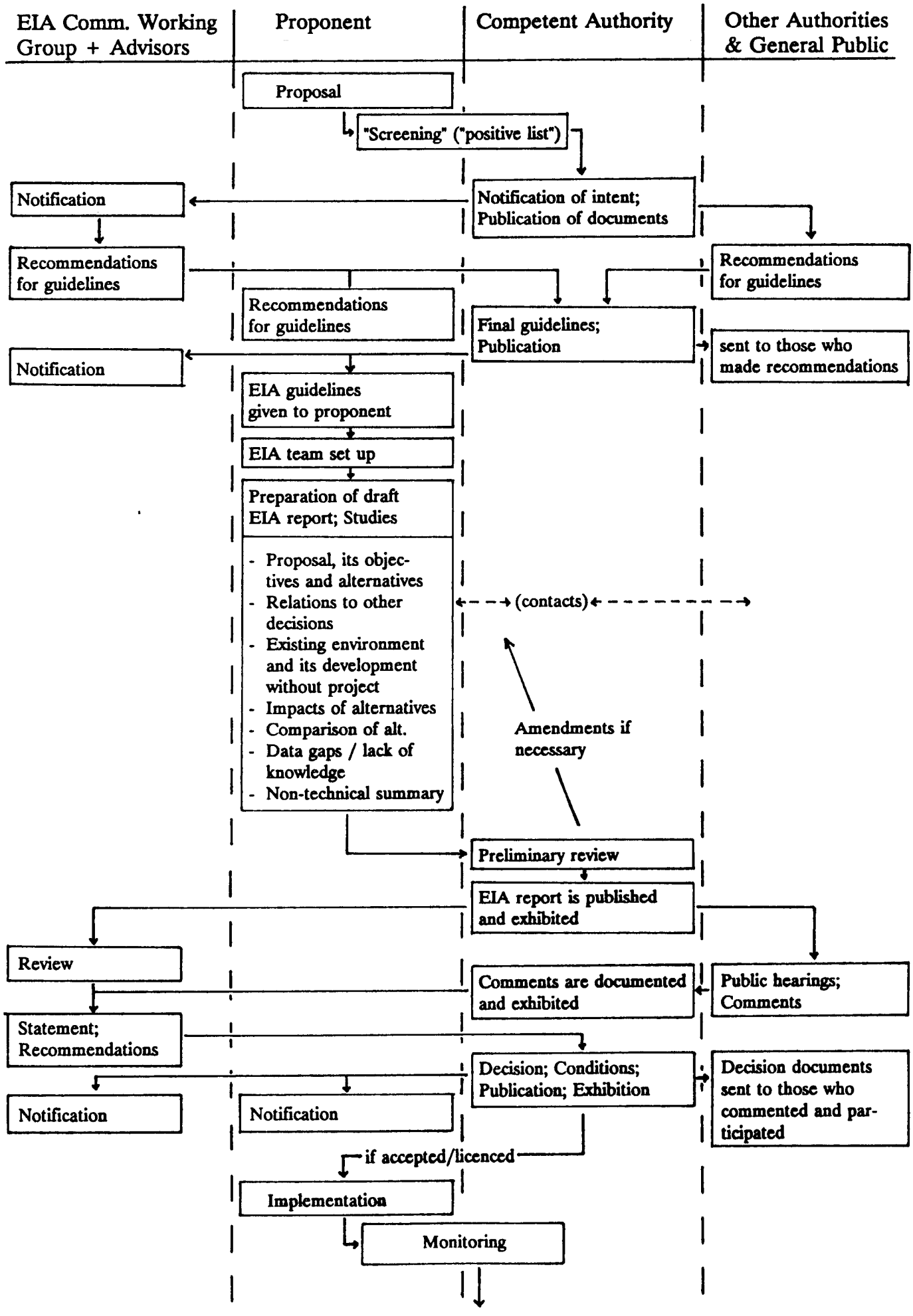
N. Impact and compliance monitoring

- What are the actual impacts?

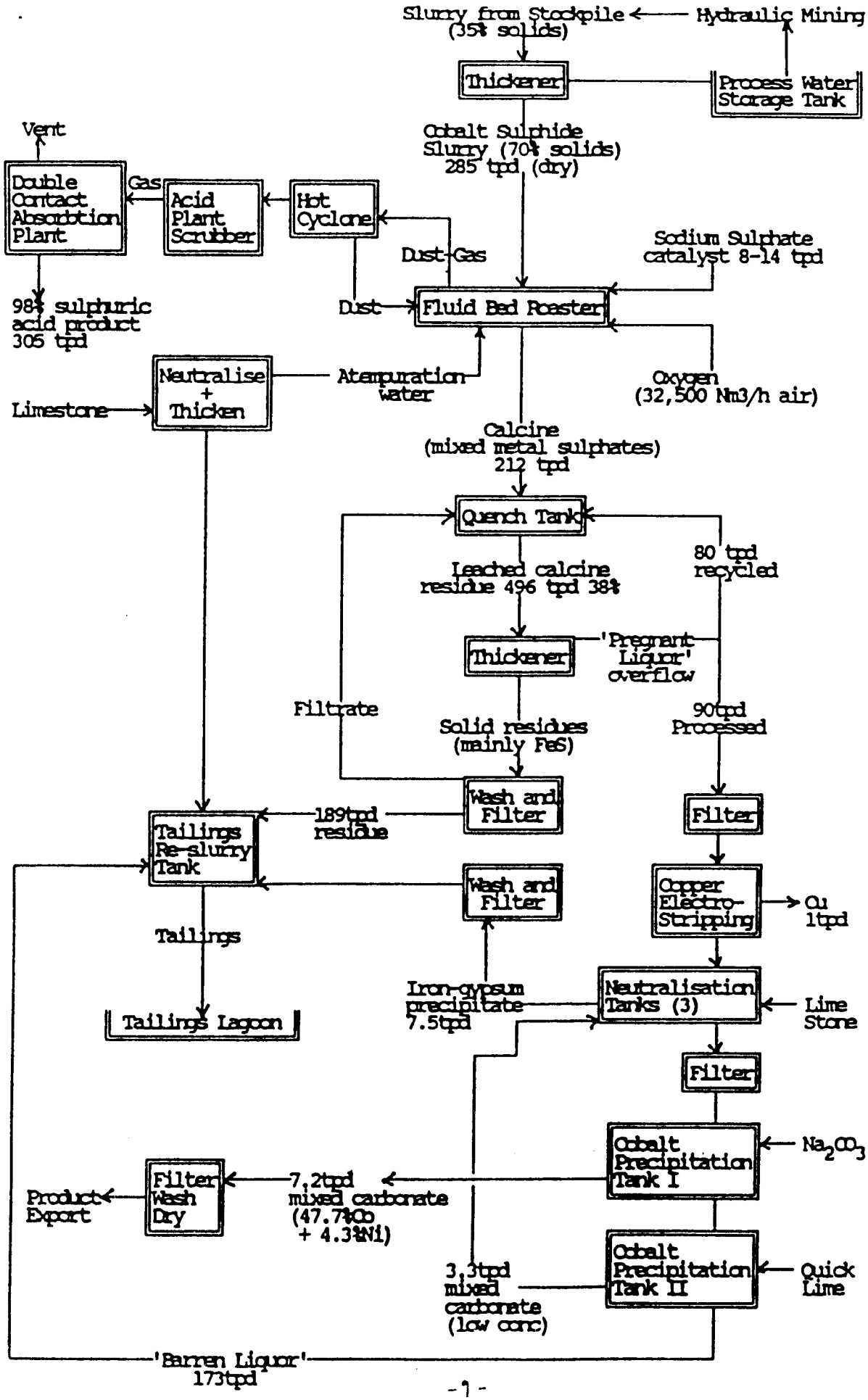
O. Post-project monitoring and "auditing"

- Comparison of predicted and actual impacts
- Were the predictions accurate?
- Did the mitigation and monitoring measures work?
- Did unpredicted impacts occur?
- Feed-back for future projects -> learning and development of methods and procedures

EIA PROCEDURE AS APPLIED IN THE NETHERLANDS
(proponent ≠ competent authority)



Example of a flow chart (cobolt and sulphuric acid plant)



Example of a checklist for identification of biological impacts (FEARO 1983)

Checklist for description of the biological environment
(extract from specific guidelines for gas production project in Sable Island Area)

(a) Microorganisms

- distribution and abundance of indigenous microbiota, with special reference to oleoclasts and their effectiveness relative to specific hydrocarbon components.

(b) Phytoplankton

- species composition, distribution, abundance and production on a seasonal basis.

(c) Macrophytes

- species composition, distribution and abundance with special emphasis on existing (and potential) commercially important species, sensitivity to hydrocarbons.

(d) Zooplankton

- species composition, distribution, abundance on a seasonal basis;
- evaluation of biomass on a seasonal and geographic basis, including an analysis of the degree of variation.

(e) Benthos

- species composition, distribution and abundance on a seasonal basis in areas liable to be affected by any facet of the drilling operation, together with supporting sediment data with respect to particle size distribution and susceptibility to oil contamination. Commercially valuable shellfish should be reviewed as a separate category.

(f) Fish

- seasonal distribution and abundance of pelagic eggs and larvae;
- seasonal distribution and abundance of juveniles and adults;
- fisheries (marine, diadromous and freshwater species) with emphasis on seasonally important areas and fish densities migration behaviour, spawning requirements, and sensitivities to disturbance;
- sensitivity to hydrocarbons.

(g) Mammals

- population size, seasonal distribution and movements to onshore, nearshore and offshore species;
- designation of areas important to any species, e.g. nursery, feeding, calving.

(h) Birds

- seasonal distribution, movements and abundance of marine and other bird populations for onshore, nearshore and offshore areas;
- location and population estimates of seabird colonies;
- identification of environmental features affecting the timing of nesting and migration of the various species of marine birds in the region;
- identification of nesting and breeding and overwintering areas for water fowl.

(i) Sensitive Species

- the identification of any species which may be sensitive to the proposed development and that act as important food resources for other co-habiting species.
- identification of species that may be considered rare or endangered, or important for subsistance, scientific, commercial or recreational use.

(j) Historic Trends

- historic trends in the use of the area by animal populations, including those of direct and indirect importance as well as those endangered by man's activities.

(k) Vegetation

- biogeoclimatic zones and forest cover; forest stand structure, maturity;
- plant communities relative abundance of species, importance to man, and importance to native fauna as habitat and food;
- identify undisturbed, rare or unique vegetation; plant life of special economic, historic, social or scenic value;
- agriculture (crops, dairying, grazing, livestock, poultry, orchards, mixed farming) and forestry (raw material use, types of production).

Typical Socio-economic Factor Checklist (Rau and Wooten, 1980)

COMMUNITY RESOURCES:

General and local community plans

Circulation	Conservation	Housing
Land use	Noise	Open space
Safety	Scenic highway	Seismic safety
Energy management/conservation	Air pollution control	Growth management

Human habitat

Aesthetics and visual effects	Barriers and privacy	Community design
Corridors	Displacement and relocation	Growth patterns
Health and safety	Population density and dispersion	Urban congestion
Community cohesion		

Public services

Fire protection	Flood control and storm drains	Medical service
Police protection	Postal service	Recreation and parks
Schools	Public transportation	Traffic flow and circulation

Utilities

Communications	Electrical power	Natural gas
Sewage waste disposal	Solid waste disposal	Water

CULTURAL AND SCIENTIFIC RESOURCES:

Community facilities

Cultural	Religious	Scientific
Special entertainment		

Regional

Aesthetics	Archaeological sites	Historical sites
Paleontological sites		

ECONOMY:

Community expenses

Public services	Utilities	Others

Community revenue sources

Building permits	Fees (motor vehicles, etc.)	Fines
Gas tax	Property tax	Sales tax
Utility connections	Utility service charges	Others

Regional expenses

Loans and subsidies	Public assistance	Others
Utilities	Public services	

Regional revenue sources

Fees	Taxes	Others
Fines		

Examples of Areas of Social Impacts, Possible Measures, and Data Sources (Forster, Roberts and Sievering, 1981)

Area of Social Impact	Possible Measures	Baseline Data	Sources for Data
Socio-demographic Characteristics	Changes in social, economic, and demographic characteristics	Household size Number of years in residence Number of years in neighborhood Age distribution -number and ages of children -number of over 65 residents Racial and ethnic groups Income distribution	Citizen Survey Census
Recreation	Changes in number and percent of residents satisfied with recreation opportunities Change in physical conditions affecting recreation activities	Usage patterns Inventory of Settings Perceptions of the settings	Direct Observation Citizen Survey Public Hearings
Perceived Environmental Quality	Change in number or percent of residents satisfied Change in physical conditions that will affect quality	Indices of Physical Quality Indices of Perceived Satisfaction Identification of physical changes	Quality Indices Citizen Surveys Observations Public Hearings
Perceived Personal Safety and Privacy	Change in number or percent of residents satisfied Number of people at risk from hazards	Perceptions of satisfaction Identification of hazards	Citizen Survey Public Hearings
Aesthetic Values	Change in number or percent of residents satisfied with attractiveness of neighborhood Number and type of landmarks lost or damaged Loss of pleasant sounds, sights	Ratings of attractiveness Perception of upkeep and maintenance Identification inventory	Citizen Survey Public Hearings Observations Local Historical Society Data Walking Survey
Employment	Change in numbers and percent of employed, unemployed, underemployed	Listing of old and new jobs	Census
Housing	Change in the number and percent of housing types	Listing of units	Census
Displacement	Number of workers displaced Satisfaction with displacement	Listing of losses	Count Worker Survey
Lifestyle and Values	Conflicts surrounding proposed project	Perception of conflicts	Public Hearings Citizen Surveys
Health	Number of persons in the area with disease conditions or susceptibilities likely to be affected	Disease Prevalence Rates Number of aged and very young	U.S. National Averages Local Death Rates Population Census of Aged and Very Young

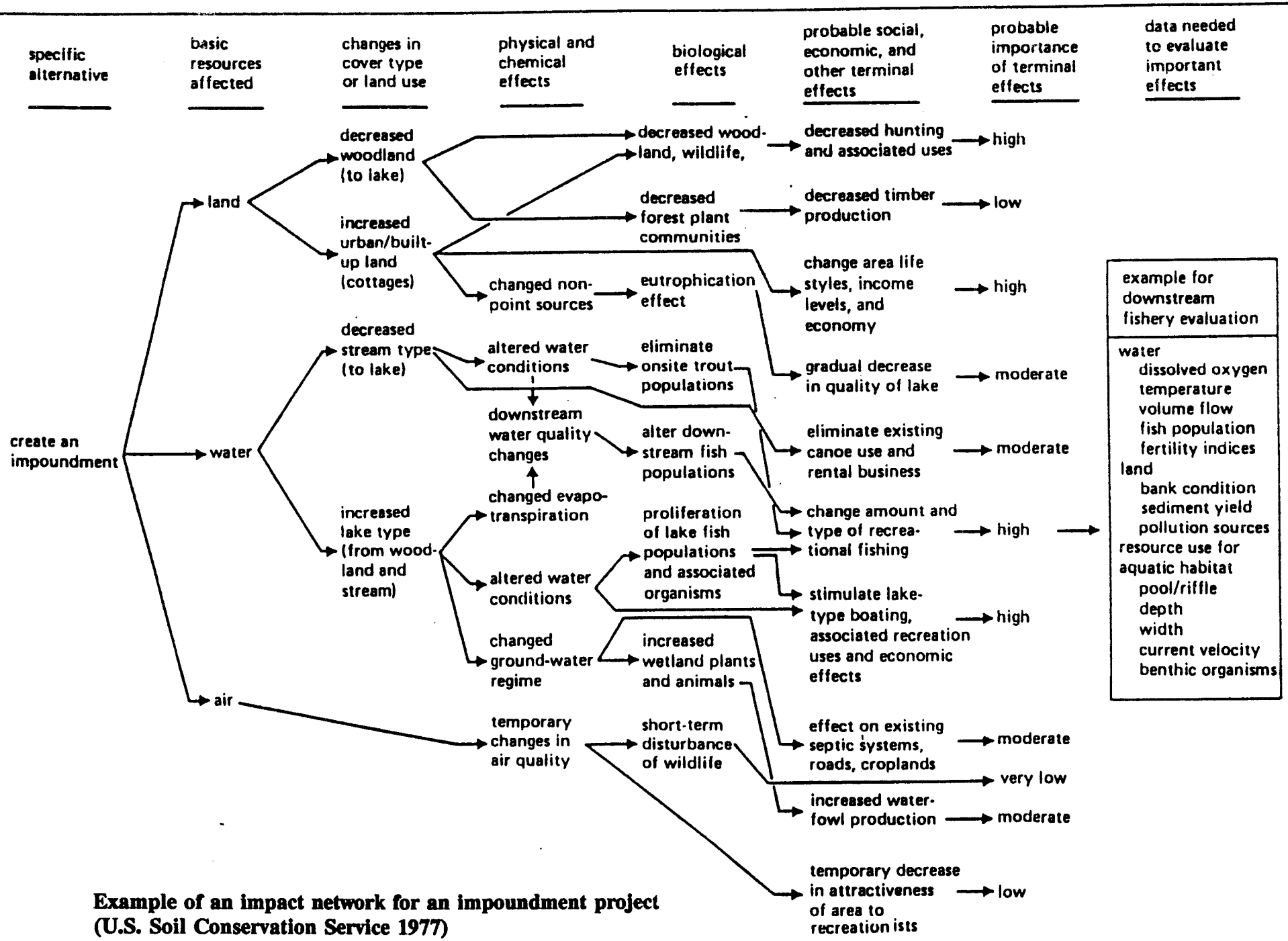
Example of a structured checklist for Quality of Life impacts

Category	Domain	Indicators (Factors)
Basic Life Needs	Income	Household income distribution Real income Income per capita Cost of living index
	Housing	Percent of owner occupied housing units Median value, owner occupied, SFDU's Net housing starts Vacancy rate Satisfaction with housing
Well-being Needs	Employment	Unemployment rate Percent of labor force employed Satisfaction with employment and job opportunities
	Health	Infant mortality rate Communicable disease index Number of physicians per 1000 people Hospital beds per 1000 people Death rate per 1000 people Satisfaction with health care
	Safety	Crime seriousness index (per 1000 people) Number of police per 1000 population Percentage of crimes cleared by arrest Percentage of recovered stolen property Perceived safety
Opportunity Needs	Education	Public school expenditures per capita Public school tax base School enrollment Continuing education opportunity Satisfaction with education opportunities
	Transportation/Mobility	Ratio of miles of surfaced streets to miles of unsurfaced streets Number of traffic accidents per 1000 people Motor vehicle registrations per 1000 population Percent of workers who use public transportation to work Satisfaction with transportation
	Information	Number of books in public library per 1000 people Local Sunday newspaper circulation per 1000 population Local radio stations per 1000 people
	Equality	Ratio of white to non-white unemployment rates Ratio of male to female unemployment rate Percent of families with incomes below poverty level Perceived inequality among residents
	Participation	Percent of eligible voters Vote turnout in local elections Satisfaction with opportunity to participate
Amenity Needs	Recreation	Acres of parks and recreational areas per 1000 population Miles of trails per 1000 population Satisfaction with recreational opportunities
	Environmental Quality	Air pollution index Mean annual inversion frequency Water pollution index Noise pollution index Satisfaction with environmental quality
	Cultural Opportunities	Cultural events per 1000 people (dance, drama, music events) Fairs and festivals, annual rate Sports events Satisfaction with cultural opportunities

Example of an interaction matrix; Midwest lake environmental impact statement (Wright & Greene 1987)

(* = significant impact, x = impact)

Accidents and upsets	Reclamation and abandonement	Project personnel and support services	Operation				Construction				Exploration		
Mine Mill Camp Transportation See "construction" and "operation"	Mine Mill Camp Transportation See "construction" and "operation"	Personnel, hiring policy, training, support services, marketing of product	Transportation people transport, raw materials transport, product transport, fuel storage	Camp waste management, power generation, water use, equipment operation, housing, recreation	Mill power generation, ore production, process wastes (water, solid, air) yellowcake, other wastes, tailings management (stability, effluent, prospect, emissions)	Mine pit dewatering, ore extraction, ore stock pile, downgradient to mill, other wastes	Transportation storage, access roads	Camp buildings and other facilities	Mill mill buildings, preparation of tailings management area, transmission lines and pipelines	Mine dewatering of lake, dam construction, mass dewatering, pre-strip transmission and disposal, pit construction, mass buildings, overburden removal, waste rock pile	Prospecting and surveying, access, exploration camp, drilling of deposit	Project actions	Environmental components
*	*		x	*	*	*	x	x	x	*		**Climatology** wind, humidity, insolation, temperature, precipitation, evaporation, visibility, snow depths	Air
*	*			*	*	*			x	*		**Meteorology** wind speed, wind direction, stability	Air
*	*		x	*	*	*	x	x	x	*	x	**Air quality** nitrogen oxides, sulphur dioxide, carbon monoxide, total suspended particulates, radionuclides	Air
*	*				*	*	x	x	x	*	x	**Soils, lichens, vegetation, community**	Terrestrial Habitat
*	*	*			*	*	x	x	x	*	x	**Caribou, moose, beaver, wolves, birds**	Terrestrial Wildlife
*	*				*	*	x	x	x	*		**Surface water** water levels, discharge, scour	Aquatic Hydrology
*	*				*	*				*		**Ground water** flow system	Aquatic Hydrology
*	*	*	x	x	*	*	x	x	x	*		**Surface water** major anions and cations, trace elements, micro and macro nutrients, radionuclides, phys. parameters	Aquatic Quality
*	*	x		x	*	*				*		**Ground water** pH, DO, ionic strength, major ions, trace elements, radioisotopes, radon	Aquatic Quality
*	*			x	*	*	x	x	x	*		**Flora** macrophytes, phytoplankton, periphyton	Aquatic Habitat
*	*			*	*	*	x	x	x	*		**Fauna** benthos, zooplankton, fish, fish predators (birds, mammals)	Aquatic Habitat
*	*	x	x	*	*			x	x	*	x	**Workers** non-radioactive dusts, combustion products, radionuclides, radon, noise and vibration, chemicals / fumes, gamma / beta radiation	Health and safety
*	*	x	x		*	*				x	x	**General public** non-radioactive dusts, radionuclides, radon, gamma / beta radiation, chemicals, combustion products	Health and safety
*	*	x	x	x	x	x	x	x	x	x	x	**Land uses** forestry, fishing, hunting and trapping, recreation / aesthetics	Socio-economic
*	x	x	x	x	x	x	x	x	x	x	x	**Community** community services, commercial services, infrastructure, transportation, communications, local government, commercial vitality	Socio-economic
*	x	*	*	x	*	*	x	x	*	*	*	**Economics** population, direct employment, direct income, indirect employment, indirect income, direct project revenue, government revenue and expenditures, economic base / stability, cost of living, external economic impacts	Socio-economic
*	x	*	x	x	*	*	x	x	*	*		**Cultural and social impacts** archaeology, religion, migration patterns, community satisfaction, social organisation, community stability, job and education aspirations, job satisfaction	Socio-economic



Example of an impact network for an impoundment project (U.S. Soil Conservation Service 1977)

Conventional CBA Approach	Suggested "EIA Approach"
- based on the neoclassical economic theory	- based rather on institutional economic theory
- one dimensional concept of economy, welfare and development	- multidimensional, holistic concept of economy, welfare, development and environment
- monetization of impacts ("monetary reductionism"); possibility of "correct" prices assumed	- impacts are described quantitatively and/or qualitatively in dimensions characteristic of different impacts
- aggregation or amalgamation of different impacts occurring in different times and affecting different individuals, groups and interests differently	- disaggregation of different impacts and their geographical, temporal and social distribution
- aims at optimization of impacts	- optimization not possible nor desirable
- assumes a consensus of the goals in the society	- does not assume consensus in the society; conflicts between different ideologies, values and interests which are common in environmental problems should be openly and explicitly adressed; aims at conflict resolution
- planner is seen as "neutral" and his/her method as objective and "value-free"	- planner is seen as a human being; planner's values and methodological choices influence the results of analysis; value-laden choices should be identified and reasoned
- problems are assumed "simple" and solvable by collecting "facts" and using "technical" solutions	- problems are seen as complex, involving both facts and values as well as uncertainties which should be explicitly dealt with
- planner's role is to present the "best" or "optimum" alternative	- planner's role is to describe and illuminate the decision-making situation, problems and impacts showing the likely consequenses of alternative decisions; no "optimum" alternative exists; the merits and disadvantages of different choices can only be judged from different values and perspectives
- expert and economist-oriented planning	- interdisciplinary (team work) and participatory planning; all methods and procedures should enable real public participation; documents should be comprehensible and accessible to all interested parties

Example of contents of an EIA report (U

1. **Executive Summary**
   - 1.1 Brief description of the proposed project
   - 1.2 Brief summary of project objectives
   - 1.3 Alternatives to the proposed project
     - a) description
     - b) comparison of suitability to meet objectives
     - c) comparison of significant impacts and mitigation measures
   - 1.4 Areas of controversy and concern to:
     - a) other agencies
     - b) the public
   - 1.5 Issues to be resolved, including:
     - a) choice between alternatives
     - b) actions to mitigate significant impacts
   - 1.6 Summary of the anticipated uses of the Environmental Impact Statement (EIS)

2. **Introduction**
   - 2.1 Objectives of the EIS: document and process
   - 2.2 Authorities (applicable laws, guidelines, etc.)
   - 2.3 Intended uses of the EIS
     - a) agencies and the decisions they are expected to make using the EIS
     - b) list of approvals requiring use of the EIS
   - 2.4 Scope of the document

3. **Project Description**
   - 3.1 Location and boundaries of the project area
   - 3.2 Needs for and objectives sought by the project

4. **Project Alternatives**
   - 4.1 Description of the project alternatives including:
     - a) technical aspects
     - b) economic aspects
     - c) environmental characteristics
     - d) engineering aspects
     - e) public facilities support required
     - f) "no project" alternative

5. **Environmental Setting**
   - 5.1 Description of the regional setting of the project, including but not limited to:
     - a) existing and planned landuses of the alternative sites
     - b) natural setting
     - c) socio-economic setting
   - 5.2 Relationship of project to applicable existing plans including but not limited to:
     - a) national plans
     - b) regional plans
     - c) air quality maintenance plans
     - d) area-wide waste handling & treatment plans
     - e) other spacial plans
   - 5.3 Relationship of the project to future developments

6. **Significant environmental impacts of proposed action (impacts and measures needed to reduce the impacts to insignificance for each of the following:)**
   - 6.1 Impacts on the natural environment, including but not limited to:
     - a) soils and geology
     - b) hydrology
     - c) meteorology and climatology
     - d) vegetation
     - e) wildlife/fisheries
   - 6.2 Impacts on the human environment, including but not limited to:
     - a) demographic factors
     - b) socioeconomic factors
     - c) municipal services and utilities
     - d) existing and potential landuses
     - e) transportation factors
     - f) areas of unique interest of beauty
     - g) visual and aesthetic elements
     - h) noise elements

7. **Significant environmental impacts which cannot be avoided if the proposed project is implemented**

8. **The relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity**

9. **Any significant irreversible environmental changes anticipated**

10. **The growth-inducing impact of the proposed action**

11. **Recommended enviromental monitoring programs**

12. **Organizations and persons consulted during the preparation of the EIS**

13. **References**

14. **Preparation staff (names and brief biographys of the people who participated in the EIS)**

15. **Initial study (used to determine the need to do an EIS and to evaluate the content of the EIS)**

16. **Other technical appendices**

17. **Comments received through the public and agency review process**

18. **Responses to the comments**

19. **List of persons, organizations, and public agencies commenting on the draft EIS**

20. **Other information added to the draft EIS**

Leskinen, Antti, Salminen, Pekka & Turtiainen Markku, 1991. Basic Features of the Environmental Impact Assessment Process. Department of Land Use Economics. Publication 10/1991. University of Helsinki. Helsinki, Finland.

Summary

The Purpose of the Study

"Environmental Impact Assessment" (EIA) is the leading system or process of environmental planning and decision-making in the world. This report is a description and a review of it in the light of its foremost advantages and problems. The problems encountered elsewhere when applying EIA may be avoided in Finland by learning from these experiences.

EIA's Main Tasks and Characteristics

The main tasks of EIA are to assess and present the impacts of various actions and their options which may significantly affect the natural, built and social environment; also studied and presented are the possibilities for mitigating the adverse impacts and the opinions expressed by the various interest groups. As the outcome of a diversity of clarifications and well organised meetings between the interest groups, the process produces material for decision-making. The majority of this material is then compiled into what is called an Environmental Impact Statement.

The EIA was first put to practice in 1970 in the assessment of federal projects in the United States. Currently, EIA has been adopted by the majority of the states in U.S.A., the Federation of Canada and most of its provinces, the Netherlands, France, Australia and its states, Ireland, Norway, Denmark and many developing countries. This report describes the EIA procedures of the United States, Canada and the Netherlands.

In the early days of the development of EIA, the emphasis was solely on improving the "objective" database serving decision-making; it was assumed that this would automatically lead to better decisions. However, the value ladenness of environmental policy decisions and assessment of environmental impacts has led to a situation in which procedures for resolving disputes and for bringing about co-operation were needed in addition to mere data. Indeed, EIA is now becoming more and more distinctly a social negotiation process striving to resolve disputes. The basic premise for a successful negotiation outcome is for effective public participation to be made possible. In many countries already, public participation constitutes a significant part of EIA.

It was especially during the 1980s that the concept of EIA encompassing not only the natural environment, but social, cultural, economic and technical matters as well, and the interaction between these, received wide-spread recognition. Indeed, it would be more to the point to speak of Impact Assessment or Integrated Impact Assessment instead of Environmental Impact Assessment.

The holistic assessment of impacts requires services of experts from many fields. International experience has been that experts of the various fields should work in close co-operation during the assessment; i.e. as teams doing teamwork. The interdisciplinary EIA teamwork is very challenging for all of the team members; especially for the team leader who in addition to being an expert in his/her own field, should be conversant in the other fields and be able to formulate logical and informative syntheses; i.e. he/she should be a "generalist".

For deciding whether an detailed assessment is needed the proposed action is "screened" according to the potential significance of the adverse impacts on the natural, built-up and social environment. In several countries, a so-called "positive list" of the actions requiring EIA has been appended to EIA legislation. Such a list may, for instance, include certain industrial processes, motorways and residential areas exceeding certain thresholds. The need for EIA may also be determined by conducting a preliminary assessment.

Typical alternatives considered in an assessment are related to different sites, designs, processes, timing, etc. by which the stated objectives can be achieved. The no-project alternative is never left unanalysed.

All the possible impacts of the options are identified, taking into consideration their entire life-cycle. This means the recognition of the direct, indirect, cumulative and synergistic impacts of the various phases of the action or project, eg. planning, implementation, start-up, operation, termination and decommissioning, including emergencies. Not every option and impact needs to be assessed thoroughly. The examination of the situation is "scoped" following careful consideration of the matters the various parties feel to be significant. Often scoping aims at the formulation of guidelines (i.e. "terms of reference") for conducting a detailed assessment.

Baseline data are acquired concerning entities subject to possible significant impacts and risks. The impacts are examined with the aim of making predictions as to the magnitude, geographical and social distribution and time-scale of the impacts, and the probabilities and risks involved. Alongside this, an evaluation is made as to whether the predicted impacts, risks, etc., are acceptable or whether they require mitigative measures. The measures for mitigating the adverse impacts and risks involved are identified and plannned and the non-avoidable adverse impacts are presented.

The information is organized and presented in a Way that enables the alternatives to be compared and to make information useful for decision-making purposes. A number of aggregative and non-aggregative decision-making methods have been developed to satisfy this need. It is important to note that these method categories represent fundamentally different views of science, planning and democracy.

The main part of the material produced during the process is compiled to form what is called an Environmental Impact Statement. The non-technical summary constitutes an important part of this statement. Its purpose is to enable as many readers as possible to gain an understanding of the decision-making situation and of the contents of the statement.

An action can be either accepted in the form set out in the applicant's recommendation, following modifications or it can be rejected. In certain countries, the authorities deciding on these matters are required to give reasons for their decisions and to explain the extent to which a particular Environmental Impact Statement has been taken into account in decision-making.

The actual impacts of the action are monitored during and after the implementation. Remedial measures are taken should any unexpected impacts (i.e. impacts that deviate from what had been predicted) occur. "Auditing" and "post-project analysis" is employed in order to get information on the degree of success of the predictions and the whole EIA process and to gain experience for future assessments.

Public participation in EIA

Public participation is a central element of EIA. Participation can have a number of different objectives. To achieve at least the objective of two-way information exchange imposes the following prerequisites on EIA:

- People must be given the opportunity to participate in the process right from the start.
- The process and decision-making material must be in a form comprehensible to the people and the decision-makers. The methods used must also serve these goals.
- The planning organisation must be capable of "learning"; i.e. it must be flexible with respect to the changes taking place in its environment. Planners function not only as experts in their own fields, but also as facilitators of negotiations and interpreters of different interest groups.

Experiences and problems

According to experiences gained in various countries EIA improves the chances of precautionary environmental management when it constitutes an integral part of planning and decision-making. EIA has improved the possibilities for taking into account ecological and social matters. People have gained a deeper awareness of environmental issues and their opportunities for participation and for gaining information have improved. It has also been possible to resolve conflicts. For industry, the application of EIA has led to savings through the timely recognition of the impacts and the viewpoints of the different parties. The costs attributable to EIA have usually amounted to 0.5-2.0 per cent of the total costs of the projects.

The history of EIA, however, includes problems due to eg. the following;

- scientifically poor quality of EIA statements,
- EIA being disjointed from other planning and decision-making,
- inadequate scoping,
- inadequate public participation,
- rigidity of planning organisations,
- poor relaying of experiences,
- and especially that of a poor theoretical base.

EIA and Finland

So far in Finland, the Environmental Impact Assessment process has not been implemented in its generally recognised form. Finland has, nevertheless, participated in the international co-operation for developing EIA. The Committee on EIA, which begun its work in 1981, made numerous recommendations concerning the implementation of environmental impact assessments in the planning of projects and policies and in the development of legislation. In 1985, the Ministry of the Environment in Finland launched an EIA development project. The implementation of EIA has been emphasised in several environmental policy documents. Recommendations for the implementation of this type of assessment have been given in many sectors of public administration. Complementary training on EIA has been started. University-level education complying with EIA principles has been given by the Department of Land Use Economics at the University of Helsinki since 1986.

The implementation of the EIA process may lead to many significant changes in Finnish environmental policy and administration. For example, when compared to EIA, current environmental analyses complying with the existing permission and notification procedures are quite fragmented and narrow in scope. The social considerations in these analyses are insufficient. This is why the overall impacts of the decisions made are difficult to perceive. Alternatives are not too often considered in the analyses. Usually, people learn of plans too late and in a form difficult to comprehend. Another shortcoming in the current practice is that assessment experiences of the post-planning monitoring period are not collected and analysed in such a way that they might be benefited from when making new plans and assessments.

EIA can be expected to impose many demands on the training of experts and researchers for the various fields as well as on the development of participation capabilities on the part of the public. The experiences from abroad would seem to suggest that we in Finland:

- should make special efforts to comprehend the political nature of EIA,
- make EIA an integral part of decision-making, including the preparation of policies and action plans, within the various administrative sectors,
- set up an independent EIA commission of experts which would have a co-ordinating role alongside its expert role,
- ensure the equal financial participation by the different interest groups; e.g. by means of a "participation fund" set up by the government,
- establish a distinct research unit to develop EIA and to monitor international developments,
- develop EIA training and education at universities and elsewhere.

SVERIGES
LANTBRUKSUNIVERSITET

Economics in relation to environment, agriculture and rural development

A non-traditional approach to project evaluation

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Preface

The present report was requested by the Policy Analysis Division of FAO in Rome and submitted to the organization in September 1988. It was accepted as consistent with the terms of reference given and I received payment for my services. But in other ways the fate of the report with the FAO is unknown to me. It is possible that my criticism of conventional techniques of project evaluation in terms of cost-benefit analysis was not well received in some circles within the Policy Analysis Division and that the report somehow disappeared in the archives of the organization. A sign that this may be the case is a comment in the "Reaction" part of the FAO journal, **Ceres**, entitled "Fashionable line of thought" (July-August 1988, page 50), where R. Gusten, from FAO I expect, is critical about my questioning of cost-benefit analysis in a review for the journal (May-June issue 1988, pages 48-49).

Incidentally, the journal **Ceres**, known for its open debate about development and environment, disappeared for some time with its July-August issue. But due to pressure and financial support from some governments, Sweden included, the journal is reappearing in the next few months. And the debate about approaches to development and evaluation will continue in **Ceres** and elsewhere.

I have written extensively in Swedish about alternatives to the monetary reductionism of cost-benefit analysis, but less in English. It therefore seems convenient to make the essay available as a report. Part of the discussion of positional analysis, some figures included, has perviously been presented under the title "Environmental Management. A Non-Traditional Approach" in the **Journal of Economic Issues**, March, 1987. Only minor adjustments have been made as compared with the paper submitted to FAO.

In writing this paper, I received help and support from Tadesse Zerihun, who has more experience about life and environmental problems in Africa and other developing countries than I have. Especially his annotated biography (Zerihun 1988), which was produced as part of the FAO request, helped me a lot.

Uppsala in July 1990

Peter Söderbaum

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Chapter 1

INTRODUCTION

Purpose of the study

Awareness about the importance of problems related to the environment and natural resources is increasing in many circles. These problems represent a challenge to citizens, farmers, businessmen, members of public interest groups, scholars at universities, government officials, politicians in all countries. The global character of many environmental problems and also the potential for learning from experiences in other countries calls for international cooperation.

The United Nations Conference on the Human Environment in Stockholm in 1972 exemplifies an early cooperative effort and the report by the World Commission on Environment and Development entitled Our Common Future (1987) is a more recent example of an attempt to identify problem areas and possible measures at the local, national and international levels. This commission was chaired by the Norwegian Prime Minister Gro Harlem Brundtland and is often referred to as the Brundtland Commission.

Multinational organizations such as the World Bank and the UN Food and Agricultural Organization, FAO, are participating in the effort to take more adequate account of environmental aspects. This report has been prepared for the Policy Analysis Division of the FAO to suggest ways of incorporating environmental aspects more systematically into training programmes on project and programme evaluation. These training activities mainly concern FAO member countries in the Third World.

More precisely I have been asked to prepare a conceptual paper covering the following ground:

a. the conceptual and methodological framework for assessing the impacts of agricultural and rural development projects and programmes on the agro-ecological system,
b. the techniques and tools available for monitoring and evaluating environmental impacts, and

c. recommendations for agricultural and programme planners in developing countries for the preparation of environmentally sound projects and programmes (FAO, terms of reference, W. Kidane, April 27, 1988).

Strategy and limitations

The three items quoted are preceded by a backgrond discussion which contains the following statement: "There is a growing awareness of the shortcomings of conventional techniques of project analysis, which put more emphasis on the quantitative measurement of the project worth without due consideration being given to their implication on the agro-ecological system within and outside their project area".

The conventional technique referred to is cost-benefit analysis, which aims at an estimate in monetary terms of net present values for each project or programme considered. It is argued in the quotation that this quantitative, monetary approach does not always go well with problems relating to the environment and ecology.

One way to proceed would be to go directly into matters of technique concerning cost-benefit analysis and the alternatives to the conventional approach that have been suggested. What is wrong with monetary cost-benefit analysis? Is it possible to modify the conventional approach or would it be better to choose some other method? What are the alternatives in terms of method and how do these alternatives compare with each other and with the conventional approach?

Instead of such direct approach I will however "travel upstream a bit" (to use a metaphor from Robert Goodland, 1987). Just as is the case with environmental pollution, it is often fruitful to deal with the problems upstream at the sources. If cost-benefit analysis is considered insufficient and thereby represents a kind of intellectual "contamination", we have to ask where it comes from.

The source in this case is mainstream or neoclassical economics. Neoclassical economics offers a perspective, i.e. a conceptual framework together with theories and methods on the micro and macro levels. Theories of economic growth in GNP terms exemplify the neoclassical approach. Other elements of this mainstream thinking are welfare theory and cost-benefit analysis.

If this neoclassical approach or paradigm has limitations in relation to environmental issues one may well ask about the alternatives. What other schools of thought in economics may contribute to the handling of environmental and rural development problems? How can these other theories contribute on their own or in combination with neoclassical theory?

In what follows I will try to indicate tensions between schools of thought in economics. I will also discuss how different views of development tend to be connected with different schools of thought. Against this background it will, I hope, be easier to see the intellectual background not only of cost-benefit analysis but also of the non-conventional approaches.

It turns out that a questioning of cost-benefit analysis is in some respects an attack on neoclassical economics as a whole. Do we need a "new" economics to deal with environment, poverty and other aspects of development?

In suggesting an answer to this question I certainly do not claim neutrality. Being in many ways a follower of Gunnar Myrdal in my own country and organized as an institutional economist in the Association for Evolutionary Economics (AFEE) in North America and among those who are launching a European Association for Evolutionary, Political Economy, I am certainly aware of the close connection between values and concepts in economics. I believe and hope that my document, together with documents produced for instance by neoclassical writers, will contribute to a many-sided discussion in multinational organizations and elsewhere about the pros and cons of different approaches. Some pluralism with respect to perspective seems in itself to be a strength. How can one argue in favour of one approach while knowing little or nothing about the alternatives?

Chapter 2

SCHOOLS OF THOUGHT IN ECONOMICS

The contemporary situation

Many economists and non-economists write and talk as if there was only one kind of economics. This is true, for instance, of the above mentioned Brundtland report, which refers to economics and economic factors in rather simplistic mainstream terms. Monetary indicators such as GNP, investments, savings, exports, imports, profit and loss statements for business firms and cost-benefit analysis at the public level seems to be at the heart of this interpretation of economics.

Non-monetary factors such as employment certainly play a role, but many of these aspects are somehow downplayed as being "non-economic" or otherwise less relevant.

In some places the Brundtland Commission recognizes, however, that something is wrong with our modes of thinking or our ways of perceiving problems and dealing with them. In one passage, for instance, a broadening of our thinking is recommended:

> "Intersectoral connections create patterns of economic and ecological interdependence rarely reflected in the ways in which policy is made. Sectoral organizations tend to pursue sectoral objectives and to treat their impacts on other sectors as side effects taken into account only if compelled to do so... Many of the environment and development problems have their roots in this sectoral fragmentation of responsibility. Sustainable development requires that such fragmentation be overcome" (World Commission p. 63).

It seems relevant here to point out that there is a school of thought in economics which makes a similar recommendation in favour of holistic thinking. I am thinking of institutional economics. This observation indicates that it might be relevant to discuss the present situation with respect to paradigms or schools of thought in

economics as a first step in our attempt to understand problems related to environment and development.

A contemporary text-book on the history of economic ideas describes how a clear dominance of the neoclassical school in the 1960s has disintegrated into a situation with no less than five different schools of thought in the middle of the 1980s. These "range from new neoclassical conservatism on the right to radical Marxism on the left. A variety of others occupy the middle ground: Keynesians, Post-Keynesians and institutionalists" (Fusfeld 1986, p. 189).

I will simplify the picture a bit by referring to three main schools (cf. figure 1): Marxist or radical economics, institutional economics and neoclassical economics.

Marxist	Institutional	Neoclassical
- radical economics	- institutional economics - social economics - humanistic economics	- Keynesian economics - Austrian economics

Figure 1. Neoclassical economics still represents the mainstream in Western countries. But there are tensions between subgroups in the neoclassical camp and outsiders such as institutionalists compete successfully in subfields of economics such as environment and development.

The potential of Marxist thought in relation to environmental problems is critically evaluated by Michael Redclift (1984, 1987).

Institutional economists are organized in the above mentioned Association for Evolutionary Economics, with its **Journal of Economic Issues**. Many of the members of AFEE are also members of a related Association for Social Economics, which publishes the **Review of Social Economy**. Other members of this institutional family in a broad sense are those who edit the **Human Economy**

Newsletter[1] (see also the writings by Lutz and Lux 1988 and Max-Neef 1982, 1988).

The term of Post-Keynesian has been used mainly in the United Kingdom, Holland and Belgium and is said to refer to non-neoclassical economists of all kinds except Austrians. Some Post-Keynesians, for instance, are institutionalists.

Fusfeld's category of Keynesians is here regarded as part of the neoclassical mainstream. Austrians, referring to Friedrich Hayek, Ludvig von Mises and others, can be looked upon as a specific subcategory among largely neoclassical economists (cf. Fusfeld's term "new neoclassical conservatism"). Austrians share a criticism of equilibrium theory with institutionalists and Marxists, but they remain part of neoclassical theory in their individualistic view of man. The same individualistic tendency is an important characteristic of other neoclassical subgroups such as public choice theorists (Downs 1957, Buchanan and Tullock 1962, Niskanen 1971) and transaction cost theorists like Oliver Williamson (1979, 1985). The latter refers to his work as the "new institutional economics", which is confusing since it deviates only slightly from the neoclassical mainstream (Hodgson 1988).

I believe that most of the schools of thought mentioned can contribute something to the debate about environment and development. I will, however, be emphasizing the possible role of institutional economics and trying to indicate how it differs from the mainstream.

Institutional economics as an alternative to neoclassical economics

According to the Finnish philosopher Georg Henrik von Wright (1986) and other observers, there is a tension within science between a mechanistic, reductionist world view on the one hand and an evolutionary, holistic world view on the other. Von Wright refers mainly to physics, chemistry and biological sciences, but others

1 The Human Economy Newsletter, with the subtitle "Economics as if people mattered", is currently edited at the Mancato State University, Economics Department, Box 14, Mankato, MN 56001, USA.

(Capra 1982) have extended this observation to social disciplines such as psychology and economics.

Von Wright's argument is that a mechanistic-reductionist world view has dominated since the eighteenth century and that in many ways this world view has been successful. In some respects, however, the endeavour to seek explanations at the level of the smallest possible units in equilibrium or other mechanistic terms is more doubtful and insufficient. Today we are witnessing environmental and other problems that indicate that we have gone too far in the direction of specialization and fragmentation. A more holistic world view is called for if we want to proceed further in any given discipline and if we wish to tackle the most important problems facing humankind.

Connected with the mechanistic, reductionist world view is a specific set of ideas concerning human inquiry, which is generally referred to as logical positivism. The scientist is an outside observer who believes himself to be objective and value-free. This view has also been challenged in recent times as constraining human thought and being too simplistic. Man interferes with nature with his instruments and there are always elements of subjectivity in scientific research. Nobody can claim to be value-free in any complete sense.

Turning now to economics, it is clear that neoclassical economics belongs to the mechanistic-reductionist tradition in science. Market theory in equilibrium terms is a good example. The ideas of economic analysis in terms of profit estimates and cost-benefit analysis are also reductionist in nature. These are, in my own words, cases of monetary reductionism. It can even be argued that the way neoclassical economists perceive their discipline, with clear borderlines between what is economic and "non-economic" or between economics and other social sciences, is of a reductionist character.

Institutional economists on the other hand are oriented in an evolutionary-holistic direction. The term evolution reminds us that history is important and that change and development can be described as a "circular process of cumulative causation" (Myrdal 1978). Not only are market mechanisms important to the process, but also cultural, social, technological, institutional and knowledge- or information-related factors. This multifaceted view is different from con-

ventional attempts to simplify analysis by disregarding everything except the market. Economics cannot be reduced to markets and pecuniary aspects, but should be understood in a broad holistic sense. It follows that, to the institutionalist, economics still has an identity of its own but there is a considerable overlapping with other social disciplines. The idea that there are economic problems that easily can be separated from "social" problems or "political" problems should be forgotten as soon as possible. Most important problems are interdisciplinary in character, i.e. they do not respect administrative borders between disciplines that humans have invented (Myrdal 1972). For this reason one may even speak of interdisciplinary economics, as I did in the subtitle of my doctoral dissertation (1973), and as is now reflected in the title of the **Journal of Interdisciplinary Economics**[1].

Neoclassical economic theory tends to take institutions as given, while institutionalists regard changes in institutions as an endogenous part of a total evolutionary process. In recent times neoclassical economists have demonstrated an interest in property rights as an important set of institutions. The above mentioned public choice theory also represents a widening of theory to incorporate factors that have traditionally been regarded as exogenous.

I certainly welcome this interest in property rights by neoclassical economists. But even institutions should be approached in a holistic manner. There are many other important institutions besides property rights and markets that influence development processes in all countries. When Gunnar Myrdal refers repeatedly to the importance of "institutions and attitudes" in Asian Drama (1968) or in The Challenge of World Poverty (1970), his interpretation of institutions is much broader than that of the neoclassical economists.

Neoclassical economics also belongs to the mechanistic-reductionist tradition in the way it approaches scientific inquiry. The value of a theory is connected with its ability to predict future events and the scientist is an outside observer whose analysis is value-free etc. Institutionalists have challenged this view as naive in all disciplines,

1 This journal is edited by Ken Penney, University of Exeter, United Kingdom.

and not least in economics. Concerning the claim to be value-free Myrdal's argument runs to follows:

> "Valuations are always with us. Disinterested research there has never been and can never be. Prior to answers there must be questions. There can be no view except from a viewpoint. In the questions raised and the viewpoint chosen, valuations are implied" (Myrdal 1978, pp. 778-779).

Myrdal's recommendation is that scholars be conscious and explicit about the valuational standpoint chosen. Where approaches to decision making are concerned, which are the main subject of this report, I would like to add to Myrdal's advice by suggesting that the analyst should try to be many-sided with respect to possible valuational standpoints. I will come back to this point later on.

Neoclassical economists seldom use the word power except in connection with the monopoly power of some business firms. For institutionalists, power is an inherent focus of their interest and analysis. Social and economic development is largely an outcome of the evolution of power relationships, institutional and technological change. And economic theory itself is part of this ongoing process of competition for power.

Neoclassical theory has become accepted in some circles not only for its scientific achievements in some limited sense, but also for its attractiveness as a way of explaining social phenomena and legitimizing certain patterns of behaviour among business leaders, bureaucrats and politicians. A theory that assumes profit maximization to be the overriding motive of business firms certainly contributes to a legitimization of narrow motives among business leaders. Environmental and social values can easily be downplayed. A different theory that refers to motives in a broader way and which discusses the possibility of alternatives to conventional views of development and also the possibility of more than one view of responsibility and ethics is certainly not attractive to all actors on the public scene.

This brings me to my concluding remark in this discussion about paradigms in economics. I regard the idea of testing theories

with respect to predictive power, too, as very restricted in scope. As I see it, the main purpose of theory is instead to offer a conceptual framework which facilitates understanding of development processes in which men and women act and influence the outcome. Economists themselves are also actors in this evolutionary process and their role in relation to establishment interests of one kind or another or outsider interests has to be discussed openly in a democratic process. This emphasis upon process and democracy rather than some perceived or estimated end result is a final distinguishing feature of institutionalist thought as compared with neoclassical writers.

Chapter 3

NATURE OF ENVIRONMENTAL PROBLEMS

Types of environmental problems

Some environmental problems are of a global character and therefore obviously also concern developing countries. I am thinking of possible global warming from increased levels of carbon dioxide in the atmosphere, depletion of the ozone layer, some forms of pollution such as stable organic compounds or radioactive substances that have been produced by man and which can now be found almost everywhere around the globe. The transfer of nitrogen and sulphur oxides, which cause acid rain, and the disposal and international movement of hazardous wastes are other examples.

Some of the problems mentioned such as depletion of the ozone layer are mainly connected with activities in industrialized countries. But the list can be continued with problems that partly originate in developing countries. A first example is loss of cropland and soil degradation in various forms. Soil erosion is a problem in some tropical countries. Desertification and deforestation are processes in which soil systems, water systems and climate interact in complex patterns.

Water systems may be depleted, resulting in water scarcity, or degraded, for instance through losses of nitrogen, phosphorus or pesticides from agriculture. Waste disposal on land or directly in the sea may add to the problems. Not only local but also regional water systems are often involved.

Examples of local and regional activities having possible global impacts are decreased biological diversity and exhaustion of non-renewable resources. Losses of species in tropical countries concern all humankind and the same is true of depletion of oil, phosphorus and other non-renewables.

The human ecosystem is of course part of the problem. We are worried about environmental degradation because it represents a threat to the health and well being of the human population. Famine,

illness, poverty and migration to marginalized land are some of the consequences of environmental degradation (cf. Bromley 1986).

The Human side of environmental problems

The above list of environmental problems is based upon a report from OECD (1982) and Zerihun (1988). It is clear from the list that environmental problems are not limited to the "environment" in a limited sense (cf. ecological systems in figure 2), but are human in character as well. The human side of environmental problems can be discussed with references to figure 2.

Industrial, agricultural and other human activities are often the source of environmental problems (cf. technology and production systems in figure 2). Chemicals used in agriculture may pollute rivers and other water systems. Irrigation systems may cause water-logging and salinization.

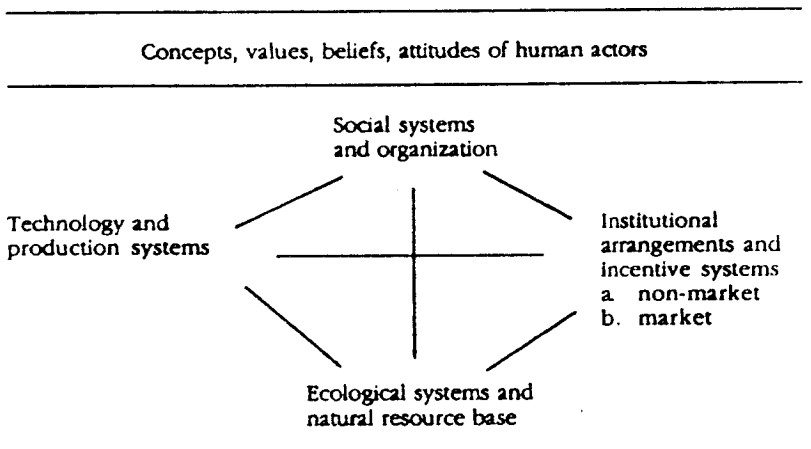

Figure 2. A frame of reference for the discussion of environmental problems which have an ecological as well as a human side.

Extensive timber cutting in tropical forests may influence water balance, climate and diversity of species. The collection of wood for energy purposes exemplifies how domestic activities are also involved.

Institutional arrangements and incentive systems represent another category of factors which may contribute to environmental degradation or improvement. Institutions are closely related to "social systems and organization" and to "concepts, values, beliefs, attitudes of human actors" (figure 2).

Among institutions, business firms and markets are connected with specific laws or other rules, which to a large extent are standardized, for instance in the case of international trade. Local trade as well as rules connected with land ownership may vary more from one cultural context to another.

Other important sets of rules concern political decision making and participation. Democracy is an umbrella label for a number of rules such as open access to information, rights for citizens to participate in a public debate, right to form organizations to influence political processes in an open dialogue, majority decision making etc. Religious organizations, the family, the tribe are other examples of institutions, each connected with a specific set of rules.

Institutions change as part of an ongoing evolutionary process. Various incentive systems are connected with each set of rules. Compliance is generally connected with rewards (benefits) which may be non-monetary, monetary or both (table 1). Disobedience may lead to punishments (costs) which again can be of a non-monetary or monetary kind or some combination thereof.

	Reward (Benefits)	Punishment (Costs)
Non-montary	I	II
Monetary	III	IV

Table 1. Categories of rewards (benefits) and punishments (costs) that influence human behaviour in an ongoing learning process.

Rewards tend to lead to reinforcement of behavioural patterns, i.e. to the formation of habits. When outcomes instead are perceived as negative, for instance in the case of environmental degradation, the individual will look for other behavioural alternatives and perhaps change his activity pattern. But choice may certainly be constrained by available monetary and other resources.

The category social systems and organization in figure 3 refers to individuals and populations with their cultural background and ways of cooperating and competing in local and national societies. Division of responsibility between public and private sectors and power relationships belong to this category, as do human action and behaviour patterns.

In any attempt to change societies, their technology and institutions, in a way that improves performance in relation to the environment or the natural resource base, it is necessary to challenge the ideas, concepts, beliefs, values, ideologies, attitudes etc that are held by various actors on the public scene. Ideas about economics, approaches to decision making, views about desirable societal development, ideas on business success or attractive life styles also belong to this category (cf. figure 2). Much of what will follow can be described as a discussion of conceptual and valuational issues.

Figure 2 claims to represent a holistic view of factors that influence human and societal development, including impacts upon the environment. Factors influence each other in mutual interdependence. Vicious circles are possible, for instance when environmental degradation leads to poverty which again leads to further problems. But so are virtuous circles, and this hope is a reason for our interest in environmental management.

Some essential characteristics

The fruitfulness of one approach as compared with another is a matter of compatibility with the problems faced. Before proceeding I will therefore list some characteristics of environmental problems that should be kept in mind:

1. The problems are multidisciplinary rather than limited to one discipline.

No single discipline, not even economics, on its own can provide the knowledge and information required for environmental management. Cooperation between representatives of different disciplines is necessary and each one of us should perhaps reconsider the appropriateness of conventional boundaries between disciplinary and more holistic or multidisciplinary abilities and identities.

2. Issues relating to development and environment are multidimensional rather than one-dimensional in kind.

Alternatives considered in a decision situation in most cases differ with respect to monetary, as well as non-monetary, dimensions. Monetary impacts on different parties are generally relevant. However, environmental management focuses to a large extent upon the non-monetary impacts of the practices and options available.

Approaches that reduce this multidimensional complexity to one dimension, whether in money, utility, or points, may certainly simplify matters, but only at the cost of considerable loss of relevance.

3. Any degradation of non-monetary resources, such as human beings, social relationships, ecosystems or natural resources, is often irreversible or very difficult to reverse.

The irreversibility of many non-monetary processes is another essential characteristic. Entropy is one aspect of irreversibility. The relevance of the laws of thermodynamics to economics has been discussed by Nicholas Georgescu-Roegen (1971). I regard irreversibility in its different forms, or more generally, influences upon future options as fundamental to economic analysis. Where environmental impacts on ecosystems, on non-renewable resources and the like are concerned, irreversibility is not a special case but rather the common case (Goodland and Ledec 1987).

4. Non-monetary resources such as ecosystems or plant species are often unique or very rare either in an objective or a subjective sense.

The extinction of species exemplifies uniqueness in an objective sense, whereas destruction of a person's native place or home district for construction purposes also refers to uniqueness but in a subjective sense. Uniqueness of either kind can be regarded as a special case of irreversibility.

5. The problems often extend beyond the actors involved in market transactions; that is, they impinge on the interests - such as the property rights - of other parties.

Environmental problems often transcend the institutional arrangements of man in the form of property rights. Here we are back to the neoclassical perception of environmental problems as negative impacts - so called externalities - on parties outside a specific market transaction. This way of looking at the problem is certainly relevant, but is not the only way.

6. The problems are multisectorial; that is, not limited to one sector of society or the economy.

Just as environmental problems do not respect administrative borders between disciplines or institutional arrangements in the form of property rights, so they cut across boundaries between sectors of the economy. It is quite difficult to delimit so called "environmental problems" from other problems, such as those related to health, employment, housing, and inequality. Limiting attention to agriculture or to the "environmental problems of agriculture", for instance, is not always meaningful. Environmental problems connected with agriculture are often problems because they interfere with other activities or sectors in society. Agriculture may negatively influence non-agricultural sectors, and the same is true of non-agricultural sectors in relation to agriculture (air pollution and acid rain, for example).

7. The problems often have considerable spatial extension, for example, they are not limited to a single municipality, county, or country.

A final case of how administrative boundary lines may be transcended concerns geographical jurisdictions. The Chernobyl reactor accident in the Ukraine indicates the potential role of airborne pollutants.

8. The problems involve uncertainty and risk (where only part of the uncertainty can be reduced through research efforts or through the acquisition of knowledge available elsewhere in the economy).

The danger mentioned earlier of reducing multidimensional issues to one-dimensional monetary figures is paralleled by a danger of reducing uncertainty to certainty or even of limiting attention to averages of possible outcomes. As analysts, we should instead be clear and explicit about the amount and kind of possible damage and the probabilities of its occurrence according to estimates from different sources. Conclusions, therefore, will reflect different possible attitudes toward risk and uncertainty.

9. The problems involve conflicts between different interests and ideologies in society.

Finally, problems with impacts on health and the environment are closely connected with emotions, values and ideologies. Conflicts of interest are the normal case, rather than the exception. As serious scientists, we cannot approach such conflict issues with the idea that we necessarily know the correct values to apply or the correct answers to offer. We can participate in the elaboration and development of possible ethical or ideological standpoints, such as sustainability or eco-development, and relate them to conventional ideas that emphasize quantitative growth (irrespective of what is growing) or employment (irrespective of the meaningfulness of such employment for the individual concerned or society at large), but the choice of one set of ethical principles in favour of another is always a matter of politics. In a democracy, scholars' approaches and analyses, including conditional conclusions with respect to values and goals sought, should be openly presented and openly appraised by all interested participants.

Chapter 4

DEVELOPMENT PERSPECTIVES

GNP growth or eco-development

For a long time, societal development was equated to "economic development" and "economic" mostly referred to monetary indicators such as GNP growth. In addition to "rapid economic growth", a number of subgoals were added as restrictions or to allow for some desired balance between different indicators; e.g. inflation should be kept down and imports should be balanced against exports. Unemployment and regional imbalances have also received attention as part of this traditional development concept.

Such an idea of development is closely related to Keynesian macroeconomics and to the system of national accounting developed for practical economic policy-making purposes. The usefulness of those concepts and macroeconomic indicators is beyond question. But such analysis is clearly insufficient. Environmental and natural resource issues do not easily fit into conventional ideas about development. Suggestions that ecology and ethics in relation to future generations are important tend to be rejected by neoclassical economists, on the basis of arguments about ecology being a discipline "outside" economics and for reasons of inconsistency with the idea of the neutral observer.

However, to institutionalists, with their holistic ideas and ambition to be explicit about values, statements in terms of ecological imperatives do fit well into the general framework and do not appear alien. Obeying certain principles of ecological ethics may in fact be a good way of managing natural resources. In other words, GNP growth is no less ideological than is the idea of ecological ethics. Ideology will always be with us.

As an alternative to maximizing growth in GNP terms, some speak about qualitative growth (Leipert 1983), thereby implying that some growth can be negative or "cancerous" and even that in some cases decline in production may be positive from an environmental point of view. In this way, an attempt is made to distinquish between

different products (goods and services) with respect to their impacts upon the environment. Others speak of eco-development, meaning "ecological development" (Sachs 1976, 1984). According to this view, development is a multi-faceted process with social as well as environmental goals, in addition to the more limited production and income aspects. Local and regional self-reliance and "participatory democracy" are further aspirations of this approach.

Another way of emphasizing the ecological aspect is to suggest that the economy should be "ecologized". Economies should be designed in ways that reflect ecological or biophysical realities. To do so one can work at three different levels: paradigmatic (using concepts and theories as building stones), ideological (pointing to different ideological standpoints and conclusions that follow from each of them) and practical (suggesting practical solutions within different fields of human activity, e.g. designing "ecological agriculture", "ecological forestry", or more generally "rural ecodevelopment").

Ecologizing research and education is one imperative according to this line of thought (Marinov 1984). Even economics can become ecological, as suggested by the title of a new international journal, **Ecological Economics**[1]. A way of emphasizing that decision making in relation to the environment is largely an ethical matter is to speak of "environmental ethics" (Goodland and Ledec 1987) or "ecological imperatives for public policy" (Söderbaum 1980, 1982, 1986).

Ecological imperatives could be formulated to avoid alternatives that involve a degradation of the environment, either in the region or nation where the planning occurs or outside it. Where uncertainty exists as to possible serious degradation of future living conditions, a policy of cautiousness is suggested. Research and development to design new technologies and alternatives that are compatible with the non-degradation aim are generally a good thing and sometimes the only reasonable long-run solution.

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The imperatives suggested may be further elaborated into behavioural rules in relation to non-renewable resources, renewable resources, and toxic materials with different characteristics. The concept of ecology may also be extended to include human beings or human resources. One may then speak of human ecology as part of ecology and "ecodevelopment". Such an approach has the advantage of bringing in the social aspects of development; e.g. personality development, human rights, and employment. In that way, human, social, or sociocultural resources may be considered part of ecological imperatives. Development policies that increase the number of unemployed are certainly doubtful and may degrade human resources.

Lester Brown (1981) preferred the concept of "sustainability", for instance "sustainable production" or "sustainable agriculture", and this is also the terminology chosen by the World Commission on Environment and Development, the "Brundtland Commission", in its report (1987). This emphasis on sustainability may be a good choice, but I believe that other terms and concepts which make a more explicit reference to the environment, ecology or ethics will also have a role to play in the future.

The Brundtland report

One feature of the Brundtland report is that it combines views that have often been regarded as hard to reconcile. Traditional objectives of economic growth are believed to be compatible with sustainability. In fact, the position taken by the Commission is that a high level of GNP growth will facilitate the transition towards sustainability. Similarly, the authors indicate a favourable attitude to economic integration and increased international trade, but also to values such as local self-reliance.

Such arguments recall the environmental debate of the early 1970s, for instance the judgement by Walter Heller, a conventional economist, that "it will be hard enough to finance the wars on poverty, discrimination, and pollution even with rigorous economic growth" (Heller 1972, p 11). While nobody denies that increased tax

revenues for governments will make reallocation of resources easier, economic growth does not, by itself, solve any problems. Qualitative judgements have to be made of the products and technologies involved and various monetary and non-monetary incentives applied to guide development in an environmentally sound direction.

There may be some element of wishful thinking in such attempts to incorporate many things in one development philosophy, but the approach is perhaps realistic in other respects. Thus, from a tactical point of view, it is hard to imagine a better way of introducing concepts like environment and sustainability into the thinking habits of various actors in the world of politics.

But the issue of compatibility between various development objectives still remains. While the Brundtland report was produced in a specific institutional setting which made compromise a necessity, the continuing dialogue about development need not be restricted to attempts to interpret this compromise or move it small steps in one direction or another.

Where attempts to change or modify values, thinking habits and behaviour are concerned, I believe that it is fruitful to dichotomize, i.e. to articulate opposites. What are the options for the future concerning rural development in Third World countries?

Rural and agricultural development. What are the options?

Figure 3 represents an attempt to contrast two different philosophies with respect to rural and agricultural development. One is closely connected with Western post-war ideals of integrating rural areas into the national and world economy. The other philosophy is described as local and national self-reliance and eco-development.

Competitiveness in the national and international economy is a key consideration within the scope of the first philosophy. Each region or sector within a region should maximize its contribution to the cash economy in terms of GNP growth and foreign exchange earnings.

The monetary market economy is also important as part of the second philosophy, but so is reduced dependence in relation to the national and international economy and reduced vulnerability to external disturbances of other kinds such as drought, soil erosion and food shortages. Expressed in positive terms, the philosophy is one of self-reliance. It does not, of course, exclude trade with other regions and nations that is found to be mutually beneficial.

Integration in the national and world economy	Local and national self-reliance and eco-development
- Maximum contribution to GNP growth and foreign exchange earnings.	- Reduced dependence on the national and international economies. Reduced vulnerability to external disturbances.
- Poverty and equality regarded as a matter of monetary income.	- Poverty and equality are multidimensional concepts.
- Culture and environment are secondary considerations.	- Non-monetary aspects such as compatibility with eco-development and with local (national) culture are essential.
- "Westernization" with respect to institutions e.g. expansion for cash economy, wage labour and "market democracy".	- Gradual institutional change e.g. no-cash economy (barter, informal etc) also regarded as important. Emphasis on meaningful work and participatory democracy.
- Large scale, high technology agriculture, i.e. high input chemical agriculture based on non-renewable resources, seed supplied by multinational firms etc.	- Small scale, "appropriate technology" agriculture, e.g. ecological agriculture (organic farming) based on renewable resources and seed from indigenous species.

Figure 3. Two philosophies for rural agricultural development.

The monetary bias of the first philosophy also influences how poverty and equality are perceived, i.e. as a matter of monetary in-

come. According to the second philosophy, poverty and equality are multidimensional concepts. Having monetary resources at one's disposal is one way of being rich, but a man or woman can be rich without any cash income, provided that basic and other needs are satisfied in other ways.

Culture and environment tend to be secondary considerations within the scope of the first view, but become essential as part of the second philosophy. Non-monetary impacts such as compatibility with eco-development and with local (national) cultural conditions are essential.

With respect to institutions "Westernization" in the sense of expansion for the cash economy, wage labour and "market democracy" characterizes the first philosophy. Those who have market power either as producers or consumers can exert their influence on the development process.

The second philosophy also involves institutional change, but an increased role for the monetary market economy is not always regarded as the best solution. Barter and other elements of an informal economy are also looked upon as progressive elements in development. And wherever monetary markets are relied upon, they are adapted to local customs and in other ways embedded in the local culture. The social aspect of markets is regarded as essential and any reduction of the view of markets to prices and quantities is questioned. Meaningful work in the cash and non-cash economies rather than just employment and wages is another characteristic of the second philosophy, as are various forms of participatory democracy.

With respect to technology, for instance in agriculture, the first philosophy tends to idealize large scale, high technology production systems. An increased role for high input chemical agriculture based on non-renewables such as oil and seed supplied by multinational companies is believed to be beneficial for the region and the nation.

The second philosophy encourages small scale, "appropriate technology" agriculture, e.g. ecological agriculture (organic farming) based upon renewable resources and seed from indigenous species. Organic farming is of course related to traditional farming techniques in developing countries, but the idea is to improve these production systems through research and development, extension services etc. It may be noted that IFOAM, the International Federation of Organic Agricultural Movements for the first time arranged its regular scientific conference in a Third World country, Burkina Faso in January 1989. This is a way of demonstrating that organic farming can be a step forward not only for industrialized countries in Europe and North America but in all parts of the world.

Returning now to the overview of figure 3, let us reflect upon the role of economic theory in relation to the two philosophies. It becomes clear how closely related the first philosophy is to mainstream neoclassical economic theory. The belief that specialization is a road to prosperity goes back to Adam Smith's Wealth of Nations, published in 1776. Smith mainly discussed manufacturing processes, but it is very likely that the same kind of thinking in efficiency terms has influenced the subdivision of government into sectors, each with limited responsibilities. There are, of course, still reasons to believe that in many cases specialization reduces average costs of production or improves administrative processes, but any specialization has to be integrated into a holistic view of development and responsibilities.

International trade theory was originally formulated by another classical economist, David Ricardo. Again, this theory cannot be dismissed easily, but it is simplistic and reductionist in its way of dealing with the interests of the countries that are trading. Certainly more than one interest is affected in each of the trading countries. Impacts of trade are multidimensional rather than one-dimensional. Non-monetary impacts relating to the energy used in transportation or environmental impacts connected with production, transportation, consumption of commodities and waste disposal should certainly be considered as part of any approach that claims to be holistic. Neglecting many dimensions and interests, such as the ones mentioned, indicates that neoclassical international trade theory is as much ideology as it is theory. (For a discussion of biological diversity in relation to the global exchange economy, see Norgaard 1987.)

Various growth theories in GNP terms of more recent origin also belong to the intellectual heritage that we have to confront. Until recently many economists regarded average GNP per capita in a country as the one and only measure of welfare. This emphasis on

GNP growth could in fact be regarded as a good example of "monetary reductionism". A concept that is complex in character, welfare, is reduced to one-dimensional terms, i.e. to a measure in money terms. Today we understand that welfare has to be measured in multidimensional terms.

While a normally indoctrinated mainstream economist will accept most of the elements of the first philosophy, he will probably have difficulties with the second development philosophy. Concepts such as culture, self-reliance, vulnerability, informal economy, meaningful work, appropriate technology, eco-development etc become either meaningless or irrelevant when viewed through neoclassical spectacles.

And yet, an increasing proportion of the citizens of Western countries and also of establishment groups now gradually turn to the second, self-reliance, eco-development philosophy as the most realistic, provided that human survival on this planet is regarded as important. Eco-development in one form or another is the best choice while "monetary development" of the more simplistic kind is regarded as dangerous to society.

With some important exceptions, economists with the World Bank or International Monetary Fund and most other economists tend to regard the debt crisis as the biggest problem facing Third World countries. I do not want to downplay the importance of these issues of monetary debt and imbalance in trade relations. But I would like to remind all those economists that there is also a debt to future generations in non-monetary terms. Human survival is at stake at a regional level and problems are also being discussed globally. Recalling the irreversible character of many environmental problems, it can be argued that the monetary debt crisis is a small problem when compared with the non-monetary debt issue.

Capter 5

ECONOMICS AND EVALUATION

Concepts of economics and efficiency

The idea of economics and efficiency referred to is certainly a key consideration when discussing **ex ante** and **ex post** evaluation of projects and programmes. This issue is of course related to the previous discussion about paradigms in economics, the nature of environmental problems and development concepts.

The neoclassical idea of economics and economic efficiency is connected with its practical recommendation to use cost-benefit analysis. This approach represents an attempt to broaden the study of impacts from one organization to society as a whole, but the idea is also to **reduce** all kinds of impacts to their monetary dimension with reference to some idea of "correct" prices. Future impacts are reduced to present impacts using a "correct" (generally positive) rate of interest, called the "discount" rate (implying that future values are played down in relation to present values). Impacts on various groups of individuals are added together, i.e. aggregated, and for each investment alternative a present value (or other one-dimensional indicator) can be estimated. This present value is believed to indicate the desirability of each alternative considered, in a way that is acceptable to all members of society. It is simply regarded as a matter of "correct resource allocation" and all other ideas about a desirable allocation of resources are automatically ruled out.

This way of dealing with values and ethics in society, for instance environmental ethics, is somewhat controversial (to use an understatement). My criticism of conventional cost-benefit analysis can be summarized in three sentences:

1. It represents a case of "monetary reductionism".
2. Its assumption that all kinds of impacts can be "traded" against each other is highly questionable.
3. It represents a "closed ethics".

Points 1 and 3 have been explained already. Point 2 refers, for instance, to the assumption that monetary costs can be traded against environmental or other non-monetary impacts that may be irreversible. If we want to forget about irreversible negative impacts on the natural resource base, cost-benefit analysis is obviously a good approach.

It can be noted that many of the international organizations referred to in the Brundtland report, like the World Bank and the OECD, rely heavily on conventional economics (welfare theory and cost-benefit analysis). Even UNEP (United Nations Environment Programme), which has the environment as its primary concern, approves of and recommends cost-benefit analysis (Ahmad 1983).

To my knowledge, little interest of paradigm discussions relating to economics has been shown by these organizations. In attempts to evaluate World Bank activities such as the Cassen study (Cassen 1986), too, economics tends to be taken as given and equated with neoclassical economics. The writings by Goodland and Ledec (1987, 1987b) from the Office of Environmental and Scientific Affairs, Projects Policy Department, of the World Bank seem to be one of the few exceptions to this rule.

And yet the thinking habits of neoclassical economics may be an important component of the problems faced. This kind of economics tends to legitimize oversimplification, narrowness and very strange ideas about how ethical issues and conflicts in society can be resolved.

If cost-benefit analysis represents a way of aggregating all kinds of impacts for all groups of individuals affected and all time periods, then the alternative is a highly disaggregated approach. Expressed in other terms one can move from a reductionist approach to one that is holistic (table 2). The previous discussion also indicates another desirable move, i.e. from closed ethics to open-ended ethics. Instead of assuming that the scientist knows what the "correct societal values" are, it is suggested that he or she should reason in conditional terms, referring, for instance, to the kind of alternative development views that have been articulated in this essay.

	Ethically	
	Closed	Open-ended
Highly aggregated (reductionist)	I	II
Highly disaggregated (holistic)	III	IV

Table 2. Categories of approach to evaluation. A move from highly aggregated and ethically closed approaches to highly disaggregated, ethically open-ended approaches is recommended.

Examples of category IV approaches are some forms of systems analysis, policy analysis and Environmental Impact Statements. These approaches will be outlined later on and one of them, positional analysis, will be described in more detail.

A holistic and ehically open-ended conception of economics means essentially that monetary and non-monetary impacts are kept separate throughout the analysis and that a many-sided analysis with respect to impacts and groups affected, now and in the future, is carried out. Environmental, social, health-related and other non-monetary impacts should be carefully estimated in addition to monetary, financial impacts.

The meaning of terms such as "economics", "resource", "capital", "value", "equality", "poverty" etc is broadened to allow for a serious treatment of non-monetary aspects. Costs and benefits may be defined as negative and positive consequences, respectively, from the point of view of specifik parties. A similarly comprehensive meaning of "cost" was used by Kapp in his early study of environmental problems (Kapp 1950).

"Capital" (vis à vis capital degradation) and "resources" (vis à vis depletion of resources) should also be taken to refer not only to monetary aspects, but also to non-monetary ones. And the non-

monetary aspect is not "less economic". References to "biological capital" or "genetic capital", for instance, will not always be made clearer by attempts to put price tags on things. Rather the opposite is true.

This recommendation also applies to our ideas about economic or housekeeping principles. Monetary principles, such as profit maximization for firms, are used today and will be used in the future. However, non-monetary principles for choosing among alternatives are often also used and fall within the category of economic principles as here defined. An attempt to safeguard the non-monetary resource base of future generations through "ecological imperatives for public policy" exemplifies a set of non-monetary principles. The analyst should be open-minded about such alternative principles, rather than assume that economic science or some specific version of economics can tell us about correct values.

Cost-benefit analysis is based on a specific idea of "economic efficiency" or "optimal resource allocation". In broadening our views about the efficiency of some industrial, agricultural or other activity, I suggest that a distinction should be made between "flows" and "positions", in addition to the previous distinction between monetary and non-monetary variables (table 3).

Flows refer to periods of time and positions to points in time. In this way we obtain four categories of objectives or variables: (I) monetary flows; (II) monetary positions; (III) non-monetary flows; (IV) non-monetary positions.

As I have already indicated, conventional economic analysis is, to a large extent, an analysis in monetary terms. GNP at the macro level and profit and loss statements at the micro level are expressed as monetary flows (category I). The balance sheet of a firm is a statement of its monetary position in terms of assets and liabilities (category II). In addition, non-monetary flows (category III) and non-monetary positions (category IV) should be carefully considered in attempts at **ex ante** or **ex post** evaluation.

	Flow (referring to a period of time)	Position (referring to a point in time)
Monetary	I	II
Non-monetary	III	IV

Table 3. Four categories of impact or objective in economic analysis.

Assuming that we are interested in some specific agricultural activity such as corn production, evaluation in monetary terms is certainly of interest, provided that the farm is part of some cash economy. But various non-monetary indicators are also of interest to the farmer and to outsiders who are concerned about his avtivities. He may, for instance, refer to the yield per hectare and make comparisons with previous years. However, further steps in the direction of a many-sided analysis can and should be undertaken.

First, there are many kinds of input and output (in addition to hectares and size of harvest) that can be studied and measured in quantitative terms. Energy input may be related to output in energy terms. Pollution, for instance leakage into nearby water systems, is a kind of output which may be related to the corn output or some other flow variable.

Second, just as monetary positions are evaluated in addition to monetary flows, there are reasons to focus on changes in non-monetary positions from the beginning to the end of some period. Are things improving or deteriorating in positional terms as a result of the agricultural activity (or set of agricultural activities) being studied? Is the activity based upon non-renewable inputs? Is the condition of the soil improving or deteriorating? Will the groundwater be more polluted at points in time t_1 and t_2 than it was at t_0?

Again, I cannot see any meaningful way of bringing all these flows and positions together into some index or other one-dimen-

sional measure. We have to live with some complexity if we want to understand what we are doing. Many-sidedness with respect to indicators seems to be the key to progress. And some "success stories" of the past indicating increased yields at some specific location may turn out to be less convincing when evaluated in relation to many indicators rather than one. Improved efficiency in terms of yield per hectare may be accompanied by decreased efficiency in other terms such as energy and by negative, irreversible changes in positional terms. In other words, the best thing we can do is to ask for the whole story.

Categories of approaches to evaluation

The previous discussion about the nature of environmental problems should be kept in mind as I now return to the question of appropriate scientific responses to environmental management and policy evaluation.

A number of approaches have been suggested, as indicated in table 4. There are similarities between these approaches, but also differences. The common features include a preference for rational analysis, that is, systematic treatment of alternatives and impacts, and claims of comprehensiveness, in the sense that more than one course of action is considered and that all significant impacts, individuals, or interested parties are taken into account. These analyses therefore claim to be societal rather than one-party oriented. Another common recommendation is that analyses carried out should be presented in written form and made available to those affected and to the public at large.

Categories of Approach	Examples
I Highly aggregated	
a) Objective function in monetary terms	- Conventional cost-benefit analysis - Revised versions of cost-benefit analysis
b) Objective function in other terms, for example utility	- Some of the approaches referred to as multi-attribute analysis
II Intermediate	- Cost-effectiveness analysis
III Highly disaggregated	- Environmental Impact Statements - Positional Analysis - Ashford's Trade-off Analysis

Table 4. A Classification of approaches to environmental decision making and evaluation.

To group the different approaches for analysis, however, we have to look for differences. For our present purpose of discussing compatibility between approaches and environmental issues, a distinction based upon degree of aggregation with respect to different impacts, different groups of individuals (or interested parties), and time will be used.

Category I approaches involve far-reaching attempts to deal with complexity in one-dimensional terms. Conventional CBA is based on the idea that there exist "correct" social values or prices for each impact, and that such prices can be used in a summation procedure. The revised versions of CBA in table 4 involve an analysis in which the idea of scientifically correct values or prices has been abandoned in favour of politically determined prices. The latter approaches have been suggested in different manuals for the appraisal of projects in developing countries. (See Ezra Mishan, who points to the danger that the economist using such approaches "assumes the role of devoted analyst" and who regards the change from conventional CBA to these forms of revised CBA as a step backwards [Mishan 1982]. See also my comment on Mishan [Söderbaum 1983].)

For a long time, conventional cost-benefit analysis was more or less unchallenged as an approach to evaluation at the public level. Today the situation is different. As suggested in Table 4, there is now a broad spectrum of approaches to evaluation. Alternatives to CBA range from those which (like CBA) aim to aggregate all kinds of impacts for all individuals affected over time, for instance multiple objective approaches (Keeney and Raiffa 1976), to the more disaggregated approaches. Among the latter, Environmental Impact Statements (EIS), Positional Analysis, and Ashford's Trade-off Analysis can be mentioned. Ashford's approach has been developed for decisions concerning the work environment. This approach makes distinctions among economic impacts (which I would call monetary), health impacts, environmental impacts, and legal impacts, while other distinctions are drawn among the different categories of individuals affected - producers, employees, consumers, and "others", such as those living in the neighborhood of a factory (Ashford 1979, 1981).

Because of its two-dimensional character, cost-effectiveness analysis exemplifies the "intermediate" category of Table 4. The monetary costs of achieving some non-monetary environmental standard may be minimized, or some environmental objective maximized, given some monetary budget constraint.

As argued before, category III approaches are multidimensional and holistic. They are compatible with, and in part reflect, commonality with institutional analysis. The idea of optimality through the maximization (minimization) of some objective function is questioned. One-dimensional thinking is referred to as reductionism and CBA, for instance, is regarded as a typical case of monetary reductionism.

It may also be noted that some approaches have been designed for specific purposes (such as the above-mentioned revised versions of CBA for projects in developing countries or Ashford's Trade-Off Analysis for the regulation of chemicals in the environment). Other approaches are more general, that is, proponents claim they are useful in many (or all?) fields of societal evaluation. This is true of CBA and positional analysis among others. The limited purposes of some methods do not rule out the possibility that their logic and conceptual framework can be extended to other fields - that Ashford's

approach, for instance, can be extended to fields outside the regulation of chemicals. It is also true that the more general approaches often have to be adapted to fit the specific institutional context and other characteristics of individual fields of application.

In this study I will mainly describe and discuss positional analysis as a possible alternative to CBA (Söderbaum 1986, 1987). Some of the arguments put forward in favour of positional analysis could also be seen as arguments that support the use of EIS or Ashford's Trade-Off Analysis.

Before coming to the description of positional analysis, a few words will be said about cost-benefit analysis. This is important, since non-traditional approaches, in many ways, can be regarded as attempts to overcome the defects of cost-benefit analysis.

Chapter 6

WHAT IS WRONG WITH COST-BENEFIT ANALYSIS?

Deficiences of the conventional approach

One of the more important European institutionalists of recent times, K. William Kapp, used environmental problems as his point of departure in a critical examination of cost-benefit analysis. Because of the cogency and significance of his analysis, I will quote from it at some length:

> Any suggestions to decide the justification of control measures in terms of a willingness to pay for them, or by assuming a capacity to compensate those who have to bear the costs of control out of increments of property values or other monetary values accruing to others, fails to take sufficient account of three factors; (a) actual markets are far from perfect - in fact they are "oligopolistic" in character, (b) the consequences of environmental disruption are highly heterogeneous and cannot be compared quantitatively with one another, and (c) the benefits obtainable from environmental control are equally heterogeneous and can neither be compared quantitatively with one another nor with the outlays for control. To quantify them nevertheless by means of some arbitrary monetary standard is at best problematical and at worst contradictory to logic if not in violation of our ethics. For what is the monetary value of human health and human life? What is the value of the quality of urban life or the beauty of a landscape that is being sacrificed in the process of urban expansion? The fact of the matter is that both disruption and improvement of our environment involve us in decisions which have the most heterogeneous long-term effects and which, moreover, are decisions made by one generation with consequences to be borne by the next. To place a monetary value on and apply a discount rate to future utilities or disutilities in order to express their present capitalized value may give us a precise monetary calculation, but it does not get us out of the dilemma of a choice and the fact that we take a risk with human health and survival. For this reason, I am inclined to consider the attempt of measuring social costs and social benefits simply in terms of monetary or market values as doomed to failure. Social costs and social benefits have to be considered as extramarket phenomena; they are borne by and accrue to society as a whole: they are heterogeneous and cannot be compared quantitatively among themselves and with each other, not even in principle.
>
> In fact, the more we admit that all benefits (secondary, indirect, intangible, etc) of control measures ultimately have to be included in benefit-cost calculations, the more problematical becomes any evaluation in terms of one single monetary standard. In short, I fail to see that cost-benefit analyses as they stand today have a solution of the problem of evaluating either the social costs of the disruption, or the social benefits of the improvement of our environment by control measures (Kapp 1970, pp. 25, 26).

A similarly pessimistic evaluation of cost-benefit analysis in relation to problems of natural resources is made by Daniel Bromley (1976, 1980) an American institutionalist of the Wisconsin tradition. He points to the many difficulties with the traditional value-deterministic approach to cost-benefit analysis and suggests that we should move in the direction of considering evaluation as a dialectic process. His review of the US experience of cost-benefit analysis in relation to water resources is concluded in the following way: "The basic dilemma of benefit-cost analysis is that it gives the impression of rigor and precision when in fact the truth is largely otherwise. It has taken us forty years to realize this; some still remain unconvinced" (Bromley 1980, p. 247).

Among non-economists, the philosopher Laurence Tribe has questioned the approach to values and ethics inherent in cost-benefit analysis. Among other things, he points to the limits of cost-benefit analysis in accommodating certain kinds of values:

Three categories of values that are particularly vulnerable or "fragile" in this regard suggest themselves. The first category encompasses those values that are intrinsically incommensurable in at least some of their salient dimensions, with the human satisfactions that are bound to play a central role in any policy analysis; here I would include values related to ecological balance, unspoiled wilderness, species diversity, and the like.

The second category encompasses values with inherently global, holistic, or structural features that cannot be reduced to any finite listing or combination of independent attributes. Here I would again include ecological balance but also urban aesthetics, community cohesion, and the like.

The third and final category encompasses values that have an "on-off" character, and usually also a deeply evocative and emotional aspect. Under this heading I would include such values as the integrity of the body (threatened, for example by chemical intrusion) or the integrity of the community or neighborhood (threatened, for example, by an influx of little-understood "outsiders").

Whenever values in any of these major categories appear to be involved, at least potentially, in a given problem, one should recognise that the techniques of policy analysis as currently conceived will tend either to filter them out of the investigation altogether or to treat them in ways inconsistent with their special character (Tribe 1972, pp. 96-97).

Tribe also critizes the tendency of some to forget about procedures and institutional context and focus exclusively on final products. "From many perspectives, the procedures that shape individual and social activity have significance independent of the final products they generate. Yet the traditional approach of both moral philosophy and welfare economics has been to focus exclusively on the end results of social and institutional processes in assessing their value" (Tribe 1972, p. 79). Similar arguments can be found in James Campen's extensive study of cost-benefit analysis (1986) from the point of view of radical political economics.

Peter Self, a British political scientist, questions one-dimensional welfare tests of the kind implied by cost-benefit analysis from the point of view of democracy. The specific valuational rules of cost-benefit analysis represent an ethic that is closed rather than open-ended (Self 1975).

Aant Elzinga, a Swedish philosopher, argues that the ethics of cost-benefit analysis is very close to a GNP-growth or net-value-added philosophy (Elzinga 1981). The consequences to society of such value premises may be perceived as reasonable by some groups and interested parties in society, but not by others.

In an article, Ezra Mishan argues that use of conventional cost-benefit analysis can be justified only so long as there is a consensus in society about the evaluation rules inherent in cost-benefit analysis (Mishan 1980). If such consensus no longer exists - and many indications point in that direction, expecially with respect to environmental and natural resource issues - then we had better put the cost-benefit manuals on a shelf to await some possible future time when the necessary consensus has (once more?) been established.

Another well-known English economist, David Pearce, has discussed problems with the use of cost-benefit analysis and has specifically questioned the approach in connection with investments in nuclear plants (Coddington, Opschoor, and Pearce 1972, Pearce 1979). The monetary discounting procedure of cost-benefit analysis becomes meaningless in relation to the intergenerational equity issues of nuclear power (for a discussion of discounting in relation to environmental problems see also Costanza and Daly 1987).

It is my belief that criticism of this kind from economists and non-economists will steadily decrease the "market share" of cost-benefit analysis compared to other approaches. But the process is a very slow one and cost-benefit analysis still seems to be taken seriously in many governmental circles. If I understand correctly, in the United States, any additional regulation of chemicals or other environmental protection measures have to be justified with cost-benefit calculations. The difficulty of measuring benefits is admitted, but this difficulty is seen as one that will be resolved eventually through additional research by conventional environmental economists.

In Sweden, so far, no general manual exists, but some agencies - notwithstanding considerable criticism - use cost-benefit analysis to choose priorities among investment projects. This is true of the National Road Administration, for instance. Any real estate owner or other interested party who opposes some particular project will meet government officials who refer to their calculations and argue that they know the correct societal values to be applied and what is optimal from a resource allocation point of view. Other ideas about whats is "good for society" will automatically be ruled out. In my view such attitudes do not facilitate public debate and democracy. It should be added, however, that since July 1, 1987 the same National Road Administration is required to use Environmental Impact Statements as part of their evaluation procedures.

What do we learn from the shortcomings of cost-benefit analysis?

It may be concluded, then, that conventional cost-benefit analysis despite criticism of the kind cited, still holds a strong position in manuals, text-books, and the thinking habits of economists. In my interpretation, however, the weaknesses of the conventional approach lead logically to a quest for alternatives of a specific kind. I will therefore put forward my own criticism and also try to point out a direction in which new approaches can be sought.

The monetary and one-dimensional character of cost-benefit analysis makes it appear clear-cut and simple. In practice, however, it is not an easy task to carry out the analysis. When market prices are available the issue of correcting for deviation from prices under perfect competition is not an easy one. Also, the choice between estimates of "shadow" prices through interviews and "revealed preferences" as inferred from past behaviour becomes arbitrary and, as we all know, many views have been raised about the "correct" discount rate to be applied. Where the environment is concerned, cost-benefit analysts themselves point to the difficulties of estimating monetary benefits. They also sometimes realize the political character of the

choice of discount rate when impacts extend over severeal generations.

Environmental problems exist now, and the attitude that we should wait for further research on methods of estimating the monetary benefits of measures to improve environmental quality (or to avoid degradation) does seem a bit cynical. We need approaches that can be used tomorrow rather than in five or ten years time. Incidentally, I do not think that ten years research will change the situation. If we look for reliable knowledge - that is, an information base relevant with respect to knowledge and values - we have to look in other directions. The technical design of CBA is inherently weak.

Conventional neoclassical economics has a preference for optimization through one-dimensional aggregation. I believe that too much relevance is lost through this kind of simplification, and that this is especially true in complex decision situations of the kind often addressed by cost-benefit anlaysts (dams, highways, energy systems, etc).

Instead of the ideal of closed models, which is often unrealistic, we should follow Gunnar Myrdal in his recommendation to use open-ended models. The picture given will be ordered but fragmented in some respects. Instead of aggregation, one can look for meaningful ways to describe impacts in multidimensional and more disaggregated terms.

As already suggested, the idea of "economic efficiency" or "efficient resource allocation" inherent in cost-benefit analysis exemplifies a kind of "monetary reductionism" that is essentially incompatible with my previous attempt to outline the nature of environmental problems. How could irreversible negative environmental impacts be traded "correctly" against monetary benefits from the sale of commodities such as electricity. Or, how do we trade one environmental impact against another environmental impact? Faced with these difficulties, the CBA idea breaks down or becomes absurd.

Discounting may hold as a partial analysis for financial impacts connected with individual parties. But discounting at an aggregated level becomes a bit strange when compared with some specific environmental ethic, where one goal may be to minimize the degradation of the future natural resource base. For those who consider

evolutionary processes and the paths that ecosystems take over time, the idea that non-monetary impacts at different periods can somehow be pressed togehter to one point in time via a calculation of present values is absurd, assuming that we want to know what we are doing.

In the manner described, the analyst addresses values in accordance with the positivist tradition. Value is equated with monetary value and is not regarded as different from other facts of life. This pecuniary idea about values is to a large extent summarized by the efficiency concept of CBA, consumer sovereignty being one of the building blocks. Present tastes and preferences of individuals affected, expressed in monetary terms, are the values that count. Whether some groups of consumers are well informed or badly informed about health impacts and environemental impacts is seldom considered. The same is true of possibly misleading information from producers and builders. And if such factors are taken seriously, there is no practical way of adjusting prices "correctly".

Also, those who advocate cost-benefit analysis realize that private monetary income and wealth differs among individuals and that each individual "votes" with his or her specific purchasing power. To deal with this problem, a special study about so-called distributive effects is often suggested but seldom carried out in practice.

To me, it seems clear that Mishan is right in his suspicion that there is a lack of consensus concerning the valuational rules of cost-benefit analysis. It is realistic to expect that social welfare functions that produce unique outcomes will be regarded as controversial by significant segments of the community. Environmental issues generally involve conflicts of interest within the present generation and between present and future generations. It is not possible to conjure away such conflict.

Rather than trying to "solve" the problem by a simple counting exercise, the task perhaps should be to produce reliable knowledge through systematic inquiry and to **illuminate** the decision-making situation with all its conflicts, uncertainties, and other complexities. The analysis should point to the options available to the decision-makers. Politicians or other decision-makers may become frustrated by the conflicts involved, but this is not necessarily a disadvantage.

Frustration is sometimes a precondition for learning to occur and for a reconsideration of values and ideologies.

Such an illumination or structuring of the information base cannot be done without recourse to values. What one should look for are values of a more fundamental kind, such as values connected with the constitution, with our ideas about democracy.

Democracy is not, or is not only, equal to a mechanical procedure where votes are counted and some majority position established. We also want to make sure that those voting have a fairly good idea of what the issue is. Democracy therefore encourages all kinds of arguments and alternatives to be put forward in a creative process through hearings and other forms of public participation. To facilitate such an exchange of opinions and information, many-sidedness in the analysis of alternatives, impacts, and interests is an imperative. Many-sidedness can be seen as the antipole of manipulation (where manipulation refers to covert attempts to influence the outcome of the decision process in a specific direction).

The idea is to make certain that different alternatives, impacts, and interests are articulated and visible not only to politicians, but to all concerned. Making as fully known as possible the implications of each choice becomes the purpose. Instead of monetary reductionism, other modes of thought, such as thinking in patterns and pictures, can be encouraged. Decision making is seen in the light of "pattern recognition" and gestalt psychology rather than number comparison.

Do the politicians or other decision makers want such impact profiles or one-dimensional monetary figures? Do they prefer to hide behind one-dimensional monetary figures and behind one-dimensional ideas about efficiency? My experience is that there is a heterogeneity of views among pliticians. Quite a number prefer a many-sided analysis with conditional, rather than unambiguous, conclusions. It should also be remembered that this question about approach concerns the community at large, and not only politicians in power. Also, the integrity of the analyst is at issue, and this integrity will, in my opinion, be furthered by a many-sided analysis.

Chapter 7

POSITIONAL ANALYSIS AS AN ALTERNATIVE

Purpose and elements of positional analysis

The existence of many approaches to evaluation can partly be explained by differences in purpose. As I have already made clear, positional analysis aims at a many-sided illumination of a decision situation. The information put forward to decision makers and others should be relevant to them with respect to knowledge and values.

In the normal case, values differ between decision makers and interested parties in a decision situation. For this reason, the analysis is expected to produce information and knowledge, not for a single decision maker with his or her specific values, but for individuals who differ among themselves with respect to values. The analysis ends up with conditional conclusions. Assuming values of type A, then alternative 1 may be the best choice, while values B, rather, point in the direction of alternative 3. Decision makers may have their own personal cognitive styles of making decisions, but the main idea of how decisions should be made according to positional analysis is through a matching procedure, where the impact profile of each alternative is related to the value or ideological profile of each decision maker. A given decision maker may experience a mismatch between his ideas about values and alernative 1 and a reasonably "good fit" in relation to alternative 2. In other cases, none of the alternatives may be accepted and a new study recommended.

Depending upon the social and institutional context, simplified versions of positional analysis can be considered. A more ambitious study may include the following components:

- Description of the decision situation. Historical background. Relationships to other decisions (previous or simultaneous). Identification of relevant institutions and interested parties.
- Identification of problem. Reproduction of problem images as stated by different actors.

- Design of alternatives and formulation of the problem (choosing a set of alternatives for further consideration).
- Identification of systems that will be differently affected depending upon the alternative chosen.
- Identification of effects (monetary and non-monetary) and comparisons between alternatives in relation to these effect dimensions.
- A study of possible inertia and irreversibilities. In what way will first-step alternatives influence future options for different interested parties?
- Analysis of interests related to the decision situation. Identification of activities that will be affected differently depending upon the alternative chosen. Assumption of goal direction for each activity. Activity, together with goal direction, defines an interest. Construction of preference order from the point of view of each interest in relation to each alternative.
- Analysis of prevailing risks and uncertainties (using relevant techniques, such as objective and subjective probabilities and scenarios).
- Summary of information basis for decisions at the two levels of effects and interests.
- Articulation of some alternative valuational standpoints or development views in relation to the decision situation.
- Conditional conclusions in which expected impacts of alternatives are related to possible values, attitudes to risk and uncertainty included.

Different ways of bringing in interested parties at different stages of the analysis should be considered. The imperative of "many-sidedness" will assure some integrity for the analyst. As argued before, steps in the direction of many-sidedness can be seen as the antipole of manipulation.

In what follows, some of the above-mentioned components and implications of positional analysis are elbaborated upon.

Systems thinking

Positional analysis is based upon the holistic conception of economics as previously described. A component of this approach is systems thinking. It is a way of broadening the analysis in the direction of holism and interdisciplinarity. Expressed in the language used previously, systems thinking can be regarded as a step in the direction of many-sidedness with respect to the kinds of consequences considered. Instead of limiting the analysis to one sector or another of society, all sectors influenced by the issue at hand are considered.

The specific set of alternatives chosen for consideration represents the starting point for the process of identifying systems and forming a systems structure (see table 5). The analyst tries to identify which systems (of different kinds) will be affected differently, depending on which alternative is chosen. In a situation with two alternatives called A_1 and A_2, for instance, a system, S_1, should be included in the systems structure if the future states (positions) of the system are expected to develop in different ways if A_1 was chosen, compared to if A_2 is chosen. The two alternatives will lead to two different trajectories of the system S_1. For another system, S_5, no such difference in future positions may be expected and this system, therefore, should not be considered part of the systems structure.

	Spatial extension of the affected system			
	Local	Regional	National	Global
System 1	X	X	X	
System 2	X			
System 3	X	X	X	X
System 4	X	X		

Table 5. Against the background of a specific set of alternatives, a systems structure may be constructed. The analyst tries to identify all the systems that will be differently affected depending upon which of the alternatives is chosen.

Systems identified in this way will then be used as a basis for describing the differences among the effects of the alternatives considered.

It should, once more, be emphasized that the systems structure is connected with the specific set of alternatives chosen. A change in the set of alternatives may (but need not) change the systems structure.

Another limitation to the analysis relates to the possibility of deliminating a specific decision situation from other public decision situations. Is it, for instance, possible to isolate environmental problems at some particular location from similar problems elsewhere? Such difficulties should always be dealt with explicitly.

Under some circumstances, however, it may be more relevant and meaningful to study a pair of decision situations rather than one decision situation. A local policy issue may be closely related to a higher level issue (for instance, a national policy issue) that remains unsettled. In order to make a wise choice at the local level, it is necessary to have a strong base of national policy information. A "good" alternative at the local level is a matter of compatibility with "good" alternatives at the national level. A study that begins at the local level may therefore shift to a study at the national level and then shift back to the local level. Conclusions may be stated in con-

ditional terms: if this is the policy or alternative adopted at the national level, then alternative 2 at the local level is the one most compatible with the higher level policy adopted. To the extent that the national policy issue can be regarded as settled, choice at the local level will, of course, be easier to handle.

Role of positional thinking

The concept of economics previously indicated points in the direction of carefully considering non-monetary impacts. As suggested by the name of the approach, positional thinking is considered useful (cf. table 3). Analysis of non-monetary flows (category III) is important, but often insufficient. It is not enough, for instance, to point to some decrease from one period to the next in discharges of mercury from a pulp factory into a nearby lake (A_1 in figure 4, as compared to A_0). Even the decreased rate of pollution may lead to further deterioration of the position in terms of parts per million (ppm) of mercury in fish (category IV). The properties of the substance and of the water ecosystem may be such that a radical decrease in discharges will be necessary for any improvement to occur (compare A_2).

Decisions about measures to influence environmental quality, for instance air, water, or food products should in most cases not be regarded as "once-and-for-all decisions". Decisions today, rather, represent the first step in a step-by-step adjustment process. Decision trees are familiar from business management textbooks. The decision tree of figure 5 differs, however, in its description of outcomes or effects. Instead of the ususal monetary "pay-offs", positions, and particularly non-monetary positions, at different points in time are described.

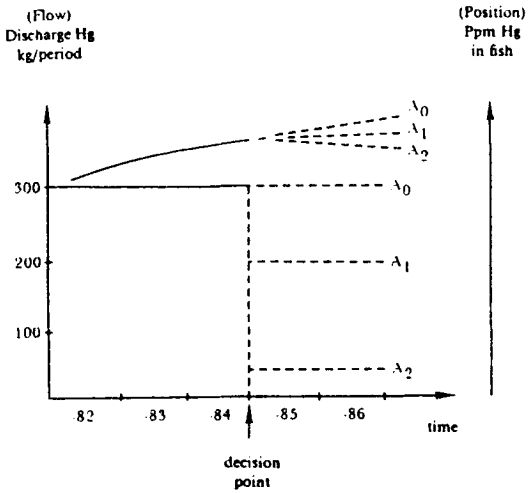

Figure 4. A decrease in discharge (a flow variable) may still mean a deterioration of the environment (a positional variable). This is illustrated by A_1. For an improvement in posititon to occur, a radical decrease in flow terms may be necessary (compare A_2).

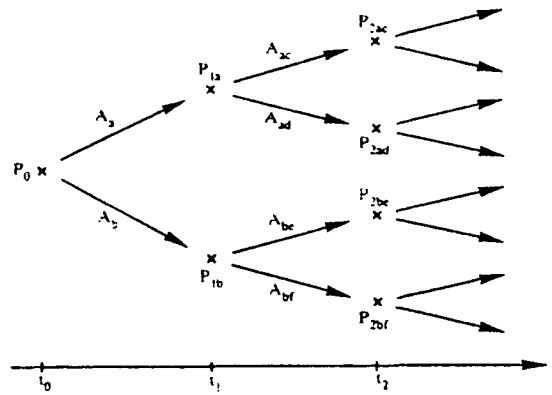

Figure 5. Description of alternative courses of action considered at t_0 and of expected positions at t_1 and t_2 for each course of action. (First index indicates the points in time of positions, while second and third indexes refer to the alternative chosen in previous decision situations.)

What will be the future positions of the systems affected if alternative A_a is chosen? What will such a position mean in terms of future options, that is, for second step movements? First step alternatives can be compared with respect to (a) expected impacts at the time of construction or implementation; (b) expected impacts as soon as the alternative has been carried out; (c) expected impacts on future options.

P_0 in figure 5 may refer to a set or pattern of states defining the position of a lake, and A_a and A_b may stand for change and no change in technology with respect to the use of mercury. At time t_1 a different set of states will describe the lake assuming that A_a was chosen rather than A_b. The lake will evolve according to a specific trajectory in each case.

In the case of transportation planning, P_0 may stand for the present position of a transportation system and P_{1a} for a broadly unchanged system while P_{1b} includes some new investment such as a road or airport.

Soil conditions or the health of an ecosystem such as a forest or the health of individuals exposed to some environmental hazard can also be described as a set of states indicating some pattern. Is recovery possible if the degree of environmental stress is reduced? Or will some irreversible impacts remain? Will the recovery of individuals or ecosystems follow specific paths? Is it possible to identify normal paths that can be distinguished from those that are unusual assuming that a group of individuals start in the same position (health status) at t_0.

Changes in land use may be described in similar terms and reversible and irreversible changes identified. It is easy to move from cultivated ground to a paved road, but perhaps not to return to the original position.

It should be observed that the idea is not to construct a specific one-dimensional index of soil status, ecosystem status or health status but instead to look for patterns or pictures at different points in time. Again, aggregation is expected to mean losses in understanding and relevance.

It is not possible here to go into detail about relevant ways of describing all kinds of possible impact whether monetary or non-

monetary. Somehow project and programme alternatives have to be compared with respect to expected performance. Qualitative and quantitative estimates will be used according to current knowledge in each field. In areas where opinions and judgements differ among scientists, the lack of agreement should be made explicit. Uncertain impacts should be so described, and not represented as impacts that are assumed to be certain.

Effects	Alternatives	
	A_1	A_2
E_1	Somewhat better than A_0	Considerably better than A_0
E_2	Somewhat inferior to A_0	Equivalent to A_0
-		
-		
-		
E_k	Considerably better than A_0	Somewhat better than A_0

Table 6. Matrix indicating alternatives in relation to effects.

In summarizing impacts, the kind of matrix found in table 6 can be used. Assuming there are three alternatives A_0, A_1, and A_2, one of these may be used as a point of reference for comparison. In the case of table 6, the "non-change" alternative, A_0, is the basis for comparison or reference alternative. A_1 and A_2 can then be described as (a) "considerably inferior to A_0"; (b) "somewhat inferior to A_0"; (c) "equivalent to A_0"; (d) "somewhat better than A_0"; or (e) "considerably better than A_0".

In cases where for some reason the no-change alternative is not considered to be relevant (it may not come up to current environmental standards, for instance), a direct comparison between A_1 and A_2 can be made.

Analysis of activities and interests

Another element of positional analysis is the identification and analysis of the various interests in a decision situation. This part of the study comprises the following steps or components: (a) identification of the activities (of individuals or organizations) that will be differently affected depending upon the alternative chosen; (b) for each activity, the making of an asumption with respect to goal direction (activity, together with goal direction, defines an interest); (c) construction of an order of preference from the point of view of each interest in relation to the alternatives considered.

A matrix combining alternatives and interests is shown in table 7. Most decison situations involve conflicts of interest and in a democracy such conflicts should be articulated, rather than hidden in the information submitted to decision makers.

Interests	Alternatives		
	A_0	A_1	A_2
I_1	3	2	1
I_2	1	2	3
-			
-			
-			
I_p	3	1	2

Table 7. Matrix indicating orders of preference from the point of view of each interest in relation to each alternative.

It should be observed that the kind of analysis suggested here is based upon the activities that will be affected and on assumptions about the goal direction of individuals participating in these activities. For instance, in the case of decisions concerning investments in transportation facilities, different activities with associated goal direction may be identified, such as transportation activities, recreational activities, or commercial activities.

As I see it, it is defensible to make **assumptions** about the goal direction of people participating in specific activities. A lower level of noise or other environmental disturbance from nearby roads for people living in a specific area is assumed to represent an improvement. No assumption is made about how individuals relate impacts connected with one activity to impacts connected with other activities. Values or attitudes of the latter kind are certainly relevant, but should be elicited through questionnaires, interviews, review processes, or hearings.

It may also be noted that, for individuals, the number of activities influenced may vary. Some may be influenced only through one activity. Others through two or more activities. for the latter individuals, choosing a specific alternative, A_1, as opposed to the reference alternative, may mean that impacts are negative in connection with one activity and positive in connection with another, according to the assumptions made about goal directions for each activity. Analysis of the kind suggested may be helpful in identifying these individuals with conflicting interests, in order to hear their opinions about preferred alternatives.

A study following positional analysis may be summarized in matrices as suggested in tables 6 and 7, with the associated conditional conclusions. One essential idea behind positional analysis is to articulate the ethical and ideological aspects of a decision situation. Conflicts of interest, for instance between present and future generations, should be articulated, rather than hidden. Decision makers, those affected, and other actors should face the complexity of a decision situation. The important thing is that decision makers know what they are doing. In fact, one criterion in judging different approaches to decision making is to what extent each contributes to the accumulation of reliable knowledge in specific communities and in society at large.

Ideas about "ecological imperatives", "sustainable production", as well as traditional growth-oriented ideologies, fit into this framework as possible ideological or ethical perspectives.

In a democracy, the role of the analyst could therefore be summarized as one of (a) serving all citizens, rather than only specific decision makers; (b) contributing to meaningful accumulation of knowledge in society, that is, among citizens and different actors; (c) contributing to a many-sided illumination of alternatives, impacts, and ethical or ideological options available.

Relation to Environmental Impact Statements

While positional analysis has been discussed and applied occasionally in the Scandinavian countries another, highly disaggregated approach, Environmental Impact Statements, is better known in various parts of the world and has provoked much debate. The EIS approach was first articulated as part of the US National Environmental Policy Act (NEPA) which came into effect in 1970.

The idea behind EIS is to illuminate all kinds of possible, significant environmental impacts of proposed actions, to compare environmental and other impacts of the proposed action with two kinds of alternatives, i.e. (1) a "no-action" or "no-build" alternative, and (2) other action alternatives than the proposed one. In addition, possible mitigation measures to reduce negative environmental impacts should be explicitly considered and negative irreversible environmental effects (judged to be unavoidable) clearly stated. The idea behind all this is to reduce the negative environmental impacts as much as possible and "to know what one is doing" if a decision is taken to adopt to the proposed alternative.

It is interesting to note that NEPA points explicitly in the direction of a "systematic interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making". Another feature of NEPA is that it contains important procedural stipulations, for instance relating to the stage in the planning process at which public hearings should be held (see for instance Caldwell, 1983).

One possible disadvantage with EIS is that it starts with an alternative that is already at the stage of being proposed, whereas conventional CBA and positional analysis enter into the planning process

at an earlier stage, at which each of a set of mutually exclusive alternatives has a more equal chance and hopefully fewer commitments have been made. The fact that EIS concentrates to a high degree on environmental impacts is at once a strength and a weakness of the approach. The law and the procedure were designed to counteract the previous emphasis upon more narrow technical and monetary efficiency criteria. Interpreted in this way, EIS is something that is added to the other kinds of information which will be brought forward under established procedures. But if EIS is only a supplement to other procedures, then it cannot claim to be a comprehensive approach comparable with cost-benefit analysis or positional analysis.

Realizing this shortcoming, some have suggested environmental impact assessment, EIA, as a more inclusive concept in which environmental impacts are not only identified but also evaluated in relation to other impacts. However, to the extent that one environmental impact is valued quantitatively in relation to other environmental impacts and various non-environmental impacts, EIA can be criticized on similar grounds to cost-benefit analysis and other highly aggregated approaches. While this is true, EIA may still represent a step forward if environmental impacts have been carefully identified and estimated and if procedural requirements are strengthened and respected when compared with previous approaches.

It is exactly these procedural and legal aspects that constitute the focus in an FAO study by Dominique Alhéritière (1982) entitled "Environmental Impact Assessment and Agricultural Development". Existing EIA legislation in a number of countries is compared in relation to various agricultural activities such as irrigation, fertilizers and pesticides, forestry and other kinds of land use, fisheries and agro-industry.

I believe that the whole national and international debate about EIS and EIA has been beneficial, in that it has increased our attention to environmental law and public participation procedures. Will environmental laws be strengthened in the sense that they protect the environment rather than the polluters? Will procedural laws be changed so that the people affected or concerned have a chance of influencing the outcome of the power game?

Chapter 8

MONITORING, EX POST EVALUATION AND LEARNING

Approaches such as positional analysis and EIS emphasize efforts to estimate impacts of various alternatives (projects or programmes) **ex ante**. Having chosen some specific project, however, it becomes important to manage project activities as an ongoing process. Information and monitoring systems are needed for this purpose. Will the project, for instance an irrigation project, perform according to expectations? Is it possible to modify the project design to improve performance in environmental, social or monetary terms? What mitigation measures can be undertaken? Do the project impacts turn out to be negative to such an extent that the project should be abandoned? In that case alternatives that were considered in the previous decision process may be reconsidered or a search start for new alternatives.

As I see it, much of the philosophy behind positional analysis is useful also in the management of an ongoing process such as water management in an irrigated area. Impacts that were estimated are compared with actual impacts and information about actual impacts is used in a learning process with the purpose of improving performance.

In designing monitoring systems and generally organizing feed back from ongoing activities, the distinctions that have previously been made between monetary and non-monetary variables or impacts is important. Flows have to be distinguished from positions (or stocks if the reader prefers) and systems as well as activities affected can be identified. The idea that changes in positional terms (depletion of deep-water aquifers, deterioration of soil quality, water quality etc) are important holds, for **ex post** measurement as well as for **ex ante** estimates.

The measurements may involve uncertainties and technical problems but philosophically such follow up studies seem relatively uncomplicated.

Things become more complicated if one wishes to compare the performance of the project programme that was chosen and carried out with some other alternative that was considered before the choice was made. Issues of this kind can be discussed in relation to figure 6.

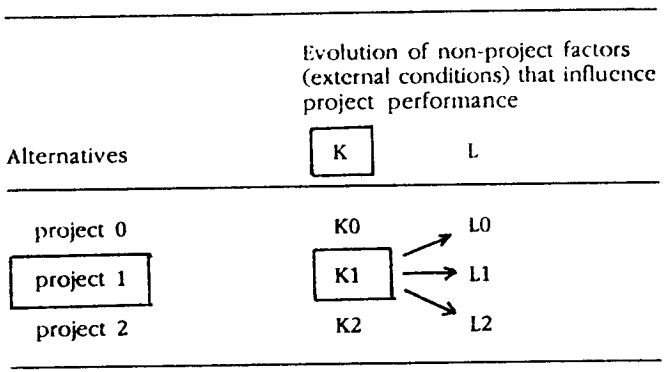

Figure 6. Frame of reference for a discussion **ex post** about what would have happened, had some other alternative been chosen or had "non-project factors" developed in a different way. Project 1 is the chosen alternative, K represents actual external conditions and K1 actual outcome of project 1.

Assuming that project 1 was chosen and external factors that influence performance developed in a certain way K, then project outcome can be symbolized by K1. As a first question one may ask what would have happened had the same project alternative 1 been combined with some other specific course of development of external factors, L. How would L1 have compared with K1?

Similar hypothetical comparisons can be made between K1 and K0, i.e. the no-action alternative. Have things turned out better with the project 1 than would have been the case without the project? What would have happened had project 2 been chosen with similar development in external factors, i.e. how would K2 have compared

with K1? And what would have happened if the no-project alternative had been chosen and non-project factors developed according to L? How would L0 have compared with K1 (or with L1 for that matter)?

Experimental designs may help us to secure more reliable information about performance under various circumstances, but in many cases we have to be content with arguments of a less conclusive kind. In any case such efforts to reason in retrospective terms can certainly be of value as part of a learning process.

Chapter 9

RECOMMENDATIONs TO PLANNERS IN DEVELOPING COUNTRIES

My recommendations to planners in developing countries and others concerned follow directly from the previous discussion.

1. Environmental problems can no longer be regarded as secondary or peripheral as compared with other issues. Instead, there are good reasons to expect that environment and natural resources will be a top priority issue in most countries for the next 50 years. One may even guess that, just as many societies were transformed from agricultural to industrial societies (to the extent, it may be added, that even agriculture became industrialized), the next challenge will be to build a sustainable society, i.e. to care for our house in an ecological sense.

In any case, environmental issues will remain important and the best thing one can do is to listen to all who have opinions about the character of the problems and possible ways of handling them. We should be open-minded and also listen to those who question the more extreme forms of modern "factory farming" in the USA for instance (e.g. Fox 1986) or to those who argue in favour of organic farming (see the **American Journal for Alternative Agriculture**[1]).

2. Another quest for open-mindedness concerns our ideas about economics. I have argued in favour of institutional economics because of its interdisciplinary, holistic, and value-conscious character, but a first step is to question simplistic ideas of economics and efficiency. There is a need for ideas of economics in which non-renewable resources are clearly distinguished from renewables and more generally where irreversibility becomes visible rather than hidden in an one-dimensional calculation.

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1 The American Journal of Alternative Agriculture is produced by the Institute for Alternative Agriculture, Inc., 9200 Edmonston Road, Suite 117 Greenbelt, Maryland 20770 with Garth Youngberg as the editor.

3. Related to ideas about economics are our views of development at various levels. Development concepts for society as a whole were discussed earlier and also for rural areas and agriculture, but a similar discussion can be carried out for various organizations of a private or governmental kind and also for individuals. What do we mean by an ecologically sound lifestyle? How do we get there? How can change be facilitated?

Again, the best thing one can do as planner or scholar is to try to articulate alternatives. A conventional business philosophy for the farm (or business company) can be compared with an alternative, "ecological" philosophy.

4. Where approaches to decision making are concerned I have recommended specific approaches such as positional analysis and Environmental Impact Statements. Positional analysis is hardly known in developing countries, but I believe that many of the characteristics of positional analysis and EIS will not appear strange in relation to thinking habits and ideas of rational behaviour in these countries. Consider the following features:

- interdisciplinarity
- holism
- systems thinking
- importance of culture and institutions
- consciousness about values and ethics
- non-reducibility of non-monetary aspects
- importance of non-monetary resource positions
- importance of equality in a broad sense, i.e. making winners and losers visible
- importance of procedures which facilitate public participation.

5. Attempts to systematically estimate impact profiles for a specific set of alternatives are an important part of environmental management. But monitoring and **ex post** evaluation are other elements of a comprehensive approach.

At the programme and policy level, articulation of alternative development concepts will probably be helpful. Scenario writing can

also be useful at this stage when detailed projects have not yet been designed. Manipulation of monetary (charges, taxes) and non-monetary incentive systems is an important way of speeding up change in a specific direction. This question, however, has been considered to be outside the scope of the present study.

6. Planning activities, education, research and development (Bengtsson 1988) can contribute to increased consciousness about environmental problems and options for the future. All citizens and actors on the public scene such as politicians, business leaders and journalists have a role to play by way of the examples they set and by way of participation in public and private debate (Söderbaum 1987, 1988).

At this level of the individual, the neoclassical (or public choice theoretical) view of man as ego-centred and rent-seeking has to be replaced by a view that, while accepting egoistic elements, also allows for ideological commitment, altruism and social responsibility. The farmers of a region are regarded as a heterogeneous category rather than a homogeneous mass of individuals. Change is then no longer only a matter of struggle between homogeneous interest groups with clear motives.

In addition there will be room for network building across conventional categories. A subset of farmers can go together with subcategories of bureaucrats, journalists, environmentalists etc with the explicit purpose of contributing to a sustainable society (Söderbaum 1989). In doing this they will compete more or less successfully with other networks and a variety of vested interests.

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TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT IN INDUSTRY
TAMPERE UNIVERSITY OF TECHNOLOGY, 1991

LECTURE HANDOUT / 6 AUGUST 1991
Kari Silfverberg, Environment advisor, FINNIDA

THE EIA-POLICY OF FINNIDA AND OTHER DONOR AND FINANCING AGENCIES AND ORGANISATIONS

This handout contains selected parts of the following documents:

1. FINNIDA's GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT IN DEVELOPMENT ASSISTANCE

2. OECD / DAC / ENVIRONMENT WORKING GROUP: GOOD PRACTICES FOR ENVIRONMENTAL IMPACT ASSESSMENT OF DEVELOPMENT PROJECTS

3. WORLD BANK: OPERATIONAL DIRECTIVE ON ENVIRONMENTAL ASSESSMENT (4.00, Annex A, October 31, 1989)

4. ASIAN DEVELOPMENT BANK: THE ENVIRONMENTAL PROGRAM, April-91

1.

2. ENVIRONMENTAL IMPACT ASSESSMENT PROCESS IN FINNIDA'S BILATERAL DEVELOPMENT ASSISTANCE PROJECT CYCLE

2.1 INTRODUCTION

FINNIDA's policy is to integrate environmental considerations into each stage of identification, preparation, implementation and evaluation of every project (45). The primary responsibility for this should rest with those designing, appraising, implementing and evaluating the projects as a matter of routine rather than a totally separate system of Environmental Impact Assessment. When required, the EIA studies are undertaken by a team consisting of qualified and experienced personnel selected particularly for the task. Where the issues are complex, additional specialist advice and multidisciplinary approach is required to supplement the expertise of FINNIDA's desk officers and special advisers. (See chapter 3.4, Personnel and Expertise Requirements for EIA).

FINNIDA has adopted the recommendations of the Council of OECD (55), where it is suggested that environmental assessment should be coordinated with the host country government; integrated at the earliest stages of project and programme planning; reflected in implementation and followed-up by monitoring and post-audit evaluation.

Environmental assessments are best prepared once a preliminary feasibility study has been undertaken, which enables a clear identification of the project and alternative solutions. The costs of environmental assessment can be minimized if the required data is identified early enough so that its collection is coordinated with the basic data collection programme of the feasibility study.

FINNIDA's project cycle is shown in Figure 2.1. A scheme for the integration of the EIA process into it provides a system for effectively implementing the EIA process in development assistance programmes.

The activities and type of personnel responsible at each step in the EIA process is summarised in Table 2.1. The sequence corresponds with FINNIDA's project cycle as described in FINNIDA's general guidelines for project preparation, appraisal and evaluation (30; 31; 46).

This chapter includes special guidance on the implementation of the EIA procedure.

FROM: FINNIDA'S GUIDELINES FOR ENVIRONMENTAL IMPACT ASSESSMENT IN DEVELOPMENT ASSISTANCE DRAFT, 15 JULY 1989.

2.

Figure 2.1 INTEGRATION OF EIA PROCESS INTO FINNIDA'S PROJECT CYCLE
(Activities not belonging to the EIA process itself are not listed)

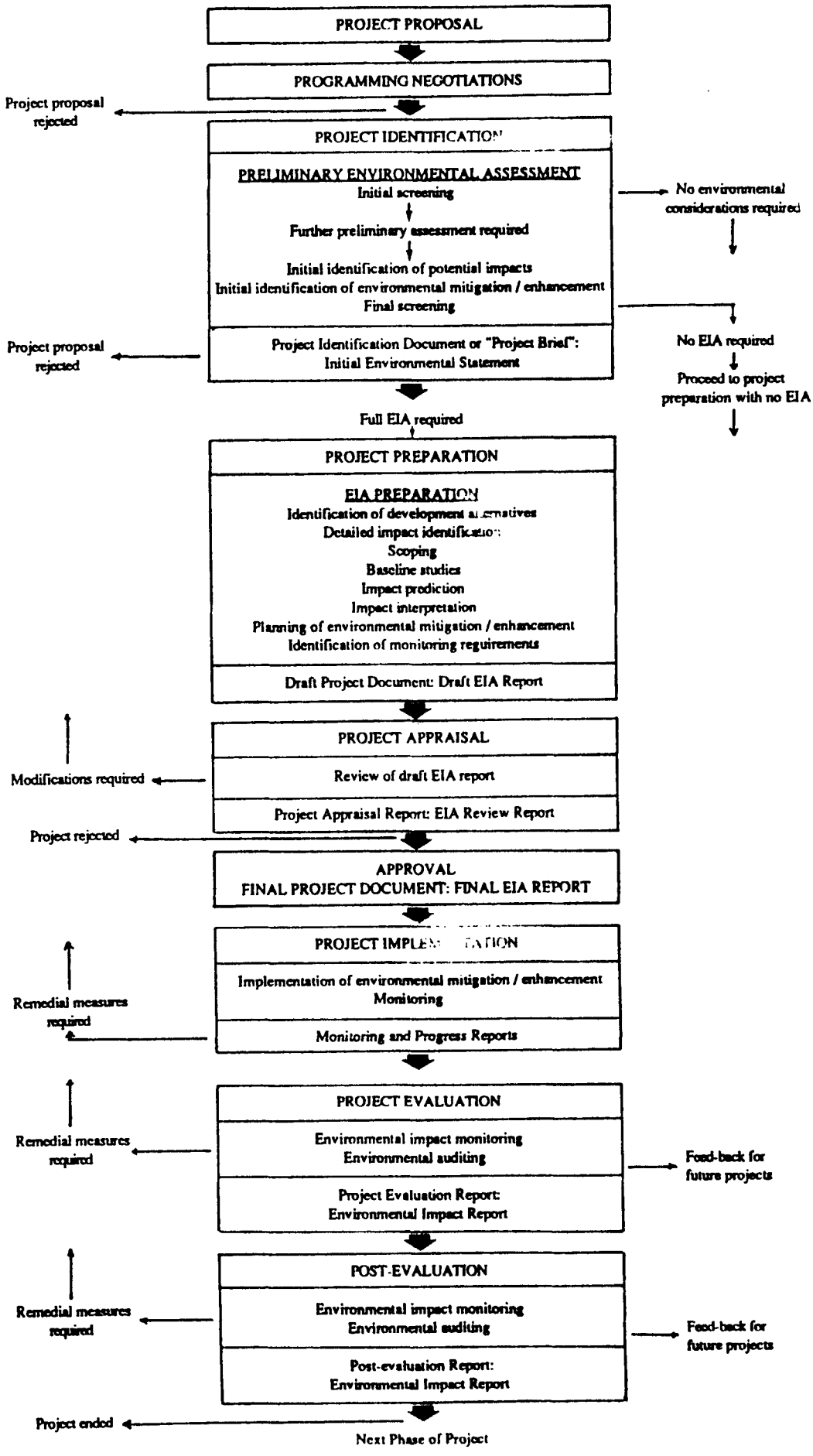

Table 2.1 SUMMARY OF THE EIA PROCEDURE IN FINNIDA'S BILATERAL DEVELOPMENT ASSISTANCE PROJECT CYCLE
(Activities not belonging to the EIA process itself are not listed)

Project Cycle / EIA Process	Required Action	Responsibility / Involvement
PROGRAMMING NEGOTIATIONS	Exchange information on environmental requlations, policies legislation, administration, procedures, etc. Identify environmental needs of the recipient country. Involve environmental authorities if possible.	FINNIDA, Recipient authorities
PROJECT IDENTIFICATION: Preliminary Environmental Assessment:		
i) Initial screening	Check whether there are any EIA regulations in the recipient country. Determine whether the activity falls into the category likely to have significant environmental impacts and most in need of environmental assessment. Check whether the environment and conditions are especially sensitive or fragile. Decide whether further environmental considerations are needed. Record the decision and its rationale in the Project Identification Document or "Project Brief" as an Initial Environmental Statement.	Programme officer, Special adviser, Environmental adviser, Project identification team
ii) Initial identification of potential impacts	Identify the main components of the project phases likely to affect the environment, name the main sources of impacts. Identify human and natural resources likely to be affected. Analyse the likely interactions of project components and components of the environments. Use the checklists of relevant Sectoral Guidelines as an aid.	As above
iii) Initial identification of environmental mitigation / enhancement	Identify measures to minimize, reduce, avoid or offset potentially significant adverse environmental impacts and to enhance and ensure environmental benefits.	As above
iv) Final screening	Determine whether more detailed analysis is needed because impacts, or ability to mitigate them, are not well known or if the identification and planning of required mitigation or environmental management requires so. Record the decision and the results of screening and initial impact identification to identification documents as an Initial Environmental Statement. Identify gaps in information. Prepare TOR for EIA as a part of TOR for project preparation. Recruit qualified experts for EIA, including experts from the host country. When impacts are easily identified and mitigated, more detailed analysis may not be required. Then record the main environmental concerns and monitoring requirements in identification documents as an Initial Environmental Statement.	Programme officer, Special Adviser, Environmental adviser, Bureau chief of FINNIDA, Recipient authorities
PROJECT PREPARATION: EIA Preparation: i) Identification of development alternatives	Identify all alternatives to achieve the desired development objectives. (The objectives, outputs and indicators, including environmental ones, will be stated as required by FINNIDA's general guidelines for project preparation.)	Project team / EIA team
ii) Detailed impact identification and "scoping"	Continue impact identification by consulting with authorities, local community leaders, scientific institutions, etc. and by further study on the existing environment. Select impacts which are important enough to deserve further study. Involve environmental authorities, local leaders and organisations in "scoping", if appropriate, in a special "scoping session".	Project team / EIA team, Recipient authorities, Affected groups and Interested organisations

iii) baseline studies	Describe the existing conditions of the biophysical and socio-economic environment agaist which subsequent changes can be predicted and monitored. Focus on parameters which the impacts shortlisted in the scoping excercise will affect. Study existing documents available and supplement study by field surveys.	Project team / EIA team
iii) Impact prediction	Collect required information on the proposed development, existing environment and prevailing conditions. Estimate the likely nature and characteristics of potential impacts (beneficial and adverse, direct, indirect and cumulative) in quantitative and/ or qualitative terms. Predict impacts of each development alternative, including the one without proposed project.	Project team / EIA team
iv) Impact interpretation	Determine significance or importance of predicted impacts. Base the judgement on e.g.: laws, requlations, standards; government policy objectives; pre-set criteria, such as protected sites, features or species; consultations with decision-makers, affected communities and other interested parties (e.g. environmental NGOs). Present quantitative data and qualitative information on impacts in a form which enables also non-expert decision-makers and general public to comprehend them.	Project team / EIA team
v) Identification of mitigation / enhancement measures	Identify measures to minimize, reduce, avoid or offset adverse impacts evaluated as significant and to enhance and ensure environmental benefits. Determine costs and organisational precautions for successful environmental management.	Project team / EIA team
vi) Identification of monitoring requirements	Recommend monitoring strategy including parameters and indicators to be measured or observed, timing, equipment needed (if any), methods, reporting and technical requirements for monitoring and auditing the actual magnitude of the potential impacts evaluated as significant. Address the question whether there is adequate pre-project data against which to compare the monitoring information. If not, include requirements for further studies in the project document / EIA report. Identify clearly the resource requirements for efficient monitoring. Examine the capacity of the host country officials to take care of required monitoring, and when necessary, make recommendations for special funding, training and other institutional and technical assistance.	Project team / EIA team
vii) Preparation of draft EIA report (as a part of the project document)	Shape and style the report according to the needs of key decision-makers and other target audience. Formulate and structure the report as described later in these guidelines. Attach the draft report as a section of the draft project document, or separately if necessary.	Project team / EIA team
PROJECT APPRAISAL: Review of draft EIA report	Review the draft EIA report and ensure that EIA was properly undertaken according to its Terms of Reference and these guidelines. Recommend remedial actions in EIA report and/or project plan, if the documents prove inadequate.	Programme officer, Special adviser, Environmental adviser, FINNIDA bureau chief, Recipient authorities, Representatives of affected communities and other interested parties, Independent appraisal team -

APPROVAL / DECISION	Approve the project document and EIA report with sufficient environmental mitigation and enhancement measures and monitoring schemes and mechanisms identified and planned. In the case that ecological or social concerns are likely to be dealt with inadequately, or if the development activity is likely to have unacceptable environmental or social costs, the project should be rejected.	Decision-makers in FINNIDA and the Recipient Government
PROJECT IMPLEMENTATION: Implementation of environmental mitigation, enhancement and monitoring	Implement the planned environmental mitigation and enhancement measures. Carry out more detailed baseline studies if required. Set up and start impact monitoring. Record monitoring results to progress reports. Ensure that standards and regulations are met and that procedures are operating effectively. Take remedial actions if problems or unexpected impacts occur.	Project team, Programme officer, Advisers, Field missions
PROJECT EVALUATION: Environmental impact monitoring, Environmental auditing	Evaluate and inspect the effectiveness of environmental mitigation and enhancement measures and established impact monitoring mechanisms. Determine the actual impacts of project implementation and compare them with predictions made in EIA. Recommend remedial measures, if needed. Record results into the Evaluation Report and make it accessible to all interested parties. Ensure efficient feed-back for future projects.	Evaluation team, FINNIDA, Recipient authorities, General public
POST-EVALUATION: Environmental impact monitoring, Environmental auditing	Organise and analyse longer-term monitoring data to establish the record of change associated with the project. Compare actual and predicted impacts and evaluate the accuracy of predictions and effectiveness of environmental management and monitoring practices and procedures. Recommend improvements to make Environmental Impact Assessment and environmental management procedures and practices more efficient. Ensure efficient feed-back for future projects.	Post-evaluation team, FINNIDA, Recipient authorities, General public

GOOD PRACTICES FOR ENVIRONMENTAL IMPACT ASSESSMENT OF DEVELOPMENT PROJECTS

I. INTRODUCTION

1. OECD Members have agreed to ensure that "development assistance projects and programmes which, because of their nature, size and/or location, could significantly affect the environment, should be assessed at as early a stage as possible and to an appropriate degree from an environmental standpoint" (OECD Council Recommendation on Environmental Assessment of Development Assistance Projects and Programmes of 1985).

2. OECD Members have also been called upon to actively support the formal adoption of an environmental assessment policy for their development assistance; to develop effective procedures establishing responsibilities at the planning, implementation and supervisory levels; and to ensure that adequate human and financial resources are provided in a timely and cost-effective way. (OECD Council Recommendation on Measures Required to Facilitate the Environmental Assessment of Development Assistance Projects and Programmes of 1986.)

3. To ensure that environmental aspects are taken into account -- for both bilateral and multilateral development assistance -- in the identification, planning, implementation and evaluation of projects and programmes, and noting that the DAC had developed a set of "Principles for Project Appraisal" (OECD, Paris 1988), the OECD Council adopted in 1989 a Recommendation concerning an Environmental Checklist for Possible Use by High-Level Decision-Makers in Bilateral and Multilateral Development Assistance Institutions. The essence of the three Council Recommendations is incorportated in the present document.

4. DAC Members have worked together to establish the following "Good Practices for Environmental Impact Assessment (EIA) of Development Projects". The following main elements have been identified:

- -- Environmental aspects must be fully integrated in project selection, design and implementation and the administrative responsibilities for the environmental aspects of assisted projects should be clearly determined;
- -- The EIA must address all the expected effects on human health, the natural environment and property as well as social effects, such as resettlement and impacts on tribal people;
- -- The EIA should consider alternative project designs (including the "non-action" alternative) as well as required mitigation and monitoring measures;

OECD / DAC / ENV / APRIL 1991, DRAFT

- The EIA must be conducted, together with screening and scoping, at least for the projects identified by the 1985 OECD Council (see below);

- The EIA should start as early as possible and be conducted at the stage of project-design;

- The EIA should use similar standards among donors for maximum "acceptable" negative effects on the eco-system;

- The utility and relevance of the EIA depend critically on the availability of Country Environmental Surveys and Strategies. They must be taken into account wherever available;

- Active arrangements should be made to obtain the views of affected local populations on the environmental impact of the project;

- The EIA should enable a clear statement of significant beneficial and adverse environmental effects and risks of the project to be made;

- Off-site effects, including transboundary effects, should be assessed;

- The governments of the developing countries bear the ultimate responsibility for the state of the environment in their respective countries and for the design of the development projects and programmes.

II. BASIC PURPOSE OF ENVIRONMENTAL IMPACT ASSESSMENT

5. Environmental Impact Assessment is a procedure used to examine the environmental consequences, both beneficial and adverse, of a proposed development project and to assure that these consequences are taken into account in project design. The EIA evaluates the expected effects on human health, the natural environment and on property; it may also include social effects such as resettlement and impacts on tribal people. The EIA should consider alternative project designs (including the "no-action" alternative), as well as mitigation measures or environmental safeguards that should be incorporated into the project design to offset adverse impacts. The assessment will be most useful if it is initiated at the earliest stage of project design to assure from the outset that aid projects are environmentally sound and sustainable.

1. Integration into the Decision-Making and Implementation Process

6. Formal EIA processes and regulations by Member governments are intended to ensure that environmental aspects are integrated into the decision-making

process of the host country, the aid agency and other institutions involved in project design and implementation. It is essential that environmental assessment is an integral part of the process of project selection, design and implementation. This should be clearly established in the project selection procedures and the administrative responsibilities for the environmental aspects of assisted projects should be specifically determined.

2. Projects and Programmes Most in Need of Environmental Impact Assessment

7. Projects or programmes generally requiring an EIA are listed in the 1985 Council Recommendation under the following headings:

a) Those which cause a substantial change in renewable resource use;

b) Those which substantially change farming and fishing practices;

c) The exploitation of hydraulic resources;

d) Infrastructure;

e) Industrial activities;

f) Extractive industries;

g) Waste management and disposal.

8. In-depth environmental assessments should be conducted not only for development assistance projects which may affect human health due to air and water pollution, but also for projects which may have impacts on endangered plant and animal species or their critical habitats, protected areas, or biological diversity. Assessments should also be conducted for all projects in very fragile environments such as tropical forests, wetlands, mangrove swamps, coral reefs and semi-arid areas.

3. Coverage of Environmental Impacts

9. The term environmental impact is understood to include:

-- Effects on human health, the environmental media, eco-systems (including flora and fauna), agriculture and buildings (classified as protected);

-- Effects on climate and atmosphere;

-- Use of natural resources (both regenerative resources and mineral resources);

-- Utilisation and disposal of residues and wastes;

-- Related aspects such as resettlement, archeological sites, landscape, monuments and social consequences as well as relevant upstream and downstream effects.

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Environmental Assessment

OPERATIONAL DIRECTIVE ADOPTED BY BANK

Bank policy and procedures have been developed for the environmental assessment (EA) of Bank lending operations. These procedures have been adopted to ensure that the development options under consideration are environmentally sound and sustainable and that any environmental consequences are recognized early in the project cycle and taken into account in project design. EAs identify ways to improve projects environmentally and to minimize, mitigate, or compensate for any adverse impacts.

EAs are intended to alert project designers, borrowers and Bank staff to environmental issues. They enable them to address these issues in a timely and practical fashion and help to avoid costs and delays due to unanticipated environmental problems.

EAs also provide a formal mechanism to help ensure inter-agency coordination and to address the concerns of potentially affected parties and local nongovernmental organizations (NGOs). In addition, they can play an important role in building environmental capability in the country.

Project-Specific EAs

These EAs are used to analyze specific investment projects (e.g., dams, factories, irrigation systems) with significant environmental issues. The level of detail and sophistication of analysis should depend upon the magnitude of expected impacts.

A project-specific EA should normally cover: (a) existing environmental "baseline" conditions; (b) potential environmental impacts, direct and indirect, including opportunities for environmental enhancement; (c) systematic environmental comparison of alternative investments, sites, technologies, and designs; (d) preventive, mitigatory, and compensatory measures, generally in the form of an action plan; (e) environmental management and training; and (f) monitoring.

Alternatives to EAs that focus on a narrower range of issues may be acceptable for projects with limited potential environmental impacts.

Regional EAs

These EAs are used where a number of significant development activities are planned for a reasonably localized area. In such cases, regional EAs are generally more efficient than a series of project-specific EAs and may identify issues that the latter might overlook (e.g., interaction among effluents, or competition for water, or land).

Regional EAs compare alternative development scenarios, and recommend environmentally sustainable growth rates, land use patterns and policies.

Sectoral EAs

Used for the overall design of sector investment programs, these EAs are particularly suitable for reviewing: (a) sector investment alternatives; (b) the effect of sector policy changes; (c) institutional capacities and requirements for environmental review, implementation and monitoring at the sectoral level; and (d) the cumulative impacts of many relatively small, similar investments which do not merit individual project-specific EAs.

Inter-Agency Coordination

Environmental issues generally involve national, regional, and local government agencies, and cover a broad range of responsibilities (wildlife, health, water and land use, tourism, etc.). Coordination among government agencies is best achieved through inter-agency meetings at key points in the EA cycle.

The ultimate success of EAs depends upon the development of environmental capability and understanding in the agencies concerned.

Involvement of Affected Groups and NGOs

The Bank expects the borrower to take the views of affected groups and local NGOs into account in project design and implementation and particularly in the preparation of EAs. This is important in order to understand both the nature and extent of any social or environmental impact and the acceptability of proposed mitigation measures.

EA Procedures

Though EA preparation is the responsibility of the borrower, the project task manager in the Bank generally assists and monitors the EA process, with support mainly from the Regional Environment Division.

The Bank is initiating a training program in environmental assessment to promote consistent application of the procedures.

The Bank also intends to carefully monitor and evaluate the implementation of the guidelines, which will be revised in due course based on the lessons learned.

--Gloria Davis

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Manual Transmittal Memorandum

October 31, 1989

Operational Directive 4.00, Annex A: Environmental Assessment

1. Attached for insertion in the new Operational Manual is OD 4.00, Annex A, which provides guidance to staff on the Bank's policies and procedures for conducting environmental assessments (EAs) of proposed projects. It standardizes and formalizes a process which is already taking place for projects with major environmental impacts.

2. This annex makes the following points:

(a) EA is a flexible procedure, whose scope, depth, and analytical techniques vary by project (para. 1);

(b) The purpose of EA is to ensure environmentally sustainable development through the timely incorporation of environmental issues into project design (para. 3);

(c) EA is part of project preparation and is therefore the borrower's responsibility (para. 4);

(d) Regional and sectoral EAs are important tools for identifying environmental issues, and can reduce the work subsequently needed on project-specific EAs (paras. 6-8);

(e) Alternatives to EA that focus on a narrower range of issues are acceptable for projects with limited potential environmental impacts (para. 9);

(f) In the EA process, inter-agency coordination and the involvement of affected groups and local NGOs are important (paras. 11-12);

(g) The EA process should be used to strengthen environmental capability in the country (para. 13);

(h) In special cases, environmental advisory panels may be needed (para. 15);

(i) In the Bank, the task manager (TM), supported by the Regional environment division (RED), assists and monitors the implementation of the EA process (para. 16);

(j) The type, timing, and main issues of environmental analysis should be confirmed at the Initial Executive Project Summary (IEPS) meeting (para. 19), and reported and updated in the Monthly Operational Summary (para. 20); and

(k) The final EA report should normally be available to the Bank prior to appraisal (para. 22), and its recommendations reviewed and incorporated into the Board documents (paras. 25-26).

3. All projects which reach the IEPS stage after October 15, 1989, are fully subject to this directive. Projects currently in advanced stages of preparation are not normally subject to this annex. For other projects already past the IEPS stage, the TM and the RED should, by December 31, 1989, review the status and recommend how to achieve the objectives of this annex within the existing time and resource constraints.

4. A systematic training program for Bank staff on the application of this directive is currently being designed under the leadership of the Environment Department.

This directive was prepared for the guidance of staff of the World Bank and is not necessarily a complete treatment of the subjects covered.

Manual Transmittal Memorandum

5. Achieving the objectives of this directive will require close collaboration between the Bank and its borrowers, and strengthening of borrower capacity for carrying out, analyzing, and incorporating the recommendations of EAs. Country departments should therefore discuss with borrowers how to achieve smooth and efficient implementation of this annex through, e.g., EA seminars for implementing agencies' management, training programs for their environmental staff, and preparation of EA manuals (by sector) and procedures for the country.

6. As this is a new directive, progress and problems in its implementation will need to be monitored carefully. A review of experience will be prepared for Board discussion during FY91, and this directive will subsequently be modified based upon the lessons learned.

7. Questions on this annex should be referred to the Director, Environment Department.

8. Additional copies are available on a self-service basis in H 4234.

Attachment

This directive was prepared for the guidance of staff of the World Bank and is not a complete statement of the policies covered

4.

Operational Directive 4.00, Annex A: Environmental Assessment

Introduction

1. This annex outlines Bank policy and procedures for the environmental assessment (EA) of Bank investment lending operations,[1] and related types of environmental analysis. EA is a flexible procedure, which can vary in breadth, depth, and type of analysis, depending on the project. It may be carried out at one point in time, stretched over a year to account for seasonal variations, or done in discrete stages.

2. For the purpose of this annex, EA covers also project impacts on health, cultural property, and tribal people, and the environmental impact of project-induced resettlement.[2] EAs utilize the findings of country environmental studies and action plans which cover nationwide issues, the overall policy framework, legislation, and institutional capabilities in the country.

Purpose and Nature of EA

3. The purpose of EA is to ensure that the development options under consideration are environmentally sound and sustainable, and that any environmental consequences are recognized early in the project cycle and taken into account in project design. EAs identify ways of improving projects environmentally, and minimizing, mitigating, or compensating for adverse impacts. By alerting project designers, implementing agencies, and borrower and Bank staff to issues early, EAs (a) enable them to address environmental issues in a timely and practical fashion, (b) reduce the need for project conditionality, because appropriate steps can be taken in advance or incorporated into project design, and (c) help avoid costs and delays in implementation due to unanticipated environmental problems. EAs also provide a formal mechanism for inter-agency coordination and for addressing the concerns of affected groups and local nongovernmental organizations (NGOs). In addition, they can play a major role in building environmental capability in the country.

4. Like economic, financial, institutional, and engineering analyses, EA is part of project preparation, and is therefore the borrower's responsibility. Close integration of EA with these other aspects of project preparation ensures that (a) environmental considerations are given due weight in project selection, siting, and design decisions, and (b) carrying out EAs does not unduly delay project processing.

Types of Environmental Analysis

Project-Specific EAs

5. Project-specific EAs are used to analyze specific investment projects (e.g., dams, factories, irrigation systems) with significant environmental issues. The detail and sophistication of analysis should be commensurate with the expected impacts. A project-specific EA should normally cover: (a) existing environmental "baseline" conditions; (b) potential environmental

1. References to the Bank include IBRD and IDA; "loans" include credits. Investment lending covers specific and sector investments including rehabilitation, loans through financial intermediaries, and the investment component of hybrid loans. Sector and structural adjustment loans are not covered by this annex, but are subject to the general policies in OMS 2.36, *Environmental Aspects of Bank Work* (to be reissued as OD 4.00, *Environmental Policies*). IFC is developing similar procedures for environmental review, which reflect the special circumstances of its work. Bearing in mind its special circumstances, MIGA will cooperate with the Bank to ensure, to the extent possible, that the objectives of the directive are met in its operations.

2. For Bank policies regarding such impacts, see (a) OPN 11.03, *Management of Cultural Property in Bank-Financed Projects*, to be reissued as OD 4.50, *Cultural Property*; (b) OMS 2.34, *Tribal People in Bank-Financed Projects*, to be reissued as OD 4.40, *Tribal People*; and (c) OMS 2.33, *Social Issues Associated with Involuntary Resettlement in Bank-Financed Projects*, and OPN 10.08, *Operational Issues in the Treatment of Involuntary Resettlement in Bank-Financed Projects*, to be reissued as OD 4.30, *Involuntary Resettlement*.

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impacts, direct and indirect,[3] including opportunities for environmental enhancement; (c) systematic environmental comparison of alternative investments, sites, technologies, and designs; (d) preventive, mitigatory, and compensatory measures, generally in the form of an action plan; (e) environmental management and training, and (f) monitoring. To the extent possible, capital and recurrent costs, environmental staffing, training, and monitoring requirements, and the benefits of proposed alternatives and mitigation measures, should be quantified. Annex A1 gives a sample outline for a project-specific EA report, and Annex A2 is a checklist of specific issues to be covered where relevant.

Regional and Sectoral EAs

6. Regional EAs are used where a number of significant development activities with potentially cumulative impacts are planned for a reasonably localized area. In such cases, they are generally more efficient than a series of project-specific EAs, and may identify issues that the latter might overlook (e.g., interaction among effluents, or competition for water or land). Regional EAs compare alternative development scenarios, and recommend environmentally sustainable growth rates and land use patterns and policies. The study area is normally defined on a physical and/or biological basis (e.g., airshed, habitat type, river basin), and may sometimes extend across national boundaries; however, regional EAs with an institutional focus might follow administrative boundaries instead.

7. Sectoral EAs are used for the design of sector investment programs. They are particularly suitable for reviewing (a) sector investment alternatives; (b) the effect of sector policy changes; (c) institutional capacities and requirements for environmental review, implementation, and monitoring at the sectoral level; and (d) the cumulative impacts of many relatively small, similar investments which do not merit individual project-specific EAs.

8. In some cases, regional or sectoral EAs cover all the normal requirements of project-specific EAs. More often, the latter are still needed for major investments (see para. 14 concerning sector investment loans), but the regional or sectoral EAs will have identified the relevant issues, collected much of the data, and, in general, greatly reduced the work needed in the project-specific EAs.

Alternatives to EAs

9. Alternative approaches that focus on a narrower range of issues are acceptable for many types of projects, especially smaller ones and those not in environmentally sensitive areas. These approaches may be more effective in integrating environmental concerns into the borrower's planning process. Such alternative approaches include:

(a) integrated pest management programs for many agricultural projects which do not involve major irrigation or land development;

(b) specific environmental design criteria and pollution standards for small- or medium-scale industrial plants; and

(c) specific environmental design criteria and construction supervision programs for small-scale rural works projects.

Other examples of projects for which alternative approaches are generally acceptable are listed in Annex A3, para. 3, under "Category B."

Consideration of Global Issues

10. A number of specialized agencies—inside and outside the U.N. system—carry out scientific investigations of global environmental issues (ozone depletion, global warming, hazardous wastes, etc.). The Bank keeps fully abreast of findings, primarily through its Principal Adviser, Science and Technology, and draws upon prevailing views

3. Indirect impacts are the induced consequences of the project which occur later or in another part of the environment, e.g., if a river is channelled or dammed, its capacity for self-purification may be reduced and the original aquatic ecosystem damaged or destroyed.

in developing its own environmental, economic, and sectoral policies, with a view to minimizing possible adverse impacts on global systems such as the atmosphere and oceans. While EAs should collect or refer to the relevant data, the Bank does not normally expect global environmental issues to require separate analysis in project-specific EAs. Such issues should, however, be addressed where relevant in policy and sector work.

Institutional Aspects of Projects

Inter-Agency Coordination

11. Because environmental issues generally involve national, regional, and local government agencies, and cover a broad range of responsibilities (wildlife, health, water and land use, tourism, etc.), coordination among government agencies is crucial. This is best achieved through inter-agency meetings at key points in the EA cycle. The first meeting, normally held soon after the decision to prepare an EA, identifies the issues, types of analysis required, sources of relevant expertise, responsibilities and schedule for the EA, and mitigating measures to be considered. Another meeting should normally be held when the EA report is completed and submitted for final government review.

Involvement of Affected Groups and Nongovernmental Organizations

12. The Bank expects the borrower to take the views of affected groups and local NGOs[4] fully into account in project design and implementation, and in particular in the preparation of EAs. This is important in order to understand both the nature and extent of any social or environmental impact, and the acceptability of proposed mitigation measures. An approach which has proven effective in many countries is to expand the initial inter-agency meeting (para. 11) into a "forum" or "scoping session" with representatives of affected groups and relevant NGOs. Similar consultations after the EA report is completed are also a valuable way to obtain feedback on the report and to increase community cooperation in implementing the recommendations.

Strengthening Environmental Capabilities

13. The ultimate success of EA depends upon the development of environmental capability and understanding in the agencies concerned. Projects with major potential impacts normally require the establishment or strengthening of in-house environmental units for the project (located or represented on site), the implementing agency and the ministry. Involvement of these units throughout the EA process (a) ensures that the agency's/ministry's knowledge and perspective are taken into account in the EA, (b) provides on-the-job training for the staff, and (c) provides continuity for the implementation of the EA's recommendations. Such projects normally need to include an institutional development and training component for such units. In addition, to help develop EA capability in the country, the Bank should (a) encourage the use of local expertise in EA preparation (in association with international consultants, where appropriate), and (b) help arrange EA training courses for local specialist staff and consultants.

Sector and Financial Intermediary Lending

14. For sector investment loans and loans through financial intermediaries, subproject details may not be known at the time of project appraisal. In such cases, the project implementing institutions will need to screen subprojects (see para. 18) and carry out environmental analyses consistent with this directive. To ensure that this can be done, the Bank should appraise the implementing agencies' capabilities for EA, and strengthen them where necessary. The appraisal mission should also indicate the proper division of responsibility for preparing and reviewing EAs between the ultimate borrower, the financial

4. See OD 14.70, *Involving Nongovernmental Organizations in Bank-Supported Activities* for the Bank's overall approach to NGOs.

intermediary or sector agency, and the agencies responsible for environmental regulation.

Environmental Advisory Panels

15. For major projects with serious and multidimensional environmental concerns, the Bank should explore with the borrower whether the latter needs to engage an advisory panel of independent, internationally recognized, environmental specialists, to review and advise on, *inter alia*, the terms of reference (TOR) and findings of the EA, the implementation of its recommendations, and the development of environmental capacity in the implementing agency/ministry. Such a panel should meet at least once a year until the project is operating routinely and environmental issues have been addressed satisfactorily.[5]

EA Procedures

Overview

16. Though EA preparation is the responsibility of the borrower, the task manager (TM) in the Bank assists and monitors the EA process, with support mainly from the Regional environment division (RED). The borrower and the Bank should agree as early as possible on the selection of consultants or borrower staff to prepare the EA, and the EA procedures, schedule, and outline. Major steps in the EA process normally include: (a) screening, (b) decisions based on the Initial Executive Project Summary (IEPS), (c) notification to the Board through the Monthly Operational Summary (MOS), (d) preparation of TORs for the EA, (e) EA preparation, (f) EA review and incorporation of environmental measures into the project, (g) supervision, and (h) ex post evaluation.

17. Since project and country conditions, national legislation, and institutional experience vary among borrowers, both the borrower and the Bank must exercise judgement in using these procedures to design and implement projects which are both environmentally and economically sound, and consistent with the environmental laws, policies, and procedures of the borrower. The Environment Department (ENV), Legal Department, and the REDs maintain information on these requirements.

Screening

[illegible]jects/components should be screened at identification by the TM, with advice from the RED, and assigned to one of the following categories based upon the nature, magnitude, and sensitivity of environmental issues:

Category A—EA is normally required as the project may have diverse and significant environmental impacts.

Category B—More limited environmental analysis is appropriate, as the project may have specific environmental impacts.

Category C—Environmental analysis is normally unnecessary.

Category D—Environmental projects, for which separate EAs may not be required, as environment would be a major focus of project preparation.

Annex 3 gives illustrative lists, to be applied flexibly, of the type of project/component in each category.

Initial Executive Project Summary

19. In the IEPS, the TM, in consultation with the RED, should (a) identify key environmental issues, (b) indicate the category (A-D) and the type of environmental analysis recommended, and (c) provide a preliminary EA schedule. If an EA is not likely to be available prior to appraisal, the

5. See OD 4.00, Annex B, *Environmental Policy for Dam and Reservoir Projects*, para. 18, for more details on the selection and functions of the panel.

IEPS should propose special procedures to address the situation. The IEPS meeting would confirm the type, timing, and issues of environmental analysis (although in the event of inadequate information, the decision may be deferred).

Monthly Operational Summary

20. The TM should ensure that the MOS, which is used to alert the executive directors to forthcoming projects, contains the following information as soon as available: (a) the category assigned (A-D); (b) the main issues to be examined; (c) whether agreement with the borrower has been reached on EA preparation; and (d) the EA schedule. The MOS entry should be updated whenever appropriate to reflect the progress of the EA, and the related Bank and borrower decisions.

Preparation of TORs for the EA

21. Following the IEPS meeting, the Bank should discuss with the borrower the scope of the EA, and assist the borrower, as necessary, in preparing TORs for the EA. For this purpose, a field visit by Bank environmental staff is generally desirable. The Bank should ensure that the TORs provide for adequate inter-agency coordination (para. 11) and consultation with affected groups and local NGOs (para. 12).

EA Preparation

22. An EA for a major project typically takes 6-18 months to prepare and review. EA drafts should be available at key points in the project cycle. The final EA should be available prior to appraisal, to minimize the risk of project design changes and resultant delays at a late stage.

23. In most cases, the EA should form part of the overall feasibility study, so that the EA's findings are directly integrated into project design. However, the EA is normally prepared separately by specialists. For projects which would have major impacts, such as large dams or projects involving large scale resettlement, it is recommended that the borrower retain independent experts not affiliated with the project. Borrowers may request Bank assistance for financing EAs through a Project Preparation Facility (PPF) advance,[6] or from the Technical Assistance Grant Program for the Environment. EAs generally account for 5-10 percent of the cost of project preparation.

24. For some projects, a full year of baseline data is desirable to capture the seasonal effects of certain environmental phenomena; however, so as not to delay critical project decisions, short-term monitoring should be used to provide conservative estimates of environmental impacts, while longer-term data collection is being undertaken. Since special care in designing the baseline monitoring program is warranted, the borrower should be encouraged to discuss the matter with the Bank.

EA Review and Project Appraisal

25. The borrower should submit the final EA report to the Bank prior to Bank appraisal. The EA report is the borrower's property, but the Bank encourages the borrower to release relevant information to appropriate interested parties. The Final Executive Project Summary should summarize the EA's status and describe how major environmental issues have been resolved or are to be addressed, noting any proposed conditionality. The appraisal mission should review both the procedural and substantive elements of the EA with the borrower, resolve any issues, assess the adequacy of the institutions responsible for environmental management in light of the EA's findings, and determine if the EA's recommendations are properly addressed in project design and economic analysis.

Loan Documents

26. The EA procedures followed and the EA's main findings should be explained briefly in the text of the Staff Appraisal Report (SAR) and the

6. See OMS 2.15, *Project Preparation Facility*, to be reissued as OD 8.00.

Memorandum and Recommendation of the President. An SAR annex should summarize the EA more fully, covering, *inter alia*, environmental baseline conditions, alternatives considered, mitigating and compensatory actions, capability of environmental units and measures to strengthen them, environmental monitoring arrangements, and the borrower's consultations with affected groups and NGOs. These factors will provide the basis for the RED's formal environmental clearance prior to the authorization of negotiations by the Regional vice president. Measures critical to sound project implementation may require specific loan conditionality.

Supervision

27. EA recommendations provide the basis for supervising the environmental aspects of project implementation. Compliance with environmental conditionality, the status of mitigating measures, and the findings of monitoring programs should be part of borrower reporting requirements and project supervision. When major issues arise, special supervision missions with adequate environmental expertise may be needed.

Ex Post Evaluation

28. The project completion report[7] submitted to the Operations Evaluation Department should evaluate (a) environmental impacts, noting whether they were anticipated in the EA report, and (b) the effectiveness of mitigating measures taken and of institutional development and training.

7. See the OPNSV memorandum, *Guidelines for Preparing Project Completion Reports*, June 7, 1989, and OMS 3.58, *General Guidelines for Preparing Project Completion Reports*, which are to be combined and reissued as OD 13.55, *Project Completion Reports*.

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Sample Outline of a Project-Specific EA Report

1. EA reports should be concise and limited to significant environmental issues. The detail and sophistication of analysis should be commensurate with the potential impacts. The target audience should be project designers, implementing agencies, and borrower and Bank staff.

2. The EA report should include:

(a) *Executive Summary*. Concise discussion of significant findings and recommended actions.

(b) *Policy, legal, and administrative framework* within which the EA is prepared. The environmental requirements of any cofinanciers should be explained.

(c) *Project description* in a geographic, ecological, social, and temporal context, including any off-site investments that may be required by the project (e.g., dedicated pipelines, access roads, power plants, water supply, housing, and raw material and product storage facilities).

(d) *Baseline Data*. Dimensions of the study area and description of relevant physical, biological, and socio-economic conditions, including any changes anticipated before the project commences. Current and proposed development activities within the project area (but not directly connected to the project) should also be taken into account.

(e) *Environmental Impacts*. The positive and negative impacts likely to result from the proposed project should be identified and assessed. Mitigation measures and the residual impacts that cannot be mitigated should be identified. Opportunities for environmental enhancement should be explored. The extent and quality of available data, key data gaps, and uncertainties associated with predictions should be identified/estimated. Topics that do not require further attention should be specified.

(f) *Analysis of Alternatives*. Proposed investment design, site, technology, and operational alternatives should be compared systematically in terms of their potential environmental impacts; capital and recurrent costs; suitability under local conditions; and institutional, training, and monitoring requirements. To the extent possible, for each of the alternatives, the environmental costs and benefits should be quantified, and economic values attached where feasible.

(g) *Mitigation Plan*. Feasible and cost-effective measures which may reduce potentially significant adverse environmental impacts to acceptable levels should be proposed, and the potential environmental impacts, capital and recurrent costs, and institutional and training requirements of those measures estimated. The plan (sometimes known as an "action plan" or "environmental management plan") should provide details on proposed work programs and schedules, to ensure that the proposed environmental actions are in phase with engineering activities throughout preparation. The plan should consider compensatory measures if mitigation measures are not feasible or cost-effective.

(h) *Environmental Management and Training*. The existence, role, and capability of environmental units at the on-site, agency, and ministry level should be assessed, and recommendations made concerning the

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establishment and/or expansion of such units, and the training of staff, to the point that EA recommendations can be implemented.

(i) *Monitoring Plan* regarding environmental impacts and performance. The plan should specify the type of monitoring, who would do it, how much it would cost, and what other inputs (e.g., training) are necessary.

Appendices

(i) *List of EA preparers*—individuals and organizations.

(ii) *References*—written materials used in study preparation. This is especially important given the large amount of unpublished documentation often used.

(iii) *Record of Inter-Agency/Forum Meeting*, including list of both invitees and attendees. Where the views of affected groups and local NGOs were obtained by other means, these should be specified.

This directive was prepared for the guidance of staff of the World Bank and is not [illegible]

Checklist of Potential Issues for an EA

Where applicable, EAs should address the following issues, which are subject to the Bank policies and guidelines identified below.

(a) *Agrochemicals*. The Bank promotes the use of integrated pest management (IPM) and the careful selection, application, and disposal of pesticides (see OPN 11.01, *Guidelines for the Selection and Use of Pesticides in Bank-Financed Projects and their Procurement when Financed by the Bank*, to be reissued as OD 4.00, Annex C, *Agricultural Pest Management. and Selection and Use of Pesticides*). The use of fertilizers, due to their impacts on surface and groundwater quality, must also be carefully assessed.

(b) *Biological Diversity*. The Bank promotes conservation of endangered plant and animal species, critical habitats, and protected areas (para. 9b, OMS 2.36, *Environmental Aspects of Bank Work*, and OPN 11.02, *Wildlands: Their Protection and Management in Economic Development*, to be reissued as OD 4.00, Annex D, *Wildlands: Their Protection and Management*).

(c) *Coastal and Marine Resources Management*. Guidelines are available from the Environmental Department (ENV) on the planning and management of coastal marine resources including coral reefs, mangroves, and wetlands.

(d) *Cultural Properties*. OPN 11.03, *Management of Cultural Property in Bank-Financed Projects* (to be reissued as OD 4.50, *Cultural Property*), confirms the Bank's commitment to actively protect archaeological sites, historic monuments, and historic settlements.

(e) *Dams and Reservoirs*. OD 4.00, Annex B, *Environmental Policy for Dam and Reservoir Projects*, provides specific guidance for addressing environmental issues in the planning, implementation, and operation of dam and reservoir projects.

(f) *Hazardous and Toxic Materials*. Guidelines are available from ENV on the safe manufacture, use, transport, storage, and disposal of hazardous and toxic materials.

(g) *Induced Development and Other Socio-Cultural Aspects*. Secondary growth of settlements and infrastructure, often referred to as "induced development" or "boomtown" effects, can have major indirect environmental impacts, which relatively weak local governments may have difficulty addressing.

(h) *Industrial Hazards*. All energy and industry projects should include a formal plan to prevent and manage industrial hazards. (See *Techniques of Assessing Industrial Hazards—A Manual*, World Bank Technical Paper No. 55.)

(i) *International Treaties and Agreements on the Environment and Natural Resources*. EAs should review the status and application of such current and pending treaties and agreements, including their notification requirements. The Legal Department maintains a list of international treaties, and could obtain, whenever required, information on applicable law in individual countries.

(j) *International Waterways*. OD 7.50, *Projects on International Waterways* provides guidance. This OD exempts from notification requirements rehabilitation projects which will not affect the quality or quantity of water flows.

(k) *Involuntary Resettlement*. OMS 2.33, *Social Issues Associated with Involuntary Resettlement in Bank-Financed Projects*, and OPN 10.08, *Operations Issues in the Treatment of Involuntary Resettlement in Bank-Financed Projects* (to be reissued as OD 4.30, *Involuntary Resettlement*), provide guidance.

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(l) *Land Settlement*. Due to the complex physical, biological, socioeconomic, and cultural impacts, land settlement should generally be carefully reviewed (see OD 4.31, *Land Settlement*, to be issued).

(m) *Natural Hazards*. EAs should review whether the project may be affected by natural hazards (e.g., earthquakes, floods, volcanic activity), and should propose specific measures to address these concerns when appropriate (see OD 8.50, *Emergency Recovery Assistance*, to be issued).

(n) *Occupational Health and Safety*. All industry and energy projects, and projects in other sectors where relevant, should include a formal plan to promote occupational health and safety (*Occupational Health and Safety Guidelines*, World Bank, 1988).

(o) *Tribal Peoples*. OMS 2.34, *Tribal People in Bank-Financed Projects* (to be reissued as OD 4.40, *Tribal People*), provides specific guidance for addressing the rights of tribal peoples, including traditional land and water rights.

(p) *Tropical Forests*. The Bank co-authored the Tropical Forest Action Plan (published in 1984); up-to-date information is available from ENV. OPN 11.02, *Wildlands: Their Protection and Management in Economic Development* (to be reissued as OD 4.00, Annex D), also addresses issues relating to tropical forests.

(q) *Watersheds*. Bank policy is to promote protection and management of watersheds as an element of lending operations for dams, reservoirs, and irrigation systems (OD 4.00, Annex B, *Environmental Policy for Dam and Reservoir Projects*, para. 6).

(r) *Wetlands*. The Bank promotes conservation and management of wetlands (e.g., estuaries, lakes, mangroves, marshes, and swamps). This is covered by OPN 11.02 on wildlands (see (s) below).

(s) *Wildlands*. The Bank is committed to protect wildlands, including through compensatory measures when lending could result in adverse impacts (see OPN 11.02, *Wildlands: Their Protection and Management in Economic Development*, to be reissued as OD 4.00, Annex D, *Wildlands: Their Protection and Management*).

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Environmental Screening

Introduction

1. The task manager, in consultation with the Regional environment division, is responsible for screening a proposed project to determine the appropriate type of environmental analysis, based on the nature, potential magnitude, and sensitivity of the issues. The categories below, based upon prior Bank staff experience, are strictly illustrative. Alternatives to EA are acceptable where they are expected to result in an environmentally sound project.

2. *Category A: Projects/Components Which May Have Diverse and Significant Environmental Impacts—Normally Require EA*[1]

(i) Aquaculture/Mariculture (large scale);

(ii) Dams and Reservoirs;[2]

(iii) Electrical Transmission (large scale);

(iv) Forestry;

(v) Industrial Plants (large scale) and Industrial Estates;

(vi) Irrigation and Drainage (large scale);

(vii) Land Clearance and Leveling;

(viii) Mineral Development (including oil and gas);

(ix) Pipelines (oil, gas, and water);

(x) Port and Harbor Development;

(xi) Reclamation and New Land Development;

(xii) Resettlement;[3]

(xiii) River Basin Development;

(xiv) Rural Roads;

(xv) Thermal and Hydropower Development;

(xvi) Tourism (large scale);

(xvii) Transportation (airports, railways, roads, waterways);

(xviii) Urban Development (large scale);

(xix) Urban Water Supply and Sanitation (large scale);

(xx) Manufacture, Transportation, and Use of Pesticides or other Hazardous and/or Toxic Materials;[4] and

(xxi) Projects which Pose Serious Accident Risks.[5]

3. *Category B: Projects/Components which may Have Specific Environmental Impacts—More Limited Environmental Analysis Appropriate*

Projects in this category normally require more limited environmental analysis than an EA.

1. Except generally for projects directed to rehabilitation, improved operation and maintenance, and limited upgrading of facilities.
2. See OD 4.00, Annex B, *Environmental Policy for Dam and Reservoir Projects*.
3. While OMS 2.33, *Social Issues Associated with Involuntary Resettlement in Bank-Financed Projects* (to be reissued as OD 4.30, *Involuntary Resettlement*), covers the social aspects of resettlement, the environmental implications of the resettlement itself can be major.
4. In some cases, adherence to existing directives is an acceptable alternative to an EA (e.g., OPN 11.01, *Guidelines for the Selection and Use of Pesticides in Bank-Financed Projects and their Procurement when Financed by the Bank*, to be reissued as OD 4.00 Annex C, *Agricultural Pest Management, and Selection and Use of Pesticides*). Certain materials (e.g. PCBs) are not to be used in Bank projects and other materials (e.g. asbestos) are to be used only under extremely restricted conditions. A Restricted Toxic Materials List (RTML) will be available from ENV and updated periodically.
5. See *Techniques of Assessing Industrial Hazard—A Manual*. World Bank Technical Paper No. 55.

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A wide range of environmental guidelines, developed by a number of organizations, are applicable. In addition, specific environmental pollution standards or design criteria can be developed for individual projects.

(i) Agroindustries (small scale);

(ii) Aquaculture and Mariculture (small scale);

(iii) Electrical Transmission (small scale);

(iv) Industries (small scale);

(v) Irrigation and Drainage (small scale);

(vi) Mini Hydro-Power;

(vii) Public Facilities (hospitals, housing, schools, etc.);

(viii) Renewable Energy;

(ix) Rural Electrification;

(x) Telecommunications;

(xi) Tourism (small scale);

(xii) Urban Development (small scale); and

(xiii) Rural Water Supply and Sanitation.

4. *Category C: Projects/Components which Normally Do Not Result in Significant Environmental Impact—Environmental Analysis Normally Unnecessary*

Opportunities to enhance environmental [illegible] should be sought in these projects.

(i) Education (except school construction);

(ii) Family Planning;

(iii) Health (except hospital construction);

(iv) Nutrition;

(v) Institutional Development; and

(vi) Technical Assistance.

5. *Category D: Environmental Projects*

Projects with a major environmental focus may not require a separate EA, as environment would be a major part of the project preparation.

6. *Emergency Recovery Projects*

Because emergency recovery projects [illegible] to be processed rapidly, and (b) seek [illegible] to restore existing facilities, they normally would not require a full EA. However, the extent to which the emergency was precipitated and/or exacerbated by inappropriate environmental practices should be determined, and corrective measures built into either the emergency project or a future lending operation.[6]

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6. See OD 8.50, *Emergency Recovery Assistance*, to be issued.

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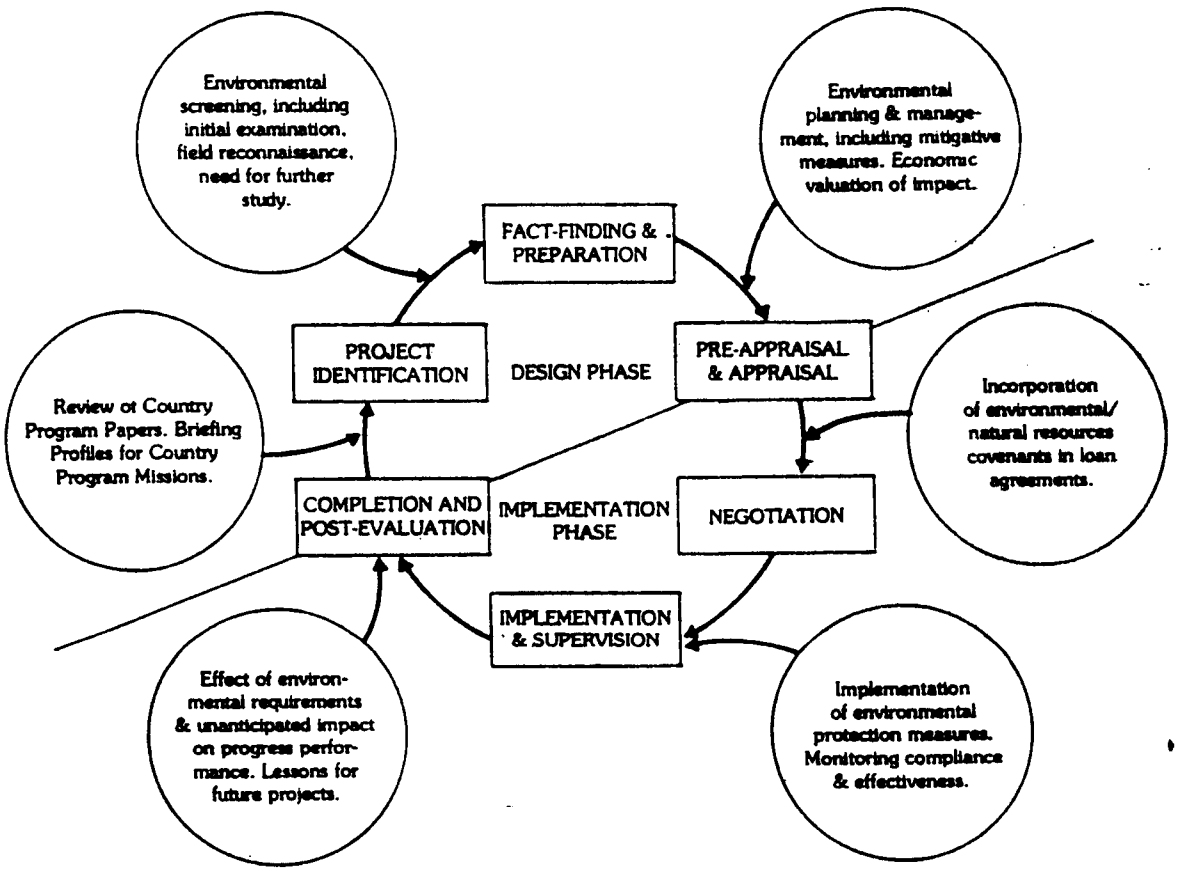
Integration of Environmental Considerations in the Project Cycle



ASIAN DEVELOPMENT BANK

TRAINING COURSE IN ENVIRONMENTAL MANAGEMENT IN INDUSTRY
TAMPERE UNIVERSITY OF TECHNOLOGY 1991

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EIA AND ENVIRONMENTAL PROTECTION MEASURES IN PULP AND PAPER INDUSTRY

1. INTRODUCTION

Forestry and forest industries are a vital part of the economy for many countries. It is in turn also one of the major sources of pollution in these countries. In the pulp and paper industry there is a tough competition in the market which reduces profitability of the industry. Thus environmental protection needs to be achieved both economically and efficiently. PPI's (Pulp and Paper International) brand new (July 1991) statistics show that the world production of pulp was 160.6 mill.tons (metric) in 1990 while production of paper was 238.8 mill.tons.

Concerning the effects of the forest industry on the environment, the following figures from a pulp and paper industry should give an indication:

Wood consumption (mill.cu.m/year)	1100
Amount of dirty wastewater (mill.cu.m/day)	80
Organic load to the recipient, as biochemical oxygen demand, BOD_5 (mill.ton/day)	20
Sulfur dioxide emissions (mill.ton/year)	2

2. ENVIRONMENTAL EFFECTS INVOLVED IN THE FOREST INDUSTRY

2.1 FORESTS

In developed countries - in which the forest area has stabilized, and in some countries, actually increased within the last decade - the forest area in most developing countries continues to decline. In some, the rate of decline is posing serious human and ecological problems, for instance, in Nepal, where the forest area has decreased by 25% in the 1970's.

At the same time, the rate of reforestation and areas where natural forest is being brought under more intensive management are far below the levels

needed to ensure future domestic self-sufficiency and to compensate for current levels of fuelwood and timber extraction.

Forests play a vital role in economic development and environmental protection (by stabilizing watersheds for instance), they provide essential products such as fuelwood and building poles for domestic consumption, and improve agricultural productivity, thereby increasing rural incomes.

Industrial forest products such as timber, newsprint, packaging, and paperboard are a significant item in world trade and an important source of foreign-exchange earnings for some nations.

The harvesting methods have developed a pace with technological progress. The aim is to regulate the cost structure of harvesting and to transfer the physically strenuous and accident-prone stages from men to machines. These measures inevitably affect the inner and outward look of the forest. About one third of timber harvesting is now done mechanically and the percentage will increase in keeping with the general trend in society.

The effects of timber harvesting on the look and nature of the Finnish forest are with the exception of forest roads only temporary. The majority have vanished within 2-3 years and any signs of harvesting are, apart from regeneration fellings, seldom visible in southern Finland after ten years. In northern Finland traces of soil preparation can often still be seen 20-30 years later.

Silvicultural measures bring about the start of a new tree species cycle from the appearance of pioneer species to the even-aged stand structure of managed forests consisting of the main Finnish tree species.

Once a viable seedling stand has been established, its growth is regulated by means of intermediate cuttings by removing the weaker, faulty and sick trees hindering the growth of the stronger ones and giving the remaining trees more light and room to grow in.

Proper management of the forest is also a means of shortening the rotation, reducing the natural loss and maintaining a forest ecosystem with a versatile range of species.

Forestry-forest management, felling and forwarding-always changes the forest landscape. The treeless stage, even after regeneration felling, is relatively short. Logging is vital to supply the forest industry with its timber; temporary changes in the landscape are thus the price that has to be paid for economic activity based on timber. On the other

hand regeneration and intermediate cutting are the only way of maintaining forests in alternate stages of development.

The following are among the measures belonging to regular forestry:

-intermediate cuttings at regular intervals and regenerating felling in forest of regenerating age

-the maintenance of the drainage network in marshes drained for tiber growth purposes

-steady reduction in new drainage

-preparation of the soil of regeneration felling areas, slash burning to ensure restocking with seedling and regeneration, to accelerate the decomposition of raw humus and to cut the costs of regeneration work

-reforestation of clear felling areas using high-quality seeds and seedling produced by means of forest tree breeding

-fertilization of oligotrophic drained marshes and some mineral soils in order to improve and maintain a nutrient balance conducive to tree growth

-the limited use of pesticides and plant protectants to ensure the initial growth of young plants and to prevent destructive fungi and insects.

2.2 WATER AND EFFLUENTS

The waterways are polluted by industry, agriculture and communities. The strain this imposes on the waterways is usually expressed by means of the biochemical oxygen demand (BOD), the solids load and the nutrient load. Other major emissions from the pulp industry include the organic chlorine compounds produced in bleaching pulp. Heavy metal emissions also have to be included.

In the following wastewater characteristics and environmental effects of the main pulp and paper production processes are presented.

2.2.1 BLEACHED SULFATE PULP

The major sources of effluent load are bleaching, debarking, washing, condensates and spills. In a modern mill the significance of bleaching and spills as contributors to wastewater load has increased. In a mill without oxygen bleaching, bleaching accounts for about 60...75% of BOD_7 and COD_{Cr} load from the mill. Oxygen bleaching reduces lignin content, BOD and COD of bleaching effluent 35...40%, conse-

quently bleaching accounts for 50% of the total wastewater load of the mill.

Bleaching is normally a 5...6 stage process where alkaline extraction stage follows chlorination stage. In chlorination stage, part of the chlorine can be substituted by chlorine dioxide. This results in reduced amount of organic chlorine in wastewater. If the bleaching is preceeded by an oxygen delignification stage the total consumption of bleaching chemicals is lower also resulting in the reduction of organic chlorine.

Lignin and its derivatives constitute about 70% of the organic substance in the total pulp mill effluent. In addition to lignin organic substances (MW<1000) most abundantly present are formic acid, acetic acid, oxalic acid, glycolic acid, methanol and sugars like xylose and galactose. These are easily degraded in biological processes.

The colour of mill effluents is estimated at 150...-200 kg Pt/t pulp, most of it originating from bleaching. In a mill with oxygen bleaching the corresponding value is lower, 70...90.

Toxicity is due to both chlorinated and non-chlorinated compounds. Toxicity increases with the increase in the number of chlorine atoms of the compounds. Of chlorinated low molecular weight (MW<1000) compounds tetrachlorguaiachols and tetrachlorcathechols have high acute toxicity. Some of the chlorinated carboxylic acids can be quite persistent to biodegradation while chlorinated phenols have a high removal rate.

Toxicity is also due to resin acids and fatty acids originating from various sources at the mill. Resin acids include compounds like abietin acid and pimaric acid which are very toxic and also quite persistent.

As the water systems of the mill have become more closed the temperature of the wastewaters has increased to 30...40 C.

2.2.2 BLEACHED MECHANICAL PULP

Mechanical pulping methods are based on either grinding of debarked logs or refining of wood chips:
- groundwood processes; SGW, PGW
- refining processes; TNP, TMP, CTMP e.g.

Mechanical pulps are normally bleached with dithionite and/or peroxide.

Debarking and bleaching are major sources of effluent load from mechanical pulp mills. The BOD_7 load from bleached groundwood processes, depending

on pulping and bleaching method, is 14...25 kg/t. BOD_7 load from refining varies from 20 to 35 kg/t. Bleached CTMP has the heaviest BOD_7: 50...65 kg/t.

The organic composition of mechanical pulping (TMP) effluents differs, compared to that of bleached sulfate in that it contains less lignin, less methanol but more carboxylic acids and wood extractives. About 35% of the organics is carbohydrates. Most of the organic substance is easily degraded in aerobic or anerobic treatment. Resin acids (extracted from wood) and hydrogen peroxide (bleaching) are major contributors to toxicity.

In a modern mill wastewaters are very concentrated. The temperature can exceed 50 C.

2.2.4 METHODS OF REDUCING THE WASTEWATER LOAD

Measures within production, processes, such as closed systems, are among the primary means of reducing the effluent load. Special attention has been paid in developing methods within the pulp and paper industry to the reduction and recycling of the water used. In the 1950s it took ten times as much water to produce one ton of pulp as it does today. Biological treatment plants have proved an effective means of treating the effluent externally. There are several treatment methods, and the most serviceable is chosen in each case.

The activated sludge method works well both in reducing the biochemical oxygen demand and in decomposing the chlorine adsorbed with the organic matter. This method has achieved a reduction of 80-95% in the BOD, 30-35% in the AOX load and 30-40% in the nutrient load. The acute toxicity of the water has at the same time been eliminated.

In addition to activated sludge treatment the forest industry also uses aerated ponds, anaerobic plants and chemical effluent treatment methods.

The bulk of the suspended solids can be removed in the effluent clarification tanks. The emissions of nutrients, such as phosphorus, can be reduced by transferring to dry debarking and by reducing both the amount of water used and the nutrients added at the biological treatment stage.

Emissions of organic chlorine compounds can also be reduced by adjusting the manufacturing process, such as replacing chlorine by chlorine dioxide, which produces fewer harmful organic compounds.

The more lignin there is in the pulp to be bleached, the more chlorine is needed. The lignin content determines the volume of organic compounds passing into the bleaching effluent. Ways of reducing the

use of chlorine include continuous cooking and oxygen bleaching.

Harmful chlorine compounds can also be prevented by correct chlorine dosing, thereby eliminating the excessive use of chlorine in bleaching. Oxygen bleaching destroys about half the residual lignin in the sulfate pulp without any deterioration in the properties of the pulp. Oxygen bleaching permits a reduction of chlorine but does not entirely remove the need for it in bleaching. Bleaching consists of several stages, nowadays typically oxygen, chlorine, chlorine dioxide and alkali stages in succession. Research is also being conducted into a new method, biological bleaching, which has now reached the experimental stage.

2.3 AIR

2.3.1 SULFUR

Sulfur is chiefly emitted by industry and in energy production as it reacts with various compounds.

The only sulfur emissions from the forest industry processes occur in the production of pulp, which uses sulfur-containing chemicals. In the paper industry and other sectors the sulfur dioxide emissions have their origin in energy production.

The sulfur emissions from the sulfate process are chemical losses, sulfur dioxide and reduced sulfur compounds occuring at different stages in the process. In the sulfite process the sulfur emissions are in turn created as the spent liquor is burnt to recover the energy contained in it.

In order to reduce these emissions the wood-processing industry has been improving its methods and investing in a plant for cleaning the flue gases. Production is relying more and more on recycling and closed systems; for example, electrostatic precipitators have been installed in order to extract the solid particles from the flue gas.

The sulfur emissions of sulfate pulp mills have been reduced by discontinuing direct flue gas evaporation and by installing systems for collecting and incinerating strong odorous gases. Air pollution control has been futher aided by closing down sulfite pulp mills because their sulfur emissions are high.

2.3.2 THE EMISSION OF ODOROUS GASES IN PULP PRODUCTION

Some of the reduced and volatile sulfur compounds produced in the course of pulp making are released into the atmosphere. In the air the reduced sulfur

compounds quickly oxidize to form sulfur dioxide. Reduced sulfur compounds smell because they occur as e.g. hydrogen sulfide and other products of albumin decomposition, and are detectable by humans in extremely small quantities. Reduced sulfur compounds do not, by contrast, occur in sulfite processes.

The most effective odour prevention systems in the pulp industry are based on the maximum collection of odours, steam distillation and oxidation, i.e. burning to form sulfur dioxide, which is then adsorbed into a suitable material. The older mills have fewer facilities for preventing odorous gases than the modern mills with state-of-the art technology.

2.3.3 NITROGEN OXIDE EMISSIONS

The nitrogen oxides from sulfate pulp mills are generated in the soda recovery boilers and lime reburning kilns, those from sulfite pulp mills; in the spent liquor incinerators. Indirectly the wood-processing industry also creates nitrogen oxide emissions through its road transports.

2.3.4 CARBON DIOXIDE

The burning of wood and spent liquor causes carbon dioxide emissions. The forest industry and forestry occupy a special position in the global carbon dioxide balance because the forests bind carbon dioxide and the situation can be improved by good forest management. Preliminary research findings indicate that e.g. the Finnish forst bind more carbon dioxide than the forest industry annually emits into the atmosphere.

2.4 SOIL

The biggest volumes of waste from the forest industry consists of sludge and ash. The sludge leaving the wastewater treatment plants is for the most part primary sludge resulting from mechanical treatment, but the increasing amount of activated sludge plants also adds to the amount of biosludge. A third category comprises chemical sludge resulting from chemically-enhanced primary and secondary clarifying and treatment of the coating water. The biggest ash quantities are inturn produced in the course of energy production and flue gas cleaning.

The most common ways of disposing of this waste are dumping and burning. Sludge is further treated by various methods and is usually deposited at the mill's own dump. The final placing of sludge is complicated due to the relatively large quantities.

The formation of solid waste is minimized by using waste as far as possible as raw material or fuel. The utilization of sludge and ash still calls for further reasearch.

Waste matter requiring special treatment includes the waste produced in the deinking of reclaimed paper, since this contains ink and deinking chemical. The volume of hazardous waste proper is slight in the forest industry.

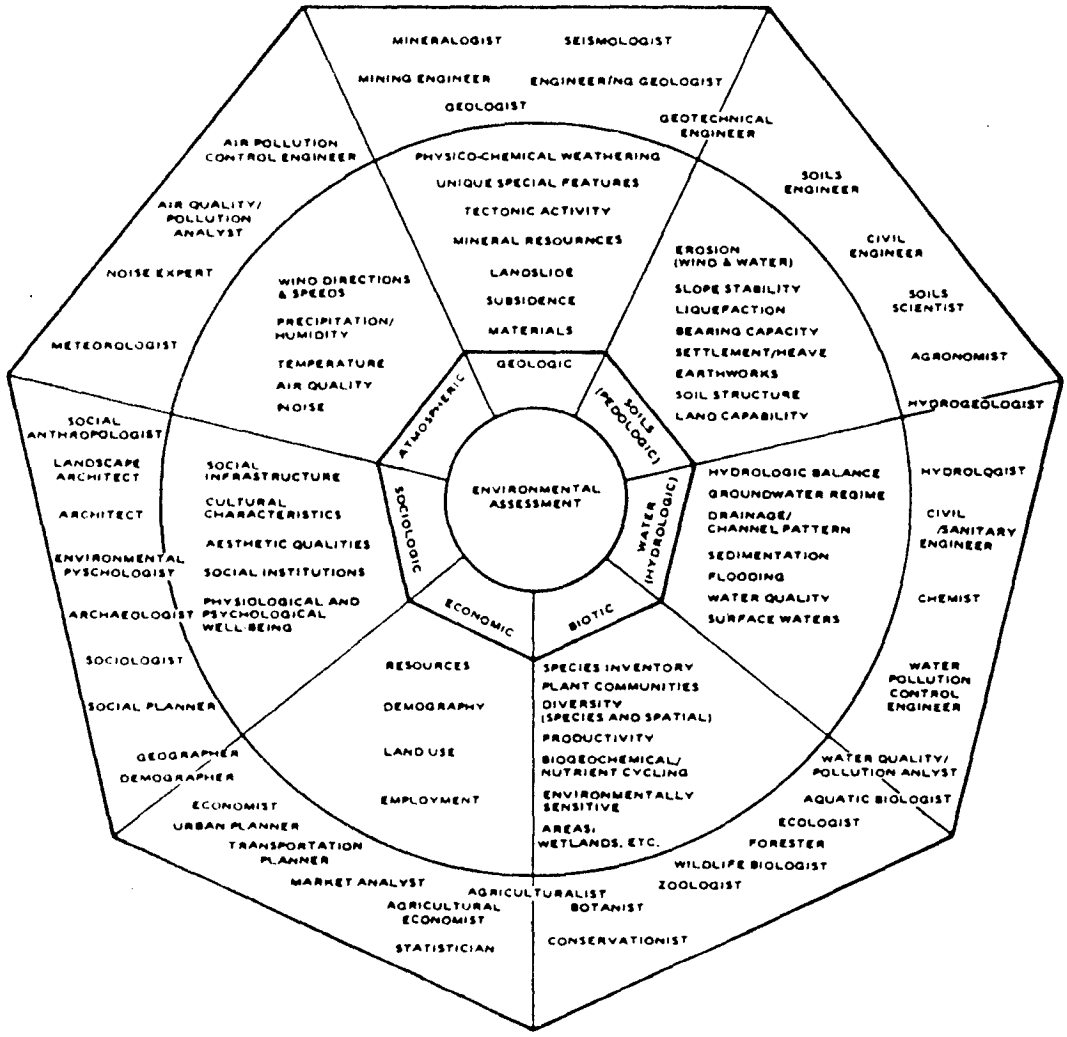
3. ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment is becoming increasingly important. In brief, it involves the following tasks:
-assessing current environmental and socio-economic conditions
-assessing the possible impact of an industrial development project, such as the effects on forest, air, waterways, infrastructure and socio-economic conditions
-preparing action plans for measures intended to reduce or eliminate harmful effects and for maximizing any benefits.

Most major economic development projects today include environmental impact assessments. This is because all UN financing and development agencies and many nation development agencies have agreed that one condition for granting finance is that environmental impacts have been assessed. Most national environmental authorities also require environmental impact assessments before they award construction and/or operating permits.

Environmental impact assessments are primarily needed in the initial stages of a development project, when planning the financing and utilization of forest resources, when defining the product mix and selecting the production processes, and when estimating investment and production costs.

Included in the appendix is the contents of a typical EIA for a pulp and paper mill project.



Environmental Impact Assessment of Waste Disposal to Land: Related Disciplines and Relevant Specialists (Ref. 12)

Training Course on Environmental Management in Industry
Tampere, August 4-24, 1991

EIA IN POWER PLANT PROJECTS

Hannu Härkönen
IMATRAN VOIMA OY

1 INTRODUCTION

Energy production is one of the fundamental premises for the development of human welfare in a modern society. At the same time, large scale energy production can have adverse impacts on the nature, compromising the quality of life by degrading our common environment.

A variety of technologies is available today for energy production, each technology having its characteristic impacts on the environment. The fossile fuels form the basis of the world's energy supply and along with the flue gas emissions giving rise to acid rain and global climatic changes pose severe threats to the future of the whole mankind. Hydro power gives no emissions, but changes in flow and water level in rivers and regulated water systems can cause big local and regional problems. Under normal operation conditions environmental impacts of nuclear power are minimal. However, nuclear power is today faced with serious acceptability problems, related to the anticipated risk of a major accident and worries about the long-term safety of radioactive waste disposal.

Despite of the ever increasing efficiency in the energy use in industrialised countries, the rise of the global energy consumption seems to be inevitable during the next few decades. Environmental impact assessment is one tool which can be used in decision making to facilitate reconciliation of the contradiction between the ever rising demand for energy and the principles of sustainable development.

2 TOOLS FOR PREDICTING ENVIRONMENTAL IMPACTS

2.1 Emissions into air

A number of computer models is available for the estimation of the transport and dilution of flue gas emissions in the atmosphere. IVO has developed own models for calculation of concentrations in air and ground surface deposition of air borne contaminants. Recently IVO has taken into use also American EPA models which are used in many countries worldwide.

The following data is needed in the calculations:

- properties of the emission source (stack dimensions, flue gas flow rate and temperature)
- meteorological conditions (codistribution of atmospheric stability class, wind speed and direction)
- topography.

Typical results from model calculations are shown in figures 1 and 2.

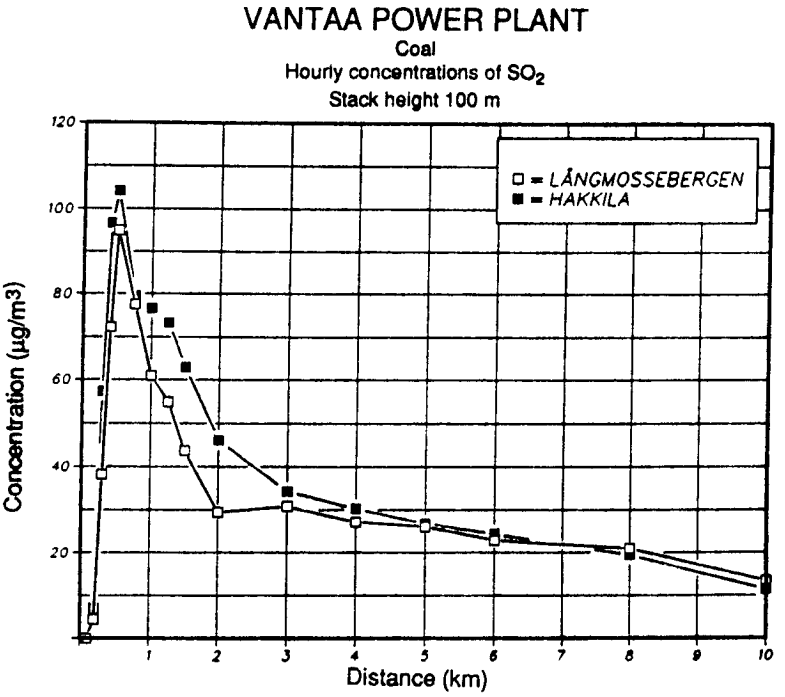


Fig. 1. Maximum hourly concentration ($\mu g/m^3$) of SO_2 around a coal fired power plant at Hakkila and Långmossebergen sites.

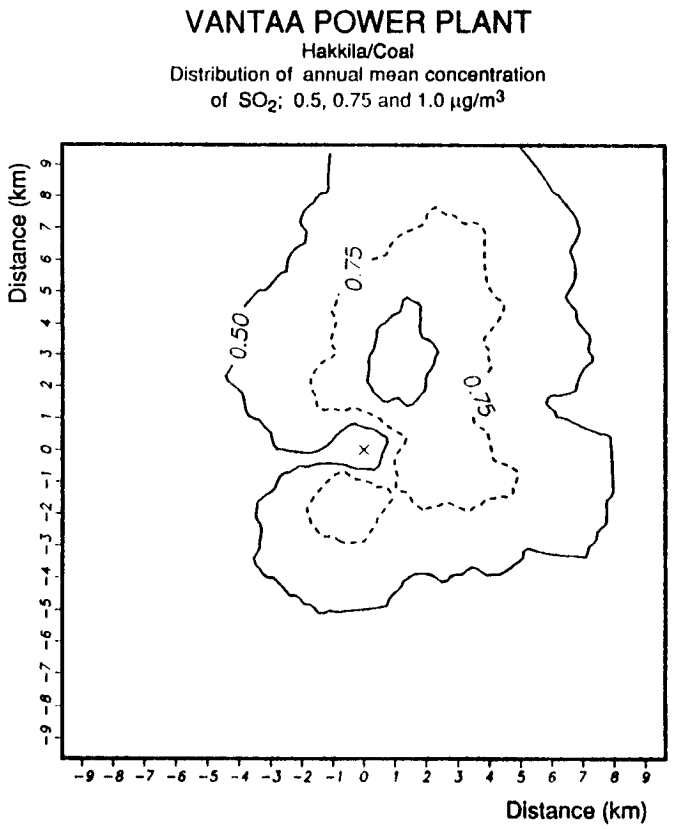


Fig. 2. Distribution of average annual SO_2 concentration of 0.5, 0.75 and 1.0 $\mu g/m^3$ around Hakkila site.

2.2 Emissions into water

Dilution of various types of emissions into rivers, lakes or sea can be calculated by water quality models. Emissions of impurities from power plants are generally small, the main type of emission being the waste heat in the cooling water. Figure 3 shows the temperature rise in the sea water around the Meri-Pori power plant calculated by the Finnish VENLA code. VENLA is most suitable for analysing lake or sea areas. IVO has developed other models better suited for river environment.

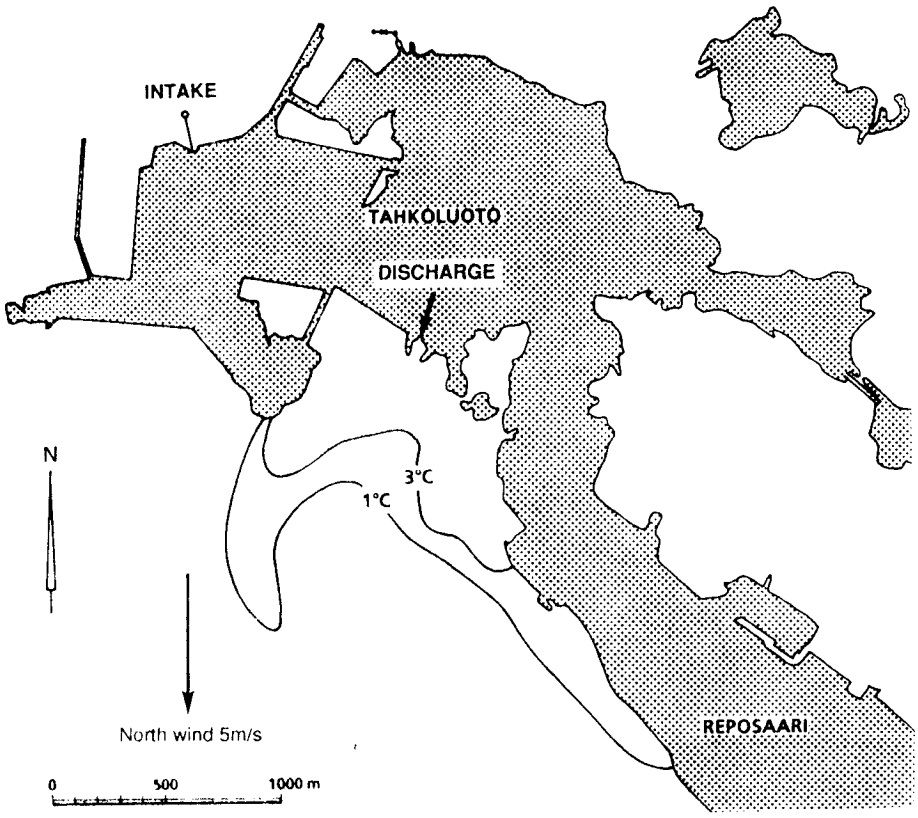


Fig. 3. Temperature rise in sea water caused by the cooling water discharge of the Meri-Pori Power Plant (500 MW)

2.3 Emissions into groundwater

Disposal of solid wastes from power plants (ashes, desulphurization wastes) can result in leaching of soluble impurities and subsequent migration into groundwater. IVO is currently studying the leaching mechanisms and developing models that describe the long term leaching behaviour of a waste deposit. The "back-end" of the modelling cycle, i.e. transport of contaminants in groundwater is already available.

2.4 Hydrological models

A number of computer codes is available for the modelling of the behaviour of a lake and river system under hydro power production and related regulation of the water system. Figure 4 shows the short term fluctuation of water level typical in Finland, where hydro power plants are often operated in a load following mode.

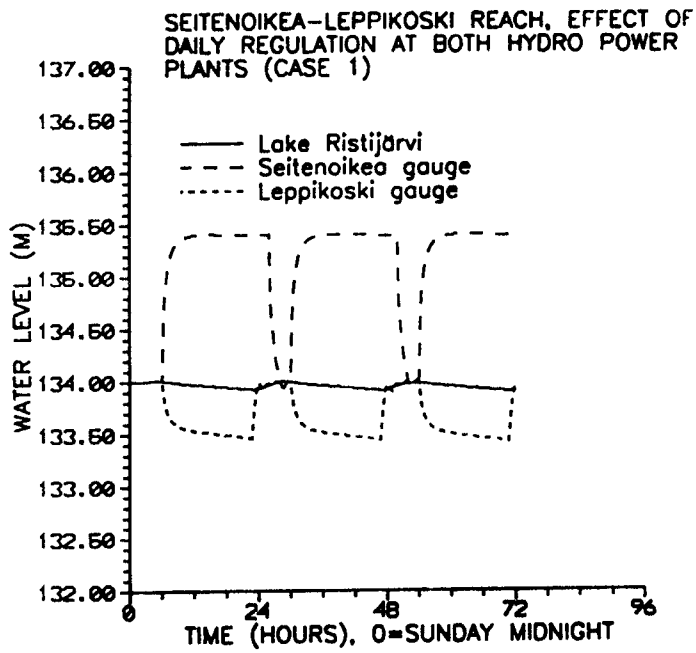


Fig. 4. Daily fluctuation of the water level in Seitenoikea-Leppikoski reach as predicted with IVOFLOW code.

2.5 Emission of radionuclides

Under normal operation conditions a nuclear power plant emits a small amount of radionuclides into air and water. A number of computer models is available for predicting the radiation doses induced by these emissions. IVO has developed own models, TUULET ("winds") and DOSES, to estimate the doses caused by the Loviisa Power Plant. Calculation of radiation doses requires a huge amount of input data, including meteorological and hydrological data, description of food chains and nuclide specific enrichment factors in various compartments of the biosphere. Among all types of impact assessment, radiation protection is perhaps the most advanced in the sense that calculated radiation doses can be readily linked to actual heath effects, which is not generally possible in case of other types of impurities.

Assessment of the safety of underground repositories for radioactive wastes is a kind of science in itself. Complex models have been developed to describe the geochemical processes taking place in a closed repository. Uncertainties are introduced by the long time frame especially in the case of long lived high level wastes. The conditions deep underground change slowly and can be predicted with reasonable accuracy, but the evolution of the biosphere and human environment during tens of thousands of years is far more difficult to assess. However, the range of radiological consequences can be estimated by studying a number of extreme scenarios covering the most probable chains of development.

2.6 Expert assessments

Mathematical models give as a result the concentration of impurities in various compartments of the ecosystem. The actual effects of the impurities on the ecosystem are highly site specific, various sites having quite different tolerance to disturbances. Site specific data and profound expertise play a key role in the evaluation of the significance of predicted environmental impacts. No generally applicable models are available for this purpose.

Expert assessments are also necessary in estimation of socio-economic impacts. To some degree the economical factors can be quantified in monetary units, but the more general factors related to human well-being are often impossible to quantify in any unanimous way. Evaluation of these factors calls for thorough understanding of the social and cultural structures in the affected regions.

3 CASE STUDY: VANTAA POWER PLANT PROJECT

3.1 Background of the project

The rising demand for energy calls for construction of new power generation capacity in the City of Vantaa towards the end of the 1990's. The revision of the general city plan is currently underway and a reservation should be made for a new power plant in the updated city plan. The planning officials had performed a preliminary screening resulting in two candidate sites, Hakkila and Långmossebergen. IVO was assigned the assessment of the environmental impacts of a power plant to be built at one of the sites. The assessment was based on the existing data, no new field studies were made. Socio-economic impacts were ruled out of the study.

3.2 Characteristics of the power plant

No decisions have been made on the type or size of the new power plant. The following assumptions were made to facilitate the environmental assessment:

- the power plant will consist three units producing electricity and heat and fueled by coal or gas
- the effect of coal fired units will be 75/150 MW and the effect of the gas fired units 150/150 MW
- the minimum volume of coal storage will be 200 000 m^3 and the maximum volume 1000 000 m^3
- the present emission limits are applicable to all units
- all power plant units will be in operation simultaneously.

3.3 Baseline environmental data

The assessment was based on the following environmental data:

- current land use plans
- land ownership
- ecological conditions (based on ecological descriptions of nearby conservation areas)
- surface and groundwater conditions and water use
- meteorological data

- air quality data
- built environment (existing residential areas, recreational areas, etc.)
- traffic densities and noice data.

3.4 Impact assessments

The following environmental effects were studied:

- impact on land use
- visual impact
- impact on air quality
- impact on surface and ground waters
- noice impact
- impact on traffic
- impact on waste management.

The significance of various types of impacts was evaluated by comparison with valid environmental guidelines and estimated development of the background conditions.

3.5 Comparison of the sites

The comparison of the sites was performed in the form of "positional analysis". The following protective functions and human activities were considered in the analysis:

- air protection
- water protection
- soil protection
- protection of nature
- landscape protection
- settlement
- recreation
- traffic
- waste management
- industry
- agriculture and forestry
- city planning
- infrastructure.

The positional analysis calls for definition of ideal "target" conditions to each activity. The alternatives are then compared with each other in the light of the defined target conditions. The analysis can not give any unambiguously best alternative. It gives a number of answers to questions of the type "if you consider factor x important, then the alternative y is the best one". It is then up to the decision makers to decide, which factors are the most important in each case.

In the case of Vantaa power plant, the Hakkila and Långmossebergen sites proved to be quite equal, no decisive differences could be found in the comparison. Both sites can be considered suitable for the construction of either a coal fired power plant or a gas fired power plant.

TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT IN INDUSTRY
August 4-25, 1991, Tampere, FINLAND

Senior Lecturer Simo Isoaho

DISCHARGE OF INDUSTRIAL WASTEWATERS INTO MUNICIPAL SEWER NETWORK

1. INTRODUCTION

A municipal sewer network can also serve an industrial mill as an infrastructure. One must always consider this possibility but never keep it directly allowable solution without carefull research and commonly approved "playrules".

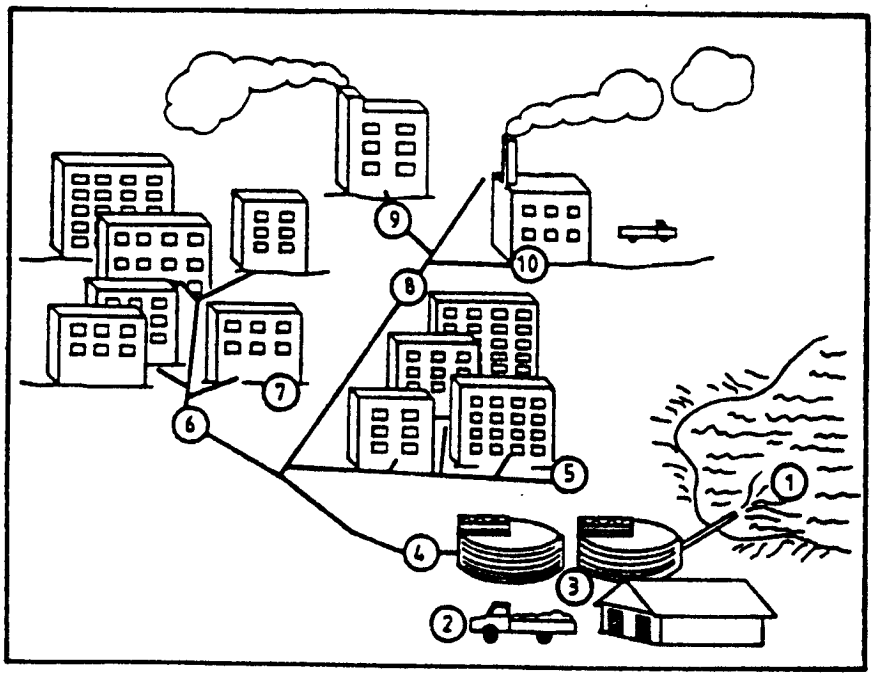
Benefits of using municipal sewer network for industrial wastewaters are obvious. Use of many different discharge sewers into a water recipient can be avoided. Quality of effluents can be monitored centralized and follow up by anthorities is easier. Combined treatment of industrial and domestic wastewaters may result better purification effiency or may diminish addition of chemicals in a treatment process. Costs of maintenance and investments may be lower.

Decision making of possibilities to have above mentioned benefits must be done separately in respect to worst conditions of every municipality.

2. DECISION MAKING

2.1 Aspects to consider

When considering to discharge industrial wastewaters into a municipal sewer network, aspects in figure 1 must be taken into account.



1. Effluent and its impacts in a receiving water course
2. Sludge from treatment plant
3. Occupational safety in treatment plant
4. Purification ability and effiency of a treatment plant
5. Impacts of purification plant on surrounding environment (e.g. aerosols)
6. Wastewater quontity and quality
7. Impacts of sewer network on near environment
8. Impacts of industrial wastewaters on sewer pipes (corrosion, clogging constituents)
9. Wastewater load from other mills (prevailing load)
10. Pretreatment need of industrial wastewaters

Figure 1: Aspects to consider when discharging industrial wastewaters into a municipal sewer network

2.2 Effluent of Municipal Treatment Plant

Industrial wastewaters should not decrease purification efficiency or give such characteristics to effluent that harmful consequences in a receiving water cource would be evident. The receiving capasity and other knowledge of water course have to be known.

2.3 Sludge from Municipal Treatment Plant

In fact there are not many alternatives to solve sludge problem with an approvable manner. Sludbe can be utilized in agricultural cultivation or in green building of cities as a fertilizer and to improve soil construction. Dumping sites are not any real solution. Therefore it is extremely important that industrial wastewaters do not

deteriorate quality of sludge with heavy metals and toxic organic compounds.

2.4 Influent of Municipal Treatment Plant

All constituents of an influent must be mechanically settleable, physically and chemically treatable or biodegrable. Purification processes are different and their capasity is limited. Situation related to these aspects is different in every municipality. Other aspects to consider are possible damages of tructures and equipments of a treatment process.

2.5 Quantity and quality of domestic wastewater

The quantity of domestic wastewater determines the dilution factor which is different during night and day as well as during different seasons. It is clear that small municipalities cannot receive very large quantities of industrial wastewaters if purification process has not been designed specially to treat combined wastewaters.

2.6 Load from other mills

The prevailing quantity and quality of wastewaters from other mills must be known. According to this knowledge it is possible to evaluate variations of the influent of the treatment plant.

2.7 Sewer network pipes

Industrial wastewaters should not damage pipes (corrosion, softening plactics, erosion) or include clogging constituents.

Hydraulic capacity of pipes must be allways checked in respect to highest volume of flow during the year along a line from a mill to a treatment plant.

2.8 Need of pretreatment

Need of pretreatment is determined by both the quantity and the quality of industrial wastewater. Sewer network and municipal treatment plant must also be considered. All physical, chemical and biological charaeteristics of industrial wastewater must be known. It is also necessary to know how sharply and with what frequence wastewater quality is changing during a working period.

2.9 Other aspects

Occupational safety of the treatment plant staff must not be risked by discharging industrial wastewaters.

Discharge of explosive, radioactive, flammable or pathogenic constituents into a sewer network must be eliminated. Discharge of solvents is not allowed. This kind of constituents could threaten the healt of inhabitants on the area of sewer network and in the neighbourhood of the treatment plant.

3. IMPROVEMENTS FOR DISCHARGING INDUSTRIAL WASTEWATERS

3.1 Characterization

Wastewater characterization is the first task to have knowledge for making interior improvements of a production process, for reconstructing sewers inside a mill and for choosing a purification process.

- Physical (specially pH and temperature), chemical, biological and toxic characteristics
- Variation and variation frequence of wastewater quality and load
- Factors of a production process causing changes of water quality and flow

The second task is to make water balance calculations.

- To list all water using unit operations.
- To have knowledge about water quality and quality demands in separate unit operations.
- To have water quality knowledge after the use in every unit operation.
- To consider all different conditions like periodic or batch use of a production process or some of its unit operations, cleaning of a process, start up or drive down a process.
- To consider all routes of water to come out from a process: wastewater, evaporation and water in a product.

Water balance must be known in stable and most probable non-stable production conditions.

On the basis of these calculations it is possible to plan

- demand and quality of water for different purposes,
- water recycling,
- dimensions of pipelines, pumps and tanks in a process, and
- materials which are needed for pipes, etc.

In addition planning must take into account possible

needs to expand production in future.

This knowledge is necessary for planning of sewers and wastewater treatment in a mill.

3.2 Internal improvements of a production process

Tagets of improvements are

- o to diminish wastewater load and flow,
- o to optimize wastewater quality and discharge,
- o to prevent unpurpose mixing of different wastes and wastewaters.

Improvement possibilities are

- o modifications of unit operations and processes,
- o substitution of raw materials and chemicals,
- o regeneration, recycling of wastes and wastewaters and
- o instrumentation (monitoring, alarms,...) of a process

Reconstruction of internal sewers

- o Separation of different types of wastewaters
- o Consideration of which floor wells are really necessary

Importance of possibilities of maintenance can never be overestimated.

- o Carefully organized waste collection
- o Prevention of excess water discharges
- o Cleaning operations
- o Maintenance valves, pipes, equipment, etc.
- o Risk analysis of a process
- o Prevention of emissions from yards and open storage fields
- o Staff training and motivation

3.3 Choice of a treatment method

Following knowledge is necessary for choosing a treatment method.

- o Scale of treatment
- o Critical design parameters
- o Macimun/minimum loads and characteristics for design parameters
- o Need of neutralization and/or emergency basins
- o Limitations given by sewer network authorities

Use batch treatment processes whenever it is economically feasible!

Allways request to have operation and maintenance instructions which are written for conditions of your mill!

4. MONITORING AND MEASURING

The monitoring of wastewaters is needed for environmental protection purposes

- o to give knowledge for estimating impacts of waste load in a water course,
- o to give knowledge for estimating the need ot wastewater treatment (selecting the type and the degree of treatment)

and for production purposes

- o to give knowledge for minimizing the use of raw materials (maintenance of production process, ideas for improving the process)

and for juridical purposes

- o to inspect the fullfilling of the orders given by the authorities

In order to have all this information, internal as well as external monitoring (samples, flow measuring, etc.) of a production process is needed.

For each mill (or combination of mills, if the sewer systems of different mills are connected together, or if the orders of the authorities concern all mills without specifying orders separately for each) an invidual monitoring programme must be made. The purpose of a programme is

- o to collect together all the backround information which is needed to arrange sampling and flow measuring points in a mill,
- o to give the background information for interpreting of results of different analyses and measurements, and
- o to be a document of monitoring methods and measures

The programme paper is also a "testament" for new employees.

The programme must include among other things the following:

- o General description of the production (including raw materials and chemicals in production) and more in detail the water-using unit opetations.
- o The present sewer system, wastewater treatment and disposal of other wastes. It is essential even for the purpose of water pollution monitoring to know where sludges and other wastes are transported and / or what is the disposal method (drying, burning, etc.).

- Description of the process monitoring and a proposal of how it can be utilized in wastewater control.

- A proposal of the monitoring of wastewaters (measuring points, type of sample, sampling method, measuring and sampling frequencies in different points, analyses and with which methods they will be analyzed.

- The interpreting of results (calculationg methods, in what form the information shall be reported.

- The reports to the authorities (reporting period, productional knowledge about the use of raw materials and the quantity of products, discharged load into the water course, comparison of results to the limit values given by the authorities, statement of exeptional conditions which may have affected the results).

The goal is to obtain information which can be utilized in evaluation of impacts on the water course, and which is comparable with other emission sources. The information is important in making plans for decreasing environmental load.

In a mill sampling and measuring equipment must be maintained carefully and frequently. Failures in sampling are also mistakes of results which are useless in such a case.

Sewer network authorities must monitor frequently not only the conventional parameters but also those parameters of industrial wastewaters from influent, efluent and sludge of the municipal treatment plant.

TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT

Arja-Riitta Haarala, Director of the Library

INTRODUCTION TO INFORMATION SOURCES

1 BACKGROUND

Our society is becoming increasingly dependent on information related activities. The production, flow and use of scientific and technological information have shown an accelerated rate of growth and there is no indication that the growth will significantly decrease in the near future.

In the nineteenth century journals started to appear in order to provide better access to an increasing number of primary sources. These publications, however, soon reached the same rate of growth as that of primary publications; the present number of printed secondary services is some thousands. Since 1950's computer techniques have been applied to the production of abstracting and indexing services to ease the information problem.

All this have become important in those multidisciplinary fields of science and technology which draw data and literature from many areas; where the individual engineer and scientist may no longer be able to keep up with the ever growing and often 'disorganised' literature. This is the case with environmental science and technology, with links from scientific areas to engineering and medicine. The importance of effective and organised communication media has, however, been realised. For example, in the field of environment there are effective information services and information analysis centres. Among the most important ones are the services by United Nations.

2 CHARACTERISTICS OF ENVIRONMENTAL INFORMATION

Environmental data and information are rich and varied because of the nature of environmental subject field itself. There is a great abundance of analysis and monitoring data which are stored in large databanks.

The three levels of environmental information are

I Bibliographic information

Libraries and information services collect and

make available bibliographic information. It is mainly secondary by nature. It is published as reference databases, bibliographies, museum catalogues, and it includes other sources of reference and indexes too. United Nations Environmental Programme has started the INFOTERRA project to disseminate information on environmental information sources.

II Interpreted information

This level of information is regarded as primary by nature. The interpretation is made by environmental specialist. It is published as articles, technical reports etc. Literature in the field of environment shows the same trend as other scientific literature; a considerable growth of published material and a trend towards more specialisation. The size of environmental literature is difficult to estimate because the primary information is widely scattered among many scientific journals, maps, some trade magazines, textbooks and proceedings, as well as within various disciplines.

III Objective information

Objective information is typically data collected in laboratories and in field studies. This kind of information has shown a considerable growth with the development of information technology and laboratory techniques. There is a international centre CODATA (Committee on Data for Science and Technology) for the cooperation of data activities.

3 INFORMATION SOURCES

There are two kinds of tools that are used to find information.

1 Referral sources

2 Search tools

3.1 Referral sources

In considering the realities of scientific and technical communication it must be remembered that communication takes place in a social system. The rationalisation of all scientific work has changed it from the individualistic science towards team work. Thus the individual scientist or engineer is cooperating with others within a group and the

institute and further as a part of wider national and international community. While the formal communication system, of which the organisation chart is simply an example of the expected and ideal communication relationships in an organisation, shows the greater stability and predictability, the informal communication networks are less structured and unpredictable.

The network of experts and specialists is a very effective information source. It is regarded as most important, so that it is talked about an invisible college. Many studies show that undocumented sources like letters and conversations are a very much used and appreciated way of communication among civil engineers too.

Guides to organisations (examples)

INFOTERRA. A database by United Nations Environmental Programme.

International Directory. INFOTERRA. UNEP.

Chelliah, T. (Ed.) Environmental Training Programmes and Policies in ASEAN: An Overview. 1981.

A Directory of Information Sources on Air & Water Pollution. INFOTERRA. United Nations Environmental Programme. 1989. 387 p.

Directory of Industrial Information Services and Systems in Developing Countries. UNIDO. 1982.

Environmental Education - List of Institutions in the Region of Asia and the Pacific. Unesco. 1983. 38 p.

Marine Environmental Centres: East Asian Seas. FAO. 1984.

Marine Environmental Centres: Indian Ocean and Antarctic. FAO. 1985.

OECD Chemicals Information Switchboard
World Directory of Environmental Information Centers. Oryx Press.

3.2
Search tools

Guides to the literature

Bragdon, Clifford R., Noise Pollution. Guide to Information Sources. Gale Research. 1979.

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Meshenberg, Michael J., Environmental Planning: A Guide to Information Sources. Gale Research. 1976.

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p.

UNIDO Guides to Information Sources:
on the Utilization of Agricultural residues for the Production of Panels, Pulp and Paper
on the Pesticides Industry
on the Petrochemical Industry
on the Pulp and Paper Industry
on the Soap and Detergent Industry

Directories

Chemical Engineering Desk Book: Environmental Engineering, Energy/Environment. Special issue of Chemical Engineering, vol. 8 (1974) no 8.

Harvey, Anthony. Directory of Scientific Directories: A World Bibliographic Guide to Medical, Agricultural, Industrial, and Natural Science Directories. Longman. 1986. 232 p.

Bibliographies

Rogers, Dilwyn J. (Comp.) A Bibliography of African Ecology: A Geographically and Topically Classified List of Books and Articles. Greenwood Press. 1979.

Warren, Betty (Ed.) The Energy and Environment Checklist: An Annotated Bibliography of Resources. Friends of the Earth Foundation. 1980.

Encyclopedias

Fairbridge, R.W., The Encyclopedia of Geochemistry and Environmental Sciences. 1972. 1321 p.

Garner, J.F. & Harris,D.J:(Eds.) Control of Pollution Encyclopaedia. 1977.

McGraw-Hill Encyclopedia of Environmental Science. 1980. 858 p.

Dictionaries

McGraw-Hill Dictionary of Scientific and Technical Terms. McGraw-Hill.

Termdok. TNC. CD-ROM

Handbooks

Ciaccio, L.I. (Ed.) Water and water pollution handbook. 1973.

Clay, H.M. Clay's Handbook of Environmental Health. 1977. 1020 p.

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Abstracting and Indexing Services

Abstract Bulletin of the Institute of Paper Chemistry.

AgrIndex.

Air Pollution Abstracts.

Aquatic Sciences and Fisheries Abstracts.

Applied Science and Technology Index.

Biological Abstracts.

Bulletin Signaletique.

Chemical Abstracts.

Current Contents: Agriculture, Biology and Environmental Sciences.

Dissertation Abstracts.

Engineering Index.

Environment Abstracts.

Microbiology Abstracts.

Pollution Abstracts.

Referativnyi Zhurnal.

Selected Water Resources Abstracts.

Science Citation Index.

WRC Information.

Databases

Directory of Online Databases. Cuadra Associations. Elsevier. 1985-

Eusidic Database Guide. Learned Information.

Yska, Gerda & Martyn, John. Databases Suitable for Users of Environmenmtal Information. Aslib. 1976.

Abstracts of Tropical Agriculture
Indexes worldwide technical literature on tropical and subtropical agriculture, including technical, economic, and sociological aspects. Also covers animal husbandry, fisheries, forestry, and public health.
From 1975 to the present
Orbit

Agricola
Provides comprehensive coverage of worldwide journal literature and monographs on agriculture and related subjects. Related subjects include: animal studies, botany, chemistry, entomology; fertilizers, forestry, soils, and more.
2 560 000 records from 1970 to the present.
Dialog

AGRIS International
Corresponds in part to AgrIndex, published by FAO. Subject coverage focuses on many topics including: general agriculture; geography and history, education and advisory work; administration and legislation; economics; development, and rural sociology; plant production; protection of plants and stored products; forestry; aquatic sciences and fisheries; machinery and buildings; pollution, and more.
1 060 000 records from 1975 to the present.
Dialog, ESA, Orbit

APILIT
The American Petroleum Institute - Central Abstracting & Indexing Service
Over 430 000 records from 1964 to the present
Orbit

APIPAT
The American Petroleum Institute - Central Abstracting & Indexing Service
Approx. 190 000 records from 1964 to the present
Orbit

APTIC
Covers all aspects of air pollution, its effects, prevention, and control. APTIC covers the field of air pollution in the broadest

sense, including social, political, legal, and administrative aspects of the field. Subjects treated in the database include: atmospheric interaction, control methods, economic aspects, effects on human health, effects on materials, effects on plants and livestock, emission sources, government participation, measurement methods, and social aspects.
89 000 records from 1966 to 1976
Dialog

Aqualine
Covers the world's literature on water and wastewater technology and environmental protection. Produced by the Water Research Centre which scans over 600 primary journals, tecchnical reports, monographs, conference papers, theses and other printed materials. Subjects include: water resources and supplies; water quality; monitoring and analysis of water and wastes; water treatment; underground services and water use; sewage; industrial effluents; and effects on pollution.
Approx. 120 000 records from 1960 to present
Orbit

Aquatic Sciences and Fisheries Abstracts
Corresponds to the printed Aquatic Sciences and Fisheries Abstracts, Part 1: Biological Sciences and Living Resources, and Part 2: Ocean Technology, Policy and Non-Living Resources. Subjects covered are science, technology, and management of marine and freshwater environments. ASFA includes citations to 5 000 primary journals, monographs, conference proceedings, and technical reports.
Over 270 000 records from 1978 to the present
Dialog

AST Covers applied science and technology.
206 000 records from 1983 to the present.
CD-ROM

BIOSIS Previews
Contains citations from both Biological Abstracts and Biological Abstracts/RRM (formerly entitled Bioresearch Index), the major publications of BIOSIS. Over 9 000 primary journals and monographs, as well as symposia, reviews, preliminary reports, semi-popular journals, selected institutional and government reports, research communications, and other secondary sources are scanned for relevant citations on all aspects of the biosciences and medical research.
6 200 000 records from 1969 to the present
Dialog

CA Search

Contains the basic bibliographic information appearing in the print Chemical Abstracts. Includes citations to the literature of chemistry and its applications. Chemical substructures can be searched in CAS Online on STN.
8 600 000 records from 1967 to the present
Dialog, ESA, Orbit, STN

CAB Contains all records in the 26 main abstract journals published by Commonwealth Agricultural Bureaux. Over 8 500 journals in 37 different languages are scanned for inclusion, as well as books, reports, theses, conference proceedings, patents, annual reports, and guides. CAB covers the following subjects: agricultural engineering, animal breeding, animal disease, arid lansa, dairy science, forestry, forest products, horticulture, nutrition, veterinary science, entomology, plant breeding, plant pathology, rural recreation and tourism, soil and fertilizers, and more.
2 240 000 records from 1972 to the present.
Dialog

Chemical Safety Newsbase

Covers a wide range of information on the health and safety effects of hazardous chemicals encountered by employees in industry and laboratories. Specific subject coverage includes: safety precautions; chemical hazards; biological hazards; new legislation; plant and laboratory design; waste management; emergency planning; risk analysis; labelling; storage practices, etc. Over 200 international journals, books, audio visual materials, press releasese; and conference proceedings are scanned each month.
Over 18 000 records from 1981 to the present
Dialog, Orbit

COLD Covers all disciplines dealing with Antarctica, the Antartic Ocean, and subarctic islands: snow, ice, and frozen ground; navigation on ice; civil engineering in cold regions; and behaviour and operation of materials and equipment in cold temperatures. Source materials include monographs, technical reports, journal articles, conference papers, patents and maps.
Approx. 145 000 records from 1951 to present
Orbit

COMPENDEX PLUS

Is the machine-readable version of the Engineering Index. The COMPENDEX PLUS database provides worldwide coverage of 4 500 journals and selected government reports and books. Subjects covered include: civil, energy,

environmental, geological and biological engineering; electrical, electronics and control engineering; chemical, mining, metals, and fuel engineering; mechanical, automotive, nuclear, and aerospace engineering; and computers, robotics and industrial robots. In addition to journal literature, over 480 000 records of significant published proceedings of engineering and technical conferences.
Over 5 200 000 records from 1970 to the present
Dialog, Esa, Orbit

CRIS/USDA
Current research Information System covers the following subjects: biological, physical, social and behavioral sciences related to agriculture; marketing and economics food and nutrition, consumer health and safety; family life, housing, and rural development; environmental protection; forestry; outdoor recreation; community, area and regional development; and more.
31 000 records
Dialog

ENVIRONLINE
Provides coverage of air environment, environmental health, land environment, resource management, and water environment. Included are such fields as: management, technology, planning, law, political science, economics, geology, biology, and chemistry as they relate to environmental issues. Source documents include more than 5 000 journals, government reports and documents, monographs, conference papers, Industry reports, newspapers, the Federal Register, and some films.
Approx. 135 000 records from 1971 to the present
Dialog, Esa, Orbit

ENVIRONMENTAL BIBLIOGRAPHY
Covers the fields of general human ecology, atmospheric studies, energy, land resources, water resources, and nutrition and health. More than 300 periodicals are indexed in the database.
Over 130 000 records from 1971 to the present
Dialog

Georef
Provides comprehensive access to more than 4 500 international journals, plus books, conference papers, government publications, theses, and maps concerned with all aspects of geology, geochemistry, geophysics, mineralogy, paleontology, petrology ang seismology.
1 450 000 records from 1785 to the present
Dialog, Orbit

INIS Atomindex

Covers all aspects of nuclear science and technology, and related fields like physics chemistry, earth sciences, and isotopes. Database is published by International Atomic Energy Agency, and input is made worldwide.
from 1977 to the present
ESA, CD-ROM

Medline

Corresponds to three printed indexes: Index Medicus, Index to Dental Literature, and International Nursing Index. Medline is one of the major sources for biomedical literature.
6 200 000 records from 1966 to the present
Dialog, CD-ROM

NTIS

Consists of government sponsored research, development, and engineering plus analyses prepared by federal agencies, their contractors, or grantees. The database covers a wide spectrum of subjects including: administration and management, agriculture and food, behavior and society, building, business and economics, chemistry, civil engineering, energy, health planning, materials science, medicine and biology, transportation, and more.
1 350 000 records from 1964 to the present
Dialog, ESA, Orbit, CD-ROM

Oceanic Abstracts

Over 9 000 citations from approximately 3 500 worldwide sources on marine-related subjects are added to the database each year. Records cite journals, books, technical reports, conference proceedings, and government and trade publications. Major areas covered are oceanography, marine biology, marine pollution, ships and shipping, geology and geophysics, meteorology, and governmental and legal aspects of marine resources.
Approx. 200 000 records from 1964 to the present.
Dialog, ESA

OSH-ROM

Corresponds with online databases HSELINE (Health and Safety Executive), NIOSHTIC (National Institute for Occupational Safety and Health Technical Information Center) and CISDOC (Occupational Health and Safety by ILO).
Dialog, ESA, Orbit, CD-ROM

Paperchem

Includes scientific and technical literature dealing with raw materials, principles, processes, technology and products of the pulp and paper. Related subjects such as packaging;

graphic arts; forestry and silviculture; the chemistry of carbohydrates, cellulose, hemicelluloses, lignin and wood extractives; and amchinery and equipment are also included.
260 000 records from 1967 to the present.
Dialog

Pascal
Produced by the Institut de l'information Scientific et Technique of CNRS. Covers the core of world's scientific and technical literature.
from 1973 to the present
Dialog, ESA

POLLUTION
Covered are air pollution, environmental quality, noise pollution, pesticides, radiation, solid wastes, and water pollution.
Over 140 000 records from 1970 to the present.
Dialog, ESA

PTS Newsletter Database
Contains the full text of specialized industry newsletters which provide concise information on companies, products, markets, and technologies, trade and geopolitical regions of the world: and government funding, rulings and regulation and other legislative activities that impact the industries and regions covered. PTS Newletter Database covers the following industries and geographic regions of the world: biotechnology, broadcasting and publishing, computers and electronics, chemicals, defense and aerospace, energy, environment, financial services, general technology, Japan, Middle East, manufacturing, medical and health, materials, packaging, research and development, telecommunication, transportation, and more.
62 000 records from 1988 to the present
Dialog

SCISearch
Covers every area of pure and applied sciences. Citations are taken from about 2 600 major scientific and technical journals.
10 720 000 records from 1974 to the present.
Dialod, CD-ROM

Water Resources Abstracts
Covers a wide range of water resource topics including water resource economics, ground and surface water hydrology, metropolitan water resources planning and management, and water-related aspects of nuclear radiation and safety. The collection is particularly strong in the literature on water planning (demand, economics, cost allocations), water cycle (precipitation, snow, groundwater, lakes, erosion, etc.), and water quality (pollution, waste treatment). WRA

contains predominantly English-language materials and includes monographs, journal articles, reports, patents, and conference proceedings.
205 000 records from 1968 to the present.
Dialog, CD-ROM

WATERNET

Provides a comprehensive index of the publications of the Americam Water Works Association and the AWWA Research Foundation. Included are books and proceedings, journals, newsletters, standards, manuals, handbooks, and watter qualilty standard test methods. Emphasis is on the technical reports and studies from water utilities, regulatory agencies, and research groups in the United States and its territories, Canada, Mexico and Latin America. European and Asian data are also reported.
20 000 records from 1971 to the present.
Dialog

4
LITERATURE

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8 Environmental Information

ROBERT R. FREEMAN
National Oceanic and Atmospheric Administration

MONA F. SMITH
National Oceanic and Atmospheric Administration

> The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of ecological systems and natural resources important to the Nation;
>
> National Environmental Policy Act of 1969 (NEPA)
> (U.S. COUNCIL ON ENVIRONMENTAL QUALITY, 1986, p. 567-577)

> . . . a tension was established, which exists to this day, between the need to act and the availability of knowledge.
>
> RUCKELSHAUS (p. 24)

INTRODUCTION

The quotations above aptly suggest the central theme of this chapter: that environmental information services today are closely intertwined with strong social forces; understanding the context and background of a particular system is as important as knowing about its internal processes and its products.

This chapter is in the public domain.

Annual Review of Information Science and Technology (ARIST), Volume 21, 1986
Martha E. Williams, Editor
Published for the American Society for Information Science (ASIS)
by Knowledge Industry Publications, Inc.

The concept of environment, as it is widely held today, is a fusion of scientific and social thought with roots ranging from religious and philosophical values to politics and economics on to the biological and physical sciences and engineering. Nonetheless, what has crystallized "environment" as a topic of broad public interest is the need for collective social action. Probably the best single book for tracing the development of the streams of thought that have led to present notions of collective environmental action is *Environment: A Challenge to Modern Society* (CALDWELL, 1970). In addition to detailing the ideas of environmental administration and policy, Caldwell traces the development of the key concepts of "environmental quality" and "environmental protection." He observes that "the American experience with attempts to define public responsibility for the quality of the environment is largely summed up by three sociopolitical developments: conservation, environmental health, and public aesthetics" (CALDWELL, 1970, p. 33).

Environmental information services are largely a product of the era since 1960 when worldwide public opinion perceptibly began to push governments toward action on threats to human health, the quality of life, and even the long-term stability of the earth's environment. To GIULIANO ET AL. (p. 24-25) and NEUFELD, environmental information epitomizes the "third era" in the development of scientific and technical information systems in the United States. The characteristics of this era are:

- Information from many disciplines is necessary, much of it local, ill-organized, proprietary, or value-oriented.
- Problem-solving responsibilities, and therefore the users of information, are decentralized at all levels of government.
- Critical value judgments and complex tradeoffs among private and social goals are required as part of the decision-making process.
- Uncertainty and conflicting information are so common that problem resolution often requires specialized intermediaries or experts to authenticate the information or to represent the views of one party to an issue authoritatively.

These observations should serve to establish the context of environmental information and to explain the remarkably wide range of systems and services discussed in this chapter.

This is the first *ARIST* chapter to cover environmental information as its main topic. Because environmental information services have been developed largely to support the social goals cited above through environmental administration and policy, we begin with a section on information needs and uses. The rest of the chapter is devoted to specific information services created to meet the goals that are so well summarized in NEPA.

Two related topics have been covered in earlier *ARIST* chapters. Toxic and hazardous materials are discussed by KISSMAN & WEXLER (1983), and all aspects of energy information are covered by COYNE ET AL. For these two topics we have concentrated on the recent literature not cited in those chapters.

NEEDS AND USES FOR ENVIRONMENTAL INFORMATION

To understand the proliferation of environmental information services, it is necessary to view them in the context of the economic, social, and political needs that spawned them. A substantial and still-growing body of literature is available to aid in comprehending these user needs and how they developed historically. The study of environmental information requirements is a fascinating area that will take the reader deep into the literature of such fields as: political decision making in representative democracies; theories of organization, information flow, and decision making in bureaucracies; and the economics of natural resources and the environment.

Theoretical Bases for Environmental Information Requirements

Environmental issues result from conflict over the long-term allocation and use of natural resources for the production and exchange of goods. This is the subject matter of economics, and the economic literature of the past 20 years clearly identifies the theoretical rationale for today's environmental information systems. Because most methods for implementing these theories involve the collection and use of various kinds of scientific and technical information, it is important for information specialists to understand how the information they provide will be used.

The key new concepts of "common property resources," "externalities," and "public goods" are explained as they relate to environmental and natural resources policy by CIRIACY-WANTRUP & BISHOP, A. FREEMAN III ET AL., and RANDALL (1975; 1983). An extensive review and bibliography of modern environmental economics has been published by FISHER & PATERSON. HUFSCHMIDT & HYMAN provide a good survey (with a lengthy bibliography) of the economic concepts needed for analysis of natural resources and environmental quality. R. FREEMAN (1977) and LORD & WARNER give analyses of the relationship between common property resources, externalities, and the development of environmental information services. DAVIS & KAMIEN summarize alternative policies, including taxation, regulation, and subsidy, pointing out the information requirements that result from each.

Science and Information in Environmental Decision Making

Participation in decision making. The political system has a dual role to play in environmental matters in a democratic society: the establishment of public policies and their administration. Both aspects call for the collection and use of information by a broad range of groups and individuals. The needs and uses for environmental information involve interactions within and among four major social groups: scientists and engineers, business executives, politicians and administrators, and the public.

The differing perceptions and needs of each group mean that more attention must be paid to the interpretation and packaging of information than for

many other applications of scientific findings. An unresolved tension exists over who should participate, the proper extent of each group's influence, and the role of scientific knowledge in the decision-making process. This tension has been thoroughly explored in books by ACKERMAN ET AL., CALDWELL (1982), and HAEFELE.

A recent and valuable article by POLLACK, documented with hundreds of references, defines three perspectives on environmental policy-making: 1) "technocratic," 2) "grass roots" (called the public participation model by others), and 3) "deep ecology." She reviews each perspective for its view of: 1) the nature and significance of environmental problems, 2) the allocation of decision making authority, and 3) the role of science and technology (and consequently of data and information) in decision making. To adherents of the public participation variant of pluralism, scientific information is a useful tool in decision making, but it is not free of interpretation and value judgments when it becomes involved with social issues (WALKER, 1973; 1974). Consequently, information should be used in a confrontational or bargaining mode as a means of resolving conflicts.

Environmental information in regulatory decision making and risk assessment. Probably the single most controversial aspect of the needs and uses for environmental information is in the area of the bureaucratic decision making process in the administration of laws. The laws passed by Congress set ambitious standards and schedules to reduce pollution, and initially the Environmental Protection Agency (EPA) was under stress to meet timetables for formulating regulations and enforcing standards in conformance with the legislation. The U.S. NATIONAL ACADEMY OF SCIENCES. COMMISSION ON NATURAL RESOURCES and the U.S. GENERAL ACCOUNTING OFFICE (1979) questioned whether EPA was using technical information to the extent necessary in writing regulations and making decisions and criticized the agency for using unpublished or unreviewed data and not making sufficient use of outside scientific experts.

Two central aspects of the process are risk assessment and risk management (U.S. COUNCIL ON ENVIRONMENTAL QUALITY, 1986, p. 200-201, 211-246), which involve the use of the best available information to make decisions to protect the public, recognizing that the information may not meet the desired standards of science. Excellent discussions of the concepts of risk assessment and risk management, including alternative definitions, methods, and references to further readings, are given by the CONSERVATION FOUNDATION (1984, p. 261-317) and the Scientific Committee on Problems of the Environment (SCOPE) (WHYTE & BURTON).

RUCKELSHAUS pleads for greater understanding of the nature of environmental administration as risk management. He points out the dilemma faced by environmental administrators: the public is so convinced that science can solve problems that, through Congress, it mandates swift and sure regulation, but science often does not have and cannot produce the needed information to a high level of certainty. He argues that we must "confront one of the... dilemmas of leadership in a democracy, that of having to choose between telling people what they want to hear and telling them what they ought to know" (p. 23). He recommends a much greater effort by environmental

agencies to communicate to the public the values, assumptions, and uncertainties that underlie decisions.

CHEN & LAGLER review the extensive literature on behavioral barriers to information flow in bureaucracies, arguing for a change in information dissemination patterns in environmental administration. They point out the dilemma that, while a responsible approach to informing the public includes making the degree of uncertainty clear, the public expects and rewards administrators who project confidence and certainty. Like Ruckelshaus, they call for full public access to the information used in decision making, including the degree of certitude. CONN & FEIMER and FISCHHOFF have reviewed past research in psychology and communications studies in an effort to formulate guidelines for environmental agencies to use in communicating risk information to the public.

The nature and quality of relevant technical information as well as access to that information, how the information is used, and public perception of risk are all topics that have aroused controversy in the course of implementation of environmental laws. ASHFORD, BOZEMAN, and HOLDGATE provide studies of the sources and channels of information, the problems of decision making under uncertainty, and issues over the influence that administrators' personal and political values have on collection and use of information. SCHMANDT has edited a collection of 14 papers that explore the issues in the use of scientific information in regulatory, judicial, and legislative processes, many of which involve environmental policy. STAFFORD and WEINBERG also discuss the tension between scientists' desire for certainty and legislators' need to act to protect the public interest.

Despite the validity of arguments favoring full public access to environmental data and information based on the principles of democratic government, significant barriers exist. Within the federal government, for example, the release of information about the Superfund toxic waste cleanup program became embroiled in the recurring constitutional clash between congressional oversight of the implementation of laws and the executive rights to secrecy of law enforcement records and intraagency recommendations (CLAVELOUX).

Industry fears damage from release of information of value to competitors as well as the possible negative impact on market sales from public reaction to environmental information. HENZ, an engineer and attorney, describes how to protect company secrets in the event of an environment audit. The disclosure of pesticide testing data is a case study of the difficulty of providing full public access while still protecting proprietary commercial interests. SMITH reviews the compromises reached between the Environmental Protection Agency (EPA), six environmental action groups, and nine chemical manufacturers that permitted access to data.

A different aspect of environmental information needs for policymaking is found in "issue identification" or "anticipatory information systems". CHEN ET AL. describe the concept of an environmental problems anticipatory system, which provides for monitoring and analyzing likely future environmental issues. The CONSERVATION FOUNDATION (1984, p. 237-259) and LANCASTER & LEE also discuss a number of approaches to identifying environmental issues and incorporating them into planning processes.

The environmental impact statement process and environmental scientific information. Probably the best known provision of NEPA is the requirement for the production of environmental impact statements (EIS). This one section of the law had two important consequences for the use of environmental information: 1) it opened the governmental planning process to extensive public participation, and 2) it spawned an entirely new segment of the information industry. Although it is no longer current in its coverage of cases, a paper by two legal scholars provides a thorough review and analysis of the uses of scientific information in litigation based on environmental impact (GELPE & TARLOCK).

O'HARE recognizes the dilemmas and paradoxes found in the public decision-making process regarding environmental impacts. After reviewing the economics of information from both the supply and demand sides and the behavioral characteristics of participants in the process, he makes innovative recommendations for restructuring environmental impact statements and the review process. Environmental impact statements would become a developing record of information exchange through debate by interested parties, completed only at the end of the negotiation process. The administrative agency would take special care to index all of the information so that all participants could retrieve and organize those portions relevant to their particular needs. The agency would manage the process to maximize the range of negotiable choices, trying to avoid a hardening of positions until the end. This paper is of fundamental importance to anyone seeking to understand public environmental decision making from a theoretical viewpoint and to anyone who wishes to consider alternatives in the management of information and the decision-making process.

HERNER analyzes the characteristics, strengths, and weaknesses of existing EIS, comparing them with the technical report literature. He describes the problems of providing access to the EIS through secondary information services and databases.

Another view of the quality of the EIS is given by CULHANE ET AL., who studied whether the most recent scientific advances on acid rain were being incorporated into EIS. They concluded that EIS fail to achieve the NEPA ideal of using scientific information in environmental policymaking. This paper is of value to anyone interested in how scientific information is incorporated into applications. LANCASTER & LEE show how bibliometrics can be used to trace the growth of the acid rain literature and show its diffusion from a narrow to broad user community.

Case studies of uses of environmental information. There are a number of worthwhile case studies of the uses of scientific information in specific areas of environmental decision making. For example, the risks and pitfalls of using environmental information in decision making under politically charged circumstances are well documented for the "yellow rain" episode by PRINGLE. The article illustrates the tenuous hypotheses, ambiguous data, and conclusions based on preconceived notions that can result when personal, bureaucratic, and national political motives mix with environmental information.

Some studies have focused on a current dilemma: the call for broad public participation in environmental decision making by a public that does not

have the technical information to understand a policy and will thus be inclined to reject it and to distrust the government agencies that try to base decisions on it. LOVRICH ET AL. studied the use of technical information by Idaho residents interested in water resources policy. A valuable and detailed case study by EBBIN & KASPER involves the efforts of citizen groups to participate in the planning process for nuclear power plants with respect to safety and environmental impact. Regarding EIS, they conclude that (p. 238):

> the failure of impact statements as sources of information for citizens can be traced to several causes: the bias inherent in their preparation, the overwhelming concern with procedural as opposed to substantive characteristics of the statements, and the emphasis on the physical as opposed to the social and human environment.

The ongoing debate over government policy on acid rain research, regulation, and legislation has produced other case studies of the role of information in environmental policy. The Office of Technology Assessment (OTA) (U.S. CONGRESS. OFFICE OF TECHNOLOGY ASSESSMENT) points out that much of the debate results from uncertainty caused by lack of information, disagreement over the extent and distribution of risk, and complexity that requires an understanding of knowledge from different disciplines.

RUSHEVSKY reviews three case studies (formaldehyde, 2,4,5-T, and mining in a national forest wetland area) to contrast different ways of using scientific information in environmental decision making. In two of the cases he criticizes officials for manipulating scientific information to achieve desired ends.

SWARTZ & STRAND report on an economic assessment of the impact of the release of information about environmental contamination. They demonstrate how the dissemination of information about kepone in East Coast estuaries, and the resulting public uncertainty over the health risks, affected seafood markets. A clear relationship was established, showing how individuals changed their buying habits to avoid pollution when they were uncertain about the extent of the danger.

Data and information needs in support of environmental and natural resources administration. In the United States, the placement and role of environmental programs, and consequently, of environmental information services, are closely related to the historical development of the nation from a sparsely populated continent to an industrialized society. CALDWELL (1970) and SCHOOLER both divide the development of the environmental movement, especially in the United States, into distinct eras. An appreciation of these eras is fundamental to an understanding of the apparent overlap among many environmental information programs.

The first wave was concerned primarily with resource development, the settlement of the land, the exploitation of mineral and animal resources, and the establishment of commerce. Environmental data and information services began as early as the 18th century, when systematic mapping and charting of

the oceans, coasts, and the lands newly discovered by Europeans began. A fascinating account of the development of the scientific and technical basis for these efforts is given in *The Mapmakers* (WILFORD).

A second wave was characterized by the conservation and public health movements. While the latter sought to control disease habitats, the former emphasized ecological balance and the avoidance of waste through scientific management practices. Through the 19th century, as detailed by DUPREE, the foundations of many of today's environmental information services came into existence to meet the needs of environmental protection, agriculture, forestry, fisheries, and wildlife management.

The third wave, characterized by the use of environmental legislation and regulation to find a new balance between public health, ecological balance, and amenities on one hand and industrial development on the other, crested in the 1970s. Most important legislation either explicitly required the collection and dissemination of information or, by its requirements for standards and regulations based on scientific data and reasoning, implicitly required it. The National Environmental Policy Act of 1969 (NEPA) (U.S. COUNCIL ON ENVIRONMENTAL QUALITY, 1986, p. 567-577) was the watershed act of the third wave in "its reliance on science-based information and its problem-solving rather than adversary approach to public issues" (CALDWELL, 1970, p. 227).

For the 1980s, CLARK concludes that one of the major impacts of President Reagan's program has been to reduce the resources devoted to environmental research and information, including both the amount of information gathered and the elimination of information services. Nevertheless, the U.S. environmental and natural resources management laws themselves require and even explicitly call for large amounts of information to be collected, organized, and used.

The management of the ocean environment and resources is a good case in point. In March 1983, President Reagan declared U.S. jurisdiction over the 200-mile Extended Economic Zone (EEZ), capping more than a decade of legislation and regulation of the marine and coastal environment. As CICINSAIN & KNECHT point out, the most basic requirement for improving U.S. governance of the EEZ is to improve both the availability of information on marine ecosystems and resources and the dissemination of this information to decision makers. ROSS discusses the increasingly close link between science and policy in the management of marine resources as national borders expand via the EEZ proclamation and as technology affords greater access to the resources.

Closely related to managing the EEZ is the Fishery Conservation and Management Act, which prescribes the systematic use of environmental and socioeconomic information in the allocation of U.S. fisheries. Both WARNER and FRICKE review the provisions of that act, explaining the key fisheries management concept of "maximum sustainable yield" (MSY) and the information needed to implement rational decision making. Other useful discussions of environmental and economic data requirements for fisheries management are given by FROST & JOHNSTON and GALE & MILLER.

Natural resource inventories, required by several federal laws, provide a vehicle for incorporating environmental information into planning and management decisions. Inventories of environmental and natural resources played a large part in the original development of environmental information systems. MONTAG describes the terms of the first such inventory, which was authorized in 1785 to cover the western territories of the United States. JOHNSON describes the vast amount and variety of data and information needed to meet the requirements of the Soil and Water Resources Conservation Act of 1977. He outlines steps being taken to inventory and classify natural resources and environmental data as well as to investigate the use of remote sensing data to augment the record and to fill gaps.

Much effort by state governments goes into compiling inventories of land use and resources. The resulting information is used to establish management programs for land, water, and other resources. The role of environmental information flow in the coordination of state environmental programs within states, between states, and from state to federal level has been analyzed by the COUNCIL OF STATE GOVERNMENTS (1975).

ARMENTANO & LOUCKS point out the need for information on plant and animal distribution, habitat, and species for state purposes, while a report by the COUNCIL OF STATE GOVERNMENTS (1978) gives agricultural service, coastal zone management, fish and game management, forestry, land reclamation, NEPA section 208 planning, taxation, and transportation as the major categories for which state governments need environmental resource data. ZETKA describes how remote-sensing data are used to meet state coastal-zone management information needs.

Industry Needs and Uses of Environmental Information

For decades, enlightened management in private industry has found the use of scientific information on the state and quality of the environment and natural resources to be in its own self-interest. With the advent of extensive government regulation in the 1960s, industry needs and uses for environmental information have increased accordingly. Scientific management of forests is just one of many examples. BLOSSER, for example, predicts that the forest products industry will need more comprehensive information on: materials used; products disposed of in the air, water, and soil; acid precipitation; and the characteristics of forest soils.

A recent study by TRAIN for the Council on Environmental Quality (CEQ) provides the most comprehensive analysis of industry uses of information. Train interviewed 229 information users in 45 of America's largest corporations, trade associations, and information companies; 110 more users completed a written survey. He found that information on environmental quality and natural resources is needed for strategic planning, market research, resource acquisition, production capacity analysis, plant siting and design, environmental compliance, production and materials purchasing, research and development, bank lending, and investment recommendations.

The findings provide a valuable list of criticisms and recommendations for improvement of government environmental information.

ARMENTANO & LOUCKS (p. 83-95) conclude that much of the data needed by industry and government was available but underutilized owing to poor awareness and access. They present a plan for a national program to improve access to environmental data based on a data catalog and a network of regional data centers. Their recommendations are reminiscent of those made earlier during hearings on Rep. John Dingell's proposal to establish a national environmental data system comprised of a distributed network of data centers linked by a central directory (U.S. CONGRESS. HOUSE. COMMITTEE ON MERCHANT MARINE AND FISHERIES).

Increasing needs for environmental information also have meant new opportunities for industry, especially for value-added information services such as environmental assessments, syntheses of information for impact statements, and interpretation of environmental satellite imagery. MERRITT, for example, describes the role of resource information companies in preparing crop forecasts, land use studies, resource inventories, groundwater surveys, and satellite image interpretation. ARMENTANO & LOUCKS (p. 80) point out that many large industries use consultants to meet their environmental data-analysis obligations, providing a demand for value-added information products.

Environmental Information and the Public

An important component of the environmental movement is the role of information in forming the attitudes of citizens from childhood on and in galvanizing those attitudes into participation in environmental decision making. A large literature on this subject has already developed; this chapter gives only a few selected references to serve as an introduction.

The topic has several distinct facets: education of children, education of the public, environmental reporting in the mass media, and action-oriented information for public participation. CAWS delves into the breadth of environmental questions and their relationship to moral and political questions. He views the provision of scientific information in the schools and to the public as necessary but not sufficient for equipping citizens to deal satisfactorily with environmental issues.

The widespread teaching of environmental concepts and values in the schools is one of the largest and most basic environmental information systems. Environmental education has developed into a substantial field in itself, with associations of environmental educators active both in North America and internationally. TANNER uses citation analysis to trace the patterns of development of the environmental education literature.

The education of information professionals is a topic of special interest in light of the unique characteristics of environmental information and its users. DOSA (1974) describes the content of such a course, which is offered to master's degree candidates at Syracuse University.

Environmental reporting in the mass media epitomizes the problems of communicating information among scientists, policymakers, business leaders, and the public. FRIEDMAN, pointing out that many people get most of their environmental information from the media, gives a good analysis of the problems faced by environmental reporters, with numerous references to other sources. The news reporter must take highly complex issues, filled with uncertainty and difficult concepts from many fields of science, and try to present objective reports to an audience that is aware that major decisions affecting money, amenities, and public safety are at stake.

Standing between the technical literature and the media, as sources of environmental information for the public, are the services of many environmental foundations and citizen organizations. In terms of community dissemination of environmental information, a significant result of the efforts of environmental action groups has been the right-to-know legislation at the state level. According to SILVER, many states now require public access to information about material safety, storage locations, and emissions of hazardous materials in the environment. TAPSCOTT gives examples of how the information made accessible through toxic substances clearinghouses established under the state and local right-to-know laws has benefited residents of neighborhoods, fire fighters, health professionals, land use planners, industrial workers, and government officials.

The level of energy devoted to education and dissemination of information to the public apparently has paid dividends in continuing public support for environmental programs and goals (ANTHONY). MITCHELL gives primary credit to public interest and environmental action groups for their role in educating the public.

The preceding section showed how diverse the needs and uses for environmental information are. Below we review some of the many systems and services that have been developed to meet these needs.

ENVIRONMENTAL INFORMATION SYSTEMS AND SERVICES: GENERAL AND COMPARATIVE STUDIES

Environmental information is a model for those emerging subjects in which knowledge is multidisciplinary and widely scattered and concepts and interpretations are constantly shifting and developing in response to new societal insights, values, political policies, and economics. In this section, environmental information systems and resources are sorted into sections on: directories and guidebooks; secondary bibliographic sources (including abstracting and indexing services and online databases); and non-bibliographic referral services, such as data catalogs and research-in-progress systems. It concludes with a section on indexing and classification systems specific to environmental information. The following section deals with specific mission- or problem-oriented systems and services.

Directories and Guidebooks

In a field where an invisible college is not static and information is scattered, there is a great need for up-to-date directories and inventories of existing information sources and services. A list of primary journals and organizations concerned with the environment could fill a book and has indeed filled several books. HAMMOND ET AL. present a comprehensive work on environmental problems, with sections describing books, journals, and organizations dealing with air pollution, water pollution, land, vegetation, animals, coastal zone, population, and energy. Appendices include selected periodicals, organizations, and federal environmental laws.

The Department of Energy (DOE) has produced regular inventories. The most recent compendium of environmental and natural resources sources includes federal referral services, public information offices, computerized databases, information analysis centers, and publication distribution systems. Published sources such as bibliographies, abstract and index journals, reports, handbooks, and atlases are also covered. Professional societies and private-sector services are included on the rationale that they will lead the reader to governmental sources. A broad range of literature references to libraries, research scientists, databases, and statistics prepared by nongovernmental and federal organizations is included (O'HARA & O'HARA).

EPA publishes a U.S. directory of sources (U.S. ENVIRONMENTAL PROTECTION AGENCY. OFFICE OF LIBRARY SYSTEMS AND SERVICES). GOUGH edited a world directory of environmental information sources. ANDREWS & NATKIN compiled a directory of government natural resource management agencies in 144 countries. A directory covering organizational sources of geosciences and oceanography in the United States was published by the U.S. LIBRARY OF CONGRESS.

A compilation of state natural resources information systems in the United States documents state or regional data on climate, energy, environmental quality, geology, hydrology, land use, soils, topography, vegetation, and wildlife (CARON & STEWART).

A guidebook on how to prepare an environmental impact assessment or statement is presented by GOLDEN ET AL. Examples are given of federal actions requiring NEPA Environmental Impact Statements (EIS) and court decisions that furnish guidance on the "significant" actions that have required EIS in the past. The book is a good source of environmental information for it contains a chapter on databases. It also explains the kind of information that may be found in an EIS.

Since 1970 an annual report to Congress assessing environmental conditions and trends in the United States has been issued by the U.S. COUNCIL ON ENVIRONMENTAL QUALITY (CEQ) (1986). A more critical assessment of environmental quality in the U.S. was made by the CONSERVATION FOUNDATION (1982). Potential global environmental problems were analyzed in 1980 (U.S. COUNCIL ON ENVIRONMENTAL QUALITY, 1981), and another analysis of global environmental conditions was done by the ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD).

Bibliographic Services

These services include abstracting and indexing services, regularly published bibliographies, online databases, reviews, current-awareness services, and descriptive syntheses of primary sources of information. The commercial databases devoted exclusively to the environment are Enviroline, Pollution Abstracts, Environmental Bibliography, Aquatic Sciences and Fisheries Abstracts, and Meteorological and Geoastrophysical Abstracts. In addition to these, the environmental literature can be approached through *CURRENT CONTENTS*, which groups journals of agriculture, biology, and environmental sciences together and journals of engineering, technology and applied sciences together.

INFORMATION MANAGER gives a vivid picture of the inner workings of a total environmental abstracting and indexing service in its interview with Environment Information Center (EIC) director, James Kollegger, producer of *Environment Abstracts* and Enviroline. Enviroline was reviewed in one of the first issues of *Online* (SHATZ), and its scope, journal selection, coverage, and document delivery were reported in detail. The *Periodicals List* from EIC contained about 1,800 journals in 1984 (EIC/INTELLIGENCE).

Almost all databases contain some morsels of environmental information. A review of publicly available scientific and technical databases was done by MARTHA E. WILLIAMS. Environmental databases are mentioned as examples of problem-oriented scientific databases. Databases useful for environmental scientists are discussed by CONKLING, who characterizes Compendex, EI Meetings, Enviroline, Pollution Abstracts, Aqualine, Water Resources Abstracts, Waternet, Chemical Abstracts, Chemname, Chemsis, Medline, BIOSIS Previews, and Toxline. He also discusses software directories, standards and patents. Both of these articles are geared toward end users.

Comparative studies of environmental databases abound. A study of energy and environmental databases was done by B. WILLIAMS. He studied 40 databases available from DIALOG, System Development Corp. (SDC), BRS (Bibliographic Retrieval Services), NIH/Chemical Information System, Questel and DOE/RECON. Little overlap was found among the 40 databases selected. However, Williams determined that for a specialized topic, such as acid rain, it was best to search a specialized database. MILLER studied overlap among three major environmental databases—Enviroline, Pollution Abstracts, and Environmental Bibliography—using eight different search strategies. All three databases had unique references and slight overlap.

BURK identifies 82 geoscience databases that are either source or reference databases. Their use has not increased because standards for geoscience data are lacking. However, recently there has been a trend toward improving geoscience databases and adopting standards.

A comprehensive study by YSKA & MARTYN examined 97 databases available to the European Economic Communities in 1976 and chose 45 for extensive study. Recommendations were made on the relevance of these databases. Only English-language databases were studied, but candidate databases that were not in English were listed for future study. CALKINS compares vocabulary selection in searching for sanitary landfills and water pollution on

Enviroline and Compendex and finds that both controlled and free-text terms are necessary.

Chemical Abstracts Service database has the best worldwide coverage of the chemical literature (HAWKINS). All databases containing significant chemical information contain environmental information. Hawkins reviews the full range of chemical databases—bibliographic, numeric, and full-text (ACS Journals Online and Kirk-Othmer Encyclopedia of Chemical Technology), the chemical name dictionaries, and the name and substructure dictionaries. Among environmentally relevant databases mentioned by Hawkins are Paperchem and two DOE/RECON databases—Separation Science Data Base and Chemicals Identified in Human Biological Media—which are restricted to DOE staff and their contractors.

In the area of environmental health and toxicology, BRIDGES states that an environmental health search is simply a chemical search combined with a medical search. She studied Chemical Abstracts, MEDLINE, BIOSIS, NTIS, Toxline, and the NIH/Chemical Information Systems (CIS) databases (now available from Information Consultants, Inc., and CIS, Inc.). The new online toxicology data retrieval system called TOX-NET was reported by *CHEMICAL & ENGINEERING NEWS* (1985b). TOX-NET contains the old Toxicology Data Bank and the Hazardous Substances Data Bank and gives information on environmental fate and exposure, standards, regulations, monitoring, analysis, safety, and handling. These files are accessible by Medical Literature Analysis and Retrieval System (MEDLARS) users. The databases of the life sciences are discussed comprehensively by SNOW. Of interest to readers are the areas of toxicology including environmental and occupational health, and legal and regulatory aspects of the life sciences. A cross-tabulation matrix for selection of databases by subject from among 110 life science databases is presented, along with other selection aids. Tables are given for comparisons of coverage, ease of indexing/access points for secondary concepts or search modifiers, and chemical substance nomenclature standards.

A compilation of databases useful for ecological information in the private sector has been compared with federal, state, and the U.N. Environment Programme's International Referral Service (now Infoterra) databases (TUCKER & HUBER). Some of these databases are no longer available or are not being updated, but they still contain information that is not covered elsewhere. OLSON (1984) provides descriptions of over 130 federal databases as well as five integrated information systems that have merit for future design considerations because they integrate data and graphics; some of these are now defunct. Canadian and U.S. databases and online systems are compared by MARSHALL in preparation of a bibliography on pollution effects on mayflies. Twenty seven databases were searched on the systems of DIALOG Information Services, SDC, CAN/OLE, and QL. BIOSIS retrieved the largest number of citations with biosystematic codes for mayflies and concept codes for water pollution. The second highest retrieval was found from Selected Water Resources Abstracts on QL Systems. Costs are compared between systems and databases as well as number of items retrieved. The bibliography is included in this paper.

Referral Services

These services refer users to nonbibliographic sources, such as numeric data and research in progress. Data catalogs are appearing more frequently because of the growth of numeric databases and the expense of collecting environmental data. The National Environmental Data Referral Service (NEDRES), an online data catalog, is described by R. FREEMAN (1986). He discusses the concept of referral to unpublished and published numeric data by means of an online catalog, as well as the database structure, online access, and a cooperative network. Agricultural research is found in 20 databases listed by WILLIAMS & ROBINS, the best known of which is probably the Current Research Information System (CRIS) database (U.S. DEPARTMENT OF AGRICULTURE). The U.S. Fish and Wildlife Service has a research database, Current Federal Aid Research, on DIALOG (*FISH AND WILDLIFE REFERENCE SERVICE NEWSLETTER*, 1985).

Subject Analysis, Classification, and Vocabulary

The problem in locating information for new fields that are interdisciplinary and rapidly expanding (as is environmental science) is that there are few starting points. The problems of pollution have created new terms that have a range of meanings, such as "endangered species," "mother earth," "fugitive dust," and "fishkill." The definitive thesaurus completed by the Committee on Scientific and Technical Information (COSATI) (ENGINEERS JOINT COUNCIL) contains the minimum number of terms necessary for air pollution, water pollution and waste disposal. However new terms that are being coined continuously as needed are not included. Thus, other, more comprehensive thesauri have been developed, and compilations of vocabularies showing source thesauri and free-language terms have been of great value. *Environmental Microthesaurus—A Hierarchical List of Indexing Terms Used by NTIS* developed by U.S. NATIONAL TECHNICAL INFORMATION SERVICE (1977) was one of the first comprehensive environmental vocabularies. A significant feature of the NTIS microthesaurus is its amalgamation of terms found in four thesauri used by NTIS in its indexing: Department of Defense, NASA, Department of Energy, and the TEST thesaurus. In addition, this microthesaurus contains a number of free-language terms that are not on any other list. This microthesaurus is divided into two parts: environmental terms and chemical terms. In 1978 another thesaurus, *Environmental/Chemical Thesaurus*, was prepared by SHRINER ET AL. at Oak Ridge National Laboratory under the sponsorship of units in EPA and NOAA. This newer thesaurus expanded environmental terminology to include economics and socioeconomics. It also recognized the importance of geographic, legal, and demographic terms. Another source of subject terms is found in *ENVIRONMENT ABSTRACTS* printed index. Up to 21 major categories are covered in the database. Subject heading lists and thesauri are available from Biological

Abstracts, Zoorecord Taxonomy, Chemical Abstracts Service, and Engineering Information, Inc.

A thesaurus for water resources was prepared by the Water Resources Scientific Information Center from the indexing terms used in *Selected Water Resources Abstracts* (U.S. DEPARTMENT OF THE INTERIOR. OFFICE OF WATER RESEARCH AND TECHNOLOGY). Another water subject thesaurus was prepared for use in the Bureau of Reclamation (DEASON).

RIGBY (1986) prepared a multilingual thesaurus on meteorology for the World Meteorological Organization. It contains equivalent terms in English, French, Spanish, and Russian. Also in the atmospheric sciences, HALPIN describes a thesaurus of air pollution terminology.

Other thesauri of interest to environmentalists are the *API Thesaurus* (AMERICAN PETROLEUM INSTITUTE), derived from 20 years' worth of terms in the API databases, and the *GEOREF Thesaurus* from the American Geological Institute covering earth science (RILEY).

Standards are important in information, but agreement on them is difficult. The acceptance of Chemical Abstracts Registry Numbers to define chemicals has made chemical identification and structure searching possible and has facilitated a number of environmental information systems such as TOX-NET, CIS, and the Environmental Chemicals Data and Information Network (ECDIN).

Classification of land has not been so easily accepted. Each scientific discipline wishes to have its classification scheme selected and used, but there is no agreement on which one to use. An insight into the problems is presented by HAYDEN ET AL. who review the suggested classifications in the literature for coastal and wetland areas and offer another classification of their own. It is based on biology, habitat, climate, and land composition. COWARDIN ET AL. present a classification for the same coastal areas as Hayden; however, Cowardin's classification was accepted by the U.S. Fish and Wildlife Service and is used to compare wetland and deep water areas. BAILEY has prepared a classification system based on ecoregions, which incorporates climate, soil type, and general geographic area for information exchange. BAILEY & CUSHWA plotted the ecoregion map with an overlay of the hydrologic unit map, combining a land and river basin standard. MOSS suggests a land classification scheme that can be used for development and environmental assessment, based on energy and moisture data for the land units; it is in keeping with Canadian environmental agencies' land classification standards.

The U.S. Geological Survey has adopted Hydrologic Unit Codes for river basins. Those who are building environmental databases that include freshwater species, such as MASON ET AL., have used river basin codes in their databases. BURK notes that geologists are only now beginning to address standards for databases because there has been no agreement on what "data" means. There have been meetings on ecological data standards and quality for long-term research (SINCLAIR). All these efforts signal attempts to develop meaningful standards for environmental information representation and exchange, but agreement on standards is slow.

MISSION-RELATED DATA AND INFORMATION SERVICES AND SYSTEMS

This section focuses on the role of information science and technology in supporting environmental programs. The environmental model for this problem-oriented field is meant to show the manner of information collection, organization, and management for users of other modern emerging disciplines.

Environmental Protection and Public Health

Laws passed by Congress to protect the environment gave environmental groups and the public a powerful means of reducing pollution. Both regulation and litigation have been used to force compliance with legislation. The complexity of governmental authority and issues in gathering and monitoring data is addressed in U.S. GENERAL ACCOUNTING OFFICE (1979).

EPA was established by executive order on December 2, 1970, to develop regulations mandated by Congress. The agency has developed numerous specific information systems to meet its needs. According to GAO, "collecting, processing, and analyzing data consume 20 percent of the agency's budget" (U.S. GENERAL ACCOUNTING OFFICE, 1980). EPA has produced a series of information system inventories (U.S. ENVIRONMENTAL PROTECTION AGENCY. OFFICE OF PLANNING AND MANAGEMENT; U.S. ENVIRONMENTAL PROTECTION AGENCY. OFFICE OF SYSTEMS AND SERVICES).

The use of online databases to prepare for court cases, administrative hearings, and regulatory-related actions of EPA was described by SEBA. These actions require technical information that can be used by attorneys during court cases or by judges to render a decision. Databases are also used to find potential polluters. Material from online searching of databases such as BIOSIS, Enviroline, Pollution Abstracts, Toxline, Predicasts, and others is supplemented and used in legal or other regulatory actions.

Access to government reports. Government environmental reports are available primarily through the National Technical Information Service (NTIS) and the U.S. Government Printing Office (GPO). NTIS, which is both a primary and secondary provider of information, publishes *Environmental Pollution and Control*, a weekly abstract bulletin, and also distributes a list of Published Searches that contains many environmental topics (U.S. NATIONAL TECHNICAL INFORMATION SERVICE, 1970; 1985). Since EPA did not have a technical information center to process reports, it sent most of its research reports to NTIS. GPO also is a source of government reports. The difference in the availability of EPA reports from each source was discussed by R. TAYLOR. NTIS has a greater number of EPA reports. GPO takes only those studies that they consider will have wide interest or be best sellers. Environmental Impact Statements are also useful sources (HERNER).

Air pollution and acid rain. DAVIS reports that since the passage of the Clean Air Act of 1970, the air has improved in most areas of the United

States. This legislation established deadlines and limits for six air pollutants: sulfur dioxide, carbon monoxide, nitrogen oxides, lead, ozone, and total suspended particulates.

The Air Pollution Technical Information Center (APTIC), established in 1964 under the Public Health Service, was transferred to the Environmental Protection Agency (EPA) in 1970. APTIC was responsible for acquiring, indexing, retrieving, and disseminating air pollution-related technical literature (HALPIN & KNIGHT). The file ceased to be updated in 1978 but remained on DIALOG until 1986. The Air Pollution Library in Research Triangle Park, N.C., still maintains a microfiche copy of all items in the APTIC file.

EPA maintains AEROS, a unified data management system concerned with air pollution data collection, processing, and reporting. Five subsystems of AEROS are also described: 1) National Emissions Data System (NEDS), which stores and reports data for the five criteria pollutants (particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and reactive volatile organic compounds); 2) Storage and Retrieval of Aerometric Data (SAROAD); 3) Hazardous and Trace Substance Emissions System (HATREMS), which reports sources and emissions for noncriteria pollutants; 4) the Source Test Data (SOTDAT) System, which contains source emission measurement data such as data from stack tests; and 5) the Emissions History Information System (EHIS), which provides historical trends on national emissions (U.S. ENVIRONMENTAL PROTECTION AGENCY. OFFICE OF AIR QUALITY PLANNING AND STANDARDS).

The problem of acid rain has spurred a new wave of reports, publications, research inventories, and databases. The AIR POLLUTION CONTROL ASSOCIATION (APCA) holds annual meetings and publishes a directory of governmental air pollution control agencies and a handbook; the final chapter of the handbook is on "Information Resources" (CALVERT & ENGLUND). The literature, research fronts, and public perceptions of acid rain are discussed by GARFIELD (1985a; 1985b).

The passage of the Acid Precipitation Act of 1980 (Public Law 96-294, Title VII of the Energy Security Act) advanced the importance of this issue and led to the formation of the National Acid Precipitation Assessment Program (NAPAP) (U.S. CONGRESS. OFFICE OF TECHNOLOGY ASSESSMENT). NAPAP is an interagency program of ten cooperating government agencies formed to provide an organized research program on acid rain, to eliminate duplication, and to determine a coordinated plan of study. The Acid Deposition Inventory was produced through its support (U.S. INTERAGENCY TASK FORCE ON ACID PRECIPITATION).

As a member of the Interagency Task Force on Acid Precipitation, the Department of Energy conducts research on acid precipitation and publishes a current-awareness bulletin, *ACID PRECIPITATION*. NAPAP funds an Acid Deposition Research Inventory (CATON ET AL.). A brief description of acid precipitation containing a bibliography was produced by U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) (1981). NOAA is also a member of the NAPAP Interagency Task Force.

The transformation of the acid precipitation issue from a subject of academic interest to an international problem that has strained relations be-

tween the United States and Canada is revealed in terms of the development of the acid rain information clearinghouse. The clearinghouse provides a number of information services such as reference, online searching, referral, education, and training. A monthly summary of news events and research is produced by the clearinghouse (DOSA AND STOSS).

EPA in Corvallis, Ore., builds and maintains two databases on air pollution. The first, Air Pollution, Its Biological Effects, started in the late 1960s. The second is the Acid Rain Information System. Both databases are located at Oregon State University and use an enhanced FAMULUS computer program for retrieval (BAKER ET AL.)

Another air pollution issue of concern is that of climate change resulting from the gradual increase of carbon dioxide in the atmosphere resulting in a global temperature rise, the so-called "greenhouse effect." The Carbon Dioxide Information Center established at Oak Ridge National Laboratory in January 1982 has published a bibliographic format guide (ALLISON & PFUDERER), a data inventory (WATTS & ALLISON), and a bibliography (OLSON ET AL.).

Toxic substances and hazardous materials. Toxicology information has been covered in detail in a previous *ARIST* chapter (KISSMAN & WEXLER, 1983). However enough additional material has appeared in the succeeding years to warrant an update here. A recent history of toxicology by KISSMAN & WEXLER (1985) shows that the societal factors that contributed to the environmental movement came to a head in toxicology in 1962. Concern about toxicology heightened when the use of thalidomide by pregnant women in Europe was linked to deformities in their infants. The amendments to the 1938 Food, Drug and Cosmetic Act that were passed in 1962 strengthened the testing of new drugs before they were marketed.

As a result of these activities the Toxicology Information Program was established at the National Library of Medicine (NLM) in 1967, and the Toxline database was begun in 1972. The growth of online databases such as Toxline, Chemline, the NLM Online Chemical dictionary, the Toxicology Data Bank (TDB), the Registry of Toxic Effects of Chemical Substances (RTECS), and the Oil and Hazardous Materials Technical Assistance Data System (OHMTADS) are described by KISSMAN & WEXLER (1985). The latter three systems are "literature-derived factual data banks."

Legislation and regulations required various information-collection activities and reports on commercial chemicals. The resulting assembly of facts, data, and literature have increased the requirements for automation and manipulation of toxicology information. The future of toxicology information is discussed with regard to animal testing, biotechnology, occupational safety, and full-text databases by TERRANT ET AL. One of the major new developments in toxicology information is the expansion of Toxline. *CHEMICAL & ENGINEERING NEWS* (1985b) reported that Toxline now has become the Toxicology Data Network (TOX-NET). TOX-NET has two parts, the old Toxicology Data Bank (peer reviewed) and the Hazardous Substances Data Bank (not peer reviewed).

Among new developments in toxicology information three are of particular interest here. One is the transfer of the NIH-EPA Chemical Information System to the private sector. The second is the new rule on "Hazard Commu-

nication" or "Right to Know" (MARSICK), which states that workers must be warned by their employers of the hazards of the chemicals to which they are exposed at work. The third is the development and growth of the European Communities Environmental Chemicals Data and Information Network (ECDIN).

Many articles have been written about the NIH-EPA Chemical Information System (CIS) since its creation at NIH and later transfer to EPA. The articles cited appeared in the 1980s literature. The four main areas of CIS were described by HELLER & MILNE and include several examples of search strategy using the Structure and Nomenclature Search System that ties chemicals by their structures or common names to their Chemical Abstracts Registry Numbers throughout the system. This was followed by an article on the use of environmental data from CIS by MILNE ET AL. In 1983 CIS had funding problems, and EPA management recommended a full review of the system, which was done by a private sector panel (LIFE SYSTEMS, INCORPORATED). It recommended a combination of government management and private-sector maintenance of the system. A government panel, chaired by the director of the Chemistry Division, National Science Foundation and the Chairman of CEQ, also reviewed CIS (U.S. ENVIRONMENTAL PROTECTION AGENCY. OFFICE OF INFORMATION RESOURCES MANAGEMENT). Each panel agreed that there were system deficiencies in management, coverage, documentation, and quality control. KADEC & JOVER reported that none of the agencies had the resources to make the necessary improvements to CIS. CIS was turned over to NTIS in order to help accomplish the transfer to the private sector. CIS magnetic tapes and software were made available by NTIS to any organization willing to provide communications, user services, software maintenance, and marketing. Both Information Consultants, Inc. (ICI) and Fein-Marquart Associates, Inc. agreed to make CIS commercially available. An article appeared on the spectral databases in CIS describing their sources, content, and search features (HELLER). Heller observed that scientific-numeric databases should be produced and maintained somewhere in the nation and looked forward to the growth of these numeric databases in the future.

Both *ICIS NEWS* and *CIS NEWS* are newsletters by Information Consultants, Incorporated and Fein-Marquart describing their CIS databases and furnishing user support. Structure searching is now offered by Chemical Abstracts Service (CAS Online), QUESTEL, and ECDIN. The Chemical Abstracts Registry Numbers have become standard for chemical compounds. The concept of numeric databases has been accepted and is represented in TOX-NET, in full-text chemical journal databases, and many other such databases (KISSMAN & WEXLER, 1985).

The U.S. ENVIRONMENTAL PROTECTION AGENCY. OFFICE OF PESTICIDES AND TOXIC SUBSTANCES (OTS) has prepared an information manual that contains lists of major sources for toxic substance information. It summarizes the functions of OTS: analysis of chemicals, control technology, economics, health effects, environmental effects, exposure, and regulatory options. A matrix showing these functions in relation to the available information resources is included. OTS produces an inventory

containing 58,000 chemical substances, which includes 1,800 generic names for chemicals whose identities must be kept confidential.

Information sources for compliance with the new "Hazard Communication" rule announced by OSHA in November 1985 are discussed by MARSICK. Chemical manufacturers and importers are required to provide information on hazardous chemicals used in the workplace by labeling or through material safety data sheets (MSDS), which must be complete, accurate, and current. MSDS are available but may not be current or complete. Chemical mixtures may be covered by data sheets of the pure chemicals making up the mixtures. Five collections of MSDS are reviewed by Marsick. Handbooks, other literature sources, online systems (Hazardline, TOX-NET, Information Consultants and Fein-Marquart CIS), the Hazardous Materials Information Center, and state information systems are all useful for locating complete information.

Newly available handbooks contain environmental data on organic chemicals (VERSCHUEREN) and toxic chemical information resources (KAUFMAN ET AL.). A manual describing chemical and physical properties of 1,200 chemicals contains data necessary for hazard assessment for the transportation of chemicals in navigable waters (U.S. COAST GUARD). Demand for this publication exceeded the supply, and this manual had to be reprinted shortly after it came out.

The Chemical Substances Inventory of the Toxic Substances Control Act contains information on more than 50,000 chemicals and their production (ZEISS & MURRAY) in document form, and 70,000 are in the online file (KISSMAN & WEXLER, 1985). The act, passed in 1976, tries to control the use of any chemical that "presents an unreasonable risk of injury to health or environment" (KISSMAN & WEXLER, 1985). This has led to the construction of a number of industrial information systems, examples of which are cited here. In 1983, chemical compounds were registered with Chemical Abstracts Service at the rate of about 70 per hour. Chemical companies will have to depend on toxicology databases to learn about possible health hazards associated with these chemicals in the workplace (BRANSFORD). A system for retrieving toxicity data at a pharmaceutical company is reported by SHER ET AL. The Toxic Substances Control Act Section 8(E) requirements were standardized and are described by VOGT & KERFOOT.

Articles about toxicology and safety and online sources of toxicology and safety data are presented by PAGE & KISSMAN, CIPRA & DAMRON, and BRIDGES. As with environmental information, one database does not meet the needs of toxicology. Textual information as well as chemical nomenclature and chemical structure searching are needed (BAWDEN & BROCK). Searching for carcinogenic properties of chemicals is discussed by EGER, who considers the problems in determining which chemicals are carcinogens. The complete information necessary for carcinogen identification is available only for a few chemicals.

Toxicity information is also found at the Food and Drug Administration. The Good Laboratory Practices Regulations are discussed with the focus on examining computerized data collections and reporting (D. TAYLOR).

A Hazardous Materials Technical Information Center was established by the Defense Logistics Agency in June 1982 to provide a central location with

information on handling, storage, transportation, and disposal of hazardous materials at army installations. Information received from government suppliers is stored and distributed quarterly on microfiche. The operation of the center is described by APPLER ET AL.

The U.S. Army Corps of Engineers Construction Engineering Research Laboratory has developed the Environmental Technical Information System (ETIS) to provide army installations with compliance information on the use, transportation, and disposal of hazardous materials. ETIS provides five interactive hazardous materials management systems, which are operational and a number of experimental systems. A subsystem, TRACKER, compares procurement to a database of known hazardous materials. TRACKER identifies locations on army bases where hazardous materials are stored (MESSENGER).

The Environmental Chemicals Data and Information System (ECDIN) stores data on any chemical compound that is produced in quantities of over 500 kg. per year, whether it is harmful or not. The database, which started with 5,000 chemicals, is in English. ECDIN was expanded by adding chemicals of interest to the Brussels Customs Union, adding the 1976 published edition of Registry of Toxic Effects of Chemical Substances (RTECS), the BIOKON "black list" of chemicals, the SRI Directory of Chemical Producers in western Europe, and substances from the European Core Inventory. ECDIN now has about 65,000 compounds listed by name and substance identity number. ECDIN was moved from the European Communities computer center in Ispra, Italy in July 1983 to the DATACENTRALEN time-shared system in Copenhagen, Denmark (HUSHON ET AL.).

The National Institute for Occupational Safety and Health (NIOSH), a research agency, developed the RTECS database, which contains toxicity data, and the National Occupational Hazard Survey, which has data on potential worker exposure to chemicals. NIOSH used these databases to relate potential health risks of industries and occupations (PEDERSEN ET AL.). NIOSH produces the Occupational Safety and Health database, file 161 on DIALOG (*CHRONOLOG*).

The major waste disposal issue at present concerns hazardous waste disposal. The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, known as Superfund, was passed in response to the uncontrolled hazardous chemicals at numerous waste disposal sites throughout the United States, which threatened public health and the environment. The act created a $1.6 billion fund for cleaning up these locations. The parties responsible for the hazardous conditions must either clean up the areas themselves or reimburse the government for cleaning them up.

Although tracking systems have been developed, they are not considered adequate to oversee and enforce the cleanup action. (U.S. GENERAL ACCOUNTING OFFICE, 1984). This indicates why most of the waste disposal information systems of the 1980s involve hazardous materials and overlap with toxicology information systems.

Another report contends that the hazardous disposal site inventory is incomplete (U.S. GENERAL ACCOUNTING OFFICE, 1985). As a result of these requirements a database was compiled of hazardous waste generators and disposal facilities (DIETZ ET AL.). The United States army has incorpo-

rated toxicological data and pathways for human exposure into models to estimate contaminant levels of discontinued chemical agents such as explosives or pesticides on army land. Before this land can be sold to nongovernmental organizations, the government must determine whether residual pollution of either water or land exists. A procedure was designed to estimate such pollution limits (SMALL).

A chemical fate database has been developed by EPA to determine chemical transport and decomposition when the chemical enters the environment. Called the Environmental Fate Data Base, it consists of three files that are cross referenced for each chemical database. One file contains the chemical dictionary information with name and CA registry number; the second file contains data taken from the primary literature; the third file contains a full citation of the article from which the data were taken. Reports can be made for 22 data types, or chemical dynamic properties, transport properties, laboratory decomposition, field studies and monitoring (HOWARD ET AL., 1982).

A section in HAMMOND ET AL. describes primary and secondary information on waste disposal. A comparison of coverage of ocean waste disposal is presented by DUEDALL. A search of NTIS, Chemical Abstracts, Pollution Abstracts, and Enviroline showed that Enviroline and Pollution Abstracts contained more citations on that subject than did Chemical Abstracts. NTIS contained twice as many citations as the environmental databases because it cites government research reports.

Land and Aquatic Resources

Agriculture, forestry, and land use. More information is collected about agriculture and forestry than about any other economic sector. The information concerns mainly economic production rather than environmental effects of this production (CONSERVATION FOUNDATION, 1982). The environmental degradation caused by soil erosion, agricultural runoff, and wetlands conversion threatens agricultural productivity.

The U.S. Department of Agriculture has one of the most effective research, information, and extension programs. Agricultural information systems are at the leading edge of technology. Agricola was one of the first online word-oriented databases made commercially available. Present agricultural databases reflect the need for site-specific information to meet the needs of preserving land and upgrading land productivity. Remote sensing is used to study land cover such as vegetation and forests. Numerous land classification systems are being proposed and evaluated, illustrating the need for combining location, soil type, biology, and climate into one name to describe an area. Geographic and integrated information systems are being developed in agriculture. Modeling studies are increasing as well, indicating the trend toward using existing data to forecast the future.

A valuable addition to the Department of Agriculture's reference tools is a directory of 428 agricultural databases or database systems (WILLIAMS & ROBINS). This directory has four indexes: database name, subject, producer,

and processor (vendor). It covers all agricultural interests from animal to weather. Twenty databases are listed under environment, but pollution and life sciences add many more to the list.

A thorough study of Agricola, CAB Abstracts, BIOSIS, and SciSearch was done by BROOKS. All four databases were compared by citations retrieved from specific journals on each database, timeliness, subject coverage, agricultural literature coverage, citation overlap, category codes, descriptors, and search strategies. The limitations and strengths of each database are discussed. Coverage of agricultural information was studied by LONGO & MACHADO to determine duplication among CAB Abstracts, Agricola, and the International Information System for Agricultural Sciences and Technology (AGRIS) database produced by the Food and Agriculture Organization. The duplication rate of periodical titles was 10.01%. The distribution of periodical titles was studied both by country and by continent, noting that participation by developing countries was low. These authors recommended obtaining CAB Abstracts, Agricola, and AGRIS in that order if databases could be acquired only one at a time.

A database that was built to cover environmentally safe new organic chemicals contains two files (ROYCE ET AL.). One file is bibliographic, and the other is an effects file containing chemical names, plant species names, and experimental design information. The database was designed to be compatible with the NIH-CIS system and to be capable of being linked through CA Registry Numbers to the Structure and Nomenclature Search System. SINGER describes a database covering contamination in food and agricultural products in the United Kingdom, that combines manual and computer files.

A microcomputer system was devised for assembling soil survey data in Pennsylvania for soil mapping and interpretation. The microcomputer assembles soil survey data into digitized soil maps and interpretive records. Answers to soil survey questions may be obtained in tabular or graphic display format (CUNNINGHAM ET AL.). Land use and land cover information compiled by the U.S. Geological Survey was used in air quality planning in the Norfolk, Va. area. This information is used for estimating emissions, diffusion, and impact patterns of sulfur dioxide and particulates. REED & LEWIS identify the types of land use and land cover information needed to evaluate air quality control strategies.

Coordination of data on soils, fertilizers, erosion, drainage, and crop yields can be used directly or integrated with submodels or models to provide management information to farmers and researchers (SHAFFER ET AL.). Minnesota has developed a database on land use, zoning, land ownership, geology, soils, forest cover, water, and highways for use in making land management decisions (HICKS). The U.S. ARMY CORPS OF ENGINEERS has compiled a directory of computerized flood plain management data.

Fish and wildlife, ecology, parks, and endangered species. After air, water, and waste disposal became regulated, other environmental values were recognized, among them the preservation of open space, archeological and historic areas, esthetic sights, quiet areas, and endangered species. Protection of these interests requires enormous amounts of information and data. In-

corporating all known information into one environmental information system may be counterproductive and hinder decision making (JENKINS). Federal responsibilities for freshwater fisheries, wildlife, and endangered species are generally focused in the Department of Interior, but state governments are very active in this area.

The U.S. National Science Foundation has supported data management at field stations for long-term ecological research by sponsoring workshops that provide opportunities to discuss common problems and fostering cooperation with the goal of system compatibility. The problem of collecting, recording, and managing ecological data was addressed at a workshop (SINCLAIR). MORSE & HENIFIN bring together the results of a symposium on data organization with respect to geography for the purposes of rare plant conservation and better habitat maintenance. This compilation of papers also contains one on finding rare plant information in the literature (CROVELLO) and a talk on the first phase of the Natural Heritage database. The changes in philosophy in gathering information for this database on threatened or endangered plants and animals improved decisions on selecting areas for protection by the Nature Conservancy (JENKINS). This association has a bimonthly newsletter, *The Nature Conservancy News*.

The National Park Service has developed a bibliographic database for archeological reports that can be used to process environmental impact statements. The system has two other databases, a research and/or contracts database and a catalog of databases needed to keep track of archeological sites and artifacts (*GOVERNMENT COMPUTER NEWS*).

KESSELL ET AL. developed PREPLAN, a Pristine Environment Planning Language and Simulation for the management of natural resources in two conservation areas in Australia. PREPLAN includes a management database with modules for predicting site-specific vegetation, fuels, animals, fire behavior, and fire effects. PREPLAN was developed specifically to provide available information and understanding on ecosystems to managers and to encourage additional research projects. A geoecology database that integrates information on soils, geology, vegetation, agriculture, forestry, and endangered species was developed by OLSON ET AL. It was prepared for use at the county or subcounty level in order to enable regional studies. An ecological database designed using the Data Base Management System 1022 for biological species distribution in Antarctica is described by MARION EDWARDS.

A database for summarizing fish and wildlife species distribution and habitat data for Pennsylvania was built by MASON ET AL. using species data in the literature and other states are developing the same type of database for their fish and wildlife species. CUSHWA delivered a paper on fish and wildlife information needs and availability. He described the institutional and biological complexities of the resource and the difficulties of finding complete data about a species or group of animals. Another database used for writing environmental impact statements, called RUNWILD, provides Arizona and New Mexico wildlife and habitat information (LEHMKUHL & PATTON). The U.S. Fish and Wildlife Service has also developed a database called The Plant Information Network (PIN). It contains information on over 5,000

plants native to Colorado, Montana, North Dakota, Utah, and Wyoming. This information was meant to be useful in planning for land reclamation after resource development in the western United States. The report by DITTBERNER & OLSON contains the entire database. WHITWORTH ET AL. report that information is required to solve resource problems. In this case the resource relates to fish communities. They describe the River Reach Fisheries Information System that assists in monitoring the condition of fish and wildlife habitats. Now managed by the Fish and Wildlife Service, it was developed for EPA to assess the water quality using biological data.

The U.S. Fish and Wildlife Reference Service provides two databases: one contains Current Federal Aid Research, which includes state fish and wildlife research-in-progress; the second includes indexed reports, papers, technical publications, theses, and special materials. Both are available on DIALOG (*FISH AND WILDLIFE REFERENCE SERVICE NEWSLETTER*).

Water resources and water quality. Water is one of our most abundant and critical resources. News of decreasing groundwater tables, toxic chemicals in drinking water, surface-water pollution, and disintegrating municipal water systems are common. The federal government has spent $37 billion during the past ten years for water pollution control, mainly for sewage treatment plants (S. DAVIS). Water research programs exist in federal and state agencies, state water research institutes, and the private sector.

Water data and information systems have proliferated for many years, and several conferences have been devoted to this topic. The proceedings of the most recent conference, held at Cornell University in 1980, provides a good overview of the field (MCELROY). Nevertheless, efforts are being made to improve water information transfer. Under Public Law 98-181 the Council on Environmental Quality sponsored studies of the feasibility of establishing a National Water Resources Research Center and "defining and planning" a National Clearinghouse for Water Resources Information. A report for the U.S. COUNCIL ON ENVIRONMENTAL QUALITY (1984) by the Chesapeake Research Consortium proposes new options for improving information management among existing institutions concerned with water research.

Water research is usually communicated through scientific and technical journals. Over 100 U.S. journals are directly concerned with water, and many other journals contain articles on water. A bibliometric study of environmental and civil engineering journals derived from 5,065 articles from 52 journals taken from the 1977 *Science Citation Index* shows that water systems are the central theme linking civil engineering and environmental engineering (MIYAMOTO & NAKAYAMA).

Given the number and diversity of water-related primary information sources, it is no wonder that there are many secondary services that cover water studies. The water databases Aqualine, Aquatic Sciences and Fisheries, Oceanic Abstracts, Selected Water Resources Abstracts, Waternet, and Waterlit were reviewed by DUELTGEN (1982) for chemical information. A study comparing retrieval from Aqualine, BIOSIS, CA Search and PASCAL using the European Space Agency information retrieval system was done by DE JONGHOFMAN & SIEBERS. The authors also compared manual searches on the same subjects. Finding biomedical information in Waterlit and Selected

Water Resources Abstracts, in this case related to acid rain, was compared with retrievals in BIOSIS by BRUCE.

The Selected Water Resources Abstracts database is produced by the Water Resources Scientific Information Center (WRSIC) of the U.S. Geological Survey. WRSIC adds about 15,000 records each year. WRSIC was created in 1966 as a result of the Water Resources Research Act of 1964 (Public Law 88-379 as amended), which directs the Secretary of Interior to make information available on those water research projects completed, in progress, or planned as well as publications of the State Water Resources Research Institutes (JENSEN & PAGE). The State Water Resources Research Institutes were also established under the same legislation. Information transfer among and by water institutes is discussed by GILL & WALKER.

In 1964 the Bureau of the Budget (now Office of Management and Budget) issued Circular A-67 to coordinate water data collection and acquisition in the federal government. The U.S. Geological Survey (USGS) was given responsibility for this activity (WARD). MELVIN EDWARDS (1983; 1984) describes the USGS's National Water Data Exchange Network (NAWDEX), the National Water Data Storage and Retrieval System (WATSTORE), the National Water Use Data System, and the National Ground Water Site Data System.

STORET is an EPA water quality data system that cooperates with NAWDEX but is maintained separately. Procedures for joining the STORET network and its user support services were discussed by CONGER. Data taken by states and other organizations to monitor water improvement and to meet the quality standards of the national permit program, called the National Pollutant Discharge Elimination System (NPDES), store and retrieve their data on STORET.

BUFFINGTON ET AL. described CEQ's UPGRADE system. UPGRADE integrated water quality data, air quality data, health, demographic, land use, and other data. UPGRADE was designed as a tool for analyzing water quality conditions and trends. The system is no longer in existence, but it was a prototype geographic information system, which is discussed later in this chapter.

State information systems are represented by Texas and New York. BASKIN described the development of the Texas Natural Resources Information System (TNRIS) from its origin as the Texas Water Oriented Data Bank. The services, costs, and access capabilities to over 300 automated Texas information systems were reported. User education programs and remote sensing applications were mentioned. MAYLATH indicated the differing state requirements by describing New York State's four water-data systems designed to meet their Environmental Conservation Law mandate. The National Pollutant Discharge Elimination System (NPDES) led to the development of a computerized system to compile information about 8,000 companies that discharged waste in New York State because they needed permits. Information is also used for permit revocation, water pollution investigations, water quality surveillance, research, and cooperation with other state agencies.

A look at Canadian water and environmental databases was presented by HEYWORTH. The Water Resources Document Reference Center (WATDOC)

is in the Inland Waters Directorate of the Canadian Department of the Environment. WATDOC produces three online databases: Canadian Environment (English language), Environnement (French language), and D-Ref. The first two databases are references to literature; the third contains referrals to numeric data. The databases are available on a Canadian online system, QL Systems Limited.

Oceans and Atmosphere

Ocean information systems and services. The critical role of the oceans as a multiple-use resource and a dominant factor in world climate entered the public awareness in the 1960s, despite the fact that systematic observation of tides and currents dates to the 18th century and modern oceanography and fisheries research dates to the 1870s. By the late 1960s, when a consolidation of federal ocean research and services activities was under study by a presidential commission, data and information services figured strongly in the needs that were considered (U.S. COMMISSION ON MARINE SCIENCE, ENGINEERING, AND RESOURCES). Ocean information services reflect the heterogeneous, multidisciplinary nature of the missions they serve. Some attempt to cover all aspects, while others concentrate on specific topics such as fisheries, marine pollution, transportation, minerals, and oceanography.

As yet no comprehensive guides have appeared, but the Unesco Intergovernmental Oceanographic Commission is compiling a handbook of marine information resources that may be published by early 1987. Guides to specialized areas have appeared. GARFIELD (1980) surveyed the literature of marine biology, identifying core journals and estimating the size of the literature. BARNETT (1982) has provided an excellent guide to the periodicals for marine affairs (ocean policy studies). A thesis by C. FREEMAN, now somewhat dated, appears to be the only attempt at a systematic analysis of the literature of oceanography. ARDERN, A. MYERS, and WHITTICK have published guides to marine technology information services. A handbook on federal marine pollution data and information systems and services has been published by the Ocean Pollution Data and Information Network (U.S. NATIONAL OCEANOGRAPHIC DATA CENTER, 1985), while the literature of marine pollution is the subject of a paper by MOULDER.

The ocean-related literature is covered by a broad range of secondary information services. Thus, marine librarians and others have found it necessary to use many databases, varying their choice according to individual requests (BEARDSLEY).

Three abstracts journals, two with equivalent online databases, specialize in marine literature. These are *Aquatic Sciences and Fisheries Abstracts* (*ASFA*), which attempts comprehensive worldwide coverage, *Oceanic Abstracts* (*OA*), which covers mainly English-language sources, and *Oceanographic Abstracts*, a section of the journal *Deep Sea Research*, which provides abstracts of peer-selected articles of highest quality research. S. STARR studied the coverage and indexing policies of *ASFA* and *OA*, comparing them with the BIOSIS database for biological oceanography and the GEOREF

database for geological oceanography. Other papers on marine bibliographic databases have been published by ADAMS & WALTER, BUETTENKLEPPER & VERDUGO, JUNEAU, and SEARS.

Many special libraries have been created to support marine research centers. The International Association of Marine Science Libraries and Information Centers (IAMSLIC), founded in 1975, now publishes an annual conference proceedings (GRUNDY & FORD). BARNETT (1984) reported on a survey of marine science libraries. A special document center was established to provide a permanent source of the published results of the National Sea Grant Program (EDEL & BARNETT).

Many different specialized data and information programs have been created to serve the needs of marine science and technology. A general survey of U.S. and international systems is given by WHEELAND. The work of the Intergovernmental Oceanographic Commission in coordinating and spurring the development of ocean data and information services is covered under the "International" heading in this chapter. Southeast Asia and the western Pacific region have been especially active in establishing marine (particularly fisheries) information programs during the 1980s; two collections of papers provide a wealth of information about these and other international programs (*ICLARM NEWSLETTER*; SOUTHEAST ASIA FISHERIES DEVELOPMENT CENTER).

Largest and best known among data centers is the National Oceanographic Data Center. ABRAM provides a good description of the center's products and services. A thorough user's guide is also available (U.S. NATIONAL OCEANOGRAPHIC DATA CENTER, 1984). As in other environmental sciences and programs, the users of oceanographic data are facing the problem of how to manage the projected large volume of data from satellites that monitor the ocean. A first approach to this problem is the NASA Ocean Data System (NODS, known as the Pilot Ocean Data System (PODS) until late 1985) (BROWN & MILLER; KUYKENDALL & ZION).

Special information services have been established in recent years to meet needs for marine pollution data and information (K. HUGHES) and marine resource assessments (EHLER & BASTA). CRANE describes the concept of a user-funded joint federal/state marine information center. The expanding uses of the ocean environment combined with increased assertion of law, regulation, and management plans point toward the continued creation of specialized information services to meet new needs.

Charting and navigational aids are found in NOAA's *National Ocean Service Product Information Guide*, which is delivered in a looseleaf notebook with provisions for updating. The guide is divided into sections such as geodetic services, oceanography, marine charting, aeronautical charting, coastal zone management, and marine operations for easy reference (U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 1984).

Weather, climate, natural hazards, and emergencies. The need for improved access to climatic data and information led to the passage of the National Climate Program Act of 1978 (Public Law 95-367). Congress found that: "(1) Information regarding climate is not being fully disseminated or used;

(2) the U.S. lacks a well-defined and coordinated program in climate-related . . . information utilization."

Following the passage of this law, several reports (U.S. NATIONAL ACADEMY OF SCIENCES. NATIONAL RESEARCH COUNCIL. CLIMATE RESEARCH BOARD, 1979) emphasized the need for improved access and referral to sources of climatic data and information. They expressed the necessity for continued geographic coverage to be ensured by the federal government and sought a means to ensure the reliability of climatic data. Systems for storing and retrieving this information were essential because the cost of managing the information was small compared with the cost of collecting the data. The Climate Research Board continued to call for the implementation of the National Climate Program Act (U.S. NATIONAL ACADEMY OF SCIENCES, NATIONAL RESEARCH COUNCIL, CLIMATE RESEARCH BOARD, 1982). A Climate Data Management Workshop held in Harper's Ferry, West Virginia, in 1979 brought managers and researchers together to produce a core climate data inventory. The resulting cooperation led to a publication and eventually the NEDRES database, mentioned earlier. Two compilations of climate data descriptions have resulted from the database (U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, 1983).

An excellent survey of the sources of climate data is given by JENNE & MCKEE. In the same volume, RIGBY (1985) provides a guide to books and journals, and R. TAYLOR summarizes research centers and libraries in meteorology and climatology.

The National Climatic Data Center (NCDC) of NOAA is the most important archive and distributor of the actual data (HATCH). The application of NCDC weather and climate information to model energy demand, to explore and develop fossil fuel sources, and to improve electric utility operation are discussed by QUINLAN.

Satellites have become the vehicle for aiding more accurate weather forecasting and providing a wealth of climatic data, but they pose a problem because they collect an enormous volume of data. NEEDHAM reports how a satellite data information center operates and handles this array of digital and photographic information.

Information is vital in dealing with disasters and emergencies and the ensuing property damage and economic disruption. The Subcommittee on Investigations and Oversight of Congress recognized the need for using modern information technology in responding to emergencies (U.S. CONGRESS. HOUSE. COMMITTEE ON SCIENCE AND TECHNOLOGY). Major information technologies were examined in the light of nine types of disasters: hurricanes, earthquakes, floods, tornadoes, volcanoes, hazardous material spills in transit, nuclear power plant accidents, boating and aircraft emergencies, and terrorism. Maintaining central telecommunications, decreasing vulnerability of computer systems to disasters, and national security issues were those the government could address in legislation.

The Natural Hazards Research and Applications Information Center was established at the Institute of Behavioral Science, University of Colorado (Boulder) with funding by a number of federal agencies. The center produces

a monograph series, special publications, bibliographies, inventories, and a newsletter, the *NATURAL HAZARDS OBSERVER*. An inventory of data resources for natural hazards covers data collected by the federal government and quasi-official agencies (LANDER ET AL.).

Energy and Environmental Information

Energy and environmental information are closely linked at all stages: exploration, extraction, production, and consumption. This section reviews those energy-related environmental information papers published since the *ARIST* chapter by COYNE ET AL. in 1983 on "Energy Information Systems and Services" and those not cited in that chapter. NEUFELD & CORNOG produced a general guide to energy and environmental sources.

The Department of Energy (DOE) research laboratories develop information products that help assess the use of energy and its impact on the environment. An inventory of environmental databases, graphics packages, and models at DOE laboratories was compiled by SHRINER & PECK. This inventory resides at Oak Ridge National Laboratory. A database of information on cooling system impacts on aquatic environments was developed for the Electric Power Research Institute at Oak Ridge National Laboratory (HANNON & CARRIER). Final studies on database development integrating biological and nonbiological data for extrapolation and analysis of thermal cooling water data at electric power plants was reported by ECOLOGICAL ANALYSTS, INCORPORATED. Regional studies of environmental and health impacts from different energy sources were addressed by OLSON (1982). Olson also compares the approaches to regional integrated systems, UPGRADE, DIDS, SEEDIS, and Geoecology and notes a benefit of the regional system for studying long-range transport and long-term effects of emissions. *Spatial Data*, mentioned earlier, provides geographic coverage for various energy-related data (COPENHAVER & BARKER).

The Surface Mining Control and Reclamation Act (SMCRA) of 1977 required that stripmined land be returned to its original productivity or contour and that a fund be established to reclaim abandoned mined lands. The act mandated a national data and information center to furnish materials, publications, and research reports about surface mining and reclamation. In addition, SMCRA directs that a cataloging center be created to coordinate information on research.

Many of the databases of the Fish and Wildlife Service were begun as a part of that agency's concern with coal mining. The offering by MASON ET AL. is an example of a publication that was developed for preparing environmental impact statements for coal mining.

Information services have been prominent in supporting the environmental studies related to offshore oil and gas production. ARDERN produced a sourcebook for offshore oil and gas deposits in the United Kingdom. The Minerals Management Service of the U.S. Department of the Interior is responsible for leasing offshore oil. Environmental studies have been in process in the Gulf of Mexico in conjunction with the leasing. The Minerals Manage-

ment Service, Gulf of Mexico OCS Region, has provided a forum for information exchange annually since 1980 (U.S. DEPARTMENT OF THE INTERIOR. MINERALS MANAGEMENT SERVICE).

INTERNATIONAL ASPECTS OF ENVIRONMENTAL INFORMATION

The 1960s brought the realization that the oceans, the atmosphere, and the rivers of the world served to transport the waste products of one country into the air and water of others. Because these problems were occurring in numerous countries, it was recognized that international sharing of information and development of standards could lead to more rapid solutions.

Two recent volumes, taken together, could serve as a compact information system for the world environmental and natural resources situation. *World Resources 1986* summarizes data on all aspects of the resource base supporting the global economy (WORLD RESOURCES INSTITUTE; INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT). CALDWELL (1984) provides an encyclopedic survey of the thousands of programs devoted to worldwide protection and improvement of the environment. Although international programs for cooperation and sharing of environmental services date to the late 19th century with the founding of the International (now World) Meteorological Organization, most of the environmental programs Caldwell describes originated in the past 25 years.

The watershed event that crystallized much of the developing international environmental concern was the U.N. Conference on the Human Environment, held in Stockholm in 1972. This conference produced 109 resolutions calling for international action. Many of the resolutions dealt with increased sharing of information and the establishment of new information services (UNITED NATIONS).

Along with the widespread recognition that large-scale environmental problems, such as deforestation, drought, and toxic chemicals, require coordinated international action has come the need for better anticipatory information. A 1984 conference of high-level environmental policymakers (WORLD RESOURCES INSTITUTE) called for substantial improvements in systems for assessing environmental conditions and trends and for the dissemination of the results. The conference urged that governments:

- Agree on environmental indicators and standard geographic information systems to be used by international organizations.
- Fully develop the Global Environmental Monitoring System (GEMS: see below under "U.N. Environment Programme") to track major changes in the earth's environment and resources.
- Spur the development of computer applications to permit local, regional, and national governments to make use of international environmental databases.

A second trend toward the development of international institutional arrangements emerged with the need to allocate rights to the use of the re-

sources of the world's oceans. This led to international research and information-sharing programs in fisheries, oceanography, and marine pollution and finally to the Law of the Sea negotiations and treaty.

In April 1982, after years of negotiations, the third U.N. Conference on the Law of the Sea (UNCLOS) approved the Law of the Sea Treaty. Although the treaty is still in the process of ratification and some major nations, including the United States, may not approve it, its extensive implications for the collection, analysis, and dissemination of environmental information make its discussion worthwhile.

Analyses published by the Unesco Intergovernmental Oceanographic Commission (UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, 1982; 1985c) show that no fewer than 11 articles in the treaty deal with the publication and dissemination of marine scientific and technical information. ROSS & KNAUSS provide a thorough analysis of the treaty provisions that deal with marine research, some of which are the most significant for determining future information flow.

From the beginning the questions of the use of scientific information in international environmental policymaking have paralleled those in the national area: who should collect, analyze, and disseminate information to whom? In numerous cases U.N. agencies have taken the lead.

International Organizations

U.N. Environment Programme. Probably the major outcome of the Stockholm Conference was the creation of the U.N. Environment Programme (UNEP). Recognizing the extensive number of environmental programs already in existence, UNEP was mandated to carry out its mission by working through other international agencies to the greatest extent possible. Nevertheless, UNEP has created and sustained some information programs of its own.

UNEP's Global Environmental Monitoring System (GEMS) program is a unique concept for monitoring and reporting on the state of the environment. Using only "seed money" from UNEP's Environment Fund, GEMS seeks to attract funds from other organizations to establish an international set of environmental databases covering climate, atmospheric transport and pollution (acid rain, ozone depletion, carbon dioxide), renewable natural resources, oceans, and pollution/health relationships (GWYNNE; READER).

As a response to the need to have integrated, geographically referenced data, UNEP is now developing the Global Resources Information Database (GRID) (CROZE ET AL.; FANSHAWE; THACHER). GRID will use geographic information system software (see the section below on "Current and Future Trends in Environmental Information Systems") to compare and assess diverse data sets for management and policy studies.

Infoterra is UNEP's international referral service to sources of environmental information. This program established national focal points in each of 110 countries and is responsible for compiling national inventories of information sources and for helping users find relevant sources. A directory of over 8,500 sources, covering 79 countries, has been published. Infoterra was

developed as one of the first priorities of UNEP as a result of recommendation 101 of the Stockholm Conference (MARTYN).

The International Register of Potentially Toxic Chemicals (IRPTC) (HUISMANS) was established in UNEP to provide a global early warning system of undesirable effects and to encourage the development of standards and controls. IRPTC disseminates information through its *IRPTC Bulletin* (UNITED NATIONS ENVIRONMENT PROGRAMME, 1982a) and a series of data profiles (UNITED NATIONS ENVIRONMENT PROGRAMME, 1982b).

Intergovernmental Oceanographic Commission (IOC) of Unesco. IOC has for many years fostered the development of national oceanographic data centers and arrangements for the exchange of oceanographic data among nations. Since the Stockholm Conference and increasingly since the conclusion of the UNCLOS, IOC has broadened its activities to include a wider range of information services (MILES). IOC also maintains a Marine Environmental Data Information referral service (MEDI), which publishes a data catalog (UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, 1985a). As part of a comprehensive plan for marine science and ocean services development, IOC has outlined plans to promote better publication, documentation, and information retrieval services (UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION, 1985b).

Food and Agriculture Organization of the United Nations. FAO has become one of the leading international organizations in the dissemination of information on environmental and renewable natural resources. FAO services grew from both internal systems designed to support other program goals and from the use of FAO as a vehicle for international cooperation.

AGRIS, an international information system for agricultural sciences and technology, is a cooperative bibliographic system with 117 national centers that cover the literature published in their countries (UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION, 1984). AGRIS contains a significant section on natural resources and environment. MANN describes the relationship of AGRIS to the International Association of Agricultural Librarians and Documentalists and to other major agricultural information services operated by the U.S. National Agricultural Library and the Commonwealth Agricultural Bureaux. The Current Agricultural Research Information System (CARIS), a companion system for research in progress, is also being developed (UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION, 1985).

FAO also has developed data and information services for world fisheries. The Aquatic Sciences and Fisheries Information System (ASFIS) is a cooperative international information service of FAO, IOC, the United Nations, and 12 countries (CAPONIO; UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION, [n.d.]).

World Meteorological Organization (WMO). The systems of WMO for worldwide exchange of weather data are the oldest example of formal scientific cooperation and data exchange through an international organization. Today, in addition to facilitating data exchange, WMO organizes research and

training programs and promotes the application of climatic data. Examples of the World Climate Data Programme's view of the uses of climate information are provided by EDDY.

Environmental Information in Developing Nations

Many developing countries face the dilemma posed by the imperative to industrialize to provide employment, food, and capital to sustain growth while minimizing dangers to public health and long-term ecological damage. Others experience severe environmental degradation as the result of traditional practices or from climatic factors. This situation is the context for a brief book by VIEIRA, which is remarkable for its breadth of coverage and depth of insight into the political and ideological surroundings of environmental information systems in developing countries. She concludes that activist environmental information specialists and librarians can make a difference in their country's progress away from environmental degradation and poverty. DOSA (1980) describes the role of information systems in supporting ecologically sound development.

CURRENT AND FUTURE TRENDS IN ENVIRONMENTAL INFORMATION SYSTEMS

Developments in the sources and types of environmental data and the means available to process, analyze, and display these data are beginning to make dramatic changes in environemtnal information systems. Specifically, information systems based on or incorporating remotely sensed data, image processors, and geographic information system software promise to revolutionize the availability of environmental information. A fourth new technology, artificial intelligence (AI), also will clearly play a role in the implementation of the new systems and their user interfaces. Each of these technologies is already generating its own massive literature; this chapter on environmental information can suggest only a few sources.

The use of earth satellites for environmental monitoring began in 1960 with the first TIROS meteorological satellite (P. HUGHES). Now satellites for observation of land, ocean, freshwater, and the atmosphere are operated by the United States, France, Japan, India, and the Soviet Union. The current status of U.S. operational environmental satellites, including information about the availability of the resulting data, is given by the U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (1985).

The economic benefits of environmental satellites for many different applications have been well documented (HUSSEY). Nevertheless, a recent summary of the status of U.S. remote sensing programs (U.S. NATIONAL ACADEMY OF SCIENCES. NATIONAL RESEARCH COUNCIL. COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS) concludes that policy and institutional issues have caused a crisis in the program. One of the major issues is whether private companies should take over (privatize) the

operation of satellites and associated data archives. The question of the government's responsibility to maintain and make available a permanent archive of data from the Landsat satellites has been addressed by the U.S. NATIONAL COMMISSION ON LIBRARIES AND INFORMATION SCIENCE and some of the commission's recommendations were incorporated into Public Law 98-365, the Land Remote Sensing Commercialization Act of 1984.

The significance of environmental satellites lies in their ability to provide data for resource management, services, and research that were not readily available through earlier monitoring capabilities (ALLAN). Many aspects of the environment are large in scale and change relatively rapidly. Thus time-series data are needed, with frequent observations made over large areas of the earth's surface. Applications for land and water resource management are described by HARDY, for ocean studies by APEL, for agriculture by YATES ET AL., for long-term ecological research and estuarine sanctuaries by KLEMAS (1986), and for disaster monitoring and early warning by KRUMPE. Satellite data also play an increasing role in discussions of technology transfer to developing countries (SZEKIELDA). KLEMAS (1981), for example, advocates that the United States make a concerted effort to promote developing-country use of these data for marine resource development.

A constant stream of new applications of environmental satellite data is being presented in journals and conferences devoted to remote sensing. In particular, readers interested in keeping up with this field should become familiar with the proceedings of six regular conferences (most recent available volume cited for each): 1) CENTER FOR EARTH RESOURCES MANAGEMENT APPLICATIONS [CERMA]; 2) the international symposia on Remote Sensing of the Environment (ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN); 3) the Pecora Symposia (INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, 1984a); 4) the joint ACSM/ASPRS conventions (AMERICAN CONGRESS ON SURVEYING AND MAPPING/ AMERICAN SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING, 1985; 1986); 5) the international conferences on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology (AMERICAN METEOROLOGICAL SOCIETY); and 6) the annual "Oceans" conferences (INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, 1984b).

The extremely high rate of data collection that characterizes environmental satellite data, eclipsing even the rapid advances in computer storage capacities, has given rise to serious concern about how these data should be managed to meet both immediate and future needs (U.S. NATIONAL ACADEMY OF SCIENCES. NATIONAL RESEARCH COUNCIL. ASSEMBLY OF MATHEMATICAL AND PHYSICAL SCIENCES, 1982). As of 1985, basic policies, institutions, and technologies for managing the data and derived information products are still under development (U.S. NATIONAL ACADEMY OF SCIENCES. NATIONAL RESEARCH COUNCIL. ASSEMBLY OF MATHEMATICAL AND PHYSICAL SCIENCES, 1985). A detailed guide to current environmental satellite data sources has been published by CORNILLON.

Applications of environmental information often involve the simultaneous use of several types of data, including both scientific and socioeconomic data. In these cases the only common point of reference is geographic location. A special class of software, the geographic information system (GIS) has been developed for the management and comparative display of georeferenced data (MARBLE ET AL.). The development of GIS has been stimulated greatly by the need to organize and use satellite data and by the development of sophisticated techniques of image processing and analysis (W. MYERS; J. STARR). MOONEYHAN gives a good overview of the principles and applications of GIS with examples of the typical mix of remotely sensed and ground-based data.

Although many GIS are designed for application to small areas, such as a city or a national park (AMERICAN CONGRESS ON SURVEYING AND MAPPING/AMERICAN SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING, 1986), their potential for use in global environmental management has not gone unnoticed. The breadth of coverage provided by satellite and surface synoptic monitoring can be combined with the historical knowledge base and the analytical aids provided by GIS to permit global information systems to be developed (R. FREEMAN, 1985; THACHER).

The application of AI techniques to GIS and remotely sensed data has already begun. CAMPBELL & ROELOFS provide and analyze probable applications. DAVIS & NANNINGA describe GEOMYCIN, a geographic expert system adapted from the well-known EMYCIN system, also providing references to other recent applications of expert system concepts to GIS. SMITH & PAZNER discuss the structure of KBGIS, a knowledge-based geographic information system. Thus, the close interweaving and the fast pace of research and development in these four technologies can be expected to have as profound an effect on our ability to use information about the dynamic environment by the end of the century as the development of improved surveying and resource inventories did for human knowledge of the static environment in the 18th and 19th centuries.

CONCLUSION

Beyond reviewing a lengthy list of publications, we hope that we have succeeded in showing that environmental information is a multifaceted field with something to hold the interest of a wide variety of individuals. It is a field without clear boundaries, drawing on the education provided by many disciplines. We have also emphasized its global character, with the impacts of population growth, industrialization, and climatic change causing most nations to recognize that they have a stake in environmental information.

Few areas can offer such scope, ranging from the basic understanding of the environment to the "high technology" of satellite remote sensing and large databases, to the making of decisions under uncertainty that can affect the lives and safety of millions, to the communication of complex ideas to grass roots citizen groups. All of these activities involve the collection, organi-

zation, dissemination, and use of environmental information. Despite the pendulum swings of popular interest and political support, environmental information is fundamental to the programs of a responsible industrial society.

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TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT

Arja-Riitta Haarala, Director of the Library

PRINCIPLES OF SUBJECT SEARCHHING: MANUAL, CD-ROM AND ONLINE TECHNIQUES

1 BACKGROUND

At the time when each year there appears nearly 100 000 serials in science and technology, there is an increasing need for efficient procedures for identifying and retrieving that reported knowledge. Since 1950's computer techniques have been applied to provide a better, and especially faster access to primary information. The increasing availability of large computerised databases has for several years served as an indicator that a greater change in providing information services is forthcoming. However, despite all promising prospects the reality is that most potential users still are non-users and they may never become users at all. In addition, the slower growth of library collections compared with that of scientific and technological information makes the libraries unable to satisfy various need of scientific and technical community.

The information to be accessed can be classified into

- bibliographic references
- full texts
- factual and numeric data.

The use of computers in searching for information has increased over recent years rapidly due to the development of telecommunication techniques. During 1980`s new technological innovations have opened up a direct access to information for environmental engineers and scientists. Personal computers with specialised software can be used by end users for information searching.

Some years ago CD-ROM techniques were introduced; databases can be bought on optical disc and searched using personal computers. The local use of databases on CD-ROM has become very popular.

2
SEARCHING FOR INFORMATION

There are some significant differences in manual and computer searching.

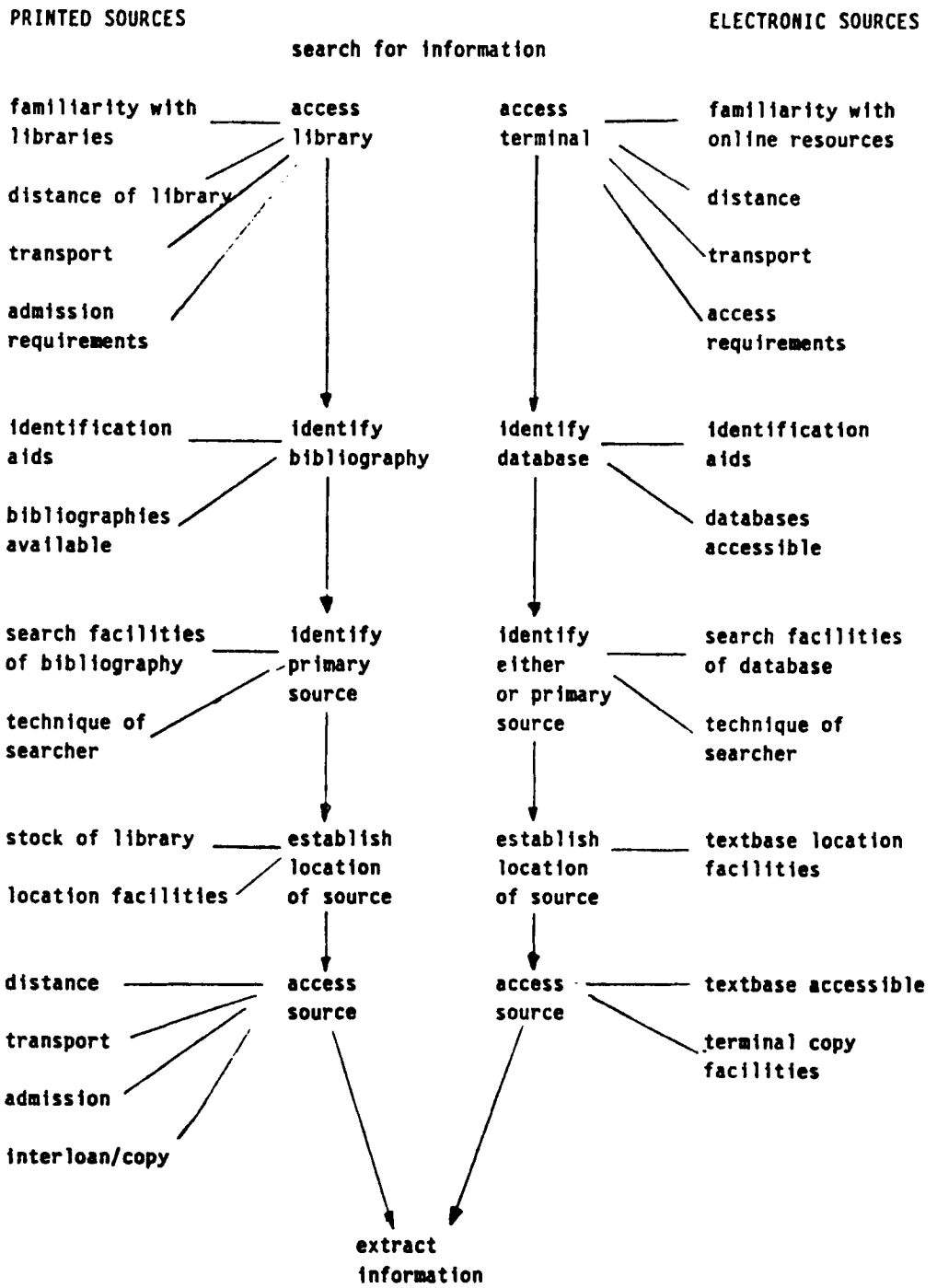

Figure 1. Searching for information in manual and online sources

3
MANUAL SEARCHING

There are different ways to locate page or pages in bibliographic information sources.

I Searching the index

An index is a systematic guide to a document. Indexes vary in several ways and provide different amounts of information.

II Searching the table of contents

III Scanning from page to page

4
COMPUTER SEARCHING FOR INFORMATION

Computer searhing is carried out either online or using CD-ROM.

There are two basic methods:

command language
menu-driven system

4.1
Hosts and systems

There are thousands of online databases available for public searching. Most wellknown host systems are:

Dialog, USA
ESA (European Space Agency), Italy
Orbit, USA
STN, USA

4.2
Command language

The growing number of information retrieval systems is available today. They vary a lot. However, an attempt is made to standardize the command language used in these systems. CCL (Common Command Language) was introduced by ISO two years ago to fill the gap.

Properties of the search systems are:

- search terms
  - free text words
  - keywords
  - subject headings
  - classification
  - other codes like language and country codes
- truncation of search terms
- wieving indexes

- searching in indexes
  - author
  - corporate source
  - source document
- use of Boolean logic
  - AND, OR, NOT
- proximity operators
- limiting of the search result
  - year
  - language
  - document type
- display of search history
- displaying of search results
  - on screen
  - printing on paper
  - as files

5
THE STRUCTURE OF THE DATABASE

The database is consisted of records which have a special structure to help the retrieval. A record consists of fields. The most general fields are

title
author
source
abstract
free indexing terms
descriptors.

6
LITERATURE

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8 Energy and the environment

John R. Luedtke

INTRODUCTION

Online literature searching on energy-related environmental issues is as diverse and complex as the subject itself. Broad, multidisciplinary subject areas must be covered. Searchers must be aware of the intricate relationships among various energy technologies, their environmental impact, and their use of natural resources. In addition, they must be aware that policy and legislative decisions at the local, state, national and international levels have a very direct impact on energy-related environmental questions. All of this is further complicated by the uneven regional impacts of the various issues. The following outline of the energy and environment labyrinth will illustrate the potential subject difficulties faced by literature searchers. It will be followed by a discussion of how searchers can approach this information.*

ENERGY-RELATED ENVIRONMENTAL ISSUES

Energy production and use are among the most important determinants of environmental quality. Current methods of fuel processing and combustion produce significant quantities of the major air pollutants. Most of the total suspended particulate and sulphur oxide emissions are produced by fossil fuel combustion (primarily coal) from stationary and transportation sources. Hydrocarbons and carbon monoxide emissions come primarily from fuels used in transportation. Radioactive emissions from nuclear power plants, though quite low under normal conditions, can have serious environmental consequences in the event of a reactor accident such as that at Chernobyl.

* This chapter is an update of a chapter on the same subject published in *Online Search Strategies*, edited by Ryan E. Hoover, Knowledge Industry Publications, 1982. Material in the Energy-Related Environmental Issues section has been taken from several reports, including: *Environmental Quality 1984: The Fifteenth Annual Report of the Council on Environmental Quality together with The President's Message to Congress* (Washington, DC: Executive Office of the President, 1984) and *Environmental Outlook 1980* (Washington, DC: US Environmental Protection Agency, 1980).

Water pollution is directly affected by effluent discharges of total dissolved solids, primarily from electric utilities; by oils and greases, primarily from petroleum refining; by heated effluents from power plants; and by chemical contamination of groundwater from leaking underground fuel storage tanks. In addition, atmospheric sulphur and nitrogen oxide emissions result in acid rain, lowering the pH of lakes as well as contributing to a world-wide decline in forest productivity. Atmospheric emissions of trace elements, particularly heavy metals, increase their concentrations in water bodies.

Coastal and marine environments receive a variety of energy-related contaminants from many sources, including land runoff *via* streams and rivers, atmospheric fallout, point source discharges, ocean dumping of dredged materials and other wastes, operational discharges from ships and offshore oil platforms, and accidental spills. Most energy-related marine pollution results from petroleum-related activities. This is almost evenly divided between offshore production, marine terminals or tanker operations, and use and disposal activities. Some of these contaminants persist in the ocean environment for long periods and are relocated through the action of currents, sediment deposition and resuspension.

Noncombustible solid wastes are an important source of energy-related pollutants. They are generated by the removal of particulates, bottom ash, fly ash and dust from combustion and production processes. Industrial sludges and spent nuclear fuel and reactor parts comprise the remainder of the environmentally significant portion of the solid waste problem.

New resources and technologies

Development of additional energy resources or alternative energy technologies also has important environmental implications. Outer continental shelf oil and gas well drilling, pipeline and supertanker projects, and new coal mining increase the chances of oil spills, pipeline ruptures, mine runoff, groundwater contamination and land degradation. Major oil shale development entails the disposal of huge volumes of spent shale which contain toxic substances that could contaminate surface and groundwaters. Wastes produced by coal liquefaction contain tars which are partially carcinogenic, requiring consideration of worker safety, handling and transportation safeguards, and combustion guidelines, in addition to waste disposal. Biomass energy production through use of wood-burning stoves generally has lower sulphur oxide, nitrogen oxide, solid waste and sludge levels than coal, but produces more total suspended particulates and is becoming a very important energy source in some localities. Solar technologies have much less direct environmental effects than either current energy practices or synthetic fuel development; however, toxic chemical discharges associated with the manufacture and construction of solar equipment and plants may offset some of these advantages.

Even energy conservation efforts, the most obvious way to reduce energy-related pollutant levels, can have significant environmental consequences. Programmes to save energy from building ventilation systems have resulted in a slower rate of air exchange and a higher degree of indoor pollution. Health hazards have been created by the use of urea-formaldehyde foam insulation in homes and by construction of more energy-efficient buildings. These measures have increased the impact of indoor air pollutants detrimental to human health such as tobacco smoke, radon decay products, carbon monoxide, carbon dioxide, nitrogen dioxide, formaldehyde, asbestos fibres, viruses, bacteria, spores, and moulds.

Water consumption

Energy-related environmental effects are not limited to pollution problems. Use of natural resources

for energy production, particularly consumption of water, is another critical environmental issue. Electric utilities account for fifty per cent of the water consumed by energy and manufacturing industries. A shift toward more nuclear power plants would increase this, as nuclear plants consume almost two and a half times as much water per kilowatt hour as conventional fossil fuel plants. Synthetic fuel plants could have a major impact on water consumption in the future since they are likely to be located in water-scarce areas where they must compete with other uses of water, such as agricultural irrigation.

Policy and legislation

Government policy as well as legislative and regulatory determinations will play an increasingly important role in energy-related environmental issues. In the United States, six major federal environmental laws which influence the way energy is produced and consumed have been established since 1976: The Clean Air Act as amended in 1977, The Clean Water Act of 1977, The Resource Conservation and Recovery Act of 1976, The Toxic Substances Control Act of 1976, The Surface Mining Control and Reclamation Act of 1977, and The Comprehensive Environmental Response Compensation and Liability Act of 1980 (Superfund). Two current energy-related laws also have environmental ramifications: The Energy Supply and Environmental Coordination Act of 1974, and The Power Plant and Industrial Fuel Use Act of 1978. Consistent with federal energy policy to promote the domestic production of energy and reduce the importation of oil, the latter two acts stipulate that coal replace oil and natural gas as fuel for new electric utilities and large industrial boilers. This will lead to sharp pollution increases, particularly in areas where oil and gas have been the primary sources of energy.

Alternative energy strategies will have different impacts on energy and environmental relationships. For example, a moratorium on the use of nuclear energy would require increased use of coal and more energy conservation efforts. This would exacerbate coal-related environmental problems by increasing plant emissions, and the discharge of total dissolved solids and solid wastes. Also, it would reduce water consumption, problems of radioactive waste disposal and the possibility of nuclear accidents. In dealing with energy and environmental concerns, policy and political trade-offs are as important as the scientific and technical aspects.

Regional impact

Geographical considerations also play a part in defining the energy and environmental picture. The goals of energy self-sufficiency and environmental quality clash most acutely in the Rocky Mountain region of the United States where much of the new coal mining, oil shale production and development of liquefaction and gasification industries is expected to be concentrated. Demographic shifts reflecting economic conditions in the Northeast are causing the closure of some traditional smokestack industries contributing to the improvement of the area's water quality, while the growing population in the Southwest is causing water supply problems there. A shift from oil- and gas-fueled utilities in the south central United States will adversely affect that region's environmental quality. In areas already heavily reliant on coal, such as the Great Lakes region, the replacement of older, coal-fired plants with newer, more stringently controlled coal-fired boilers will cause some improvement.

Long-range issues

Lastly, certain broad, long-term effects not presently regarded as immediate threats may emerge as vital issues in the future. For example, atmospheric build-up of carbon dioxide caused primarily by fossil fuel combustion may alter the earth's climate significantly and affect agricultural and coastal areas adversely. The exact amount of warming produced by a given concentration of carbon dioxide in this so-called greenhouse effect is currently unknown, but the alteration in the global air circulation pattern associated with atmospheric warming has concerned some scientists. Similar concern has been expressed about the destruction of ozone in the stratosphere, acid rain and impaired visibility or atmospheric discolouration.

From this overview, it can be seen that the boundaries to be covered in order to find information on energy-related environmental issues are far-reaching, cutting across many subject disciplines, encompassing legislative and policy matters, involving both short- and long-range scientific and technical aspects, and carrying geographic connotations. Within this broad framework, a myriad of information sources may also be required. Journal articles, conference proceedings, books, technical reports, patents, statistics, ongoing research, theses and dissertations, press releases, congressional hearings and newspaper articles are among the kinds of information needed. All of this places a huge challenge before the information seeker to identify and locate the appropriate information resources for each energy-related environmental request.

THE DATABASES

The initial problem faced by searchers is to identify the most likely databases. There are special difficulties for the searcher in this area because of the large number of databases which cover at least one aspect of energy or the environment. More than eighty different databases could be used, depending on the specific question to be searched and the type of information needed. For the most part, these databases span five online services: Bibliographic Retrieval Services, Inc. (BRS), DIALOG Information Service, Inc. (DIALOG), Pergamon InfoLine (InfoLine), STN International: The Scientific and Technical Network (STN), and Orbit Search Service (Orbit). Other services such as the Chemical Information System (CIS), Mead Data Central (LEXIS/NEXIS) and the National Library of Medicine (NLM) provide important topical files.

In order to deal with this multitude, it is useful to separate them into several groupings: the primary comprehensive databases, which contain extensive information and cover most energy-related environmental issues; the specialized subject databases, some of which contain extensive information, but are limited in subject coverage; and the specialized document-type databases, which may cover a wide range of subjects, but are limited to a specific form of literature, such as patents. Both bibliographic and complete or full-text databases can be classified in this way. While these groupings are somewhat arbitrary and may not work for every search topic, they do provide a practical approach to database selection in what would otherwise be an overwhelming maze, especially for new and relatively inexperienced searchers.

The primary comprehensive databases are suitable for most energy-related environmental topics. Included in this group are CA SEARCH, COMPENDEX (Computerized Engineering Index), ENVIROLINE, ENERGYLINE, ENVIRONMENTAL BIBLIOGRAPHY, INSPEC (Information Services for the Physics and Engineering Communities), NTIS (National Technical Information Service Bibliographic Database), POLLUTION ABSTRACTS, SCISEARCH, and the DOE ENERGY DATABASE (EDB). Each of these databases contains at least three hundred references per year on the overall subject, and many include considerably more. They each also cover most aspects of the subject. These databases are listed in Table 8.1.

TABLE 8.1: Primary comprehensive databases covering energy and the environment

NAME	PRODUCER	SEARCH SERVICE(S)
DOE ENERGY DATABASE	US Department of Energy	DIALOG,STN
CA SEARCH	Chemical Abstracts Service/ACS	BRS,DIALOG,InfoLine,Orbit,STN
COMPENDEX	Engineering Information, Inc.	BRS,DIALOG,InfoLine,Orbit,STN
INSPEC	Institute of Electrical Engineers	BRS,DIALOG,Orbit,STN
NTIS	National Technical Information Service	BRS,DIALOG,Orbit,STN
SCISEARCH	Institute for Scientific Information	DIALOG
ENVIROLINE	EIC/Intelligence, Inc.	DIALOG,Orbit
ENVIRONMENTAL BIBLIOGRAPHY	Environmental Studies Institute	DIALOG
ENERGYLINE	EIC/Intelligence, Inc.	DIALOG,Orbit
POLLUTION ABSTRACTS	Cambridge Scientific Abstracts	BRS,DIALOG

DOE ENERGY DATABASE

While any of the databases named above can provide useful results, for most searches the best file with which to start in this group is the DOE ENERGY DATABASE (EDB). It has extensive subject coverage, includes most types of literature, covers more years, is well indexed and contains the most references on the subject.

EDB coverage

The EDB is produced by the United States Department of Energy Technical Information Center, in Oak Ridge, Tennessee. It contains information published in *Energy Abstracts for Policy Analysis, Energy Research Abstracts, Solar Energy Update, Fossil Energy Update, Controlled Fusion Update, Energy Conservation Update, Geothermal Energy Update* and *Atomindex*. The broad subject coverage of EDB is shown in Table 8.2.

Started in 1974, the EDB contains material dating back to the 1800s. Older literature has been added in many subject areas to increase the comprehensiveness of the database. All types of literature are covered by the more than 1,579,000 citations in the EDB. Approximately fifteen thousand new citations are added each month. The unit record for each item has an accession number, title, author, complete bibliographic information, subject descriptors, subject categories and abstracts for all entries added after June 1976.

Indexing in EDB

The major subject approaches to the EDB are by controlled subject descriptors, subject categories or free-text searching. Descriptors are controlled by the *Energy Information Data Base: Subject Thesaurus*. Rules for assigning descriptors are given in the *Energy Information Data Base: Guide to Abstracting and Indexing:* descriptors are picked on the basis of the most specific descriptor available to identify the subject content of each document uniquely. Broader terms are added only if information of a general nature is also included in the document. A journal article on air pollution control for coal liquefaction processes would be indexed using the descriptors 'air pollution control' and 'coal liquefaction', but not the descriptor 'pollution control' unless the article also contained general information on pollution control (for example, on the economics of pollution control).

Table 8.2: Subject areas covered by the ENERGY DATABASE (EDB)

advanced automotive propulsion systems	economic and social aspects of energy technologies
biomedical sciences	explosives and explosions
safety and health	fusion energy
coal	geothermal energy
natural gas	hydro energy
petroleum	instrumentation
hydrogen	isotopes and radiation source technology
oil shales and tar sands	nuclear energy
natural and synthetic fuels	particle accelerators
electric power engineering	physical sciences
energy conservation, consumption and utilization	chemistry
energy conversion and storage	geosciences
energy policy and planning	materials
engineering	physics
environmental sciences: aquatic, atmospheric and terrestrial	solar energy
	tidal energy
	wind power

Since narrower terms in the subject thesaurus are automatically up-posted to their broader terms in a separate subject index, it is also possible to search broad concepts easily. For example, if all citations on coal liquefaction processes were required, selection of 'coal liquefaction' would retrieve all citations to which the indexer assigned the descriptor 'coal liquefaction' as well as all citations to which the indexer had assigned narrower terms listed in the thesaurus under coal liquefaction such as 'bergius process', 'costeam process', 'zinc halide process', 'fluidized bed process', etc.

Approximately three major descriptors are assigned which best represent the main content of each document. These major descriptors are linked or paired with other descriptors or qualifiers which indicate the properties, characteristics, processes or actions determined. Descriptor pairs are the most specific form of subject access to the EDB because they indicate the major emphasis of the document as well as the precise relationship between each of the descriptors in the pair. The major descriptor, 'coal mining' qualified by 'water pollution' means that the document covers water pollution from coal mining, not merely that coal mining and water pollution are both discussed. For an example of this, see Figure 8.1.

Figure 8.1: Sample EDB record

1178700 EDB – 86:133283
Theoretical technique for determining the cumulative impact of iron and manganese oxidation in streams receiving coal-mine discharge
Bobay, K.E.; Banaszak, K.J.
Geological Survey, Indianapolis, IN
Univ. Ky., Off. Eng. Serv., (Bull.) (United States) Dec 1985, 105 – 114 p.4
Coden: UKOBD
7. annual national symposium on surface mining, hydrology, sedimentology and reclamation Lexington, KY, USA 8 Dec 1985
Journal Announcement: EDB8608
Report No.: CONF – 851213 –
Document Type: Journal Article; Conference literature
Language: English
Work Location: United States
Two US Geological Survey computer programs are modified and linked to predict the cumulative impact of iron and manganese oxidation in coal-mine discharge on the dissolved-chemical quality of a receiving stream. The coupled programs calculate the changes in dissolved-iron, dissolved-manganese, and dissolved-oxygen concentrations, and the pH of surface water downstream from the discharge. First, the one-dimensional, steady-state stream water-quality program uses a dissolved-oxygen model to calculate the concentration changes as a function of the reaction rates and the time-of-travel. Second, a program combining pH, reduction-oxidation potential, and equilibrium equations (PHREEQE) uses an aqueous-ion association model to determine the saturation indices and to calculate the pH; it then mixes the discharge with a receiving stream. The kinetic processes of the first program dominate the system, whereas the equilibrium thermodynamics of the second define the limits of the reactions. A comprehensive test of the technique was not possible because a complete set of data was not available. However, the cumulative impact of representative discharges from several coal mines on stream quality in a small watershed in southwestern Indiana was simulated to determine the effectiveness and sensitivity of the coupled programs. 20 references, 5 figures, 3 tables.
Descriptors: *COAL MINING – – ENVIRONMENTAL IMPACTS; *COAL MINING – – WASTE WATER; **COAL MINING – – WATER POLLUTION*; *IRON – – CONCENTRATION RATIO; *IRON – – ECOLOGICAL CONCENTRATION; *IRON – – REDOX POTENTIAL; *MANGANESE – – CONCENTRATION RATIO; *MANGANESE – – ECOLOGICAL CONCENTRATION; *MANGANESE – – REDOX POTENTIAL; *WASTE WATER – – WATER CHEMISTRY; * WATER CHEMISTRY – – COMPUTER CALCULATIONS; *WATER CHEMISTRY – – COMPUTERIZED SIMULATION; INDIANA; MATHEMATICAL MODELS; OXIDATION; pH VALUE; QUANTITY RATIO; SURFACE MINING; US GS; WATER POLLUTION CONTROL; WATER QUALITY
Special Terms: CHEMICAL REACTIONS; CHEMISTRY; CONTROL; ELEMENTS; ENVIRONMENTAL QUALITY; FEDERAL REGION V; HYDROGEN COMPOUNDS; LIQUID WASTES METALS; MINING; NATIONAL ORGANIZATIONS; NORTH AMERICA; OXYGEN COMPOUNDS; POLLUTION; POLLUTION CONTROL; SIMULATION; TRANSITION ELEMENTS; US DOI; US ORGANIZATIONS; USA; WASTES; WATER
Class Codes: 010900*; 520200

Another very useful subject approach to the EDB is by subject categories represented by numeric codes. These are used to arrange citations in the printed indexes and are assigned according to the content and purpose of the document. Multiple categories are assigned only where neither the content nor the purpose fits a single category. Unlike with descriptors, no effort is made to categorize to the most specific level, and the purpose of the document is emphasized. Three pairs of two-digit numbers (category codes) are used to denote categories. The first two digits designate the main category, the second pair designates subsets of the first pair and the third pair designates subsets of the second pair. For instance, radioactive effluents, as an environmental aspect of nuclear reactor technology, would be assigned the number 220502; the first two digits, 22, denote nuclear reactor technology, 05 denotes environmental aspects and 02 denotes radioactive effluents. Each level is searchable, and may be combined with descriptors. A complete list of categories is given in *Energy Information Data Base: Energy Categories*. For additional details on the use of category codes, see the *Guide to Abstracting and Indexing*. Table 8.3 shows examples of representative environmental subject categories.

Table 8.3 Representative EDB subject categories

Category Code	Category Description
500000	ENVIRONMENTAL SCIENCES, ATMOSPHERIC
500100	BASIC STUDIES (Any basic atmospheric studies that establish information from which environmental effects of energy-related activities can be predicted, calculated, or measured.)
500101	*RADIOMETRIC TECHNIQUES* (Use of radioisotopes or ionizing radiations in basic atmospheric investigations.)
500200	CHEMICALS MONITORING AND TRANSPORT (Transport, monitoring, characterization, removal, or reactions of pollutants from the energy cycle during transit through or presence in the atmosphere, e.g., carbon, lead, nitrogen, or sulfur compounds, or respirable particulates. Also includes measures for control and abatement of these pollutants. Biological effects of these pollutants or chemicals are included under BIOMEDICAL SCIENCES, APPLIED STUDIES.)
500300	RADIOACTIVE MATERIALS MONITORING AND TRANSPORT (Atmospheric studies on, e.g., plutonium, krypton, xenon, iodine, and strontium radioisotopes; tritium; and other radioactive materials, especially from fission or fusion power plants and any phase of the fuel cycle.)
500400	THERMAL EFFLUENTS MONITORING AND TRANSPORT (Studies of atmospheric consequences of moisture and heat releases from power plant cooling towers or from any energy-related technology. Includes studies on cooling tower plume behavior, aerodynamic and thermal exchange over cooling ponds, meteorological and climate studies. Also includes effects from energy conservation measures such as thermal pollution from increased use of heat pumps. Also includes control and abatement. Biological effects of

Table 8.3 (cont.)

	thermal effluents or elevated temperatures are included under BIOMEDICAL SCIENCES, APPLIED STUDIES.)
500500	SITE RESOURCE AND USE STUDIES (Meteorological and atmospheric aspects of existing or potential sites for any phase of energy development and use.)
500600	REGULATIONS (Legislation, ordinances, rules, litigation, hearings, decisions, etc. Recommended or adopted guides, criteria, and standards for allowable atmospheric emission limits or pollutant concentrations; air quality standards).
510000	**ENVIRONMENTAL SCIENCES, TERRESTRIAL**
510100	BASIC STUDIES (Any basic geological or soil studies that establish information from which environmental effects of energy-related activities can be predicted, calculated, or measured.)
510101	*RADIOMETRIC TECHNIQUES* (Use of radioisotopes or ionizing radiation in basic terrestrial studies.)
510200	CHEMICALS MONITORING AND TRANSPORT (Transport, monitoring, characterization, removal, or reactions of pollutants from the energy cycle during transit through or presence in the terrestrial environment or ecosystem, e.g., carbon, lead, nitrogen, or sulfur compounds. Also includes measures for control and abatement of these pollutants. Biological effects of these pollutants or chemicals are included under BIOMEDICAL SCIENCES, APPLIED STUDIES.)

The third approach, free-text searching, uses title and abstract terms together with the descriptor words to provide broad, complete coverage of subject information. In addition, the EDB may be searched by type of document, language, country of publication, country of author affiliation and many other standard indexes. The several printed tools available to assist searchers in becoming more familiar with the EDB are listed in Table 8.4.

Table 8.4: DOE ENERGY DATABASE (EDB) searching aids*

Document Number	Title
DOE/TIC – 7000 – R6	Energy Information Data Base: Subject Thesaurus, DOE TIC, 1984.
DOE/TIC – 4583 – R3	Energy Information Data Base: Guide to Abstracting and Indexing, DOE TIC, 1981.
DOE/TIC – 4584 – R5	Energy Information Data Base: Subject Categories, DOE TIC, 1983.
DOE/TIC – 4579 – R13	Energy Information Data Base: Serial Titles with ISSN Listing, DOE TIC, 1984.
DOE/TIC – 85 – R13	Energy Information Data Base: Report Number Codes, DOE TIC, 1979.
DOE/TIC – 4585 – R4	Energy Information Data Base: Corporate Author Entries, DOE TIC, 1984.
DOE/TIC – 4045 – S2	Index to Conference Titles: Selected Conferences Cited in the Energy Data Base 1977 – 1982, DOE TIC, 1982.

*These documents are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, USA

Other primary databases

The EDB has been described in some detail because it is so central for energy-related environmental issues, and because it is comparatively unknown. However, the other nine primary databases should not be ignored. Five of these are large files covering broad, traditional scientific and technical fields, and for this reason may not always be thought of as important energy/environmental databases. Four are smaller and more limited, specializing in energy or environmental topics. A brief description of each of these databases follows.

CA search

Chemical Abstracts Service (CAS) covers worldwide the literature of chemistry and its applications from 1967 and contains approximately seven million citations. About 34,000 new citations covering all types of literature, including patents, are added each month. The unit record available through all online services except STN does not include the abstract. Therefore online searching typically is based on a combination of author, uncontrolled terminology, controlled vocabulary from the *Chemical Abstracts Index Guide*, CAS Registry Numbers and Section Codes. Document type and language are also searchable. Full-text searching is available for a small group of core CAS journals through CHEMICAL JOURNALS ONLINE.

COMPENDEX

COMPENDEX and its companion database, EI ENGINEERING MEETINGS, (the online versions of the *Engineering Index*) cover all types of engineering and technology. Worldwide coverage of the literature is provided from 1970. The databases contain more than 1.8 million citations and abstracts, with 19,500 new records added each month. Online retrieval is facilitated in COMPENDEX by the ability to search terms in the title and abstract as well as the rather general main or subheadings and the subject category codes. Treatment codes serve as a guide to the general orientation of the paper; theoretical versus practical, for example. Abstracts are not available for the MEETINGS database.

INSPEC

INSPEC corresponds to four *Science Abstracts* publications: *Physics Abstracts, Electrical and Electronics Abstracts, Computer and Control Abstracts* and *IT Focus* produced by the Institution of Electrical Engineers. Major subject areas include electrical power generation systems. Material from 1969 to the present is covered online. While all types of literature are included in its 2,629,000 citations and abstracts, journal articles are emphasized. Approximately fifteen thousand new entries are added per month. Descriptor terms assigned from the *Inspec Thesaurus* are a useful search tool in addition to title and abstract words. Category code schemes are available for each of the major publication areas, but must be used with caution as some sections are revised periodically. Treatment codes of the type described for COMPENDEX are provided.

NTIS

The NTIS database consists of government-sponsored research and development reports plus analyses, reprints and translations from over 250 federal agencies. It contains all references published in *Weekly Government Abstracts* and *Government Reports Announcements*. Environmental pollution and control, and energy production and conservation are among the many topics covered by

the more than 1,164,000 citations (dating from 1964 on DIALOG and STN, and from 1970 on Orbit and BRS). Approximately five thousand new reports are added per month.

Since the material is entered from a variety of agencies using different thesauri, controlled vocabulary is not consistent. Four major thesauri and five minor thesauri are currently used, while a number of others are used periodically. However, NTIS has compiled two composite thesauri, one on energy and another on the environment, which bring together similar terms from each of the major thesauri.* These tools assist the searcher by indicating what terms are used in each thesaurus to represent a particular concept. Subject category searching, when combined with keywords, can be helpful to eliminate false selections. Abstracts are available for most citations, but are not directly searchable on Orbit.

SCISEARCH and SOCIAL SCISEARCH

SCISEARCH and SOCIAL SCISEARCH are prepared by the Institute for Scientific Information and correspond to the printed *Science Citation Index* and *Social Science Citation Index*, with additional items selected from *Current Contents*. They are multidisciplinary indexes to the journal literature of science and technology, and the social sciences, respectively. Several criteria, including citation analysis, are used to select the most significant journals for inclusion. Together these databases cover almost eight million citations. SCISEARCH, online since 1974, is updated biweekly with about 25,000 new citations. SOCIAL SCISEARCH covers the period from 1972 and adds nine thousand new citations each month. Both files must be searched for scientific questions with social implications, a common situation for searches on energy-related environmental questions. Keyword searching is limited to title words – no additional vocabulary or abstracts are included.

The strength of these files is in their citation linking, which permits access to the literature by cited references. Searching by document type is also an important criterion since all significant articles, reports of meetings, letters, editorials and correction notices are entered into the databases.

Smaller databases

The four smaller databases devoted to energy or environmental matters are ENVIROLINE, ENVIRONMENTAL BIBLIOGRAPHY, ENERGYLINE and POLLUTION ABSTRACTS.

ENVIROLINE contains citations from *Environment Abstracts*, a publication of the EIC/Intelligence, Inc. It emphasizes coverage of the air environment, environmental health, the land environment, resource management, solid wastes management and the water environment. More than 118,000 citations are currently available, with about six hundred new references added each month. Roughly five thousand sources of information including technical, trade, professional and general periodicals, papers from conferences, research reports, Congressional hearing transcripts, environmental project reports and newspaper articles are scanned for enclosure. Journal papers comprise more than sixty per cent of the database. A significant amount of popular literature is also included. Title words, abstract terms and thesaurus-controlled descriptors along with review classifications and document type form the basis for searching. Coverage starts in 1971. Abstracts are not available before 1975. A sample record is shown at the end of Search 8.4.

*These are the *Energy Microthesaurus: A Hierarchical List of Indexing Terms used by NTIS*, PB-254800 (Washington, DC: National Technical Information Service, 1976) and the *Environmental Microthesaurus: A Hierarchical List of Indexing Terms used by NTIS*, PB-265261 (Washington, DC: National Technical Information Service, 1977).

ENVIRONMENTAL BIBLIOGRAPHY is the online version of *Environmental Periodicals Bibliography* and is produced by the Environmental Studies Institute, in Santa Barbara, California. This database provides broad coverage of the environmental sciences, including human ecology, air, energy, land resources, water resources, and nutrition and health. Three hundred of the world's journals dealing with the environment are scanned to create the database. More than 295,000 citations are in the file from 1973 to the present, with 4200 added bimonthly. Controlled indexing and title words provide subject access. There are no abstracts. See Figure 8.2 for a sample record.

Figure 8.2: Sample ENVIRONMENTAL BIBLIOGRAPHY record

0910501
Power Plant Impacts on Visibility in the West: Siting and Emissions Control Implications
Latimer, D A.
Journal of the Air Pollution Control Association,
1980 VOL. 30, NO. 2 (February), p. 142
DESCRIPTORS: Air pollution control; Power plant; Environmental impact statement

ENERGYLINE, like ENVIROLINE, is produced by the EIC/Intelligence, Inc. It contains energy material from *Environment Abstracts* from 1971 through 1975, and all materials from *Energy Information Abstracts* starting with 1976. ENERGYLINE deals with a wide range of energy-related issues including economics, policy and planning, resources and reserves, solar energy, fuel processing and transport, electric power generation, nuclear resources and power, consumption and conservation, and environmental impact. Literature coverage and type is similar to that of ENVIROLINE. It is the smallest of the primary databases with more than 58,000 citations; 450 new citations are added monthly. Subject access is furnished through title and abstract terms, controlled vocabulary descriptors and review classification. Document type is also distinguished. Abstracts are not available before 1975. The record format is the same as that of ENVIROLINE.

POLLUTION ABSTRACTS corresponds to the printed *Pollution Abstracts* produced by Cambridge Scientific Abstracts. Subjects covered include air pollution, environmental quality, noise pollution, pesticides, radiation, solid wastes and water pollution. Technical literature from books, conference proceedings, government reports, periodicals and research papers is emphasized. The database contains more than 116,000 citations dating from 1970 and is updated bimonthly with one thousand new citations. Controlled index terms, free language terms, title words and (since 1978) abstract terms are available for searching. Document type and language may also be used. See Figure 8.3 for an example of the record format.

Figure 8.3: Sample POLLUTION ABSTRACTS record

81 – 02385
Meteorological measurement methods and diffusion models for use at coastal nuclear reactor sites.
Raynor, G. S.; Michael, P.; SethuRaman, S.
BNL, Atmospheric Sciences Div., Upton, NY 11973
Journal of Environmental Economics and Management 7(3), 749 – 765,

Figure 8.3: (cont.)

Coden: JEEMDI Publ.Yr: Sep 1980
illus. 58 refs.
Abs.
Languages: ENGLISH
Doc Type: JOURNAL PAPER
TREATMENT CODES: M (METHODOLOGICAL) ; T (THEORETICAL/ MATHEMATICAL)

A literature review study, examining the adequacy of recommended meteorological measurement programs and diffusion prediction methods for coastal zone nuclear power plants, focussed primarily on coastal internal boundary layers, tower location, instrument heights, atmospheric stability classification, and diffusion calculations. It is recommended that the presence and characteristics of coastal internal boundary layers should be considered at all coastal sites, and that the models developed by Raynor et al, and by Venkatram be used to calculate the layer height. The primary meteorological tower should be in such a location that the upper measuring level is always within the internal boundary layer. Instrument height of primary towers should be selected so that representative measurements are obtained while maintaining adequate separation between levels. Instrumentation for measuring the horizontal and vertical spread of the plumes should be required at all coastal sites. Current procedures for using meander to reduce concentrations at wind speed >1 m/sec should be considered tentative and subject to revision. Values for plume spread should be determined from values measured in the layers from which diffusion calculations are to be made. Conservative values of the wake correction to the diffusion equation should be considered tentative and subject to revision for coastal sites. (FT AM)

Descriptors: Nuclear power plants; Meteorology; Diffusion; Siting criteria; Coastal zones; Engineering; Measuring methods; Plumes; Boundary layers; Air pollution forecasting; Literature reviews; Mathematical models

Specialized subject databases

The above are the ten primary databases which cover energy-related environmental issues. For a number of questions, however, another group of databases, the specialized subject databases, should also be considered.

The specialized subject databases (see Table 8.5) cover a variety of topical areas bearing on energy-related environmental matters. They are: atmospheric and climatological sciences, business and industry, electric power, land resources, legislation and government policy, nuclear power, oil and gas, toxicology and health, transportation and water resources. Most specialized subject databases fall primarily into one of these areas, although a few have a somewhat broader orientation. Several of these databases are covered in some detail in other chapters. All are discussed briefly below.

Table 8.5: Specialized subject databases covering areas related to Energy and the Environment

NAME	PRODUCER	SEARCH SERVICE(S)
Atmosphere and Climatology		
AEROSPACE DATABASE	American Inst. of Aeronautics & Astronautics	DIALOG
APTIC	Air Pollution Technical Information Center	DIALOG
METEOROLOGICAL & GEOASTROPHYSICAL ABST.	American Meteorological Society	DIALOG
Business and Industry		
ABI/INFORM	Data Courier, Inc.	BRS,DIALOG,Orbit
BIOBUSINESS	BioSciences Information Service/Information Access	DIALOG
BUSINESSWIRE	BusinessWire	DIALOG
CHEMICAL INDUSTRY NOTES	CAS/American Chemical Society	DIALOG,Orbit
FOREIGN TRADE & ECON ABSTRACTS	Netherlands Foreign Trade Agency	DIALOG
MANAGEMENT ABSTRACTS	Information Access	BRS,DIALOG,Orbit
MCGRAW – HILL BUSINESS BACKGROUNDER	McGraw-Hill, Inc.	DIALOG
MOODY'S CORPORATE NEWS	Moody's Investor Service, Inc.	DIALOG
PTS INDEXES	Predicasts, Inc.	BRS,DIALOG
TRADE AND INDUSTRY INDEX	Information Access	BRS,DIALOG
Electric Power		
EPIA	Edison Electric Inst./Utility Data Inst.	Orbit
EPRI	Electric Power Research Institute	DIALOG,DOE
Land-related Resources		
AGRICOLA	National Agricultural Library	BRS,DIALOG,Orbit
AGRIS INTERNATIONAL	National Agricultural Library	DIALOG
BIOSIS PREVIEWS	BioSciences Information Service	BRS,DIALOG,Orbit, STN
CAB ABSTRACTS	Commonwealth Agricultural Bureaux	BRS,DIALOG,Orbit
GEOARCHIVE	Geosystems	DIALOG
GEOREF	American Geological Institute	DIALOG, Orbit
LIFE SCIENCES COLLECTION	Information Retrieval Ltd.	DIALOG
Legislation and Government Policy		
CIS/INDEX	Congressional Information Service	DIALOG,Orbit
CONGRESSIONAL RECORD ABSTRACTS	Capitol Services, Inc.	DIALOG,Orbit
FEDERAL INDEX	Capitol Services, Inc.	DIALOG,Orbit
FEDERAL REGISTER ABSTRACTS	Capitol Services, Inc.	DIALOG,Orbit
LEXIS	Mead Data Central	MEAD
PAIS INTERNATIONAL	Policy Review Information Service	BRS,DIALOG
Nuclear Power		
FALLOUT RECORDS CENTRALIZATION	US Department of Energy	DOE
NUCLEAR SAFETY INFORMATION CENTER	Nuclear Regulatory Commission	DOE
NUCLEAR SCIENCE ABSTRACTS	US Department of Energy	DOE
RADIATION SHIELDING INFORMATION	US Department of Energy	DOE
Oil and Gas		
APILIT	American Petroleum Institute	Orbit
APIPAT	American Petroleum Institute	Orbit
P/E NEWS	American Petroleum Institute	DIALOG,Orbit
TULSA	University of Tulsa	DOE,Orbit

Table 8.5: (cont.)

NAME	PRODUCER	SEARCH SERVICE(S)
Toxicology and Health		
AQUIRE		CIS
BIOSIS PREVIEWS	BioSciences Information Service	BRS,DIALOG,Orbit, STN
CANCERLIT		NLM
CESARS	Michigan Dept. of Natural Resources/US EPA	CIS
EMBASE	Elsevier Publishing Co.	BRS,DIALOG
ENVIROFATE		CIS
HSELINE	Health and Safety Executive	InfoLine
LIFE SCIENCES COLLECTION	Information Retrieval Ltd.	DIALOG
MEDLINE	National Library of Medicine	BRS,DIALOG,NLM
OCCUPATIONAL SAFETY AND HEALTH	National Inst. for Occupational Safety & Health	DIALOG
OHM/TADS	US EPA	CIS
TOXICOLOGY DATA BASE	National Library of Medicine	NLM
TOXLINE	National Library of Medicine	NLM
Transportation		
TRIS	US Department of Transportation	DIALOG
ALTERNATIVE FUELS DATA BANK	US Department of Energy	DOE
Water Resources		
AQUALINE	Water Research Centre (UK)	InfoLine
AQUATIC SCIENCES & FISHERIES ABSTRACTS	NOAA/Cambridge Scientific Abstracts	DIALOG
OCEANIC ABSTRACTS	Cambridge Scientific Abstracts	DIALOG
WATER RESOURCES ABSTRACTS	US Department of the Interior	DIALOG

Atmospheric and climatological sciences

Three databases are of interest; the AEROSPACE DATABASE which combines two publications, *Scientific and Technical Aerospace Reports* and *International Aerospace Abstracts*, the APTIC (Air Pollution Technical Information Center) file published as *Air Pollution Abstracts* and the METEOROLOGICAL AND GEOASTROPHYSICAL ABSTRACTS (MGA) which corresponds to the printed publication of the same name. The AEROSPACE DATABASE provides extensive coverage of air pollution issues from key scientific and technical documents. APTIC was produced by the United States Environmental Protection Agency, but has not been updated since September 1978. It should be used when a comprehensive, retrospective search on any aspect of air pollution is required. MGA is produced by the American Meteorological Society in co-operation with the Environmental Science Information Center of the National Oceanic and Atmospheric Administration (NOAA), and is a good source of research information.

Business and industry

A large number of databases cover business and industrial aspects of energy-environmental issues. Among the most useful are: ABI/INFORM which has no print counterpart, BIOBUSINESS, CHEMICAL INDUSTRY NOTES, FOREIGN TRADE & ECON ABSTRACTS, MANAGEMENT CONTENTS, MOODY'S CORPORATE NEWS, the PREDICAST series of databases such as PTS

F&S INDEXES (*Funk & Scott*) and PTS PROMT (*Predicasts Overviews of Markets and Technology*), TRADE AND INDUSTRY INDEX, BUSINESSWIRE and MCGRAW-HILL BUSINESS BACKGROUNDER. A few databases are devoted to individual industries such as PAPERCHEM and PIRA which cover the pulp and paper industry.

Electric power

Information on the environmental effects of all types of electric power plants and associated transmission lines, power plant siting studies and methodologies, fuel transportation, storage and use, licensing and permit data, monitoring programmes, safety and risk assessment, coastal zone management plans and waste disposal facilities is contained in EPIA (*Electric Power Industry Abstracts*). It includes reports prepared by electric utilities and their consultants, federal and state agencies, siting commissions and control boards. The ELECTRIC POWER DATABASE (EPRI) covers United States and Canadian research and development projects of interest to the electric power industry, including environmental assessments.

Land-related resources

AGRICOLA, produced by the United States Department of Agriculture, AGRIS INTERNATIONAL, which corresponds in part to the Food and Agriculture Organization's *AgrIndex* and CAB ABSTRACTS (CAB), a compilation of twenty-five abstract journals published by the Commonwealth Agricultural Bureaux, cover agricultural and forestry aspects. BIOSIS PREVIEWS (BIOSIS) contains citations from *Biological Abstracts* and *BioResearch Index* and covers botanical as well as agricultural facets. GEOARCHIVE and GEOREF (Geological Reference File) deal with fossil energy sources and geothermal energy, mining geology and environmental geology. GEOREF offers better coverage of energy-related environmental questions. *Ecology Abstracts* is contained in the IRL LIFE SCIENCES (IRL) database.

Legislation and government policy

Extensive coverage is provided by CIS/INDEX which indexes the publications and working papers of the nearly three hundred committees and subcommittees of the United States Congress; CONGRESSIONAL RECORD ABSTRACTS (CRECORD) which covers the printed *Congressional Record*; FEDERAL REGISTER ABSTRACTS (FEDREG) which includes federal regulatory actions as published in the *Federal Register*; and the FEDERAL INDEX which includes hearings, speeches, bill introductions and roll calls of the United States Congress. FEDREG and the FEDERAL INDEX also cover existing and proposed rules and regulations, notices and hearings of the executive departments and agencies, presidential views, proclamations and final action on legislation, and court decisions and other judicial activities. However, the FEDERAL INDEX is no longer updated. Legal aspects, particularly United States federal code and case law, are found in LEXIS, a full-text database service of Mead Data Central. Contemporary public issues and the making and evaluation of public policy are covered by the PAIS INTERNATIONAL (PAIS) database.

Nuclear power

A great deal of information on environmental aspects of nuclear energy developments, published before June 1976, is contained in NUCLEAR SCIENCE ABSTRACTS (NSA), which corresponds to the printed index of the same name. Literature on this topic published after June 1976 is found in the EDB database. Another useful file is the NUCLEAR SAFETY INFORMATION CENTER (NSIC)

database. Siting of nuclear facilities, transportation and handling of radioactive materials, reactor accidents and all kinds of safety information is covered. NSIC also includes special studies or evaluations and operating experience data such as licensee event reports, which deal with environmental considerations. Other more specialized databases such as the RADIATION SHIELDING INFORMATION and the FALLOUT RECORDS CENTRALIZATION files may also be useful.

Oil and gas

Air, land and water pollution, along with solid wastes and health hazards resulting from petro-refining are encompassed in the APILIT (API LITerature) database of the American Petroleum Institute (API). Another API database, P/E NEWS, covers petroleum and energy business news. TULSA, which corresponds in part to *Petroleum Abstracts* published by the University of Tulsa, GEOARCHIVE and GEOREF are also appropriate in this field.

Toxicology and health

The TOXLINE database provides coverage of toxicology information taken from eleven sources including CAS, MEDLINE and BIOSIS PREVIEWS. *Toxicology Abstracts* is contained in the IRL database. All aspects of environmental health are covered by EMBASE (EXCERPTA MEDICA), BIOSIS, MEDLINE, and CANCERLIT. HSELINE and OCCUPATIONAL SAFETY AND HEALTH (NIOSH) have an industrial focus. Several full-text databases on CIS contain toxicity data extracted from published literature and other sources. Among them are: CESARS (Chemical Evaluation Search and Retrieval System) which provides detailed information on a group of chemicals of particular importance to the Great Lakes Basin; OHM/TADS (Oil and Hazardous Materials/Technical Assistance Data System) which was established to aid spill response teams in the retrieval of chemical-specific response information; AQUIRE (Aquatic Information Retrieval) which contains information on acute, chronic, bioaccumulative and sublethal effects data from tests performed on freshwater and salt water species; and ENVIROFATE (Environmental Fate) which covers data extracted from papers dealing with the ecological fate or behaviour of chemicals released into the environment. NLM's TOXICOLOGY DATABASE (TDB) is a similar type of database with a broader subject orientation.

Transportation

TRIS (Transportation Research Information Service), produced by the Transportation Research Board and the United States Department of Transportation, is a major database for energy-related environmental aspects of air, highway, rail and maritime transport, mass transit and other modes of transportation. Pollutant emissions from alternative fuels for transportation uses, particularly alcohol fuels, are covered in the ALTERNATIVE FUELS DATA BANK (AFDB) of the DOE.

Water resources

Energy issues which impact on the water environment are dealt with most extensively by AQUATIC SCIENCES AND FISHERIES ABSTRACTS (ASFA), WATER RESOURCES ABSTRACTS (WRA), AQUALINE and OCEANIC ABSTRACTS.

Specialized document-type databases

A third group of databases, the specialized document-type databases (see Table 8.6), also meets specific needs. They cover government documents, popular or consumer-oriented information, ongoing research, patents, contracts and statistical information. Databases in these categories are outlined below. As with the specialized subject databases, many of these are discussed more fully in other chapters.

Table 8.6: Specialized document-type databases covering energy and the environment

NAME	PRODUCER	SEARCH SERVICE(S)
Government Documents		
EBIB	Texas A&M University/Gulf Publishing	Orbit
GPO MONTHLY CATALOG	US Government Printing Office	BRS,DIALOG
INDEX TO THE U S GOVERNMENT PERIODICALS	Infordata International, Inc	BRS
POWER	US Department of Energy	Orbit
Popular or Consumer-oriented Sources		
ABSTRAX 400	Information Sources. Ltd.	BRS
AP NEWS	Press Association, Associated Press	DIALOG
EARTHNET	Queens College	Queens College
ENERGY INFORMATION RESOURCES	US Department of Energy	DOE
GENERAL AND POPULAR LITERATURE	US Department of Energy	DOE
MAGAZINE INDEX	Information Access	BRS,DIALOG
MONITOR	Bell and Howell	Orbit
NATIONAL NEWSPAPER INDEX	Information Access	BRS,DIALOG
NATIONAL REFERRAL CENTER	US Library of Congress	DOE
NDEX	Bell and Howell	Orbit
NEWSEARCH	Information Access	DIALOG
NEW YORK TIMES	New York Times Information Service	MEAD
UPI NEWS	United Press International, Inc.	DIALOG
WASHINGTON PRESSTEXT	PressText News Service	DIALOG
Ongoing Research		
CRIS	US Department of Agriculture	DIALOG
ENERGY RESEARCH IN PROGRESS	US Department of Energy	DOE
FEDERAL RESEARCH IN PROGRESS	National Technical Information Service	DIALOG
GERMAN RESEARCH IN PROGRESS		DOE
SSIE CURRENT RESEARCH	Smithsonian Science Information	DIALOG
WATER RESOURCES RESEARCH IN PROGRESS	US Department of Energy	DOE
Patents		
APIPAT	American Petroleum Institute	Orbit
INPADOC	International Patent Documentation Center	InfoLine
WPI	Derwent Publications, Ltd.	DIALOG,Orbit
Procurement and Contracts		
COMMERCE BUSINESS DAILY	US Department of Commerce	DIALOG
USGCA	Washington Representative Services	Orbit
Statistics		
ASI	Congressional Information Service, Inc.	DIALOG,Orbit
FEDERAL ENERGY DATA BASE INDEX	US Department of Energy	DOE

Government documents

Beside the government report coverage of NTIS, there are other significant energy collections and government databases which should be considered. Books, maps, government documents and technical reports in the Texas A&M University Library are indexed in EBIB (Energy Bibliography and Index). POWER contains catalogue records from the book collection of the DOE Energy Library. The GPO MONTHLY CATALOG (GPO) corresponds to the *Monthly Catalog of United States Government Publications*. Its sources are federal government agencies. Government-produced journals are covered in the INDEX TO THE U.S. GOVERNMENT PERIODICALS. Over half of these publications are not indexed elsewhere.

Popular or consumer-oriented information

News articles contain much energy-related environmental information and are indexed in such broad scope databases as the NATIONAL NEWSPAPER INDEX (NNI), NDEX (*Newspaper Indexes* and *Index to Black Newspapers*) and MONITOR (*Christian Science Monitor*). Full-text coverage is provided by AP NEWS (Associated Press), UPI NEWS (United Press International), WASHINGTON PRESSTEXT and THE NEW YORK TIMES. The MAGAZINE INDEX (MI) and ABSTRAX 400 provide indexing to articles, news reports, editorials on major issues, product evaluations and reviews from several hundred popular American magazines. MI also comes in a full-text version. NEWSEARCH covers the most recent month of MI and NNI. Pamphlets and technical reports designed for the consumer, especially *how to* materials, are listed in the DOE GENERAL AND PRACTICAL DATABASE (GAP). The EARTHNET database at Queens College, NY takes a non-technical approach to energy and environmental concerns. Information sources such as organizations, laboratories and programme offices can be located in the ENERGY INFORMATION RESOURCES and NATIONAL REFERRAL CENTER databases.

Ongoing research

Most current energy and environmental research information can be obtained from the DOE ENERGY RESEARCH IN PROGRESS (ERP) or the FEDERAL RESEARCH IN PROGRESS databases. Research projects begun before February 1982 are found in the SSIE CURRENT RESEARCH (Smithsonian Science Information Exchange) file. The GERMAN RESEARCH IN PROGRESS database covers current research in the Federal Republic of Germany. Topical research is found in the CRIS (Current Research Information System) and WATER RESOURCES RESEARCH IN PROGRESS (WRRP) databases.

Patents

Patents are important in energy and environmental technology. The WPI (World Patents Index), INPADOC and APIPAT (API Patents) databases cover patents worldwide. Searching patents databases is discussed in Chapter 3.

Procurement and contracts

The federal government procurement and contracting system vets requests for proposals (RFPs) or bids on energy and environmental projects. Announcements of these proposals, along with lists of awarded contracts, appear in the COMMERCE BUSINESS DAILY database produced by the United

States Department of Commerce. The USGCA (United States Government Contract Awards) database also announces awarded contracts. Technical reports resulting from government contracts are found in NTIS.

Statistics

The FEDERAL ENERGY DATA BASE INDEX (FEDEX) yields bibliographic references to statistical publications of the DOE Energy Information Administration and in addition indexes tables and graphs contained within these publications. Other air quality, water supply, environmental measurements and energy data are furnished by the ASI (American Statistics Index) database.

THE SEARCH STRATEGY

The key to developing a successful search strategy on any topic is to determine the actual information need as accurately as possible in terms of the concepts expressed by the information request. A specific description of the question is required, including qualifying or limiting statements which help to define the context. Synonyms, closely related phrases and alternate spellings should be obtained for both scientific and technical terms and common vocabulary. The purpose or intended use of the search results, along with the amount of information needed, help the searcher to determine the required scope. Pertinent journals, known papers or authors help portray the subject. Language or geographic constraints, the time period to be covered and the type of information needed are also useful parameters. This information is typically collected through a pre-search interview, a search request form or a combination of both. Once the question has been set forth in as much detail as possible, it is necessary to select the appropriate database(s) and search terms.

Database selection

As has been pointed out earlier, database selection in the energy-related environmental area can be difficult because of the enormous number of databases which may be applicable. Several factors influence the selection of databases:

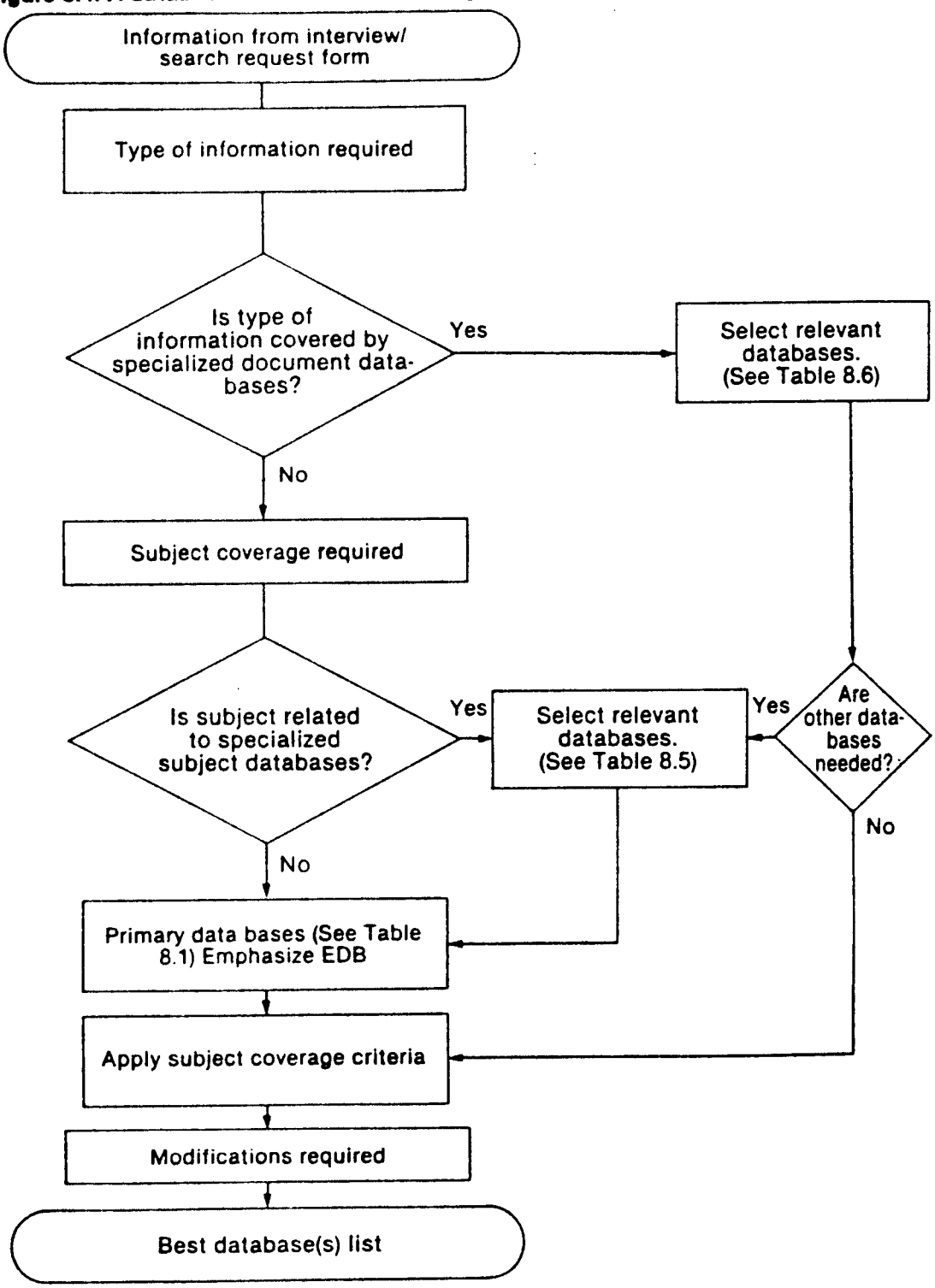
1. the type of information desired, which can be bibliographic or non-bibliographic and can range from books, patents or current research to popular articles or statistics;
2. suitable subject coverage and degree of comprehensiveness required;
3. the timeliness or time lapsed between publication and appearance in a computerized database;
4. the number of years covered;
5. availability of appropriate indexes to search the requested topic adequately;
6. accessibility of the complete document; and
7. costs of the respective databases.

Not all of these parameters are equally important for every search request. Most searches emphasize three or four of them. Trade-offs may also be necessary depending upon the individual request.

To select the best database(s) for a specific energy-environment topic, it is essential to apply the database selection criteria to the database groups discussed in the preceding sections and listed in Tables 8.1, 8.5 and 8.6. One method of doing this is described below and is illustrated in Figure 8.4.

First, determine from the interview or search request what type of literature is required. If a specialized document or literature type is needed, make the appropriate selection from the databases listed in Table 8.6. Sometimes a single database from this list will suffice.

Figure 8.4: A database selection methodology



Next, if specialized literature is ruled out, or if additional databases from the specialized subject database category are required, examine the databases in Table 8.5. Here again, one or two of these files may be sufficient for the request.

If the request does not relate to the databases in either of these categories, or if additional databases are needed to complete the search, select the appropriate primary databases from Table 8.1.

The final list of selected databases should be examined for best subject coverage of the request topic according to the following criteria:

1. searching experience and familiarity with the databases,
2. printed aids from database producers and service vendors,
3. journal or document coverage of selected databases, and
4. crossfile search index files of online vendors.

The crossfile search index files are extremely useful tools for ranking subject coverage of databases, and for setting up crossfile searches. For multidisciplinary fields, where most energy and environmental questions fall, they are particularly valuable strategies. They allow the searcher to scan a selected number of databases most likely to be useful. Databases other than those routinely searched are also suggested. (Remember that EDB deserves serious consideration for almost any energy-related environmental topic. When in doubt, EDB is a good place to begin.)

This refined list of databases, now ranked by type of information and subject coverage, should be modified further through use of the other selection factors. These will vary in importance for each request. Among them are the degree of comprehensiveness or amount of information required, timeliness, retrospective coverage, appropriate indexes, content of printout, availability of complete documents and database costs. This last step allows the searcher to fine tune the database list. For example, a request for citations on particulate emissions from coal-fired power plants would yield a sizeable list of potentially acceptable databases after the type of literature and subject coverage criteria are used. However, adding the criterion of only a few good, current citations, would help the searcher to single out a database such as SCISEARCH from this list, because of its coverage of journal literature, its quick processing time during preparation of the database updates and its use of title word searching which gives higher precision results. On the other hand, if thorough coverage of the subject is desired but the search budget is limited, the EDB database would be a good choice because of its extensive coverage of journal and report literature and its relatively inexpensive print charges.

Concept development

Search concept development, including the establishment of the logical relationships between concepts, is the last major step in search strategy formulation before going online. Returning to the information furnished in the interview or by the search request form, list each distinct concept and its relationship to the others. Next add all singular and plural keywords, synonyms, abbreviations, acronyms, jargon or other subject elements which describe the topic. Watch out for terms with different American and British spellings such as aluminum/aluminium, sulfur/sulphur and color/colour. Compound words such as power plant, wastewater and online are sometimes found with varying segmentation; that is, as powerplant, waste water and on-line.

Suggestions for relevant terms can be provided by the thesauri which cover the database(s) to be searched. In addition, there is an *Integrated Energy Vocabulary* which compiles energy terms from ten different database vocabularies.* A sample page from this compilation and the list of its vocabulary sources are displayed in Tables 8.7 and 8.8.

**Integrated Energy Vocabulary*, PB-259000 (Washington, DC: National Technical Information Service, 1976).

Table 8.7: Sample entries from the *Integrated Energy Vocabulary*

Source Code*	Term
P	AIR PERMEABILITY USE PERMEABILITY
T	AIR PERMEABILITY USE PERMEABILITY
B	AIR POLLUTANT (LINK TO SPECIFIC POLLUTANTS) BT WASTE MATERIAL NT OXIDANT
D	AIR POLLUTANTS USE AIR POLLUTION
B	AIR POLLUTION UF + AIR POLLUTION CONTROL EQUIPMENT AIR POLLUTION SOURCE UF ATMOSPHERIC POLLUTION
C	AIR POLLUTION UF SMOG
D	AIR POLLUTION UF AIR CONTAMINANTS AIR POLLUTANTS UF + AIR POLLUTION ABATEMENT AIR POLLUTION CONTROL UF AIR POLLUTION EFFECTS AIR POLLUTION PROBLEMS UF + AIR WATER POLLUTION ATMOSPHERIC POLLUTANT UF ATMOSPHERIC POLLUTION UF + CONTAMINATED AIR PARTICULATE AIR POLLUTANTS TOXIC AIR POLLUTANTS BT CONTAMINATION POLLUTION NT SMOG
E	AIR POLLUTION UF ATMOSPHERIC COMPOSITION-POLLUTION EARTH ATMOSPHERE-POLLUTION ENVIRONMENTAL ENGINEERING-AIR POLLUTION
G	AIR POLLUTION
I	AIR POLLUTION UF + THERMAL POLLUTION (AIR) BT POLLUTION
N	AIR POLLUTION UF ATMOSPHERIC IMPURITIES BT ENVIRONMENT POLLUTION POLLUTION
P	AIR POLLUTION UF ATMOSPHERIC POLLUTION BT CONTAMINATION
T	AIR POLLUTION UF ATMOSPHERIC POLLUTION BT POLLUTION
D	AIR POLLUTION ABATEMENT USE ABATEMENT and AIR POLLUTION
D	AIR POLLUTION CONTROL USE AIR POLLUTION and CONTROL
G	AIR POLLUTION CONTROL ASSOCIATION USE POLLUTION ASSOCIATIONS AND GOVERNMENT AGENCIES
B	AIR POLLUTION CONTROL EQUIPMENT USE AIR POLLUTION and POLLUTION CONTROL EQUIPMENT
T	AIR POLLUTION CONTROL EQUIPMENT
D	AIR POLLUTION EFFECTS USE AIR POLLUTION
D	AIR POLLUTION PROBLEMS USE AIR POLLUTION
B	AIR POLLUTION SOURCE USE AIR POLLUTION and POLLUTION SOURCE
E	AIR POLLUTION-ANALYSIS
E	AIR POLLUTION-CONTROL
E	AIR POLLUTION-LEGISLATION
E	AIR POLLUTION-STANDARDS
E	AIR PREHEATERS
T	AIR PREHEATERS USE AIR HEATERS
D	AIR PURIFICATION USE AIR and PURIFICATION
I	AIR PURIFICATION USE AIR CLEANING
N	AIR PURIFICATION BT PURIFICATION
T	AIR PURIFICATION USE AIR CONDITIONING
D	AIR QUALITY UF + AIR QUALITY MONITORING NETWORK
B	AIR QUALITY MEASUREMENTS
D	AIR QUALITY MONITORING NETWORK USE AIR QUALITY and MONITORING
N	AIR SAMPLING BT SAMPLING

*See Table 8.8.
Source: *Integrated Energy Vocabulary*, PB-259000 (Washington, DC: National Technical Information Service, 1976).

Table 8.8 Source thesauri comprising the *Integrated Energy Vocabulary*

Source Code	Source Vocabulary or Thesaurus	Database(s)
B	*American Petroleum Institute Thesaurus*, 11th ed. (January 1974).	APILIT,APIPAT
C	Current concept file used by Chemical Abstracts.	CA SEARCH
D	Defense Documentation Center Thesaurus, AD-773 330 (January 1974).	DOD/RECON
E	*Subject Headings for Engineering* (1972) used by Engineering Index.	COMPENDEX
G	*Termatrex Thesaurus* used by Institute of Gas Technology, publishers of Gas Abstracts (April 1971).	
I	*INIS: Thesaurus*, IAEA-INIS-13 (Rev. 4), used by the International Nuclear Information System (includes USAEC vocabulary).	INIS
N	*NASA Thesaurus* (1976). Update (1971) and Supplements.	NASA/RECON
P	*Exploration and Production Thesaurus*, 4th ed., used by University of Tulsa, publishers of *Petroleum Abstracts* (January 1970).	TULSA
R	*GeoRef Index* used by the American Geological Institute.	GEOREF
T	*Thesaurus of Engineering and Scientific Terms*, used by the National Technical Information Service (1967).	NTIS

Source: *Integrated Energy Vocabulary*, PB-259000 (Washington, DC: National Technical Information Service, 1976).

Category codes for individual databases are another subject-related field which should be considered as part of concept development. While they usually cover broad areas, some contain hierarchical levels and can be truncated. Table 8.3 gives an example of EDB subject categories and codes. All EDB documents assigned to category 500000 ENVIRONMENTAL SCIENCES, ATMOSPHERIC shown in the example, would be retrieved by truncating to the first two digits, 50. This would include 500100 BASIC STUDIES, 500200 CHEMICAL MONITORING AND TRANSPORT, etc. Only general atmospheric environment studies would be retrieved wth the code 5000000.

Occasionally, corporate or organizational sources are also useful for subject access. Terms such as 'pollution' or 'environment' can appear as part of the organization title, providing in essence additional indexing. This is especially valuable for databases such as SCISEARCH, where the only other available subject field is the title. Other non-subject parameters or qualifiers such as date of publication, language restrictions or document type can also be included on the worksheet. A sample worksheet illustrating concept development for the topic, 'air pollution aspects of siting electric power production facilities', is given in Table 8.9.

In the example listed in Table 8.9, the relationships between the concepts or subject elements are indicated by the general AND and OR Boolean logic. This approach will have a high recall; that is, it will retrieve a high percentage of the relevant citations to be had from the database. However, the precision of the search – the percentage of retrieved citations actually relevant to the topic – will be comparatively low.

Table 8.9: Sample concept development

Topic: Air pollution aspects of siting electric power production facilities.

Concept 1		Concept 2		Concept 3
Siting		Power plant(s)		Air pollution
OR		OR		OR
Site selection		Powerplant(s)		Air pollutant(s)
OR		OR		OR
Site survey(s)		Electric utility(ies)		Air quality
OR	AND	OR	AND	OR
Site plan(s)		Electric power		Emission(s)
OR		OR		OR
Site planning		Electric plant(s)		Particulate(s)
OR		OR		OR
Site preparation		Energy facility(ies)		Nitrogen oxide(s)
				OR
				Nitrogen dioxide
				OR
				Sulfur oxide(s)
				OR
				Sulfur dioxide
				OR
500500 (EDB			*	Sulphur oxide(s)
subject code		Concept 2		OR
for SITE RESOURCE	AND	terms		Sulphur dioxide
AND USE STUDIES				OR
See Table 8.3)				50 (EDB subject code
				for ENVIRONMENTAL
				SCIENCES, ATMOSPHERIC—
				see Table 8.3.)

*Note that since EDB subject code 500500 is a subset of the atmospheric environmental sciences category 50, it does not need to be co-ordinated with Concept 3. Combining it with Concept 2 is adequate.

Multiple database searching

Searching one database is often not adequate to satisfy energy-environmental requests. In these cases, a multiple database search strategy ought to be planned. The search strategy must be expanded to account for database variations. For example, databases use different thesauri resulting in diverse controlled vocabulary terms, some databases have a policy of segmenting words while others do not, numeric characters are sometimes converted to alphabet characters or vice versa, and searchable fields vary. Online service supplier database manuals and database producer search aids provide the searcher with much useful information on these differences.

Multiple database strategy planning follows the same work sheet approach outlined above, but relies more heavily on free-text searching, truncation and a less restrictive logic. Usually, the most efficient and effective technique is to use all possible forms and variations of keywords, including both controlled and uncontrolled vocabulary, together with a high recall logic. If the strategy produces an overly broad result in some databases, it is a relatively straightforward process to refine this outcome. The reverse is not usually true. Limiting by special fields such as language or document type, or by keyword fields such as titles and descriptors, should be left until last to avoid getting zero hits for

databases without these fields. When searching multiple databases on the same computer system, the search-save capability should be used to save time, energy and money by not having to re-enter the strategy for subsequent search runs.

Full-text database searching

The online availability of the complete text of documents such as directories, encyclopedias, journal and newspaper articles and textbooks has added a new dimension to searching. Because essentially every word in the text is both searchable and printable, requestors have immediate access to all the information. They no longer have to take a second step to locate the documents found in a computer search. Beside providing the complete text of documents, full-text databases can be searched for specific information such as product names or people which are mentioned in the text of an article but do not appear in the title, abstract or indexing. Also, footnotes and bibliographies of important articles can be a good online source of additional secondary references.

Searching full-text databases differs from bibliographic files primarily because of the much larger size of the full-text record. Their basic indexes not only contain words from the titles, descriptors, identifiers, abstract and section headings, but also words from the text field. The basic indexes of full-text databases may contain thousands of words per record. Consequently when searching for a broad concept the text field should be avoided. Broad concepts should be limited to title, descriptor, identifier and section heading fields. Conversely, text fields should be included when searching for a very specific concept. In order to increase the precision of full-text database searches, the most effective strategies make frequent use of narrower Boolean operators such as ADJACENT and WITH. An AND logic is seldom useful when dealing with large numbers of searchable terms. This is illustrated in Searches 8.1 and 8.2.

Search 8.1: AND logic in the full-text TRADE AND INDUSTRY INDEX database

```
__: (powerplantS1 or power adj plantS1) and pollutS5
RESULT                    61 DOCUMENTS

  1
East Europe seeks equipment that will contribute to planned goals; U.S.
export outlook improves as five-year plans start.

  2
Forecast for 1986. (1986 Planning and Purchasing Handbook).

  3
The future of nuclear power.

  4
Refrigerator reform: guidelines for energy gluttons.

  5
Underwriting update: get the lead out. (presence of lead in drinking water
systems).
```

Search 8.1: (cont.)

```
  1
TI  East Europe seeks equipment that will contribute to planned goals;
    U.S. export outlook improves as five-year plans start.
OC  PARAGRAPH  SENTENCE  NS-WORD
     TX    (16)     2        7
     TX    (18)     4       10
END OF REQUEST

ENTER DOCUMENT SELECTION.__: *ti,hits
  1
TI  East Europe seeks equipment that will contribute to planned goals;
    U.S. export outlook improves as five-year plans start.
CP  COPYRIGHT U.S. Dept. of Commerce 1986.
TX  (16 OF 18) The Chernobyl nuclear power plant accident resulted in
    contaminated crops through much of the region, sharply affecting
    exports of foodstuffs in the second quarter; the region's imports of grain
    could go up. Hungary and Bulgaria also face reduction of electricity
    imports from the U.S.S.R., because of the Chernobyl shutdown.
TX  (18 OF 18) East European demand is up in 1986 for U.S. corn, soybeans,
    coal, agricultural chemicals, energy systems, oil field equipment, medical
    equipment, and tractors. Interest has been shown in American food
    processing and packaging, transportation, mining, pollution control, and
    specialized agricultural equipment.
```

Search 8.2: WITH logic in the full-text TRADE AND INDUSTRY INDEX database

```
__: (powerplantS1 or power adj plantS1) with pollutS5
RESULT                    7 DOCUMENTS

  1
The future of nuclear power.

  2
U.S. show will take advantage of growing market in Mexico for pollution
control equipment.

  3
Acid rain curbs seen hiking elec. rates.

  3
TI  Acid rain curbs seen hiking elec. rates.
CP  COPYRIGHT Fairchild Pub. Inc. 1983.
TX  (3 OF 16) Prospects for legislation were boosted last week by the release of
    a major acid rain study by the independent, and prestigious, National
    Academy of Sciences. It concluded that reductions in sulfur emissions
    from coal-burning power plants would reduce acid rain pollution,
    apparently ending the scientific uncertainty over that linkage.
```

A search of the full-text TRADE AND INDUSTRY INDEX database for power plant pollution information using an AND logic yielded 61 documents. The first five titles are displayed along with the paragraphs which caused their retrieval. These titles are not very closely related to the search question. The reason for this can be seen by examining the paragraphs which caused the retrieval. The power plant term is in paragraph number 16 while the pollution term is in paragraph number 18. There is no relationship between the two terms. Using a WITH logic to search the same database retrieved seven documents. In this case, both search terms are in the same sentence, causing the results to be much more specific.

All of these factors should be taken into account when developing the search strategy. Once the overall strategy is formulated, the search is ready to be undertaken.

SAMPLE SEARCH

The search to be illustrated is based on the question discussed in the search strategy section: a request for current technical information on the air pollution aspects of siting electric power production facilities. Formulation of the search strategy followed the approach outlined in the last section. After reviewing the question, the appropriate databases were chosen using the selection methodology depicted in Figure 8.4. Initially thirteen databases were picked for consideration: the ten primary databases plus CDI from the specialized document-type group and the EPIA and NSIC databases from the specialized subject group. The APTIC database was excluded because it does not cover current information.

Cross-database index searching was used with an abbreviated, indicative search strategy to check the subject coverage of these files. Since the databases are not all on the same search service system, three different crossfile searches were used. NSIC was checked separately because the DOE system does not have a crossfile capability. Comparison of the results indicates that four databases seem best suited to the topic: EDB, ENVIROLINE, EPIA and NTIS. The cross-database search is shown in Searches 8.3 to 8.5. Note that the use of logical operators on Orbit will not produce a ranked database list. However, a ranking of the single term 'siting' yielded enough information to confirm that the EPIA file was a good choice for this topic. No other factors were felt to be important enough to modify the database list further. Each of them was searched.

The search terms and term relationships used were those developed in Table 8.9, with the addition of a publication date parameter where applicable. A multiple database approach was employed, relying on a free-text strategy with numerous terms and synonyms, truncation and a high recall logic. The siting concept was represented by the term siting together with site truncated to one character and in close proximity to either select(ing,ion,ed), survey(s,ing) or plan(s,ning). The power plant concept was searched with power plant(s) as a single word and as a two-word phrase and the term electric adjacent to power, plant(s) or utility(ies). The air pollution idea was represented by the broad air pollution, air pollutant(s), air quality, emission(s) or particulate(s) terms along with the specific pollutants nitrogen oxide(s), nitrogen dioxide, sulfur oxide(s) or sulfur dioxide. Both spellings of sulphur were used. In order to make sure that the siting concept was emphasized, siting terms were required to be in the title or keyword fields. Subject categories were added to the EDB search strategy. The basic strategy was amended by using a specific subset of subject category 50, 500500 SITE RESOURCE AND USE STUDIES, in conjunction with the title or keyword requirement. Note that 'power plants — site selection' appears as a paired descriptor in the sample EDB record retrieved by the search. This phrase would be good to use if more precise results were required. In the EPIA database, the electric utility/power plant concept is implied and did not have to be included as a search term. The actual search strategy and a sampling of results are illustrated in Searches 8.3–8.5.

This multiple database strategy gave several important citations on the topic of air pollution aspects of electric power plant siting. A similar strategy would find solutions to many requests on energy-related environmental issues.

Search 8.3: Siting search in BRS: CROS and NTIS

```
CROS
1  LIFE SCIENCES            (LFSC) 2  MEDICINE/PHARMACOLOGY   (MDPH)
3  PHYSICAL/APPLIED SCI.    (PHAS) 4  BUSINESS                (BUSN)
5  SOCIAL SCI/HUMANITIES    (SOSC) 6  EDUCATION               (EDCA)
7  REFERENCE                (REFC) 8  ALL DATABASES           (FALL)
9  USER OPTION

ENTER CROS CATEGORY NUMBER DESIRED.__: 9
ENTER DATABASE NAMES SEPARATED BY COMMAS__: diss,insp,ntis,poll

BRS SEARCH MODE - ENTER QUERY

  1__: siting and power adj plantS1 and (air adj pollutS5 or air adj quality)

     DISS        0
     INSP        6
     NTIS      183
     POLL       30

1__: ..c/ntis

NTIS 1970 - JUL 1986

BRS SEARCH MODE - ENTER QUERY

    1__: siting. ti,de,id. or siteS1.ti,de,id. with (selectS5 or surveyS3 or plan or plans or
planning)
     RESULT  7802

    2__: powerplantS or power adj plantS1 or power-plantS or electric adj (power or
plantS1 or utilitS3)
     RESULT 37113

    3__: air adj (pollutS5 or quality) or air-pollutS or air-quality or emissionS1 or
particulateS1 or nitrogen adj oxideS1 or nitrogen-oxideS
     RESULT 52979

    4__: nitrogen adj dioxide or nitrogen-dioxideS or sulfur adj oxideS1 or sulfur-
oxideS or sulfur adj dioxide or sulfur-dioxideS or sulphur adj oxideS1 or sulphur adj
dioxide
     RESULT  6564

    5__: 1 and 2 and (3 or 4)
     RESULT   186

    6__: 1/5 yr gt 1983
     RESULT    11
```

Search 8.3: (cont.)

```
7__: . . p 6 ti/doc = 1 - 5
  1
TI   ACID RAIN CONTROL LEGISLATION: COSTS TO MARYLAND ELECTRIC
     UTILITIES AND IMPLEMENTATION ISSUES.

  2
TI   CHEMICAL COMPOSITION OF PRECIPITATION AND WATERSHED SAMPLES
     COLLECTED AT DEEP CREEK LAKE, GARRETT COUNTY, MARYLAND - FINAL
     REPORT.

  3
TI   MARYLAND POWER PLANT SITING PROGRAM RADIOECOLOGY DATABASE
     MANAGEMENT SYSTEM: FORMAT FOR CODING RADIOECOLOGY DATA.

  4
TI   FULL-SCALE FIELD EVALUATION OF WASTE DISPOSAL FROM COAL-FIRED
     ELECTRIC GENERATIING PLANTS. VOLUME 2. SECTIONS 6 THROUGH 9.

  5
TI   PRACTICAL CONSEQUENCES OF THE ASSESSMENT OF DIFFERENT ENERGY
     HEALTH RISKS.

END OF REQUEST

7__: . . p 6 all/doc = 1

  1
AN   PB86 - 163102 - XAB. 8606.
AU   KETE - N.  ROIG - R - A.  BROWN - D - H.
IN   MARYLAND DEPT. OF NATURAL RESOURCES, ANNAPOLIS. POWER PLANT
     SITING PROGRAM. JOHNS HOPKINS UNIV., BALTIMORE, MD. DEPT. OF
     GEOGRAPHY AND ENVIRONMENTAL ENGINEERING.
     050001004.
TI   ACID RAIN CONTROL LEGISLATION: COSTS TO MARYLAND ELECTRIC
     UTILITIES AND IMPLEMENTATION ISSUES.
NT   FINAL REPT., 212 PAGES
     PREPARED IN COOPERATION WITH JOHNS HOPKINS UNIV., BALTIMORE, MD.
     DEPT. OF GEOGRAPHY AND ENVIRONMENTAL ENGINEERING.
YR   DEC 1985.
JN   U8611.
RN   PPES - 86 - 1.
PR   NTIS PRICES: PC A10/MF A01.
CC   5D. 68A. 68D. 92D. 43F.
MJ   AIR - POLLUTION - CONTROL. LEGISLATION. MARYLAND.
MN   ENVIRONMENTAL - IMPACTS. SULFUR - DIOXIDE. NITROGEN - OXIDES.
     PROJECTION. COST - ANALYSIS. ECONOMIC - FACTORS. PUBLIC - UTILITIES.
     ELECTRIC - POWER - PLANTS. REGULATIONS. MARYLAND.
ID   *ACID RAIN. POWER PLANT SITING PROGRAM. NTISMDNRPS.
AB   THE REPORT IS ONE OF A SERIES OF STUDIES PPSP IS CONDUCTING TO
     DETERMINE THE SOURCE AND EXTENT, ENVIRONMENTAL IMPACTS, AND
     COSTS OF CONTROLLING ACID RAIN IN MARYLAND. THE REPORT ESTIMATES
     THE POTENTIAL COSTS TO MARYLAND'S FOUR MAJOR UTILITIES, AND
     HENCE THEIR RATE PAYERS, OF IMPLEMENTING ONE POSSIBLE NATIONAL
```

Search 8.3: (cont.)

```
        ACID DEPOSITION CONTROL STRATEGY. THIS WAS DONE BY EXAMINING
        PRESENT AND PROJECTED MARYLAND SULFUR DIOXIDE AND NITROGEN
        OXIDE EMISSIONS, REVIEWING AND ANALYZING LEGISLATION INTRODUCED
        DURING THE 97TH AND 98TH CONGRESSES, DEVELOPING A HYPOTHETICAL
        ACID DEPOSITION CONTROL STRATEGY BASED ON THE LEGISLATIVE
        ANALYSIS, AND HAVING EACH OF MARYLAND'S FOUR MAJOR UTILITIES
        DETERMINE ITS COSTS OF COMPLYING WITH THE HYPOTHETICAL SCENARIO.
END OF REQUEST
```

Search 8.4: Siting search in DIALOG: DIALINDEX, EDB and ENVIROLINE

```
File 411:DIALINDEX(tm)

? sf 34, 40, 68, 69, 103, 311

File  34: SCISEARCH - 84-86/WK24
File  40: ENVIROLINE - 70-86/APR
File  68: ENVIRONMENTAL BIBLIOGRAPHY - 74-86/APR
File  69: ENERGYLINE - 70-86/APR
File 103: DOE ENERGY - 83-86/MAY (ISS12)
File 311: CA SEARCH 1982-86 UD=10426

File  Items  Description

? s siting and power(w) plant? ? and (air(w)pollut? or air(w)quality)

34: SCISEARCH - 84-86/WK24
                 53  SITING
                746  POWER(W)PLANT? ?
                453  AIR(W)POLLUT?
                121  AIR(W)QUALITY
                  0  SITING AND POWER(W)PLANT? ? AND (AIR(W)POLLUT? OR
                     AIR(W)QUALITY)

40: ENVIROLINE - 70-86/APR
               1360  SITING
               6210  POWER(W)PLANT? ?
               7781  AIR(W)POLLUT?
               4074  AIR(W)QUALITY
                 86  SITING AND POWER(W)PLANT? ? AND (AIR(W)POLLUT? OR
                     AIR(W)QUALITY)

68: ENVIRONMENTAL BIBLIOGRAPHY - 74-86/APR
                225  SITING
               2909  POWER(W)PLANT? ?
               6143  AIR(W)POLLUT?
                703  AIR(W)QUALITY
                  3  SITING AND POWER(W)PLANT? ? AND (AIR(W)POLLUT? OR
                     AIR(W)QUALITY)
```

Search 8.4: (cont.)

```
69: ENERGYLINE - 70-86/APR
                1453  SITING
               11350  POWER(W)PLANT? ?
                 782  AIR(W)POLLUT?
                 536  AIR(W)QUALITY
                  54  SITING AND POWER(W)PLANT? ? AND (AIR(W)POLLUT? OR
                      AIR(W)QUALITY)

103: DOE ENERGY - 83-86/MAY (ISS12)
                1432  SITING
               35031  POWER(W)PLANT? ?
               20589  AIR(W)POLLUT?
                3118  AIR(W)QUALITY
                  43  SITING AND POWER(W)PLANT? ? AND (AIR(W)POLLUT? OR
                      AIR(W)QUALITY)

311: CA SEARCH 1982-86 UD=10426
                  92  SITING
                3191  POWER(W)PLANT? ?
               40165  AIR(W)POLLUT?
                 496  AIR(W)QUALITY
                   4  SITING AND POWER(W)PLANT? ? AND (AIR(W)POLLUT? OR
                      AIR(W)QUALITY)
```

File 103: DOE ENERGY - 83-86/MAY (ISS12)

Set	Items	Description
? s siting or site? ?(3n)(select? or survey? or plan or plans or planning)		
	1432	SITING
	4814	SITE? ?(3N)((((SELECT? OR SURVEY?) OR PLAN) OR PLANS) OR PLANNING)
S1	5491	SITING OR SITE? ?(3N)(SELECT? OR SURVEY? OR PLAN OR PLANS OR PLANNING)
? s powerplant? or power(w)plant? ? or electric(w)(power or plant? ? or utilit??? ?)		
	411	POWERPLANT?
	35031	POWER(W)PLANT? ?
	16221	ELECTRIC(W)((POWER OR PLANT? ?) OR UTILIT??? ?)
S2	45600	POWER PLANT? OR POWER(W)PLANT? ? OR ELECTRIC(W)(POWER OR PLANT? ? OR UTILIT??? ?)
? s air(w)(pollut? or quality) or emission? ? or particulate? ? or nitrogen(w)(oxide? ? or dioxide) or sulfur(w)(oxide? ? or dioxide) or sulphur(w)(oxide? ? or dioxide)		
	21624	AIR(W)(POLLUT? OR QUALITY)
	31792	EMISSION? ?
	6905	PARTICULATE? ?
	6836	NITROGEN(W)(OXIDE? ? OR DIOXIDE)
	8103	SULFUR(W)(OXIDE? ? OR DIOXIDE)
	574	SULPHUR(W)(OXIDE? ? OR DIOXIDE)
S3	54708	AIR(W)(POLLUT? OR QUALITY) OR EMISSION? ? OR PARTICULATE? ? OR NITROGEN(W)(OXIDE? ? OR DIOXIDE) OR SULFUR(W)(OXIDE? ? OR DIOXIDE) OR SULPHUR(W)(OXIDE? ? OR DIOXIDE)

Search 8.4: (cont.)

```
? s sc = 50
    S4      22292  SC = 50
? c 1 and 2 and (3 or 4)
    S5        134  1 AND 2 AND (3 OR 4)
? s sc = 500500
    S6        168  SC = 500500
? c 6 and 2
    S7         28  6 AND 2
? s s1/ti,de
    S8       4045  S1/TI,DE
? c 8 and 5
    S9         90  8 AND 5
? c 9 or 7
    S10       108  9 OR 7
? s py = 1984:py = 1986
    S11    256220  PY = 1984:PY = 1986
? c 11 and 10
    S12        24  11 AND 10
? t 12/6/1 - 5
 12/6/1
1039181  ERA - 11:001317, EDB - 85:176874
  Computerized radiological emergency response and assessment system
  International symposium on emergency planning and preparedness for
nuclear facilities

 12/6/2
1036009  AIX - 16:075627, EDB - 85:173702
  Equity and electric power generation facility location in California

 12/6/3
1015087  EDB - 85:152778
  Impact of a power station on air flow and temperature fields
  Air pollution. Volume IV: Meteorology
 6. international conference on air pollution

 12/6/4
1007443  EDB - 85:145133
  Coal-fired plant meets strict standards from air to aesthetics (New York)

 12/6/5
974523  ERA - 10:033637, EPA - 11:003328, EDB - 85:112216
  Western Maryland Power Plant Siting Study: discussion of licensing issues
and site boundary considerations at three candidate sites. Final report

? t12/5/2
12/5/2
 1036009  AIX - 16:075627, EDB - 85:173702
  Equity and electric power generation facility location in California
  Warren, E.H. Jr.; Huning, J.R. (Jet Propulsion Lab., Pasadena, CA (USA));
```

Search 8.4: (cont.)

Hutchinson, C.F. (Arizona Univ., Tucson (USA). Office of Arid Lands Studies)
Energy (Oxford) (United Kingdom) 10:6 749 – 760 P. Jun 1985 Coden: ENEYD
Journal Announcement: EDB8510
Document Type: Journal Article
Languages: English
Work Location: United States
An alternative to cost/benefit analysis for analyzing the equity of electric power generation facility location, utilizing the potential for air quality degradation, is developed and applied to California. Siting issues motivating disagreement on facility location are reviewed. Equity concepts are introduced, and their implementation is discussed. Several measures for assessing the equity of facility location are proposed, and the equities of existing facility locations in California are analyzed for each measure. Equity considerations for future siting decisions are examined.
Descriptors: *CALIFORNIA---POWER PLANTS; *POWER PLANTS---ENVIRONMENTAL IMPACTS; *POWER PLANTS---SITE SELECTION; AIR POLLUTION; ECONOMIC ANALYSIS; ELECTRIC POWER; POWER GENERATION; RURAL AREAS; SOCIO-ECONOMIC FACTORS; SOCIOLOGY
Special Terms: ECONOMICS; FEDERAL REGION IX; INSTITUTIONAL FACTORS; NORTH AMERICA; POLLUTION; POWER; USA
Class Codes: 200203*; 290300; F11*00

? **end/save temp**
Temp Search – save "TA159" stored

File 40:ENVIROLINE – 70 – 86/APR

? **.exs ta159**

Set	Items	Description
	1360	SITING
	559	SITE? ?(3N) ((((SELECT? OR SURVEY?) OR PLAN) OR PLANS) OR PLANNING)
S1	1830	SITING OR SITE? ?(3N) (SELECT? OR SURVEY? OR PLAN OR PLANS OR PLANNING)
	110	POWERPLANT?
	6210	POWER(W)PLANT? ?
	1976	ELECTRIC(W) ((POWER OR PLANT? ?) OR UTILIT??? ?)
S2	7399	POWERPLANT? OR POWER(W)PLANT? ? OR ELECTRIC(W) (POWER OR PLANT? ? OR UTILIT??? ?)
	10024	AIR(W) (POLLUT? OR QUALITY)
	10073	EMISSION? ?
	4183	PARTICULATE? ?
	2715	NITROGEN(W) (OXIDE? ? OR DIOXIDE)
	3889	SULFUR(W) (OXIDE? ? OR DIOXIDE)
	66	SULPHUR(W) (OXIDE? ? OR DIOXIDE)

Search 8.4: (cont.)

```
 S3    18413  AIR(W) (POLLUT? OR QUALITY) OR EMISSION? ? OR
              PARTICULATE? ? OR NITROGEN(W) (OXIDE? ? OR DIOXIDE)
              OR SULFUR(W) (OXIDE? ? OR DIOXIDE) OR SULPHUR(W)
              (OXIDE? ? OR DIOXIDE)

>>>Prefix "SC" is undefined
 S4        0  SC = 50

 S5      183  S1 AND S2 AND (S3 OR S4)

>>>Prefix "SC" is undefined
 S6        0  SC = 500500

 S7        0  S6 AND S2

 S8     1136  S1/T1,DE

 S9      150  S8 AND S5

 S10     150  S9 OR S7

>>>Prefix "PY" is undefined
 S11       0  PY = 1984:PY = 1986

?t10/8/1 – 5

 10/8/1

0179609  *85/025473
  POTENTIAL IMPACTS OF PROPOSED EPA TALL STACK REGULATIONS,

 10/8/2

0176326  *85/005944
  MANAGEMENT AND PLANNING OF ENERGY/ENVIRONMENT SYSTEMS
IN ITALY (NATIONAL PERSPECTIVES ON THE MANAGEMENT OF
ENERGY/ENVIRONMENT SYSTEMS),

 10/8/3

0175043  *85 – 001173
  LOCATING VEGETATION "AT – RISK" TO AIR POLLUTION: AN
EXPLORATION OF A REGIONAL APPROACH,

 10/8/4

0173893  84 – 005802
  ENVIRONMENTAL IMPACTS OF DISPERSED AND CONCENTRATED SITING
OF COAL – FIRED POWER PLANTS,

 10/8/5

0172478  *84 – 004387
  ENVIRONMENTAL CONSIDERATIONS IN SITING ALTERNATIVE FUEL
GENERATING FACILITIES,
```

Search 8.4: (cont.)

```
?t10/5/3

 10/5/3

0175043  *85-001173
  LOCATING VEGETATION "AT-RISK" TO AIR POLLUTION: AN
EXPLORATION OF A REGIONAL APPROACH,
  KRUMMEL J. R. ; GILMORE C. C.; O'NEILL R. V.
  ORNL,
  J ENV MANAGEMENT, APR 84, V18, N3, P279(12) RESEARCH ARTICLE
  A REGIONAL APPROACH FOR LOCATING FIELD RESEARCH SITES WAS
USED TO ASSESS THE IMPACT FROM NEW COAL- FIRED POWER PLANTS AND
SYNFUEL FACILITIES ALONG THE OHIO AND GREEN RIVERS IN KENTUCKY.
THE STUDY AREA WAS SEGMENTED INTO 1600 GRID LOCATIONS, AND THE
PROBABILITY OF EXCEEDING THREE HOUR AVERAGE LEVELS OF 210 AND
262 MG/CU M OF SULFUR DIOXIDE WAS COMPUTED FOR EACH GRID
LOCATION. ONLY SITES ALONG THE WESTERN OHIO RIVER VALLEY
PORTION OF THE STUDY REGION WERE FOUND TO HAVE A REASONABLE
PROBABILITY OF EXCEEDING THE SO2 AVERAGES DURING THE GROWING
SEASON. FORESTED AND NON-FORESTED WETLANDS APPEARED IN 37%
OF THESE GRID LOCATIONS. THE APPROACH IDENTIFIED A VEGETATION
TYPE AT-RISK WHICH MAY HAVE BEEN IGNORED IN A SITE-BY-SITE
APPROACH. ( 4 MAPS, 25 REFERENCES, 3 TABLES, )
  DESCRIPTORS: *KENTUCKY; *AIR POLLUTION EFFECTS ; *BIOLOGY,
PLANT ; *BIOLOGICAL INDICATORS-AIR ; *POWER PLANT EMISSIONS ;
*COAL PROCESSING EMISSIONS ; *SULFUR DIOXIDE ; MONITORING, ENV
-AIR ; ATMOSPHERIC POLLUTANT DEPOSITION ; POWER PLANT SITING;
LAND USE CLASSIFICATION
  REVIEW CLASSIFICATION: 01
```

Search 8.5: Siting search on Orbit: DATABASE INDEX and EPIA

```
YOU ARE NOW CONNECTED TO THE DATA BASE INDEX DATABASE.

SS 1 /C?
USER:
siting

PROG:
SS 1: (45) DATABASES

SS 2 /C?
USER:
prt rank 5

PROG:

  -1-
  DN   -  EPIA (PROXIMITY SEARCHABLE)
  PSTG -  AT LEAST 1701.

  -2-
  DN   -  ENERGYLINE (PROXIMITY SEARCHABLE)
  PSTG -  AT LEAST 1401.
```

Search 8.5: (cont.)

```
 -3-
 DN   -  ENVIROLINE (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 1301.

 -4-
 DN   -  NTIS (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 1201.

 -5-
 DN   -  COMPENDEX (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 941.

SS 2 /C?
USER:
air quality

PROG:
SS 2: (12) DATABASES

SS 3 /C?
USER:
prt rank 5

PROG:

 -1-
 DN   -  NTIS (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 2401.

 -2-
 DN   -  EPIA (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 2201.

 -3-
 DN   -  P/E NEWS (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 601.

 -4-
 DN   -  LC/PRE84 (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 131.

 -5-
 DN   -  INSPEC (PROXIMITY SEARCHABLE)
 PSTG -  AT LEAST 131.
```

```
YOU ARE NOW CONNECTED TO THE EPIA DATABASE.
COVERS 1975 TO (8403)

*PROXIMITY SEARCHABLE.*

SS 1 /C?
USER:
/ti,iw siting or site(w) all select: or site(w) all survey: or site(w) all plan:

PROG:
SS 1 PSTG (1752)
```

Search 8.5: (cont.)

SS 2 /C?
USER:
/ti,iw air(w) all pollut: or air(w)quality or all emission # or

PROG:
CONTINUE ENTERING SS 2.

USER:
all particulate # or nitrogen(w) all oxide # or nitrogen(w)dioxide or

PROG:
CONTINUE ENTERING SS 2.

USER:
sulfur(w) all oxide # or sulfur(w)dioxide or sulphur(w) all oxide # or

PROG:
CONTINUE ENTERING SS 2.

USER:
sulphur(w)dioxide

PROG:
SS 2 PSTG (2906)

SS 3 /C?
USER:
1 and 2

PROG:
SS 3 PSTG (145)

USER:
prt ti

PROG:

-1-
TI - Characterization of Transformer Noise Emissions - Volume 2: Transformer Environmental Noise Siting Guide.

-2-
TI - The Maryland Power Plant Siting Program (PPSP) Air Quality Model User's Guide.

-3-
TI - CONSIDERATIONS IN ELECTRIC POWER PLANT SITING: AIR QUALITY.

-4-
TI - STACK DESIGN AND EMISSIONS DATA FOR THE IPP PLANT.

-5-
TI - AIR QUALITY CONSTRAINTS ON THE SITING OF COAL POWER PLANTS AND COAL CONVERSION FACILITIES IN EASTERN WY AND MT.

Search 8.5: (cont.)

```
SS 4 /C?
USER:
prt full 5
PROG:
-3-
AN - 83-028858
TI - CONSIDERATIONS IN ELECTRIC POWER PLANT SITING: AIR
     QUALITY.
SO - MINNESOTA ENVIRONMENTAL QUALITY BOARD, 6P., 12/79
DT - PUBLIC INFORMATION BROCHURE
IT - COAL PLANT; SITING; AIR QUALITY; STACK EMISSION; ACID
     DEPOSITION; FLUE GAS DESULFURIZATION
AB - THIS BROCHURE DESCRIBES SOME OF THE AIR QUALITY EFFECTS
     OF SULFUR OXIDES AND PARTICULATE POLLUTION FROM COAL
     FIRED POWER PLANTS. ACID RAIN IS GIVEN PARTICULAR
     ATTENTION. IT THEN DISCUSSES SOME OF THE EQUIPMENT
     CURRENTLY AVAILABLE TO CONTROL THESE EMISSIONS,
     INCLUDING ELECTROSTATIC PRECIPITATORS, BAGHOUSE FILTERS,
     AND SCRUBBERS.
```

FURTHER READING

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Yska, G. and Martyn, J. *Databases Suitable for Users of Environmental Information.* London: Aslib Research Development Department, 1978

Håkan Nylund: Public Relations
13.8.1991

PR AND THE ENVIRONMENT

* ENVIRONMENTAL ISSUES ARE TODAY THE LARGEST SOURCE OF CONCERN TO THE GENERAL PUBLIC

* PROTECTION OF THE ENVIRONMENT IS NO LONGER ONLY A CONCERN FOR RICH COUNTRIES

* ENVIRONMENTAL MANAGEMENT IS A PART OF ALL MANAGEMENT

* ENVIRONMENTAL CONCERN AND "GREEN ISSUES" AFFECT

- POLITICS
- CONSUMPTION
- INVESTMENTS
- RECRUITING
- EVERYTHING

PR = COMMUNICATION

* A TWO LANE ACT: TALK AND LISTEN
* NOT AN ISOLATED "NICE TO DO" ACTIVITY

* PR'S TASK IS TO SUPPORT THE ACHIEVEMENT OF AN ORGANIZATION'S OVERALL OBJECTIVES

* INCLUDE INTERNAL, EXTERNAL AND COMMERCIAL COMMUNICATIONS

* PR CAN'T TURN BLACK INTO WHITE

* BETTER STRENTHENING A POSITIVE IMAGE THAN EXPLAINING AWAY A BAD

* "THINGS ARE WHAT THEY SEEMM TO BE"

SPECIAL PROBLEMS OF ENVIRONMENTAL PR

* HIGHLY TECHNICAL AND SCIENTIFIC

* DISTRUST AND LACK OF CREDIBILITY

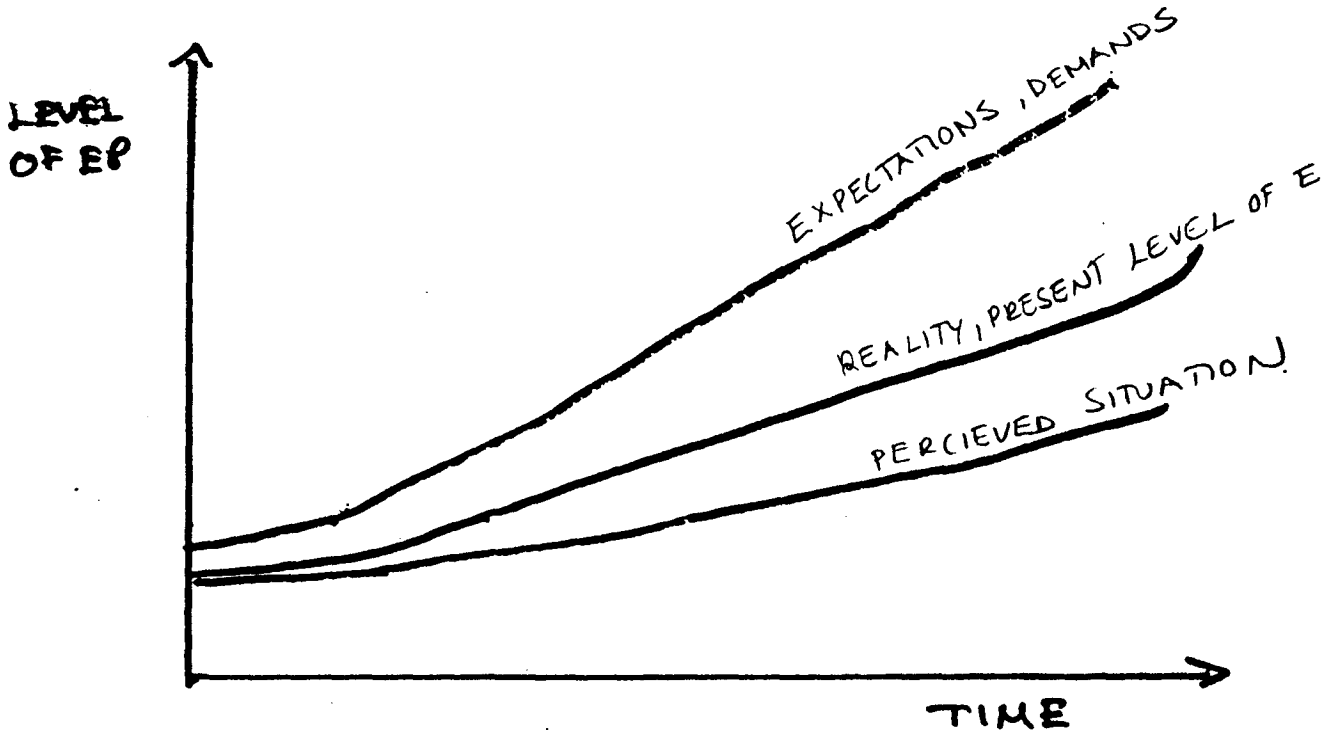
* GOOD NEWS ARE NORMAL = NO NEWS (I DON'T BEAT MY WIFE ANYMORE)

* RISING EXPECTATIONS AMONG THE PUBLIC

* FOCUS PLACED ON SYMPTOMS, NOT CAUSES

* NOT IN MY BACKYARD

EXPECTATIONS, REALITY AND PERCEPTIONS OF INDUSTRY'S ENVIRONMENTAL PROTECTION



ENVIRONMENTAL PR-MESSAGES

* WHAT YOU DO, HOW AND WHY

* LIFECYCLES

* HOW YOU AFFECT THE ENVIRONMENT
    - POSITIVE EFFECTS
    - NEGATIVE EFFECTS

* WHAT YOU HAVE DONE FOR THE ENVIRONMENT

* WHAT YOU WILL DO

* (WHAT YOU WILL DO WHEN THINGS GO WRONG)

WITH WHOM SHOULD YOU COMMUNICATE?

* YOUR STAFF
* YOUR STAFF (NETWORK-EFFECT)
* YOUR STAFF
* CUSTOMERS
* LOCAL COMMUNITY
* AUTHORITIES
* SPECIAL INTEREST GROUPS
* FINANCIERS
* POTENTIAL STAFF (STUDENTS e.a.)
* GENERAL PUBLIC
* THE PRESS

HOW?

* "NORMAL CHANNELS"
- line organization
- marketing and sales channels
- reports to authorities e.a.

* INTERNAL "MASS" COMMUNICATIONS
- house magazines
- billboards
- information meetings
- training programmes

* EXTERNAL MASS COMMUNICATIONS
- regular press contacts
- customer magazines
- visits
- advertising

* COMMUNITY PROGRAMMES
- open doors
- school programmes
- civic action

WHO SHOULD COMMUNICATE?

* EVERYBODY

* TOP MANAGEMENT AND LINE MANAGEMENT IN CHARGE

* ENVIRONMENTAL EXPERTS

* PR-OFFICERS

(BUT REMEMBER THAT MANAGEMENT NEEDS COMMUNICATIONS TRAINING)

REMEMBER

* ALWAYS TELL THE TRUTH
- AS SOON AS POSSIBLE
- FIRST TO YOUR STAFF (& AUTHORITIES)
- TELLING THE TRUTH IS NOT THE SAME THING AS TELLING EVERYTHING

* TELL IT AGAIN AND AGAIN (BUT LISTEN IN BETWEEN)

* REMEMBER YOU ARE HUMAN

* EXPLAIN HOW MUCH IS MUCH

* HEED THE ADVICE OF YOUR PR-PROFESSIONALS - ON A SLOW NEWSDAY ANYTHING CAN HAPPEN - OR BE DONE

TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT FOR INDUSTRIAL MANAGERS AND ENGINEERS FROM ESCAP COUNTRIES (1989), rev. 1991

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NEGOTIATIONS WITH AUTHORITIES

1. INTRODUCTION

Industrial managers and engineers work within a framework of economical, technical, legal and social possibilities and restrictions. Within this framework the environmental objectives are of growing importance. In aiming at an optimal environmental protection and a rational use of natural resources enterprises and authorities have different roles, responsibilities and means. To meat the objectives the society and the environment call for they have to collaborate and to negotiate.

In Finland the environmental legislation is very split. There are the Water Act (264/61), the Waste Management Act (673/78), the Air Pollution Control Act (67/82) and the Chemical Act (744/89) just to mention some acts of central importance. The water protection is supervised by the National Board of Waters and Environment and its 13 districts. Permits for effluent dicharge or other pollution or change of a watercourse are given by the Water Court. Waste management and air pollution control are supervised by the County Governments and on a local level by the municipal authorities. Permits are given by the County Governments. Other authorities with environmental responsibilities are the labour protection authorities, the health authorities and the technical inspection authorities. In many countries the environmental legislation is more coherent. In Finland a more uniform legislation and administration is under development.

2. ITEMS AND OBJECTIVES FOR NEGOTIATIONS

2.1 Establishment of new plant or production change

Already at the preliminary stage of planning a new establishment the necessary permits and environmental aspects are to be surveyed. The enterprise is expected to comprehend that the environmental criteria may affect localization as well as other economic and technical decisions. Even in case of changing the production, raw materials or technical devices at an existing plant the authorities should be informed as soon as the principal decision has been made and negotiations should be initiated to survey the possible need for renewing the permits.

The information to be given to the environmental authorities on a new project is quite comprehensive and should cover production processes, use of raw materials and chemicals, pollution control measures, lay out of sewerage and landfills, estimates of effluents and emissions and their impact on the environment, description of the recipient, timetable of the project etc. At the first meeting the authority will probably ask for more information, e.g. on technical alternatives and details, emergency plans, waste handling, effluent and emission quality, toxicity data, state of the art on the environmental quality etc. Essential information called for to assess the need for wastewater pollution control measures is drawn up in figure 1.

The enterprise, for its part, might wish to know about application procedures, environmental criteria and standards and likely permit conditions. The authorities can, however, in general not be expected to give detailed permit conditions at this stage.

To sum up, the aim of the first negotiations is to exchange information and to find out which permits are needed and what plans and reports and other information are to be included in the application documents. Special studies and research programs to be carried out by the enterprise and-more rarely - by the authorities, should also be looked into.

At the next stage negotiations may be called for to assess the results of new studies and to make sure that application documents are sufficient. At the same time more information on details and likely permit conditions might be exchanged. It should, however, be pointed out that the enterprise prepares the application documents independently and that no definite agreements on permit conditions can be made at this stage. The aim of achieving an understanding is mainly to speed up the handling of the case.

When a permit is issued the permit conditions might not satisfy the enterprise or the authorities concerned. At this stage, the court appealed to might initiate negotiations between the enterprise and the authority. The aim of the negotiations is to help the court to find the right solution and to accelerate the procedure.

2.2 Implementation of permit conditions

There ought to be an understanding between the enterprise and the supervising authority on the interpretation of the permit and the permit conditions. There also ought to be an agreement on the supervision policy. It is therefore most important to agree upon a monitoring, control and reporting program, that is documented and approved at a responsible level.

The effluent and air emission monitoring programs are mostly carried out by the enterprise itself or by a consultant payed for by the enterprise. The control and reporting system should also include record-keeping at strategic processes and plants like wastewater treatment plant, and reporting on the use of raw materials and chemicals. Since monitoring is quite expensive it is important to find a cost efficient control program. However, it should be understood that the supervising authorities' need for information is great. Moreover, it should be pointed out that the supervising authority always has the right to make inspections, take samples, check the diaries, talk to the staff and so on.

In case permit conditions include an obligation to make some studies or plans for future pollution abatement, these should also be supervised and approved of by the authority. In this case as well as in the case of formulating the control program referred to above it is usual that negotiations are initiated by the enterprise, who also should prepare the preliminary documents for discussion.

Whenever an enterprise deviates from permit conditions the supervising authority should be informed. The situation might also call for a written report and negotiations. In case a disturbance can be foreseen the information should be given in good time so that interim arrangements can be agreed upon to minimize the effects of the disturbance. Accidents, on the other hand, might call for studies of technical efficiency, responsibilities, emergency plans and environmental effects.

In case of prolonged illegal situation the enterprise must be prepared to make extended efforts to meet the permit and other legal conditions. If this does not seem feasible technically and/or economically it might be preferrable to apply for new permit conditions. In this case it should, however, be advisable to check whether the supervising authority can agree with the enterprise on the technical reasons for a new permit. This procedure is very exceptional and has resulted in new permits only in a few cases. Mostly, the enterprise ought to check its own pollution control policies.

4.3 Other kinds of negotiations

Sometimes there might be other reasons for arranging meetings between enterprises and authorities than the permit of a single plant. Such reasons might be sectorial and regional. Items to be discussed might concern for instance research and development, regional plans, laws under development, or international recommendations.

3. PRACTICAL ARRANGEMENTS FOR NEGOTIATIONS

Most of the items negotiated between an enterprise and the authorities call for well prepared documents, reports and discussion papers. Generally contact is taken by the enterprise, who also prepares most of the papers and hosts the meeting. Quite often the authorities are interested in visiting the production plant where they can be come aquainted with processes, treatment plant, laboratory, landfills and surroundings. However, if the authority is well aquainted with the plant and there is no need for such a technical visit or if the negotiations are of a more general sectorial or high level nature the meetings may as well be hosted by the authority.

The first contact is taken in good time before the meeting in writing or orally. At the same time the items to be discussed are clarified and the necessary background papers noted. Sometimes negotiations are extended with informal meetings. This helps to a better knowing of each other.

The enterprise has to accept and be prepared for unannounced visits by the local authorities. During such visits technical inspections and sampling are often made. The enterprise may be requested or ordered to give some technical assistance to the visitors but it is not assumed that managers attend the inspections.

4. PSYCHOLOGY OF NEGOTIATIONS

The psychology of negotiations between enterprises and authorities differs somewhat from the psychology of business relations.

The relation between enterprise and authority should be open, friendly and - above all - pertinent. It is important that there is an understanding of each others' role and responsibility. A good rule is - like in business relations: be yourself and get to know your partner.

If permit conditions are violated, if the negotiation partners cannot agree upon the legality of the situation or if they cannot agree upon the technical economical possibilities that the enterprise has or should have to abate the pollution or to monitor effluents, emissions or the quality of the environment, then the negotiations might turn to a battle. Such a situation demands for much time and effort from both sides and it should be avoided at least as resulting from personal antipathy and impertinent means. Such situations should also in time be brought up to a sufficiently high level, ultimately to the court. Another good rule in this context is: never show aggressions. Promise rather to do what you can, although, at the moment, you do not think you can do anything. As soon as a conflict such as referred to above is overcome the situation should be followed up and the contact continued on an equal and respectful basis.

In Finland as well as in many other countries bribery is not allowed. Neither must an official neglect his duty. Both are crimes which can be punished with a fine or up to one or two (in grave cases of bribery even four) years of prison. The rules for secrecy are also important for the psychology of negotiations. Documents under preparation are not public. Neither is it allowed to diclose so called business secrets or other economic facts given with confidence to the authorities.

The authority should not be used as a consultant, he can never be responsible for a failure. Although he might be keen on knowing the best pollution control techniques he is never a specialist on the circumstances at the enterprise which will affect costs and applications.

Be long-sighted. The enterprise as well as the society will profit from people who understand that business and environmental objectives are not antagonistic.

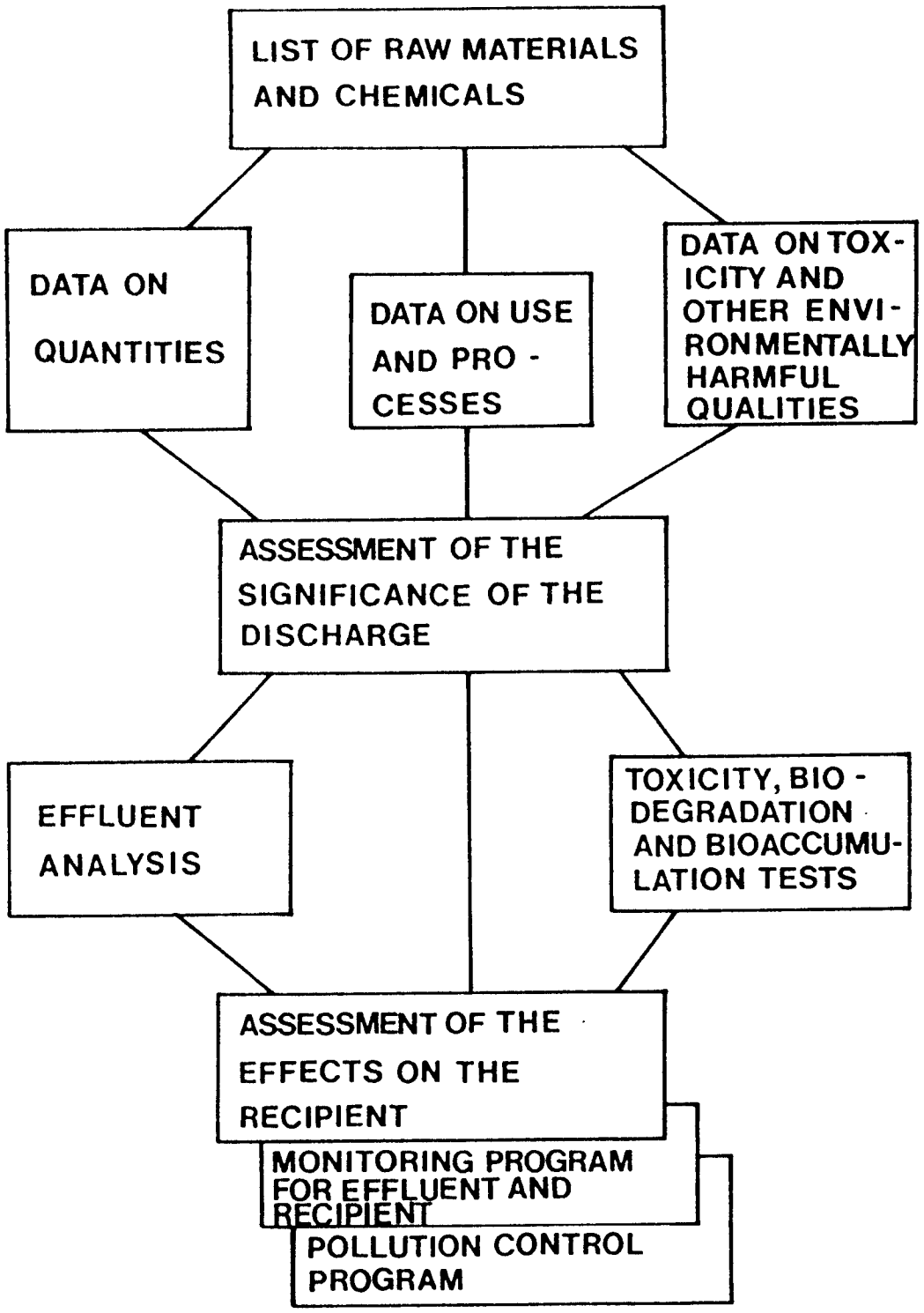

FIGURE 1. PROCEDURE FOR ASSESSMENT OF EFFLUENT TOXICITY, MONITORING AND POLLUTION CONTROL

THE WATER INDUSTRY OF FINLAND

Risto Timonen
The National Board of Waters and the Environment
31.5.1991

The most recent Ice Age had marked effects on the Finnish soil and landscape. Movements of the ice sheet abraded the bedrock, and resulted in the formation of eskers and lake basins. Glacial deposits, e.g. moraines, are abundant. The average thickness of the overburden is about 2 metres.

In Finland there are about 33 500 km^2 of inland water, 10% of the total area of the country. There are 56 000 lakes 0,01 km^2 or more in area, and almost 190 000 lakes or ponds of 500 m^2 or more. The average depth of the lakes is only 7 metres. Their total volume is only about 230 km^3. The mean total flow of watercourses is 3 100 m^3/s. Groundwater resources are 60 - 80 m^3/s.

In central and eastern Finland many lakes are joined by rivers and torrents, and thus form major waterways. In many of the larger lakes, water levels are artificially controlled. More than 300 regulated natural and artificial lakes cover about 35% of the total lake area of Finland. Almost half of the regulated lakes are used for energy production. A quarter are for flood control and a quarter are for water supply purposes.

Several hundred hydroelectric power plants have been constructed on rivers in Finland. About 50 plants have generating capacities of over 10 MW. The electricity produced by hydro power stations amounts to 12 TWh per year, about 25% of the total electricity demand. Despite considerable declines in the proportion of hydroelectric power to total energy production, it remains important, because output can be rapidly adjusted to meet demand. Ability to regulate the flows of watercourses determines this flexibility.

Drainage has been important economically for a long time. Over the last two centuries, levels of almost all lakes have been lowered to extend hayfields and other arable areas. Navigation and timber flotation, widely employed until recently, have necessitated dredging of the rivers and clearing of the rapids.

Floods have affected agriculture, traffic and, to some extent, houses in river valleys, especially in those in the western coastal areas, almost every year. The land in the western coastal areas is very flat, and river flows fluctuate greatly. As a result of the latest Ice Age, isostatic recovery causes land upheaval by up to a metre per century in the western part of the country. This exacerbates flood problems. Approximately 50 000 hectares have been protected by flood control facilities (dykes, river dredging and flood water reservoirs) since 1950.

Because of Finland's geology, river and lake waters are naturally low in nutrients, but contain high levels of humic substances from marshy areas, imparting a brown colour to the waters. The buffering capacity of inland waters is low. Long periods of ice cover reduce atmospheric oxygen uptake.

Water supply

There are about 800 waterworks in Finland. Municipalities own 63% of the plants, 30% are owned by private companies and 7% by industry, hospitals and other bodies. The number of people served by public waterworks is about 4.2 million (over 80% of the population). The total length of public water-supply systems is nearly 60 000 km.

Average water use is about 280 litres per person per day. The volume of water distributed by public waterworks in 1990 was about 420 million m^3.

The Finnish population and industry are concentrated in the South of the country. This has led to scarcity of water in some areas, and has made it necessary to bring water from relatively long distances, to construct reservoirs, and to regulate watercourses. The Helsinki metropolitan area has, since 1979, obtained its water from Lake Päijänne through a rock tunnel 120 km long.

Groundwater is ideal for a municipal water supply. In most cases it needs no treatment. However, groundwater resources do not meet the needs over large areas of Finland. Nearly all of the major cities have to obtain their water mainly or totally from surface water. Many cities increase groundwater resources by infiltrating surface water to groundwater aquifers. About half of the water distributed by public waterworks is natural or artificial groundwater.

The most common water treatment methods at groundwater works are alkalization and removal of iron. In surface water works they involve treatment with aluminium sulphate and rapid sand-filtration. In 350 groundwater works the water needs no treatment before it is distributed to consumers. The microbiological quality of potable water has improved markedly over the last decades. During the last 10 years, only one epidemic has been attributed to water supplies.

Dwellings and farms in sparsely populated areas often have their own wells. Most have piped water. The population not served by the public waterworks uses about 40 million m^3 of water yearly. Dairy farms take about 60 million m^3 from their own wells. Water uptake for irrigation amounts to 10 - 30 million m^3 yearly, depending on weather.

Fish farming uses about 2 000 million m^3 of water yearly, of which about 500 million m^3 is used in inland plants. The amounts used increased considerably in the 1980s. Most new fish-breeding plants are in sea areas.

Water used by industry is derived almost totally from surface water. Less than 1% of it is supplied by public waterworks. In 1990 the total water use by industry was 6 500 million m^3, of which over 80% was for cooling, mostly of thermal and nuclear power plants. Water used for purposes other than cooling amounted to 1 200 million m^3, 70% of which was employed by the pulp and paper industries. Water consumption, in absolute terms and per tonne of production

in the pulp and paper industries, has decreased over the last two decades.

About 80% of the water used by industry needs treatment, mostly only mechanical. Some is alkalized or treated by some other chemical method.

Wastewater treatment

Over the last two decades the volume of wastewater has increased greatly, but the biological oxygen demand (BOD) of and phosphorus load on recipient waters have decreased by 50 - 60% because of development in industrial processes and other measures, and because BOD and phosphorus load are reduced by 90% in municipal treatment plants. Nitrogen load from industry has decreased by 50% but that from municipalities has doubled. Average nitrogen removal efficiency in treatment plants is only slightly over 30%.

In 1990, about 75% of Finland's population and 95% of inhabitants of densily populated regions were served by public sewerage systems. The rest of the population is so scattered that most will probably never be served by such systems. Residences in rural areas have septic tanks or their own sewage treatment facilities. In 1990, the volume of wastewater in the public sewers was about 700 million m^3, 88% of which was treated biologically and chemically and 12% biologically or chemically. The length of the sewer systems exceeds 30 000 km.

Most of the wastewater load on recipient waters comes from the pulp and paper industries. In 1990, the volume of wastewater from the pulp and paper industries was about 1 000 million m^3 and contained about 57 000 tonnes of suspended solids. The pulp and paper industries and large-scale metallurgical, chemical and other industries (about 300 factories) have their own wastewater treatment plants. Small industry discharges its wastewater into the municipal sewer systems. One quarter of the wastewater in municipal treatment plants originates from industry.

There are about 50 pulp and paper mills in Finland. All have mechanical wastewater treatment facilities, at least. About 10 mills treat their wastewater chemically, about 30 treat it biologically. The latter use oxidation ponds in 5 cases, activated sludge treatment in over 20 cases and anaerobic activated sludge treatment in 3 cases. More than half of the wastewater from the pulp and paper industries is treated biologically. Nearly all of it will be treated chemically or biologically by 1995.

In 1989, total fish production was 18 000 tonnes, 75% in sea plants, mostly situated in the south-western archipelago. Nutrient removal efficiency at sea plants is virtually zero, because there are no sludge removal facilities. In inland plants it is 10% at most. In fish breeding plants nutrient removal efficiency can be 30-40% because sludge removal and wastewater treatment methods are better. Such metods include flocculation and sedimentation, flotation

and filtration. However, only 2% of fish production plants are for breeding. The control and reduction of pollutant load from fish farming are based on restrictions concerning maximum allowable production levels and uses and properties of feeds.

Volumes of diffuse polluting discharges are rising, and their loads on the recipient waters have increased, as municipal and industrial loads have decreased. Diffuse pollution arises mainly from agriculture, forestry, isolated dwellings and summer houses, forest drainage and peat mining. In farming, liquid manure and urine are collected in tanks and discharged on to the fields once or twice a year. Effluents from cowsheds are mainly treated in septic tanks but absorption trenches are also used to some extent. The major problems are discharges of urine and liquid manure to fields in winter and excessive use of phosphorus and nitrogen in fertilizer. However, increases in nitrogen and phosphorus loads from agriculture have declined in recent years.

The amount of sewage sludge produced is about 1 million m^3 yearly (150 000 tonnes of dry matter). No marked growth in this amount is expected. Most of the sludge is stabilized. About 75% of it was used in agriculture, and for landscaping in 1987. Use of sludge in agriculture will probably decrease because of farmers' attitudes and very strict new guidelines recently issued by the water and environment authorities.

Effluents to the recipient watercourses in 1989 were as follows:

	tonnes/year			
	Suspended solids	BOD_7	P_{tot}	N_{tot}
Pulp and paper industries	57 000	112 000	740	4 400
Chemical industries	5 300	3 300	40	740
Mining and metal industries	2 100	250	10	830
Food processing industries	800	1 400	30	230
Other industries	1 000	2 800	10	120
Fish farming		23 000	250	1 700
Agriculture*			3 000	30 000
Municipal treatment plants		11 000	440	14 500

* P_{tot} 2 000 - 4 000
N_{tot} 20 000 - 40 000

Water quality

The state and changes in the usability of inland waters have been monitored systematically since the 1960s in Finland. The water quality classification system was revised in 1988. This system contains of three utilization-specific watercourse classifications, i.e. for recreational purposes, for water supply purposes and for fishing, and of a general classification. The classifications are based primarily on the treshold values of chemical and physical parameters indicating water quality. The quality criteria are divided into five or six groups from excellent to bad or unsuitable.

The quality of inland waters for water supply purposes is classified as:

Excellent: The water is free of indications of eutrophication, clay turbidity or humus content. There are no off-flavours or odours. In many cases the water can be used as household water without any pretreatment. For municipal water supply, only light pretreatment is needed, such as alkalization and mild disinfection.

Good: Slight eutrophication or humus content are observed. The water may be slightly affected by effluents, diffuse load or other activities. There are no off-flavours or odours in the water. For municipal water supply, normal pretreatment is needed, such as sedimentation, clarification, filtration, disinfection and alkalization.

Satisfactory: High eutrophication or humus contents characterize the water, and it may be affected by effluents, diffuse load or other activities. Unpleasant odours are occasionally recorded in the water. No public health risk factors are present in the water. For municipal water supply, normal treatment with the requisite additional treatments are needed.

Bad: The watercourse is significantly affected by effluents, diffuse load or other activities. The water may also be highly eutrophic or contain very high levels of humus. The water may frequently give off unpleasant odours and may contain factors constituting a public health risk. For municipal water supply, activated physical and chemical treatment are needed, additional treatment being, e.g., multistage precipitation, filtration and pH adjustment, ozonization, slow-filtration, or production of artificial groundwater.

Unsuitable: The watercourse is spoiled by effluents, diffuse load or other activities. The water is unsuitable for municipal water supply purposes except under exceptional circumstances.

The general class of a watercourse can be calculated directly from the utilization-specific classifications if all the three are determined at the same time, or it can be defined on the basis of directly measured variables. According to the latest general classification, in 1988, the water quality in 78% of the Finnish lake area has been classified as good or excellent, and 18% as satisfactory. Two thirds of the latter 18% group have high humus contents and one third is contaminated by wastewater. The wastewater load has led to classification being reduced to poor or bad in 4% of the lake area. Nearly half of the total length of rivers is classed as having water of good quality. The other half is classed as satisfactory or poor. Eutrophication of

inland waters is primarily dependent on phosphorus levels. Nitrogen has a marked effect in southern sea areas and some inland lake areas.

The quality of groundwater is generally good but has deteriorated slightly over recent decades. The main threats to quality are gravel and sand extraction, the use of fertilizers and pesticides by agriculture, the salting of roads in winter, heavy metal effluents from industry and leakage from dumping sites.

The state of the Baltic Sea has deteriorated to a point at which it is alarming, mostly because of eutrophication caused by phosphorus and nitrogen loads from agriculture and communities. The Finnish contribution to the load is about 9% (phosphorus) and about 12% (nitrogen).

Water courts and water administration

Finland is covered by three Water-Rights Courts, in Helsinki, Kuopio and Oulu. Each Water-Rights Court is precided over by a judge aided by at least two specialists in engineering or limnology. The Court has authority to deal with and issue licences pertaining to water and assess infringements of water legislation. They also handle criminal cases and lawsuits concerning water. Appeals against decisions taken by a Water-Rights Court are come before the Superior Water-Rights Court and then before the Supreme Administrative Court if it gives the right to appeal, or before the Supreme Judicial Court in lawsuits and criminal cases.

Compliance with water legislation and with decisions taken by the Water-Rights Courts is overseen by government bodies, namely the National Board of Waters and the Environment and Water and Environment Districts.

Direction, guidance and supervision in relation to water protection is the responsibility of the Ministry of the Environment. The Water and Environmental Administration came under the Ministry in 1986. It consists of the National Board of Waters and the Environment and 13 regional Water and Environment Districts. The Board consists of four departments: Water Resources Department, Water and Environment Protection Department, General Department and Water and Environment Research Institute. The Administration ensures that the public interest is taken into account at the various procedural stages in the Water-Rights Courts, e.g. by submitting statements relating to applications to the Court for permits (see next Chapter).

Although the Water and Environmental Administration is under the Ministry of the Environment, the handling of water matters in the Administration is spread over two ministries. Flood protection, land drainage, water supply, sewerage, and operations and maintenance linked to these are directed by the Ministry of Agriculture and Forestry, under which the Administration was until 1986.

The Municipal Environmental Protection Boards established in most of Finland's 461 autonomous municipalities act as local authorities dealing with water supplies, sewerage systems and wastewater. They have limited rights to deal with and issue licenses in minor connections, and chech that water legislation and decisions taken by the Water-Rights Courts are respected.

Legislation

In Finland, waters are mainly owned by the owners of adjacent land. Where the State owns adjacent land, the State's legal status is identical to that of a private landowner. The judicial bases relating to use of water and watercourses are described in the Water Act, the Act for the Prevention of Marine Pollution, and in the statutory instruments relating to these acts. In principle, the use of surface water is governed by general usage rights based on the Water Act, which allows swimming, navigation and timber flotation. However, owners have priority rights relating to the use of water, e.g. for fishing or hydroelectric power facilities.

Closure, alteration or pollution of water is forbidden by law. Anyone wishing such a prohibition to be waived must petition the Water-Rights Court. A licence will be granted if the project will not result in extensive harmful changes. The overall benefit must be substantial compared with the damage caused. No licence will be granted if a project would endanger public health, cause significant and widespread damage to environmental ecosystems or markedly impair living standards and commercial activities in the region concerned.

In practice, any undertaking or project likely to affect water use significantly must begin with an application to the Water-Rights Court. The Court uses a special enquiry procedure to facilitate its decisions. A group examines the plans for the project and quantifies any potential damage. The group consists of an engineer from the National Board of Waters and the Environment and two representatives of the municipality in which the project would be sited. At the engineer's request, the National Board may co-opt one of its experts on fisheries, biology, limnology, technology etc. All those with rights or interests likely to be affected by the project have a right to be heard at the initial meeting and subsequent enquiry. When the group has concluded its enquiry, it draws up a report, which is made available for consultation at town halls in the area affected by the project. Parties involved may submit comments and suggestions on the report to the Water-Rights Court during a specified period. The Court may also decide to hold a hearing.

When the procedure has been completed, the Court's decision to approve or reject the project is notified in writing to the applicant and other parties concerned. If a permit is granted, the Court will attach to the permit conditions to which the applicant must adhere. These conditions impose various obligations allowing the undertaking to be integrated with other uses of the watercourse.

Decisions concerning permits for wastewater discharges are mostly valid for 3 - 10 years, after which a fresh application must be made. Permits include various conditions concerning, for instance, wastewater treatment methods, load on recipient waters and monitoring of treatment efficiency, and of the quantity, quality and effects of wastewater. The conditions are based primarily on the statement issued by the National Board of Waters and the Environment. No emission standards exist but requirements are examined case-by-case, taking account of needs for load-reduction and other water-protection measures, and of technical and economic possibilities of meeting requirements. Treatment requirements are expressed as maximum allowable concentrations and minimum allowable percentage-reduction values, relating to BOD and phosphorus, at least. The figures relate to weighted average values over a specified period (3, 6 or 12 months), including any by-passes, overflows and process disturbances at the treatment plant.

The permit procedure described above is substituted by a notification procedure for small plants employing certain hazardous substances and a number of other plants specified by decree, such as sewage works serving less than some tens or some hundreds of inhabitants. Under this procedure, there is an obligation to notify the National Board of Waters and the Environment or Water and Environment District of the activities well in advance of their commencing operation. The authorities can issue a license, provided the project is unlikely to lead to any appreciable environmental change.

Drinking-water quality is regulated by the Public Health Act and by decree. Quality is monitored by municipal public health authorities or laboratories authorized by the National Board of Health.

Finance

About three quarters of the expenditure on various hydraulic engineering works in Finland relate to water supplies, sewerage and water pollution control. The rest is spent on flood protection, drainage, irrigation, hydro-electric schemes, waterway construction, and the fishing industry.

Municipal investments and costs for water supplies and sewerage in 1988 amounted to some 4 000 million FIM (45% for water supplies, 55% for sewerage). About 370 million FIM have been spent annually by industry on measures for controlling water pollution in recent years. In addition, large industrial companies and large municipalities pay water protection fees, issued by the Water-Rights Courts, to the water authorities in relation to effluent discharges. These fees amount to about 1.5 million FIM yearly at present.

Under the Water Act, the polluter-pays principle usually applies in Finland. However, since there is an urgent need for drinking water, the Government has introduced financial measures to speed the implementation of water-supply and pollution control projects.

Municipal projects relating to drinking water supplies and pollution control can receive subsidies of up to 30% of the expenditure. They can also benefit from a 2-4% interest subsidy on commercial loans up to 60% of the expenditure for urban centres and 80% in the case of sparsely populated areas. The government also supervises purification projects and drinking water distribution projects in sparsely populated areas. However, state finance for such projects covers only a small proportion of total expenditure.

Purification projects undertaken by private industry benefit from a 2-4% interest subsidy on commercial loans up to 38.5% of expenditure, and on reduced-rate public loans up to 38.5% of expenditure.

The State can provide up to 20% of expenditure on agricultural water pollution control schemes. It can also grant loans at reduced rates of interest.

Apart from receiving direct and indirect financial support from the State, municipalities fund water supplies and sewerage expenditures through clean water charges (averaging about 3 FIM per m^3 in 1990), sewage charges (averaging about 4 FIM per m^3 in 1990) and annexation fees.

Research

The main research bodies in relation to water are the Water and Environment Research Institute (WERI, a department of the National Board of Waters and the Environment), the Technical Research Centre of Finland (TRCF, under the Ministry of Trade and Industry) and, in the private sector, the Finnish Pulp and Paper Research Institute.

The main responsibility for hydrological research lies with the Hydrological Office of the WERI. Hydrological research has recently concentrated on the effects of climatic changes on water resources, and on the development of hydrological and hydraulic models. An other important task of the Office is hydrological monitoring and measurement.

Research into and monitoring of the state of inland and coastal waters is primarily carried out by the Water and Environmental Research Office of the WERI, and to some extent by universities and Water Protection Associations. The main topics of research concern the effects of climatic change, eutrophication, acidification, ecotoxicology, diffuse pollution from agriculture, forestry and peat mining, and development of monitoring methods. The Finnish Institute of Marine Research carries out research on and monitors offshore areas.

The main bodies carrying out technical research are the Technical Research Centre of Finland, the Technical Research Office of the WERI, the Research and Development Division of the Imatra Power Co. Ltd., the Finnish Pulp and Paper Research Institute, the technical universities and some consultant engineering companies. Main areas of research

are environmental protection and the development of forestry industry processes, such as the bleaching of pulp by hydrogen peroxide and formic acid, which would make the use of sulphur and chlorine compounds unnecessary. Other research topics are, e.g., nitrogen removal from wastewater and the development of treatment plant operation.

In 1989, the Ministry of the Environment, the Central Association of Finnish Forest Industries, and the Maj and Tor Nessling Foundation drafted an Environmental Research and Development Programme for the Finnish Forest Industry (the SYTYKE programme) for 1990 to 1992. The total costs of the Programme will be over 20 million FIM. Under the Programme, 25 research projects will be conducted, mainly aimed at technological development and assessment of environmental impact.

Other prominent bodies involved in water research are the Game and Fishery Research Institute, the Geological Survey of Finland and the Institute of Meteorology.

The main source of finance for research is the State. Funds are channelled through the Ministry of the Environment, the Ministry of Agriculture and Forestry, the Ministry of Trade and Industry, the Finnish Academy, the Finnish National Fund for Research and Development, and the Technology Development Centre of Finland. The main private sources of funds are the Maj and Tor Nessling Foundation, the Association for Promotion of Soil and Hydraulic Engineering, and, in relation to research carried out by the Finnish Pulp and Paper Research Institute, the pulp and paper industry.

Professional organizations

Organizations involved in water-related activities include:

The Finnish Water Supply and Sewerage Association, an organization of municipal and other water supply and sewerage works.

Water (and Environmental) Protection Associations. These regional, voluntary associations have been founded by municipalities and other (major) sources of pollution. The associations monitor the environment, make proposals for the elimination of unsatisfactory treatment, and promote environmental protection through education and information.

The Water Association of Finland. The Association aims to further knowledge and co-operation in various fields of water research and management. Membership includes both individuals and corporations. The Association is a member of the EWPCA and IAWPRC and a corresponding member of the WPCF.

The Finnish Limnological Society. A scientific organization for theoretical and applied limnology. A member of S.I.L.

Organizations also taking an interest in matters related to water as well and aiming to promote the professional status of their members mostly through education are the Association of Finnish Civil Engineers (RIL), the Engineering Society of Finland (STS), the Finnish Society of Environmental Law, the Finnish Society for Environmental Sciences, and the Trade Union for Environmental Experts (YAJ).

Conclusion

The Finnish wood-processing industry underwent an appreciable structural change in the latter half of the 1970s with the introduction of increasingly integrated production methods. At the same time it made effective use of the modern technological developments. The production of sulphite pulp has now almost ceased with the closing down of several mills. However, demand for bleached sulphate pulp and paper has increased. It seems likely that the advantages resulting from economies of large-scale production and modernization of production processes have helped to reduce the load on the environment in various sectors.

In 1988, The Finnish Council of State took a decision in principle to set up a programme of objectives for water protection to be achieved by 1995. Public authorities responsible for water protection, and authorities in other branches of the administration must take account of the objectives in the Decision in performing their duties. The Decision is not binding on the Water-Rights Courts but its programme will also form a basis for decisions about the granting or withholding of permit.

As a result of this decision in principle there will be an overall reduction in oxygen demand load on recipient waters by 1995 to less than half of the 1986 level, and a reduction of almost 40% in phosphorus load. Other substances harmful to water will also be significantly reduced. Although the objectives reflect Finland's need to reduce load on its own watercourses and coastal waters, load on the Baltic will also be reduced to a degree sufficient to meet Finland's international commitments.

The decision in principle will mean that major sources of pollution will have to spend some 2950 - 3600 million FIM on external treatment equipment. Extra operating costs of FIM 160 - 250 million per year, depending upon which protection measures are chosen, will be incurred. The amount of this expenditure to be borne by industry will be approximately FIM 1500 - 2150 million. About 800 million FIM will come from the communities. Agriculture will provide about FIM 500 million and fur farming about FIM 150 million.

In accordance with the decision in principle, the Ministry of the Environment decided in 1989 that the pulp and paper industry should reduce the load caused by chlorinated organic compounds from bleached pulp production by 1995 to an annual maximum of 1.4 kg chlorine per ton of bleached pulp produced, on average. In 1986 the value was 4.6 kg, and since that it has already decreased to about 2.0 kg.

Statistics (1990)

Population	5	million
Land area	337 000	km^2
Population density	15	individuals/km^2
Length of land/water interface		
Lakes	186 700	km
Sea	39 100	km
Length of main rivers	20 500	km
Lake area	33 500	km^2
Number of waterworks	800	
Population served by public water supply	4.2	million (84%)
Number of sewage treatment works	580	
Population served by		
public sewers	3.8	million (75%)
sewage treatment works	3.8	million (75%)
septic tanks or own facilities	1.2	million (25%)
Population equivalent of separately treated industrial effluent	5	million
Annual biological oxygen demand		
Municipal treatment plants	11 000	tonnes
Industry	110 000	tonnes
Annual sewage sludge disposed of (1987)		
Landfills	37 500	tonnes
Agriculture	75 000	tonnes
Landscaping	37 500	tonnes

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SENIOR ADVISERS TO ECE GOVERNMENTS ON ENVIRONMENTAL AND WATER PROBLEMS

SEMINAR ON WASTE-WATER MANAGEMENT
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CONTROL AND SURVEILLANCE OF INDUSTRIAL WASTEWATERS IN FINLAND */

Transmitted by the Government of Finland

(Prepared by Ms. E. ENCKELL-SARKOLA)

1. Introduction

The first Finnish nation-wide pollution load investigation was carried out in the 1950s. It was based mainly on population and production figures, which were related to pollution factors (Q, BOD_5, N and SS) found in the literature. Only in the middle of the 1960s the actual effluent discharges from certain branches and urban areas were investigated. The Finnish Water Act was designed in 1962 and the first wastewater permits were issued at the end of the 1960s. According to the Water Act, permits for effluent discharge or other pollution or change of watercourse are granted by the Water Court. The water pollution control is supervised by the National Board of Waters and Environment and its 13 districts.

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Today, the principal aim of effluent monitoring is to assess the wastewater ingredients, their quantity and toxicity, to control the compliance with permit conditions and to assess treatment efficiency and factors affecting the efficiency. The monitoring is done according to a programme approved by the supervising authority. In most cases it is carried out by an "officially supervised water laboratory". Big communities and industrial plants with laboratories of high standard can implement their wastewater monitoring themselves. In any case the supervising authorities make unannounced inspections and take control samples, which are analysed by their own laboratories or by a consulting officially supervised laboratory. Every two or three years the laboratory of the National Board of Waters and Environment carries out an intercalibration of the analytical methods used by the different laboratories.

The analytical methods have, of course, developed since the 1960s. Today there are 40 Finnish SFS-standards for physical-chemical determinations, roughly half of which are applied to wastewaters, also. Many of the SFS-standards are identical to standards used in the other Scandinavian countries. In some cases other methods than those included in the SFS-standards may be used.

2. Application and permit conditions

2.1 Application

Already at the preliminary stage of planning of a new establishment the necessary permits and environmental aspects are to be surveyed. Even in case of changing the production, raw materials or technical devices at an existing plant the authorities should be informed and negotiations should be initiated to survey the possible need for renewing the permits. Additionally, a time limit for renewing the permit is included in the permit conditions.

The information to be given to the environmental authorities on a new project is quite comprehensive and should cover production processes, use of raw materials and chemicals, pollution control measures, layout of sewerage and landfills, evaluation of discharges and their impact on the environment, description of the recipient, timetable of the project etc. The authority will probably ask for more information, e.g. on technical alternatives and details, emergency plans, waste handling, effluent quality, toxicity data, state of the art on the environmental quality etc. Essential information called for to assess the environmental impact of the effluents and the need for wastewater pollution control measures is drawn up in figure 1.

2.2 Permit conditions

The permits given for discharging industrial effluents include, inter alia, conditions for internal process measures as well as for wastewater treatment and for monitoring. The limiting values for the discharge are mostly given as total load per time unit. In some cases limits are given in addition as specific load per ton of product or as concentrations and removal efficiencies. In general, the limits must be attained as mean values for 1,3 or 6 months, depending on the size and type of the plant.

The monitoring of the industrial effluents and the recipient is done according to a programme approved by the Water and Environment district. The monitoring programmes are made specifically for each factory according to guidelines given by the National Board of Waters and Environment.

The importance of biological methods has increased in the 1980s. The most common methods used in biological investigations are concerned with the sediments and bottom fauna, plankton algae and macrophytes. Toxicity, biodegradation and bioaccumulation tests of effluents have only been used occasionally. New recommendations will give more attention to the toxicity tests of effluents.

3. Monitoring of industrial effluents

3.1 Coverage of monitoring

The monitoring of effluents consists of two parts supporting each other: internal operation control and external discharge control. Furthermore, the discharge monitoring may be occasionally intensified with regard to sampling frequency, ingredient analysis and toxicity testing. The quidelines for monitoring programs do stress a case by case approach. Factors to be taken into account are pollution load, quality and quantity variations, treatment objectives, toxicity and effects in the recipient.

The coverage of the discharge monitoring programs is considered fairly good. Even quite small factories are obliged to report the evaluated discharge 2-4 times a year. Thus the monitoring and reporting system covers discharges of the magnitude as small as 100 kg/year for BOD, 50 kg/year for total nitrogen and 10 kg/year for total phosphorous, 1 kg/year for mercury and cadmium, 10 kg/year for other heavy metals and cyanides. Besides, total organic carbon, mineral oil and specific organic and inorganic compounds are measured by certain industries. The chemical oxygen demand is measured by all pulp and paper mills and by many chemical factories. Essential information still lacking is related to organic discharges from the metal industry and mining, metal discharges from pulp and paper industry, effluent toxicity and specific toxic and stable organics in effluents in general. Discharges are always measured as total load and, in some cases, the dissolved fraction is analysed additionally.

3.2 Flow measurement

At big plants, i.e. at nearly all pulp and paper mills, at metal works, big chemical industries and many other factories continuous flow measuring with recorders and totalizers are applied for the control of polluted effluents. Most big plants have also computers for data processing. At small plants the flow is measured regularily with fixed venturi or parshall flume or during the sampling period with portable equipment. Clean cooling water flows are mostly estimated from the water intake or from the running time of effluent water pumps (table 1).

Table 1. Flow measurement of industrial effluents in 1982

Branch	Cooling Waters 10^6 m^3/a	Process and other waste-waters 10^6 m^3/a	Total flow measured 10^6 m^3/a	Conti-nuous measuring %	Other measuring with fixed equipment %	Measured without fixed equipment %
Pulp and paper	232	1084	1122	95	3	2
Mech. wood process	7	17	0	26	39	35
Chemical industry	727	34	201	96	4	0
Mining	0	43	40	56	44	0
Basic Metals	230	17	203	85	15	0
Metal products	9	1	1	80	3	17
Textile and leather	1	2	1	85	12	3
Food, beverage	30	11	12	91	5	4
Power plants	3298	4	14	99	1	0
Total	4534	1213	1594	92	6	2

3.3 Sampling and analysing

At all big industries sampling is accomplished with automatic composite samplers installed at the main effluent channels. Thus it is not unusual that a factory has 3...5 samplers installed. Most of them are flowdependent while some of them are timedependent. Samples are mostly taken over 24 hours 2-7 days a week. Samples for measuring

nutrients and metals are in some cases combined to cover a longer period. Sampling frequency depends on the size of the plant as well as on the quality variations in the effluent, that is on the equalization and the detention time in the treatment system. Effluents of little importance are often manually sampled. At very small factories 4...8 hours composite samples are taken manually a few times a year. Samples for oil analyses are also mostly taken manually but at some steel rolling mills.

The effluent monitoring program at each factory may include 5-15 parameters, depending on the branch. Analyses are made from fresh samples, frozen samples or frozen combined samples, depending on the situation.

The daily operation surveillance and alarmsystems are an essential part of the monitoring program. The bigger the variations of the discharge and the lower the frequency of sampling for pollution load estimation, the more important is it to make the estimate based on operation surveillance data as well.

3.4 Discharge calculation and reporting

The results of the monitoring must be reported to the supervising authority at the end of the control period for which mean values must meet the requirements. However, violation of limit values and other exceptional loading must be reported immediately. Furthermore, an annual report must be given, covering the entire calendar year.

The pollution load is calculated as flow-weighted mean values (e.g. kg/d, kg/t or mg/l) corresponding to the total discharge during the period. In other words, whenever the sampling is not continuous the water quality during the period is assumed to be the same as during the sampling days. Small plants, however, sampling only 4-6 times a year, are obliged to report the laboratory results and the calculated load for the sampling day immediately, while the total load is flow-weighted and reported at the end of the year.

3.5 Data processing

Based on the annual reports sent to the National Board of Waters and Environment, statistics on water intake and effluent flow, pollution load, waste-water treatment and water pollution control costs have been produced since 1972. In the middle of the 1980s the data processing system was changed to better serve the supervision. At least that was the aim, but in fact the system does not yet work properly.

The data base system already implemented is planned to serve the follow up of the compliance with the permit conditions, the effectiveness of the wastewater treatment, the overall water balance of the factory, the pollution load and the sludge treatment. The system is also planned to serve mathematical water quality modelling with input load data. Additionally it should provide decision makers with information and help the authorities to answer the steadily increasing amounts of official and non-official, national and international questionnaires.

The planned data base is quite a complex system. It is tested but still only partly taken into use. Updating will be partly done at the district level, partly at the central level. For the time being the main problems are related to overloading of the central computer (mainly by other register systems than this one) and limited personnel resources in the districts.

4. Procedure in case of permit violation

Whenever an enterprise deviates from permit conditions the supervising authority should be informed. This obligation is, as a rule, included in the permit conditions. In case a disturbance can be foreseen the information should be given in good time so that interim arrangements can be agreed upon to minimize the effects of the disturbance. Accidents, on the other hand, might call for studies of technical efficiency, responsibilities, emergency plans and environmental effects.

In case of intentional or prolonged permit violation investigations are made to find the reasons. The illegal situation should, of course, be corrected as fast as possible. In some cases the correction might take several months. The measures taken by the supervising authorities depend both on the behaviour of the enterprise and on the nature and the consequences of the violation. Measures taken include, inter alia, negotiations, requests, technical measures on the enterprise's expense (provided the Water Court so decides) and prosecution against the enterprise.

In a few cases the pollution load limit values have proved to be too stringent. In such cases the enterprise has, after discussions with the authorities, applied for new permit conditions.

5. Discussion

The control and surveillance of wastewaters have developed remarkably during the last two decades. The principle of self-monitoring as a vital part of the supervision system has been applied at big industries in Finland since the end of the 1960s. Many factories also use consulting, officially supervised laboratories. The self-monitoring provides for well-defined responsibilities and professional competence at the factory, procedure for regular intercalibration of analytical methods, well-defined and documented monitoring programs (including calibration of flow measurement) approved by the authorities and last but not least unannounced inspections and control sampling. The system is also a vital part of environmental auditing. Experience has learnt the enterprises that underestimating pollution load and "hiding the truth" is not worth-while in a long-term perspective.

The monitoring of the effluents from big industries in Finland fairly well meets it's pricipal aims. Still, it can be observed that the calibration of flow measurement is not always sufficient. Where sampling is carried out manually, sampling methods cannot be sufficiently supervised either. There is also a need for detailed guidelines, e.g. for sampling for oil analyses. At small plants samples are, for economic reasons, taken only 4-6 times a year, by a consulting, officially supervised laboratory. This, of course, does not meet the aims of wastewater control and supervision, and the use of this kind of monitoring has been questioned. A better use of economic resources at very small plants might be to develop the supervision of operatorion control and to investigate the discharge more deeply e.g. every three years.

Data processing and updating is quite a complex and expensive task, which needs to be developed. Today, the accumulating amounts of monitoring and supervision data are not effectively used.

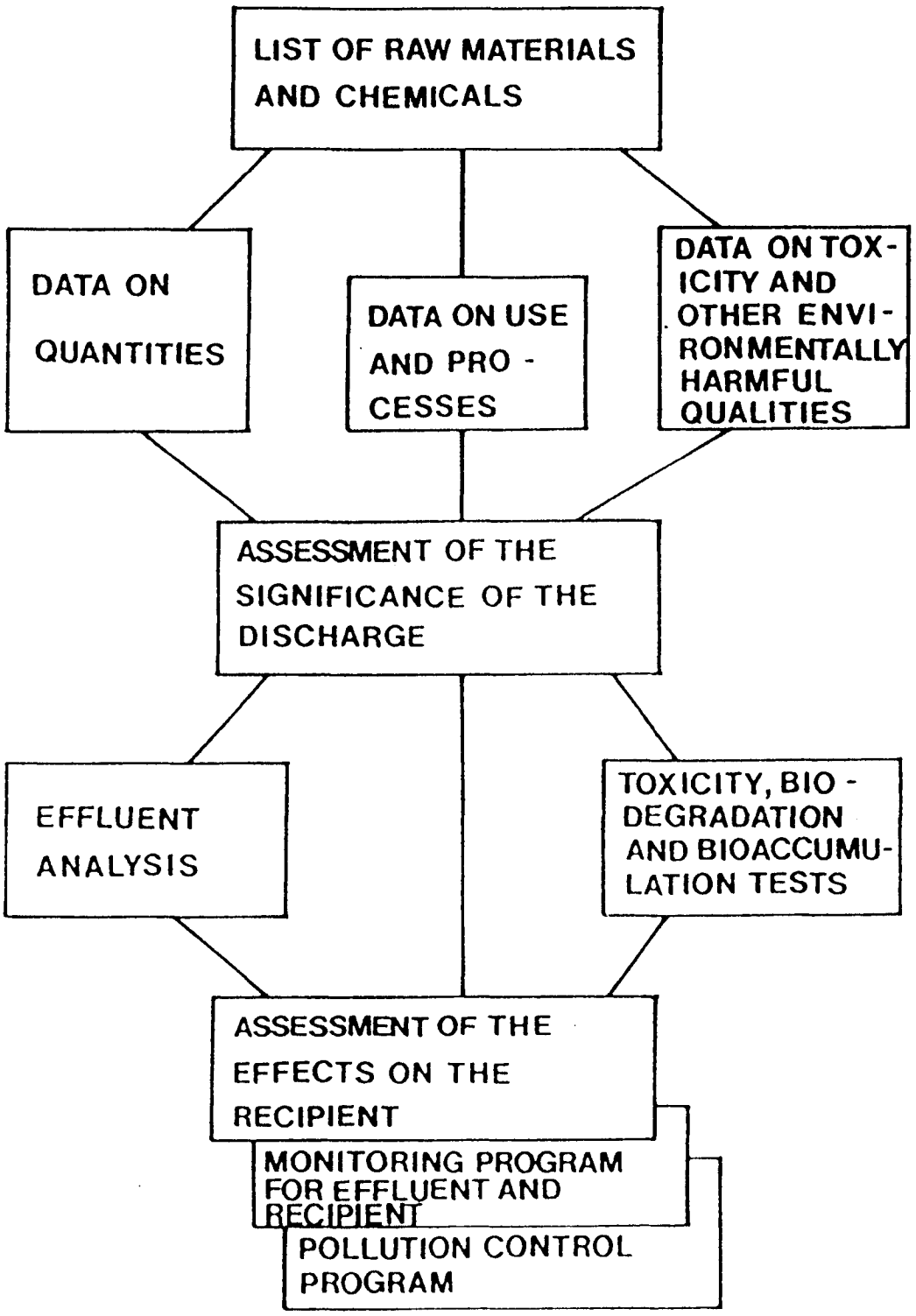

FIGURE 1. PROCEDURE FOR ASSESSMENT OF EFFLUENT TOXICITY, MONITORING AND POLLUTION CONTROL

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PLANNING OF INDUSTRIAL INVESTMENTS

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1.1 LONG-TERM ALTERNATIVE CALCULATIONS

-PLANNING INVESTMENT AND CAPITAL BUDGETING

1.1.1 THE TERM OF INVESTMENT AND ITS PROBLEMS

-WHEN INVESTING MONEY INTO THE BUSINESS, THE CAPITAL BECOMES A VERY IMPORTANT FACTOR CALCULATING THE CAPITAL BUDGETING

-EXECUTING AN INVESTMENT REQUIRES MANY RESOURCES

-INVESTMENT

= ALL THE WAYS TO SPEND MONEY WITH THE PURPOSE OF GAINING PROFIT

-GROUPS THAT CAN BE SEPARATED

A. FINANCIAL INVESTMENTS

-The investment is made to a manufacturing company

-Examples

-purchasing shares

-loaning money

B. REAL INVESTMENTS

-Investing in the means of production for the purpose of gaining profit

-Generally speaking the investments amount to spending money in long-term means of production

-THE PROBLEMS OF INVESTMENT AND CAPITAL BUDGETING MUST BE SOLVED WHEN

-A new company is founded

-A factory is being expanded

-The place of business is being expanded

-new machinery is purchased or old machinery is replaced

-Alternative production methods are compared

-the most inexpensive method among buying, renting or leasing is studied

-INVESTING CAN ALSO BE

- -Spending money on research and development
- -Creating a marketing organization abroad
- -Etc.

-INVESTMENTS HAVE A CRITICAL EFFECT ON THE COMPANY'S BUSINESS, BECAUSE

- -Investments provide the basis for the operation
- -Investing on a machinery of a certain type ties the company to a certain technology
- -A bad investment endangers the continuity of the firm

-THERE ARE ALWAYS PROBLEMS IN THE INVESTMENT DECISIONS

1.UNCERTAINTY

- -The effects of an investment will reach far into the future
- -Uncertainty grows as time goes on

2.MEASURING

- -Everything can't be measured by the means of money
  - => There are things that must be considered otherwise

3.COMPARING THE PERFORMANCES OF DIFFERENT DATES

- -The original investment and the returns of investment occur on different dates
- -" does a return of one dollar after four years cover the expense of fifty cents today ?"
- -The difference due the different dates performing of the expense and the return is taken care by discounting

-INVESTMENTS ARE BASED ON THE CORPORATE MANAGEMENT PLANS TO DEVELOP THE COMPANY

-THE INVESTING PROCESS OF A COMPANY CAN BE CATEGORIZED AS FOLLOWS:

- -A decision to make an investment
- -Searching for the investment projects
- -Estimating the factors that have an effect on the expenses referring form the investment
- -Calculating the costs of the investment and comparing alternatives
- -Planning the financing of the investment
- -Decision making, taking notice of the things that require consideration
- -Following up on the investment

1.1.2 THE FACTORS THAT HAVE AN EFFECT ON THE LUCRATIVITY OF AN INVESTMENT

1.FACTORS THAT CAN BE MEASURED

-INVESTING PROPOSAL SHOULD BE IN A CONCRETE FORM, ALSO THE EXPENSES AND THE RETURNS OF AN INVESTMENT MUST BE DETERMINED

-Factors that can be measured

- -Cash inflows
- -Cash outflows
- -Initial investment
- -Investment period
- -The book value of the investment at the end of the investment period
- -The future-value interest rate

-ESTIMATING THE FACTORS MENTIONED ABOVE ARE CRITICAL TO THE SUCCESS OF THE INVESTMENT

-THERE IS ALWAYS UNCERTAINTY WHICH MUST BE CONSIDERED

1 A CASH INFLOWS AND OUTFLOWS

-The difference between yearly revenues and expenses is called the net profit

-Instead of rise in the revenues there may be a decrease in expenses

-Estimating the profits market research and estimations of sales and prices

-Estimating the expenses the profits must also be estimated, then the flexible costs can be figured, after this the change in the fixed costs must be determined

1 B THE ORIGINAL COST OF INVESTMENT

-The original investment covers both the purchasing price and the installation costs of the investment

-Examples

  -Land

  -Buildings

  -Machinery, equipment

-There are also other expenses that are included to the original cost of investment like the costs of investments searching, planning, carrying out the investment, market research etc.

1 C INVESTMENT PERIOD

-Investment period means the entire time period during which the investment is used

-Investment period can be limited by the physical or technical age of the machinery, also the time the product is on the market can restrict the investment period

-The result of the investment calculation is largely dependent upon the investment period, therefore the

period must be determined

1 D PROCEEDS FROM THE SALE OF AN OLD ASSET

-Means the net cash inflow resulting from the sale of old asset at the end of investment period

-Generally the proceed from an old asset = 0

-Although the investment had a proceed from the sale of an old asset, its effect on investment calculations is very small

1 E THE DISCOUNT RATE

-When investing, capital gets involved into business

-Since the capital isn't free, there must be a set requirement for the profitability of the investment

-The discount rate is used in the investment calculations to enable a comparison between the cost of capital needed and the discount rate to examine the profitability of the investment

-The discount rate allows a comparison of the performances over different time periods

-There are no ways to determine the discount rate, it depends on the decision-maker

the -One way to estimate the discount rate is to use the return of a market shares portfolio
(about 16 %)

-When discount rate is used the future cash inflows and outflows are discounted to show their present value

-The discounting factor (R) can be calculated from the following formula

$$R = \frac{1}{(1 + i)^n}$$

Where

n = number of periods

i = the discount rate

-The discount rate is used to show the future value of money

-An example, a thousand dollars ($ 1000) received after one year form now, with the discount rate of 10 %, has a present value of:

$$V = \frac{1}{(1 + 0,1)^1} * \$\ 1000 = \$\ 909$$

-When making capital budgeting, the amount of fixed assets tied to the investment must be considered

Fixed assets = Financial assets
+ Inventories
- short-term debt

-Fixed assets gets tied to the investment differently from the operations, because they are freed and can be used for other purposes after the investment period

=> Fixed assets are mainly a financial problem

2. FACTORS THAT CAN'T BE MEASURED

-MAKING CAPITAL BUDGETING THERE ARE THINGS THAT CAN'T BE MEASURED, THEY CAN ONLY BE CONSIDERED ONLY

-FOR EXAMPLE

- -Managerial investment policy
- -Investments effects on surroundings
- -Investments effects on employment
- -Technical solutions
- -Juridic factors

-A commonly used way to consider the factors that can't be measured is to classify the investments by some suitable arguments

-Classifying investments is usually a part of companys written investment policy

-Examples for classifying investments

Class 1
Investments based on the laws
-No demands for profit

Class 2
Investments for recovering and maintaining the operating order
-calculations needed, demand for profit small

Class 3
Strategic investments
-Improving and ensuring the future operation order

Class 4
Investment for improving the profitability
-Demand for profit high, calculations required

Class 5
Investments for expanding the business
Reasons for investment must be cleared, profitability must be carefully calculated, demand for profit very high

DIRECT FOREIGN INVESTMENT

A multinational firm that is considering a direct investment in a foreign market will have a number of motives for doing so. These motives are either strategic, behavioral, economic or perhaps a combination of these.

STRATEGIC MOTIVES FOR DIRECT FOREIGN INVESTMENT

Various case studies have shown that firms tend to base their foreign investment decisions on a number of strategic factors. In doing so the firms wish to become the following:

MARKET SEEKERS- firms wish to open new markets for their products or to satisfy local demands for the company's goods.
RAW MATERIAL SEEKERS- these firms are looking for raw materials wherever they may be found. An example would be an oil company.
PRODUCTION EFFICIENCY SEEKERS- such firms are looking to produce in a country where production costs, such as labor, are cheaper than in their own country.
KNOWLEDGE SEEKERS- firms that invest in a foreign country in order to gain access to technology or other expertise fall into this category.
POLITICAL SAFETY SEEKERS- these firms invest in a country where there is little political instability or government interference in their business.

Independent studies have shown that strategic motives for investing in foreign countries tend to be more important than economic factors. In other words, firms are more concerned with being a market seeker or production efficiency seeker than they are in gaining a high rate of return. Once the foreign investment has been made, the firm will then focus on the economic factors such as gaining a satisfactory return on investment.

BEHAVIORAL MOTIVES FOR DIRECT FOREIGN INVESTMENT

Behavioral motives mean that the foreign investment decision is based on a strong stimulus from the outside environment. This means that the firm is actually reacting to something happening outside of the company. Some examples could include:

- an investment proposal from a foreign government which appears to be favorable for the company.
- If a competitor invests in a foreign country, the company may decide to also invest or risk losing a market.
- A firm may wish to follow successful firms into the foreign market. "Since they're doing it, we should too."
- Strong competition from abroad in the company's home market may cause the company to seek foreign investment as a response.
- Personal biases or favoritism among the decision-makers in the company towards a certain country, type of investment etc.

Many times the type of investigation used in deciding whether to invest may be the determining factor in the foreign investment decision.

ECONOMIC MOTIVES FOR DIRECT FOREIGN INVESTMENT

Although studies of the foreign investment decision have emphasized strategic and behavioral motives, such motives may actually be in agreement with sound, rational economic motives. The modern theory of direct foreign investment is concerned with product and factor market imperfections within the host country.

Product and factor market imperfections

According to the Hymer-Kindleberger theory, product and factor market imperfections in a country open the door to direct foreign investment. These imperfections are seen as opportunities by potential investors. The imperfections may occur naturally or they may result from certain governmental policies. An example was the formation of the European Economic Community. It removed a number of trade restrictions between member nations. American companies

saw this as an opportunity to invest in a member country and thus enjoy the benefits of having a protected market.

In order for a firm to be able to take advantage of market and product factor imperfections, a foreign firm operating a manufacturing plant in such a market must possess a competitive advantage over local firms. The most important competitive advantages enjoyed by multinational firms include the following:

Economies of scale. A large firm is able to use its size to an advantage. Production economies can occur when a large manufacturer is able to construct a highly efficient automated plant which a local firm could never afford. Marketing economies can occur when a firm is large enough to create a world-wide brand identification. Financial economies can arise from a firm being large enough to have access to a wide range of financial instruments and sources of funds.

Managerial and marketing expertise. A firm can enjoy an advantage in managerial and marketing expertise over local firms. Managerial expertise includes the necessary skill in running a corporation efficiently as well as a knowledge of modern analytical techniques. Marketing skills can include prior experience at marketing products in a similar foreign market.

Technology. Technology includes both scientific and engineering skills. Multinational firms are able to take new technology developed in their home country and employ it in a foreign market which lacks such technology. The result is a competitive advantage for the multinational.

Financial strength. This includes not only economies of scale but also the ability to reduce financial risk through diversification. Usually, multinationals have lower costs and better availability of capital than local firms.

Differentiated products. Since multinational firms tend to have a high amount of research and/or marketing intensity, they are able to constantly produce new products and ideas. The result can be a line of differentiated products which can then be marketed in foreign countries. Local firms tend to lack the resources to copy the different product lines.

DEFENSIVE FOREIGN INVESTMENTS

Defensive investments are those which are made in order to preserve profit margins both at home and in the foreign market. They are not necessarily profitable investments by themselves. Rather they are made to protect the company as a whole.

Product cycle theory. This assumes that a product goes through a life cycle beginning with development and ending with its decline. This theory states that direct foreign investment is a natural part of the product life cycle. Foreign investment will occur when a product being exported to a country begins to suffer a loss of profit margin due to competition from nearly similar products. At this stage, foreign manufacturing locations are sought in order to take advantage of any existing market imperfections. In this way the costs of production can be lowered.

Follow the leader theory. This states that when one firm makes a foreign investment, the company's closest competitors are likely to invest directly in the same country. They may do this to diversify risk to the company as a whole or to disrupt the competitors easy market share in that country.

Creditability. A company may make a defensive investment in order to maintain its reputation in that particular market. If the company has a large export market in a certain country, it may feel obligated to set up a manufacturing facility there in order to maintain credibility. This may occur even though the investment in such a manufacturing facility is not a profitable one.

Growth to survive. This type of defensive investment occurs when a company has saturated the home market and any further market expansion would lead to retaliation by the competition. So the company sees foreign markets as the only way for the company to continue growing. This is especially true for companies whose attitude suggests that a company must continue to grow to survive.

Knowledge seekers. A company may purchase a foreign firm in order to gain that firm's expertise in a certain area such as technology, managerial expertise or product and market knowledge. An example is the purchase of U.S. semiconductor firms by foreign electronics companies.

Follow the customer. Service-related firms in the areas of banking, advertising, legal counseling and accounting will follow their customers into a foreign market. They do this in order to prevent foreign or domestic competitors from stealing their customers.

For a company to successfully invest in a foreign country, it must possess a firm-specific competitive advantage which is not easily copied. These competitive advantages are maintained by possessing proprietary information and controlling the human capital that can generate new information through expertise in research, management, marketing and technology. Basically, this means that large research intensive firms are better able to possess such competitive advantages but they can only receive the full benefit of these innovations through direct foreign investment. This idea is known as the theory of internalization.

An alternative to direct foreign investment is through the use of management contracts and licensing agreements. Host countries may seek to only purchase the managerial and marketing expertise along with the technology that the company may possess. Thus, companies can sell marketing and management expertise through management contracts and technology through licensing agreements. The host country can also gain financial strength through loans.

These all serve as sound alternatives to direct foreign investment providing the company is willing to give up control of the use of proprietary information.

POLITICAL RISK MANAGEMENT

Every company that decides on direct foreign investment will [illegible] a certain amount of political risk. Political risk is the possibility that a multinational firm may be adversely affected by political events within a host country, or by a change of political relationships between the host country and another country. Conflict can arise from differences between the objectives of the firm and those of the host government.

GOAL CONFLICTS BETWEEN MULTINATIONAL FIRMS AND HOST GOVERNMENTS

These have historically arisen over such issues as the firms impact on economic development, perceived infringements on national sovereignty and control of vital industries. A multinational firm must be able to predict the national priorities of the host country and then adapt to them. This is a difficult task because governmental policies are often unclear.

GOAL CONFLICT BETWEEN THE MNC AND GOVERNMENT ECONOMIC POLICIES

Most countries desire a high rate of growth in GNP, full employment, price stability and other positive economic goals. Certain policies are set up by the government to achieve these goals. Problems arise when the operations of multinational firms interfere with these policies.

Monetary policy. A government may for some reason set restraints and limits on available credit. Multinationals can avoid such restrictions by having access to capital from the home country. [illegible] firms would not have such access to capital. The result is a conflict with a host country's set monetary policy.

Fiscal policy. The operations of a multinational firm may conflict with a host country's fiscal policy if that company has been given a tax break in order to set up a facility in that country. Later on, conflict may arise when the multinational is seen as having preferential tax treatment over local firms.

Balance of payments and exchange rate policies. When a country is facing a balance of payments or exchange rate crisis, it may have to implement regulations which can hamper the operations of multinationals in that country.

Economic protectionism. Several countries impose tariffs and other restrictions on imports in order to improve their balance of trade and to promote economic development. Since trade agreements have reduced the number of tariffs, governments have found other methods of imposing restrictions.

Economic development policies. Governments will give favoritism to local industries with the intention of protecting them. They may also place restrictions on the multinationals for the same purpose.

GOAL CONFLICT BETWEEN THE MNC AND NON-ECONOMIC GOVERNMENT POLICIES

Even though foreign countries feel that direct foreign investment will be favorable economically, they may still oppose it due to the following non-economic reasons:

Economic imperialism. Countries, especially those in the third world, may view multinational firms as a sort of modern-day imperialism.

National security and foreign policy. Host countries have become alarmed at the amount of foreign ownership of vital and defense related industries. Such investments have frequently been prevented by the host government for these reasons.

Social transition. The most dramatic conflicts between multinationals and the host country have occurred during times of great social transition. Examples include Cuba in 1959 and Iran in 1979.

Religious and cultural heritage. Western customs frequently conflict with those of middle-eastern and other countries.

GOVERNMENT REGULATIONS THAT CONFLICT WITH THE OPERATIONS OF THE MNC

Many times host governments will adopt laws and regulations which will either intentionally or inadvertently restrict the operations of multinational firms. They can be classified as nondiscriminatory, discriminatory and wealth-depriving.

Nondiscriminatory. These are regulations not directed at foreign firms but they affect foreign firms more than local firms.
Discriminatory. These are regulations which are intentionally meant to favor local firms and restrict foreign firms.
Wealth-deprivation. These involve host government regulations which cause economic loss for foreign firms. Many times these are the result of social upheaval or political retaliation against the actions of a foreign company.

ASSESSING POLITICAL STABILITY

A firm will try to assess political stability in the host country by first looking at that country's overall political stability and attitude towards foreign investors. Then firms will analyze whether or not their firm-specific activities will conflict with the national goals and policies of the host country.
Predicting political stability. This involves careful research into the history and government of the country. However, history has proven that a low risk country one year can become a high risk country the next year.
Predicting firm-specific risk. This involves studying how the operations of the firm will either follow or conflict with the goals of the host country. Within a country, firm-specific risk may vary greatly from firm to firm depending upon the type of business involved. Even with a complete risk analysis, it is impossible for a firm to predict the future. Thus it is necessary to take a few protective measures.

NEGOTIATING THE ENVIRONMENT PRIOR TO INVESTMENT

This involves making a formal investment agreement with the host country in order to provide some insurance against negative government action. Such an investment agreement should spell out governmental policies towards the firm such as taxation, import and export rights, use of foreign personnel and distribution of profits, among others. Also, the contract should spell out whether or not the firm must eventually be turned over to local control.

Many firms decide to transfer political risk to a public

agency such as the Overseas Private Investment Corporation (OPIC). Agencies such as OPIC will insure against loss from political and commercial risk and also provide feasibility studies for investing in developing countries.

OPERATING STRATEGIES AFTER THE INVESTMENT DECISION

Once a firm has committed to a foreign investment, it may find the situation in the country has changed from before the decision was made. To combat this, a firm must be able to adapt to ensure that it is operating in the best interests of the host nation. It can enhance its bargaining position in the event of sudden changes by using as many local people, production and logistical facilities as possible. The location of production and distribution or refining facilities in different areas, control of transportation and control of patents and processes can also help to reduce risk once a company has made the investment decision.

Marketing policies and techniques can also lessen the amount of risk. Control of markets and maintaining brand name and trademark control are examples of risk-reducing marketing policies. Various organizational strategies may also be used to achieve the same purpose. Multinationals can avoid local ownership requirements by participating in joint ventures with the host country. In this way they may have access to the host country's markets while keeping with the policies and goals of that country. However, the political risks can increase if the wrong partner is chosen. Other organizational strategies can include locating regional headquarters in a "friendly" location along with using licensing agreements.

CRISIS PLANNING

Firms should plan in advance what they will do if the general uncertainty in a foreign country should turn to chaos. The best defense is to anticipate any trouble that might soon occur. In this event, the company should maintain a low profile and take measures

to maintain the safety of the personnel of the company. The key here is to constantly stay informed of the situation by whatever means possible.

TRAINING COURSE ON ENVIRONMENTAL MANAGEMENT IN INDUSTRY

Case: Benefit-cost analysis

Jouko Peltokangas
Professor, TUT

We can use many different economic comparative methods also concerning water pollution control in industry. This is maybe not enough for decision making, but for example by using benefit-cost analysis you can get more information for that.

In this paper you find a description of one possible method for helping desicion making.

Soon after this research the production in Kaipola and Jämsänkoski mills was enlarged drastically. When it was in year 1985 about 740 000 tons paper per annum, it shall be double (about 1 400 000 tons paper per annum) in year 1993. Also reduction in activated sludge process have been much better than we assest five years ago.

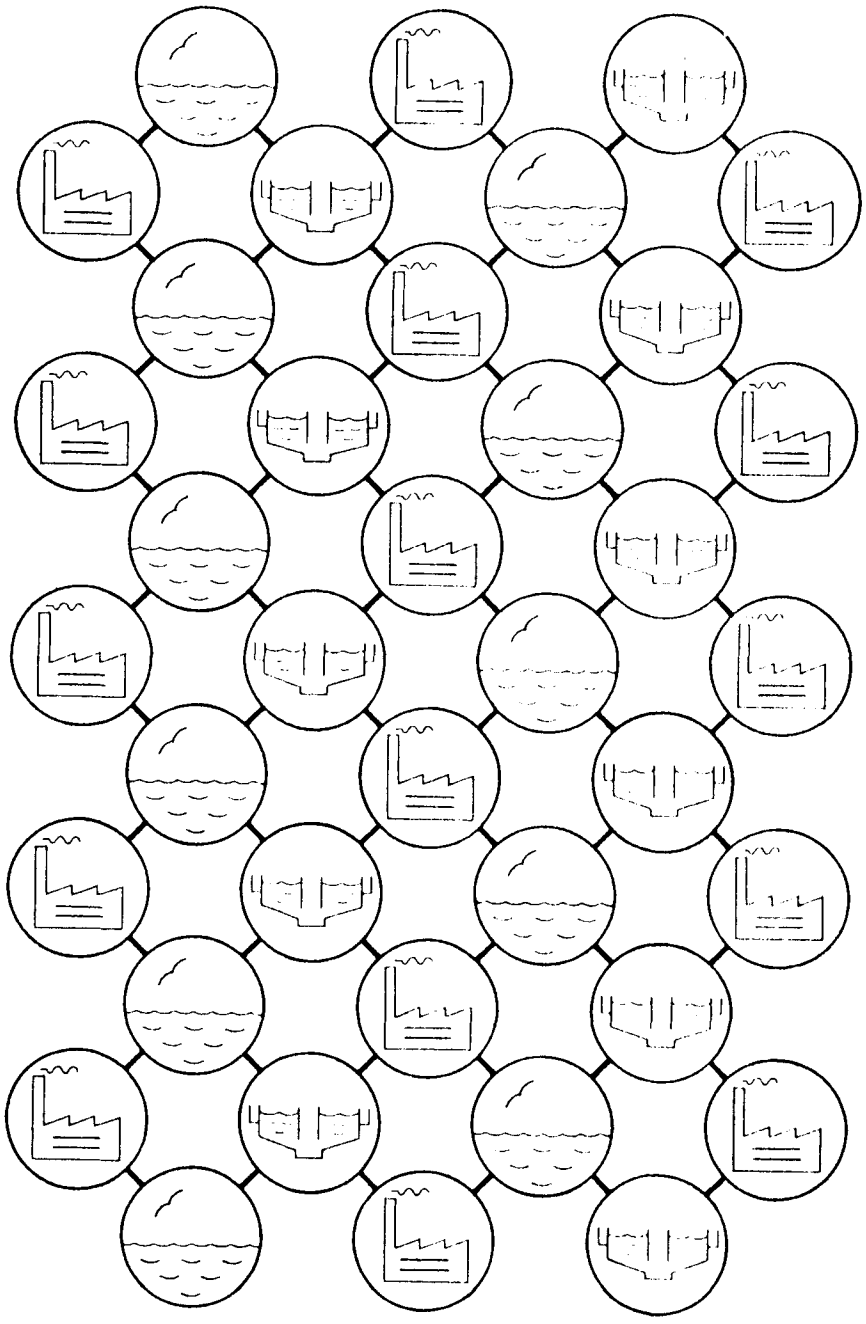
The choice was the construction of very effective treatment plants for Kaipola and Jämsänkoski paper mills. Costs were:

	Investments (1000 Fim)	Operation (1000 Fim/a)
Kaipola	80 000	7 000
Jämsänkoski	> 100 000	10 000

Pollution load after treatment (kg/d) is:

	ss	BOD_7	N	P
Kaipola	300	200	100	10
Jämsänkoski *)	?	~500	?	< 20

*) Assessment after increased production



PROCEEDINGS
EUCEPA SYMPOSIUM HELSINKI 19—22.5.1986

"ENVIRONMENTAL PROTECTION IN THE 90'S"

Organizers: Finnish Pulp and Paper Research Institute
Finnish Paper Engineers' Association

Sponsor: EUCEPA

EU CE PA

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MODIFIED BENEFIT-COST ANALYSIS FOR WATER POLLUTION CONTROL MEASURES IN THE WOOD-PROCESSING INDUSTRY

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Abstract

The objective in water pollution control should be to preserve or improve the usability of the watercourse. Traditional water pollution control planning has principally started from technical preconditions. In this presentation a method is presented for the comparison of the profitability of water pollution control solutions in the wood-processing industry. In the method the objectives of water pollution control are set by the usability of the watercourse. A preliminary elimination (screening) is carried out by comparing the properties of the alternatives with the choice criteria at the elimination level. The profitability of the alternatives approved in the preliminary elimination is investigated by comparing their values to costs in three stages. In the analysis the various groups of value factors: ecological, monetary, and non-monetary, are combined in the comparison according to the principles of value analysis. At various stages water quality, planning, and cost models are used as an aid. In the example case it has been possible to demonstrate the applicability of the method to practical estimation work.

Introduction

The wood processing industry is by far the greatest polluter of Finnish waters in terms of solids and BOD. Its share of pollution load in relation to them is about 90 %. Share of the total nutrient load is 20 - 35 %. The waste waters are treated mechanically and in some cases also biologically. The first phase of the water pollution control work in the wood-processing industry can be regarded as completed. Expectations with regard to the results of water pollution control have, however, increased. This leads unavoidaply to the use of external cleaning methods in the treatment of waste waters to complement internal methods.

In the report of the Finnish Council of State (2) the goal has been presented of changing over in the wood-processing industry to the biological or biological-chemical treatment of waste waters.

The costs of water pollution control have been shown to rise steeply in relation to the effectiveness demanded. In the administration of limited resources an attempt must also be made in water pollution control to allocate funds as beneficially as possible. The objectives in water pollution control should be set taking the watercourse, its condition, and usability, as the point at departure and carrying out a systematic comparison of the alternatives to find the most profitable solution to water pollution control.

Various methods, among others general benefit-cost analysis, ratio of intangible benefits to costs, and cost-effectiveness analysis, has been used in traditional comparison of alternatives (11, 14). It is also possible to use multicriteria analysis in the comparison stage (19, 22). In this presentation a comparison method based on the thinking model of value analysis is presented (17).

The principal features of the method of comparison

The general procedure of the water pollution control profitability comparison can be presented as the diagram in Fig. 1. In the diagram the progression of a general profitability comparison (10, 18) has been adapted for handling the problem of water pollution control. The stages can be depicted as follows.

Problem specification

Generally a new choice situation arises, if the need changes, when changes take place in the availability of resources or in costs, or when technical development produces new solutions. The special features of the study area, water resources and their quality and usability, the load discharged to the waters, as well as the use and use requirements of the water and shores, are clarified as the background data of the profitability comparison.

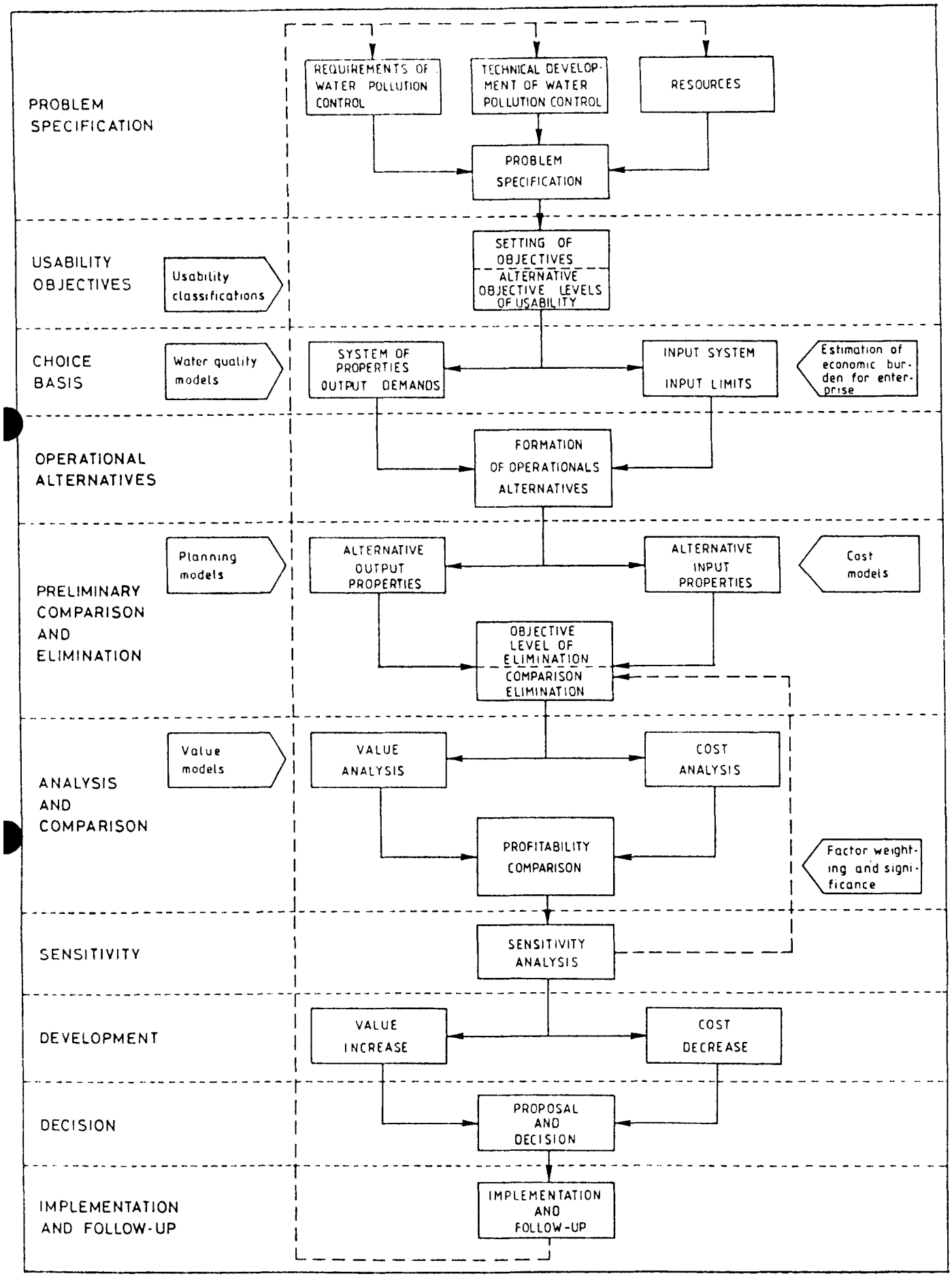

Fig. 1. The general procedure of the water pollution control profitability comparison.

The setting of objectives

The goal of water pollution control is to preserve or improve the usability of the watercourse. It is thus natural to set the water pollution control objectives directly to the usability of the watercourse from a basis of the watercourses state and use requirements. In Finland there are no officially approved recommendations for demands to be set for water quality for different forms of water use. A working group set by the National Board of Waters has prepared in 1984-85 proposals concerning usability for recreational use, raw water for the water supply of communities, fishing water and general classification. Depending on the watercourse the alternative objective levels must be set using one or more classifications (on the usability classifications see 1, 6, 12).

Choice bases

With the aid of the classification it is possible to achieve a content objective for each important variable from the point of view of the watercourse. The content objectives can then be transformed into permitted loads, with the aid of mathematical water quality models, when hydrological factors are also taken into account in them at the same time (3, 4). Thus a connection is achieved with the alternatives and the load level achieved by them.

The factors influencing the choice can be others in addition to the load. Permissible limits must also be determined in relation to them. Correspondingly possible input limits must be determined.

The formation of alternatives

The water pollution control measures of the wood-processing industry can be divided into measures internal to and measures external to the production process. The external measures can be further divided as follows:

- waste water treatment
- channelling of waste waters and choice of disharge point
- measures in the watercourse itself.

From those basic elements alternative measures to examined are formed in each case. The group of alternatives schould embrase all the central lines of action.

Preliminary comparison and elimination

The properties affecting the choice of alternatives centrally are load removal ability, costs, value changes achieved by load reduction, as well as operational and other properties. Planning models have been developed for the dimensioning and estimation of costs of various kinds of treatment plants (21), with the aid of which the most important properties of the alternatives may be determined.

For elimination a basic level must be chosen; i.e. a usability objective level, which is the minimun that should be achieved. The level can be altered if required, and the calculations can be repeated starting from different basic levels.

In the preliminary elimination the properties of the alternatives are compared to the choice criteria of the basic level. The alternatives that clearly do not fulfil the demands of the elimination level can be removed from further consideration. There is reason to include borderline cases for further consideration in order to estimate their possibilities of development.

A more precise analysis and comparison is made of the alternatives remaining after elimination.

Analysis and profitability comparison

General

The profitability of the water pollution control alternatives to be examined can be determined with various profitability criteria:

* When meagre resources prevail the choice may be made on the basis of the investment costs. This criteria may, however, lead to a wrong result, because the small investment costs may recoil as high operating costs, nor are values taken into account at all.
* A more developed method takes into account the operating costs of the period of examination and the balance value. In this method too the value factors are not taken into account, even though there may be considerable differences between them.
* The monetary influences can be all that are taken into account of the value factors. In

benefit-cost analysis the net benefit or the relation between benefits and costs can then be examined, which should be as great as possible (9, 15, 20).

The problem in this method is that all the factors that affect the choice cannot be directly measured in money, although they may have a central significance in the choice.

* In the research that has been carried out the means of determining the order of profitability has been the value/cost relation, in which the value of the alternatives is determined by taking into account all the value factors influencing the choice. This relation is called as profitability index.

$$P = V/C = \sum_{t=0}^{n} v_t (1+i)^{-t} / \sum_{t=0}^{n} c_t (1+i)^{-t},$$

where

P = profitability index

v_t = change in value in year t

c_t = cost in year t

The analysis progresses by stages.

Value factors in water pollution control

The value factors related to water pollution control can be divided into three main groups (17) (Fig. 2):

- the ecological factors
- the monetary factors
- the non-monetary factors.

The ecological quality of the operational alternatives can be estimated by turning to a comparison of the pollution load discharged into the watercourse and the ecological value with the aid of value analysis after that. (The ecological value used in this does not mean the total worth of an ecosystem.) The monetary values relate to housing, production, and leisure. The values can be estimated with the aid of for example the growth in production, savings in costs, and willingness to pay. With respect to the non-monetary factors the quality of the alternatives can be estimated on among other things the basis of technical properties.

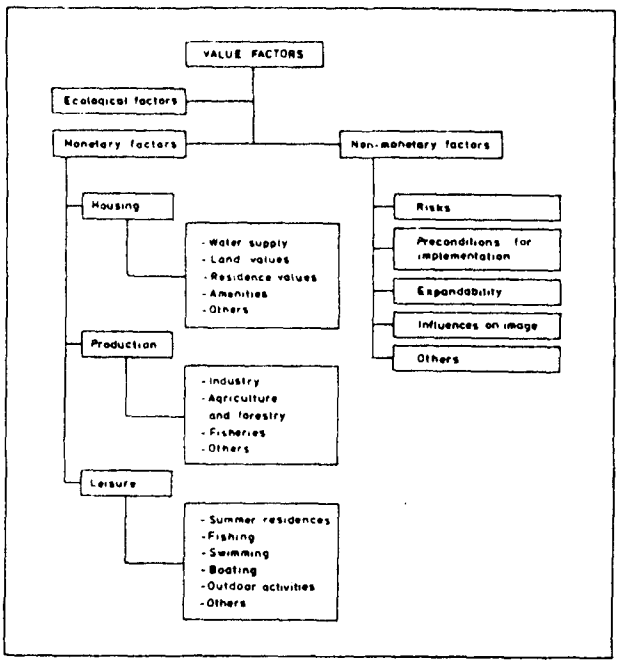

Fig. 2. Value factors in water pollution control.

Costs

The investment, operational, and maintenance costs related to the alternatives are taken into account in the costs. For the preliminary comparison predetermined cost calculation are examined if necessary with more detailed cost estimates.

Profitability on the basis of ecological values

In the first phase the ecological quality of the alternatives is examined and is measured by the ability of the alternatives to reduce the pollution load discharged into the watercourse. The ecological quality of the alternatives is determined with the aid of load parameters.

The approval limit used in the preliminary elimination of the alternatives can be seen as being represented by the grade 7 (satisfactory). Even the best alternative is not worth of excellent (10) unless it removes the pollution load entirely. Fig. 3 is obtained as an example diagram for the grades.

The relation between the pollution load and the ecological quality is not generally linear. The shape of the curves can be estimated with the aid of the connections between the load and the usability.

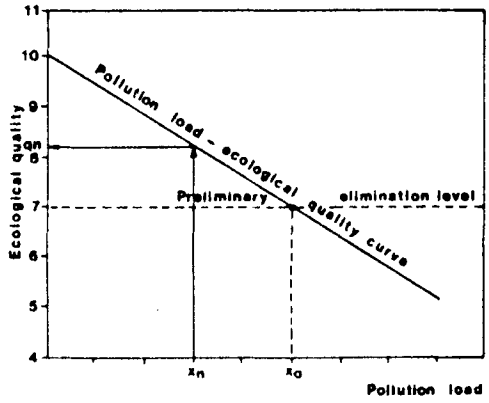

Fig. 3. The determination of the ecological quality of the alternatives. At the chosen elimination level the permitted load in relation to each load parameter is represented by a grade of satisfactory (7) and a zero load by a grade of excellent (10). From the determined quality functions the quality of the various alternatives in relation to the parameter in question is thus obtained in the manner shown by the illustration.

Xo = permitted pollution load for the preliminary elimination level
Xn = pollution load of the alternative n
qn = ecological quality of the alternative n.

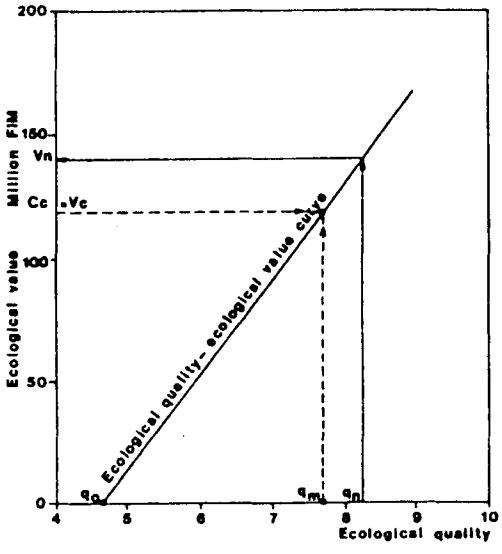

Fig. 4. The ecological value of the alternatives. By setting the cheapest alternative with approved properties as a value its costs can a curve between ecological quality and value be determined, with the aid of which the values of the other alternatives can be determined.

qo = ecological quality before new pollution control measures
qc = ecological quality for the cheapest acceptable water pollution control alternative
qn = ecological quality for the alternative n
Vc=Cc = ecological value for the cheapest acceptable alternative = costs of the alternative
Vn = ecological value for the alternative n.

When combining the grades the load parameters can have a different emphasis. The weights can be estimated e.g. on the basis of the territorial extent of the influence and on the other hand of the strength of the influence.

When the weighted ecological quality of the alternatives has been determined, their ecological value can be determined by the principles of value analysis.

In the objectives and in the preliminary elimination a start is made from the fact that at least the chosen elimination level should be achieved. One is then justified in claiming that the cheapest alternative that achieves level is worth its price and in comparing the properties and costs of the other in relation to it. A curve can be formed when the alternatives are compared to the level of the water pollution control measures of the comparison situation (Fig. 4).

After this the profitability index of each alternative on the basis of ecological values can be determined.

(5) Pe = Ve/C, where
Pe = the profitability index on the basis of ecological value
Ve = ecological value
C = present worth of the costs.

Profitability on the basis of ecological and monetary factors

In the second phase the territorial monetary benefits are brought into the comparison. These can be regarded as an additional value and be calculated directly together with the ecological values of the previous phase. The new values thus obtained can be used to calculate the profitability index of each alternative in this stage:

(6) Pem = (Ve + Vm)/C, where
Pem = the profitability index on the basis of ecological and monetary values
Ve = ecological value
Vm = present worth of the changes in monetary values
C = present worth of the costs.

Profitability taking all factors into consideration

The fitness of the alternatives in relation to the operational and non-monetary factors is defined as grades on the basis of technical and other similar properties. Weights are given to the factors and the influence on profitability is examined by giving the properties various significances compared to the original value. The basic calculation is the value obtained on the basis of the ecological and monetary factors. A curve of the change in the profitability index according to the properties and their significance is drawn for each alternative. The curves can be drawn as follows:

* By assuming that improvement of the non-monetary factors beyond usable (= satisfactory 7) has no further influence in increasing the value of the alternatives. The profitability is in accordance with the previous phase.

* By assuming that the improvement of the non-monetary factors from satisfactory to very good (= 9) increases the values of an alternative by w %. The profitability index is then

(7) $P_{tot} = [(Ve+Vm) + 0.5\ \nabla f \cdot w \cdot (Ve+Vm)]\ /C$,

where

∇f = difference between the weighted fitness of alternative and the basic level (satisfactory 7) in relation to non-monetary factors

w = significance of the non-monetary factors (e.g. 50 %)

Ve = ecological value

Vm = present worth of the changes in monetary values

C = present worth of the costs.

On the basis of the results obtained the curve of the profitability index of each alternative can be drawn (cf. Case-study, Fig. 7).

Sensitivity analysis

With the aid of sensitivity analysis the objective is to examine which factors most significantly influence profitability and how sensitive the profitability order of the alternatives is to changes in these factors. The stages of the analysis can be grouped as follows:

1. The sensitivity of the profitability of the alternatives to changes in ecological quality.

2. The sensitivity of the profitability of the alternatives to changes in costs.

3. The sensitivity of the profitability of the alternatives to changes in the monetary values:
   - the significance of the changes in the connections between the loading and usability of the water system,
   - the significance of time and evaluation factors (interest, appreciation increase)
   - the significance of pricing factors.

4. The sensitivity of the profitability of the alternatives to changes in the weighting of operational factors.

The development of alternatives

Through the comparison carried out an attempt is made to find the most profitable solution to water pollution control in the case under examination. If the profitability order of the alternatives proves unstable in the sensitivity examination there is reason to examine the critical factors still more fundamentally. There is also reason to examine the possibilities of reducing the costs and increasing the values of the most profitable alternative. Complementary measures to the basic solution may then also come into consideration.

Proposals and further measures

The results of the profitability comparison are presented to the decision-makers. If the result is not unambiguous the factors affecting profitability and their influence should be pointed out. A proposal for further measures is presented.

A profitability comparison for water pollution control alternatives for the wood-processing industry in the Jämsä district, a case-study

Study area

The study area is located in central Lake Päijänne in the Kymi River drainage basin (Fig. 5). The area is divided into five sub-areas (Fig. 6).

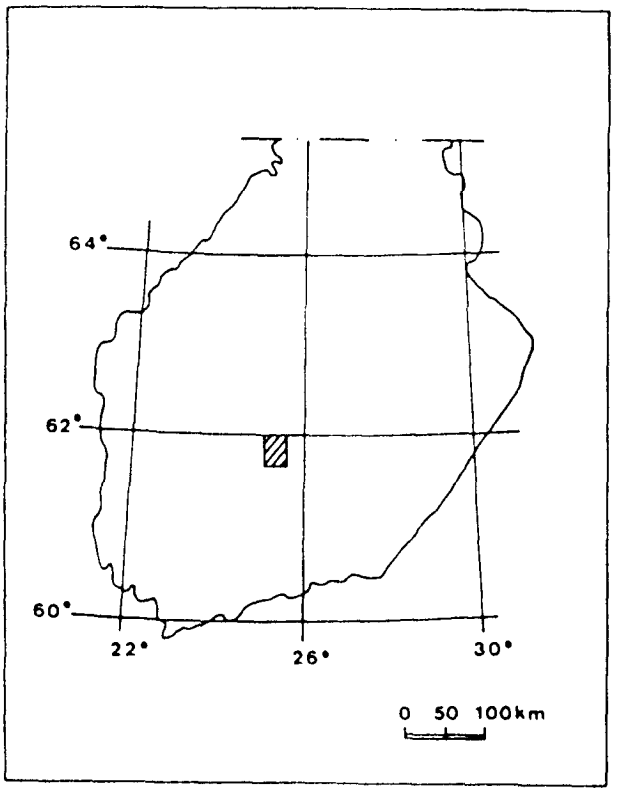

Fig. 5. Location of the study area.

The permanent population of the study area is about 12 000 persons, of whom 10 000 live in the area of influence of the River Jämsä.

The detriments caused by the waste waters are seen as a worsening of the oxygen situation, the eutrophication of the water system, as well as detriments caused by the sedimentation of solids. Especially the state of the River Jämsä during periods of low flow has been unusable (Fig. 7).

The greatest polluters of the watercourse in the study area are the Jämsänkoski and Kaipola production plants of the United Paper Mills. Ltd. Compared to them the significance of other polluters is small. Both factories manufacture mechanical pulp and paper, with a combined capacity of about 740 000 tons of paper per annum.

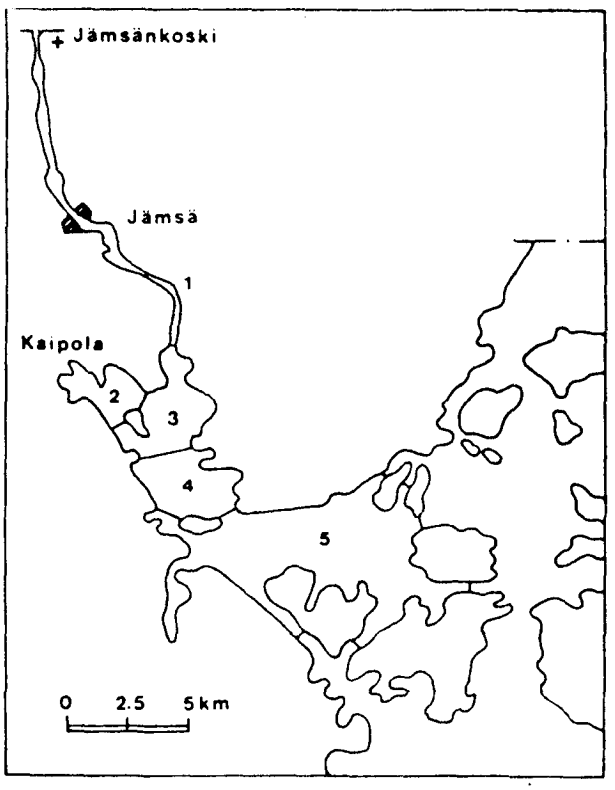

Fig. 6. Division of the study area into sub-areas. The sub-areas are:
1. River Jämsä;
2. Olkkola Bay;
3. Tiirinselkä northern part;
4. Tiirinselkä southern part;
5. Lehtiselkä

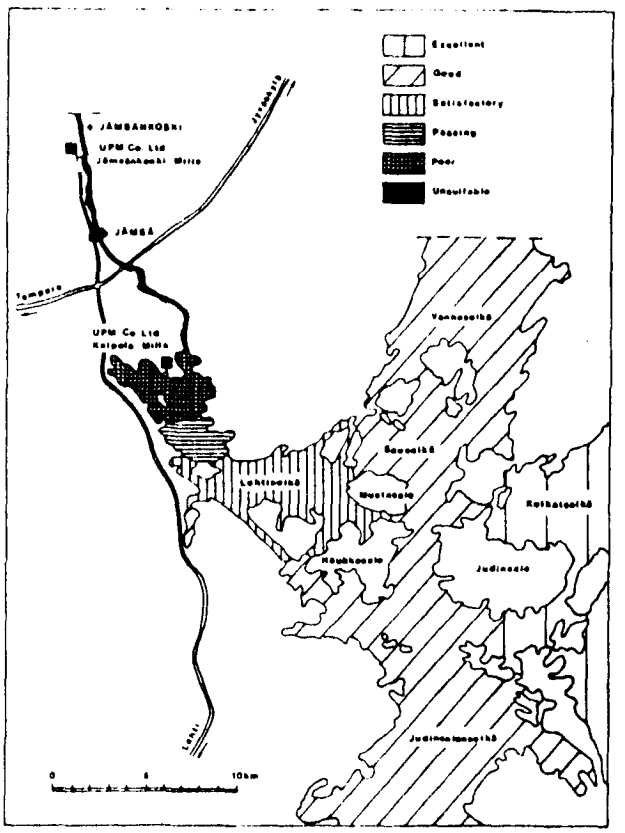

Fig. 7. The usability of the watercourse for recreational use in the study area in 1983.

The waste waters of the factories are treated mechanically. In 1983 the pollution load discharged into the water course was on average as follows (Table 1):

Table 1. The pollution load from the Jämsankoski and Kaipola Paper Mills in 1983.

Polluter	Waste water flow $m^3 d^{-1}$	Pollution load kg d^{-1}				
		SS	BOD_7	N	P	CaLS
UPM Ltd. Jämsänkoski Mills	26000	3200	8200	100	20	4000
UPM Ltd. Kaipola Mills	22000	4300	7900	70	20	5700

The watercourses of the study area are in heavy use especially for fishing and leisure purposes. The River Jämsä is a significant environmental factor from the point of view of settlement.

Alternative objective levels for the usability of the watercourse

The alternative levels are depicted in the study using a classification of usability for recreational use (6). The classification takes into consideration the general state of the watercourse, its suitability for swimming, and its suitability for fisheries.

The alternative levels of objectives for the usability of the sub-areas are presented in Table 2.

The return of the watercourse or parts of it to a usability corresponding more of less a state of nature was the highest objective level (level C). The second limit-value was the situation made possible by the pollution permissions in present in force, which is approaching when the mills are running at full capacity (state according to permissions). The other levels of objectives were from in between.

Table 2. The alternative levels of objectives for the usability of the watercourse of the study area.

Sub-area	State according to permissions	Present state (1983)	Classification of usability for recreational use[1] Levels of objectives			
			A	B1	B2	C
River Jämsä	6	6	5	4	3	3
Olkkola Bay	5	5	5	5	4	3
Tiirinselkä northern part	5	5	4	4	3	3
Tiirinselkä southern part	5	4	4	3	3	2
Lehtiselkä	3	3	3	2	2	2

1) Usability classification:
1. Excellent
2. Good
3. Satisfactory
4. Fair
5. Poor
6. Unsuitable

Choice bases

It is possible to derive the pollution load limits in Table 3 for the achievement of the objective levels from the model examinations adapted to the study area (5, 7, 8, 13, 16).

In relation to the other properties the demands were set as being technically familiar, operationally reliable technology. Input limits were not set beforehand.

Table 3. The permitted pollution load of the watercourse at different levels of objective.

Alternative levels of objectives	Flow in the Jämsä River $m^3 s^{-1}$	Permitted pollution load							
		SS td^{-1}		BOD_7 td^{-1}		Phosphorus $kg\ d^{-1}$		CaLS td^{-1}	
		Jämsän-koski	Kaipola	Jämsän-koski	Kaipola	Jämsän-koski	Kaipola	Jämsän-koski	Kaipola
Permission	-	3.5	8	17	14	*	*	*	*
1983	-	3.2	4.3	7.9	8.2	20	20	4	5.7
Level A	5	3.5	5	5	5	25	25	4	5
Level B1	5	3.5	5	3	5	25	25	2.5	5
Level B2	2	1	5	2	4	5	25	0.5	5
Level C	2	1	5	0	2	5	10	0.5	1

* The permission does not include a limit concerning the parameter in question.

Operational alternatives

The basic elements of the alternatives to be examined were:
- sedimentation
- aerated lagoon
- activated sludge plant
- activated sludge plant + chemical sedimentation
- channelling the waste waters of the Jämsänkoski mills to the combined treatment at Kaipola.

From these 15 different treatment and channelling alternatives were formed, the operation and costs of which were estimated.

Preliminary comparison and elimination

The properties and costs of the alternatives were determined with the treatment costs model for waste waters from the wood-processing industry developed in the National Board of Waters (Uimonen 1983). The pollution load objectives presented in earlier permissions as investigation objectives and in intergrated water resources development plans (13) were used as the basic level (elimination level) of the choice. Six alternatives were approved to investigate in more detailed analysis, these were:

I Present sedimentation + activated sludge plant complemented with the use of chemicals in post-sedimentation at Jämsänkoski. Sedimentation + aerated lagoon + sedimentation at Kaipola.

II Jämsänkoski as in alternative I. Sedimentation complemented with chemical feeding + aerated lagoon + sedimentation at Kaipola.

III Jämsänkoski as in alternative I. Sedimentation + activated sludge plant complemented with the use of chemicals in post-sedimentation at Kaipola.

IV Waste waters from Jämsänkoski to be channelled after sedimentation to Kaipola for combined treatment. Separate sedimentation at Kaipola. Aerated lagoon and sedimentation as combined treatment.

V Sedimentation complemented with chemical feeding at Jämsänkoski and Kaipola. Combined treatment as in alternative IV.

VI Sedimentations at Jämsänkoski and Kaipola. Activated sludge plant complemented with the use of chemicals in post-sedimentation as combined treatment.

The remaining loads and the costs of the alternatives are shown in Tables 4 and 5.

Table 4. Remaining loads of the alternatives approved in the preliminary elimination.

Alternatives	Pollution load $kg\ d^{-1}$				
	SS	BOD_7	N	P	CaLS
I	5500	7300	560	50	7200
II	4400	6300	520	45	6000
III	3400	4700	690	50	5300
IV	10300	9500	430	40	8800
V	6200	7800	350	40	8600
VI	3400	4800	670	50	5300

Table 5. Costs of the alternatives approved in the preliminary elimination.

Alternatives	Investment costs 1000 FIM	Operating and maintenance 1000 FIM/a	Present value of costs 1000 FIM
I	58500	6700	123600
II	63500	7800	139300
III	62100	9200	151400
IV	65700	4600	110400
V	68800	5300	120300
VI	71700	9200	161100

Analysis and profitability comparison

Value analysis

The value factors of the study area were grouped in the manner presented earlier. The rate of interest used in the calculations was 6 % and the period of calculation was 15 a.

The territorial monetary values were determined according to the principles presented earlier. The following summary can be presented of the monetary values (17).

In the example case lack of risk, preconditions for implementation, expandability, and influences on image were dealt with as non-monetary values having an influence on the choice (17).

Comparison costs

The costs obtained by calculation which contained investments and operating and maintenance costs, were used as comparison costs for the alternatives. Construction was estimated as lasting 2 years and interest during the construction period was taken into consideration in the comparison.

Table 6. Monetary surplus values of the alternatives.

Value factor	Value changes compared to present state 1000 FIM							
	In natural state	Futur state without new pollution control measures	Alternatives					
			I	II	III	IV	V	VI
HOUSING								
Residence values	7 300	-	-	900	900	6 400	6 400	7 300
Land values	400	-	-	-	-	400	400	400
Energy	(3 900)	-	-	-	-	3 900	3 900	3 900
PRODUCTION								
Industry	-	-	-	-	-	-	-	-
Agriculture and forestry	100	-	100	100	100	100	100	100
Fisheries	6 500	- 900	3 000	4 000	4 000	1 000	3 200	5 200
LEISURE								
Summer residences	7 800	- 1 400	4 600	5 400	5 400	1 600	4 800	6 500
Fishing	10 000	- 300	5 700	5 900	5 900	1 900	6 700	7 600
Swimming	2 900	-	1 500	2 900	2 900	-	1 500	2 900
Boating	2 700	- 500	1 800	2 400	2 400	2 000	2 000	2 600
Outdoor activities	5 000	-	3 300	4 200	4 200	4 000	4 000	5 000
Total	46 600	- 3 100	20 000	25 800	25 800	21 300	33 000	41 500

Profitability comparison

The profitability comparison was carried out in stages in the manner presented before. In the first stage profitability was determined on the basis of ecological values, in the second stage monetary values were taken into consideration in addition. The profitability index of the alternatives is shown in Table 7.

Table 7. Profitability of the alternatives.

Criteria	Profitability index P = V/C					
	I	II	III	IV	V	VI
- Profitability on the basis of ecological values	1.10	1.14	1.11	1.00	1.22	1.04
- Profitability on the basis of ecological and monetary values	1.28	1.34	1.29	1.21	1.51	1.31

By giving the non-monetary factors between the satisfactory and very good level a significance of 50 % in relation to the basic calculation of the previous stage, it was possible to prepare curves of the influence of the non-monetary factors on the profitability index. The curves of the profitability of the alternatives are shown in Figure 8.

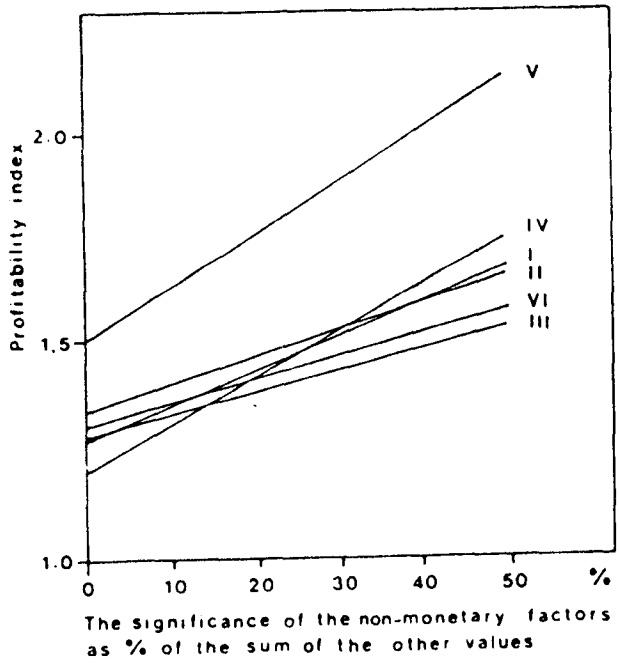

Fig. 8. The effect of the non-monetary factors on the profitability of the alternative.

According to the basic calculation (ecological values + monetary values) the most profitable alternative was V and the second most profitable was II. When examining the influence of the non-monetary factors it can be observed, that alternative V is still clearly the best in all cases and, that if the significance of the non-monetary factors is regarded as being at least 30 % of the magnitude of the ecological value and the territorial monetary values, alternative IV rises to second place.

Sensitivity analysis

The sensitivity of the profitability of the alternatives to changes was examined separately in relation to ecological values, costs, monetary values, and other profitability factors.

The profitability of alternative V compared to the other alternatives did not appear to be sensitive to changes in any of the factors.

Comparison starting from a higher level of elimination

The effect of the choice of level of elimination on the result was tested by choosing a higher level of objective as the new level of elimination which, compared to the elimination previously carried out, means tightening the demands in the lake area by the amount of one usability class.

Of the previously approved alternatives only alternative IV was then eliminated.

A corresponding examination to the previous round was now made for alternatives I, II, III, V and VI. Alternative V remained the most profitable if it was permitted to exceed the CaLS load slightly.

The second most profitable solution starting from this level would be alternative VI or I depending on the significance given to the non-monetary factors.

Development

Soon after carrying out the case-study a more precise general plan for the water pollution control solution of the area has been prepared on the basis of the study. After that, however, the production of the Kaipola mills has decided to enlarge and to a certain extent change. This leads to increasing pollution load, which means the need of a more effective treatment than that in original situation proposed.

Discussion and conclusions

The foundation for a new way of thinking about water pollution control has been laid in the presentation. It has been possible to demonstrate the adaptability of the method to practical estimation work.

The following conclusions can be drawn from the study:

The procedure presented makes it possible to set water pollution control objectives beginning from the watercourse.

By using alternative levels of objectives the basic level can be left to be chosen by the decision-makers.

By using value concepts it is possible to combine all factors affecting the choice in the comparison.

At the chosen basic level it is possible to claim, that the cheapest alternative fulfilling the demands is worth its price.

The linking of non-monetary factors to the comparison can be presented by a profitability index curves, in which case the decision-makers can apply their own preferences in relation to them when making the choice.

For estimating risks and sources of error it is possible and necessary to use sensitivity analysis.

The fundamental realization of the comparison presupposes abundant basic knowledge of the study area and the co-operation of many experts.

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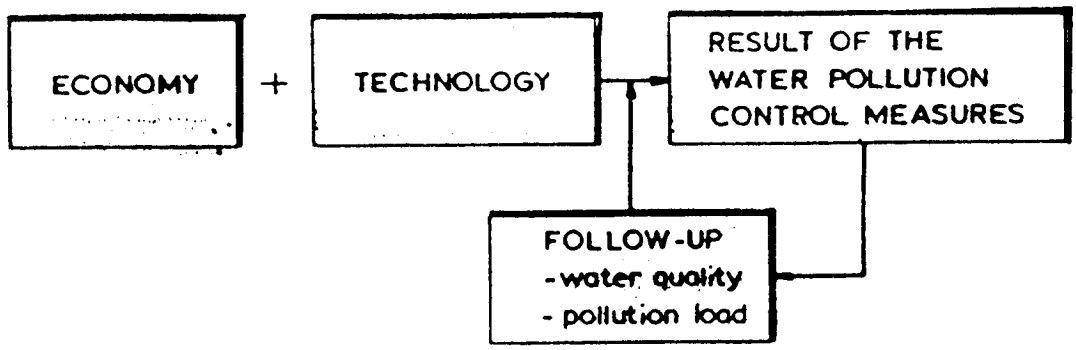
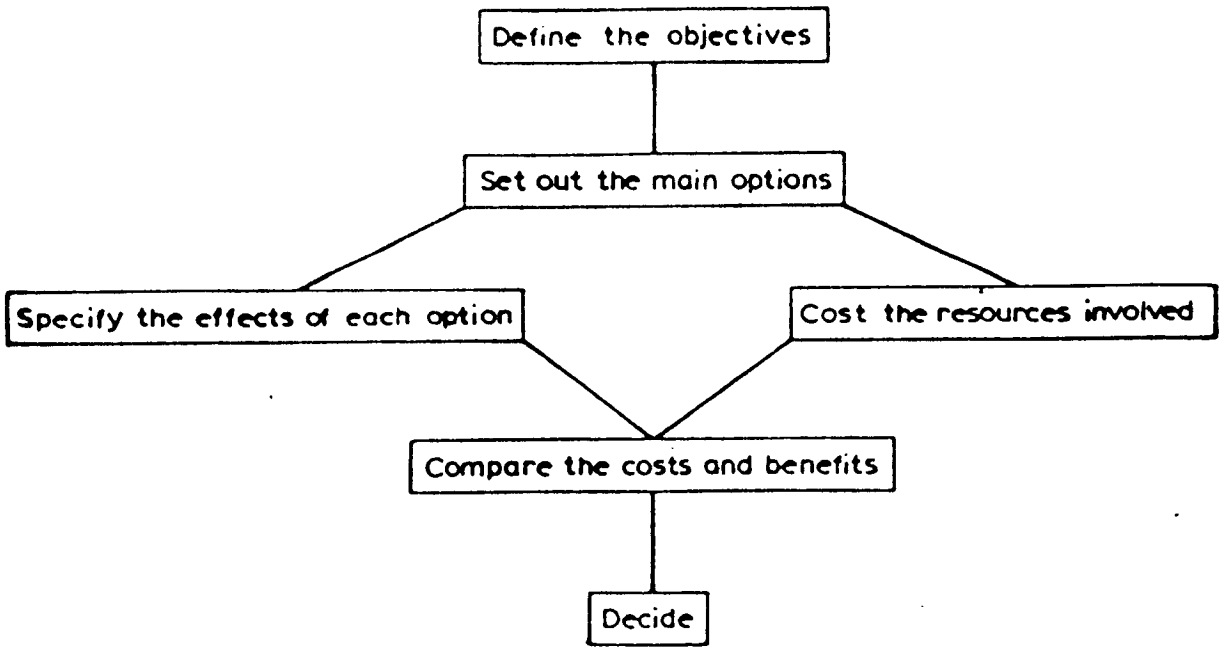
Jouko Pöttökangas cost-benefit case (appendices) 1.



The present procedure in water pollution control (compare Heinonen 1983, Kinnunen 1984).



A framework for benefit-cost analysis (Ahmad 1984).

The effects of the waste waters of the pulp and paper industry and their causes.

Effects in a watercourse	Causes of the effects
oxygen deficiency	- sugars, alcohols, organic acids and other easily decomposable organic compounds
eutrophication	- nutrients
smell and taste detriments	- resinous acids, phenol compounds and products of their chlorination, reduced sulphur compounds
colour	- lignine
turbidity	- insoluble organic and inorganic solids
poisonousness	- organic chlorine compounds, resinous and fatty acids, inorganic acids and alkalis, reduced sulphur compounds
sedimentation and collection in the bottom sediment	- fibres, lignine, and other slowly decomposing organic compounds, nutrients

COMPARATIVE METHODS USED IN FINLAND

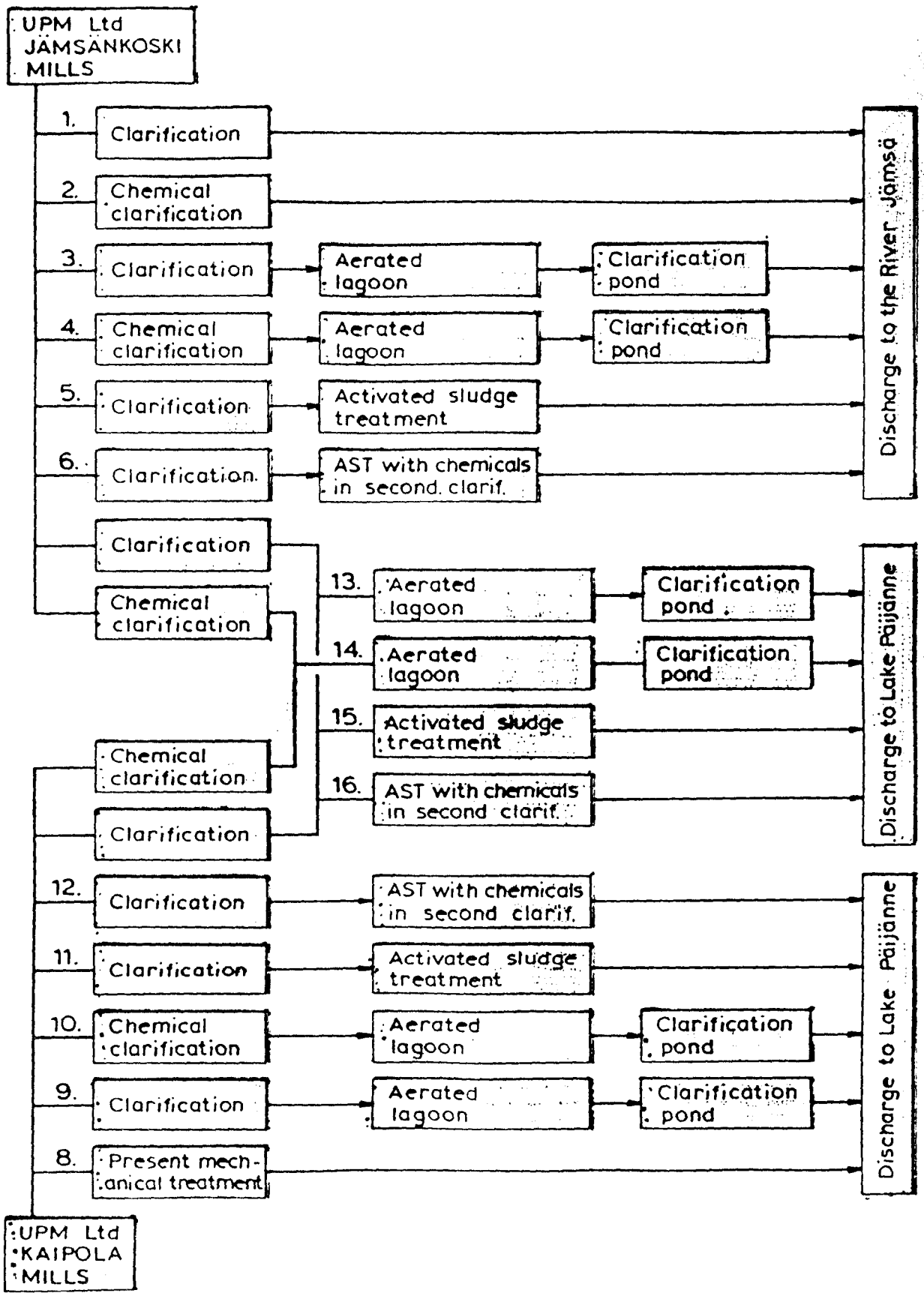
IN
- regional water resources planning
- water pollution control
- planning of land drainage and flood control
- planning of other uses of waters

- INPUT - OUTPUT ANALYSIS
- BENEFIT - COST ANALYSIS
- FACTOR PROFILES
- RATIO OF INTANGIBLE BENEFITS TO COSTS
- COST - EFFECTIVENESS ANALYSIS
- COST OPTIMATION
- DESCRIPTION OF IMPACTS
- (ENVIRONMENTAL IMPACT ASSESSMENT)
- VALUE - COST ANALYSIS

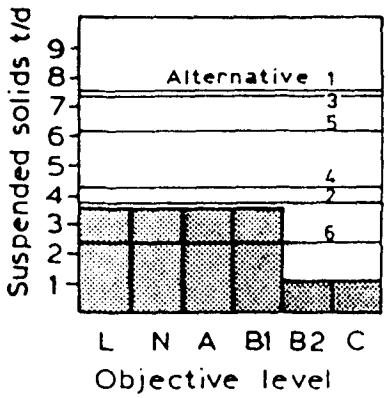
The permitted pollution load of the watercourse at different levels of objectives.

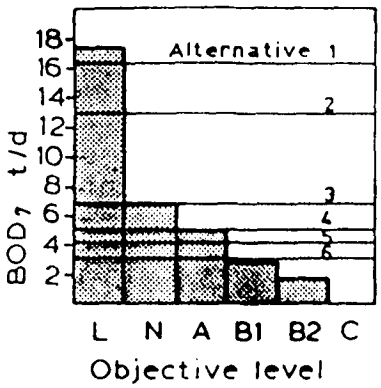
Alternative levels of objectives	Flow in the River Jämsä m^3/s	Permitted pollution load							
		SS t/d		BOD7 t/d		Phosphorus kg/d		CaLS t/d	
		Jämsän-koski	Kaipola	Jämsän-koski	Kaipola	Jämsän-koski	Kaipola	Jämsän-koski	Kaipola
Permit	-	3.5	8	17	14	*	*	*	*
1983	-	3.2	4.3	7.9	8.2	20	20	4	5.7
Level A	5	3.5	5	5	5	25	25	4	5
Level B1	5	3.5	5	3	5	25	25	2.5	5
Level B2	2	1	5	2	4	5	25	0.5	5
Level C	2	1	5	0	2	5	10	0.5	1

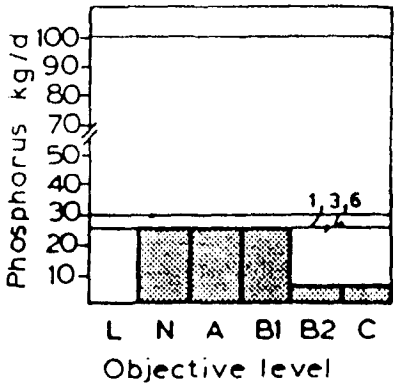
* The permit does not include a limit concerning the parameter in question.

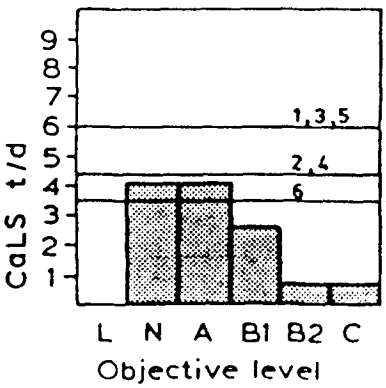


Water pollution control techniques studied for Jämsänkoski and Kaipola mills.
1 is the number of the alternative. The code number 7, given to the channelling solution in the case-study is missing from the numbering of the alternatives.



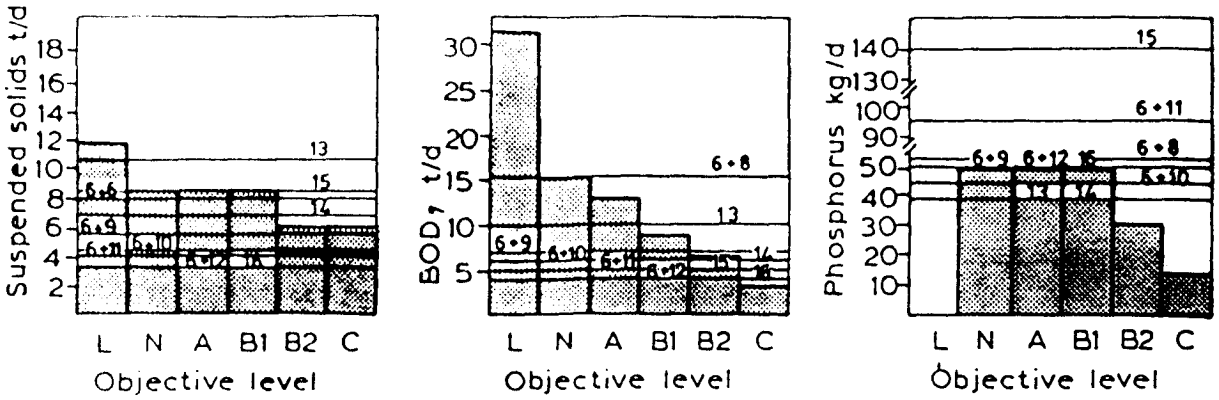


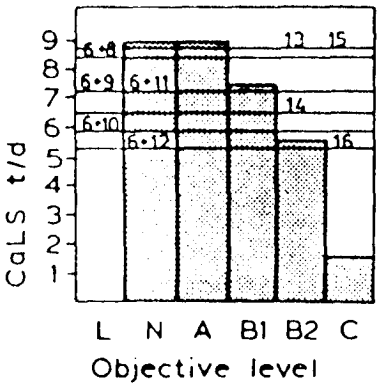




The objective levels are:
L = situation according to the permit in force
N = load situation in 1983
A, B1, B2, C = alternative objective levels.

The properties of the alternatives and permitted loads at different objective levels at Jämsänkoski.



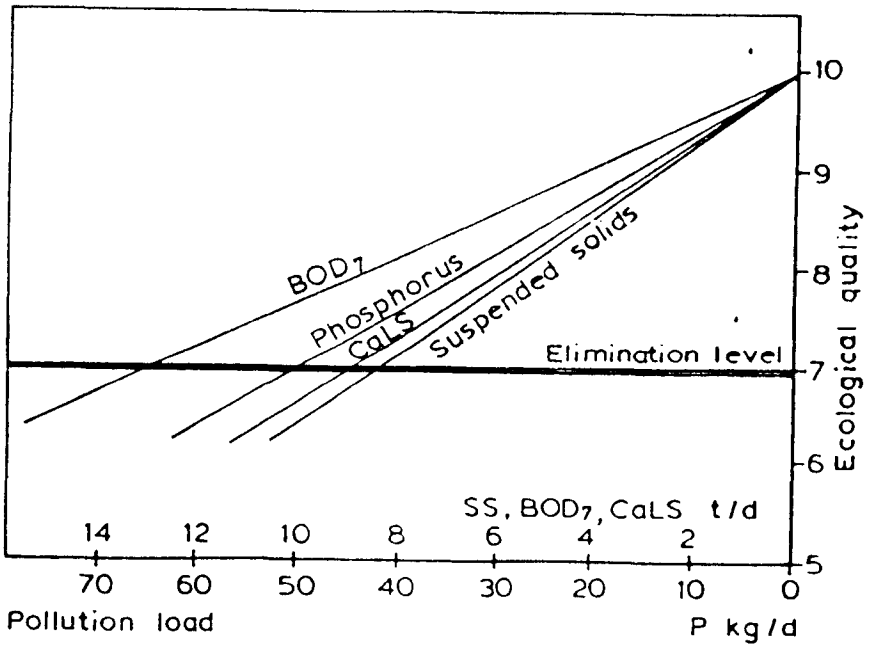


The objective levels are:
L = situation according to the permit in force
N = load situation in 1983
A, B1, B2, C = alternative objective levels.

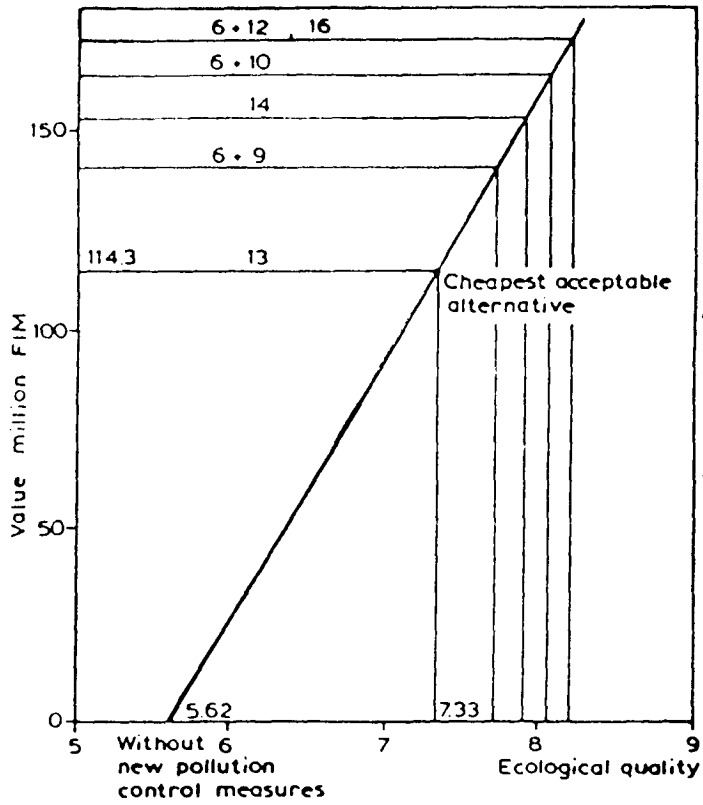
The properties of the alternatives and permitted loads at different objective levels. Jämsänkoski and Kaipola, combined effect.

The profitability of the alternatives taking only monetary factors into consideration.

Factor	Alternative					
	6+9	6+10	6+12	13	14	16
Present value of total costs (inc. interest during construction) 1000 FIM	127100	143100	155200	114300	124400	165400
Profitability order on basis of total costs	3.	4.	5.	1.	2.	6.
Monetary surplus value compared to present water pollution control measures 1000 FIM	23100	28900	28900	24400	36100	44600
Net costs 1000 FIM	104000	114200	126300	89900	88300	120800
Profitability order on basis of net costs	3.	4.	6.	2.	1.	5.



Ecological quality of the load parameters.
The permitted load at the elimination level represents a satisfactory result. An excellent result is when there is no need to discharge any load into the watercourse.



Relative ecological value of the alternatives.

Cheapest acceptable is worth of its costs !!

Profitability of the alternatives on the basis of ecological factors.

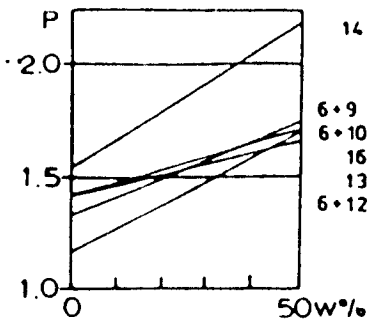
Criterion	Alternative					
	6 + 9	6 + 10	6 + 12	13	14	16
Value (Ve, from Fig.23)	140	163	172	114.3	152	172
Total costs (C)	127.1	143.1	155.2	114.3	124.4	165.4
Pe = Ve/C	1.10	1.14	1.11	1.00	1.22	1.04
Profitability order	4.	2.	3.	6.	1.	5.

The profitability of the alternatives on the basis of ecological and monetary factors.

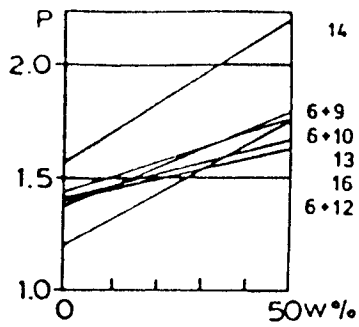
Criterion	Alternative					
	6 + 9	6 + 10	6 + 12	13	14	16
Value (Ve+Vm)	163.1	191.9	200.9	138.7	188.1	216.6
Total costs (C)	127.1	143.1	155.2	114.3	124.4	165.4
Pem = (Ve + Vm)/C	1.28	1.34	1.29	1.21	1.51	1.31
Profitability order	5.	2.	4.	6.	1.	3.

The relative quality of the alternatives in relation to operational value factors.

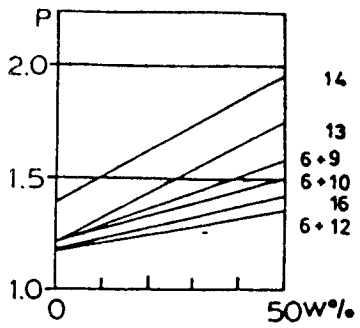
Value factor	Weighting	Alternative					
		6 + 9	6 + 10	6 + 12	13	14	16
- lack of risk	0.50	7.8	7.8	7.7	8.5	8.5	7.7
- preconditions for implementation	0.15	8.8	8.0	8.0	9.4	9.2	7.6
- expandability	0.20	9.0	8.0	7.0	9.0	8.0	7.0
- influence on image	0.15	7.7	8.0	8.1	8.4	8.9	9.1
Weighted total quality	1.00	8.17	7.90	7.67	8.72	8.57	7.76



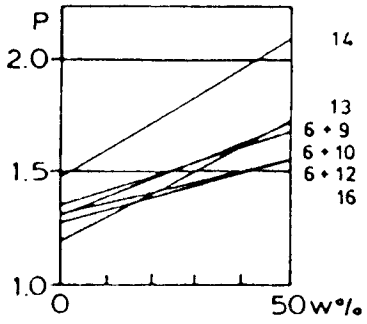
Effect of changes in reduction of BOD_7



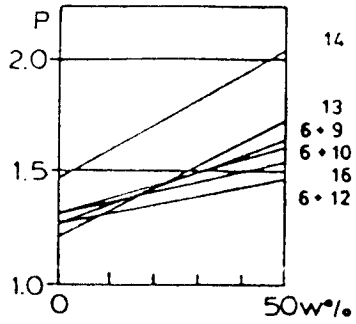
Effect of changes in the weighting of the load parameters



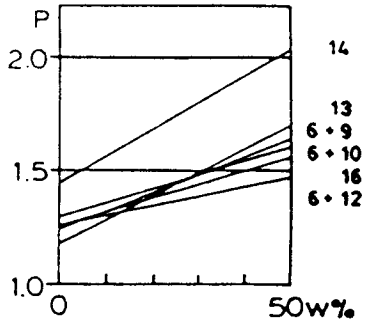
Effect of CaLS and load parameters' weighting



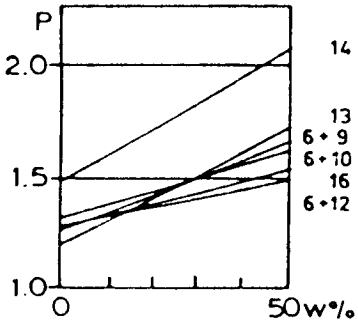
Effect of the usability of the River JÄMSÄ (+1 class)



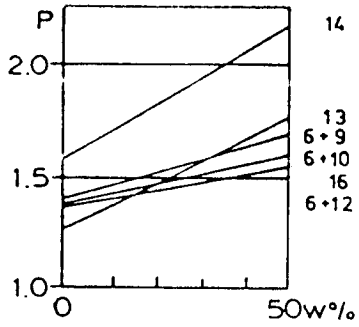
Effect of the usability of TIIRISELKÄ and LEHTISELKÄ (-1/3 class)



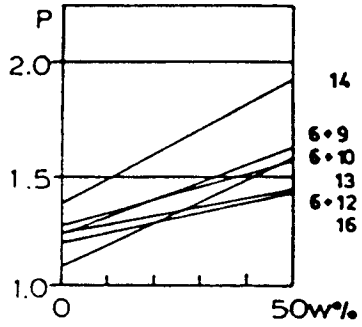
Effect of a delay (+ 3 a) in the value factors



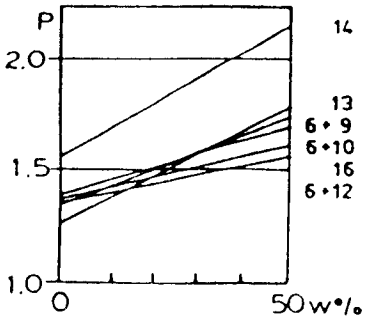
Effect of change in the rate on interest (+ 2 %)



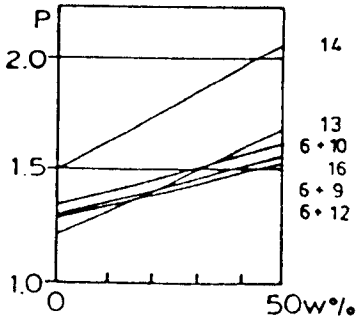
Effect of change in the rate of interest (-2 %) and of change in surplus value (+2 %)



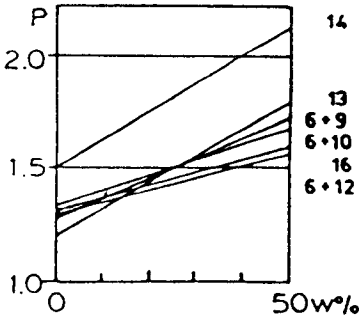
Effect of reduction in grounds of pricing



Effect of increase in grounds of pricing



Effect of operational factor (only lack of risk taken into account)



Effect of weighting values of operational factors

Changes in the profitability of the alternatives as a result of changes in different factors.

(this is nowadays
" old technology

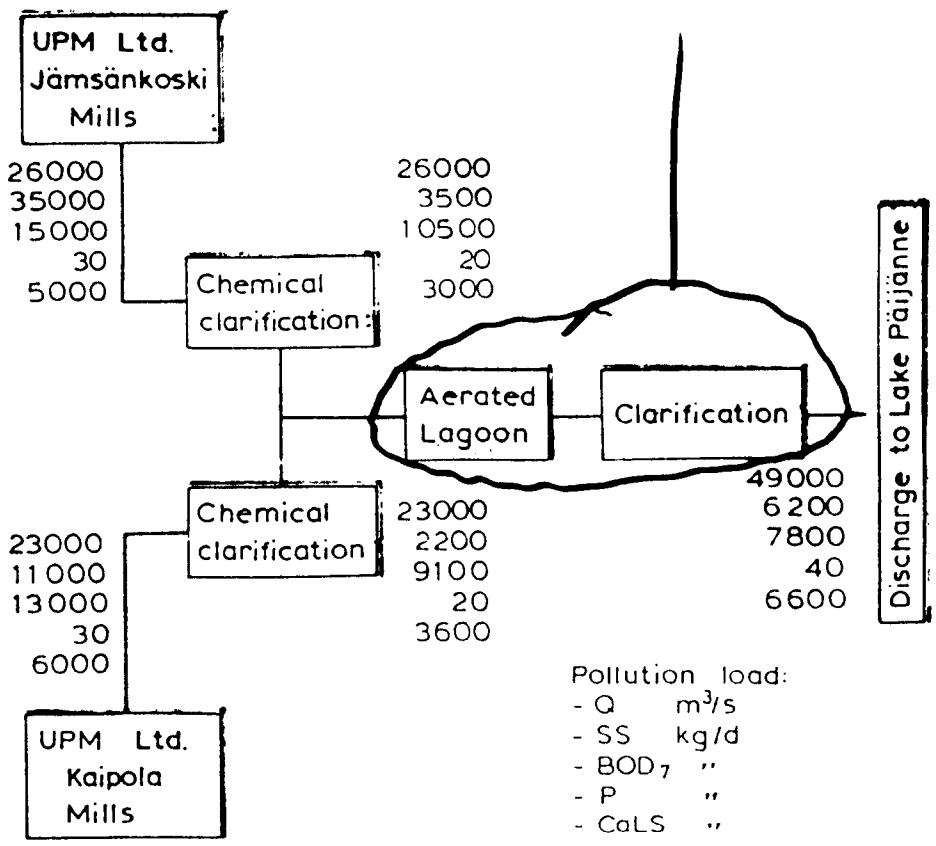
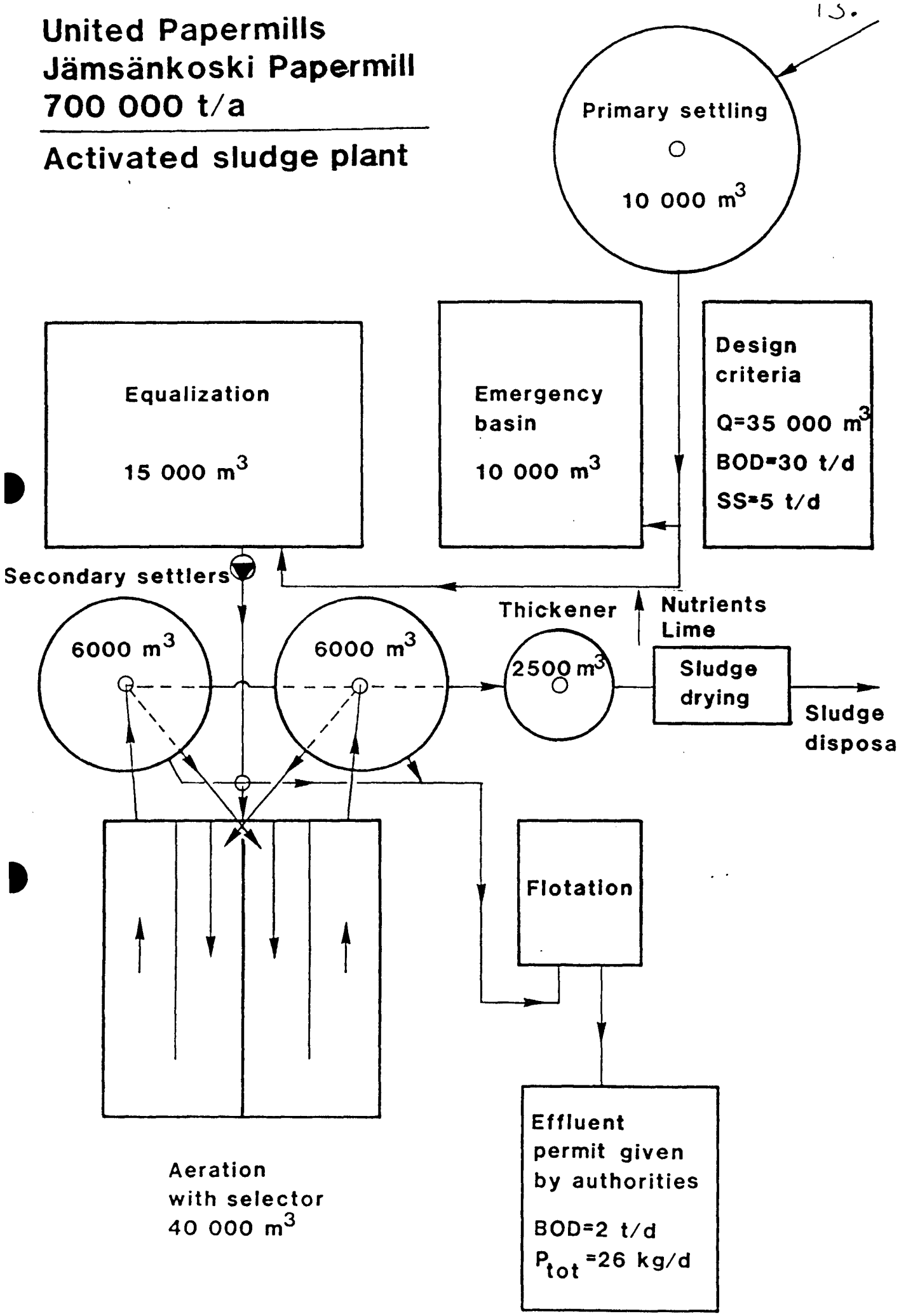
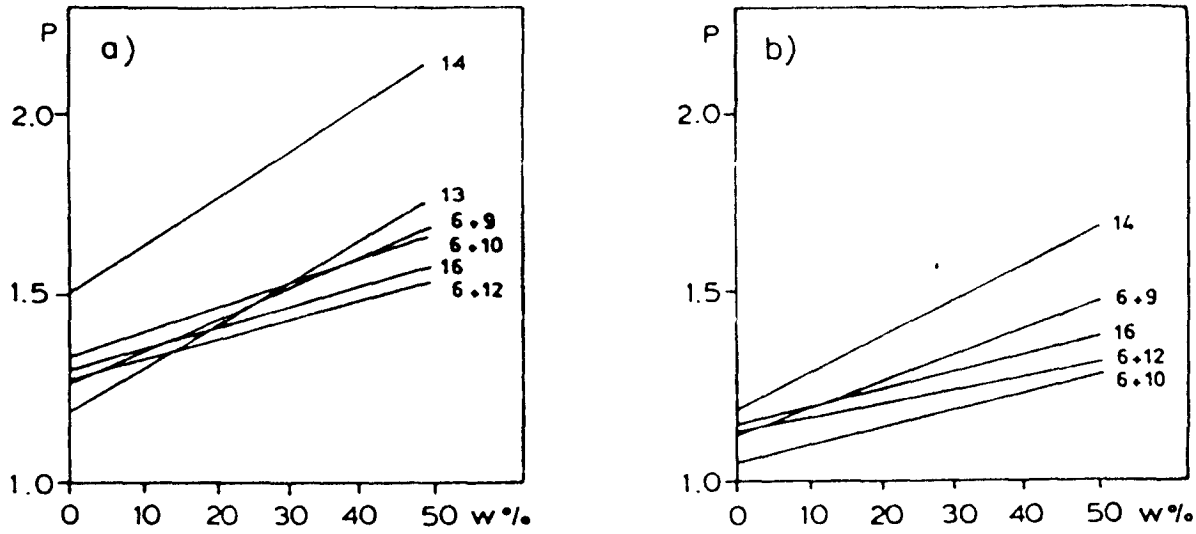


Diagram of the most profitable water pollution control alternative in the case-study.

United Papermills
Jämsänkoski Papermill
700 000 t/a

Activated sludge plant





Effect of change in the level of elimination on the profitability of the alternatives.
a = basic calculation
b = Profitability of the alternatives starting from a higher level of elimination. Alternative 13 of the basic calculation has been eliminated and as a result of raising the level of elimination the profitability indices fall. Changes also take place in the relations of the alternatives, but alternative 14 clearly retains its position.

11.7.1991

SAFETY AND RISK ANALYSIS AS A PART OF SAFETY MANAGEMENT

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1 INTRODUCTION

There has for some decades now been a marked tendency for the size of plants to increase. This tendency has been concomitant with the growing potential for accidents with even more far-reaching consequences for employees, the public and the environment, as well as the potential for costly production disturbances. On the other hand, the complexity of systems has made it more difficult for the designer to consider carefully even the most important hazards in the planning of a system, or for the operator to handle all normal situations and disturbances in a safe manner at the operational stage.

Quality control, use of standards and check lists, and the development and use of safety analysis have been useful design tools to manage complex systems and their risks. The development of safety analysis began in the fields of nuclear industry, civil and military aviation and space technology, where the aforementioned factors were considered to be the most apparent. It then spread to other sectors, such as the offshore technology, chemical industry, the transportation of hazardous materials, the mining and paper industries, to mention just a few examples.

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Tampere University of Technology
Institute of water and environmental engineering
4.-24.8.1991, Tampere, Finland

The early applications of safety analysis have mainly been voluntary and based on the motivation and benefit perceived by individual enterprises. After the EC Seveso-directive the trends in legislation are increasing the number of safety analyses which are likely to be carried out on an authority's initiate. The objective of safety analysis may then easily be to demonstrate the safety level in order to achieve a licence for operation.

This trend also incurs an increasing need for more precise knowledge of the limitations of different methods of safety analysis and explicit definitions of the acceptable level of detail of an analysis and the documentation required.

Safety analysis has proven to be a useful tool for assisting the design of new production systems and in establishing a basis for systematic risk management procedures during the operational phase. The main advantages concern the better possibility for preventing and mitigating industrial accidents through a more systematic knowledge on accident potentials and their contributors.

Though there are the obvious advantages, safety analysis also has certain restrictions and pitfalls. The main problems concern the need for competent resources and the completeness and accuracy of the results. Several studies have been carried out for determining the limitations of safety analysis:

- the effect of assumptions employed
- the factors possibly covered better by different methods
- the accuracy of component failure and human error data
- the validity and accuracy of gas release and dispersion models
- the validity of toxicity criteria
- the accuracy of fire and explosion models
- the role of expertise of analysis teams.

The results of these investigations can be used when planning and executing safety analyses. They give valuable information for assuring the quality of safety analysis. However, they do not produce a systematic framework for the quality control and management.

2 SAFETY ANALYSIS, RISK ANALYSIS, RISK MANAGEMENT

2.1 What is safety and risk analysis?

Risk management aims to protect the property, incomes and activities of a company so that the total costs are the lowest possible (Fig 1). The protection costs include costs from risk reducing measures and costs from insurances. Accident costs cover both direct and indirect costs which often are 3 - 10 times higher than the direct accident costs.

Risk management is a systematic approach supporting the search for the optimum risk/cost-level and the fulfillment of safety requirements defined by the society. Risk management is managerial approach and safety/risk analysis is a tool used for hazard identification and assessment. Safety and risk analysis gives a sound basis for evaluating the tolerability of risks and for deciding on necessary risk reducing/controlling measures. The main steps of risk management are shown in Fig. 2.

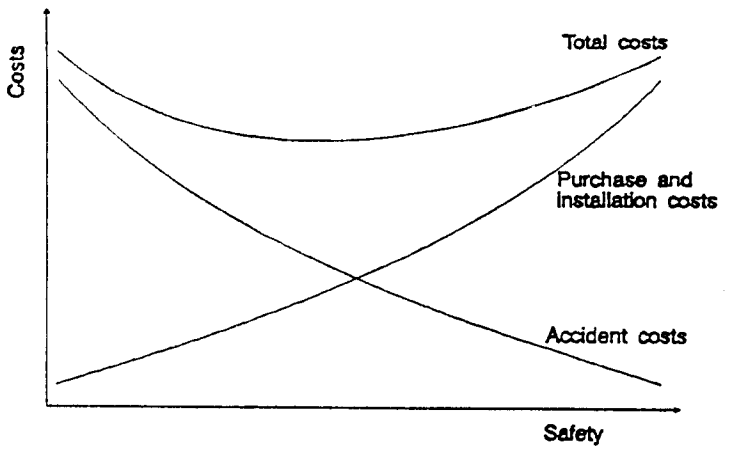


Fig. 1. A schematic figure on cost estimation in risk management.

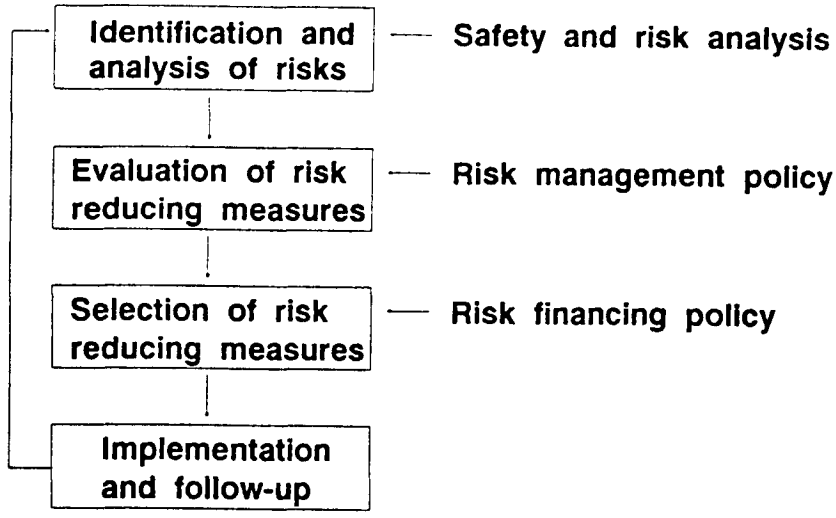


Fig. 2. The main steps in risk management.

Safety analysis is a systematic examination of the structure and functions of a system or an activity aiming at identifying potentials for accidents and their contributors, and finding risk reducing measures. It usually begins with a qualitative examination of hazards and a modelling of accidents. It may then be followed by a semiquantitative prioritisation of accident risks based on subjective evaluations. The modelling phase in safety analysis may also include the application of component failure and human error data in order to calculate the frequencies of potential accidents. The different steps in a safety analysis are shown in Fig. 3.

Safety analysis may be continued with a risk estimation phase including the estimation of consequences of potential accidents and the calculation of the size of the risk. Sometimes a preliminary consequence assessment is carried out as a first step. The aim of the investigation is then to support the decision making on plant localisation, alternative processes and plant lay-out. In the field of chemical accidents the consequence estimation usually means the use of gas release and dispersion models, fire and explosion

models, toxicity data, meteorological data and population data. Throughout the safety analysis system changes are made and they are reevaluated. The estimated risk is described typically as risk contours giving the probability that an individual will die during a given time period as a consequence of the identified hazards, or giving the social risk as f/N-curves expressing the frequencies of accidents resulting in accidents with at least N fatalities. This procedure, resulting in a numerical value for the magnitude of the risk, is usually called risk analysis (sometimes also probabilistic safety analysis - PSA or probabilistic risk analysis - PRA, cf. Fig. 2).

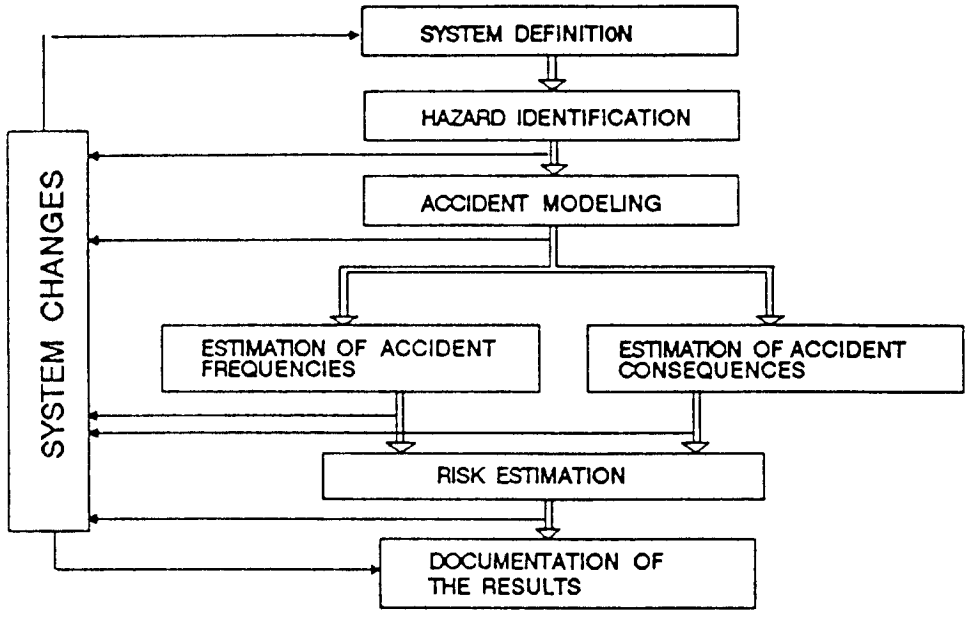


Fig. 3. The steps in a risk and safety analysis. The decision on the level at which the analysis is stopped is made on the basis of the complexity of the object for analysis and the risk potential.

The terms - risk analysis and safety analysis - are often used with the same meaning, describing the whole process in Fig. 3 or only a part of it. Various methods of analysis are then employed at different stages of an examination (cf. Table 1). There seems to be a tendency to use the term "risk analysis" in the field of major hazards, and the term "safety analysis" in the field of aviation and product safety, and increasingly also in the nuclear industry.

However, different practices do exist, varying according to country and language. In this book the term safety analysis is used as a general term and it has the meaning of describing the whole process of Fig. 3 or a part of it and the term risk analysis is used for reasons of clarity only when the quantitative estimation of risks in discussed.

Table 1 Different methods are used in order to meet the aims in various steps of a risk or safety analysis.

Phase	Aim	Examples of the methods used
Identification of hazards	To obtain a general view on potential hazards	Potential problem analysis (PPA) Reaction matrix Checklists
	To find relevant objects for detailed analyses	DOW index MOND index
	To obtain a detailed view on hazards and their contributors	Hazard and operability study (HAZOP) Human error analysis (HEA) Failure mode and effect analysis (FMEA) Management oversight and risk tree (MORT) Work safety analysis (WSA)
Modelling of accidents	To get a deeper understanding of the mechanisms of potentially serious accidents	Fault tree analysis (FTA) Event tree analysis (ETA) Cause-consequence analysis (CCA)
	To get a basis for the quantification of accident frequency	FTA ETA CCA
	To find Common-Cause -failures	CCA
Estimation of risks	To estimate and compare accident frequencies	FTA ETA CCA
	To estimate and compare consequences	Discharge and evaporation models Gas release and dispersion models Models of the dispersion of heat and pressure Vulnerability models

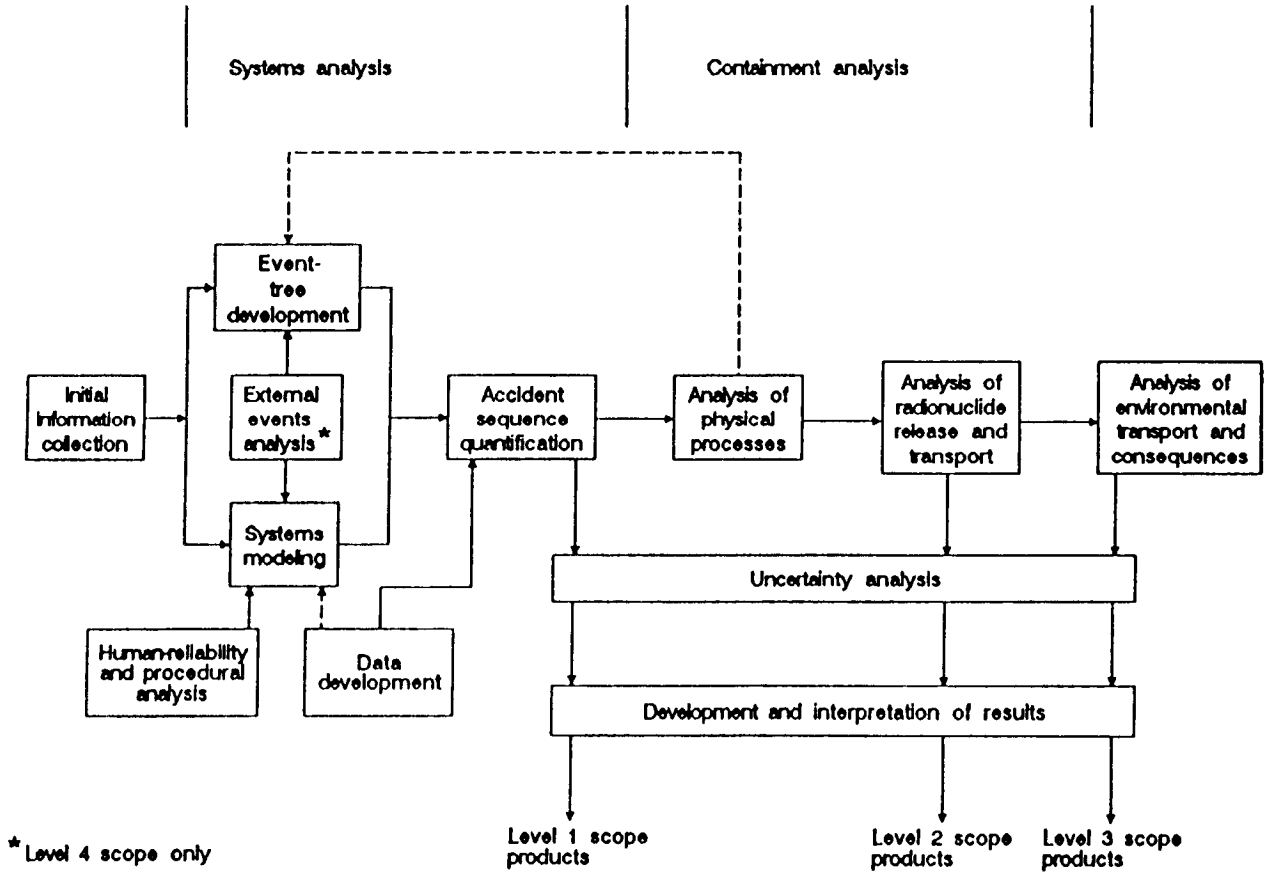
2.2 Probabilistic risk analysis, probabilistic safety analysis

Probabilistic risk analysis (PRA) has been developed in the nuclear industry to meet the same objectives as the safety analysis described before. A PRA can be performed on any of three levels of resolution. The level which is chosen for a particular study

depends on the nature of the results desired. The levels of PRA are (Dunphy 1985) (Fig. 4):

- **Level one.** Analysts make a systematic search of plant design and operation for contributors to risk. For example event tree analysis is used to identify a sequence of events that could lead to an accident; fault tree analysis is used to determine how safety systems could fail.
- **Level two.** The analysis focuses on the physical processes of an accident predicting when and how a containment system could fail and what would result from that failure.
- **Level three.** Analysts look at the possible movement of contaminants outside the plant. Many experts believe that only a level-three study permits an overall assessment of risk.

Fig. 4. The levels of probabilistic risk analysis (Hickman et al. 1981).



The levels of PRA are rather similar with the phases of a conventional safety analysis. The difference between PRA and conventional safety analysis is, that PRA concentrates more on estimating the probability and consequences of accidents, because a nuclear plant has only a few initiating events and relating hazards, whereas a chemical plant usually has much more of them.

More detailed descriptions of PRA can be found e.g. in (Hickman et al. 1981) and (Breeding et al. 1985). Instructions for performing a PRA can be found e.g. in (Haasl et al. 1985, von Herman et al. 1984, Iman & Prairie 1985, Leverenz et al. 1985, Lofgren & Cramond 1985a, b, Orvis et al. 1985, Ritchie et al. 1985).

PRA of a nuclear power plant evaluates safety issues of regulatory significance. If the analysis is carried out only at level one or at level two, it is called probabilistic safety analysis (PSA). PSA concentrates to assessing safety issues more on the plants point of view (Bari et al. 1985).

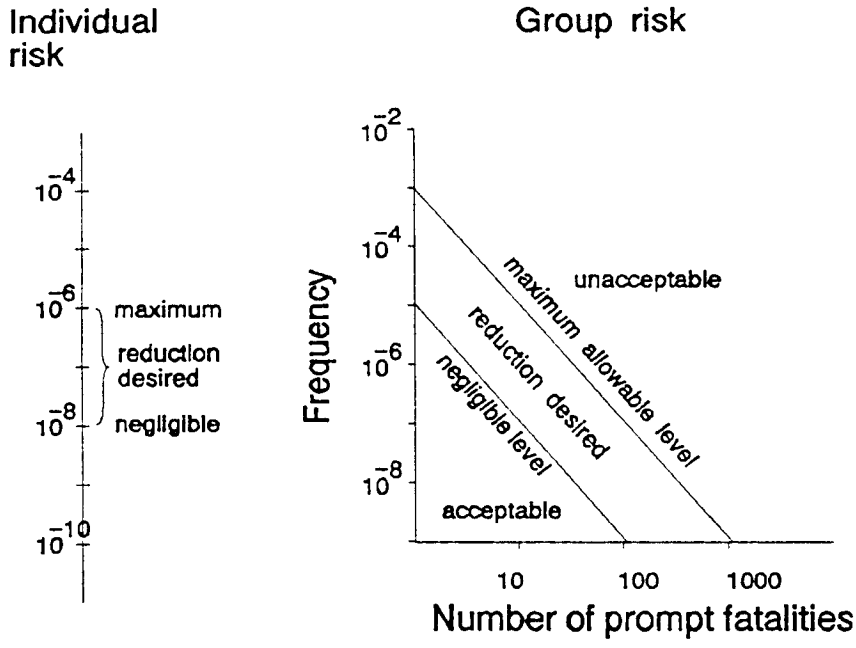
2.3 Legislation concerning safety analysis

Major accidents, such as Flixborough (1974), Seveso (1976), Bhopal (1984), Mexico (1984) and Sandoz (1986), have raised the interest among the authorities and the public to make use of safety analysis mandatory in certain potentially hazardous installations. Norway was one of the first countries to require probabilistic safety analysis on off-shore installations (Guidelines... 1981). The frequency of 10^{-4}/year for certain catastrophic events was defined the acceptability limit. The same requirements has also been applied in Denmark.

In 1982, the joint EC-recommendation Seveso-directive was accepted which recommended for example the use of safety study in the context of potentially hazardous process/storage installations. The national legislation developed enables the authorities in EC-countries to require so called safety report. Most of the

requirements concern qualitative analyses of the system. Such is the case for example in West Germany (Zwölfte... 1980, Erste... 1981, Zweite..... 1982) and in Denmark (Bekendtgo/relse... 1984, Pligter... 1985). A lately approved environmental program in the Netherlands is the first attempt to require a quantitative risk analysis and to present quantitative acceptability limits for individual and group risks (Fig. 5).

Fig. 5. The limits for risk acceptance in the Netherlands (Environmental... 1985).



In the United Kingdom, the NIHSS Regulations (Notification... 1982) concern the identification of hazardous sites, and CIMAH (Guide... 1985) and Health and Safety at Work Act concern the assessment and control of the risks. The CIMAH regulations require the preparation of the safety report. A safety report includes, among other things, the identification of the type of consequences and relative likelihood of potential major accidents (Cassidy 1987). HSE has a statutory role to judge the adequacy of the investigation of hazards and risks, and can in the case of significant consequences or risks require systematic quantitative safety analysis.

The regulations above have mainly been developed to protect people who live in the neighborhood of a process plant or a large storage system. In the Netherlands, the occupational safety authorities have also required a qualitative safety analysis on certain potentially hazardous process installations (Operational... 1982).

The occupational safety legislation is recently renewed in several countries. According to the new law, for example in Finland, it is the employer and the designer that are responsible for the investigation of the safety of a new production system or machine (Laki... 1987). The explanatory memorandum states that in the case of complex and particularly hazardous system the investigation may require the use of systematic safety analysis. Corresponding ideas on safety analysis and consequence assessment are also presented by the committee preparing new laws for chemical industry (Asetus... 1990).

2.4 How sosiety can benefit from safety analysis

In the past ten years society has become interested in the use of safety analysis. Using this analysis as a means of assessing whether the operations carried out on an industrial complex places local residents at too high a level of risk. Well known studies in Europe include the two Canvey Island studies in the United Kingdom (Canvey... 1978, Canvey... 1981), the COVO (Risk... 1982) and LPG Integraalstudie in Germany (Jäger et al. 1983, 1984). Comments about these studies are presented, for example, in Hauptmanns 1984, Schimetschka 1985).

Most of the studies carried out for societal desicion making have concentrated on major hazards incidents. Such studies may not contribute to the preventation of incidents involving very few fatalities. Such incidents have been shown to cover the large majority of all process industry related fatalities (Cox 1985). However, the safety analysis have shown that the safety of the

installation or operation si acceptable to the society. They have also been used to suggest how risk may be reduced by design changes.

Safety analysis and risk assessment benefit a society, for example, in the following situations:

- licensing of new plants and modifications of plants in operation
- evaluation of design modifications
- evaluation of conditions for operation and hazardous operations, for example, transportations
- evaluation of safety precautions and contingency plannins (also major accidents)
- planning of industrial areas (location of plants and residences).

In all cases a society can benefit from identification of design deficiences and selection between alternatives. Planning of industrial areas is a significant field where a society can utilize results of safety analyses and risk assessments. Remarkable economic savings can be gained, when different kind of special equipments cna be organised in common for several industrial plants. This kind of special equipments are, for example:

- railway and its reserve systems and rails
- fire-fighting and rescue equipment
- drainage systems
- refinery system of waste water
- garbage of problematic disposals.

Experience from safety analysis used in regulatory authorisation have shown many advantages:

- Even limited studies cna be of great value, because illustrations are drawn from the planning process, control of hazardous installations and the control of dangerous

substances (Fisk 1986).

- Safety analysis will give an indication of whether the design of the installation is adequate.
- A qualitative approach is valuable in structuring the problem and highlighting areas needing more carefull investigation.
- Systematical identification of hazards and realisation the remedial measures after it guides to more systematic thinking and to more systematic safety precautions.

Criticism against safety analysis presented by industry is often directed to the costs of quantification. It has often said, that "we now only describe it, what have done before too". There, sometimes occure inconsistency between authorities and industry when performing safety analyses: authorities ask sometimes quantitative assessments but industry is not always motivated in doing this. Industry often perceives gaining more advantage when carrying only qualitative safety analysis.

It is very common opinion, that the authorisation of a production system can not be based fully and only on quantitative (or qualitative) safety analysis (Bjordal & Lans 1983, Jäger et al. 1983, 1984, Kafka 1984, Lans & Bjordal 1983, Hauptmanns 1985). The following are the most often presented topics of criticism:

- Demands for safety analysis can divert resources away from achieving practical safety towards artificial targets (Cox 1985).
- Absolute criteria based on tisk alone can lead to automatic acceptance of proposals that just meet the criteria.
- The quantification process have many uncertainties and results are not accurate enough (Jäger et al. 1983, Rindfleisch 1984).
- There can not be accurate numerical acceptance criteria.
- Resources offered in quantification do not reduce the risk.
- Companies will not publish their new production technology.
- Terrorists can misuse safety analyses.
- Full quantitative safety analysis is very expensive.

The use of safety analysis in authorisation has many problems, but working together the authorities and industry can eliminate or manage most of them (Cox 1985, Hezel 1986). In stead of an exact acceptance criteria, it is possible to specify, in order of magnitude terms, levels at which an additional risk imposed on an individual must be considered unacceptable, becauce it would exceed levels of risk associated with voluntary undertaken activities. At this level the risk may begin to contribute significantly to the avarage overall individual risk of fatality in any one year from all causes. It is also possible to specify, again in order of magnitude terms, levels of risk to individuals, which can be considered to be significant as they are very much lower than the average risk of death from accidents (Cox 1985). In cases where the full quantitative safety analysis is too expensive, it can be asked instead of it, the use of more detailed methods of analysis on selected parts of the installation or quantification of a part of the installation only.

When applied in a proper manner safety analysis can be of great value for industry and society. However, before applying quantified safety analysis to the more standard type of process plant for the purposes of granting licenses or planning permission, one should ensure that the design, construction, operation and maintenance of the plant are up to adequate standards.

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25.7.1991

POTENTIAL PROBLEM ANALYSIS

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GENERAL DESCRIPTION

Potential problem analysis (PPA) can be used to obtain a general view of the hazards and their contributors - which in this context are called problems - connected to a plant and its operations. PPA is especially applicable to the identification of the plant's areas of vulnerability. These areas may then be examined in more detail by applying other hazard identification or accident modelling methods. The basic activities which provide the framework for PPA when applied to studying plant safety are presented in figure 1.

PPA is carried out by a team whose members have good knowledge, expertise and experience of the activity or system being analyzed. According to figure 1, the team identifies potential safety problems in three phases. The basic element in each phase is the application of a formal method to seek ideas.

It is proposed that the identification of potential problems begins with brainstorming. The silent brainstorming applied in the phase 1 means that each team member is given a piece of paper and is given about five minutes to write down at least three significant accident potentials connected with the object being analyzed. After this, each member is asked to pass his paper to the person next to him, and who should add another three potential problems to the paper. This procedure is then repeated until the members of the team are no longer able to produce ideas. The aim is to quickly collect the problems each member knows through his own experience and regards as significant. It is also possible that the members will be stimulated by each others ideas, leading to the identification of new problems.

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In the second phase of problem identification, the search for ideas is stimulated and systematized by specific sets of key words, which the team leader gives set by set. The list of key words is shown in the table 1. The team members should be encouraged to pay special attention to major problems involving serious consequences. The output of the first and second phase is a summary containing the potential problems that have been identified. The problems may be mapped, e.g. according to their point of existence, under the headings of:

- plant site
- buildings and structures
- process.

Each of the headings should be further divided into their major sub-systems.

A	IDENTIFICATION OF POTENTIAL SAFETY PROBLEMS	
	Phase 1	
	-	Searching for ideas (potential problems) by applying silent brain storming technique.
	Phase 2	
	-	Searching for ideas by applying silent brain storming technique.
	-	Application of key words to stimulate the search for ideas.
	-	Paying special attention to major problems.
	Phase 3	
	-	Searching for ideas by applying brain storming technique by proceeding systematically according to the process description of the plant under study.
B	EVALUATION OF THE IDENTIFIED SAFETY PROBLEMS	
	Phase 1	
	-	Identification of areas of vulnerability and selecting the problems to be evaluated.
	Phase 2	
	-	Identification of the contributors and consequences of the selected problems.
	-	Ranking the problems.
C	IDENTIFICATION OF PREVENTIVE AND CONTINGENT ACTIONS	

Figure 1. The phases of potential problem analysis (PPA) when applied to studying safety problems (Reunanen & Rouhiainen 1987).

Table 1. List of key words to stimulate and systematize the search for potential problems (Reunanen & Rouhiainen 1987).

A) Extreme natural effects
- seasons with their special features
  * rain, water, flood, snow, ice, frost in the ground, cold weather, hot weather, sun, thunderstorm etc.
- other natural phenomena
  * storm, earthquake, caving of the ground etc.

B) Physical locations and structures
- the plant site
- buildings and structures
- traffic in the plant site
- environment and the vicinity of the plant site
- process

C) Materials and energy
- supply of material, energy and information
- handling, transpotation, storage, loading and unloading of raw materials
- handling, transportation, storage, loading and unloading of intermediate produtcs and waste materials

D) Activities in the plant
- process
- commissioning
- start up
- shut down
- disturbance
- inspection, permits to work
- maintenance, repair, annual repair, service
- cleaning, housekeeping
- transportation, hoisting of equipment, storage, loading, unloading

E) Organization
- information flow
- hurry
- vacation
- strike
- emergency, exceptional situation
- unfamiliar or strange people
- instructions
- training, education

F) Concentrations/vulnerability
- property concentration
- personnel concentration
- information concentration
- energy concentration
- transportation concentration
- other concentrations

G) Other
- fault, failure, leakage, blokage
- fire, explosion, runaway reaction
- toxicity
- radiation
- electrocution
- asphyxia
- noise, vibration, mechanical failure

In the third phase of the problem identification, the brainstorming is continued verbally, proceeding systematically according to the process material flow. Rough diagrams of the operation principles of the whole system and corresponding diagrams of the most important subsystems and equipment may be used as a support. As each subsystem is concerned, the mapping of problems may be continued where the first and second phase left off. This is easily checked because of the structure of the summary of the first two phases.

The evaluation process of PPA begins by rejecting problems which do not need further consideration. This is done by specifying which problems can be classified into either of the following categories and rejecting those which belong to the categories B and C:

Category A:	Considerable problems which may result in considerable consequences and which should be further investigated.
Category B:	"Old" problems which are already well taken care of or "wild" problems and "problems of eternal nature" which cannot be influenced positively by reasonable measures.
Category C:	Minor problems which fall below the present level of interest.

The problem selection process described here and the evaluation of the problems selected together provide a view of the plant's vulnerable areas.

The evaluation also includes the identification of factors contributing to the problems selected in as much detail as possible, evaluating the consequences and ranking the risks according to their relative magnitudes. The more carefully the contributors of a selected problem are examined, the more fruitful is the last activity of PPA, i.e. identification of preventive and contingent actions. When the contributors are identified in detail, it is often possible to find effective and profitable measures for avoiding potential problems. The results of PPA are recorded on an analysis form, according to figure 2.

PURPOSE AND OBJECTS

The purpose of PPA is to give a general view of the safety problems associated with a plant and its operations and of their contributors. A general view of this type can be obtained by identifying the vulnerable areas and the major problems and their contributors specific to the object under study. Identified areas of vulnerability may then be examined in more detail by applying some other methods, e.g. hazard and operability study, failure mode and effect analysis, or action error analysis. This also means that if the vulnerable areas and major problems specific to the object to be analyzed are already well known, other method than PPA should be used from the start of the hazard identification process.

RESOURCES REQUIRED

Team work is applied for a PPA study. The resources needed for PPA may vary considerably, depending on the size of the system and whether complementary methods

VTT SAFETY ENGINEERING LABORATORY POTENTIAL PROBLEM ANALYSIS		SYSTEM: BLACK LIQUOR RECOVERY BOILER		PAGE: 7 DATE: 26.1.1982 DRAFTED BY:PPA-TEAM
SUBSYSTEM, TASK - POTENTIAL PROBLEM	CONSTITUENTS	CONSEQUENCES - MAXIMUM CONSEQUENCES	RANKING P*(I+M+L)= R	PROPOSALS FOR IMPROVEMENTS
STRONG LIQUOR LINE				
7 Dilution of the strong liquor		Smelt water explosion in the boiler	1 * (2+3+3) = 8	Independent means to double-check the strong liquor solids (density gauge located after the liquor pre heater)
	7A Weak liquor from the evaporation plant - leaking weak liquor entering the strong liquor tank (wash liquor from the evaporation plant or from the discharge well)			Removing unnecessary pipe lines
	7B Washing the liquor feed pumps (valve inadvertantly open or leaks)			Avoiding high pressure washing (instructions)
	7C Water or weak liquor from the soap line when soap is burned			A pump for each mixing tank for the right dosage of extra materials to be burned (designing the system so that the liquor will remain strong enough even if the incoming liquid is water)
	7D Too much sulphate liquid in the mixing tank			
	7E Washing the strong liquor line (liquor guns in firing position and liquor gun valve inadvertantly open)			
	7F Strong liquor dilution by condensate through liquor pre heater			Checking the pre heater pipe line and removing condensate if necessary before start up (instructions)
	7G Water in the liquor because of liquor feed pump seal failure			A flow rotameter into the sealing water pipe line

Figure 2. An example of the analysis form used in PPA (Reunanen & Suokas 1986).

will be employed afterwards. Five PPAs yielded the following average results, which give some illustration of the need for and distribution of resources:
- average meeting time: 2.5 h
- four meetings for hazard identification
- four meetings for the hazard evaluation and identification of preventive actions.

INFORMATION REQUIREMENTS

PPA requires good knowledge of the analysis object and its operation. When analyzing existing plants, the information requirements are met mainly by choosing people for the team who have good operating experience. In the last phase of problem identification, diagrams describing the main characteristics of the process being studied are needed. Photographs of the process are also useful in this phase. When analyzing an activity or a system which is in its design phase, the operating experience must be replaced partly by data obtained from design documents similar to those used for a hazard and operability study.

ADVANTAGES AND LIMITATIONS

PPA is based on the conviction that one can glimpse into the future, see what it may hold, and then return to the present to take action when it can do the most good.

PPA does not purposely exclude the identification of any safety-related problem type. It is hard to determine how good PPA is in identifying "everything". At least PPA applies a much wider perspective to problem identification than the identification methods (e.g. hazard and operability study, failure mode and effect analysis) commonly used.

In practice, the wide perspective applied to problem identification also restricts the depth of the results. PPA does not reveal, e.g. complicated process-related safety problems at the same level of detail as a hazard and operability study does. As already mentioned, PPA is suitable for the identification of areas of vulnerability and specific major problems. If these are already well known, other methods which focus on the hazards in more detail should be directly used.

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IDENTIFICATION OF HAZARDS; HAZOP AND WORK SAFETY ANALYSIS

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THE IDENTIFICATION PROCESS

Because of the large variations in system structures, the nature of risks, the needs of and resources available for safety analysis different types of methods have been developed to meet these different situations. Methods of safety analysis are often grouped into two classes: qualitative and quantitative or described as inductive and deductive. The methods can also be grouped according to the phase where they are used: methods for hazard identification, methods for accident modelling, and methods for consequence assessment.

In this paper two methods - HAZOP and Work Safety Analysis - are reviewed with the emphasis on their applicability. The description includes the general features of method, purpose and objective of its use, resources and information required, and an evaluation of the benefits and limitations of a method. The methods may have different names and small variations from the basic ones described in this paper.

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Hazard identification methods focus on individual causes of hazards and on the effects of hazards. If some hazards are considered to result in serious consequences the combination of their potential causes should be investigated with accident modelling methods. Here, the combinations of causes which may result to serious consequences are investigated in detail. After modelling of the accident scenarios and critical chains, it is possible to assess their probabilities.

The estimation of the consequences of a potential accident in the process industry requires the use of gas release and dispersion models, the use of fire and explosion models in the case of flammable materials, and the use of toxicity models in the case of toxic materials. The different phases in consequence modelling and estimation include simplifications and assumptions limiting the use of the results. These are discussed in more detail in other papers of this course.

HAZARD AND OPERABILITY STUDY (HAZOP)

General description

Hazard and operability study (HAZOP) is based on the assumption, that a system is safe when all the operating parameters have their normal states or accepted values. The systematics of HAZOP is based on the identification of critical deviations in the main process units such as tanks, pipelines and reactors. The deviations concern process parameters such as flow temperature, pressure, viscosity, pH, composition etc. Component failures, human errors and threats from the operating environment are reflected as changes in the process units (cf. Fig. 1). The aim is to include factors outside the process units in the examination when the contributors of the deviations in the process units are traced.

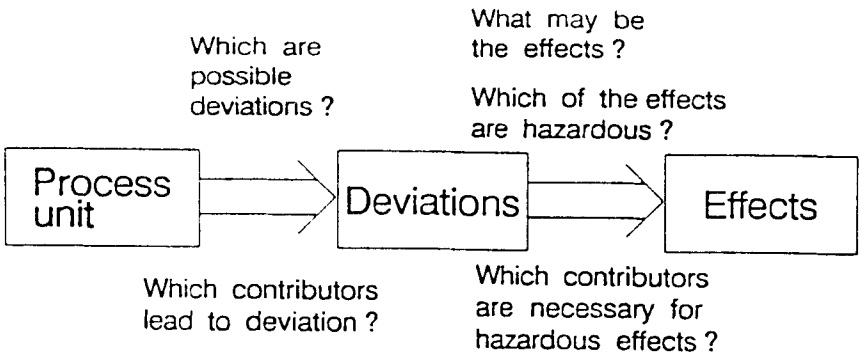


Figure 1. A simplified description of the search procedure of hazard and operability study (HAZOP).

HAZOP is carried out by a small team which has sufficient knowledge, expertise and experience on the activity and on HAZOP. The analysis is based on a description of the process typically in the form of flowsheets, line diagrams, and pipe and instrumentation diagrams (PID). The aim is to identify all conceivable deviations in the parameters, such as flow, temperature, pressure, viscosity, etc. by asking a set of key word questions. Table 1 presents main process parameters with typical deviations.

The key words (sometimes the deviations directly) are applied on process units such as pipelines, tanks and reactors. The intention is to generate a creative discussion in the team on potential deviations and their contributors. If conceivable causes have been identified their consequences are then propagated to evaluate potential hazards.

HAZOP results are typically documented on forms as shown in Figure 2. More detailed description of HAZOP can be found e.g. in Guide...(1977), Kletz (1983) and Balemans et al. (1979).

Table 1. Typical deviations applied in hazard and operability study (Fieandt et al. 1983).

Process parameter	Deviation
Flow	No flow Reverse flow More flow Extra flow Lower flow Change in flow proportions Flow to wrong place
Temperature	Higher temperature Lower temperature
Pressure	Higher pressure Lower pressure
Volume	Higher level (in tank) Lower level (in tank) Volume changes faster Proportion of volumes is changed
Composition	More component A Less component B Missing component C Composition changed
pH	Higher pH Lower pH Faster change in pH
Viscosity	Higher viscosity Lower viscosity
Phase	Wrong phase Extra phase

OCCUPATIONAL SAFETY ENGINEERING LABORATORY HAZARD AND OPERABILITY STUDY	SYSTEM: BLACK LIQUOR RECOVERY BOILER PLANT SUBSYSTEM: EVAPORATION PLANT 1 UNIT: EVAPORATION UNIT 1 – STRONG LIQUOR TANK	PAGE: 8 DATE: 18.2.1982 DRAFTED BY: HAZOP TEAM

DEVIATION	POTENTIAL CAUSES	CONSEQUENCES	ACTION REQUIRED
NO FLOW	LINE BLOCKAGE, VALVE ERRONEOUSLY CLOSED, PUMP FAILURE, FAILURE IN ELECTRICITY SUPPLY	15. OVERFILLING OF THE EVAPORATION UNIT 1	
HIGH FLOW	LEAKAGE OF THE PUMP WASH WATER LINE VALVE OR THE VALVE IS ERRONEOUSLY OPEN	16. DILUTION OF THE STRONG LIQUOR – ENTRY OF WATER INTO THE STRONG LIQUOR LINE	USING AS-NEEDED MOUNTED HOSES INSTEAD OF FIXED WATER PIPE LINES
	VALVE V1 ERRONEOUSLY OPEN	17. DILUTION OF THE STRONG LIQUOR – ENTRY OF WEAK LIQUOR INTO THE STRONG LIQUOR LINE	REMOVING THE VALVE V1 AND INSERTING BLANKS
	LEAKAGE OF THE VALVES HV1 AND HV3 LEAKAGE OF THE VALVE HV4 WHEN WASHING THE STRONG LIQUOR LINE FALSE OPERATION OF THE INTER-DEPENDENT AUTOMATIC VALVES HV1/HV4 AND HV3/HV4 WHEN WASHING THE STRONG LIQUOR LINE	18. DILUTION OF THE STRONG LIQUOR – ENTRY OF INTERMEDIATE OR STRONG INTERMEDIATE LIQUOR INTO THE STRONG LIQUOR LINE	CHANGING THE VALVE TYPE OF HV1, HV3 AND HV4 INTO BALL VALVES ALARM ON THE FALSE OPERATION OF THE VALVES

Figure 2. An example of the form used in HAZOP.

Purpose and objects

The purpose of HAZOP is to identify all possible deviations from the way the design is expected to operate and all hazards associated with these deviations (Guide... 1977).

Typical objects of HAZOP are the process systems in design or in operation. However, HAZOP is useful for examining all kinds of material, energy or information flows in different systems. Cases where HAZOP may not become as cost-effective as elsewhere are for example:

- standardized systems (proven solutions, no need for HAZOP)
- when the design concept is well known and experienced (proven solutions, no need for HAZOP)
- batch-processes (many human activities and different stages in the process. HAZOP can be used on the process and partly on the process sequences but needs to be complemented by e.g. action error analysis).

Process design stage is the most useful time to carry out a HAZOP-analysis. It should be seen as a part of the normal quality assurance of design. This means the integration of analyses already at a basic design stage when preparing conceptual flow sheets. These studies are later up-dated and complemented when more detailed PIDs are available. The final up-dating should be made during construction and commissioning of the system.

HAZOP can also be used on operating process installations. Here, the most economic time is when changes are planned in the installation. When carried out in other contexts HAZOP can produce valuable information to improve and assure the safety of a system but the freedom to implement changes particularly in the process system is more limited. The most important value in other contexts is in the improved knowledge of conceivable disturbances and their contributors and better instructions to deal with them.

Resources required

A HAZOP team should consist of 2 - 4 persons who know well the system to be studied, and of one person having experience in HAZOP. Table 2 presents two examples of team compositions.

Table 2. Recommendations on the composition of a HAZOP team (Kletz 1983).

Situation	HAZOP team
Object is in design phase	Design engineer Process engineer Commissioning manager Instrument design engineer Research chemist Independent chairman
Object is in operation	Plant manager Process foreman Plant engineer Instrument manager Process investigation manager Independent chairman

Once a HAZOP-study begins, the team should meet two or three times per week, for no more than 3-4 hours per session, until the study is completed.

A typically study of an existing chemical facility takes often at least 10-20 meetings. The need for resources mainly depends on:

Table 3 presents some examples of resources used in HAZOP.

- the size of the system
- the complexity of the system
- the experience of the group.

Table 3. Resources needed in HAZOP analysis.

Reference members	Team meetings	Number of meeting time	Average	Resources per process unit	Remarks
Taylor (1982)				0,5 - 1 team hr/ container 3 - 6 man hr/ container	Average value from several analyses
Kletz (1983)	5 - 7	10 - 20	max 6 hr	1,5 - 3 team hr/ plant item	Existing chemical facility
Flothmann & Mjaavatten (1984)	4 - 8	14	3 hr		Storing systems of ammonia
Rindfleish (1984)				0,25 team hr/item	Case study
Guidelines... (1985)	5 - 7			3 team hr/piece of equipment (0,25 team hr/ simple item)	Recommendation
Haastrup (1986)				4 team hr/piece of equipment	
Reunanen & Suokas (1986)	5	32	2,5 hr	3,5 man hr/ pipeline and tank	Black liquor recovery boiler plant
Heilman (1987)				40 man power days/ 2 - 3 process vessels	Average value in a safety analysis performed

Information requirements

HAZOP requires detailed and updated descriptions on the equipment and procedures of the object, such as:

- description of the operation of the object
- flow charts
- process and instrumentation diagrams (PID)
- technical specifications and descriptions of components
- properties of the process materials
- installation and environmental conditions of the equipment
- operation procedures and instructions
- logic diagrams (sensors and information logic) and chart of interlockings
- assumptions of test and maintenance intervals.

Benefits and results achieved

As benefits of the HAZOP method can be mentioned:

- it is a systematic examination of a restricted system
- the level of the examination can be chosen in accordance with goal
- it is a good method for training the operating personnel and designers and for obtaining a deeper knowledge of the system behaviour
- it gives the basis for modelling and quantification of hazards with other methods.

The results are the team findings: hazards and operating problems caused by the process, recommended changes in design, procedures, etc. to improve safety and recommendations for further studies in order to obtain complementary information. Table 4 presents results achieved in some HAZOP-analyses.

Table 4. Results of some HAZOP-studies.

Reference	Results	Total
Taylor (1982)	1 - 3 changes/meeting hr 0,5 - 1 changes/meeting hr	
Reunanen & Suokas (1986)	0,25 - 0,5 changes/meeting hr	
Suokas (1985)	3,5 man hr/changes	About 108 changes
Flothman & Mjaavatten (1984)		About 40 changes
Fieandt et al. (1988)	38 identified hazards/ meeting	1200 hazards/whole safety research

Restrictions

While the search for hazards is based on deviations in the process units, hazards having constant deficiencies (e.g. dimensioning and localisation of a device) as the only contributors are excluded. Constant deficiencies are included when the contributors to deviations or to hazards generated by deviations are sought. the information usually available in a HAZOP and the examples of the contributing factors direct the examination mainly at the process system and partly also at the human activities (particularly at operator activities). It is therefore unusual to identify contributors, for example, from the information or management subsystems (Suokas 1985).

There are also other factors, which HAZOP don't always reveal, e.g.:

- hazards generated by factors outside the system
- occupational accident hazards in a work task (slips, trips and falls)
- component failures, hazards of chemicals and chemical reactions are only partly within the analysis
- consequences of complicated event chains (usually events with one or two necessary causes are covered; events requiring the occurrence of three or more different causes are covered only by modelling methods)
- deficiencies in the installation and location of the equipment.

The reasons for oversights and omissions in the HAZOP-analysis are noted to be (Taylor et al. 1986).

- oversights due to simple lack of knowledge
- hazards overseen due to the administration of the analysis
- the depth of hazard identification studies is necessarily limited
- evaluation of the hazards identified may be difficult.

Alternative methods

Instead of HAZOP-analysis e.g. design reviews and check lists are more applicable in standardized and well known systems. If the object is completely new laboratory tests, PPA, reaction matrix and general check lists may give useful results with lesser amount of resources in the beginning of system design. For completing the results of HAZOP e.g. HEA, FMEA and WSA are applicable methods. For modelling the identified hazards fault trees and event trees may be used. For considering the importance of a potential disturbance preliminary consequence estimations and reliability calculations may be needed.

WORK SAFETY ANALYSIS

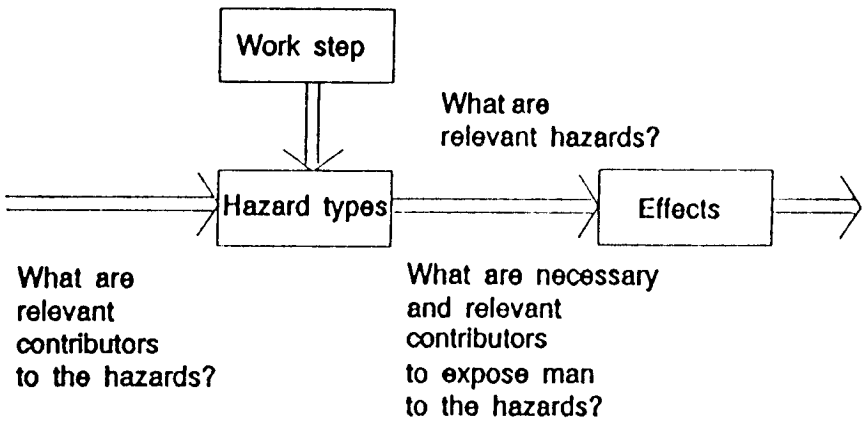
General description

Work safety analysis (WSA) is a systematic investigation of working methods, machines and working environment in order to find out accident potentials affecting to the worker (Suokas & Rouhiainen 1984). WSA has several similarities with the method called job safety analysis (Accident... 1972).

The search of hazards and accident contributors is based on breaking a task down into as small sub-tasks as required. At each of the steps the search begins with a heuristic consideration of relevant hazard types (cf. Fig. 3).Relevant contributors to the hazards and the contributors necessary (and relevant) to expose a worker to the hazards are then sought. The main emphasis is, however, on the search for hazards and their contributors.

In identifying hazards possible causes of the hazards are searched for. Attention is paid to constant deficiencies in the machines and working environment, and to various disturbances and changes in normal work performances. A list of hazards and examples of their contributors can be used to support the hazard identification.

Figure 3. A simplified description of the search procedure of work safety analysis.



Work steps and the identified hazards with their contributors are entered in the form shown in Fig. 4. After that, proposals for risk reducing measures are brought up.

The hazards identified in the analysis are classified by estimating the severity of the hazard. In the estimate the probability and consequences of an accident due to these hazards are considered. Tables 5 and 6 present the scales used in estimating the hazards.

SAFETY ENGINEERING LABORATORY WORK SAFETY ANALYSIS	MACHINE/SYSTEM: BLACK LIQUOR RECOVERY BOILER PLANT JOB: SK2 STOKER'S TASK; THE BOILER START UP	PAGE: 1 DATE: 10.9.1982 DRAFTED BY: RK/HP/MR

WORK STEP MACHINE/SYSTEM COMPONENT AUXILIARY DEVICE	HAZARD	CAUSATIVE FACTORS	CLASSIFICATION BEFORE P C R	CLASSIFICATION AFTER P C R	CORRECTIVE ACTIONS
1. PREPARING THE BOILER START UP					
1.1 CHECKING THE POSITION OF THE OIL PREHEATER STEAM VALVE AND IF NECESSARY EMPLOYING THE VALVE	THE POTENTIAL FOR CONTACT WITH EXCESSIVE TEMPERATURE	THE SAFETY VALVE OF THE PREHEATER, IF RELIEVES, DISCHARGES ON HANDS	1 3 3	0	EXTENDING THE DISCHARGE TUBE OF THE SAFETY VALVE AND DIRECTING IT AWAY FROM THE USER
1.2 EMPLOYING THE BY-PASS OF THE OIL PREHEATER STEAM LINE ADJUSTMENT VALVE	OR STRIKING AGAINST	IF THE HEATING STEAM VALVE AND THE DISCHARGE LINE TO THE DUCT ARE OPEN, WATER AND STEAM ARE DISCHARGED IN THE DUCT, WATER SPLASHES AND STEAM IMPEDES VISIBILITY	1 2 2	1 1 1	A GUARD AROUND THE DISCHARGE PIPE PREVENTING WATER FROM SPLASHING
1.3 STARTING UP THE OIL BURNERS	THE POTENTIAL FOR FALLING ON THE SAME LEVEL OR OVEREXERTION	THERE IS ONLY ONE IGNITION TRANSFORMER WHICH HAS TO BE REMOVED AROUND THE BOILER (THE TRANSFORMER IS HEAVY, IT HAS NO HANDLES, THERE ARE ALSO OTHER THINGS TO BE CARRIED)	3 2 6	1 2 2	ANOTHER IGNITION TRANSFORMER AND HANDLES ATTACHED TO THE TRANSFORMERS

Figure 4. An example of the form used in work safety analysis (WSA).

Table 5. Classification according to the probability (P) of an accident.

Point value	Probability (P)
0	Hazard eliminated
1	Very improbable (more rarely than once in ten years)
2	Improbable (once in ten years)
3	Slightly probable (once in three years)
4	Rather probable (once a year)
5	Very probable (many times a year)

Table 6 Classification according to the consequences (C) of an accident.

Point value	Consequences (C)
1	Insignificant (call at a first-aid station)
2	Little (1 - 2 days of disability)
3	Considerable (3 - 21 ")
4	Serious (22 - 300 ")
5	Very serious (over 300 ")

The probability multiplied by the consequences of a hazard can be used as a severity index yielding an estimate of the severity of the hazard. Classification "before" corresponds to the analysis situation and "after" to the level achievable by implementing the proposed measures. Thus, when directing the improvements, decisions can be based on two criteria: on the severity of the hazards at different work steps and on the cost effectiveness of proposed improvements.

Purpose and objects

Work safety analysis aims at identifying direct accident hazards affecting to a worker. Common hazards found in the analysis are, for example, potentials of striking against, falling and overexerting.

The most suitable cases for applying WSA are those man-machine systems with immediate accident hazards. The analysis object may be

- a production task
- a maintenance task
- tasks in a certain job
- a machine or a part of it.

The difficulty in a job-related analysis is the definition of the analysis object. The work under surveillance often demands moving about in the working area. Some of the tasks are repeated relatively seldom, e.g. only once a year. Facts like that demand special carefulness from the analyst.

The object of WSA should not be as large as paper production or building a house. The activity must be more strictly limited and a better cost-effectiveness is achieved if the work is repeatedly performed. Suitable objects in paper production are, for instance, web threading and changing rolls or wires in a paper machine. In a chemical plant loading/unloading of a chemical or a maintenance task are examples of suitable activities for WSA. When building a house, the mounting of building elements or the tasks of a concrete station operator are suitable objects for WSA. The work under surveillance must be structured enough also. Thus for example car driving is not a suitable object.

Resources required

If the object is in operation, the most suitable persons for performing the analysis are

- a safety technician
- a foreman
- a work-study officer
- a safety engineer or
- a consultant.

The analyst makes the actual analysis. After that, the analysis should be evaluated and improvements decided in a reference group. Suitable members for the reference group would be

- a line engineer/department chief
- a safety engineer
- a safety technician
- an experienced foreman (well familiar with the object)
- the safety representative of the workers
- the worker, whose job has been analysed and is now evaluated in the group
- the analyst(s).

A WSA typically requires from 2 man days to 2 man weeks depending on the size and complexity of the activity to be studied.

Information requirements

The analysis object can usually be chosen based upon accident frequency or the size of potential hazards. Therefore, for example, accident statistics can be used in selecting the object. By interviewing operational and maintenance personnel, further information can be obtained on tasks and machines,

- at which critical incidents have occurred
- which are considered the most hazardous ones or
- at which high precision is needed or the work is otherwise very demanding.

The analyst has to acquire a list of all tasks belonging to the worker in the object. The analyst should also know in detail all the methods to perform the tasks. Information sources may be:

- working instructions
- work guidance instructions
- work studies (if available)
- operating instructions of the machine
- repair and maintenance instructions
- workers and foremen
- personnel observation
- accident reports.

Besides the task under surveillance, the analyst should get familiar with the working environment. Several environmental factors often cause accidents, e.g. forklift truck and crane traffic near the job site, disorder and hazards caused by other jobs.

Benefits and results achieved

Work safety analysis gives a general view on hazards existing continuously in work performance. All types of system functions and states should be critically considered. The result is that hazards induced by constant deficiencies - determining factors - are slightly better covered than those induced by deviations (Suokas 1985).

WSA provides a systematic explanation of direct accident hazards and an estimate of the severity of the hazards. The information on accident hazards may be utilized in the following tasks:

- in evaluating the need for modifications in machines and process devices
- in developing working methods
- in developing auxiliary devices
- in preparing and completing working instructions
- in preparing safety instructions.

Restrictions

WSA is not applicable method, if the hazards of the whole plant are examined. Because of the nature of the search pattern the main search for hazards and their contributors focuses on the physical and human subsystems (Suokas & Rouhiainen 1984). WSA will cover only occasionally common hazards which are only indirectly connected with the work steps under study. The information subsystem is partly reviewed and the management subsystem completely excluded. An example of the hazards not systematically included in WSA is the potential for contact with chemicals or an explosion in the proximity of the process part under study, but not operated in the task under analysis.

The main problem in WSA is to identify potentials of wrong working methods and extraneous human acts. This demands carefulness and a good imagination faculty of the analyst. The analysis may concentrate on search for hazards existing in system operation or maintenance. Installation and trial run of new equipments, or hazards in adapting a new system are often left out of the analysis.

The hazards in a production system caused by complicated sequences of events will not be systematically covered by the WSA. The hazards caused by process disturbances, failures and operator errors will not be gone over systematically, either.

Alternative methods

Tasks of too narrow an area are not applicable to the object of WSA, even if they can be defined exactly enough. Starting a pump, tightening a screw and opening a valve are examples of such tasks. Sometimes wrong performance of such a step may cause remarkable hazards. In consideration of the operating and controlling tasks of a technical system, involving no immediate hazards, a better method is human error analysis, for example.

If the work under surveillance is joined to a process system, the hazards caused by the process can be identified by HAZOP.

Instead of WSA accident statistics can be used, if appropriate statistics can be found. Accident reports can also be used for completing the results of WSA. If the object is very simple, checklists give results with noticeable lesser amount of resources.

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MANAGEMENT OF ACCIDENTAL RELEASES IN PULP PLANT

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Accidental chemical releases often become public, and thus can cause very negative impacts for a pulp plant. They can only be prevented by identifying hazards, after which, the technical measures and necessary procedures can be developed for managing risks caused by such potential accidental releases. In this article a procedure is described for identifying, analysing and managing accidental releases.

Environmental impacts caused by a process plant can be divided into continuous process emissions and accidental releases. **Continuous process emissions** occur when the plant is operating and they may spread to air, water, or to the soil. **Accidental releases** are usually sudden (although small releases can continue for long times and have similar effects), and they may be caused e.g. by failures or process disturbances.

Requirements for protection of the environment have forced the industry to develop technology to manage the effects of continuous process emissions. Now, many acute and heavy environmental impacts originate in industrial accidents and similar accidental releases. In many fields of industry the importance of continuous releases has therefore decreased, and the accidental releases play the more important role. In pulp plant, the role of the accidental releases is emphasized by the fact that one major release can destroy the micro-organism of the sewage treatment system. This interrupts the operation of the treatment plant - and thus the whole plant - for several weeks. A research project has been carried out to develop a procedure for eliminating accidental chemical releases in pulp plant.

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PROCESS FOR MANAGING ACCIDENTAL RELEASES

According to the draft for IEC standard titled "Requirements and guidelines for analysis of technological risks" (Anon. 1991) risk analysis and risk assessment are important elements of the **risk management process. Risk analysis** generally contains the following steps: scope definition; hazard identification; and risk estimation.

In this context **release hazard** can be defined to mean a condition with the potential for causing an accidental release (cf. Anon. 1991). It should be noted that there is a difference between the terms hazard and risk. According to (Anon. 1991) **release risk** can be defined to be a measure of the likelihood of a specified accidental release and its consequences. **Risk estimation** means, in this context, the process used to produce a measure of the level of environmental risks being analyzed. In **risk assessment**, value judgements enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and a range of alternatives identified for managing the risks, in order to consider whether or not the proposed choice as a whole is acceptable.

A procedure has been developed for managing accidental chemical releases (Figure 1). It begins with the definition of the object and collection of the information needed in different phases of the procedure. Perhaps the most important phase is the identification of the release hazards. In the next step the selected hazards are analyzed by identifying their causes and contributory factors, and by estimating their consequences. For assessing the magnitude of risks the effects of potential releases to the environment and to the sewage treatment plant are evaluated. The last phase includes the implementation of the remedies developed during the procedure.

INFORMATION NEEDED CONCERNING THE PROCESS SYSTEM

As a preliminary, the following information needed in the identification of potential releases should be collected:

- plant layout
- diagrams describing the main characteristics of the process being studied
- descriptions of the releases and disturbances which have previously occurred in the plant.

PID's are usually needed only for resolving uncertainties in the process system. RRA requires good knowledge of the analysis object and its operation. When analyzing existing plants, the information requirements are met mainly by choosing people for the analysis teams who have good operating experience.

After that the potential releases have been identified and their magnitude estimated, their effects should be assessed and their management can be planned. For this, the following information is needed:

- vessels and their shielding pool
- process diagrams
- sewerage system (both rain water and waste water)
- chemicals applied
- sewage treatment plant
- current state of the plant operations, including, e.g. amounts of waste water of each department, sewage treatment plant, control of waste water, flow of information, maintenance, readiness to operation in disturbances.

All this information should be collected at the beginning of the analysis, since it may also support the hazard identification phase.

IDENTIFICATION OF POTENTIAL RELEASES

The identification and analysis of potential accidental releases is made by using the **Release Risk Analysis** (RRA) method. RRA is based on a method usually known as potential problem analysis (PPA) (Reunanen & Rouhiainen 1987). Figure 2 presents the main phases of RRA. The method aims to obtain a general view of the release hazards and their contributors to a plant and its operations.

Organization of the analysis

RRA is carried out by teams whose members have good knowledge, expertise and experience of the plant and its operations. The scope of each team should be selected so that it covers one restricted part of the plant. The basic element in each phase is the application of a formal method to generate ideas.

For the work to be effective, the teams should be small, i.e. three to four persons plus one person leading the work. Members from plant operation as well as from maintenance should be included in the teams. For example, the following persons should be included in each team in the hazard identification phase:

- plant operator
- shift foreman
- department supervisor
- department engineer.

Once the analysis begins, the teams should meet one or two times every week, for no more than 3-4 hours per session, until the analysis is completed. In the second phase of the analysis, when analysing selected release potentials and estimating consequences, the teams should be supplemented by a person familiar with the sewage treatment system of the plant.

Identification of the potential releases

The teams usually identify potential accidental releases in the following three phases (Figure 2):

- application of silent brainstorming
- application of brainstorming and key words concerning extreme situations
- application of brainstorming and systematically following the process.

It is proposed that in **the first phase** the identification of potential releases begins with silent brainstorming. It means that each team member is given a piece of paper and has about five minutes to write down at least three significant release hazards. After this, each member is asked to pass his paper to the person next to him, and who should add another three potential releases to the paper. This procedure is then repeated until the members of the team are no longer able to produce ideas. General key words can be used to stimulate ideas. The aim is to quickly collect the release hazards each member knows through his or her own experience and regards as significant. It is also possible that the members will be stimulated by each other's ideas, leading to the identification of new release potentials.

In **the second phase** of hazard identification, the search for ideas is stimulated and systematized by specific key words or sets of key words, which the team leader gives set by set. The team can now discuss the aspects revealed. The key words used should direct the discussion from general aspects to more specific ones. The team members should be encouraged to pay special attention to major releases involving serious consequences. The output of the first and second phases is a summary containing the potential releases that have been identified. They may be mapped, e.g. according to their point of existence or material concerned.

In **the third phase** of the problem identification, the brainstorming proceeds systematically according to the process material flow. Rough diagrams of the operation principles of the whole plant and corresponding diagrams of the most important subsystems and equipment may be used as a support. As each subsystem is examined, the mapping of release potentials may be continued where the first and second phase left off. This is easily checked because of the structure of the summary of the first two phases.

ANALYSIS OF RELEASE POTENTIALS

The evaluation process of RRA begins by rejecting release hazards which do not need further consideration. This is done by ranking the hazards into the following categories:

A. Risk significant - release potential should be analyzed in more detail
B. Risk significant - release potential, however, does not need more detailed analysis
C. Risk not significant - probability is negligible
D. Risk not significant - consequences negligible.

Release hazards ranked into the second group are usually "old" problems, which are already taken care of, or "wild" ideas and "problems of eternal nature" which cannot be positively influenced by reasonable measures.

The analysis of the hazards includes the identification of factors contributing to the hazards selected in as much detail as possible, estimating their consequences and ranking the risks according to their relative magnitudes.The more carefully the contributors of a selected hazard are examined, the more fruitful is the last activity of RRA, i.e. identification of preventive and contingent actions. When the contributors are identified in detail, it is often possible to find effective and economic measures for avoiding potential releases. The results of RRA are recorded on an analysis form, according to Figure 3.

The ranking of analyzed release potentials is made by estimating the probability (P) and consequences (C) of each release potential. The estimation can be carried out by using the scales presented in the Figure 4. In addition to this, the team should present an estimate for the amount of released chemical e.g. in tons, cubic metres, etc.

The ranking process described and the analysis of the hazards selected, together provide a view of the plant's most significant release risks and vulnerable areas. The most important areas of vulnerability may be examined in more detail by applying some other methods, e.g. hazard and operability study, failure mode and effect analysis, or action error analysis.

ASSESSMENT OF THE EFFECTS OF POTENTIAL RELEASES

In the last phase of the procedure developed, the effects of the most significant release potentials and the importance of the risks can be assessed. For doing this the effects of the releases in sewage treatment plant should be known. Therefore, a new team should be selected from persons who worked in the previous teams and from the plant management. The team should have the best possible knowledge of the sewage treatment system of the plant, as well as of the effects of different chemicals on the sewage treatment system and on the environment.

The team reviews the reports of the previous teams, which carried out the RRA, i.e. the identification of release hazards and their evaluation. The main emphasis is on the most significant release possibilities selected by the leader of the analysis and on the extreme release potentials seen as significant by any member of the team.

The aim of the work of this team is to:

- evaluate the current state of the sewage treatment plant and evaluate, how the control of the sewage treatment plant could be improved
- evaluate the current state of the management of accidental releases and evaluate which kind of releases cannot be managed well enough
- assess the effects of the most significant potential releases on the operation of the sewage treatment plant and on the environment
- make decisions concerning proposals for procedures and mitigation principles.

MANAGEMENT OF ACCIDENTAL RELEASES

The management of accidental releases begins with the management of the production process. The evaluation of the preventive maintenance is included as an essential element to the evaluation of the process control. The sewerage system affects the possibilities to control accidental releases and should include the ability to return released chemical back to the process or to conduct it into a buffer system. Control and alarm systems and procedures also have an important role. They should detect any release as early as possible and give appropriate information to the persons responsible for the operation of the plant and of the sewage treatment plant. This means that the ability of the organization to manage these kinds of disturbances should also be evaluated.

The ability of the biological sewage treatment plant to treat accidental releases varies greatly, depending on the load of the plant as well as on the internal condition of the plant and its adaptability to changing loads. If possible, the capacity of the treatment plant in different situations should be evaluated and means to improve the control in such situations should be identified. The evaluation can be based on the current loading, it's changes and experiences on effects of the changes on the operation of the sewage treatment system.

EXPERIENCES OBTAINED FROM THE PROCEDURE

The methodology has been tested on two pulp plants. In **the first experiment** the research organization took the main responsibility and researchers worked as the team leaders. The release risk analysis was made in four teams. Their scopes were the following: digester system; bleaching plant; soda recovery boiler and power plant; and chemical system and sewage treatment plant. Each team used three meetings of 3-4 hours for hazard identification and two meetings of 3-5 hours for evaluation of the hazards. There was no "higher level" team for evaluating the significance of the risks and for assessing the management of the risks identified.

The test experiment revealed a remarkable number (about 350) of release possibilities, of which the majority were previously unidentified. However, there were problems in the estimation of the effects of releases potentials and in the assessment of the significance of risks. These problems were mainly caused by two reasons: the teams had not enough knowledge concerning the hazardousness of the chemicals and the sewage treatment plant; and there was no "higher level" team for assessing the most significant risks. Therefore it was also difficult to form a general view of the most significant risks in the whole plant. This emphasizes the importance of expertise on the effects of different kind of chemicals and on the treatment of released chemicals. If such knowledge is not available "in plant", the services of an outside consultant should be used.

In **the second experiment** personnel from the plant itself carried out the procedure and the researchers had a consultative role, i.e. they taught the method and gave support when needed. The release risk analysis was made by three teams. Their scopes were the following: digester system and bleaching plant; power plant; chemical system and sewage treatment plant. Each team used only two meetings of about 4 hours for hazard identification. The second meeting (cf. Figure 2) was replaced by individual analyses. Each team evaluated the most significant risks in one meeting of four hours. In this meeting each group was supplemented by a person familiar with the sewage treatment plant. The less significant risks were left to be evaluated later by the department. The most significant risks concerning the whole pulp plant were evaluated in a team selected from persons who worked in the previous teams and from the plant management.

In this test experiment about the same number of release potentials was identified, although the teams used only two meeting for hazard identification. However, this plant was older than in the first experiment and therefore it was perhaps easier to identify release hazards. It could also be noticed that most of the mapped release potentials, or their causes, had occurred in the history of the plant. Due to the "upper level" team it was easier to form a general view on the most significant risks of the whole plant.

CONCLUSIONS

The developed procedure for eliminating the accidental releases of pulp plant has been tested with positive results. Release risk analysis is based on the conviction that one can look into the future, see what it may hold, and then return to the present to take action when it can do the most good (cf. Kepner & Tregoe 1981).

The approach used does not purposely exclude the identification of any safety-related problem type. It is hard to evaluate how good RRA is in identifying "everything". At least RRA applies a much wider perspective to problem identification than the identification methods (e.g. HAZOP or failure mode and effect analysis) commonly used in safety and risk analysis.

In practice, the wide perspective applied to problem identification also restricts the depth of the results. RRA does not reveal, e.g. complicated process-related release potentials at the same level of detail as a HAZOP analysis does. As already mentioned, RRA is suitable for the identification of areas of vulnerability and the most important release risks.

In many cases, the lack of information on the properties and effects of the chemicals in different situations is likely to cause problems in assessing the effects of the potential releases. Therefore the estimation often has to be based on the plant's own experiences, i.e. incident data from releases which have previously occurred and on expert opinions.

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Figures

Figure 1. Phases of the procedure for managing risks caused by accidental chemical releases.

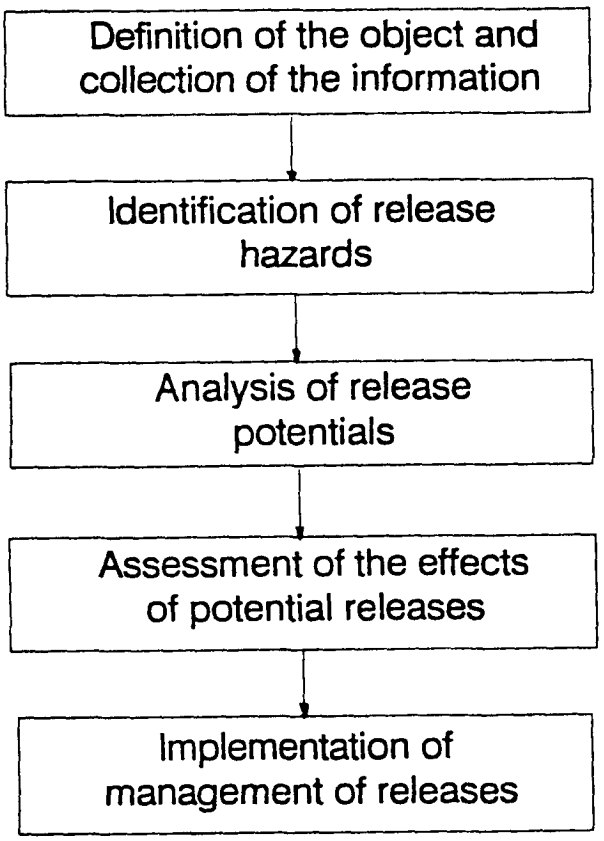

Figure 2. Main phases of the release risk analysis (RRA).

A. IDENTIFICATION OF POTENTIAL RELEASES

Phase 1
- Searching for ideas (potential releases) by applying silent brainstorming technique
- Application of key words concerning general latent failures and omissions

Phase 2
- Searching for ideas by applying brainstorming and discussion
- Application of key words concerning extreme situations; activities; structures; natural effects; concentrations; etc.

Phase 3
- Searching for ideas by applying brainstorming and proceeding systematically according to the process of the plant under study
- Application of key words concerning extreme subsystems; materials; operating procedures; causes of disturbances; etc.

B. EVALUATION OF THE IDENTIFIED RELEASE POTENTIALS

Phase 1
- Selecting the release potentials to be evaluated

Phase 2
- Identification of the contributors and consequences of the selected releases
- Ranking of the release potentials by estimating their probability and consequences

C. IDENTIFICATION OF PREVENTIVE AND CONTINGENT ACTIONS

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RELEASE RISK ANALYSIS

Object
Department
System

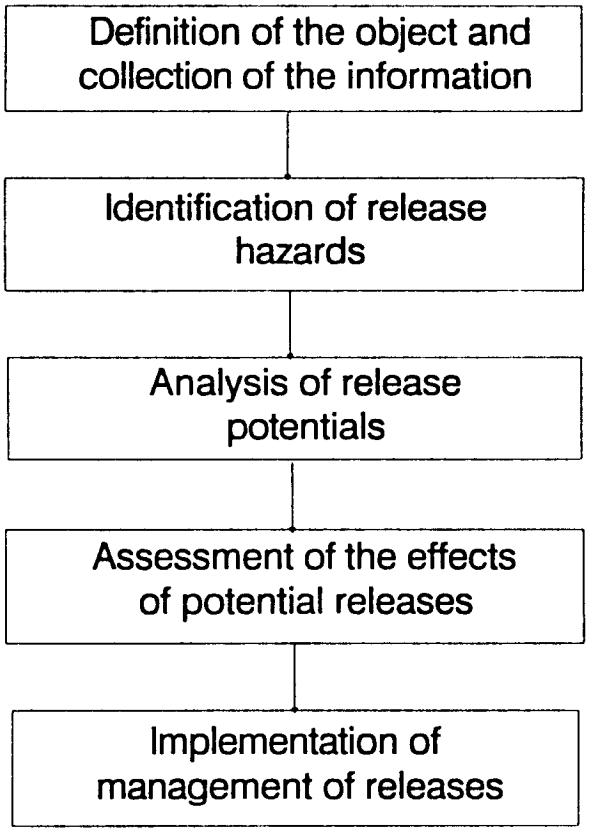
Page
Date
Team

Potential release and its causes	Consequences of the release	Detection of the release	P	C	Remedial measures

Figure 3. An example of the analysis form used in RRA.

Figure 4. The scales used when estimating the probability and consequence of each release potential.

Probability of the release (P)	**Consequence (magnitude) of the release (C)**
1. Very improbable - less frequently than once in ten years	1. Insignificant release - harm only at the point of existence
2. Improbable - less frequently than once in a year	2. Minor release - harm in the plant area or increase in the load of the sewage treatment plant
3. Possible - yearly	3. Moderate release - minor harm to the environment or problems in the sewage treatment plant
4. Probably - monthly	4. Significant release - harm to the environment
5. Very probably - weekly	5. Serious release - serious harm to the environment or interruption of the operation of the sewage treatment plant


Definition of the object and collection of the information
Identification of release hazards
Analysis of release potentials
Assessment of the effects of potential releases
Implementation of management of releases

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RELEASE RISK ANALYSIS

Object
Department
System

Page
Date
Team

Potential release and its causes	Consequences of the release	Detection of the release	P	C	Remedial measures

TECHNICAL RESEARCH CENTRE OF FINLAND
(V T T)

Laboratory of Electrical Engineering
and Automation Technology

Helena Mälkki

FAILURE MODE AND EFFECTS ANALYSIS, EFFECT OF MAINTENANCE ON SYSTEMS SAFETY, MAINTENANCE EFFECTS ANALYSIS AND LIFE CYCLE COST ANALYSIS

PROGRAMME

RELIABILITY

ROLE OF AVAILABILITY

DEFINITIONS OF MAINTENANCE TIME

CONCEPTS OF AVAILABILITY

MANUFACTURER AND USER CONTROLLED PARAMETERS

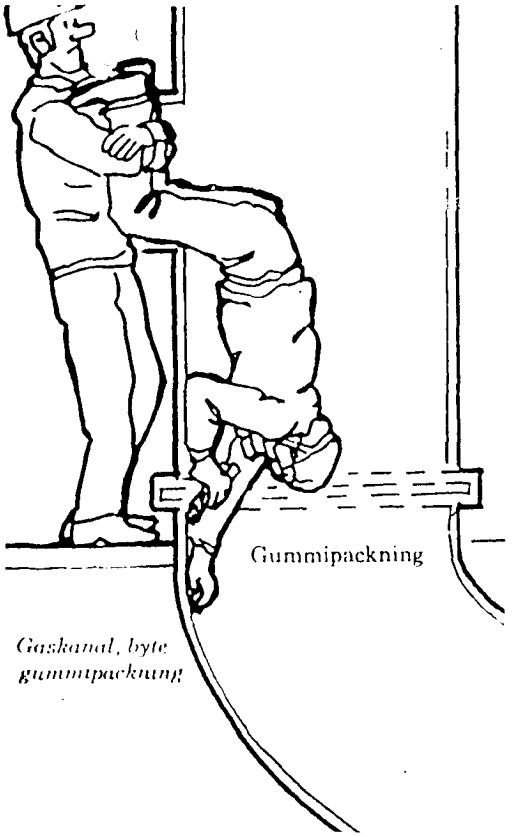
PROCEDURE OF AVAILABILITY ANALYSIS

METHODS OF AVAILABILITY ANALYSIS

LCC - ANALYSIS

ACTIVITIES FOR LIFE CYCLE COSTING

PILOT CASE



RELIABILITY

ABILITY TO DO WHAT IS EXPECTED OR REQUIRED.

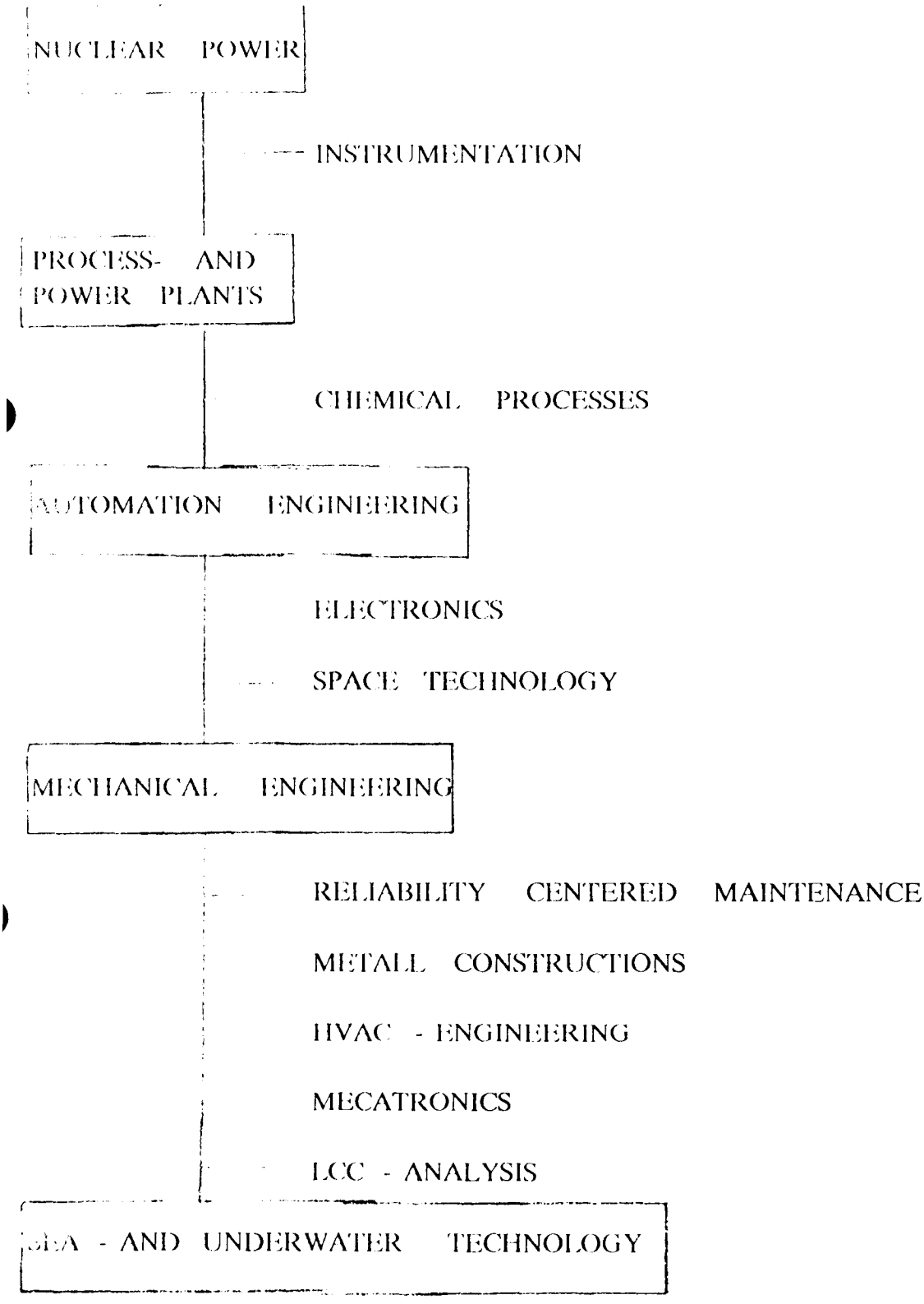
"THE ABILITY OF AN ITEM TO PERFORM A REQUIRED FUNCTION UNDER STATED CONDITIONS FOR A GIVEN TIME INTERVAL"

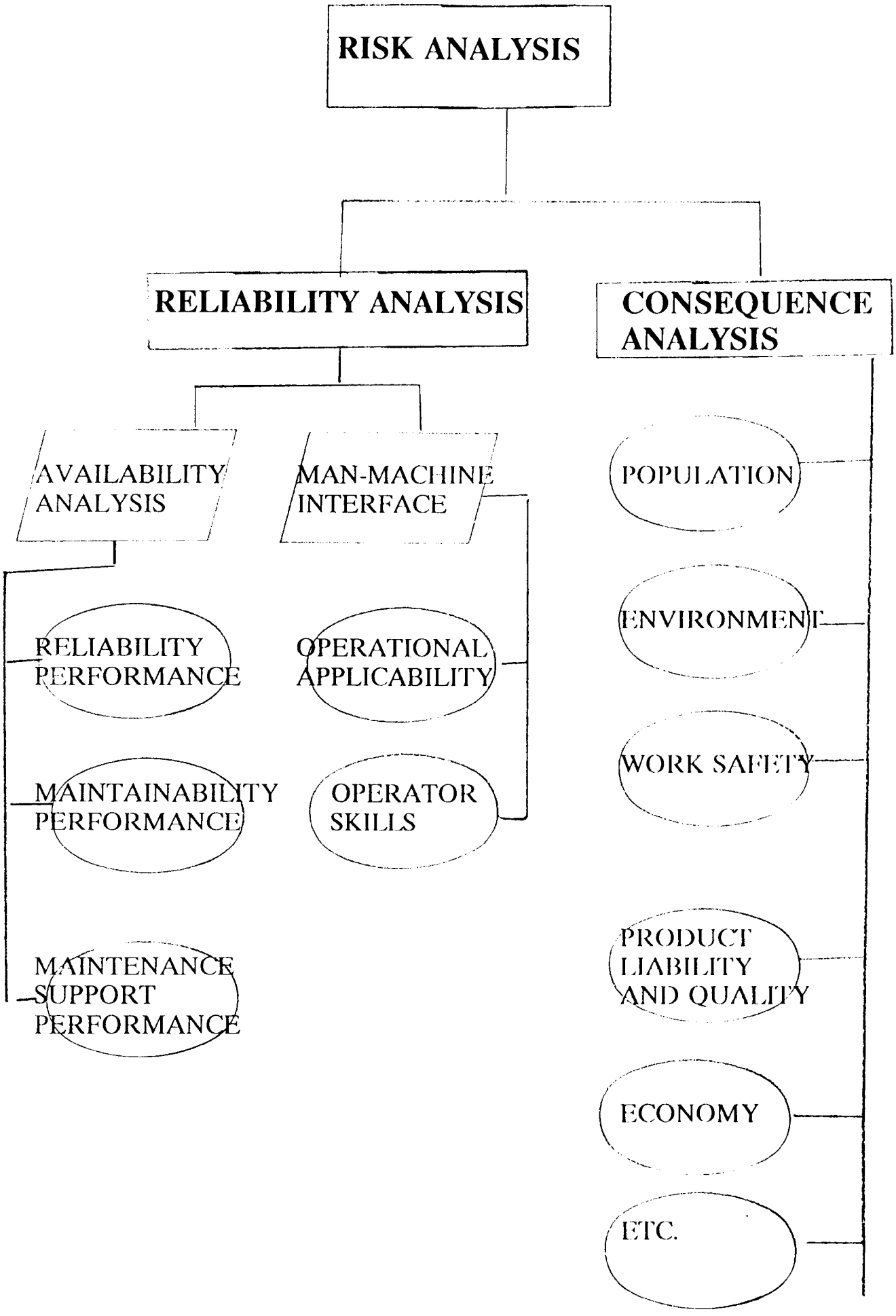
RELIABILITY ENGINEERING

MAKE MAINTENANCE MORE EFFECTIVE BY MEANS OF AVAILABILITY AND SAFETY MANAGEMENT.

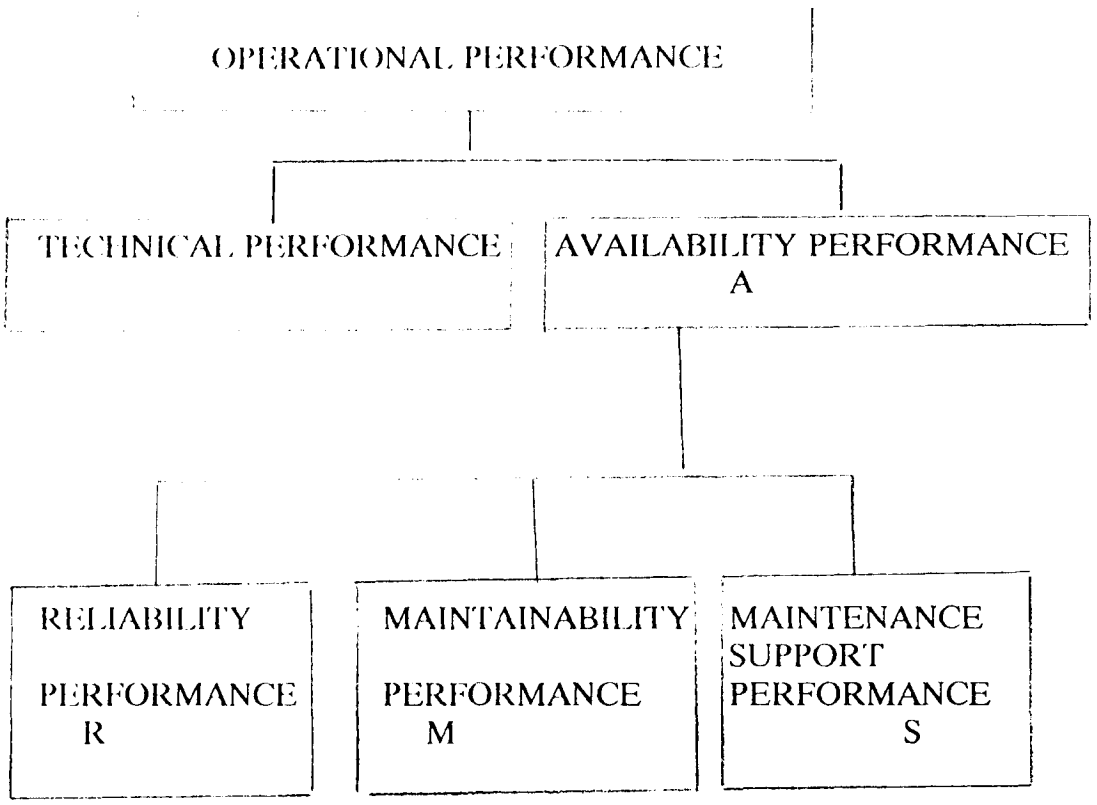
- INCREASE AVAILABILITY PERFORMANCE
- INCREASE SAFETY
- MORE EFFECTIVE MAINTENANCE
- HELP IN DECISION MAKING

RELIABILITY ENGINEERING




RISK ANALYSIS
RELIABILITY ANALYSIS
CONSEQUENCE ANALYSIS
AVAILABILITY ANALYSIS
MAN-MACHINE INTERFACE
RELIABILITY PERFORMANCE
MAINTAINABILITY PERFORMANCE
MAINTENANCE SUPPORT PERFORMANCE
OPERATIONAL APPLICABILITY
OPERATOR SKILLS
POPULATION
ENVIRONMENT
WORK SAFETY
PRODUCT LIABILITY AND QUALITY
ECONOMY
ETC.

AVAILABILITY OF TECHNICAL EQUIPMENT



AVAILABILITY PERFORMANCE

THE ABILITY OF AN ITEM TO BE IN A STATE TO PERFORM A REQUIRED FUNCTION UNDER GIVEN CONDITIONS AT A GIVEN INSTANT OF TIME OR OVER A GIVEN TIME INTERVAL, ASSUMING THAT THE REQUIRED EXTERNAL RESOURCES ARE PROVIDED

Reference number: INTERNATIONAL STANDARD CEI/IEC 50(191): 1990
International Electrotechnical Vocabulary,
Chapter 191: Dependability and quality of service.

AVAILABILITY

$$A = \frac{\text{REAL OPERATION HOURS}}{\text{PLANNED OPERATION HOURS}}$$

OR

$$A = \frac{\text{OPERATING TIME}}{\text{OPERATING TIME + FAULTY TIME}}$$

$$A = 1 - \overline{A}$$

EXAMPLE: The operating time of system is 8000 h/year and due to repairs, it has been unavailable 500 h/year.

AVAILABILITY A = (8000 - 500)/8000 = 93.75%

UNAVAILABILITY $\overline{A}$ = 500/8000 = 6.25%

AVAILABILITY $A = f(R, M, S, O)$, where

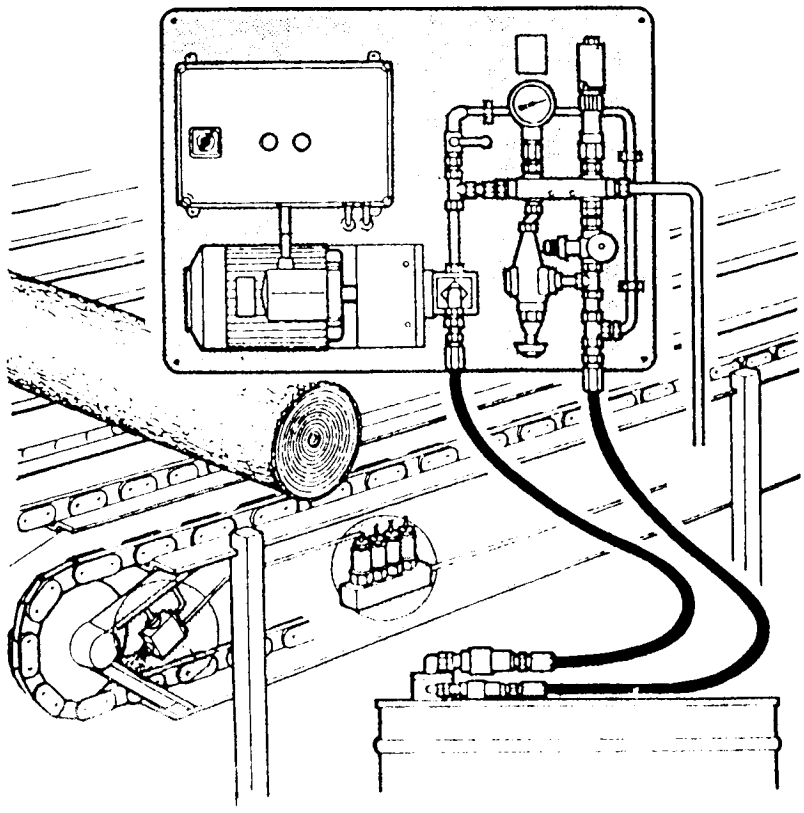
O = OPERATOR SKILLS

RELIABILITY PERFORMANCE

THE ABILITY OF AN ITEM TO PERFORM A REQUIRED FUNCTION UNDER GIVEN CONDITIONS FOR A GIVEN TIME INTERVAL.

PARAMETERS:
e.g.

- cumulative number of failures N
- failure intensity z(t) or failure rate λ
- mean time to failure MTTF = 1/z(constant)
- mean time between failures MTBF = MTTF + repair time
- survival probability R(t) and
  failure probability F(t), F = 1 - R



RELIABILITY ENGINEERING

High reliability performance is obtained by design techniques to either prevent failures from occuring (fault avoidance) or eliminating their effects (fault tolerance).

Tasks e.g.

- application of fault tolerance and fail-safe techniques
- application of design procedures
- elimination of critical single point fault modes
- reduction of stresses applied to individual parts and components
- reduction of effects on design performance from parameter variation
- limitation of use of technology with unproven reliability performance
- definition of methods to reduce sensitivity to manufacturing processes

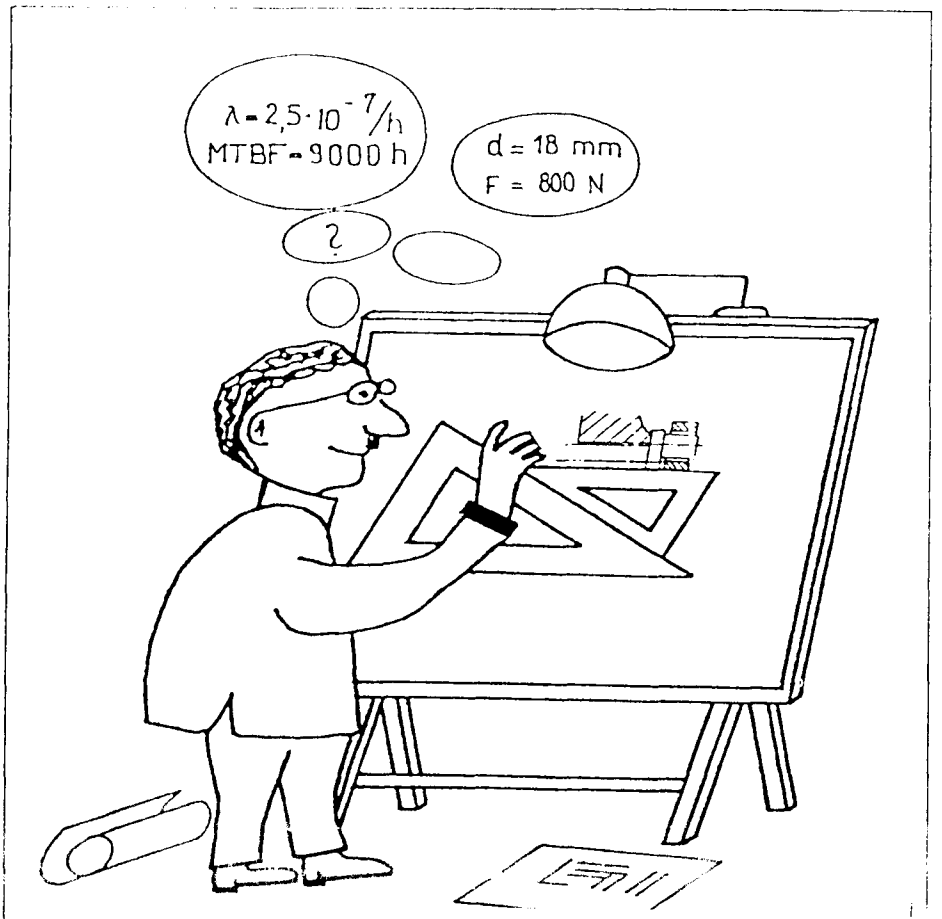


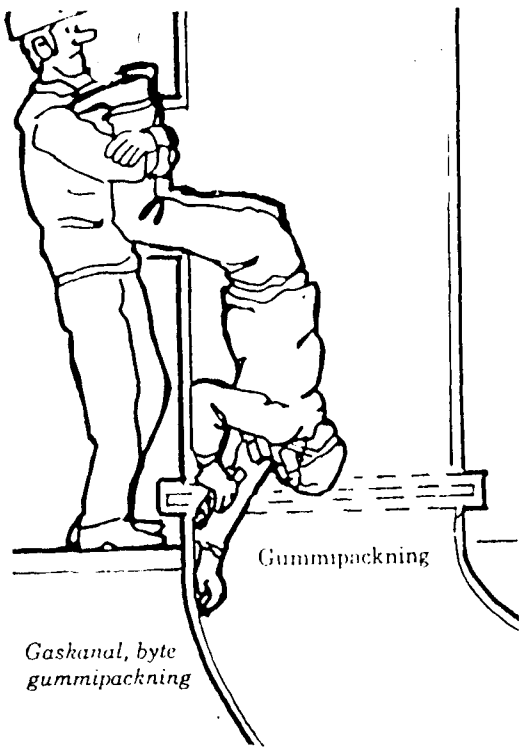
Figure 1. Information problem of a designer

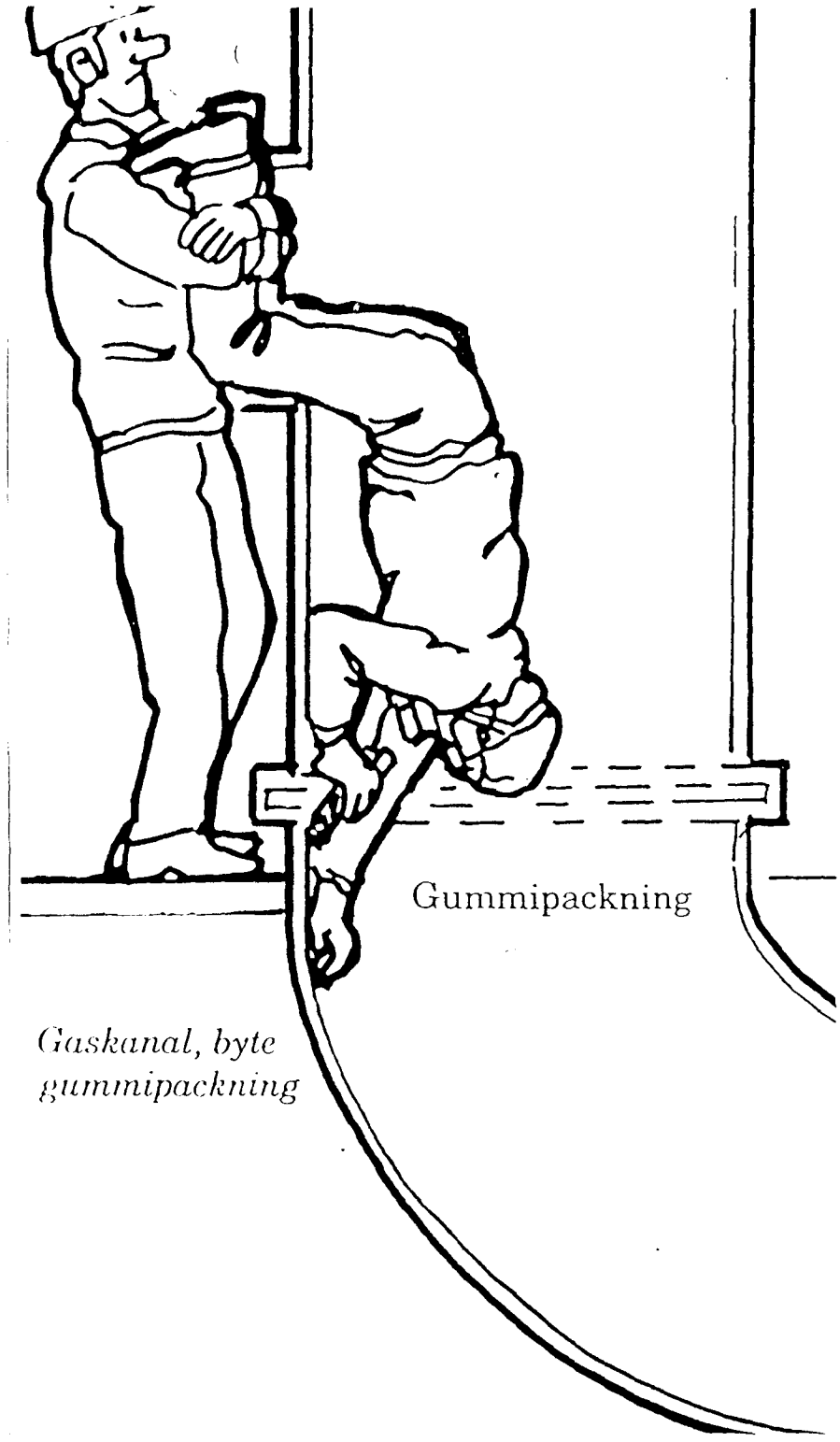
MAINTAINABILITY PERFORMANCE

THE ABILITY OF AN ITEM UNDER GIVEN CONDITIONS OF USE, TO BE RETAINED IN, OR RESTORED TO, A STATE IN WHICH IT CAN PERFORM A REQUIRED FUNCTION, WHEN MAINTENANCE IS PERFORMED UNDER GIVEN CONDITIONS AND USING STATED PROCEDURES AND RECOURCES.

PARAMETERS:
e.g.

- active maintenance time
- repair rate r(t)
- mean time to recovery MTTR
- mean down time MDT
- mean maintenance man-hours
- costs of maintenance





Maintainability design would have facilitated the replacement of the sealing outside the channel

MAINTAINABILITY ENGINEERING

High maintainability performance may be obtained if the product is easy to maintain and repair, and allows application of automatic maintenance techniques (e.g. automatic restarts at software failures).

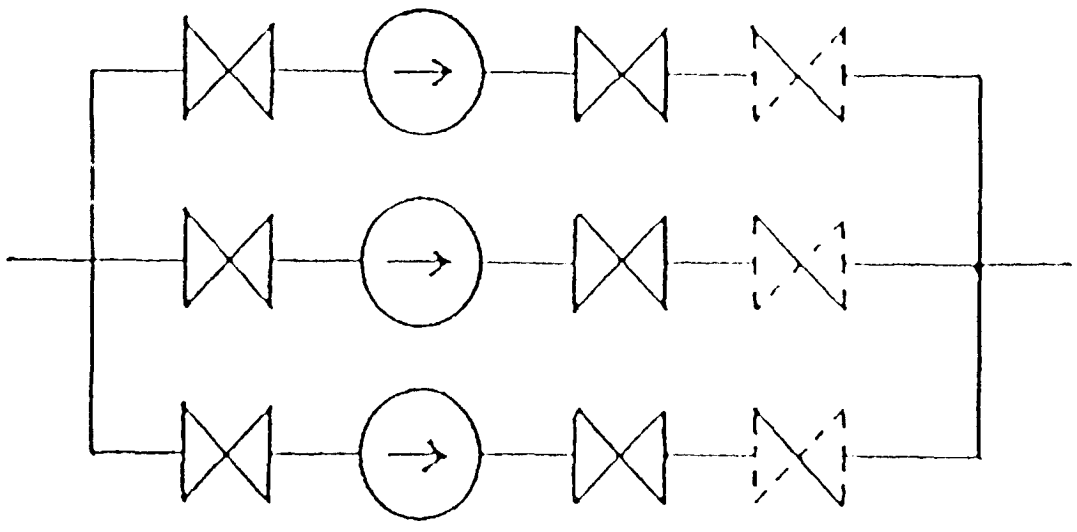
Tasks e.g.:

- reduce the complexity of maintenance
- reduce the frequency of preventive maintenance activities
- reduce product specific parts of down time
- reduce maintenance support costs
- reduce maintenance personnel skill requirements by the application of human engineering principles
- reduce the potential for maintenance mistakes

Maintenance policy, e.g.:

- fault detection and fault isolation principles
- intended levels of maintenance
- intended lines of maintenance

IEC 300 (TC56)



3 x 50 %

Figure. Complementary closing valves should be added to the high pressure side of the pumps to facilitate their safe maintenance without interruption of water feeding

MAINTENANCE SUPPORT PERFORMANCE

THE ABILITY OF A MAINTENANCE ORGANIZATION, UNDER GIVEN CONDITIONS, TO PROVIDE UPON DEMAND, THE RECOURCES REQUIRED TO MAINTAIN AN ITEM, UNDER A GIVEN MAINTENACE POLICY.

PARAMETERS:
e.g.

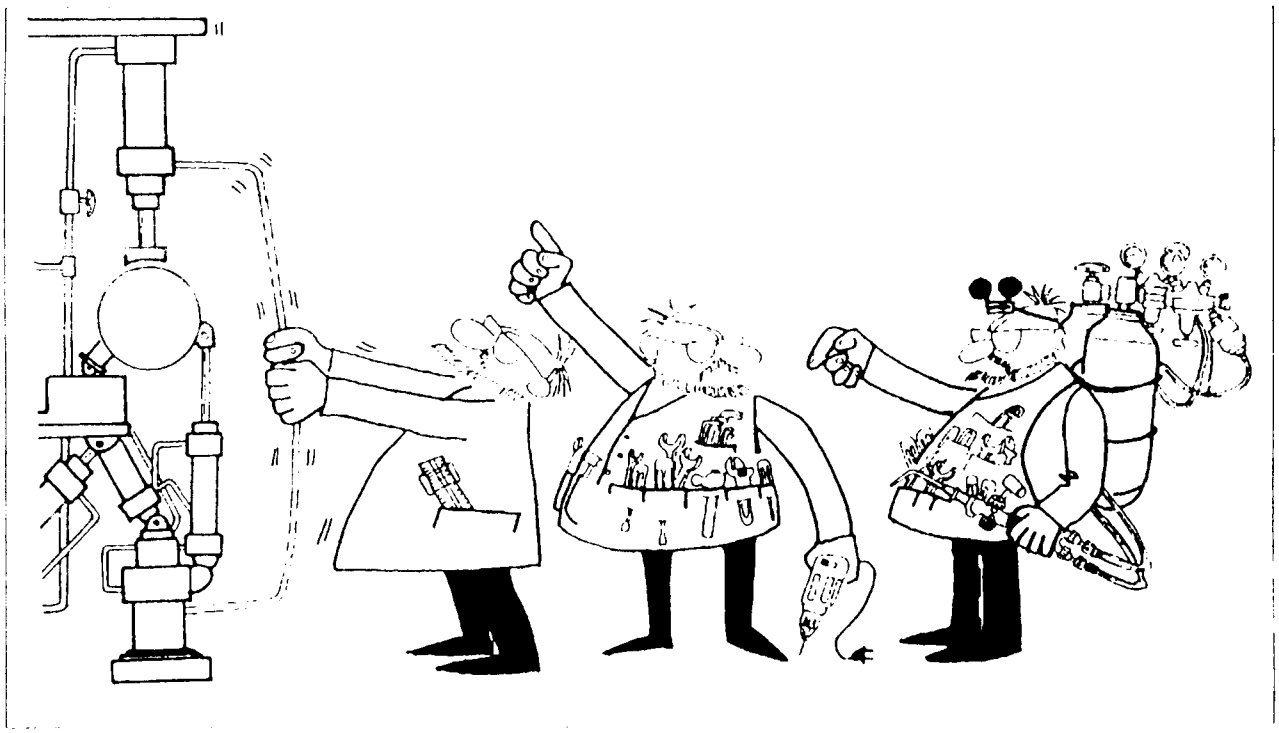
- logistic delay of maintenance
- administrative delay
- external disabled time

MAINTENANCE SUPPORT ENGINEERING

Maintenance support is required during the installation and the operation and maintenance phase and requires resources and a policy. In addition to definition of a maintenance policy, the procedures, tools, documentation and other facilities required to support that policy, training programmes for maintenance personnel, etc.

MAINTENANCE SUPPORT PLANNING

- specification of the product's indenture levels, and the levels of of maintenance and lines of maintenance to be used, optimization of spares provisioning.
- specification of personnel skills, maintenace tools and equipment, optimization of scheduling of maintenance forces.
- specification of the support period for the whole and parts of the product.



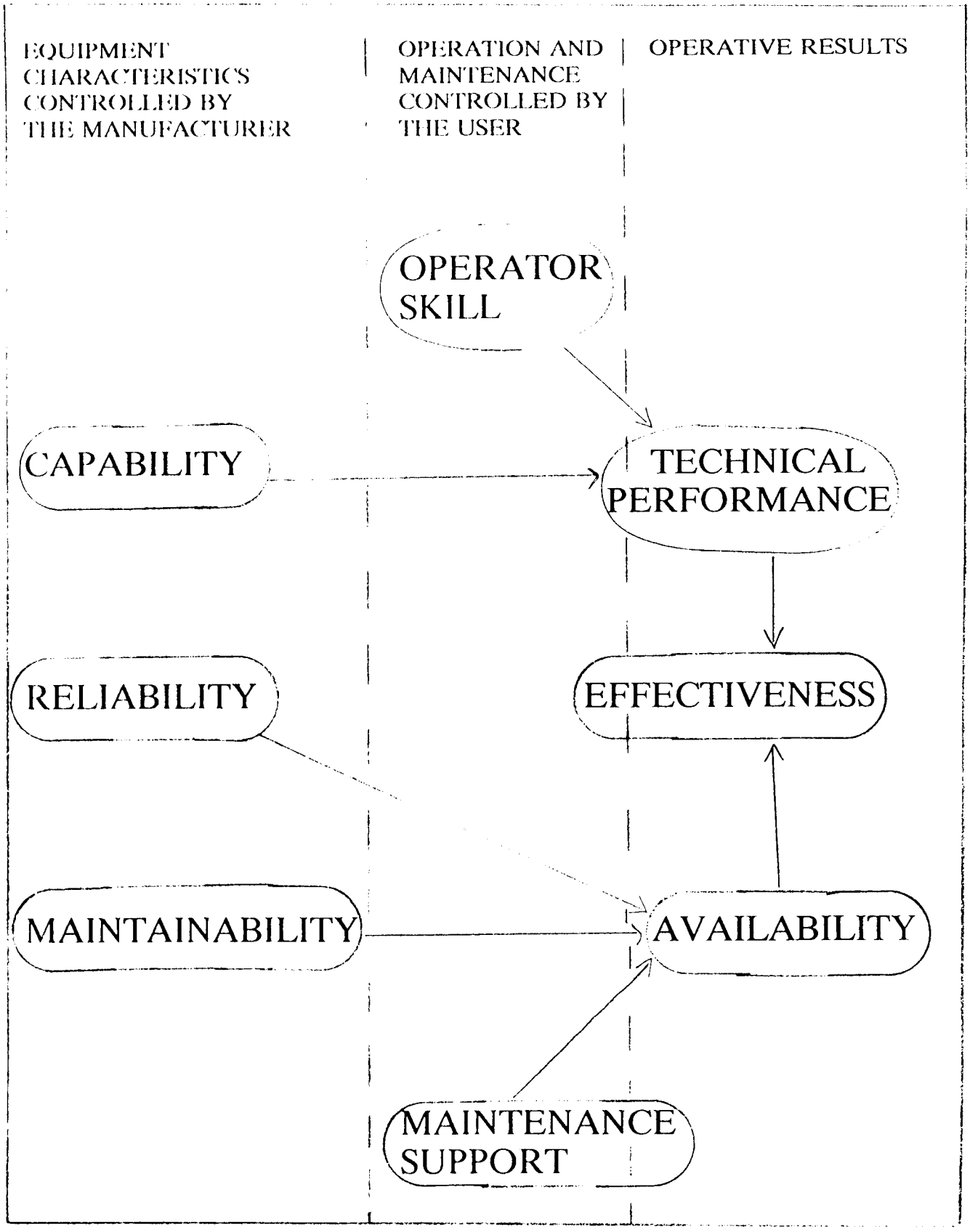


Figure. Manufacturer and user controlled parameters.

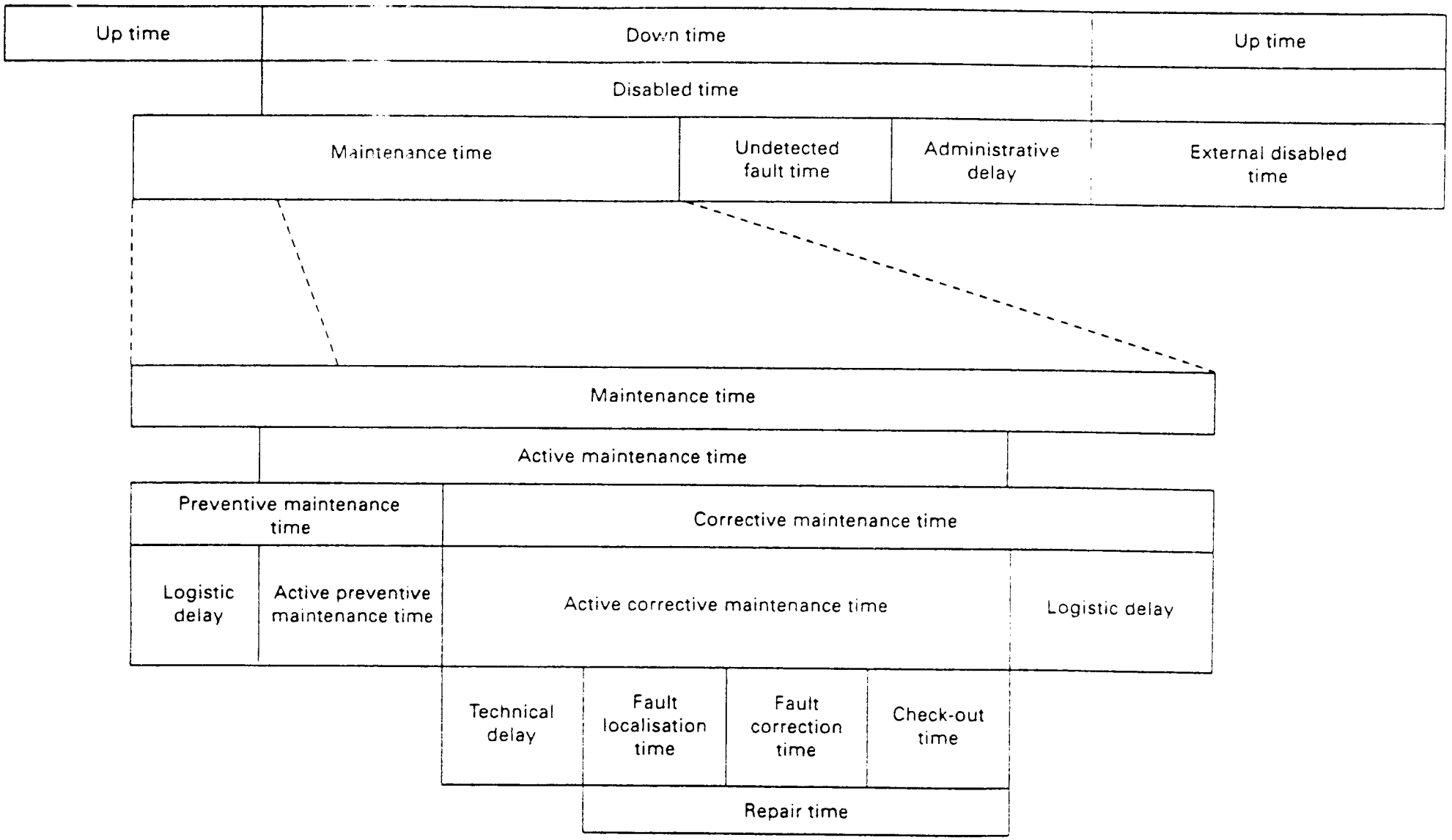


Figure 191-10 - Maintenance time diagram

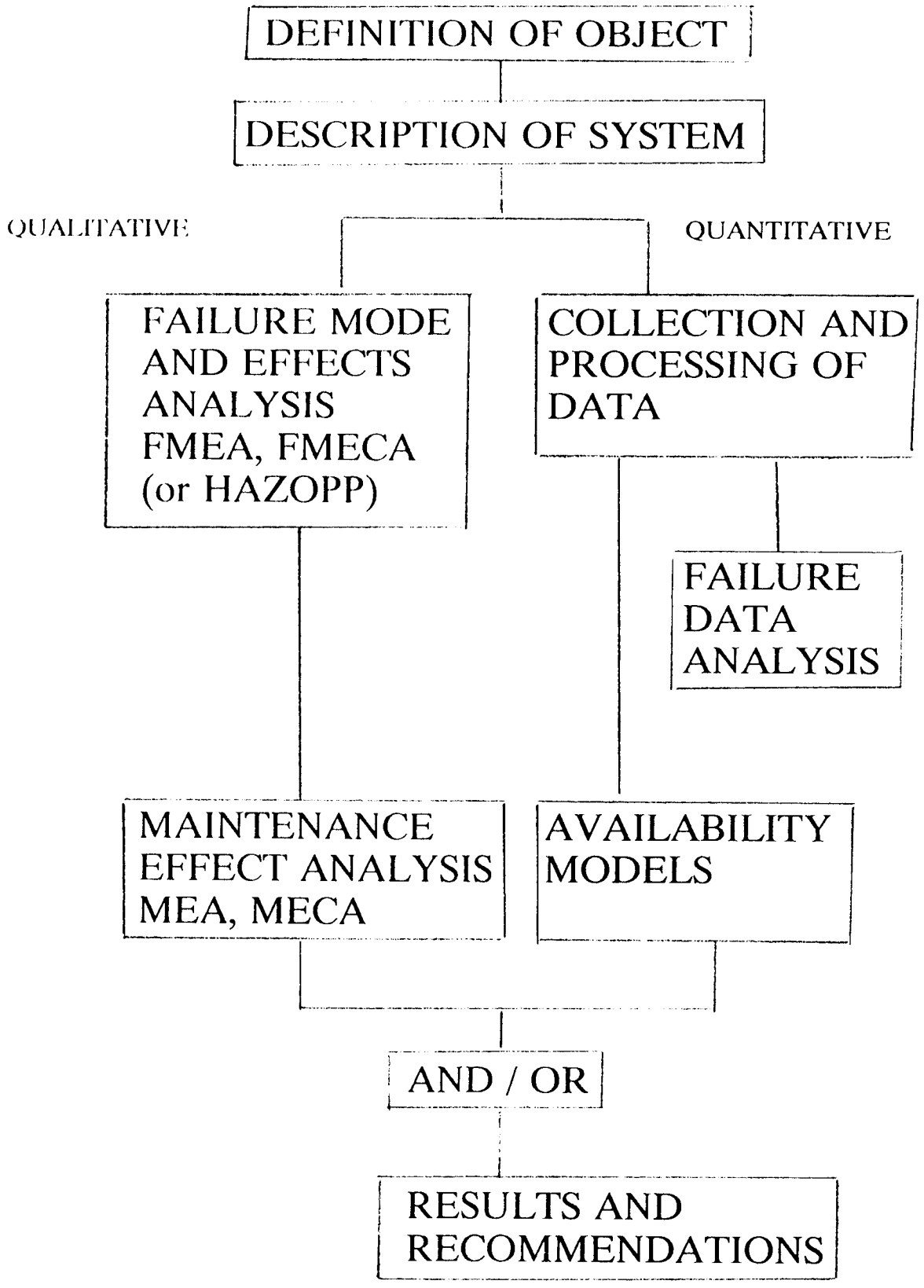


Figure. Example of availability analysis procedure.

AVAILABILITY ANALYSIS METHODS

IT IS IMPORTANT TO CHOOSE THE METHODS, WHICH SUIT TO THE CASE

METHODS SHOULD BE SIMPLE, EASY AND QUICKLY TO USE WITHOUT LONG RELIABILITY EDUCATION

QUALITATIVE METHODS

- FAILURE MODE AND EFFECTS ANALYSIS, FMEA
  FAILURE MODE AND EFFECTS AND CRITICALITY ANALYSIS, FMECA
- MAINTENANCE EFFECTS ANALYSIS, MEA
  MAINTENANCE EFFECTS AND CRITICALITY ANALYSIS, MECA
- HAZARD AND OPERABILITY STUDY

QUANTITATIVE METHODS

E.G.

- FAULT TREE ANALYSIS
- RELIABILITY BLOCK DIAGRAM METHODS
- LCC-MODELS

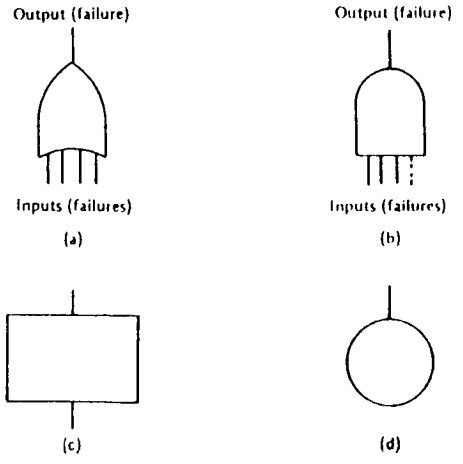


Figure 16.4 Fault tree technique symbols: (a) OR gate, (b) AND gate, (c) resultant event, (d) basic fault event

QUALITATIVE METHODS

- FAILURE MODE AND EFFECTS ANALYSIS, FMEA
  FAILURE MODE AND EFFECTS AND CRITICALITY ANALYSIS, FMECA

- MAINTENANCE EFFECTS ANALYSIS, MEA
  MAINTENANCE EFFECTS AND CRITICALITY ANALYSIS, MECA

- HAZARD AND OPERABILITY STUDY

METHODS HELP TO STUDY INDIVIDUALLY THE FAILURES, FAULTS, DISTURBANCES AND MAINTENANCE ETC. OF THE SYSTEM. THE SYSTEM IS SYSTEMATICALLY STUDIED AND IT GIVES THE BEST RESULTS IN THE FORM OF SET OF ACTIONS, DOCUMENTATIONS AND RECOMMENDATIONS.

CRITICALITY INFORMATION CONNECTED WITH QUALITATIVE ANALYSIS MAKES IT POSSIBLE TO ESTIMATE E.G. UNAVAILABILITY FACTORS AND COSTS.

Table 5. An example of hazard and operability study (Reunanen & Suokas 1986).

OCCUPATIONAL SAFETY ENGINEERING LABORATORY HAZARD AND OPERABILITY STUDY	SYSTEM BLACK LIQUOR RECOVERY BOILER PLANT SUBSYSTEM: EVAPORATION PLANT 1 UNIT: EVAPORATION UNIT 1 – STRONG LIQUOR TANK	PAGE: 8 DATE: 18.2.1982 DRAFTED BY: HAZOP TEAM	
DEVIATION	POTENTIAL CAUSES	CONSEQUENCES	ACTION REQUIRED
NO FLOW	LINE BLOCKAGE, VALVE ERRONEOUSLY CLOSED, PUMP FAILURE, FAILURE IN ELECTRICITY SUPPLY	15 OVERFILLING OF THE EVAPORATION UNIT 1	
HIGH FLOW	LEAKAGE OF THE PUMP WASH WATER LINE VALVE OR THE VALVE IS ERRONEOUSLY OPEN	16 DILUTION OF THE STRONG LIQUOR – ENTRY OF WATER INTO THE STRONG LIQUOR LINE	USING AS NEEDED MOUNTED HOSES INSTEAD OF FIXED WATER PIPE LINES
	VALVE V1 ERRONEOUSLY OPEN	17 DILUTION OF THE STRONG LIQUOR – ENTRY OF WEAK LIQUOR INTO THE STRONG LIQUOR LINE	REMOVING THE VALVE V1 AND INSERTING BLANKS
	LEAKAGE OF THE VALVES HV1 AND HV3	18 DILUTION OF THE STRONG LIQUOR – ENTRY OF INTERMEDIATE OR STRONG INTERMEDIATE LIQUOR INTO THE STRONG LIQUOR LINE	CHANGING THE VALVE TYPE OF HV1, HV3 AND HV4 INTO BALL VALVES
	LEAKAGE OF THE VALVE HV4 WHEN WASHING THE STRONG LIQUOR LINE		ALARM ON THE FALSE OPERATION OF THE VALVES
	FALSE OPERATION OF THE INTER-DEPENDENT AUTOMATIC VALVES HV1/HV4 AND HV3/HV4 WHEN WASHING THE STRONG LIQUOR LINE		

FMEA - INTRODUCTION

A SIMPLE DESIGN EVALUATION TECHNIQUE FOR SYSTEMATICALLY IDENTIFYING POTENTIAL FAILURES IN AN EQUIPMENT/SYSTEM DESIGN AND ANALYZING THE RESULTING EFFECTS ON THE PERFORMANCE OF THE EQUIPMENT/SYSTEM.

CLEARLY RELATES COMPONENT FAILURE MODES, THEIR CAUSATIVE FACTORS, AND EFFECTS ON THE EQUIPMENT/SYSTEM.

EFFECTIVELY IDENTIFIES THE MOST CRITICAL AREAS OF A DESIGN, NEEDED DESIGN IMPROVEMENTS OR OPERATIONAL MODIFICATIONS IN ORDER TO ACHIEVE THE REQUIRED EQUIPMENT/SYSTEM RELIABILITY PERFORMANCE.

MOSTLY QUALITATIVE, CAN BE QUANTIFIED.

PROVIDES INPUT TO OTHER DETAILED RELIABILITY ANALYSES SUCH AS FAULT TREE ANALYSIS.

DOES NOT REQUIRE SPECIAL SKILLS, CAN BE EASILY USED BY DESIGNERS (AND SHOULD BE!)

1	2	3	4	5	6	7	8	9	10	11	12
Identification of item	Function of item	Item failure mode	Phase (operational or mission)	Effects of failure on				Method used for failure detection	Corrective measure	Category of criticality	Remarks
				Subsystem	Total system	Associated personnel	Intended mission				
Failure Mode and Effects Analysis				By : ____ Date : ____ Page : ____				System : ____ Subsystem : ____ Drawing : ____			

Figure 16.2 Typical FMEA worksheet

FMEA - PROCEDURE

- DEFINE SCOPE
- DEFINE RESOLUTION, THE ROLE OF COMPONENTS FOR THE PURPOSE OF ANALYSIS
- IDENTIFY AND LIST ALL COMPONENTS
- ESTABLISH GROUND RULES/ASSUMPTIONS (E.G. COMPONENT FAILURES)
- DEVISE FMEA-WORKSHEET
- COMPLETE WORKSHEETS CONSIDERING RELEVANT COMPONENT FAILURE MODES
- IDENTIFY PROBLEM AREAS
- DOCUMENT THE ANALYSIS

TYPICAL FAILURE MODES

- FAILS TO OPEN
- FAILS TO CLOSE
- INTERNAL LEAKAGE
- EXTERNAL LEAKAGE
- RUPTURE
- PREMATURE OPERATION
- FAILURE TO OPERATE AT A PRESCRIBED TIME
- FAILURE TO CEASE OPERATION AT A PRESCRIBED TIME
- FAILURE DURING OPERATION

FMECA - FAILURE MODES, EFFECTS AND CRITICALITY -ANALYSIS

Project: KOTUREL

Object: SM - Trains/VR, DC-Battery systems

System: 1. Batteries

Author :VTT/HEM,VR

Inspected by:VTT/AYL,VR

Subsystem/ Device/Part	Failure mode and failure cause	Failure effects	Failure detection	Criticality Freq.	Criticality Class.	Suggestions of improveme and notes
1. BATTERIES						
1.1 Cells	1.1.1 Cracking Cause:Misuse, manufacturing failure	Alkaline leakage	In use: Dripping box In maintenance:Surface level	T0-T1	K4,E1	Caustic alkaline is corroding. Inside the box must be a vessel and then collection into transparent tank. When filling,alkaline can overflow,if broken cell.
	1.1.2 Overflow Cause:Filling error, boiling (high charging current)	Alkaline leakage, splashing	In maintenance and in filling situation	T1-T2	K4,E1	Overfilling must be prevented. Empty space must be left on the upper part of cell.
1.2 Electrodes (anode, cathode)	1.2.1 Getting dirty Cause:Unclean electrolyte (maintenance failure)	Bad charging ability. Short circuit,if water involved. Cell must be scrapped.	Low voltage gauge	T1-T2	K2,E2	Right equipments and instructions to check the purity of electrolyte.
	1.2.2 Mechanical damage: broken/short circuit Cause:Collision	Bad charging ability, voltage decreases	Low voltage,no capacity	T1-T2	K2/K3, E1/E2	Handling of batteries must be easy during maintenance.
1.3 Coupling wiring (between batteries)	1.3.1 Wire loose Cause:Maintenance failure or fastening failure	No current,no operation	In maintenance, in use	T0-T1	K3,E1	Rare (wire loose often, see 1.3.4)
	1.3.2 Miscoupling Cause:Maintenance failure, unclear markings	Short circuit:no operation Short circuit:sparking, explosion possibility	In maintenance	T0	K3,E1	Not possible(wires too short).

Frequence: T0=never, T1=once during syst.service life, T2=once during maint.period, T3=often in normal use, T4=every time during shift

Repair urgency: K0=no effect in operation, K1=repair within the year, K2=repair in the next maintenance, K3=actual need of repair, K4=dangerous failure

Repair cost: E0=no costs, E1=small costs, E2=remarkable costs, E3=expensive repair,short outage, E4=expensive repair,long outage

Figure 3. Failure Modes, Effects and Criticality Analysis

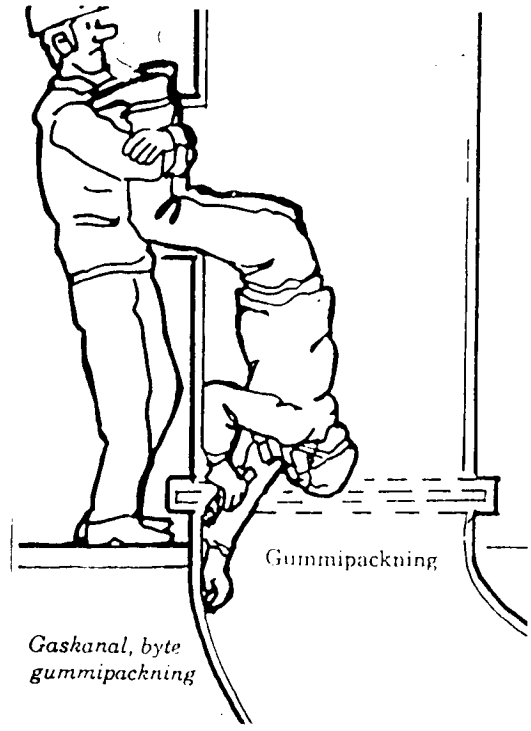
MEA - INTRODUCTION

ANALYSIS IS APPLIED TO PLAN AND ESTIMATE CORRECTIVE AND PREVENTIVE MAINTENANCE BEFOREHAND.

MEA-ANALYSIS REFERS TO THE SAME FAILURE MODES AS IN THE FMEA-ANALYSIS.

MEA-ANALYSIS CONTAINS FOLLOWING INFORMATION ABOUT MAINTENANCE, E.G.:

- REPAIR TIME
- DECOUPLING TIME
- OUTAGE TIME
- REPAIR ACTIVITIES
- SPARE PARTS
- MAINTENANCE MAN HOURS
- REMARKS AND RECOMMENDATIONS



CMA - CORRECTIVE MAINTENANCE ANALYSIS

Project :KOTUREL

Object: SM-trains/VR, DC-Battery systems

System: 1. Batteries

Author :VTT/HEM,VR

Inspected by:VTT/AYL,VR

Subsystem Device/Part	Failure mode	Ref.	Description of repair	Act. rep. (h)	Decoupling, preparations description	Prep. time (h)	Outage time (h)	Number of persons	Spare parts, equipments description	Prev. maint code	Suggestions of improvements and notes
1.1 Cells	Cracking	1.1.1	No repair	5	Change	1	2	1+1*	New cell(s)	V25	Rare fail.(accident).
Cells	Overflow	1.1.2	Pump.extra liq.off	3	Cleaning	*1	3	1	New electrolyte	V25	Measuring and raising
Cells	Boiling	1.1.2	Pump.extra liq.off	3	Cleaning	*1	3	1	New electrolyte	V25	of specific gravity.
1.2 Electrodes	Dirt	1.2.1	Change of battery	2	Coupling	1	2	1+1*	New battery	V25	Only 2 watering places.
Electrodes	Mech.damage	1.2.2	Change of battery	16	Coupl.,load test	2	2	1+1*	New cell(s)	V25,S600	Usual.(cell-short circ.)
1.3 Coupling wiring	Wire loose	1.3.1	New cable clamp	1	Coupling	0.5	1.5	1	Clamp,tin,solder		
Coupling wiring	Wire loose	1.3.1	New wire	0.1	Coupling		0.2	1			
Coupling wiring	Wire end dirty	1.3.3	Clean.,filing,polish	0.5	Coupling	0.5	1	1		V25	Wires may be oxidized,
Coupling wiring	Wire end dirty	1.3.3	Change	0.1	Coupling				New wire	V25	caused by overflow
Coupling wiring	Wire loose	1.3.4	Tightening of joints	2		0.5	2.5	1			
1.4 Cell linking	Oxidized plate	1.4.2	Cleaning	2	Coupling	0.5	2.5	1	New wire	V25	
1.5 Electrolyte	Carb.cont.high	1.5.1	Change of battery	24	Dens.meas./maint.	0.5		1+1*	New electrolyte	S600	Complete maintenance
Electrolyte	Sediment	1.5.2	Change of battery	5	Load test in train	1		1+1*	Scrap if>60 Ah	S600	Scrapping value 60Ah
Electrolyte	Water vanished	1.5.3	Watering	3	Coupling	0.5		1	Distilled water	V25	Danger of explosion

Coupling= detachment+fastening

Figure 4. Corrective Maintenance Analysis

QUANTITATIVE METHODS

E.G.

- FAULT TREE ANALYSIS
- RELIABILITY BLOCK DIAGRAM METHODS
- LCC-MODELS

THE USE OF AVAILABILITY MODELS PRESUPPOSES KNOWLEDGE OF RELIABILITY TECHNICS.

INFORMATION OF QUALITATIVE ANALYSIS CAN BE ALSO USED AS A BASIS IN ESTIMATING AND DEFINING MEASURES OF RELIABILITY AND MAINTAINABILITY PERFORMANCE (E.G. FAILURE RATE, REPAIR TIME).

QUANTITATIVE METHODS AND AVAILABILITY MODELS CAN BE USED IN PREDICTING AVAILABILITY MEASURES OF TECHNICAL SYSTEMS, E.G.:

- PRODUCTION LOSSES
- RELIABILITY PERFORMANCE,
  MAINTAINABILITY PERFORMANCE,
  MAINTENANCE SUPPORT PERFORMANCE,
  UNAVAILABILITY
- RATING OF COMPONENTS IN REGARD TO AVAILABILITY

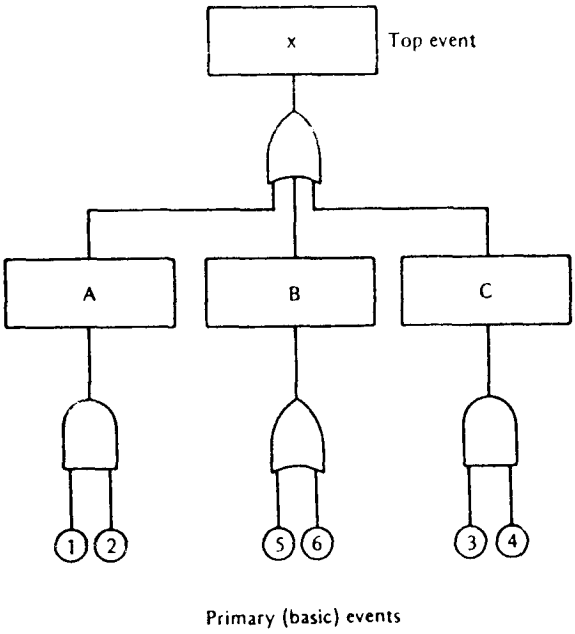


Figure 16.5 Example of a fault tree

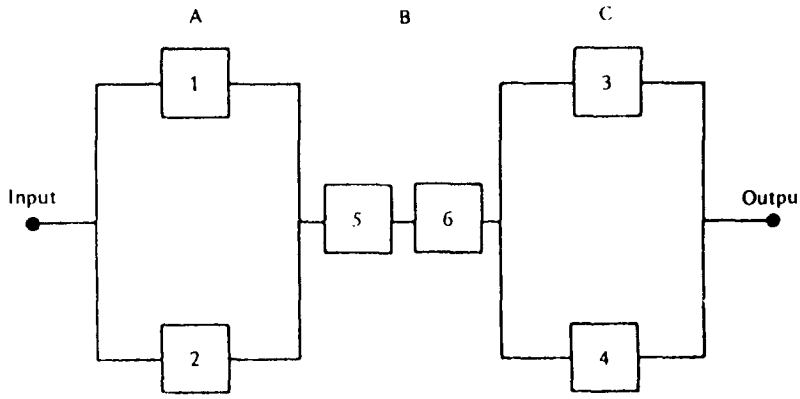


Figure 16.6 Reliability block diagram equivalent of the fault tree in Figure 16.5

LCC - ANALYSIS

LCC-methodology means evaluating the effect of failures and outages on system life time economy.

LCC-costs:

- the initial investment
- the preventive maintenance
- the corrective maintenance
- the losses and outages

LCC-analysis can be used in design, procurement and maintenance planning of technical systems.

LCC - LIFE CYCLE COSTS, SUMMARY

Author :VTT/HEM,VR
Inspected by:VTT/AYL,VR

Project: KOTUREL

COSTS	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3		ALTERNATIVE 4		ALTERNATIVE 5		ALTERNATIVE 6	
	1 YR	20 YRS	1 YR	20 YRS	1 YR	20 YRS	1 YR	20 YRS	1 YR	20 YRS	1 YR	20 YRS
INVESTMENTS:												
Batteries (110 Ah)	0	3634200	0	3580200	0	3914400	0	4200000	0	3200000	0	4200000
(75 Ah)							0	3100000			0	3100000
Low voltage-relays	0	300000	0	300000	0	0	0	0	0	0	0	0
Casing	0	0	0	0	0	0	0	0	0	3200000	0	0
Central watering system	0	0	0	1050000	0	350000	0	350000	0	350000	0	0
Maintenance stands	0	0	0	0	0	0	0	0	0	0	0	300000
Spare parts 10% (110Ah)	0	363420	0	358020	0	391440	0	420000	0	320000	0	420000
(75Ah)							0	310000			0	310000
TOT.INVEST. (110 Ah) FIM	0	4297620	0	5288220	0	4655840	0	4970000	0	7070000	0	4970000
(75 Ah) FIM							0	3760000			0	3760000
PREV.MAINTENANCE:												
25-Maintenance												
Labour costs	43200	864000	79200	1584000	43200	864000	79200	1584000	93600	1872000	187200	3744000
Material costs	0	0	4000	80000	0	0	4000	80000	4000	80000	4000	80000
600-Maintenance												
Labour costs	18000	360000	20250	405000	38250	765000	87300	1746000	43200	864000	103050	2061000
Material costs	0	0	625	12500	0	0	55188	1103760	2688	53760	55188	1103760
TOT.PM-COSTS FIM	61200	1224000	104075	2081500	81450	1629000	225688	4513760	143488	2869760	349438	6988760
CORR.MAINTENANCE:												
Batteries	3365	67300	9679	193580	7016	140320	9679	193580	9679	193580	9679	193580
Regulation	1080	21600	1080	21600	1080	21600	1080	21600	1080	21600	1080	21600
Dir.-current circuit	2205	44100	2205	44100	2205	44100	2205	44100	2205	44100	2205	44100
Central watering system	0	0	27	540	27	540	27	540	27	540	0	0
Others	544	10880	758	15160	758	15160	758	15160	758	15160	758	15160
TOT.CM-COSTS FIM	7194	143880	13749	274980	11086	221720	13749	274980	13749	274980	13722	274440
OTHERS:												
Energy losses	456	9120	456	9120	438	8760	493	9860	493	9860	493	9860
Scrapping		22500		22500		7500		7500		7500		7500
TOT. OTHERS FIM	456	-13380	456	-13380	438	1260	493	2360	493	2360	493	2360
TOT.(110 Ah) MFIM	0.07	5.65	0.12	7.63	0.09	6.51	0.24	9.76	0.16	10.22	0.36	12.19
(75 Ah) MFIM							0.24	8.55			0.36	10.98
PRESENT VALUE MFIM		3.89		5.15		5.72		7.72		8.88		9.09
MFIM								6.51				7.88

NOTES: The LCC for one year does not include the costs of the investments and scrapping. The energy losses depend on the type of the battery (1.35-1.2 FIM/day

Figure 8. LCC - Summary Report

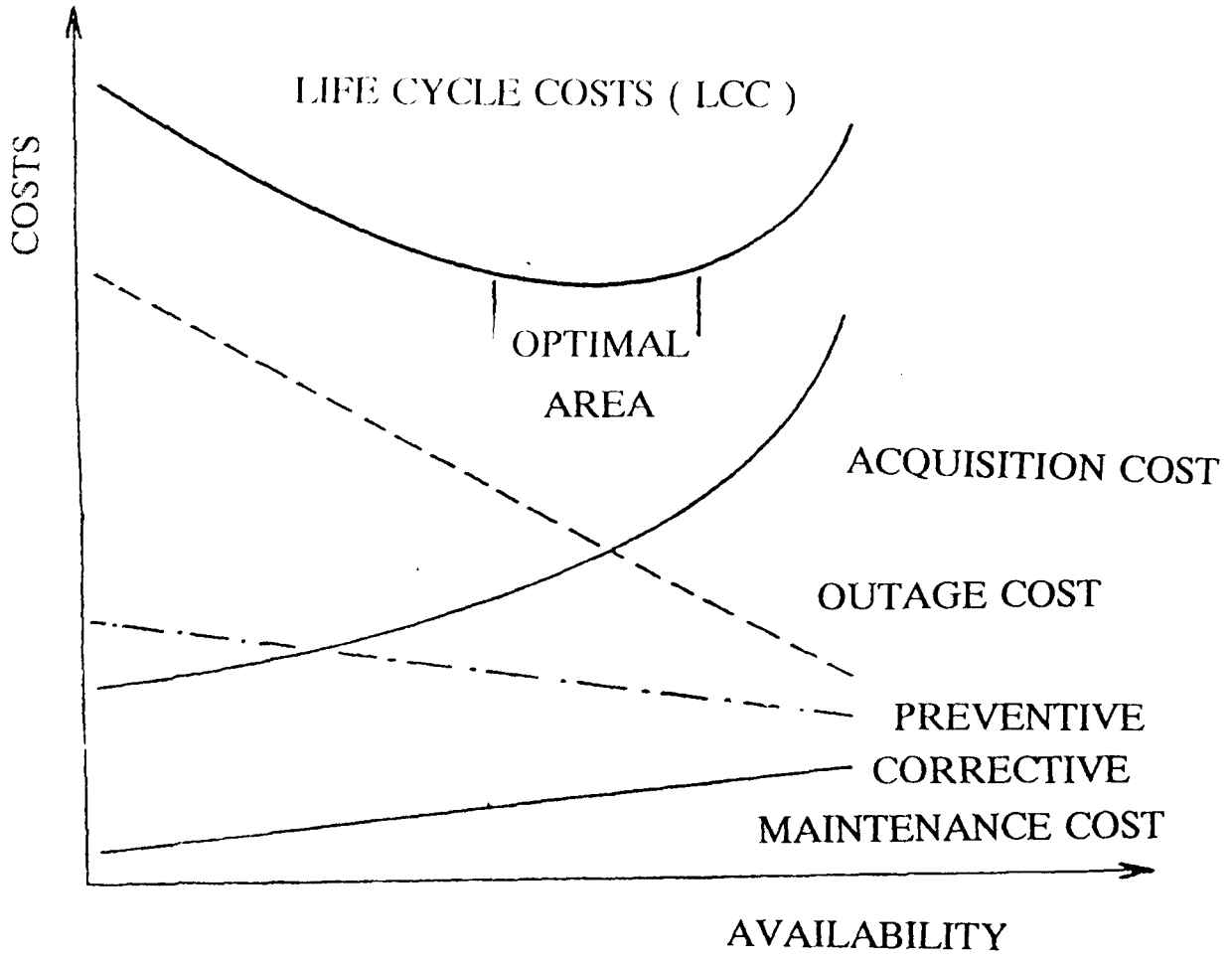


Figure. Availability and life cycle costs.

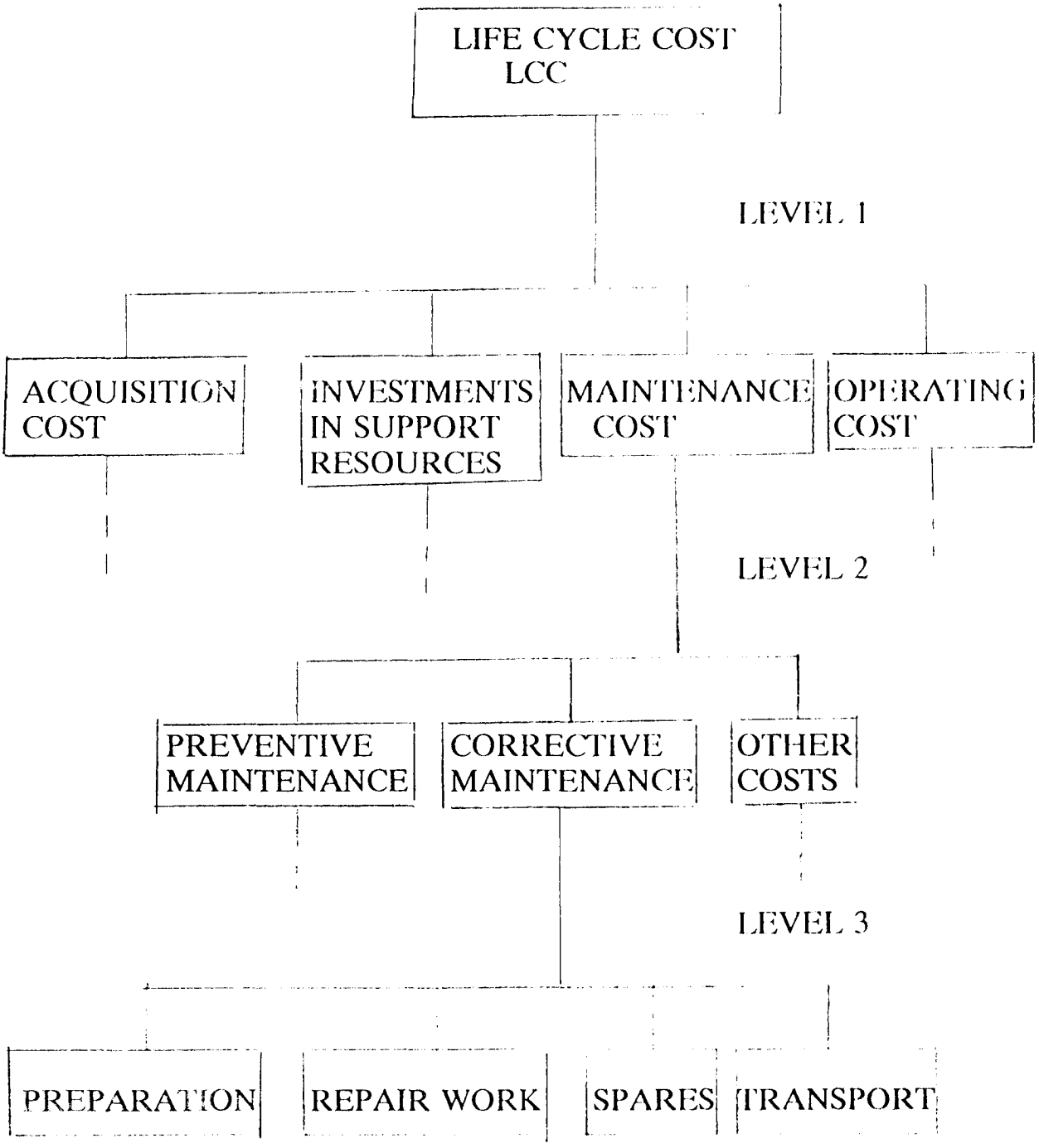


Figure. An example of a part of a cost breakdown structure.

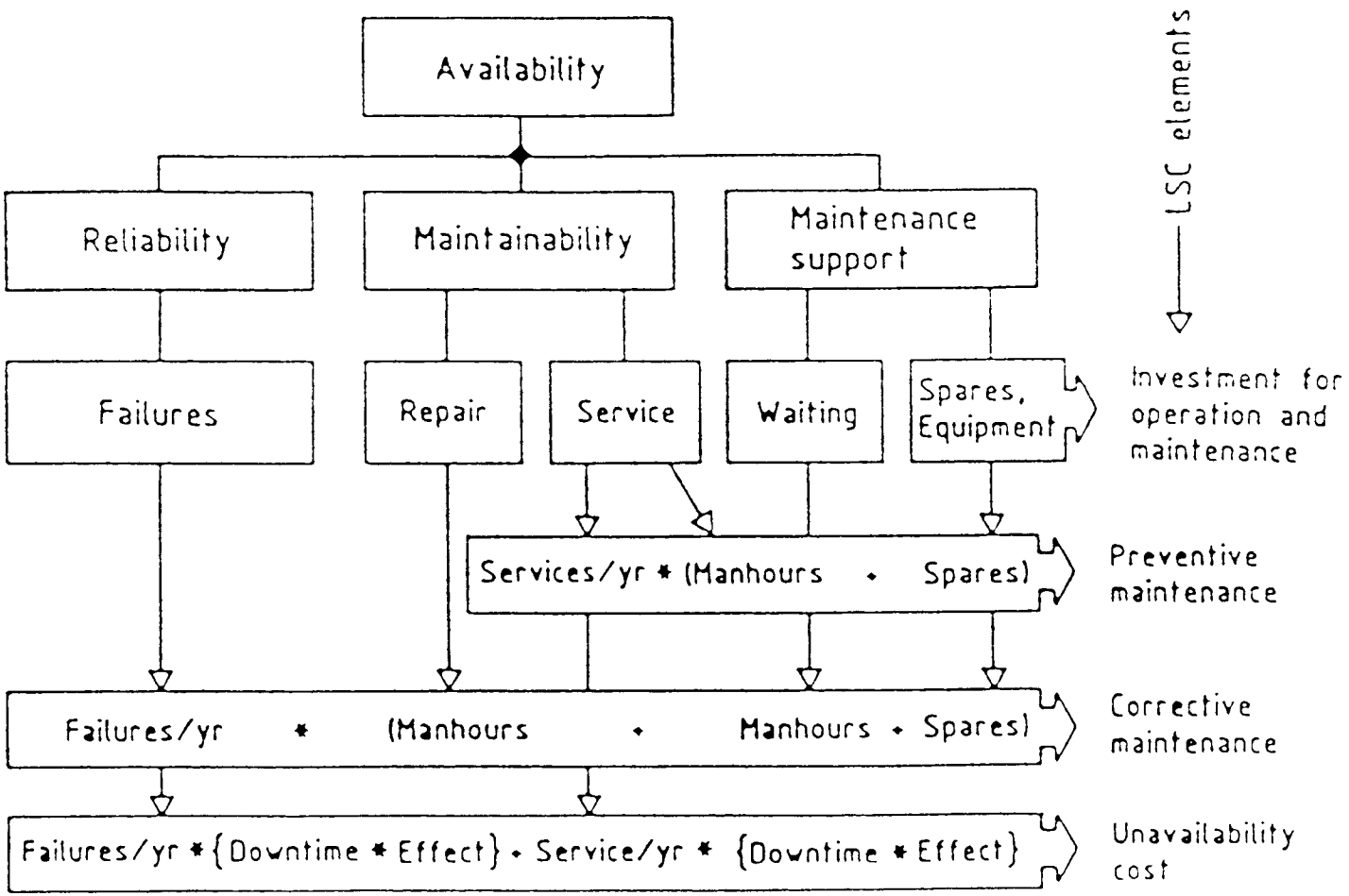


Figure 3

Influence of Reliability, Maintainability and Maintenance Support upon Life Cycle Cost

Table 1. Activities for life cycle costing.

Product phase	Manufacturer application	User application
Concept and Definition	LCC modelling on the basis on typical use of the user's specification. Rough analyses of LCC for comparisons of technologies and design concepts	Establishing the model and the cost driving parameters based on intended use. Define LCC requirements and the user's responsibilities.
Design and Development	Comparisons between alternative design solutions. Trade-off between reliability, maintainability and maintenance support. Identification of appropriate corrective actions in order to reduce the LCC.	Quotation evaluations by the LCC model and requests for complementary information. Choice of contractor (early in this phase).
Manufacturing and Installation	Verification of parameters assessable from product manufacturing and installation.	Verification of parameters assessable form product installation and testing.
Operation and Maintenance	Verification of parameters assessable from product use and maintenance reporting.	
Disposal		

FMECA → FAILURES, FAILURE MODES

CMA → DESCRIPTION OF CORRECTIVE MAINTENANCE ACTIVITIES

CMCA → TASKS AND COSTS OF CORRECTIVE MAINTENANCE

PMCA → TASKS AND COSTS OF PREVENTIVE MAINTENANCE

INV → INVESTMENTS ON SYSTEMS AND SYSTEM FACILITIES

$$LCC = \sum^{AGE} COSTS$$

- THE MOST ECONOMIC ALTERNATIVES
- DISTRIBUTION OF COSTS
- AREAS OF SAVING POTENTIAL
- IMPROVEMENT SUGGESTIONS
- BASIS FOR LCC-GUARANTEES
- AVAILABILITY AND LCC TARGET VALUES

ANALYSIS OF OPERATIONAL EXPERIENCES

Urho Pulkkinen

Technical Research Centre of Finland
Laboratory of Electrical Engineering
and Automation Technology

CONTENTS

1. INTRODUCTION

2. OBJECTIVES OF OPERATIONAL EXPERIENCE ANALYSIS

3. COLLECTION OF OPERATIONAL EXPERIENCE DATA

4. ANALYSIS OF COMPONENT FAILURE DATA

5. ANALYSIS OF SYSTEM DISTURBANCES

6. CONCLUSIONS

1. INTRODUCTION

* LEARNING FROM EXPERIENCE IS ALWAYS USEFULL

* AID FOR

  - OPERATIONAL PROCEDURES
  - MAINTENANCE
  - DESING CHANGES
  - NEW DESING
  - IDENTIFICATION OF RISKS
  - RELIABILITY AND RISK ANALYSES

* CONCENTRATES ON MOST FREQUENT FAILURES AND DISTRURBANCES

* RATHER SIMPLE AND COST-EFFECTIVE APPROACH

* DOES'NT REQUIRE KNOWLEDGE ON RELIABILITY ENGINEERING METHODS

* ORGANIZATION OF ACTIVITIES HAS BEEN DIFFICULT IN SOME CASES

* BASIS FOR QUANTITATIVE RISK ASSESSMENTS

* OFTEN THE FIRST AND ONLY APPROACH

* APPLIED IN MANY INDUSTRIAL SYSTEMS

2. OBJEVTIVES OF OPERATIONAL EXPERIENCE ANALYSIS

* IDENTIFICATION OF

  - COMPONENT FAILURE MODES
  - SYSTEM FAILURES
  - HIDDEN DEPENDENCIES BETWEEN COMPONENTS AND SYSTEMS
  - DESIGN ERRORS
  - HUMAN ERRORS IN OPERATION AND MAINTENANCE
  - NEEDS FOR TECHNICAL IMPROVEMENTS

* FOLLOW-UP OF THE SYSTEM STATUS

  - PERFORMANCE INDICATORS

* COLLECTION OF INFORMATION FOR

  - PLANNING OF CORRECTIVE AND PREVENTIVE MAINTENANCE
  - NEW DESIGNS
  - RISK AND RELIABILITY ANALYSES

* IDENTIFICATION OF AGEING TRENDS

* EDUCATION OF PLANT PERSONNEL

3. COLLECTION OF OPERATIONAL EXPERIENCE DATA

* ANALYSIS OF OPERATIONAL EXPERIENCES IS IMPOSSIBLE WITHOUT WELL-ESTABLISHED DATA COLLECTION PROCEDURES

* CAREFULL PLANNING OF DATA COLLECTION IS ESSENTIAL

* IN MANY CASES THE ORGANIZATION OF DATA COLLECTION IS DIFFICULT

* THE DATA SHOULD BE COLLECTED BY THE PLANT PERSONNEL

  - BEST KNOWLEDGE OF THE SYSTEMS
  - DIRECT FEEDBACK FROM THE EXPERIENCES
  - EDUCATION OF PERSONNEL

* COMPUTERIZED DATA COLLECTION PROCEDURES ARE USEFULL FOR

  - DATA BASE MANAGEMENT
  - DATA CLASSIFICATION
  - DATA RETRIEVAL
  - DATA ANALYSES
  - DECREASING THE EXTRA WORKLOAD

* PRINCIPLES OF DATA COLLECTION:

A. SELECTION OF COMPONENTS AND SYSTEMS FOR DATA COLLECTION

- IMPORTANCE OF THE SYSTEM: SAFETY, OPERATIONAL AVAILABILITY ETC.
- DEPENDS ON THE AVAILABLE RESOURCES

B. SELECTION OF THE DATA TO BE COLLECTED

- COMPONENT FAILURE DESCRIPTIONS
- DESCRIPTIONS OF REPAIR ACTIVITIES
- OPERATIONAL DISTURBANCES OF THE SYSTEMS
- OPERATION AND MAINTENANCE ERRORS
- DATA ON OPERATION OF THE SYSTEMS
- DEPENDS ON THE USE OF THE DATA

C. ORGANIZATION OF THE COLLECTION

- COMPONENT FAILURE DATA IS USUALLY COLLECTED BY MAINTENANCE PERSONNEL
- SYSTEM LEVEL DATA MAY ALSO BE COLLECTED BY THE OPERATION PERSONNEL

D. DATA SOURCES

- REPAIR WORK ORDERS AND FAILURE REPORTS (IF EXISTING)
- DISTURBANCE DESCRIPTIONS
- SYSTEM LOGBOOKS
- INTERVIEWS OF PERSONNEL
- COMPONENT AND SYSTEM DESCRIPTIONS

E. DOCUMENTATION OF DATA

- FAILURE REPORT FORMS
  + POSSIBLY COMPONENT AND SYSTEM SPECIFIC
- COMPUTERIZED DATA BASE
  + USUAL DATA BASE PROGRAMS FOR PCs MAY BE USED
- THE USE OF DATA AND THE FURTHER ANALYSES DETERMINE FORM OF DPCUMENTATION

* MOTIVATION OF PERSONNEL IS ESSENTIAL
  - EDUCATION
  - EMPHASIS ON THE BENEFITS OF DATA COLLECTION
  - INCENTIVES: EXTRA SALARY, POSSIBLE IMPROVEMENTS IN WORKING ENVIRONMENT, ETC.

* THE SUPPORT FROM THE PLANT MANAGEMENT

3. ANALYSIS OF COMPONENT FAILURE DATA

* DATA NEEDED:

- FAILURE DESCRIPTION
- INFORMATION ON THE FAILURE LOCATION
- INFORMATION ON FAILURE CAUSE
- THE EFFECT OF FAILURE ON THE SYSTEM
- INFORMATION OF FAILURE DETECTION
- AGE OF THE COMPONENT AT FAILURE TIME
- TIME ELAPSED FROM PREVIOUS FAILURE
- INFORMATION OF REPAIR:
  + REPAIR TIME, REPAIR WAITING TIME
  + PERSON HOURS OF REPAIR
  + ACTIVITIES PERFORMED
- PRODUCTION LOSSES

* CLASSIFICATION OF FAILURES

  - FAILURE MODE (usually component specific)

  - FAILURE TYPE AND CRITICALITY

  - FAILURE TIME:
    + during operation
    + during stand-by time
    + at the start of component

  - FAILURE DETECTION
    + monitored failures
    + latent failures

  - FAILURE LOCATION
    + part of component

  - FAILURE CAUSE
    + design error
    + manufacturing error
    + maintenance error
    + operation error
    + corrosion
    + etc.

* FAILURE MODE AND EFFECTS ANALYSES (FMEA) AND MAINTENANCE EFFECTS ANALYSES (MEA) ARE USEFULL IN CLASSIFICATION

* POSSIBLE CO-OPERATION WITH THE COMPONENT MANUFACTURER

* STATISTICAL ANALYSES:

- FAILURE TREND ANALYSES
- IDENTIFICATION OF DOMINATING FAILURE CAUSES
- ESTIMATION OF FAILURE RATES
- ANALYSIS OF REPAIR TIMES

Motor operated valve data

Data source

TVO I and TVO II failure data collection system

Σ 104 MOVs in

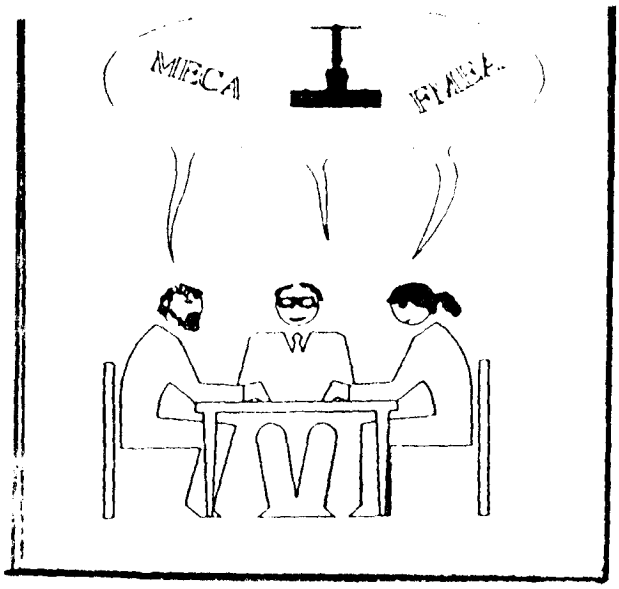
+ Shut-down cooling system
+ Containment vessel spray system
+ Core spray system
+ Auxiliary feed water system

Observation period

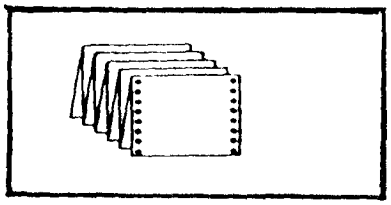
1.1.1981 - 31.12.1989

Σ 181 failures in 67 valves

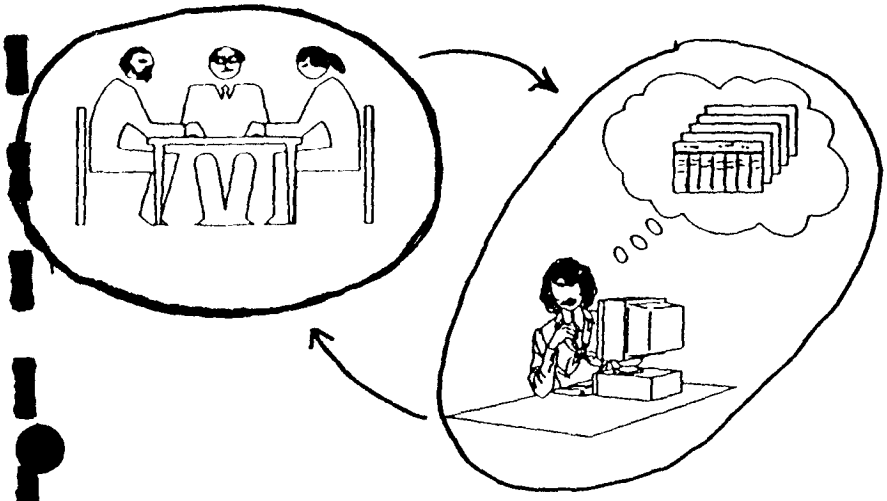
mechanical valve + actuator + power supply + control systems



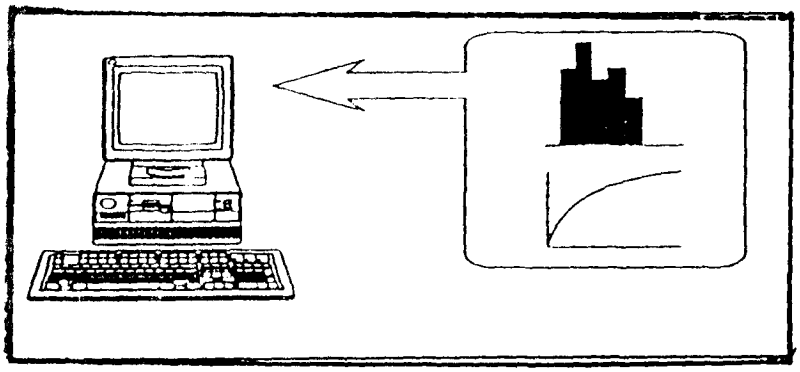
- CLASSIFICATION
- DEVELOPMENT OF FMEA & MECA SHEETS



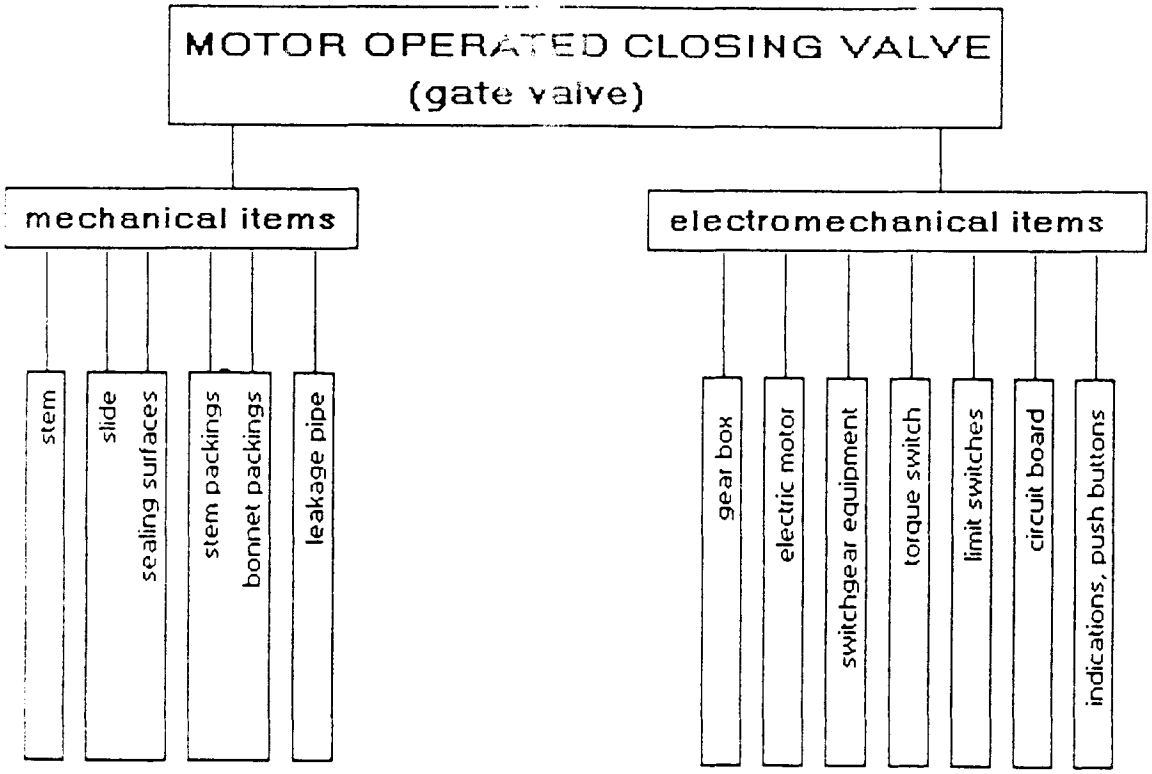
FAILURE DATA FROM POWER PLANT



- REVIEW OF CLASSIFICATION
- DATA ANALYSIS AND STORING



QUANTITATIVE ANALYSES


MOTOR OPERATED CLOSING VALVE
(gate valve)
mechanical items
electromechanical items
stem
slide
sealing surfaces
stem packings
bonnet packings
leakage pipe
gear box
electric motor
switchgear equipment
torque switch
limit switches
circuit board
indications, push buttons

1. SYSTEM MALFUNCTION

- UNSUITABLE DESIGN DUE TO INSUFFICIENT KNOWLEDGE OF BEHAVIOUR OF PROCESS VARIABLES
- UNSUITABLE DESIGN DUE TO INSUFFICIENT KNOWLEDGE OF MAN-PROCESS INTERFACE
- INSUFFICIENT CAPACITY
- POOR REDUNDANCY

2. COMPONENT FAILURE

- COMPONENT UNSUITED TO ENVIRONMENT

- UNRELIABLE COMPONENT WHICH
  CAN BE A RESULT OF
  POOR PREVENTIVE MAINTENANCE
  OR AGEING

3. INADVERTENT PROTECTION FUNCTION

- PROTECTION FUNCTION WAS TRIPPED EVEN THOUGH THE EVENT WOULD NOT HAVE CAUSED ANY DAMAGE
  (IF THE TRIP HAD NOT OCCURED)

4. TESTING

- INTENTIONAL TRIP DUE TO PLANNED TEST

- UNPLANNED TRIP INITIATED DURING TESTING

5. HUMAN ERROR

- INCORRECT, INCOMPLETE OR UNCLEAR OPERATING INSTRUCTIONS (PROCEDURES)

- DEVIATIONS FROM OPERATING INSTRUCTIONS

4. CONCLUSIONS

- LEARNING FROM EXPERIENCE!
- COST-EFFECTIVE AND USEFULL APPROACH
- NECESSARY FOR QUANTITATIVE ANALYSES
- SUPPORTS THE QUALITATIVE RISK ANALYSES
- THE DOMINATING DISTURBANCES MAY BE ELIMINATED
- MAY BE PERFORMED WITHOUT HIGHLY EDUCATED PERSONNEL
- DATA COLLECTION MAY NOT BE EASILY MOTIVATED
- SUPPORT FROM THE PLANT MANAGEMENT NECESSARY

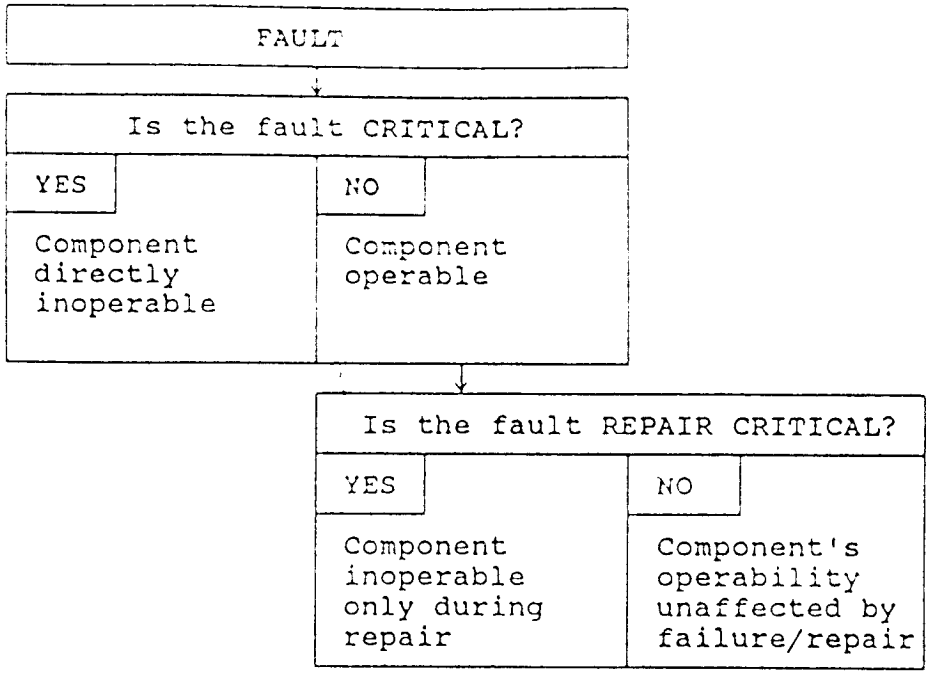

FAULT
Is the fault CRITICAL?
YES
Component directly inoperable
NO
Component operable
Is the fault REPAIR CRITICAL?
YES
Component inoperable only during repair
NO
Component's operability unaffected by failure/repair

FIGURE 6.

4. ANALYSIS OF SYSTEM DISTURBANCES

* DATA NEEDED:

  - SYSTEM DESCRIPTIONS

  - EVENT DESCRIPTIONS

  - RISK ANALYSIS MODELS (if existing)

* ANALYSIS PERSONNEL:

  - OPERATION PERSONNEL

  - CONSULTS

  - DESIGNERS OF THE SYSTEM

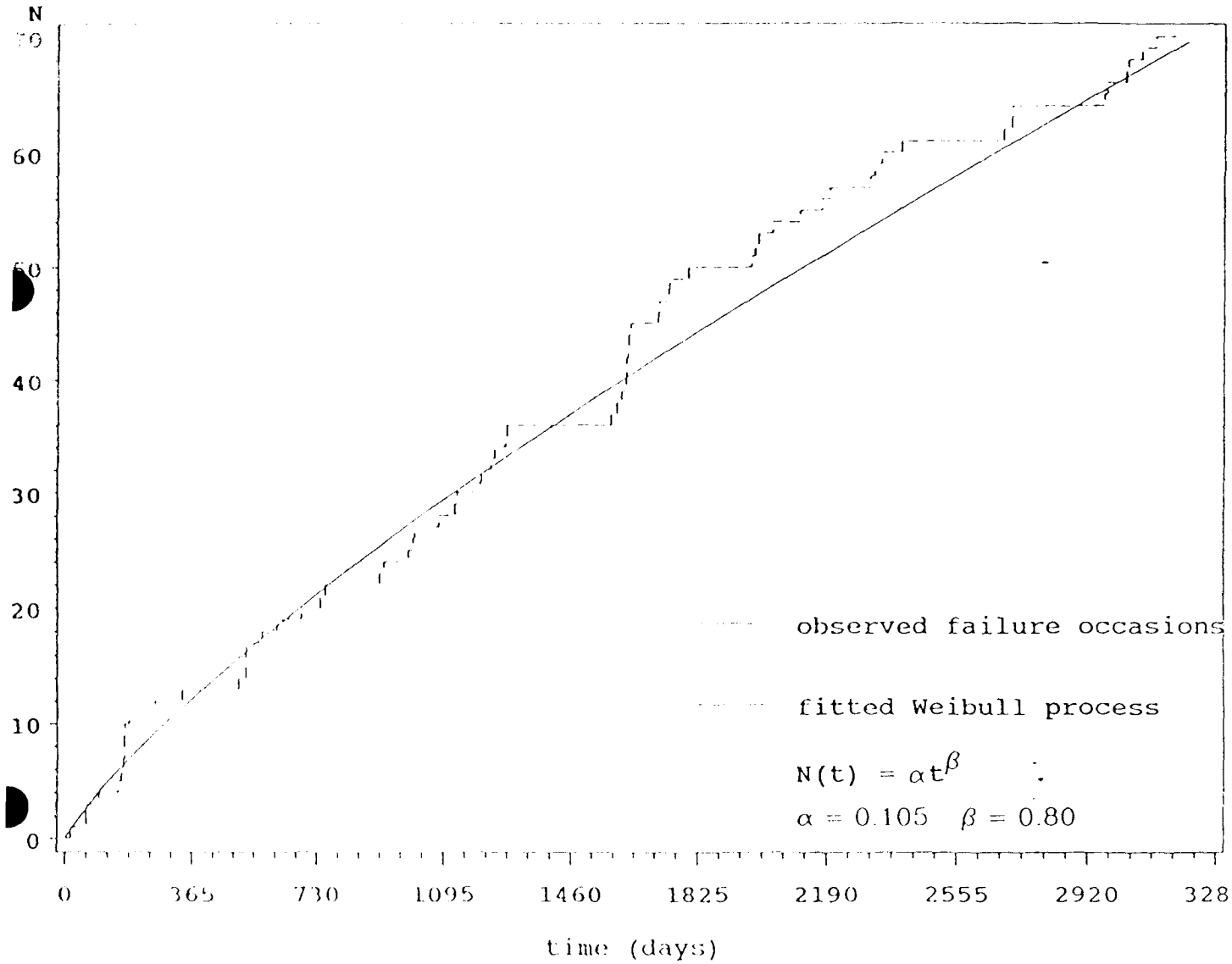

N
70
60
50
40
30
20
10
0
0
365
730
1095
1460
1825
2190
2555
2920
328
time (days)
observed failure occasions
fitted Weibull process
N(t) = αt^β
α = 0.105 β = 0.80

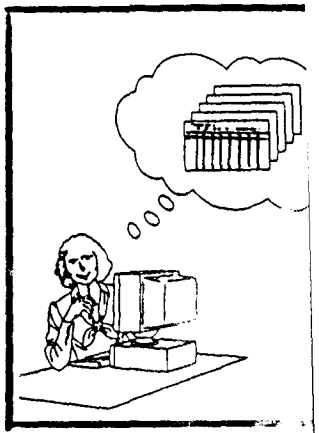
FIGURE 16.

Failure mode and effects analysis (FMEA)

Plant: TV01 Activation interval: 3 d
Comp. identif.: 322V204 Valve type: Gate, Stenberg, DN 150
Function: External isolation valve, basic operational position closed

Name of analyst: KS/SH Date: 4.1.90

ITEM	I	FAILURE MODE	FM	FAILURE CAUSE	FC	FAILURE EFFECT ON VALVE OPERABILITY	FE	FAILURE DETECTION	FD	COMMENTS	DATE OF FAILURE DETECTION
stem	M	stuck	M	normal wear	W	does not close	C	revision test	R	revision	3-Jun-81
circuit board	C	missing control	C	electrical damage	E	no effect	N	control-room monitoring	C		1-May-87
torque switch	T	wrong operation of torque switch	T	wrong adjustment	A	does not close	C	revision test	R	revision	30-May-89



Maintenance effects and criticality analysis (MECA)

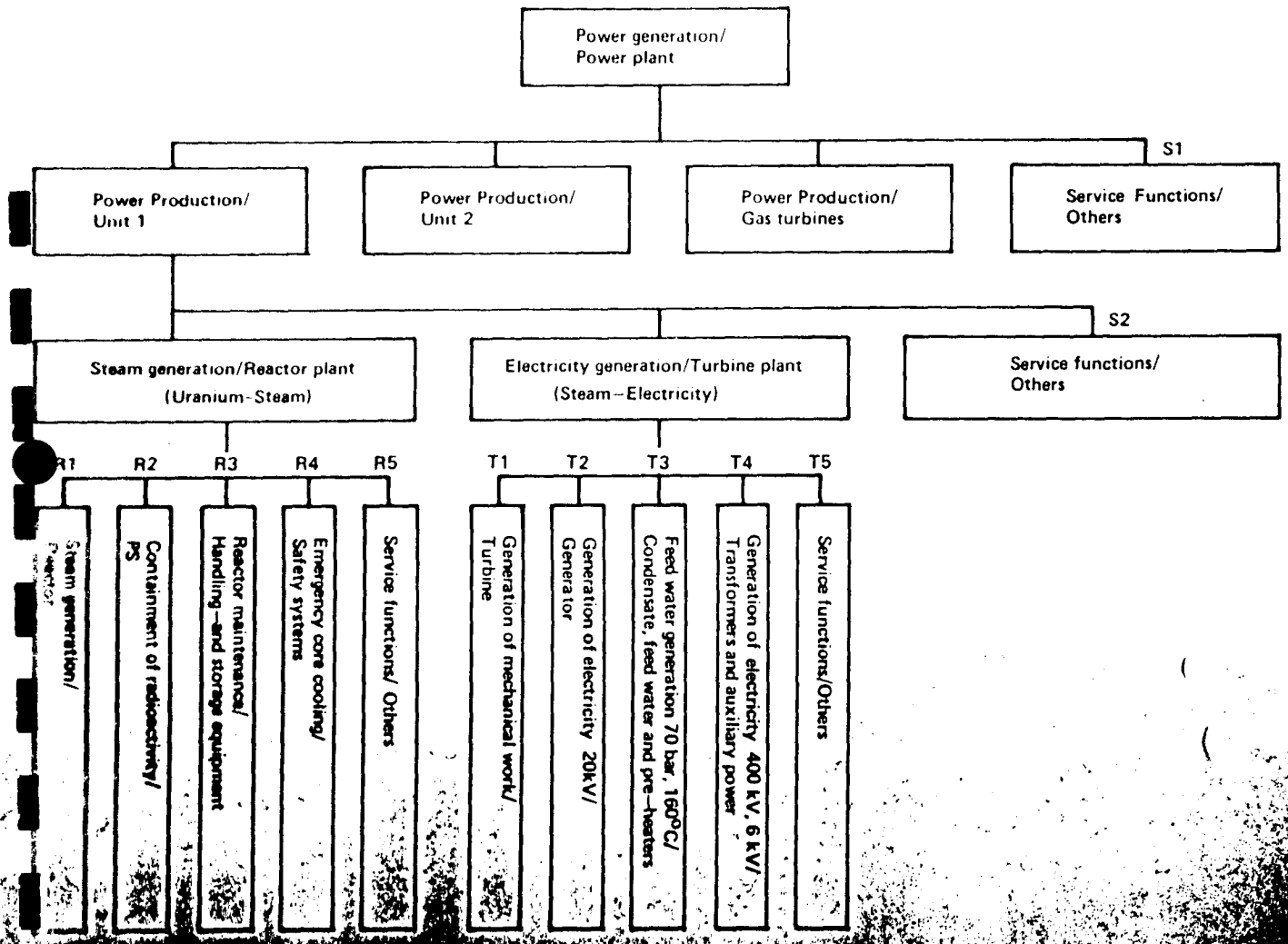
Plant: TV01 Activation interval: 3 d
Comp. identif.: 322V204 Valve type: Gate, Stenberg, DN 150
Function: External isolation valve, basic operational position closed

Name of analyst: KS/SH Date: 20.7.89

ITEM	DATE OF FAILURE DETECTION	CORRECTIVE MAINTENANCE ACTIVITY	ISOLATION FROM SYSTEM	CRITICALITY LEVEL	UNDET. UNAV. TIME (h)	DELAY TIMES (h)	MAN HOURS/ MEN	ACTIVE REPAIR TIME (h)	UNAVAIL. TIME (h)	COMMENTS
stem	3-Jun-81	control circuits checked, stem lubricated, box tightness checked	isolation	latent critical	36	3	8 / 2	28	67	repair during revision
circuit board	1-May-87	circuit board replaced	no	monitored non critical	0	430	2 / 1	2	0	
torque switch	30-May-89	torque switch adjusted	-"-	latent critical	36	9	4 / 2	4	49	repair during revision

Failure and repair history of motor-driven valves (Finnish nuclear power plants)

BREAKDOWN OF THE POWER PLANT INTO FUNCTIONAL GROUPS



FAILURE TYPES

1. SYSTEM MALFUNCTION

2. COMPONENT FAILURE

3. INADVERTENT PROTECTION FUNCTION

4. TESTING

5. HUMAN ERROR

THESE FAILURE TYPES ARE SPECIFIED SO THAT EACH ONE IS MATCHED WITH ONE TYPE OF CORRECTIVE ACTION REQUIRED.

EVENT ANALYSIS - OSKARSHAMN 2

BLOCK DATE 760714 TIME 11.10 SKI NO 2-4/76

TRIPPING CONDITION
1:
2: TSS TURBINE TRIP
3: SS10 EXTRA HIGH NEUTRONFLUX RELATIVE TO CORE COOLANT FLOW

	OPERATIONAL DATA BEFORE DISTURBANCE	OPERATIONAL DATA AFTER DISTURBANCE
OPERATIONAL STATE	8	
REACTOR POWER (MWT)	1200	
MC-FLOW (KG/S)	3100	
CONTROL ROD CONFIGURATION	9160	
GENERATOR POWER (MWE)	365	000

FAILURE EVENTS	FUNCTIONAL GROUP	FAILURE TYPE
1. IMBALANCE PROBLEMS OCCURED IN THE TURBINE.	T1:04	1
2. AN ATTEMPT WAS MADE TO COUNTER THE VIBRATIONS, BY INCREASING THE BEARING OIL TEMPERATURE, WITHOUT ANY SUCCESS. ON REDUCING THE TEMPERATUR TO NORMAL OPERATING LEVEL, VIBRATIONS INCREASED FURTHER LEADING TO TURBINE TRIP.	T1:04	4
3. THE MISMATCH OF TURBINE INLET VALVES AND BYPASS VALVES CAUSED A PRESSURE TRANSIENT IN REACTOR CORE.	T1:10	1
4. A "VERY SHORT LIVED" INCREASE OF THE NEUTRON FLUX IN THE CORE RESULTED IN TRIPPING OF REACTOR SCRAM (SS10).	R1:02	3

FUNCTIONAL GROUPS:(FUNCTION/EQUIPMENT)

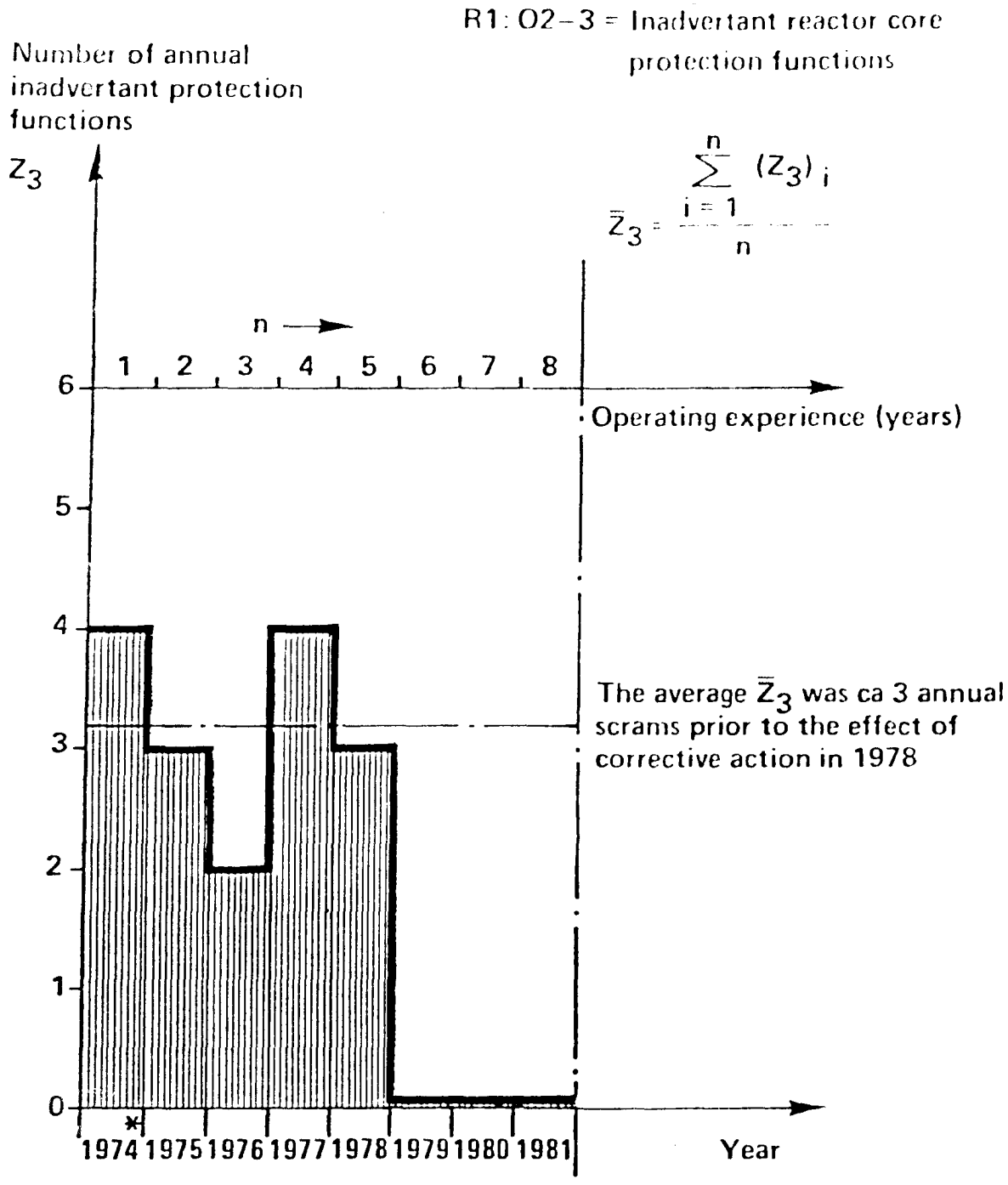
R1 STEAM GENERATION/REACTOR
R2 CONTAINMENT OF RADIO-ACTIVITY/PS
R3 REACTOR MAINTENANCE/HANDLING AND STORAGE EQUIPMENT
R4 EMERGENCY CORE COOLING/SAFETY SYSTEMS
R5 SERVICE FUNCTIONS/OTHERS

T1 GENERATION OF MECHANICAL WORK/TURBINE
T2 GENERATION OF ELECTRICITY 20KV/GENERATOR
T3 FEED WATER GENERATION 70 BAR,180 C/CONDENSATE,FEED WATER AND PRE-HEATERS
T4 GEN. EL 400 KV, 6 KV /TRANSFORMERS AND AUXILIARY POWER
T5 SERVICE FUNCTIONS/OTHERS

S1,S2 SERVICE FUNCTIONS/OTHERS

FAILURE TYPES:

1 SYSTEM MALFUNCTION
2 COMPONENT FAILURE
3 INADVERTENT PRO-TECTION FUNCTION
4 TESTING
5 HUMAN ERROR



*) The analyzed period is from the date of first synchronization with the grid (1974-10-02)

Unit Oskarshamn 2.
Scram analysis. The annual frequency of inadvertant reactor core protection functions

ANALYSIS OF HUMAN FACTORS AND ORGANISATIONAL SAFETY

PEKKA PYY
VTT

Table 8. The human contribution to the meltdown frequencies per year.

Plant	core melt frequency	impact of human errors	impact of recovery
Oconee	2.5 E-4 (mean, modified plant)	4 %	75 %
Seabrook	2.3 E-4 (mean for a single unit)	30-50 % (estimate)	not clear, evidently remarkable
Calvert Cliffs	1.3 E-4 (mean)	12 %	90 % (order of magnitude)
Biblis	9.0 E-5 (mean)	63-69 % (with other failures)	not documented
Sizewell	1.0 E-6 (median)	1.4 %	not documented

It should be noted that in most cases the human contribution could not be directly seen from the PRA summary. Therefore, the table should be used carefully to avoid misunderstandings.

HUMAN RELIABILITY

PSYCHOLOGICAL DEFINITION :
THE ABILITY TO ADAPT THE BEHAVIOUR ACCORDING TO THE CHANGING REQUIREMENTS OF THE ENVIRONMENT IN AN OPTIMAL WAY.

RELIABILITY BASED DEFINITION :
THE PROBABILITY OF SUCCESS OF A REQUIRED ACTION (GIVEN NO SPURIOUS CONTEMPORARY ACTIONS)

ERROR AND KNOWLEDGE FLOW FROM THE SAME SOURCE AND ONLY THE SUCCESS CAN TELL ONE FROM ANOTHER.

E. MACH 1904

THREE LEVELS OF HUMAN BEHAVIOUR

(ACCORDING TO JENS RASMUSSEN)

SKILL BASED BEHAVIOUR

RULE BASED BEHAVIOUR

KNOWLEDGE BASED BEHAVIOUR

J. REASON´S CLASSIFICATION

SLIPS
ERRORS IN FAMILIAR SITUATIONS

MISTAKES
ERRORS, WHERE A ' STRONG BUT WRONG' ACTION PROGRAMME IS DELIBERATELY SELECTED

VIOLATIONS
DELIBERATE OR UNINTENTIONAL ACTS AGAINST THE PROCEDURES

MEMORY LAPSES

Table 3-1 Categories of incorrect human outputs related to human reliability analysis*

ERRORS OF OMISSION

(1) Omits entire task

(2) Omits a step in a task

ERRORS OF COMMISSION

(1) Selection error:

- (a) Selects wrong control**
- (b) Mispositions control (includes reversal errors, loose connections, etc.)
- (c) Issues wrong command or information (via voice or writing)

(2) Error of sequence

(3) Time error:

- (a) Too early
- (b) Too late

(4) Qualitative error:

- (a) Too little
- (b) Too much

*As shown in Figure 3-1, the incorrect human outputs (Box D) become incorrect inputs to the system (Box E). Incorrect human outputs may be due to errors in providing correct information to the human (Box A), in his receipt of the information (Box B), in his processing of the information (Box C), in the type of responses he makes (Box D), or any combination of these errors.

**Types of controls are listed in Chapter 13.

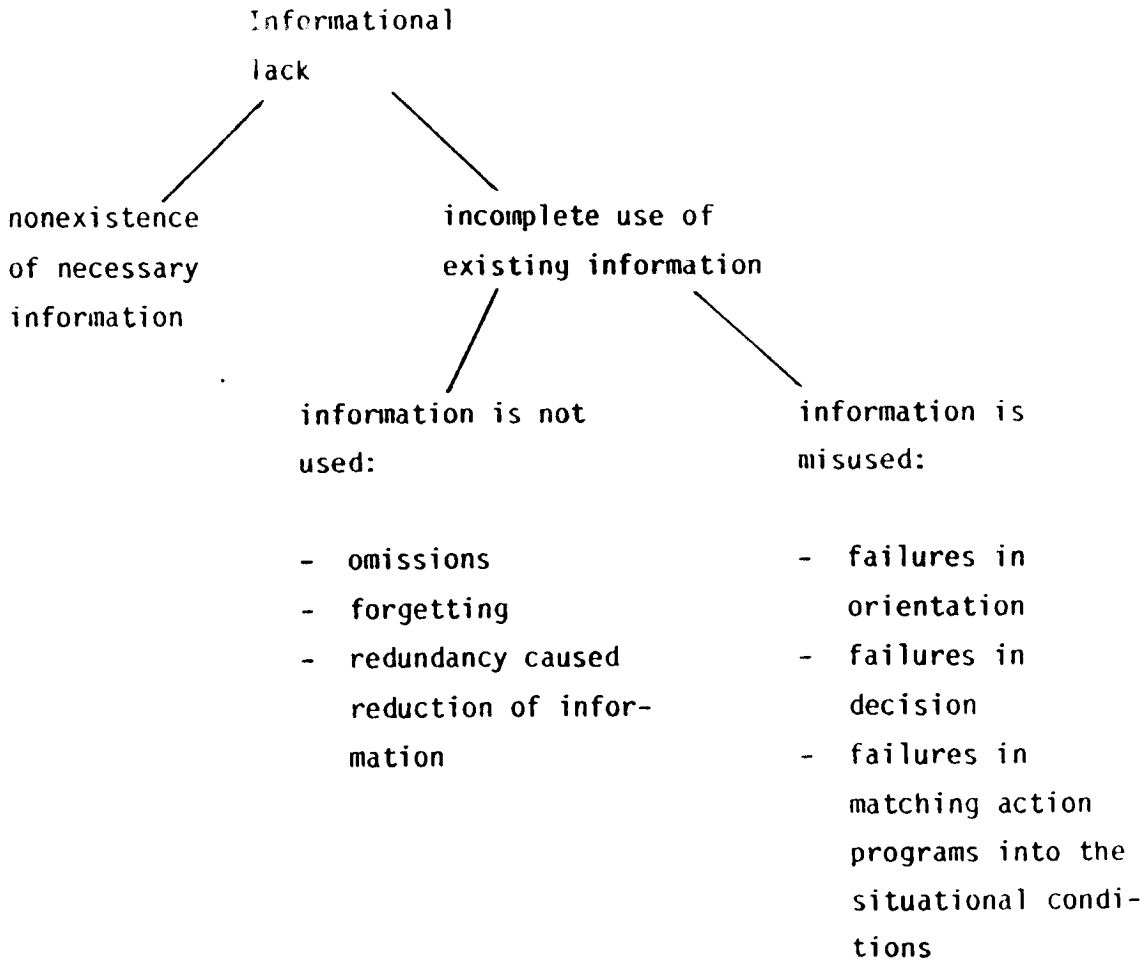


Figure 5.

Classification of errors according to the different information lacks in activity control Hacker 1978.

HOW TO GET INFORMATION ON HUMAN BEHAVIOUR

FEEDBACK OF EXPERIENCE

QUESTIONING TECHNIQUES
(E.G. AEA)

PROBLEMS OF THE FEEDBACK OF EXPERIENCE (SPECIALLY WITH REGARD OF HUMAN ERRORS)

1. PEOPLE DO NOT TEND TO REPORT EXPERIENCE EASILY

2. PEOPLE ARE AFRAID THAT THEY WILL BE PUNISHED BECAUSE OF THEIR ERRORS (OR THEIR CO-WORKERS WILL BE PUNISHED)

3. EVEN IF THE ERRORS ARE REPORTED, DETAILS REMAIN UNCLEAR BECAUSE:

   A) THE REPORTER DOES NOT KNOW ALL THE DETAILS
   B) THE REPORTER DID NOT EVEN WANT TO TELL THEM FURTHER.

INTERVIEWING TECHNIQUES

ACTION ERROR ANALYSIS

HAZOP

FREE INTERVIEW E.G. STARTING FROM THE DEGREES OF FREEDOM IN THE BEHAVIOUR

ETC.

OCCUPATIONAL SAFETY ENGINEERING LABORATORY ACTION ERROR ANALYSIS	MACHINE/SYSTEM: FLUE GAS BLOWER TASK: MAINTENANCE	PAGE: 11 DATE: 1.6.1982 DRAFTED BY: AEA-TEAM

WORK STEP	ACTION ERROR	PRIMARY CONSEQUENCES	SECONDARY CONSEQUENCES	DETECTION	MEASURES
24 MOUNTING THE IMPELLER HUB AND THE IMPELLER BLADE ANGLE ADJUSTMENT WHEELS	THE HUB NUTS REMAIN UNTIGHTENED OR UNLOCKED	LOOSENING OF THE COUPLING WHEN THE IMPELLER IS RUNNING	THE BLADE ANGLE ADJUSTMENT DOES NOT FUNCTION	ADJUSTMENT DIFFICULTIES	
25. FASTENING THE OIL AND COOLING WATER PIPES	FALSE CONNECTION OF THE PIPES	DISTURBANCES IN LUBRICATION AND COOLING	EQUIPMENT FAILURE	TEST RUN (FOAMING ACTION IN OIL RESERVOIR, OIL IN THE COOLING WATER)	MARKING THE PIPES OR USING DIFFERENT TYPE OF FITTINGS FOR OIL AND WATER PIPE CONNECTION SO THAT FALSE CONNECTION IS IMPOSSIBLE
26. MOUNTING THE LIP SEAL	SEAL FORGOTTEN OR DAMAGED WHEN MOUNTED	OIL LEAK	DISTURBANCES IN THE ADJUSTING UNIT	EXCESSIVE OIL CONSUMPTION	
27. MOUNTING THE RETAINING RING AND THE LOCK NUT OF THE IMPELLER	INADEQUATE FASTENING EG. LOCK NUT LOOSE OR FORGOTTEN	THE IMPELLER MAY MOVE AXIALLY	EQUIPMENT FAILURE		CHECK-UP (THE FOREMAN BEFORE FASTENING THE HOOD)

Fig. 6. An example of action error analysis (Reunanen & Suokas 1985).

System:	Analyzed by:	Date:		Page:	Revision date:			
	HCCF ANALYSIS FOR TEST AND MAINTENANCE							
	THE ERROR PART		THE REVEALING PART					
COMPONENT GROUP	TASK; CCF SOURCE	TASK FREQUENCY	CONSEQUENCES	DETECTION PROCEDURE	T&I FREQ.	CCF CLASS	MEASURES	REMARKS

Figure 2. The analysis form

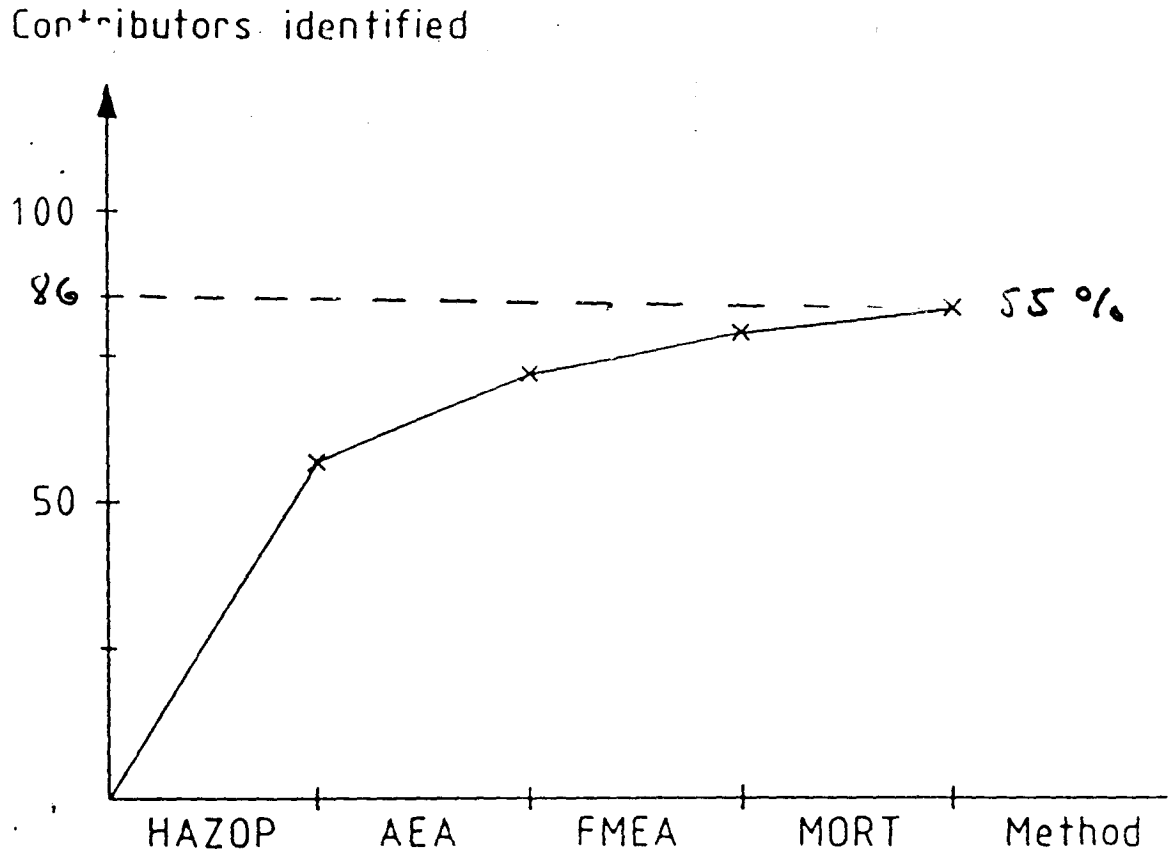


Fig. 10. An heuristic figure on the amount of contributors expected to be identified by hazard and operability study (HAZOP), action error analysis (AEA), failure mode and effect analysis (FMEA) and management oversight and risk tree (MORT) if the methods were applied in this order in a plant-wide analysis. The total number of contributors employed in the evaluations was 157.

THE SECRETS OF THE IDENTIFICATION:

RIGHT QUESTIONS

RIGHT PEOPLE

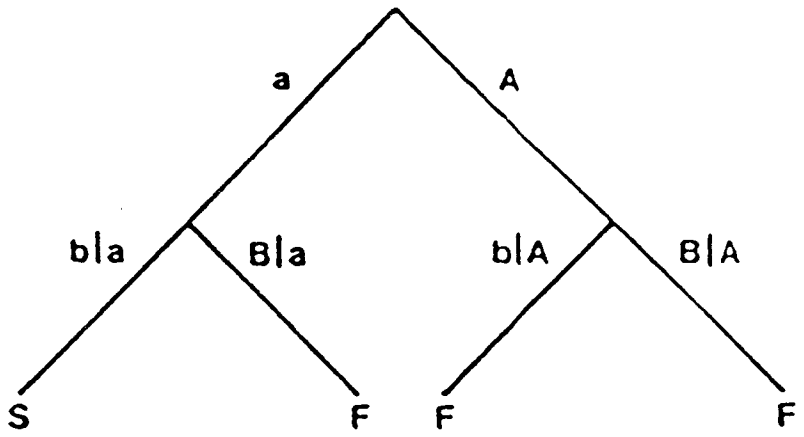
RIGHT ATTITUDE

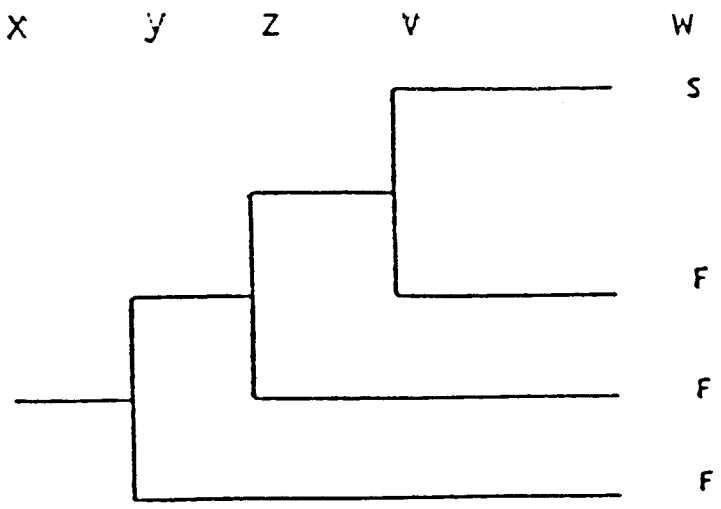
HUMAN RELIABILITY MODELLING

ONLY THE SIGNIFICANT CONTRIBUTORS ARE MODELLED

CONVENTIONAL RELIABILITY MODELS CAN BE USED WITH CONSIDERATION

GENERALLY EACH PRESENTATION INCLUDES A MATHEMATICAL MODEL, WHICH PRODUCES THE HEP (HUMAN ERROR PROBABILITY)





a) THERP

A = correct action

a = error

B|A = conditional probability, B given A

S = success

F = failure

b) OAT,

x = initiating event

y = detection

z = diagnosis

v = actions

w = consequences

Figure 7. a) THERP-model, b) OAT-model (event tree)

Table 6-2 Some PSFs in man-machine systems*

EXTERNAL PSFs		STRESSOR PSFs	INTERNAL PSFs
SITUATIONAL CHARACTERISTICS THOSE PSFs GENERAL TO ONE OR MORE JOBS IN A WORK SITUATION	**TASK AND EQUIPMENT CHARACTERISTICS:** THOSE PSFs SPECIFIC TO TASKS IN A JOB	**PSYCHOLOGICAL STRESSORS:** PSFs WHICH DIRECTLY AFFECT MENTAL STRESS	**ORGANISMIC FACTORS:** CHARACTERISTICS OF PEOPLE RESULTING FROM INTERNAL & EXTERNAL INFLUENCES
ARCHITECTURAL FEATURES QUALITY OF ENVIRONMENT: TEMPERATURE, HUMIDITY, AIR QUALITY, AND RADIATION LIGHTING NOISE AND VIBRATION DEGREE OF GENERAL CLEANLINESS WORK HOURS/WORK BREAKS SHIFT ROTATION AVAILABILITY/ADEQUACY OF SPECIAL EQUIPMENT, TOOLS, AND SUPPLIES MANNING PARAMETERS ORGANIZATIONAL STRUCTURE (e.g., AUTHORITY, RESPONSIBILITY, COMMUNICATION CHANNELS) ACTIONS BY SUPERVISORS, CO-WORKERS, UNION REPRESENTATIVES, AND REGULATORY PERSONNEL REWARDS, RECOGNITION, BENEFITS	PERCEPTUAL REQUIREMENTS MOTOR REQUIREMENTS (SPEED, STRENGTH, PRECISION) CONTROL-DISPLAY RELATIONSHIPS ANTICIPATORY REQUIREMENTS INTERPRETATION DECISION-MAKING COMPLEXITY (INFORMATION LOAD) NARROWNESS OF TASK FREQUENCY AND REPETITIVENESS TASK CRITICALITY LONG- AND SHORT-TERM MEMORY CALCULATIONAL REQUIREMENTS FEEDBACK (KNOWLEDGE OF RESULTS) DYNAMIC vs. STEP-BY-STEP ACTIVITIES TEAM STRUCTURE AND COMMUNICATION MAN-MACHINE INTERFACE FACTORS: DESIGN OF PRIME EQUIPMENT, TEST EQUIPMENT, MANUFACTURING EQUIPMENT, JOB AIDS, TOOLS, FIXTURES	SUDDENNESS OF ONSET DURATION OF STRESS TASK SPEED TASK LOAD HIGH JEOPARDY RISK THREATS (OF FAILURE, LOSS OF JOB) MONOTONOUS, DEGRADING, OR MEANINGLESS WORK LONG, UNEVENTFUL VIGILANCE PERIODS CONFLICTS OF MOTIVES ABOUT JOB PERFORMANCE REINFORCEMENT ABSENT OR NEGATIVE SENSORY DEPRIVATION DISTRACTIONS (NOISE, GLARE, MOVEMENT, FLICKER, COLOR) INCONSISTENT CUEING	PREVIOUS TRAINING/EXPERIENCE STATE OF CURRENT PRACTICE OR SKILL PERSONALITY AND INTELLIGENCE VARIABLES MOTIVATION AND ATTITUDES EMOTIONAL STATE STRESS (MENTAL OR BODILY TENSION) KNOWLEDGE OF REQUIRED PERFORMANCE STANDARDS SEX DIFFERENCES PHYSICAL CONDITION ATTITUDES BASED ON INFLUENCE OF FAMILY AND OTHER OUTSIDE PERSONS OR AGENCIES GROUP IDENTIFICATIONS
JOB AND TASK INSTRUCTIONS: SINGLE MOST IMPORTANT TOOL FOR MOST TASKS		**PHYSIOLOGICAL STRESSORS:** PSFs WHICH DIRECTLY AFFECT PHYSICAL STRESS	
PROCEDURES REQUIRED (WRITTEN OR NOT WRITTEN) WRITTEN OR ORAL COMMUNICATIONS CAUTIONS AND WARNINGS WORK METHODS PLANT POLICIES (SHOP PRACTICES)		DURATION OF STRESS FATIGUE PAIN OR DISCOMFORT HUNGER OR THIRST TEMPERATURE EXTREMES RADIATION G-FORCE EXTREMES ATMOSPHERIC PRESSURE EXTREMES OXYGEN INSUFFICIENCY VIBRATION MOVEMENT CONSTRICTION LACK OF PHYSICAL EXERCISE DISRUPTION OF CIRCADIAN RHYTHM	

* Some of the tabled PSFs are not encountered in present-day NPPs (e.g., G-force extremes) but are listed for application to other man-machine systems.

A PRACTICAL WAY TO PERFORM THE HEP CALCULATIONS

1. USE CONSERVATIVE VALUES FROM 5E-3 TO 1.0 (= SCREENING VALUES) OR ENSITIVITY ANALYSIS (0-1).

2. CALCULATE THE PLANT MODELS AFFECTED BY THE HUMAN ERRORS BY USING THE SCREENING VALUES.

3. IF THE HUMAN ERRORS APPEAR SIGNIFICANT, PERFORM A MORE THROUGH INVESTIGATION ON THE IMPORTANT ONES.

4. GIVE MORE ACCURATE HEP'S

SOME OBSERVATIONS ON THE QUANTIFICATION

1. NOT MUCH OBJECTIVE EVIDENCE EXISTS. THE RESULTS REMAIN ALWAYS SUBJECTIVE.

2. THE LEVEL OF ANALYSIS HAS TO BE CHOSEN SO THAT ALL THE EVIDENCE CAN BE USED.

3. THE QUANTITATIVE ASSESSMENT REVEALS MANY DETAILS WHICH OTHERWISE WOULD HAVE REMAINED OUTSIDE THE CONSIDERATION.

ORGANISATIONAL STUDIES VERSUS REALITY

FORMAL (=STUDIED) ORGANISATION

Impersonal
Rigid power delegation schemes
Predetermined information flow routes

INFORMAL (=REAL) ORGANISATION

Personal relationships
Temporary deviations in delegation of responsability
Information flow irregular

REAL ORGANISATION CHARACTERISTICS LEAD TO DEVIATIONS, WHICH LIE IN THE BACKGROUND OF SO CALLED HUMAN ERRORS CAUSING OPERATIONAL DISTURBANCES

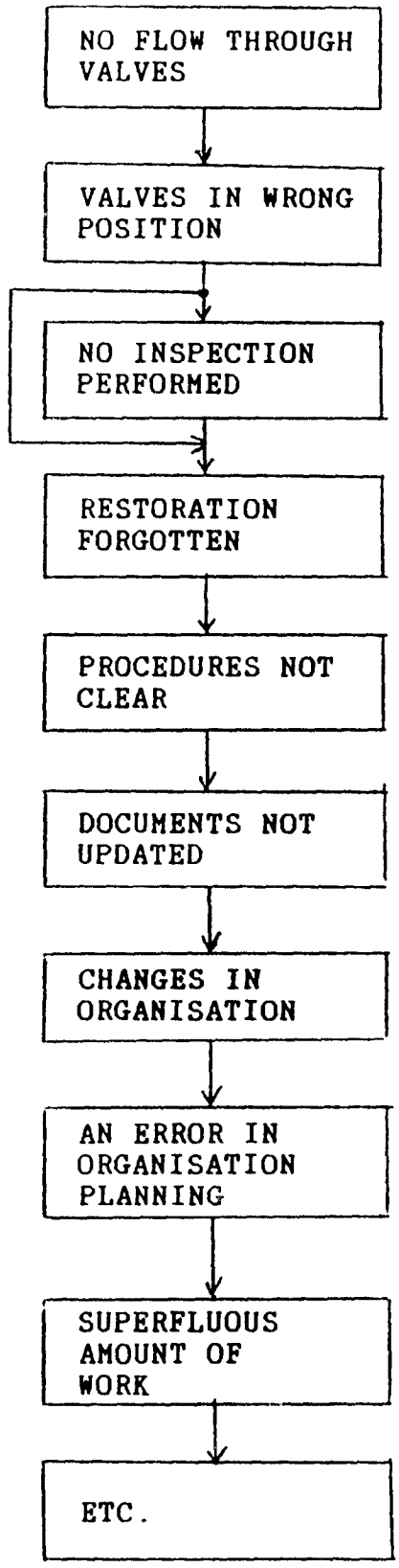


Figure 1. Analysis of an imaginary human error in depth.

SUBCLASS	EXAMPLES OF DEVIATIONS	EXAMPLES OF DETERMINING FACTORS
PHYSICAL		
a) component level	Ageing Random failure	Fabrication error
b) system level	Chemical reaction (sudden) External event	System interactions Complex structure Missing alarms etc.
HUMAN	Sudden slips e.g. forgetting of valve restoration	Mistakes in decision making Wrong work method Task outside capability
ORGANISATIONAL		
a) information	Forgotten messages	Deficiencies in information practices
b) supervisory and management	Wrong instructions Missing action due to e.g. changes in organisation	Accepted risks No updating of documents No personnel training
DESIGN	All the factors are determining since they date back to the history of the installation	Technical Design Organisational planning Man-machine interface design

METHODS FOR SAFETY STUDIES INCLUDING THE ASSESSMENT OF ORGANISATIONAL IMPACT

MORT

HPES
ASSET
MTO, ORGRIP

HAZOP (?)

RATHER THAN TO USE BLINDLY METHODS IT IS MORE IMPORTANT TO UNDERSTAND THE CONSTRAINTS (E.G. TIME, HIERARCHY) AND THE REQUIREMENTS (E.G. SPEED, EFFECTIVENESS) UNDER WHICH THE DECISIONS ARE MADE IN REAL ORGANISATIONS

AVOIDING HUMAN ERRORS

feedback on actions

interlocks

procedures

operator support systems

training

organizational measures

CONCLUSIONS

IT IS POSSIBLE TO STUDY HUMAN FACTORS
WITH LIMITED RESOURCES

THE HUMAN ACTIONS ARE
TIME/PLACE/INDIVIDUAL SPECIFIC

QUANTITY IMPROVES QUALITY

INTERPRETATION OF RESULTS IS IMPORTANT

CORRECT MANAGEMENT ATTITUDE TOWARDS
THE HUMAN FACTORS IS VITAL

CONSEQUENCE ANALYSIS IN CHEMICAL RISK ASSESSMENT

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ABSTRACT

A review on consequence analysis in chemical risk assessment. This paper illustrates the procedure used in a quantitative top-down analysis of risk assessment. Then some problems in the identification of hazards and assessment of consequences are discussed. Finally recommendations for reducing uncertainty and future development of consequence analysis in risk assessment are presented.

1 INTRODUCTION

Consequence and risk analyses are increasingly employed in the process industry to assure the safety of old and new installations. So far this use has been voluntary, but in the beginning of 1980's and particularly since the EC-directive 82/501 (1982) legislation in several countries has given authorities the opportunity to require a consequence and/or risk analysis on installations using hazardous materials in their processes.

This paper presents a short description of consequence and risk analysis methods used in Finland. Some problems and limitations concerning the identification of hazards and consequences of accidents are discussed in general. Finally, some future needs of consequence and risk analyses are presented.

2 COMMON PROCEDURE CARRYING OUT CONSEQUENCE ANALYSIS IN RISK ASSESSMENT

In carrying out risk assessment of a chemical process plant containing toxic and/or flammable gases it is necessary to

- identify and subsequently quantify the potential hazardous events;
- determine the behaviour of the material after its release e.g. gas concentrations versus distance from release point;
- calculate the risks of release cases. Apply toxicity data, information about ignition points and ignition probabilities, and take account the wind and weather data. Summation of risks of significant releases separately for the toxic and the flammable cases.

Figure 1 shows distinct stages in estimating the potential consequences and risks

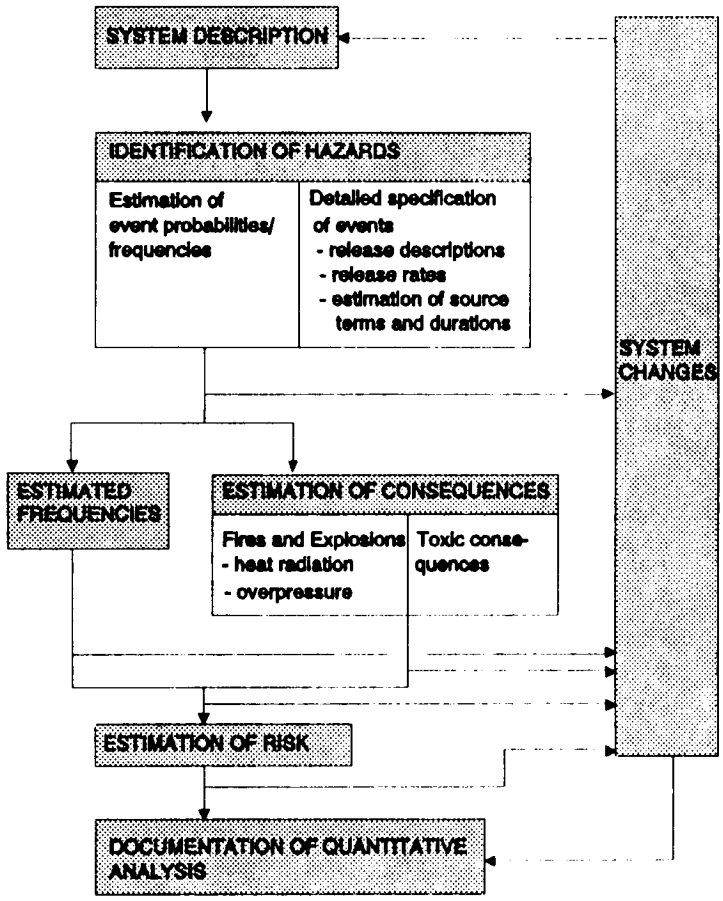

Figure 1. Main phases of safety analysis on chemical installations and the connections with system changes.

of toxic and/or flammable gases. The decision as to the level at which the analysis is stopped is made on the basis of the complexity of the activity for analysis and the potential risk.

The objective of a consequence analysis is to quantify the harmful impacts of potential events. In consequence analysis, the two main harmful characteristics associated with a gas are its toxicity and/or flammability. Potential consequences of hazardous releases are exposure to: toxic materials; missiles and overpressure from explosions; and thermal radiation. Such a consequence analysis requires data on chemical, physical and toxic properties of the chemicals, weather statistics and locations of ignition sources. Figure 2 shows the main phases of consequence analysis.

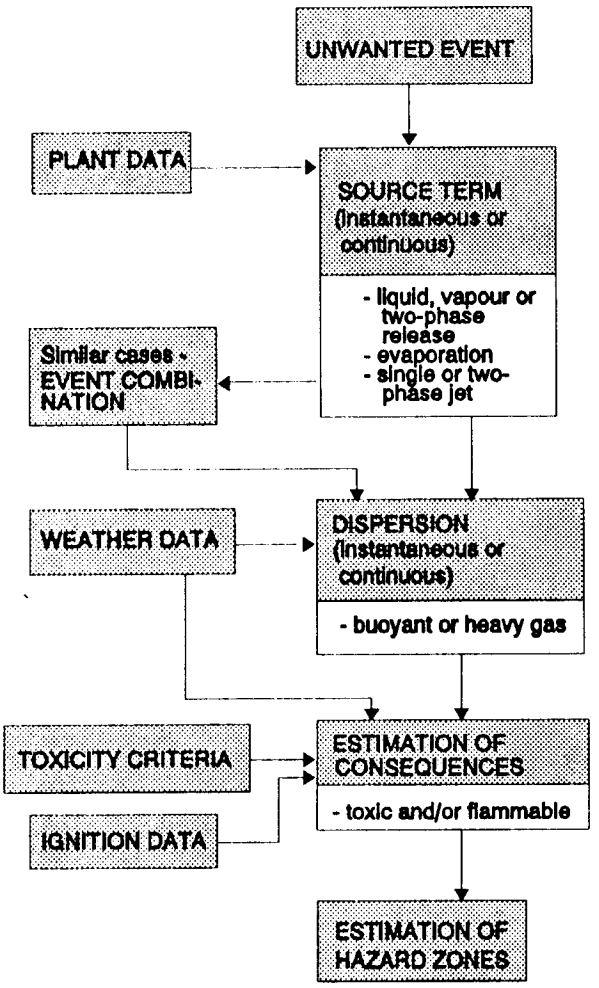

Figure 2. Main phases of consequence analysis concerning chemical releases.

The final result for a given toxic material is an exposure estimate for each event of concern and the different levels of severity of these events. Fire and explosion models convert the information on the cloud for flammable releases into hazard potentials such as thermal radiation and explosion overpressures. Effect models convert these casespecific results into effects on people (injury or death) and structures. Additional refinement is provided by mitigation factors, such as sheltering or evacuation, which tend to reduce the magnitude of potential effects in real accidents.

3 COMMON PROBLEMS OF CONSEQUENCE ANALYSIS METHODS

A substantial amount of research has been conducted to minimize the uncertainty which exists in many of the models applied to consequence analysis. Nevertheless, because much is still unknown about the phenomena behind the models and because many of the phenomena are intrinsically random, significant uncertainties remain in most consequence analyses [Amendola 1986].

In a consequence analysis, an important feature of many of the physical models should be the ability to extrapolate from the results of relatively small-scale experiments to large-scale accidental releases. All models suffer to some degree from errors arising from extrapolation, but those that are the best from this point of view are the ones that have a sound fundamental basis and the minimum of empirical constants [Rijnmond Report 1982]. Table 1 presents a summary of the main deficiencies in models employed in the different phases of consequence analysis.

In order to estimate the final consequences of various accidental cases, it is necessary to use exposure-response relationships for determining the degree of harm to people, property or the environment. For flammable substances, such response relationships are associated with heat radiation and/or explosion overpressure and they have been identified by experiment and/or experience. For toxic substances such relationships are not readily so identified and the experience of the effects on people and the environment is very limited for many substances.

Table 1. A summary on the main problems of the models in consequence assessment [Rouhiainen 1990, Slater et al. 1986, Harris 1987, Nussey and Pape 1987, Hanna and Drivas 1987, Kakko 1990].

Phase of the conseq. analysis	Deficiencies and restrictions
Source term	Only a limited number of spill scenarios have been modelled. There are no models for multicomponent materials
	Some models have had limited testing and their uncertainties are not well known
Dispersion	Some variation in the results of heavy gas dispersion models
	Only few models exist for estimation of the effects of topography and obstacles
Estimation of consequences	
A. Toxicity	Great variation in existing toxicity data and in the application of the data
B. Flammable	Unconfined vapour cloud explosions (The effects of obstacles and partial confinement are not enough understood)
Estimation of hazard zones	Escape of people difficult to include, because of unpredictable behaviour of people in accidents
	The effects of obstacles or topography cannot be estimated

In applying risk assessment techniques to loss prevention in chemical plants, there are several theoretical problems encountered with some of the calculations. One of the major problems is the time-variability of a failure case. Another problem is connected with the so-called "worst case approach" which is often used in safety analysis. This approach is in many cases, however, questionable because of the extremely low probability of the "worst case". In practice, the event frequency often increases rapidly as the release rate decreases. Often so-called "design base accidents" are used instead of the "worst case" approach in order to define the extent of consequences and the types of accidents considered as reasonably possible and to be included when planning risk reducing measures in a plant.

As an example of the respective contributions of frequency and consequence to the total risk consider a pipeline for anhydrous ammonia. The diameter D of the pipeline is 305 mm and its length 680 m. Ammonia temperature and pressure are, respectively, 20 °C and 7.6 bar. Three hole sizes whose estimated frequencies are given in Table 2 are considered as possible ruptures.

Table 2. Source terms and event frequencies of a pipeline release [Kakko 1990].

Length of the pipe [m]	Hole size	Source term [kg/s]	Basic event frequency [$x10^{(-6)}$/m/year]	Event frequency [$x10^{(-6)}$/year]
680	D	52	2.5	1 700
	D/2	26	3.8	2 580
	D/4	11	17.5	11 900

The individual risk of a person outdoors receiving a lethal toxic dose was calculated with the program RISKIT [Kakko 1989, Kakko and Haapavirta 1990]. A 10 min exposure to a 5000 ppm concentration was takes as the minimum toxic dose causing death. The example case was calculated for the Pasquill stability category D and wind speed 5 m/s, only. All wind directions were assumed to be equally probable and the isorisk curves were, consequently, concentric circles.

The total individual risk and the contributions of the three hole sizes calculated at 50 m intervals are given in Figure 3. The curves for the hole sizes D/4 and D/2 end at 100 m and 200 m, respectively, since the toxic dose attains the minimum value at these distances. It is seen from Figure 3 that the risk at distances up to 100 m is dominated by the smallest hole size D/4 since it has the largest frequency (Table 2). Typically, the high probability - low consequence events dominate the risk close to the plant.

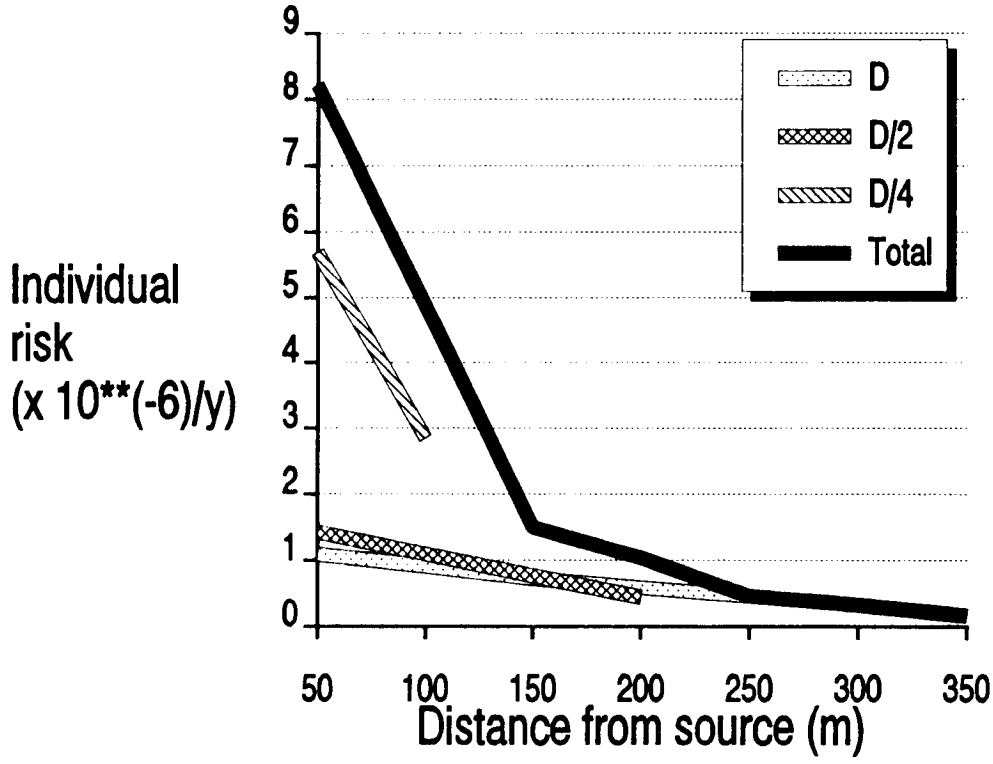

Figure 3. Individual risk values for diffrent rupture diameters (D, D/2 and D/4) when the pipelength is 680 m [Kakko 1990].

4 FUTURE NEEDS

In identification of hazards the information of incidents would help in quality evaluation if good incident descriptions were available. The development of the accident data banks like FACTS [Bockholts 1983] and MHIDAS [Clifton and Wilkinson 1987] improve the access of accident information. Still there remains the problem of the quality of the data. Further attempts should be made to develop a systematic analysis and collection of accident information and critical production disturbances in order to achieve better incident data [Suokas and Kakko 1989].

In consequence analysis the source term models are mostly based on empirical engineering approximations to basic physical principles [Hanna and Drivas 1987]. Only a small fraction of the source models has been adequately evaluated with field data. There are well validated codes for predicting the spreading and time dependency of the vaporization of liquid spills [Webber 1987], but still there are problems in source term modelling. For example, critical two-phase flow is still based on empirical tests and more both experimental and theoretical techniques are needed for predicting two-phase discharges. The situation with transport and dispersion models for hazardous materials is similar, but the number of available models is much larger. In source term and dispersion calculation possible significance of aerosol is still an open area although there has been efforts to improve it [Vesala, Kukkonen and Kulmala 1989]. Also the time-variability of source term and its effects on the cloud propagation is not yet properly modelled.

The main problem in toxicity modelling arises from the possible physiological differences between animals and human. The subsequent extrapolation of animal data obtained from homogeneous populations under controlled conditions to a highly heterogeneous human population which may be in a state of panic and exposed to fluctuating rather than steady concentrations are highly questionable.

In fire and explosion modelling are needed more experiments for investigating the influence of various parameters like; obstacles, degree of confinement, mixture reactivity and ignition location. The extension of heavy gas dispersion into risk assessment for flammable gases is more complex than is generally realized, and requires greater emphasis on a more thoroughly reasoned model to interpret the effects in a more realistic manner.

A very important area which often is poorly considered in risk assessment is the combustion products of chemical substances in chemical plant and storage fires. Often in risk assessment, the fire of a storage facility is considered to be harmless although this kind of fire can give rise to formation of toxic gases.

5 CONCLUSION/SUMMARY

The uncertainties in current risk assessment has been reviewed. Consequence analysis has still some serious problems, concerning the quality of the analysis and the time needed in the analysis. The quality problems mainly involve the level of the identification and consequence analysis and the assessment of their effects. In future, analysis will become more important in comparing siting, layout, and basic design alternatives in investment projects.

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PRRINCIPLES OF QUANTITATIVE RISK ASSESSMENT

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and Automation Technology

CONTENTS

1. INTRODUCTION

2. OBJECTIVES OF QUANTITATIVE RISK ASSESSMENT

3. DEFINITIONS OF RISK

4. PHASES OF QUANTITATIVE RISK ASSESSMENT

5. RISK ANALYSIS MODELS

6. CONCLUSIONS

1. INTRODUCTION

* QUANTITATIVE PERSPECTIVE IS NEEDED IN ECONOMICAL DECISIONS

* PURELY QUALITATIVE INSIGHTS ARE OFTEN INSUFFICIENT

* QUANTITATIVE APPROACH MAY LEAD TO BETTER QUALITATIVE ANALYSES

* EXPERIENCES GAINED FROM NUCLEAR POWER INDUSTRY

2. OBJECTIVES OF QUANTITATIVE RISK ASSESSMENT

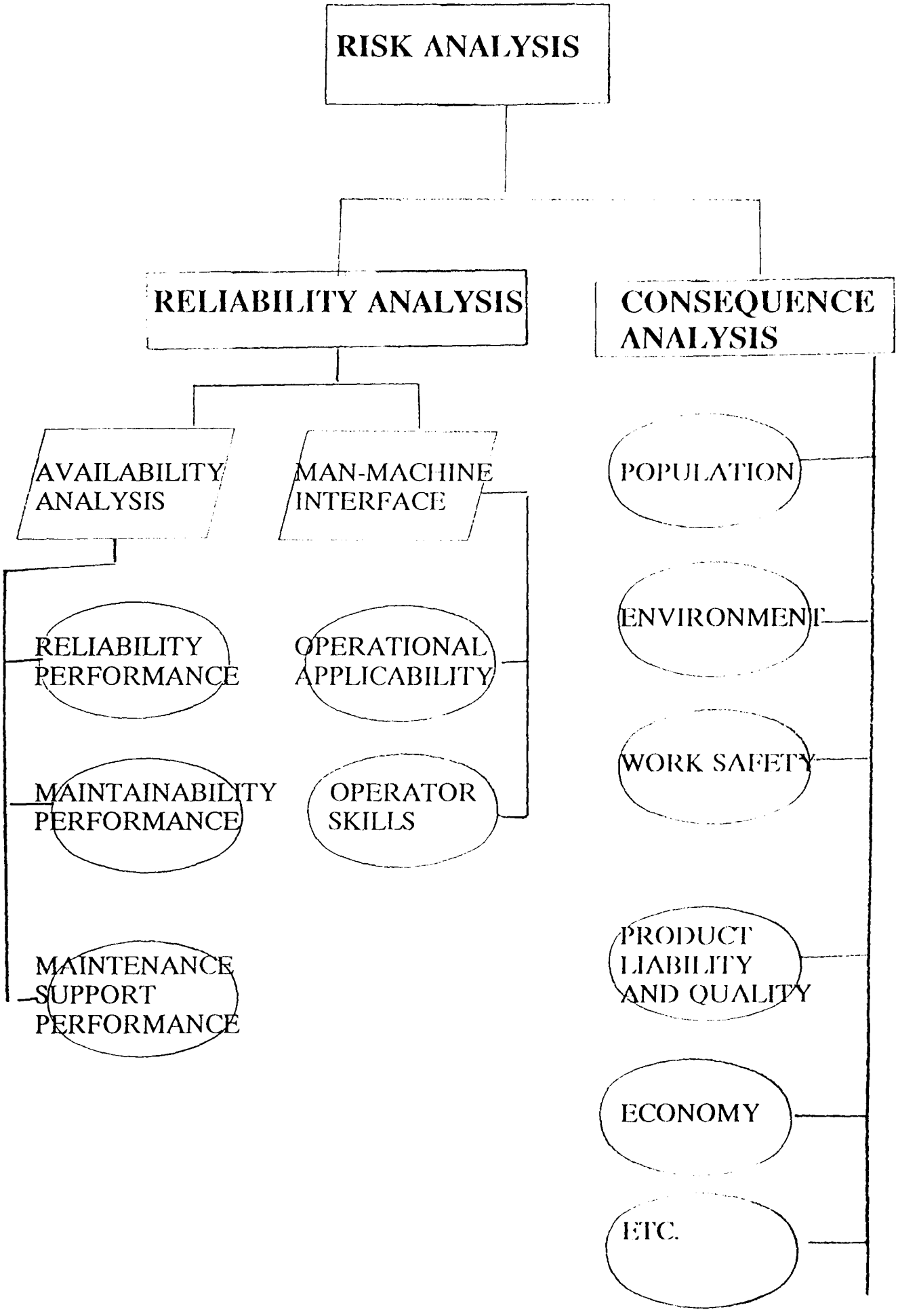
* QUANTITATIVE ESTIMATION OF RISK

* IDENTIFICATION OF MOST IMPORTANT CONTRIBUTORS TO RISK

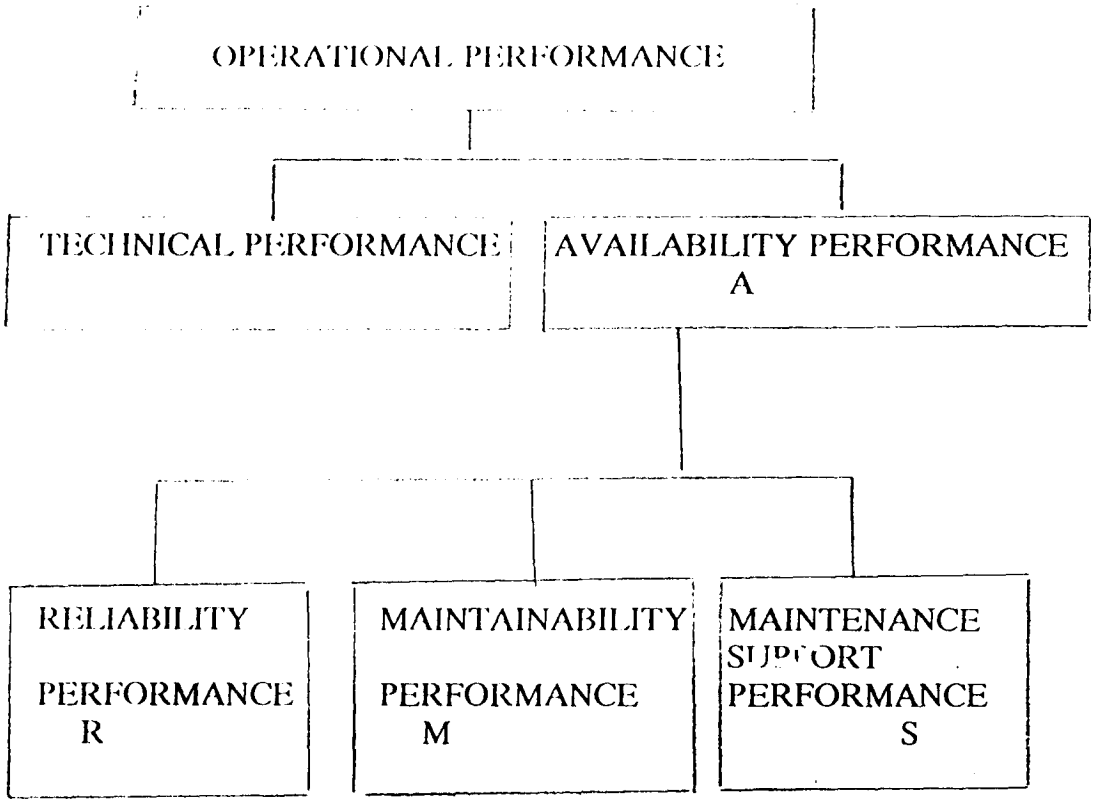
* IDENTIFICATION OF IMPROVEMENT POSSIBILITIES

* COST-BENEFIT ANALYSES

* STRUCTURED VIEW OVER THE SYSTEM


RISK ANALYSIS
RELIABILITY ANALYSIS
CONSEQUENCE ANALYSIS
AVAILABILITY ANALYSIS
MAN-MACHINE INTERFACE
RELIABILITY PERFORMANCE
MAINTAINABILITY PERFORMANCE
MAINTENANCE SUPPORT PERFORMANCE
OPERATIONAL APPLICABILITY
OPERATOR SKILLS
POPULATION
ENVIRONMENT
WORK SAFETY
PRODUCT LIABILITY AND QUALITY
ECONOMY
ETC.

AVAILABILITY OF TECHNICAL EQUIPMENT



3. DEFINITIONS OF RISK

* RISK =

+ POSSIBILITY OF LOSSES DUE TO UNEXPECTED EVENTS

* RISK =

{POSSIBILITY OF HARMFULL EVENT, LOSSES DUE TO THE EVENT}

* RISK =

{UNCERTAINTY, LOSSES OR NEGATIVE CONSEQUENCES}

* A MEASURE OF UNCERTAINTY IS PROBABILITY

* RISK =

{PROBABILITY OF HARMFULL EVENTS, LOSSES DUE TO HARMFULL EVENTS}

* LOSSES : L1, L2,..., Ln

* PROBABILITIES OF THE LOSSES:

P(L1) = P1, P(L2) = P2,...,
P(Ln) = Pn

* RISK =

R = {(P1,L1), (P2,L2),...,(Pn,Ln)}

R = E[L] = EXPECTED VALUE OF LOSSES

R = fL = frequency of accident x losses due to accident

* ALSO MORE COMPLICATED MEASURES OF RISK ARE POSSIBLE:

$R = fL^{a}$,

a = WEIGHTING CONSTANT

* RISK IS MULTIDIMENSIONAL CONCEPT:
  + economical aspects
  + public safety
  + etc.

4. PHASES OF QUANTITATIVE RISK ASSESSMENT

A. SYSTEM FAMILIARIZATION

- the details of the system are studied

- the scope of the analysis is determined

B. QUALITATIVE PHASE

- the most important risks and their consequences are identified

- qualitative methods: HAZOP, potentional problem analysis, etc.

C. MODELLING PHASE

- the structure of the system is described with suitable models
- the models for accident probabilities are constructed
- the statistical data on component and system failure probabilities is collected and analysed
- the models for the amount of the consequences of accidents are constructed

D. QUANTIFICATION PHASE

- the accident probabilities are calculated using the models
- the consequences are quantified
- sensitivity and importance analyses are performed

E. DECISION MAKING PHASE

- the results of risk assessment are interpreted
- various designs are compared
- design changes are proposed and priorizised

* EXAMPLES OF QUANTITATIVE ANALYSES

- statistical analyses of component failure probability
- systems reliability analyses
- LCC-analyses
- Probabilistic Safety Assessments (PSAs) + nuclear power plant analyses

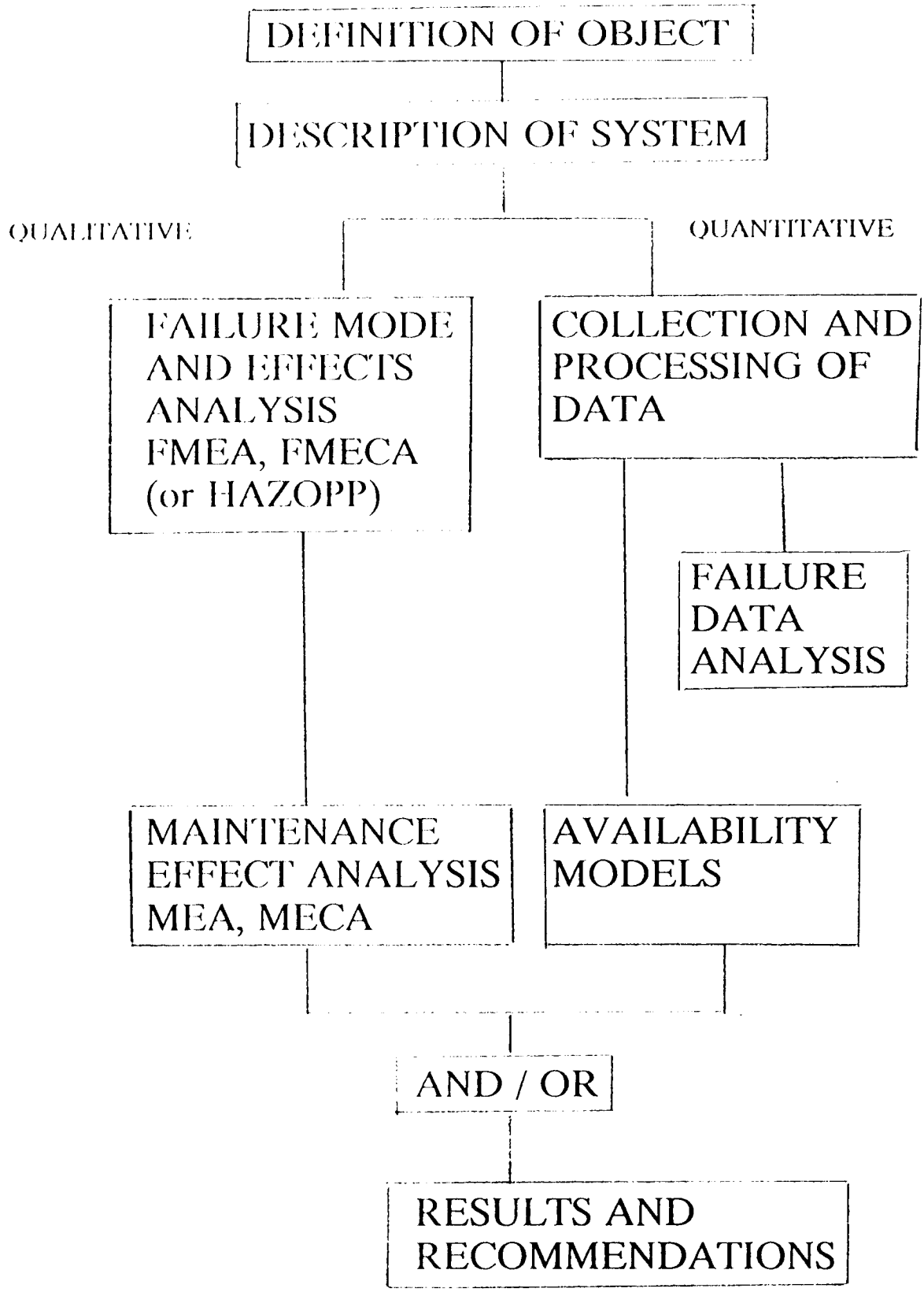


Figure. Example of availability analysis procedure.

5. RISK ANALYSIS MODELS

* COMPONENT FAILURE MODELS:

- models describing the component failure modes and their probability
- lifetime probability distributions
- failure rate models
- empirical statistical models
- repair time models
- models of LCC for components
- example:

  component unavailability = failure rate x mean repair time
- models are based on qualitative analyses at component level (FMEA, MEA, etc.)

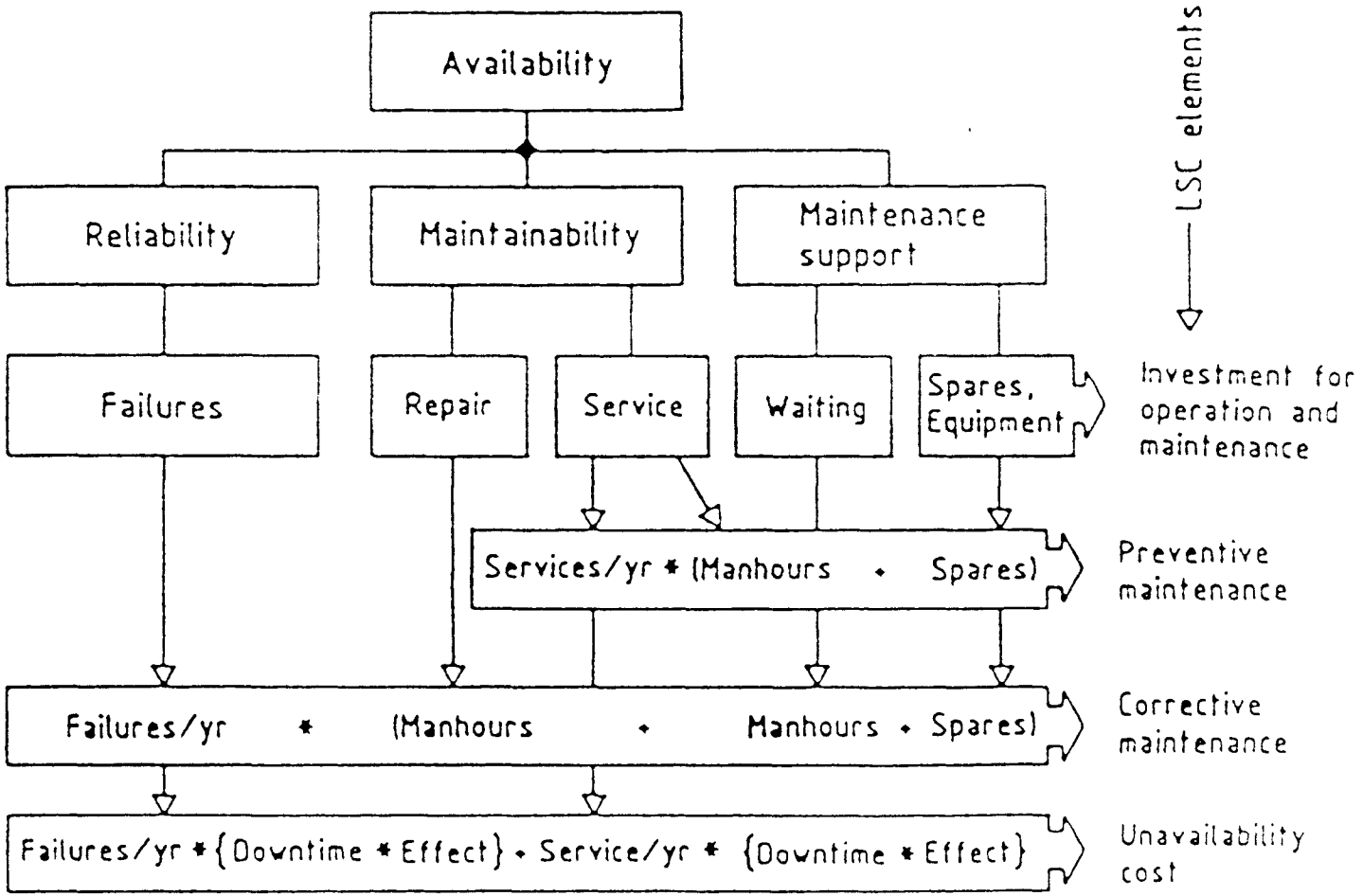


Figure 3

Influence of Reliability, Maintainability and Maintenance Support upon Life Cycle Cost

* SYSTEM RELIABILITY MODELS:

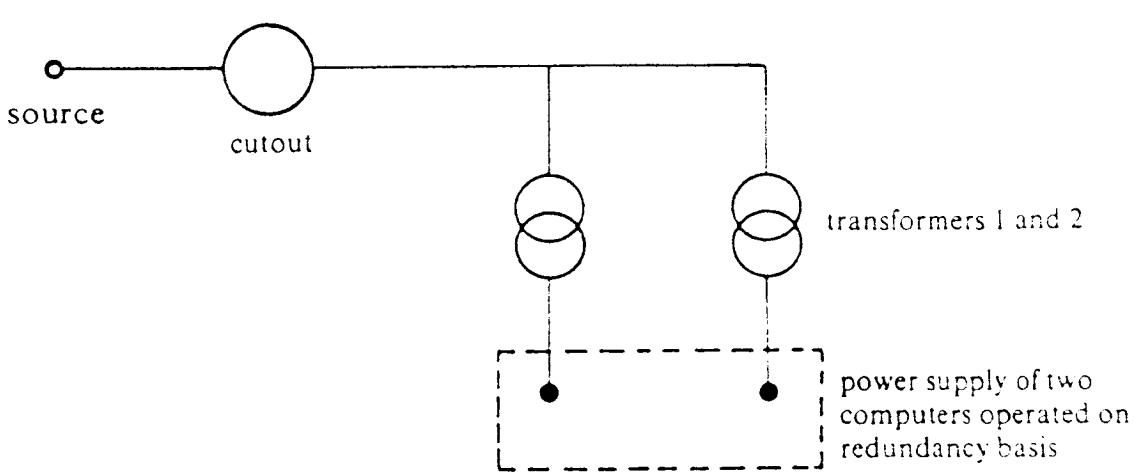
- models describing the failure of the system as a function of component failures

- describe both the structure of the system and the system failure probability

  + fault trees
  + reliability block diagrams
  + Markov-models for system unavailability
  + go-models

- based on the system level qualitative analyses (HAZOP, FMEA, etc.)

- the construction of system reliability models requires knowledge of reliability engineering


source
cutout
transformers 1 and 2
power supply of two
computers operated on
redundancy basis

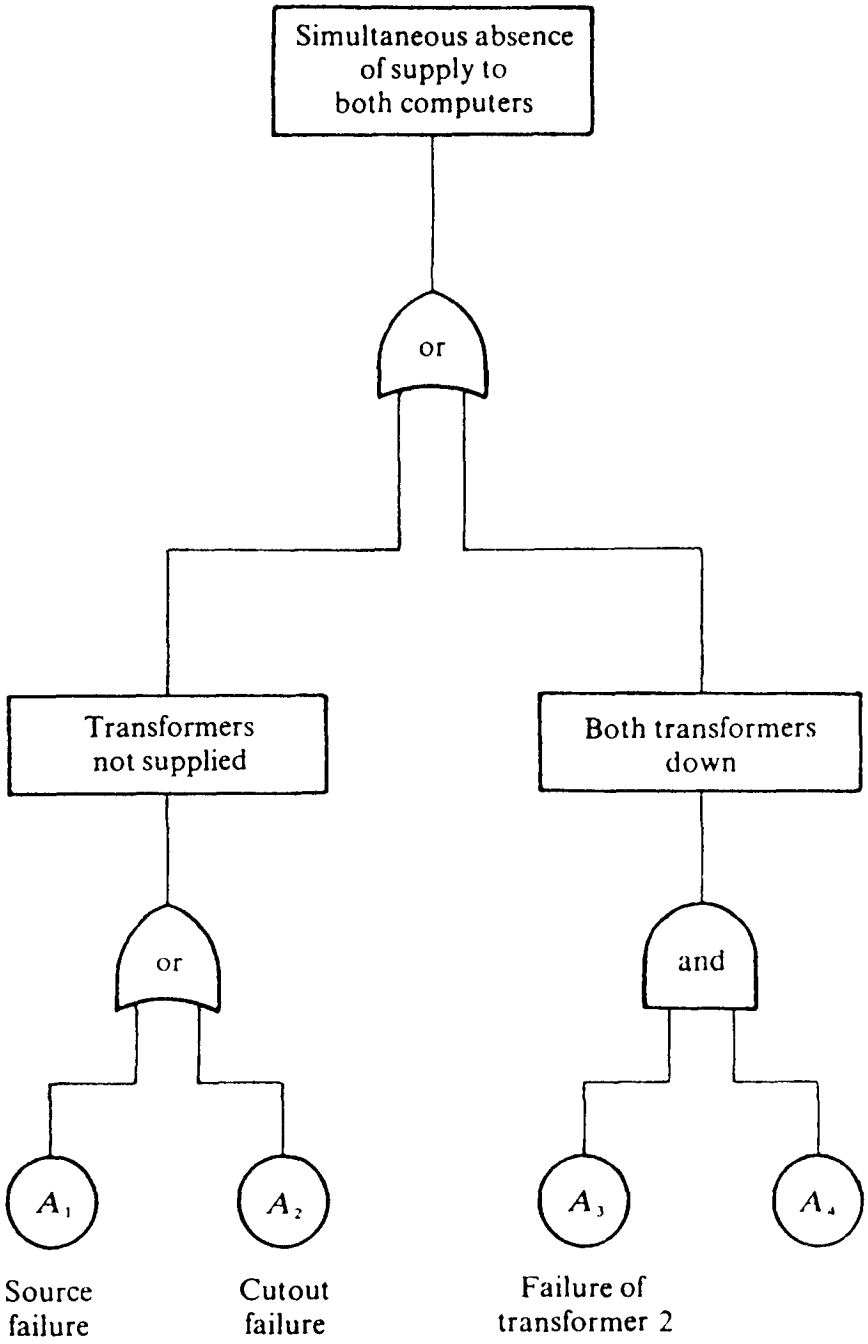


Fig. 5. *A fault tree.*

* ACCIDENT SEQUENCE MODELS

- describe propagation of accident or the structure of accident sequence

- based on physical or chemical models of the process under analysis

  + event trees
  + fault trees
  + cause consequence diagrams
  + go-models
  + etc.

- systems reliability models are often included in accident sequence models

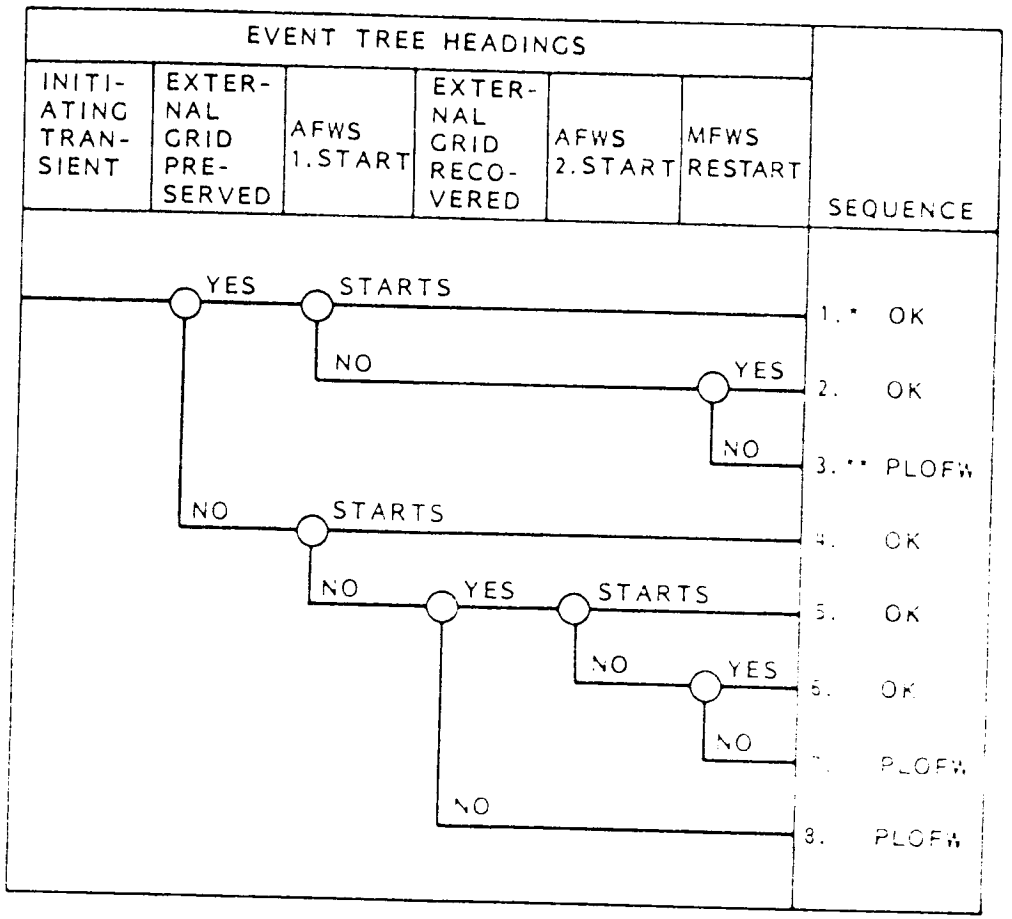


Figure 3.2.2 Sample Event Tree.
The initiating event includes trip of the reactor, turbine and MFWS.
* High Pressure Feedwater available
** Prevaling Loss of Feedwater (Depressurization required).

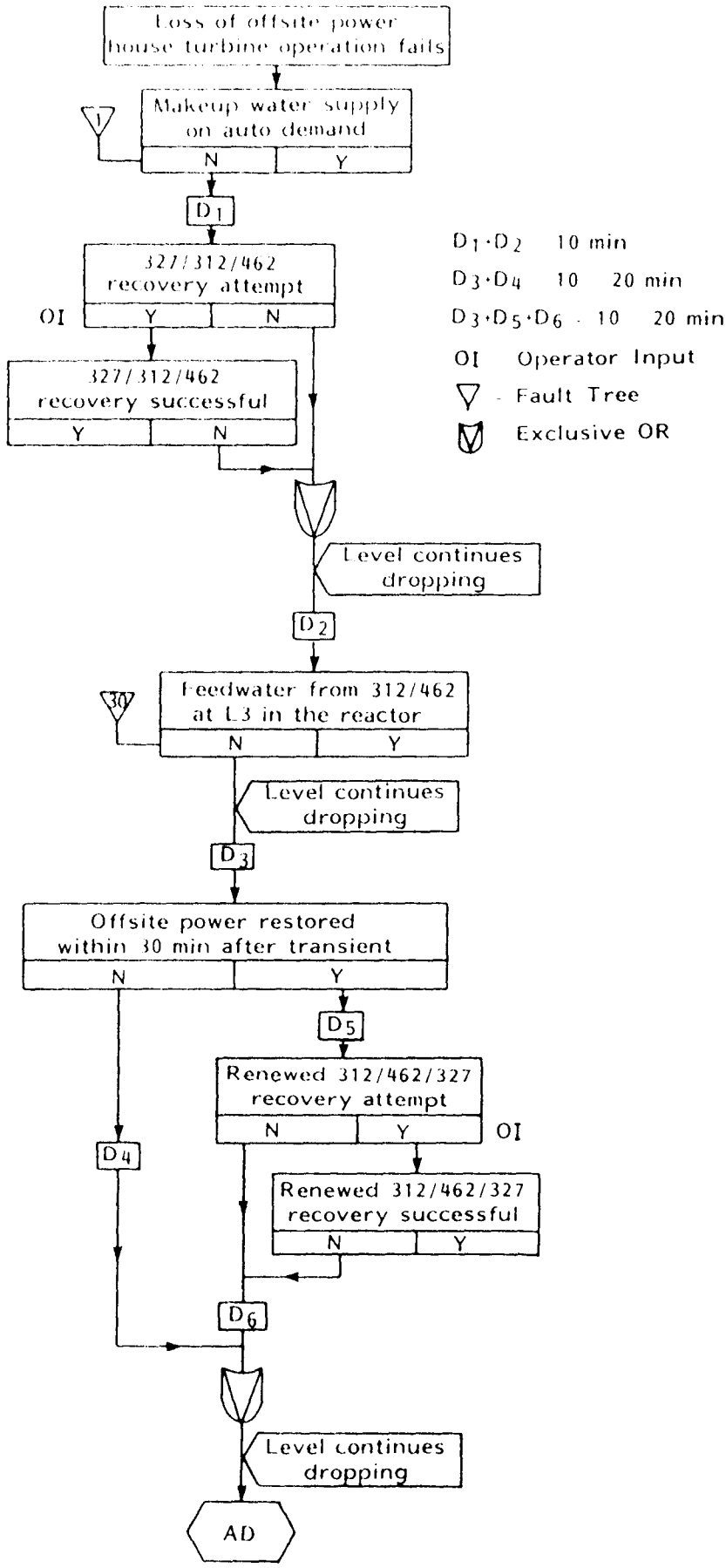


Figure 3.2.3 Sample Cause-Consequence

* MODELS OF ACCIDENT CONSEQUENCES

- describe

  + behaviour of the accident consequences
  + economical value of consequences
  + public health risk

- models for releases from accidents into atmosphere

- LCC-models

* PROBABILITY MODELS

- give estimate of accident probability

- statistical models
  + based on operational experiences and statistical inference

- subjective assessment models
  + based on expert judgements

- compbination of system models, statistics and expert judgement (=risk analysis)

- it is possible to evaluate the uncertainty included in the models!

6. CONCLUSIONS

* QUANTITATIVE ANALYSES ARE NEEDED FOR ECONOMICAL DECISIONS

* THEY MUST BE BASED ON CAREFULL QUALITATIVE ANALYSES
(which are often enough)

* THEY REQUIRE SPECIAL EXPERTISE AND KNOWLEDGE ON RATHER THEORETICAL METHODS, but

* THERE ARE ALSO SIMPLE QUANTITATIVE METHODS

* GOOD EXPERIENCES FROM NUCLEAR POWER INDUSTRY

METHODS FOR SYSTEMATIC ANALYSIS OF PLANT DISTURBANCES

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24-27.5.1988. Helsinki, Finland.

METHODS FOR SYSTEMATIC ANALYSIS OF PLANT DISTURBANCES

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ABSTRACT

This paper contains a description of methods to be used in a systematic analysis of opportunities for reducing the number of unplanned production losses.

The use of the model, developed for analysis of operating experience, ensures that possible measures for significantly reducing the number of plant disturbances will be systematically identified, analyzed and ranked.

Emphasis is given to reduction of the number of inadvertent process disturbances, leading to forced outages. This reduction has also a beneficial effect on plant safety, because the number of possible accident initiators is decreased.

Examples of steps included in the model are given as follows:

- collection of incident reports as well as operational and maintenance reports
- detailed analysis of the event sequences and the contributing causes to the plant disturbances in production plants
- identification and quantification of recurring failure events and their long-term trends at a suitable functional level in individual plants
- analysis and ranking of possible, proven or yet unproven, measures for the plants, based on their expected efficiency in reducing the number of production disturbances
- presentation and discussion of incident analyses performed and measures recommended at the plants.

The analysis of process parameters, using a computerized disturbance recording function with a high sampling rate, significantly improves the possibilities to identify the contributing causes to sudden plant incidents.

The model can also be used for comparison of rather similar plants' failure frequencies and trends at the functional group level, in order to identify significant improvements achieved, or opportunities for improvements, to be transferred between the plants. The studies performed at Swedish nuclear power plants resulted in several recommendations, which should significantly reduce the number of unscheduled reactor shutdowns and turbine trips and thus reduce the production losses. The recommendations are based on cost/benefit considerations and they resulted in several modifications of equipment as well as improvements of operating and maintenance procedures.

Similar steps as above are now also being further developed, and introduced for analysis and experience feedback of different categories of plant incidents, including technical and human elements, at Imatran Voima Power Company's conventional power plants in Finland.

Application of rather similar methods is also recommended for the specific processes in other complex industries to be used effectively in the fields of design, maintenance, operational and training improvements.

BACKGROUND TO THE INCIDENT ANALYSIS METHODS DEVELOPMENT

The background to the basic study [1] was that the reduction of inadvertent process transients in a nuclear power plant has a beneficial effect on nuclear safety and on unanticipated production losses. Sufficient reason existed therefore to aim at decreasing the plant disturbance frequency even further. Such a reduction of transient frequency would also lead to a reduction of thermally, dynamically and electrically induced stresses that may contribute to leakage or damage in equipment.

The basic model [1, 2] was earlier developed for follow-up and analysis of BWR plant operating experience in Sweden. The nuclear power units studied were of earlier Asea-Atom design and they (Oskarshamn 1 and 2, Ringhals 1, Barsebäck 1 and 2) are owned by Swedish utilities. The study covered an analysis and feedback of a total of 44 years operating experience.

The methods were applied in analysis of plant disturbances leading to reactor shutdowns, turbine trips and generator load rejections in these units.

This research project was performed under the auspices of the Swedish Nuclear Power Inspectorate, in close cooperation with Swedish power utilities, within the Engineering Department of Asea-Atom.

The steps in the model are now being further developed, completed and applied for systematic analysis and experience feedback of different categories of plant incidents, including human contribution, at Imatran Voima Power Company's (IVO) conventional power plants in Finland.

An attention in the present study [3] will also be given to the sector, where the methods and model now described are being applied and developed to concern the production losses, material damages, near-misses and other significant incidents at IVO's conventional power plants.

The joint development work between IVO and the Technical Research Centre of Finland (VTT) has concerned the Inkoo coal-fired 1000 MW power plant consisting of four similar 250 MW electricity producing units [3].

Particular emphasis has been laid on finding out the technical and human elements and how to distinguish them in a proper way, so that the results could be used effectively in the fields of operation, maintenance and design, as well as in the safety analyses, quality assurance and training.

METHODS UP TO DATE DEVELOPED AND USED FOR THE ANALYSIS

The first analysis step, in the basic model for feedback of plant disturbance experience in nuclear power plants, was to perform individual incident analyses.

The sequence of power plant disturbances, including the failure functions and human errors contributing to reactor shutdowns, turbine trips and generator load rejections, has been analyzed using the event reports or analyses, operation reports and maintenance reports from the power plants as source material. Additional information, concerning the disturbances occurred and the corrective actions realized or planned, has been collected through discussions at the units. The preliminary event analyses prepared have then been used as source material for discussions with the operational management and personnel.

To be able to systematically identify the contributing causes to the plant disturbances, and to divide the contributing causes into failure types, five different failure types were defined. The failure types are shown in Table I.

Table I Failure types

1. System malfunction - Unsuitable design due to insufficient knowledge of behaviour of process variables or of man-process interface - Insufficient capacity - Poor redundancy
2. Component failure - Component unsuited to the environment - Unreliable component which can be a result of poor preventive maintenance or ageing
3. Inadvertent protection function - Protection function was tripped even though the event would not have caused any damage (if the trip had not occurred)
4. Testing - Intentional trip due to planned test - Unplanned trip initiated during testing
5. Human error - Incorrect, incomplete or unclear operating instructions (procedures) - Deviations from operating instructions

The failure types are specified so that each one is matched with one type of corrective action required.

Improved specification, planning, functional testing or follow-up of maintenance, for example, can be needed in improving the human performance contributing to the failure type 2. A poor human performance in turn can be caused by organizational deficiencies.

Implementation of suitable information presentation in control room or improved operating instructions, for example, can be required in eliminating the human errors, included in failure type 5.

In order to be able to systematically divide the contributing causes, including human errors, to the plant parts and equipment involved, a suitable functional group division was developed for the Swedish BWR nuclear power units.

A rough functional division of a complete nuclear power plant is shown in Fig. 1 as follows.

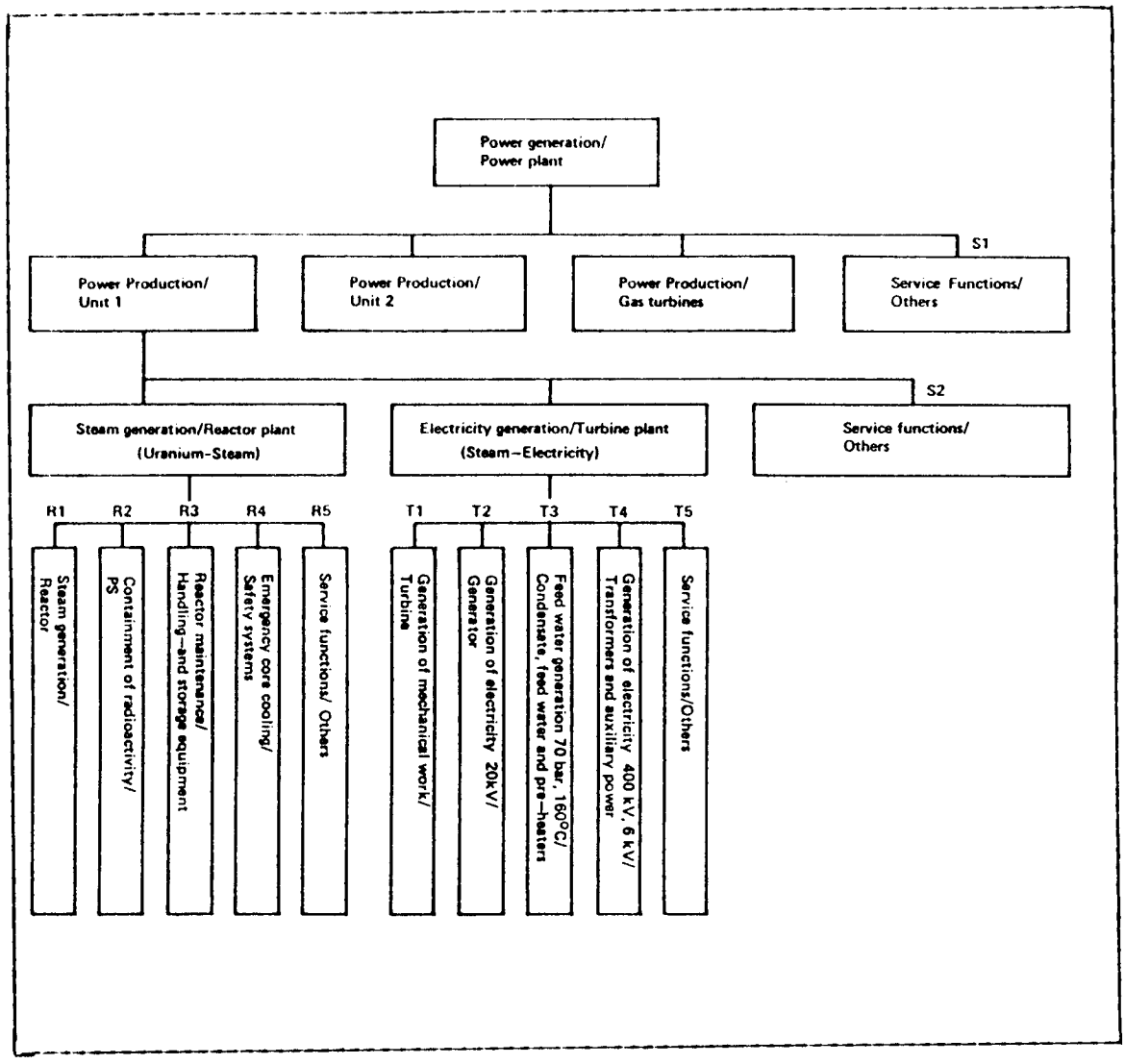

Fig. 1 Breakdown of the power plant into functional groups

These functional groups (FG) have been made similar for the different units. Therefore these FGs can also easily be used for transfer of operating experience between the different units at the functional group level. Quantification of failure functions and human errors occurred during several incidents, and identification of corrective actions implemented and improvements achieved in individual units, can be performed using trend analyses of these functional groups.

This detailed functional group division is also based on function, and not on the hardware, which makes a functional analysis of the plant disturbances easier than by using the traditional plant system and equipment classifications.

An example of an incident analysis is shown in Fig. 1 as follows.

EVENT ANALYSIS - UNIT 2

BLOCK 2 DATE 760714 TIME 11.10 SKI NO 2-4/76

TRIPPING CONDITION
1:
2: TSS TURBINE TRIP
3: SS10 EXTRA HIGH NEUTRONFLUX RELATIVE TO CORE COOLANT FLOW

	OPERATIONAL DATA BEFORE DISTURBANCE	OPERATIONAL DATA AFTER DISTURBANCE
OPERATIONAL STATE	B	
REACTOR POWER (MWT)	1200	
MC-FLOW (KG/S)	3100	
CONTROL ROD CONFIGURATION	9160	
GENERATOR POWER (MWE)	365	000

FAILURE EVENTS	FUNCTIONAL GROUP	FAILURE TYPE
1. IMBALANCE PROBLEMS OCCURED IN THE TURBINE.	T1:04	1
2. AN ATTEMPT WAS MADE TO COUNTER THE VIBRATIONS, BY INCREASING THE BEARING OIL TEMPERATURE, WITHOUT ANY SUCCESS. ON REDUCING THE TEMPERATUR TO NORMAL OPERATING LEVEL, VIBRATIONS INCREASED FURTHER LEADING TO TURBINE TRIP.	T1:04	4
3. THE MISMATCH OF TURBINE INLET VALVES AND BYPASS VALVES CAUSED A PRESSURE TRANSIENT IN REACTOR CORE.	T1:10	1
4. A "VERY SHORT LIVED" INCREASE OF THE NEUTRON FLUX IN THE CORE RESULTED IN TRIPPING OF REACTOR SCRAM (SS10).	R1:02	3

FUNCTIONAL GROUPS: (FUNCTION/EQUIPMENT)

R1 STEAM GENERATION/REACTOR
R2 CONTAINMENT OF RADIO-ACTIVITY/PS
R3 REACTOR MAINTENANCE/HANDLING AND STORAGE EQUIPMENT
R4 EMERGENCY CORE COOLING/SAFETY SYSTEMS
R5 SERVICE FUNCTIONS/OTHERS

T1 GENERATION OF MECHANICAL WORK/TURBINE
T2 GENERATION OF ELECTRICITY 20KV/GENERATOR
T3 FEED WATER GENERATION 70 BAR, 180 C/CONDENSATE, FEED WATER AND PRE-HEATERS
T4 GEN. EL 400 KV, 6 KV /TRANSFORMERS AND AUXILIARY POWER
T5 SERVICE FUNCTIONS/OTHERS

S1,S2 SERVICE FUNCTIONS/OTHERS

FAILURE TYPES:

1 SYSTEM MALFUNCTION
2 COMPONENT FAILURE
3 INADVERTENT PROTECTION FUNCTION
4 TESTING
5 HUMAN ERROR

Fig. 2 Incident analysis. An example

It should be noticed that one plant incident, e.g. reactor scram (forced shutdown), is usually caused by several interacting failure events and/or functional deficiences in different plant parts and functional groups of the unit. E.g. an automatic scram is seldom caused by a sole failure event only.

In the example incident analysis a human activity is identified as the secondary contributing cause involved in the disturbance sequence. The testing/calibration attempt (failure type 4), performed by the plant personnel, initiated unintentionally the turbine trip, which lead to a reactor scram (forced shutdown).

A computerized disturbance recording, of both analogue and digital process signals, has in many cases facilitated excellent information of the process behaviour during these or similar incidents occurred at the TVO power plant in Finland. The analysis of process parameters, recorded at some units by these means with a very high sampling rate, has thus significantly improved the possibilities to understand the contributing causes, including operator actions, to these sudden disturbances.

The incident analyses, similar to Fig. 2, were commented by and discussed with the personnel at the units prior to the final documentation. All 625 event analyses, worked out for the earlier BWR-units, were systematically documented in the similar standardized forms, as shown in the Fig. 2 above. Thus storing of all event analyses in a transient analysis data base was facilitated.

THE MODEL FOR SYSTEMATIC ANALYSIS AND FEEDBACK OF PLANT DISTURBANCE EXPERIENCE

The steps included in the complete model for analysis and evaluation of opportunities, to improve both the plant reliability and the nuclear safety, are summarized in Fig. 3 as follows.

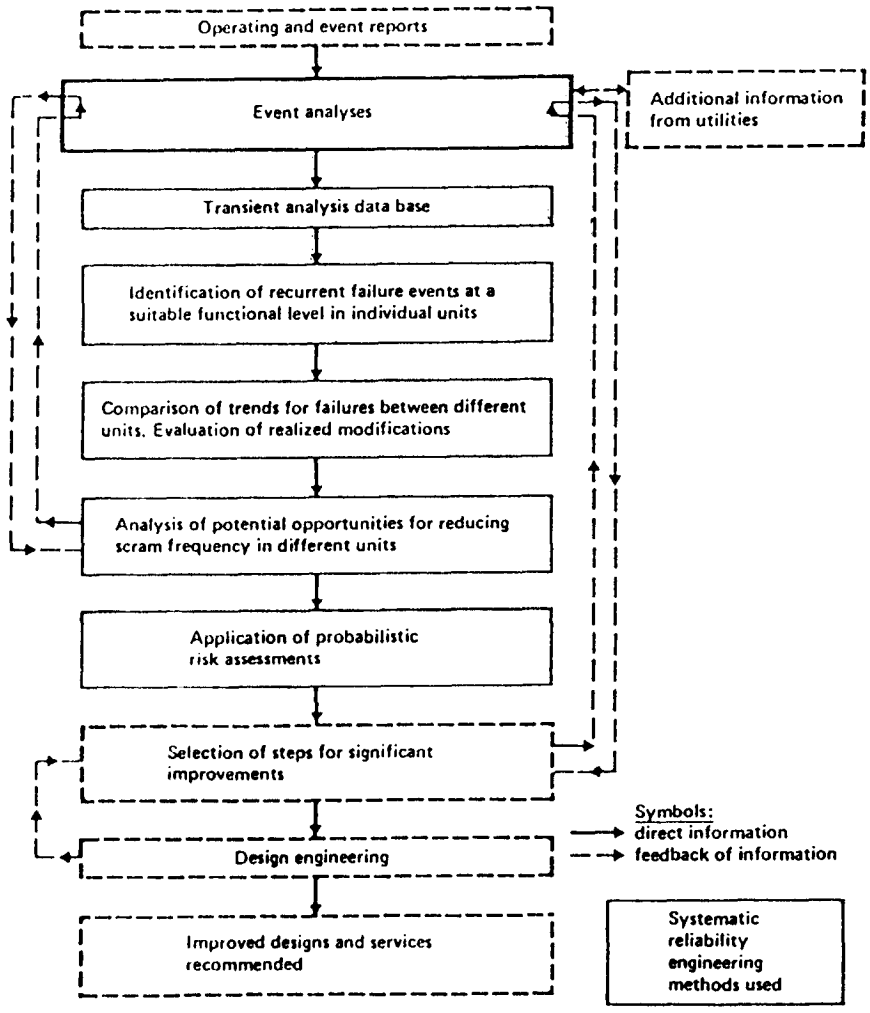

Fig. 3 Steps included in the model for systematic analysis and feedback of plant disturbance experience

It is known that partially similar projects to this, concerning feedback of operating experience or analysis of accident sequence precursors, are being performed in U.S.A. by e.g. the Institute of Nuclear Power Operations, Electric Power Research Institute, Nuclear Regulatory Commission and plant owners and vendors and in other parts of the world. The development work at e.g. the Swedish Nuclear Power Inspectorate [4], the Technical Research Centre of Finland [5, 6] and IVO Power Company [7, 8] has also contributed to tie together the systematic reliability analyses (PSA), the event analyses and human factors analyses in such a way that a systematic feedback is provided to a number of safety activities.

AN EXAMPLE OF SELECTION OF AREAS FOR FURTHER REDUCTIONS OF THE PLANT DISTURBANCE FREQUENCY

Several opportunities for reducing the plant disturbance frequency in individual units have been identified during the earlier analyses performed. As seen e.g. in Fig. 4 below a significant number of failure events, which have contributed to reactor scrams (shutdowns) in Swedish BWRs, originate also from:

- component failures in the turbine plants (which can be a result of e.g. poor planning, performance, testing or follow-up of preventive maintenance).
- operators' human errors (which can depend on e.g. poor instrumentation displays and control equipment or incomplete operating instructions and training).

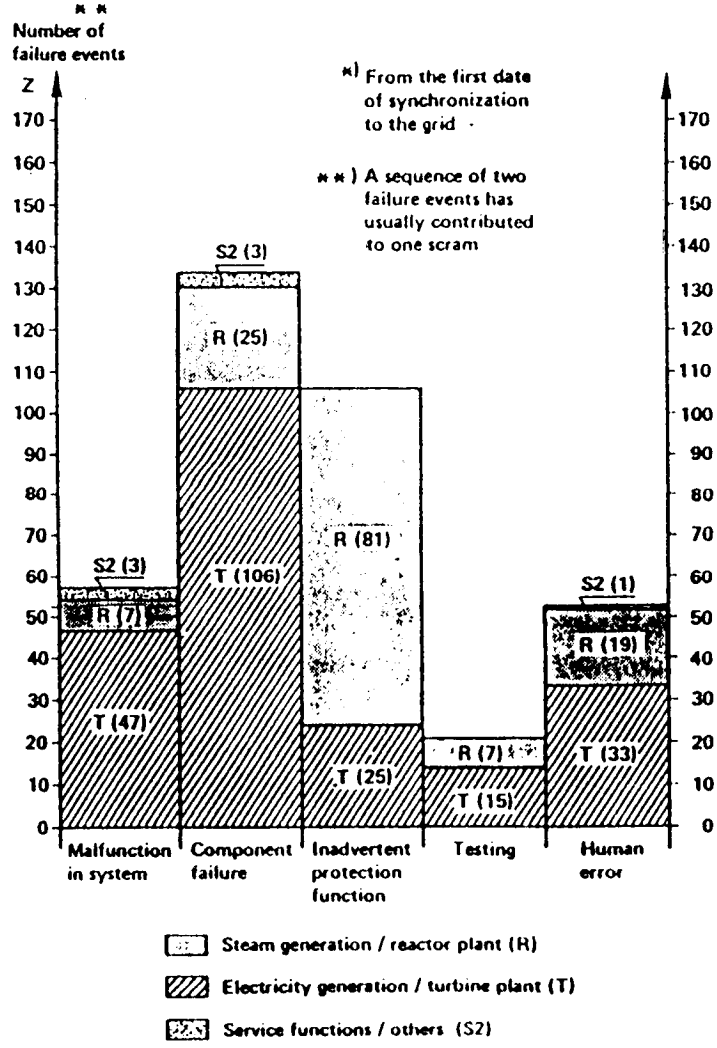

Fig. 4 Reactor scram analysis of a BWR unit. Breakdown of the failure events

ESSENTIAL RESULTS AND FURTHER DEVELOPMENTS OR APPLICATIONS

One important result from the work done earlier [1, 2] is that a model and methods, for systematic analysis and feedback of plant disturbance experience, have been developed and used as a powerful tool for both the plant reliability and safety improvement work. This research project [1] was performed under the auspices of the Swedish Nuclear Inspectorate, in close co-operation with the utilities, within the Engineering Department of Asea-Atom.

Several opportunities, for reducing the frequency of reactor scrams (forced shutdowns) and turbine trips, have been identified during this study of plant disturbance experience. Recommendations for improvements in the operating units have been made and they have resulted in modifications of equipment and improvements of operating and maintenance [9, 10] procedures. These improvements are aimed at eliminating either the primary failures or the secondary contributing causes in the disturbance sequences, otherwise leading to tripping of protection functions at plant level and to losses of the electricity production.

A clear experience exists, arising from the earlier study, that significant reductions of plant disturbances have been achieved, and further reductions can be achieved, with relatively modest efforts and capital costs within systematically selected problem areas. The extra costs for such selected measures (e.g. equipment modifications and improved procedures) in nuclear power units can be compared with expected recurring costs for unplanned power replacement. Viz. in the event of disturbances, a more expensive reserve production from conventional power plants is usually needed.

This analysis also provided an improved understanding of the plant processes, operator actions and maintenance activities, contributing to the experienced disturbances.

The analysis of selected process parameters, using a computerized disturbance recording function with a very high sampling rate, has significantly improved the possibilities to identify and understand rapidly the causes to the failures or failure sequences, leading to near-misses or plant outages.

Further development and application of the analytical methods as presented above, is going on for analysis of various kinds of incidents occurred at the Inkoo coal-fired power plant owned by IVO Power Company in Finland.

The development work started with definition and testing of the structure and contents of the incident reporting (see enclosure 1) primarily required for the experience reporting and feedback within the plant, but also the needs for extraction of this reporting to a central organization for systematic analysis and feedback of the plant disturbance experience is taken into account.

One goal for the reporting at the units, to be jointly performed by the control room personnel and the operational management, is to identify causes and report the whole course of the incident sequence, including human contribution, leading to a plant incident.

The development project will continue with further definition of the methods and model for systematic analysis of the accumulating operating experience to ensure that possible measures for significantly reducing the number of plant disturbances will be effectively identified, analyzed and ranked. Emphasis on the monitoring of weak signals indicating a degraded or improved performance [11, 12, 5] should also be placed.

In order to achieve this goal it is desirable to create a plant incident data base to support and improve the knowledge of e.g. poor and successful operator actions, maintenance activities and designs, which are important contributors in relation to plant disturbances and possible accidents.

The future safety related applications should also concentrate on incidents, which may have a possible effect on the defence-in-depth principle, where several lines of defence could be made inoperable. Thus a systematic operational safety experience analysis should be applied both backwards in the direction of causes and forwards in the direction of possible consequences [5, 12].

The operating experience of equipment and technical systems, as well as man-process interface, in different complex industrial plants, should preferrably be analyzed in a systematic manner by using these kinds of methods. As a results it should be possible to identify cost-effective measures to improve plant reliability in order to reduce the number of incidents, which cause safety risks, production losses or equipment damage in complex industrial plants.

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List of Proposed Contents for an Incident Report at a Conventional Power Plant

(to be reported in succession by the control room personnel and operational management)

INCIDENT REPORT

- Report identification number
- Unit's name
- Author(s)
- Date
- Incident
- Disturbance initiation time
- Incident termination time
- Significant process parameters and other information prior to incident
- Plant operational state prior to incident
- Tripping condition(s), (incl. main technical systems involved)
- Course of the event sequence (from the first deviation identified up to and including the original power level)
- Failure causes
- Corrective actions implemented or proposed
- Operational difficulties in management of the event and lessons learned
- Extra costs
- Costs for energy replacement
- Functional groups
- Enclosures (Alarm lists, process parameter recordings)
- Other investigations
- Checked by/Date

Obs. The primary emphasis is placed on the describing text, but the text is completed with a classification for explanatory and statistical analysis purposes needed.

3. ENVIRONMENTAL MANAGEMENT IN INDUSTRY

3.1 Every Mill is unique

3.1.1 Mill Individualism

A widely spread concept is to consider environmental protection of industrial mills on the basis of industry branch related standards and general orders. This can be called the authorities' point of view or an administrative attitude. For managers and engineers who have to specify problems and to develop solutions, the basic attitude should be to see every mill as an unique one. Otherwise, the measures taken might produce ecologically, socially and economically insufficient results.

Industrial production usually comprises utilization of a complex set of natural resources. There are also numerous technologies available for the production. Therefore, the scope of environmental effects caused by an industrial mill is wide both qualitatively and quantitatively, if all activities are included. In addition to the primary and secondary effects which are caused directly at the mill site there are also considerable tertiary effects from the manufacture of the process equipment and from the production of various raw materials and supplies which are continiously used in production. The numerous alternatives in arranging the whole system results in every mill to be unique.

The assesment of the tertiary effects is a wide ranging and difficult task. Measures and methods are still so called first generation procedures and they are not well enough defined. However, the demand of this kind of assesments will be higher in the future. It must be recognized that the more resources are used for emission control of a mill the more overall adverse environmental effects may be caused. This applies after the certain optimum level of efforts as illustrated in figure 3.1.1.

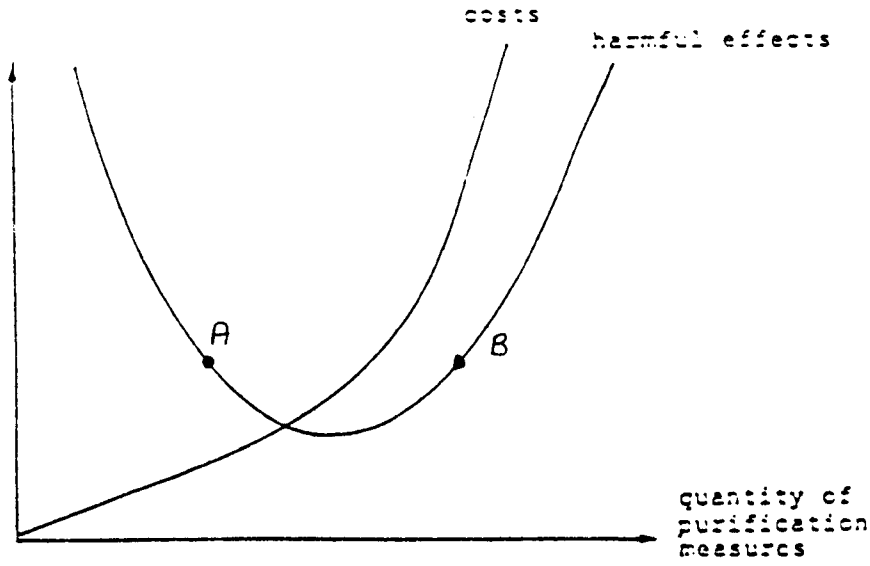

Figure 3.1.1 Overall environmental effects and costs versus the quantity of control measures in mill site (Airanne and Ruonala, 1988, modified Schaumburg effect curve).

The major difference of the two same effect situations A and B in Figure 3.1.1 is that the effects with higher level of control measures are more tertiary and outside the mill site in places where the materials for extensive operation are manufactured and processed.

The tertiary effects are a part of external characteristics of a mill. There are also in-mill characteristics which make every mill unique. The table 3.1.1 describes main factors for causing different characteristics of a mill.

Table 3.1.1 Main Characterizing Factors of a Mill.

In-Mill Characteristics	External Characteristics
Specified type of a product	Geographical and climatic conditions
Process entity	Infrastructural environment
Mill history	Demand of tertiary services

In planning and implementation of an environmental investment the consideration of the overall effects is the wider the more comprehensive the project is. In general, selection and effective use of raw materials and energy are the best means of minimizing the effects which are not directly under the control of the single mill.

3.1.2 In-Mill Characteristics

The selected and available raw materials and aid chemicals and the degree of refinement determine the specified type of the product and give physicochemical characteristics of waste-waters, air emissions and solid wastes. For example, kraft pulp is a common and widely used semi-product name. But it is possible to produce such a pulp from many different raw material sources like scandinavian pine and pruce, eucalyptys tree, straw and bagasse. There are many alternatives for digestive chemicals. Obviously, kraft pulp as a keyword is too general for specifying and seeking environmental protection measures of the certain mill. Another good example of difficulties to utilize generalized information is textile industry. One textile mill may use over three hundred different chemicals by trade mark in a year.

Even when the end product is the same considerable differences may exist due to process entity, which

specially effects in terms of quantity and concentration to the amount of emissions and wastes. Main characteristics of the process entity are in-mill water management, degree of instrumentation, type of a process (continuous or batch) and process devices, degree of an integration to pre- and post-refining processes, and in-mill energy production including energy sources.

The third group of characterizing factors comes from mill history, which particularly determines the need of external purification measures and reconstruction of process. Age and development history of the production process, in-mill sewer system, accidental and non-specified emissions like leakage of pipes, valves, pumps and reservoirs, and an operational practice are typical factors of this group.

3.1.3 External Characteristics

Geographical and climatic conditions give main external characteristics of the mill. The environmental body receiving the emissions and the wastes can vary drastically from place to place. For example, the water body can receive various loads of organics (BOD) depending on its nature (river, lake, sea), temperature and diluting conditions. In an oligotrophic lake only minor rise e.g. in nutrient concentrations can generate severe eutrophication. Climate with extensive rainfall and higher temperature can progress biodegradation of solid wastes but can also create problems by leaching harmful compounds rapidly e.g. from sludges to groundwater.

Climatic conditions can provide good possibilities for applying special methods. Biological and chemical reactions are temperature dependent i.e. the rate increases with increasing temperature. Elevated temperature conditions are attractive e.g. for utilizing anaerobic method for biodegradable material because the net energy yield will be higher due to lower requirements

for reactor heating. On the other hand, a need of cooling water in the production process may be higher.

Quantitative and qualitative water supply sourses, applicable energy and raw material sourses are much dependent on geographical and climatic conditions, but also on infrastructural environment. For example, the sugar cane processing mill can use wastes for in-mill energy production and deliver wastes for pulp and fiber plate production.

The infrastructural environment includes such factors like the local opportunities for combined treatment with municipal or other industrial wastewaters and wastes, the services for hazardous waste disposal, the services for water and energy supply as well as the areal character and extent of agriculture and other industries.

The vicinity of housing is related to accidental risks, smells, noise and aesthetics aspects and leads to tringent environmental requirements for an industrial mill in every respect.

The industrial mill needs the certain amount tertiary services depending on the afore mentioned factors and the market. These include storaging and transportation services, water and energy supply, telecommunication services, waste management and wastewater treatment which all consume energy and produce consequent emissions and wastes outside the actual mill site.

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Training Course on Environmental Management in Industry

In-mill Characterization of Wastewater

Tampere, 16 August

Pertti Keskitalo
Air-Ix Consulting Engineers

ENVIRONMENTAL ISSUES

* FROM LOCAL TO GLOBAL

MASS BALANCE

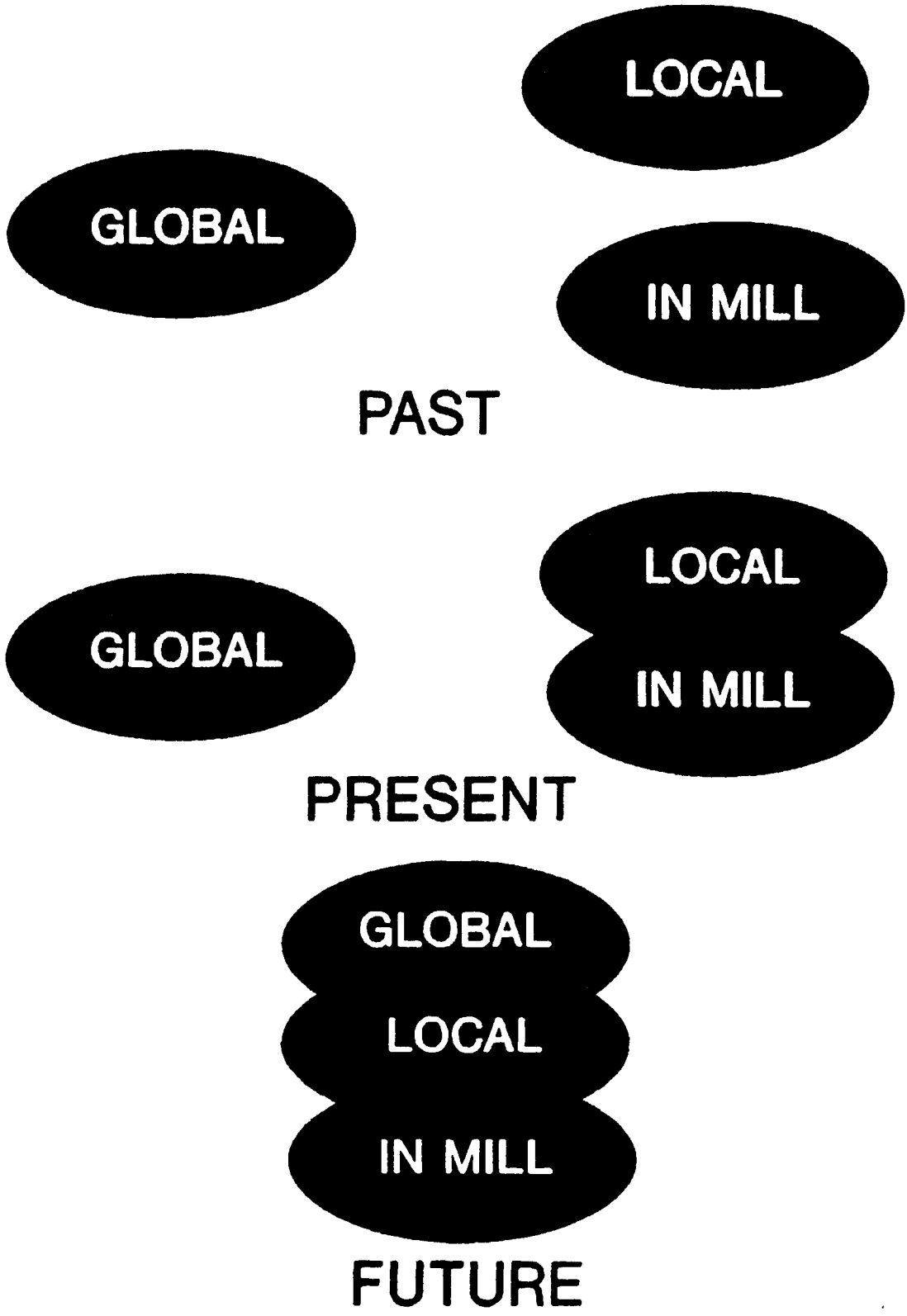
* WATER BALANCE
* WASTEWATER TREATMENT

PROCESS DESIGN

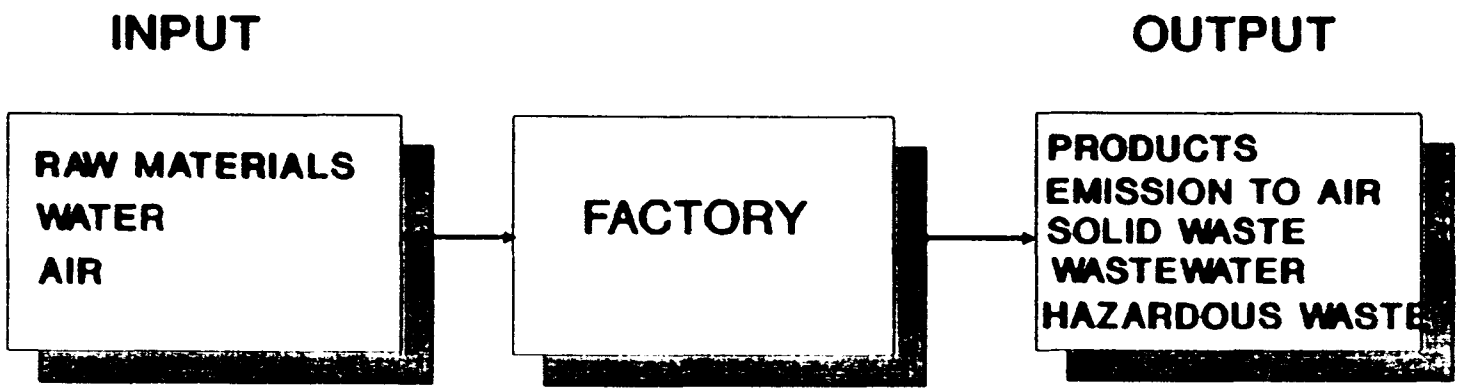
* PROCESS EVALUATION
* WATER SYSTEMS

IN FIELD STUDIES

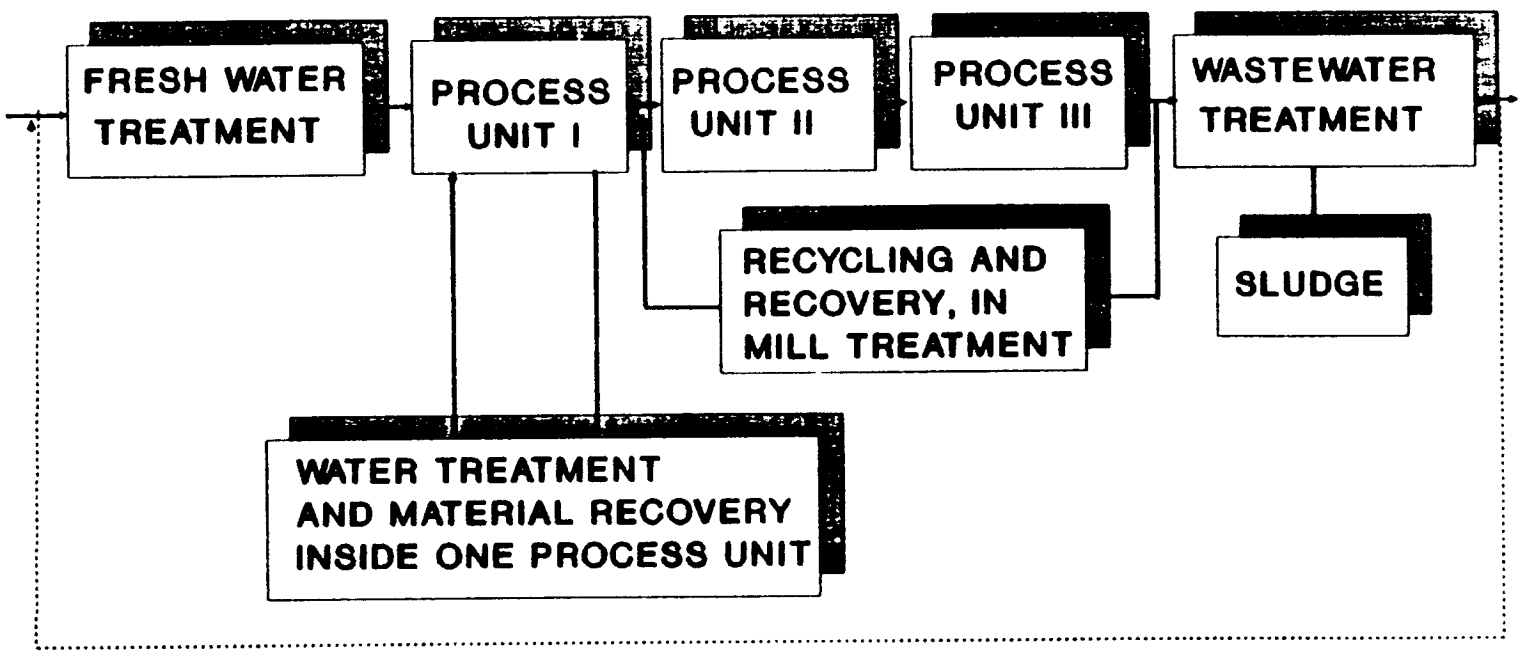
MAIN ISSUES OF THE PRESENTATION



ENVIRONMENTAL ISSUES:
PAST, PRESENT and FUTURE



MASS BALANCE OF A FACTORY



WATER AND WASTEWATER TREATMENT IN A MANUFACTURING PROCESS

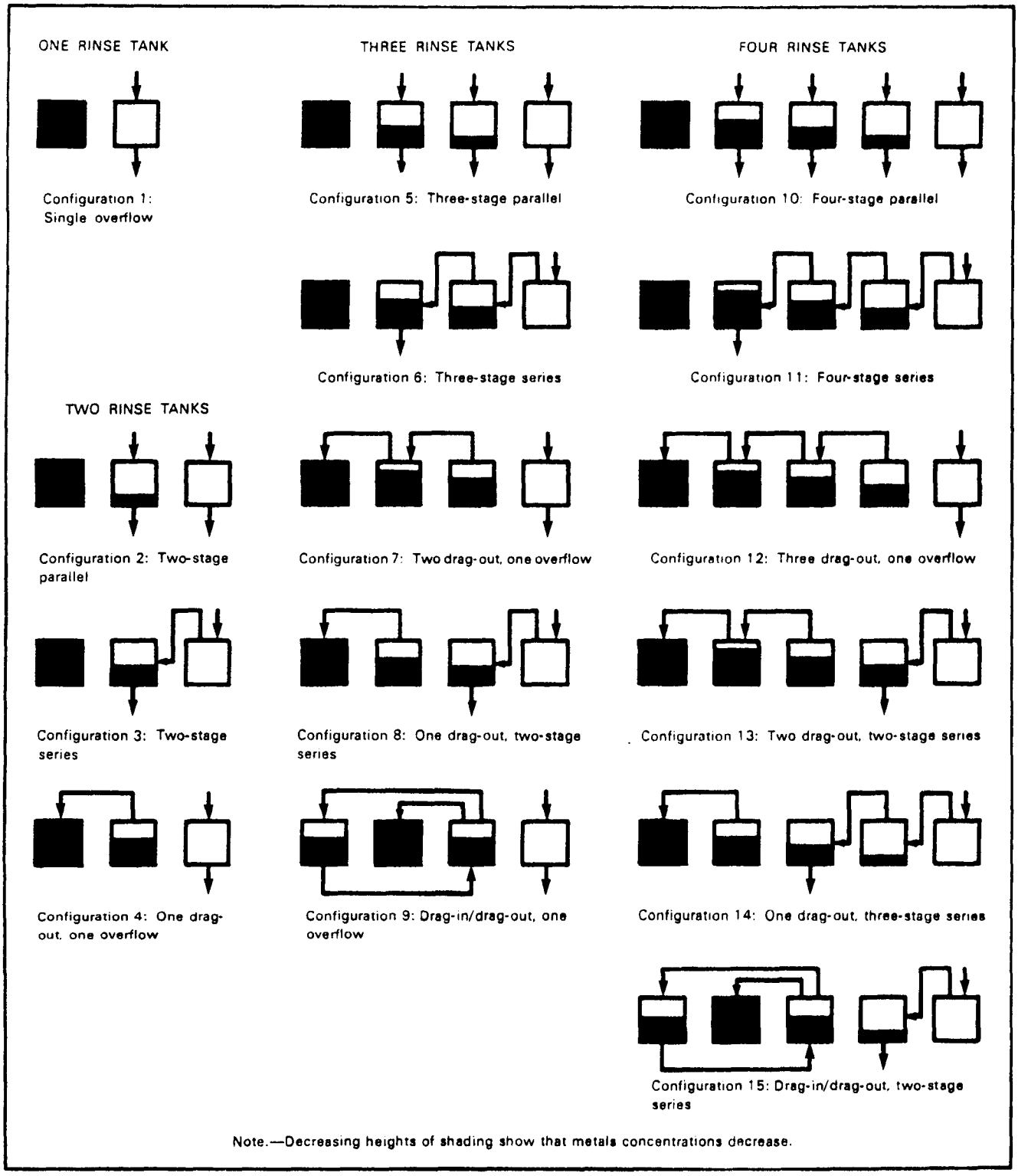


Figure 7.

Rinsing Configurations

WATER-BALANCE STUDY: THE FIRST STEP TO IMPROVE THE IN-PLANT EFFLUENT CONTROL

O. Keski-Saari and P. Rantala

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ABSTRACT

In-plant measures have been found in numerous cases the most economical way of reducing the paper or pulp mill's effluent load. A systematical procedure of a water balance study to help the selection of the most practicable in-plant measures is presented. First the flow-schemes are up-dated then the relevant parameters are selected for the intensive follow-up period. The values of the parameters are recorded at predetermined intervals in a computer's memory. Simultaneously extra water samples are taken from critical points of the system and analyzed. After the follow-up period the material is examined and the water balance is developed. From the results of the study conclusions are made concerning the fresh water consumption, functioning of the white water system as well as the fiber recovery and the effluent load.

KEYWORDS

Paper mills; Water balance; Fresh water; White water, Waste water, Water conservation; Closed systems; Recycling.

ARGUMENTS FOR THE WATER BALANCE STUDY

In-plant water conserving measures have proved an effective way to reduce not only the paper mills' water consumption but the fiber, chemical and energy losses as well. The same modifications of the process that save water can and often do save a great deal of money in the external wastewater treatment too.

The identification of the most econimical in-plant measures for each mill has often proved difficult. In this paper it is suggested that a systematic water balance study should be carried out first. By the study one finds out the background facts that are needed for the decision making. The most common arguments for the water balance study are shown in figure 1.

WATER BALANCE STUDY

Water balance can be studied either in mill-scale or e.g. in only one paper machine's system. Which is more appropriate approach depends on the amount of readily available information and of course the needs in each case.

For practical reasons it is in our experience usually more advisable to concentrate in one paper machine at a time. The mill scale water balance can finally be calculated by adding the parts together. Examples of both mill-scale and paper machine water balances are in figures 2 and 3.

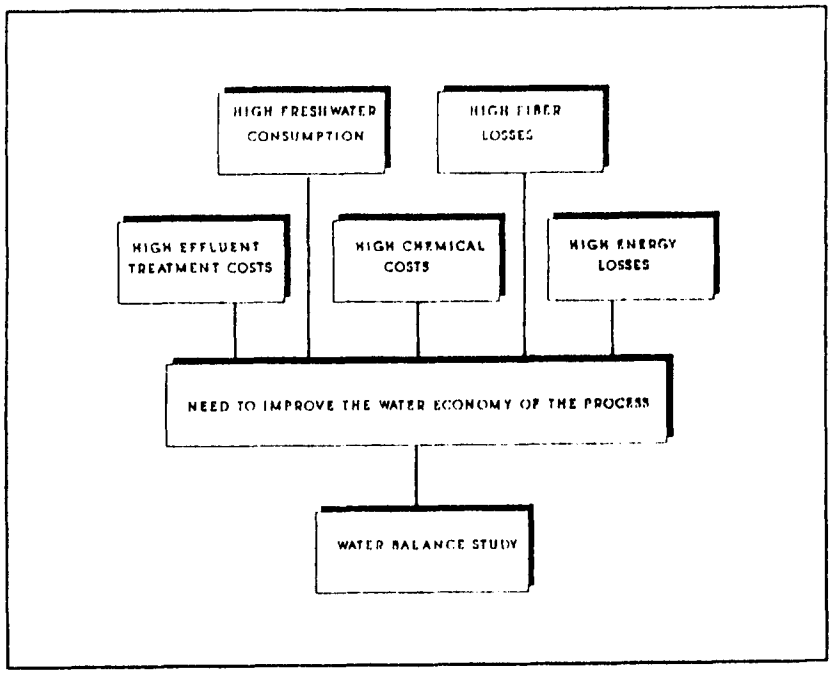


Fig.1. Most common arguments for the water balance study.

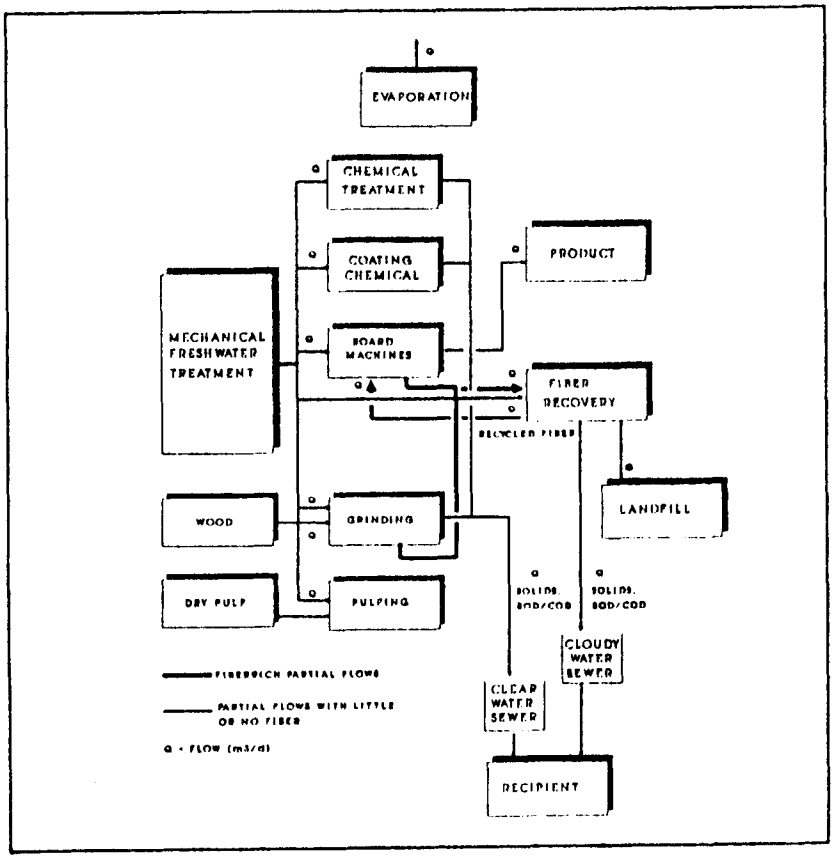


Fig.2. Example of the mill-scale water balance (without numerical values).

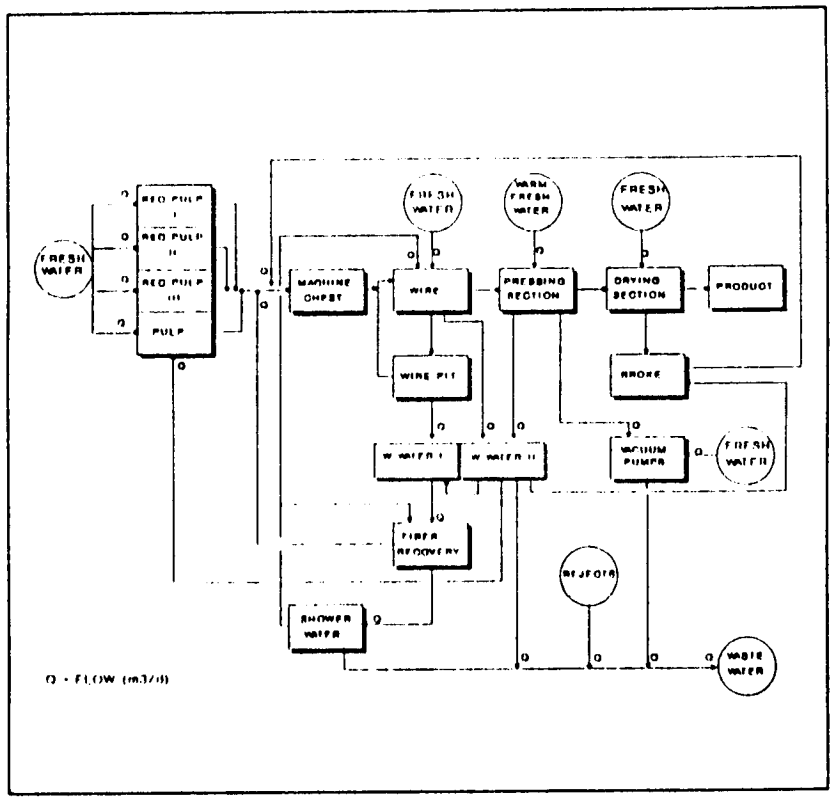


Fig.3. Example of the paper machine water balance (without numerical values).

The idea and target of the water balance study is to clear up the characteristics and weak points of the mill's existing water system:

- total fresh water usage and the major points of consumption,
- balance of the white water system and its "degree of closure",
- partial flows of the total effluent,
- proportion of the occasional spills compared to the "normal" discharges,
- most common reasons of the occasional spills.

The procedure that is demonstrated was developed and tested in the field during 1985-1989. Three paperboard machines (with integrated mechanical pulp mill) and three tissue machines in two different mills using varying proportions of deinked pulp were investigated.

The phases of the water balance study are basically the same in different cases even if the realization differs very much from mill to mill. The steps are:

1 involved persons become acquainted with the water system

2 the follow-up period is prepared

3 follow-up period(s)

4 collected data is processed

5 conclusions are made, water balance is reported and recommendations given

The water balance study can most effectively be carried out as an intensive short term project. In some mills the necessary personnel is available and the mill can execute the task independently.

Very often however the mill's own R & D department is not capable of managing the effort of this size. Then an outside research institute or consultant is hired for the task.

IMPLEMENTATION OF THE STUDY

Becoming Acquainted With The System

Basic structure of any paper mill water system can be found out by going deep into the existing flow schemes and other drawings.

In most cases there is a flow scheme available of each paper machine as well as other units of the process. Many times however the fresh water consumption is roughly presented and waste water partial flows hardly considered at all. Drawings are often out-dated i.e. a number of changes have occurred since their last renewal.

When the existing information has been carefully looked into, the production personnel and sometimes the design engineers of the mill are interviewed. This way the difficulties met in the every day operation and recent modifications of the process can be taken into account while planning the study.

There seems allways to be such features in the system that must be checked in the field. None of the mill staff can say for sure e.g. how some level controls or pipings are build. After the field visit(s) the researcher has eventually become familiar with the water system.

Preparation Of The Follow-up

The essence of the water balance study as we have done it is the intensive follow-up period. However a great deal of preliminary work is needed in order to get the best benefit of the effort.

Relevant process parameters must be selected for the computer based data collection. When the schedule allows it, even some new continuous measuring devices are installed where it is found useful. Some 15-25 variables are registered during the follow-up period.

Whether the right parameters are chosen or not has a strong effect on the final results of the study, whether it will be a success or a failure. So the selection must be done carefully.

During the preparation phase the critical points of the white water system are identified for the water sampling. The samples should preferably be collected samples but even random samples have been used.

The analyzing resources restrict the number of sampling points usually to some 10-15. That is because suspended solids (SS) between 20-3 000 ppm are measured by hand (filtration and weighing, in Finland with the GF/A filter media).

In the case of high fine particle content in the white water even the ash content is analyzed at least from a number of samples. Analyzing of the ash content is done by hand like that of the suspended solids.

Follow-up Periods

The duration of the follow-up period has in our studies been between 48 and 72 h. So the timing of the follow-up period must be defined accurately in order to get the desired information.

Data collection is made with a normal multichannel datalogger. The sampling interval of the logger can be 1-5 minutes. So the total number of datapoints comes up to some 30 000-40 000.

The datapoints represent any measured parameters which can be converted into a 1-5 volt signal. In our studies the parameters have been flows, chest levels, turbidities and temperatures. Just as well they can be steering signals of certain important valves or frequency converters.

The water sampling is started at the same time with the data collection. Usually varying from one sampling place to the other the water samples are taken 2-8 times during every 8 hours shift. Total number of the samples is therefore around 300-400.

Most of the samples are white water or waste water. Also different kinds of pulp and even paper samples after the wire and pressing section of the paper machine have been taken.

The samples are analyzed continuously during the follow-up period and the variations are surveyed. In this way we try to avoid collecting unnecessary samples and perhaps decide to take a few extra samples from some other points. Figure 4 shows how a follow-up system may look like.

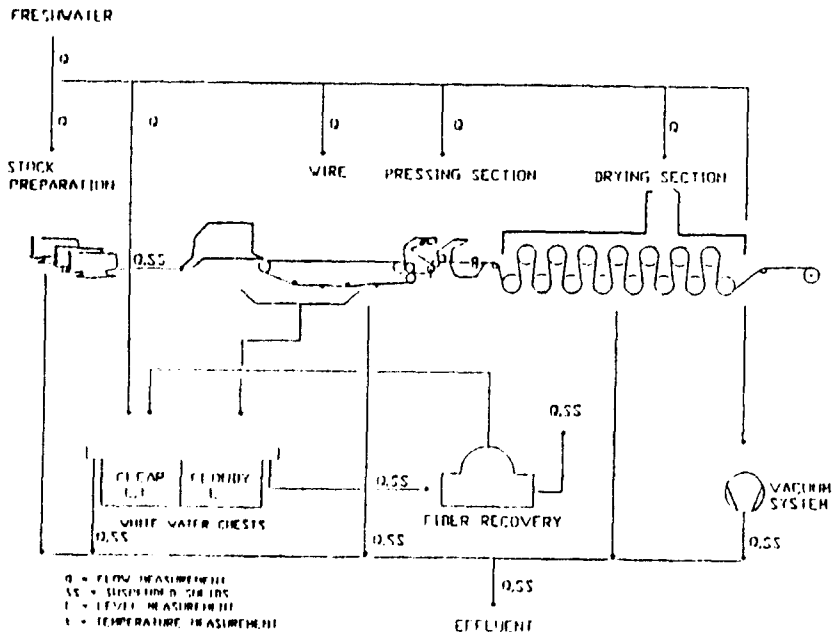


Fig. 4. Typical follow-up system lay out in a paper machine water balance study.

Processing Of The Collected Data

After the follow-up period is completed the data processing begins. The collected information is to be converted into easily read pictures and figures.

Datalogger's data is processed in a computer and plotted out in colours and in desired combinations. Addition of any measured data with the others and scaling (multiplication by a constant) can be done before plotting. Same PC-programme calculates the averages and variations in desired intervals.

The results of the water analyzes are handled manually. The abnormal results are picked out and the averages of the "normal" values corresponding to the full production are calculated.

In this stage a steady state water balance is build on the basis of the flow-schemes, datalogger drawings and water sample analyzes.

The input of our PC-adaptation of Lotus 1-2-3 consists of the known and measured variables. The inputs are relevant flows, consistencies of certain partial flows and solid contents in the chests.

Water balance is developed by roughly modelling the water system and then iterating. The output of the calculation includes all the significant partial flows. Each flow is defined in the terms of the water flow (l/min), solids flow (kg/min) and consistency (%).

Sometimes a few extra measurements and water samples are needed during the building of the water balance. Even a second follow-up period has been carried out in certain cases.

Conclusions And Reporting

In the last phase of the study all the material that has been ignored so far, especially the findings attached to the process irregularities and disturbances are examined.

The causes of the exceptional water usages, disturbances in the white water system and peaks of the effluent load are identified and possible remedies are drafted.

Final conclusions are drawn of the normal fresh water consumption and its distribution inside the mill/paper machine. The functioning of the white water system, its disturbances, the "normal" acceptable level of the effluent loading and its variations are considered as well.

In the following checklists are given for the drafting of the final report. In normal case all the listed properties of the system are discussed.

Checklist 1: freshwater consumption

Shower systems (fiber preparation, wire and pressing section, fiber recovery)

vacuum systems (pressing section)

chemical diluting systems

chest level controls using fresh water

cooling and sealing water

Checklist 2: white water system

Efficiency of the fiber recovery

accidental spills from tanks and chests

water retention times in chests

water economy of the broke system

Checklist 3: waste water

Partial flows carrying no fibers

partial flows containing high concentration of suspended solids

partial flows containing certain kinds of solids e.g. coating chemicals

partial flows with remarkable variations in the flow or in the solids content

The last part of the study report presents the final views of how the water system could be improved. The recommendable in-plant measures are listed whenever possible in the order of their profitableness. The risks and advantages of each process modification can be evaluated.

In the last figure some examples of the internal measures that we have recommended after a water balance study are presented.

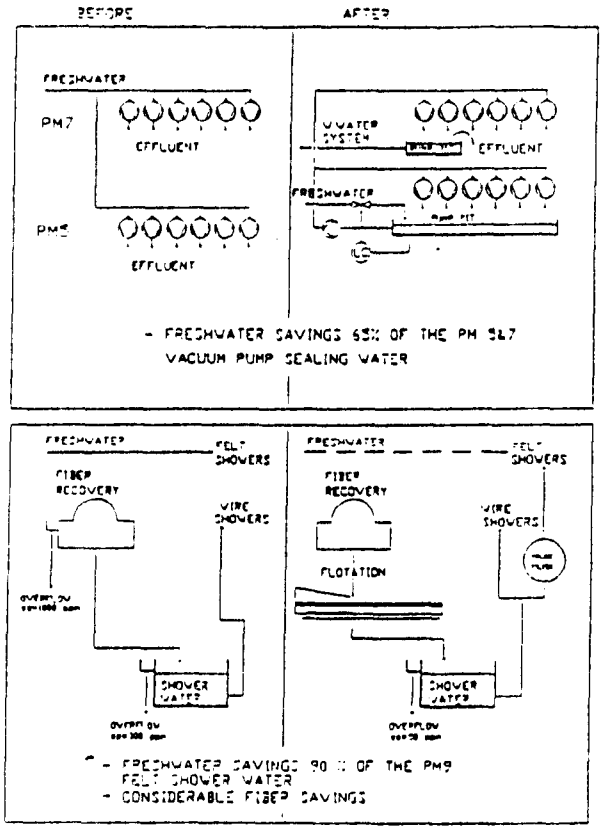
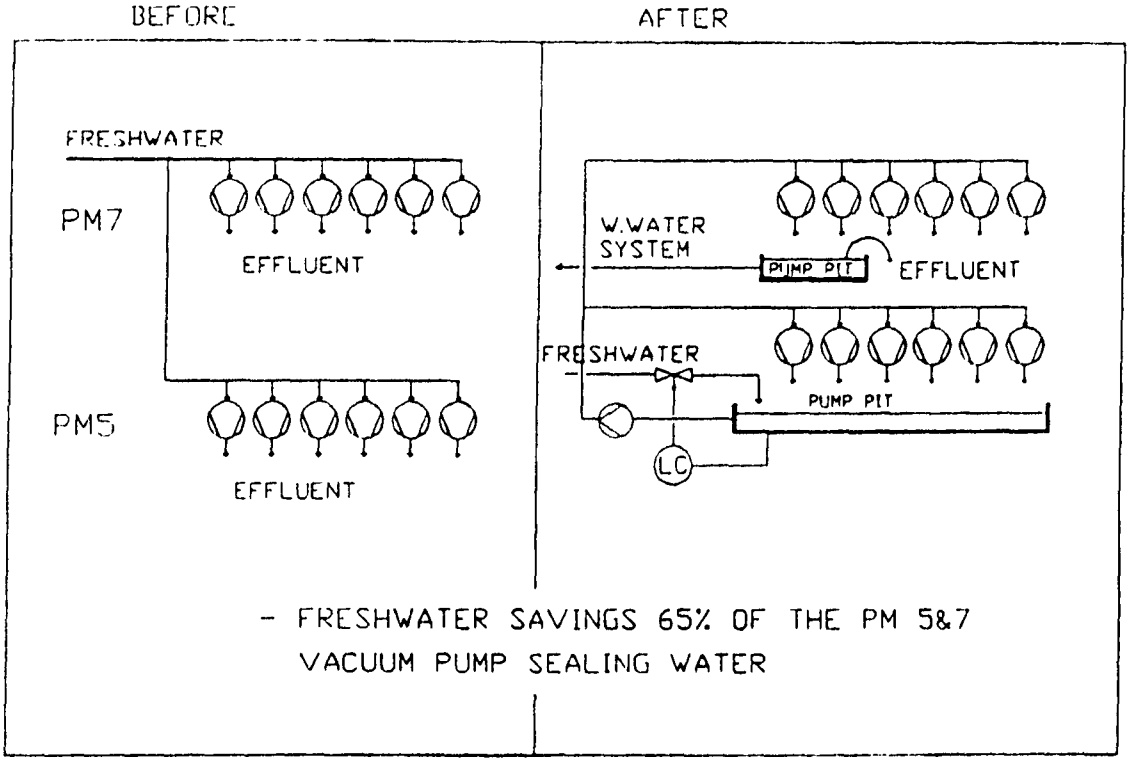
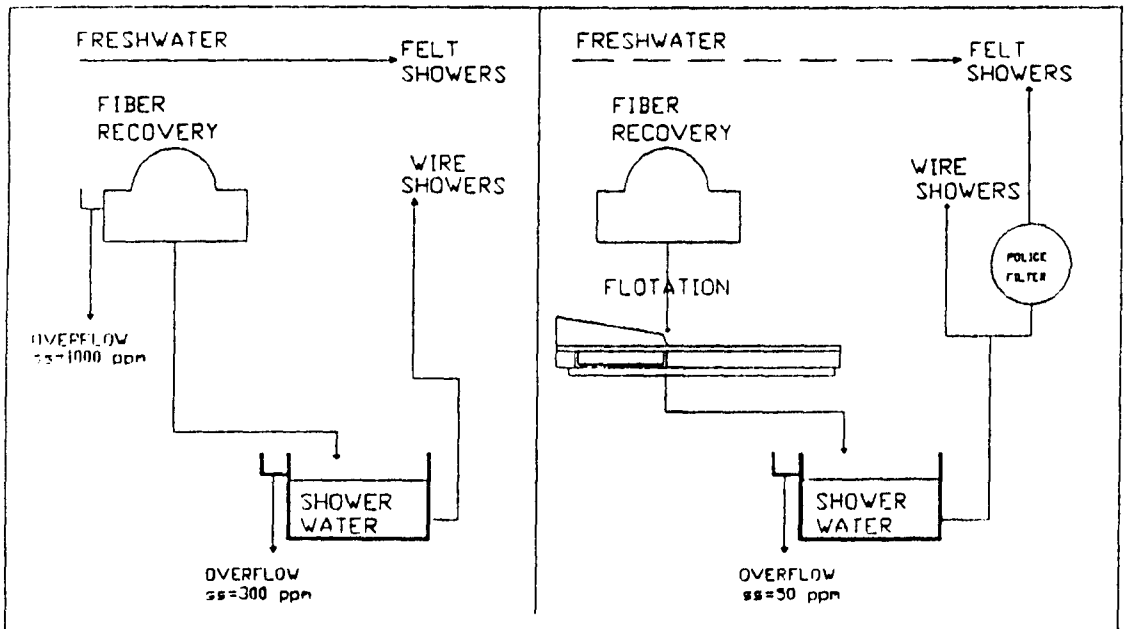


Figure 5. Examples of the recommended in-plant measures in specific cases.



- FRESHWATER SAVINGS 65% OF THE PM 5&7 VACUUM PUMP SEALING WATER



- FRESHWATER SAVINGS 90 % OF THE PM9 FELT SHOWER WATER
- CONSIDERABLE FIBER SAVINGS

CONCLUSION

According to our experience it is allways worth the effort to examine the water balance carefully at least before:

- planning in-plant water saving measures
- designing the external wastewater treatment plant
- designing an expansion of the existing treatment plant

The water balance study seems to succeed very well when it is carried out by an outsider but in close co-operation with the mill personnel. In this way the possible tensions and contradictions inside the mill don't so easily affect the results, but all available expertise is considered and made use of.

The duration of the preparation phase can hardly be estimated, it seems to vary so much from mill to mill. However from the beginning of the follow-up phase to the completion of the final report it seems to take for each studied paper machine some 5-10 weeks.

In all the water balance studies we have made, the results have given rise to the planning of process modifications and to more detailed investigations. At the same time the personnel responsible for the everyday operation of the mill have become better aquainted with the system they are running.

AIR POLLUTION

Man`s pursuit of development has caused air pollution problems on various scales: locally, especially in urban areas; regionally, often beyond national frontiers; globally, affecting the planet as a whole.

Worldwide, fuel combustion is the principal cause of man-made air pollution problems. Energy demand and the combustion of fuels have risen as population and industrial activity have increased.

The variety of airborne matter is so great that it can be classified in several ways. For example:

1. Sulphur-containing compounds
2. Nitrogen-containing compounds
3. Carbon-containing compounds
4. Halogen-containing compounds
5. Toxic substances
6. Radioactive compounds

Air pollutants may also be classified according to physical state:

1. Gaseous
2. Liquid
3. Solid

Air pollutants may also be classed according to the manner in which they reached the atmosphere, namely

1. **Primary Pollutants.** Those emitted directly from sources.
2. **Secondary Pollutants.** Those formed in the atmosphere by chemical interactions among primary pollutants and normal atmospheric constituents.

AIR QUALITY IN EUROPE AND IN FINLAND

Trend analysis shows that SO_2, carbon monoxide, lead and particulate emissions have generally decreased in in the OECD region compared to 1970 levels.

In contrast NO_x and volatile organic carbon (VOC) emissions have continued to increase or have remained stable.

In southern Finland sulphur deposition is about 1,5 g/m^2 and in northern Finland about 0,4 g/m^2.

AIR-IX has made many city-wide air quality studies which have been based on emission in ventories, dispersion modelling and biological monitoring of impacts.

DISPERSION MODELS

Dispersion models can be used to estimate the level of the air pollutant concentrations. The most common pollutant which is modelled is SO_2 but also other gases and particles can be used.

AIR POLLUTANTS AND BIOLOGICAL EFFECTS ON PLANTS

Hypogymnia physodes is a widely distributed epiphytic lichen which is relatively resistant to impurities in the air. It is commonly found on the trunks and branches of trees. Since the epiphytic lichens receive the majority of their nutrients from rainwater, they are particularly suitable for the analysis of airborne substances. They accumulate sulphur and heavy metals which can be analysed. Most of the surveys conclude that concentrations are highest close to known sources of pollution or in places where regional deposition is high.

Some another lichen species are more sensitive to impurities in the air and the number of species on the tree is one kind of air quality measurement.

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EPA-450/4-88-002a December 1987
Air

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Industrial Source Complex (ISC) Dispersion Model

1.2 Background and Purpose

Air quality impact analyses for pollutant sources other than emissions from isolated stacks often require consideration of factors such as fugitive emissions, aerodynamic wake effects, gravitational settling and dry deposition. The Industrial Source Complex (ISC) Dispersion Model consists of two computer programs that are designed to consider these and other factors so as to meet the needs of those who must perform complicated dispersion model analyses. The ISC Model computer programs are designed to be flexible, economical and as easy to use as possible without sacrificing the model features required to address complicated problems. Three evaluation studies of the ISC model have been published (Bowers and Anderson, 1981; Bowers et al., 1982; Schulman and Hanna, 1986).

Cautionary Note -- The ISC Model contains a number of options that are designed to consider complicated source configurations and special atmospheric effects. These options include: site-specific wind-profile exponents and vertical potential temperature gradients, time-dependent exponential decay of pollutants, stack-tip downwash, revised procedures for building wake effects, plume rise calculated as a function of downwind distance, buoyancy induced dispersion, and dry deposition. If one or more of these options is not specified by the user, the programs will assign preselected default values to

various parameters. For regulatory applications, the use of the "regulatory default option" is recommended. If the user believes that the use of site-specific or source-specific parameters is appropriate, their use should be discussed with the responsible air pollution control agency prior to the model calculations. Also, because proper application of many of the ISC Model features requires a fundamental knowledge of the concepts of atmospheric transport and dispersion, the user should seek expert advice before using any ISC Model feature that is not fully understood. Finally, because a comprehensive model is required to address complicated problems, the ISC Model is not necessarily the model of choice for all applications. Simpler and less expensive computerized models such as the Single Source (CRSTER) Model (EPA, 1977) should be used for applications that do not require at least one of the ISC Model features.

The ISC Model computer programs are suitable for application to pollutant sources in the following types of studies:

- Stack design studies
- Combustion source permit applications
- Regulatory variance evaluation
- Monitoring network design
- Control strategy evaluation for SIP's
- Fuel (e.g., coal) conversion studies
- Control technology evaluation
- New source review
- Prevention of significant deterioration

1.3 General Description

The Industrial Source Complex (ISC) Dispersion Model combines and enhances various dispersion model algorithms into a set of two computer programs that can be used to assess the air quality impact of emissions from the wide variety of sources associated with an industrial source complex. For plumes comprised of particulates with appreciable gravitational settling velocities, the ISC Model accounts for the effects on ambient particulate concentrations of gravitational settling and dry deposition. Alternatively, the ISC Model can be used to calculate dry deposition. The ISC short-term model (ISCST), an

extended version of the Single Source (CRSTER) Model (EPA, 1977), is designed to calculate concentration or deposition values for time periods of 1, 2, 3, 4, 6, 8, 12, and 24 hours. If used with a year of sequential hourly meteorological data, ISCST can also calculate annual concentration or deposition values. The ISC long-term model (ISCLT) is a sector-averaged model that extends and combines basic features of the Air Quality Display Model (AQDM) and the Climatological Dispersion Model (CDM). The long-term model uses statistical wind summaries to calculate seasonal (quarterly) and/or annual concentration or deposition values. Both ISCST and ISCLT use either a polar or a Cartesian receptor grid. The ISC Model computer programs are written in Fortran 77 and require approximately 80,000 words of memory. The major features of the ISC Model are listed in Table 1-1.

The ISC Model programs accept the following source types: stack, area and volume. The volume source option is also used to simulate line sources. The steady-state Gaussian plume equation for a continuous source is used to calculate concentrations for stack and volume sources. The area source equation in the ISCST Model programs is based on the equation for a continuous and finite cross-wind line source. In the ISCLT Model program, the area source treatment uses a virtual point source approximation. The generalized Briggs (1969, 1971, 1972, 1973, 1975) plume-rise formulas are used to calculate final as well as gradual plume rise. Revised procedures are used to evaluate the effects of aerodynamic wakes and eddies formed by buildings and other structures on plume dispersion. Either the methods of Huber and Snyder (Huber and Snyder, 1976, 1982; Huber, 1977) or those of Schulman and Scire (1986) are used, depending on the ratio of the stack height to the building height. The Schulman and Scire downwash approach 1) reduces plume rise, 2) enhances plume spread as a linear function of the plume height, and 3) uses building heights and cross-sectional widths input by direction. A wind-profile exponent law is used to adjust the observed mean wind speed from the measurement height to the emission height for the plume rise and

TABLE 1-1

MAJOR FEATURES OF THE
ISC MODEL

Polar or Cartesian coordinate systems
Rural or one of three urban options
Plume rise due to momentum and buoyancy as a function of downwind distance for stack emissions (Briggs, 1969, 1971, 1972, 1973, and 1975)
Building wake effects using methods of Huber and Snyder (Huber and Snyder, 1976, 1982; Huber, 1977) or Schulman and Scire (Schulman and Hanna, 1986; Schulman and Scire, 1986) depending on the stack height to building height ratio (see Section 2.4.1.1.d), for evaluating building wake effects. The Schulman and Scire approach uses building dimensions as functions of direction.
Procedures suggested by Briggs (1974) for evaluating stack-tip downwash.
Separation of multiple point sources
Consideration of the effects of gravitational settling and dry deposition on ambient particulate concentrations
Capability of simulating point, line, volume and area sources
Capability to calculate dry deposition
Variation with height of wind speed (wind-profile exponent law)
Concentration estimates for 1-hour to annual average
Terrain-adjustment procedures for elevated terrain including a terrain truncation algorithm
Consideration of time-dependent exponential decay of pollutants
The method of Pasquill (1976) to account for buoyancy-induced dispersion.
A regulatory default option to set various model options and parameters to EPA recommended values.
Procedure for calm-wind processing
Capability to treat height of receptor above ground ("flagpole" receptors)

concentration calculations. Procedures utilized by the Single Source (CRSTER) Model are used to account for variations in terrain height over the receptor grid. Except for Urban Mode 3, the Pasquill-Gifford curves (Turner, 1970) are used to calculate lateral (σ_y) and vertical (σ_z) plume spread. The ISC Model has one rural and three urban options. In the Rural Mode, rural mixing heights* and the σ_y and σ_z values for the indicated stability category are used in the calculations. In Urban Mode 1, the stable E and F stability categories are redefined as neutral D stability. In Urban Mode 2, the E and F stability categories are combined and the σ_y and σ_z values for the stability category one step more unstable than the indicated stability category (except A) are used in the calculations (see Section 2.2.1.1). In Urban Mode 3, the Briggs urban dispersion coefficients derived from McElroy-Pooler observations are used. Urban mixing heights are used in all three urban modes.

1.4 System Description

1.4.1 The ISC Short-Term (ISCST) Model Program

Figure 1-1 is a schematic diagram of the ISC Model short-term computer program (ISCST). As shown by the figure, ISCST directly accepts the preprocessed meteorological data tape produced by the RAMMET preprocessor. This meteorological preprocessor program is described in the User's Manual for Single-Source (CRSTER) Model (EPA, 1977), as updated by Catalano (1986). Alternatively, hourly meteorological data may be input by card deck. Program control parameters, source data and receptor data are input by card deck. The program produces printouts of calculated concentration or deposition values.

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* The mixing height is the height above the surface at which an elevated stable layer restricts vertical mixing and confines pollutant emissions within the mixing layer.

1.4.2 The ISC Long-Term (ISCLT) Model Program

Figure 1-2 is a schematic diagram of the ISC Model long-term computer program (ISCLT). As shown by the figure, program control parameters, meteorological data, source data and receptor data are input by card deck. The program produces printouts of calculated concentration or deposition values. Additionally, all input data and the results of all calculations may be stored on an optional master tape inventory which can be used as input to update future runs. The master tape file stores the concentration or deposition calculated for each source at each receptor. Sources may be added, deleted or altered in update runs using card input for the affected sources. Concentration or deposition calculations are then made for those sources only and the concentration or deposition values calculated for each source are resummed to obtain an updated estimate of the concentration or deposition produced at each receptor by all sources.

1.5 Summary of Input Data

1.5.1 The ISC Short-Term (ISCST) Model Program

The input requirements for the ISC Model short-term computer program (ISCST) consist of four categories:

- Meteorological data
- Source data
- Receptor data
- Program control parameters

a. Meteorological Data. Meteorological inputs required by the ISCST program include hourly estimates of the wind direction, wind speed, ambient air temperature, Pasquill stability category, mixing height, wind-profile exponent and vertical potential temperature gradient. The magnetic tape

output of the meteorological data preprocessor program and the program default values for the wind-profile exponent and the vertical potential temperature gradient satisfy all ISCST hourly meteorological data requirements. Alternatively, hourly meteorological data can be input by means of a card deck. When this is done, the use of the calm processing feature (described in Section 1.5.1.d) is not permitted. The number of hours for which concentration or deposition calculations can be made ranges from 1 to 8,784 (i.e., up to every hour of a 366-day year).

b. Source Data. The ISCST program accepts three source types: stack, area and volume. For each source, input data requirements include the source location with respect to a user-specified origin, the source elevation (if terrain effects are to be included in the model calculations) and the pollutant emission rate. For each stack, additional source input requirements include the physical stack height, the stack inner diameter, the stack exit temperature, and the stack exit velocity. If aerodynamic wake effects due to an adjacent building are to be considered, the length, width, and height of the building are required as well. For certain stack heights and building dimensions, thirty-six direction specific building heights and widths are input. The horizontal dimensions and effective emission height are required for each area source or volume source. If the calculations are to consider particulates with appreciable gravitational settling velocities, source inputs for each source also include the mass fraction of particulates in each gravitational settling-velocity category as well as the surface reflection coefficient and settling velocity of each settling-velocity category. Because industrial pollutant emission rates are often highly variable, emission rates for each source may be held constant or varied as follows:

- By hour of the day
- By season or month
- By hour of the day and season
- By stability and wind speed (applies to fugitive sources of wind-blown particulates)

c. Receptor Data. The ISCST program uses either a polar (r, θ) or a Cartesian (X,Y) coordinate system. The typical polar receptor array consists of 36 radials (one for every 10 degrees of azimuth) and five to ten downwind ring distances for a total of 180 to 360 receptors. However, the user is not restricted to a 10-degree angular separation of receptors. The polar receptor array is always centered at X=0, Y=0. Receptor locations in the Cartesian coordinate system may be given as Universal Transverse Mercator (UTM) coordinates or as X (east-west) and Y (north-south) coordinates with respect to a user-specified origin. Discrete receptor points corresponding to the locations of air quality monitors, elevated terrain or other points of interest may also be used with either coordinate system. If terrain effects are to be included in the calculations, the ground level elevation of each receptor is required. If receptor heights above ground ("flagpole" receptors) are to be modeled, the receptor height above local terrain is also required. Both terrain elevation and receptor height above local terrain may be input for the same receptor.

d. Program Control Parameters and Options. The ISCST program allows the user to select from a number of model options. The program parameters for these options are discussed in detail in Section 3.2.3. The available options include:

- Concentration/Deposition Option — Directs the program to calculate average concentration or total deposition
- Receptor Grid System Option — Selects a Cartesian or a polar receptor grid system

- Discrete Receptor Option -- Allows the user to arbitrarily place receptors at any points using either a Cartesian or a polar coordinate system

- Receptor Terrain Elevation Option -- Allows the user to specify an elevation for each receptor (level terrain is assumed if this option is not exercised)

- Tape/file Output Option -- Directs the program to output the results of all concentration or deposition calculations to tape/file

- Print Input Data Option -- Directs the program to print program control parameters, source data and receptor data; the user may also direct the program to print the hourly meteorological data if this option is exercised. This option prints all input data after all input data has been read.

- Output Tables Option -- Specifies which of the five types of output tables are to be printed (see Section 3.1.3)

- Meteorological Data Option -- Directs the program to read hourly data from either the meteorological preprocessor format or a card image format. When card image format is selected, the calm processing feature, and the regulatory default option are not used.

- Rural/Urban Option -- Specifies whether the concentration or deposition calculations are made in the Rural Mode, Urban Mode 1, Urban Mode 2, or Urban Mode 3 (see Section 2.2.1.1)

- Wind-Profile Exponent Option -- Directs the program to read user-provided wind-profile exponents or to use the default values

- Vertical Potential Temperature Gradient Option -- Directs the program to read user-provided vertical potential temperature gradients or to use the default values

- Source Combination Option -- Allows the user to specify the combinations of sources for which concentration or deposition estimates are required

- Single Time Period Interval Option -- Directs the program to print concentration or deposition values for a specific time interval within a day (for example, the third 3-hour period)

- Variable Emission Rate Option -- Allows the user to specify scalars which are multiplied by the source's average emission rate; the scalars may vary by season or month, by hour of the day, by season and hour of the day, or by wind speed and stability

- Plume Rise as a Function of Distance Option -- Allows the user to direct the program to calculate plume rise as a function of downwind distance or to calculate final plume rise at all downwind distances

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IN-MILL MANAGEMENT
Wastes

by **Pentti Rantala**
Air–Ix Consulting Engineers

Section 1
Introduction

Waste minimization (WM) has been successful for many organizations. By following the procedures outlined in this manual, a waste generator can:

- Save money by reducing waste treatment and disposal costs, raw material purchases, and other operating costs.
- Meet state and national waste minimization policy goals.
- Reduce potential environmental liabilities.
- Protect public health and worker health and safety.
- Protect the environment.

Waste minimization is a policy specifically mandated by the U. S. Congress in the 1984 Hazardous and Solid Wastes Amendments to the Resource Conservation and Recovery Act (RCRA). This mandate, coupled with other RCRA provisions that have led to unprecedented increases in the costs of waste management, have heightened general interest in waste minimization. A strong contributing factor has been a desire on the part of generators to reduce their environmental impairment liabilities under the provisions of the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA, or "Superfund"). Because of these increasing costs and liability exposure, waste minimization has become more and more attractive economically.

The following terms, used throughout this manual, are defined below:

Waste Minimization (WM). In the working definition currently used by EPA, waste minimization consists of *source reduction* and *recycling*. This concept of waste minimization is presented in Figure 1-1. Of the two approaches, source reduction is usually preferable to recycling from an environmental perspective. Source reduction and recycling each are comprised of a number of practices and approaches which are illustrated in Figure 1-2.

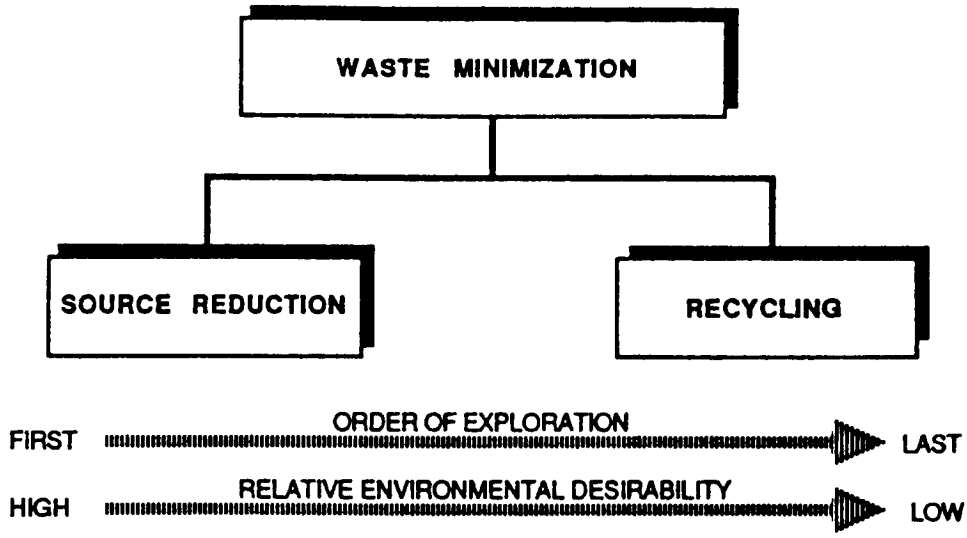
The present focus of WM activities is on hazardous wastes, as defined in RCRA. However, it is important that all pollutant emissions into air, water and land be considered as part of a waste minimization program. The transfer of pollutants from one medium to another is not waste minimization. For example, the removal of organics from wastewater using activated carbon, in and of itself, is not waste minimization, since the pollutants are merely transferred from one medium (wastewater) to another (carbon, as solid waste).

Waste minimization program (WMP). The RCRA regulations require that generators of hazardous waste "have a program in place to reduce the volume and toxicity of waste generated to the extent that is economically practical." A waste minimization program is an organized, comprehensive, and continual effort to systematically reduce waste generation. Generally, a program is established for the organization as a whole. Its components may include specific waste minimization projects and may use waste minimization assessments as a tool for determining where and how waste can be reduced. A waste minimization program should reflect the goals and policies for waste minimization set by the organization's management. Also, the program should be an ongoing effort and should strive to make waste minimization part of the company's operating philosophy. While the main goal of a waste minimization program is to reduce or eliminate waste, it may also bring about an improvement in a company's production efficiency.

EPA will publish separate guidance on the elements of effective waste minimization programs. This guidance will discuss the following elements likely to be found in an effective WM program:

- Top management support
- Explicit program scope and objectives
- Accurate waste accounting
- Accurate cost accounting
- Pervasive waste minimization philosophy
- Technology transfer

Waste minimization assessment (WMA). A waste minimization assessment is a systematic planned procedure with the objective of identifying ways to reduce or eliminate waste. The steps involved in conducting a waste minimization assessment are outlined in Figure 1-3. The assessment consists of a careful review of a plant's operations and waste streams, and the selection of specific areas to assess. After a specific waste stream or area is established as the WMA focus, a number of options with the potential to minimize waste are developed and screened. Third, the technical and economic feasibility of the selected options are evaluated. Finally, the most promising options are selected for implementation.



WASTE MINIMIZATION

The reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste or (2) the reduction of toxicity of the hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment (EPA's Report to Congress, 1986, EPA/530-SW-86-033).

SOURCE REDUCTION

Any activity that reduces or eliminates the generation of hazardous waste at the source, usually within a process (op. cit.).

RECYCLING

A material is "recycled" if it is used, reused, or reclaimed (40 CFR 261.1 (c) (7)). A material is "used or reused" if it is either (1) employed as an ingredient (including its use as an intermediate) to make a product; however a material will not satisfy this condition if distinct components of the material are recovered as separate end products (as when metals are recovered from metal containing secondary materials) or (2) employed in a particular function as an effective substitute for a commercial product (40 CFR 261.1 (c) (5)). A material is "reclaimed" if it is processed to recover a useful product or if it is regenerated. Examples include the recovery of lead values from spent batteries and the regeneration of spent solvents (40 CFR 261.1 (c) (4)).

Figure 1-1. Waste Minimization Definitions

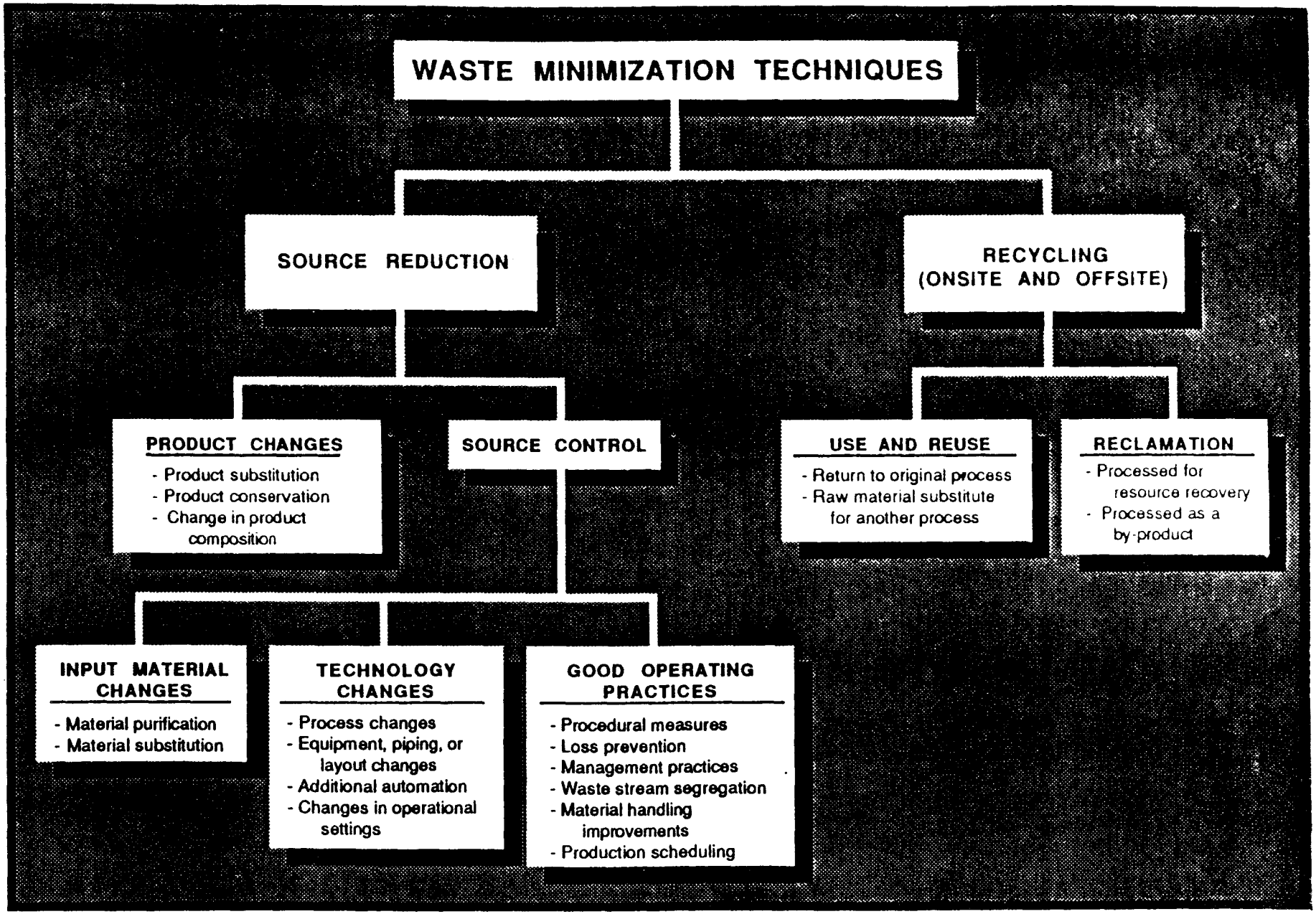
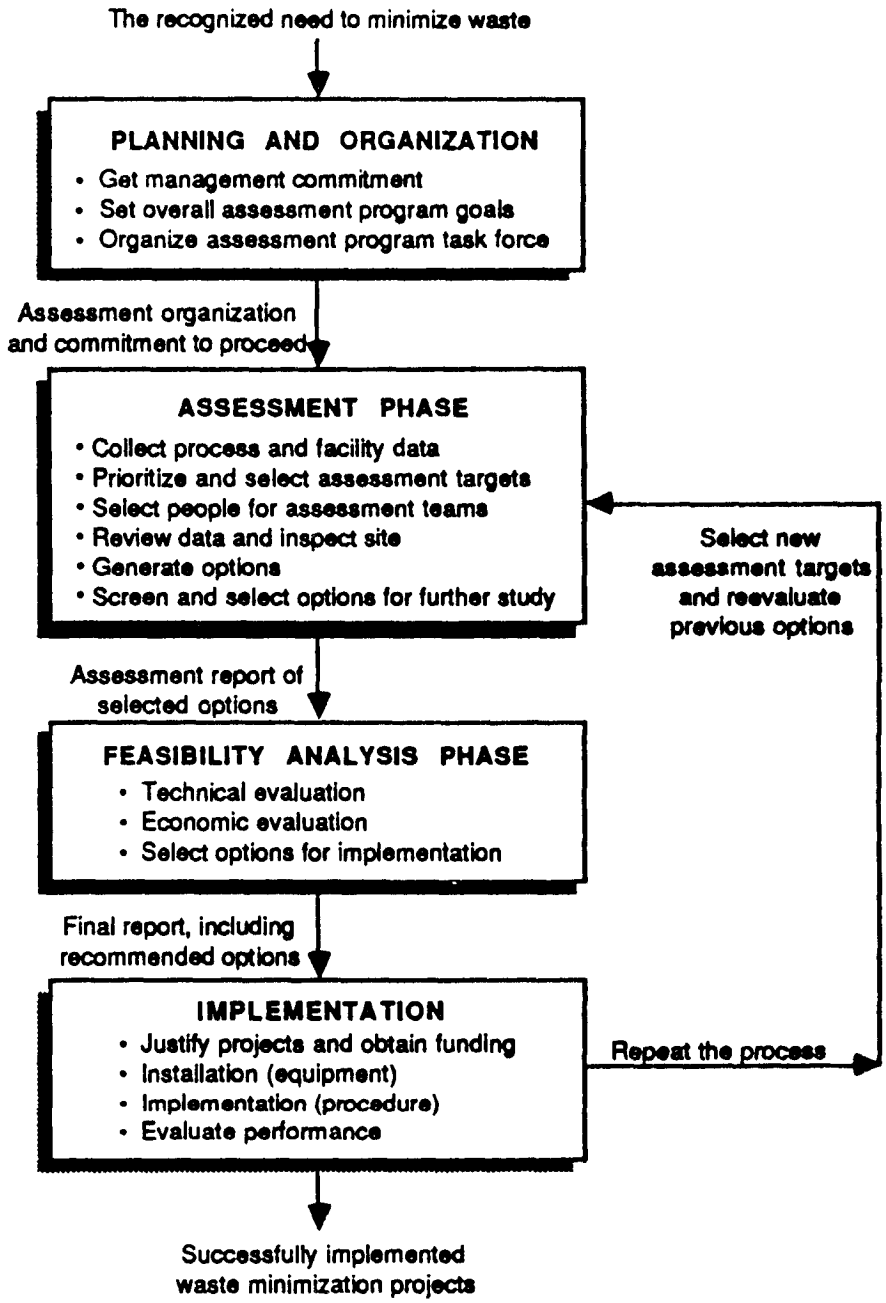


Figure 1-2. Waste Minimization Techniques

Figure 1-3. The Waste Minimization Assessment Procedure



Incentives for Waste Minimization

There are a number of compelling incentives for minimizing waste. Table 1-1 summarizes some of these incentives.

Table 1-1. Waste Minimization Incentives

Economics
- Landfill disposal cost increases.
- Costly alternative treatment technologies.
- Savings in raw material and manufacturing costs.

Regulations
- Certification of a WM program on the hazardous waste manifest.
- Biennial WM program reporting.
- Land disposal restrictions and bans.
- Increasing permitting requirements for waste handling and treatment.

Liability
- Potential reduction in generator liability for environmental problems at both onsite and offsite treatment, storage, and disposal facilities.
- Potential reduction in liability for worker safety.

Public Image and Environmental Concern
- Improved image in the community and from employees.
- Concern for improving the environment.

EPA intends to publish a manual entitled "Waste Minimization Benefits Handbook" which will discuss in detail the cost/benefit analyses of WM options.

About this manual

This manual has been prepared for those responsible for planning, managing, and implementing waste minimization activities at the plant and corporate levels. The manual concentrates on procedures that motivate people to search, screen, and put into practice measures involving administrative, material, or technology changes that result in decreased waste generation. It is also a source of concepts and ideas for developing and implementing a waste minimization program.

The manual is organized as follows:

- Section 2 outlines the planning and organizational aspects that provide a necessary foundation for a waste minimization assessment.

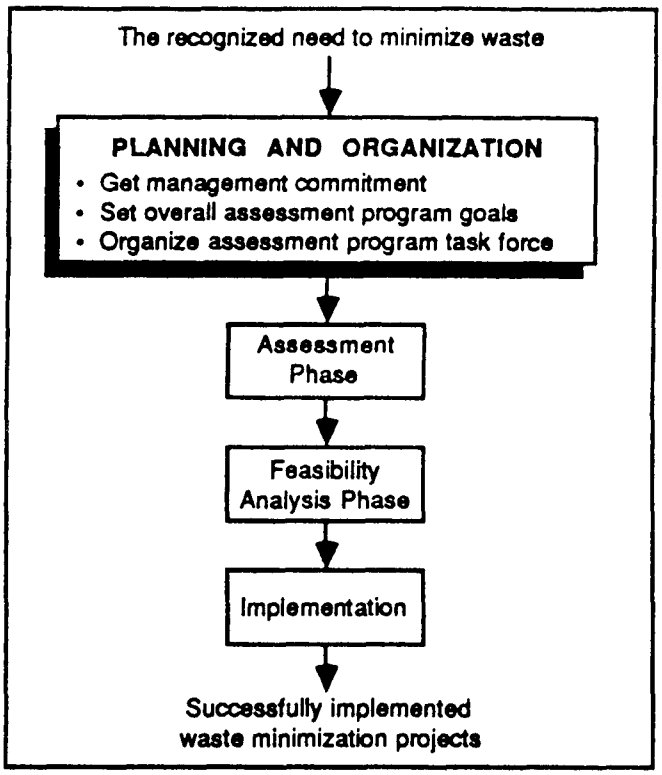
- Section 3 describes the assessment phase, including collecting information, selecting assessment targets, selecting assessment teams, and identifying potential WM options.

- Section 4 discusses the methods for evaluating options for technical and economic feasibility.

- Section 5 describes the implementation of attractive options: obtaining funding, installation and implementation, and measuring the effectiveness of implemented options.

A set of worksheets useful in carrying out assessments is included in Appendix A. Because individual generators' circumstances and needs vary widely, users of this manual are encouraged to modify the procedures and worksheets to fit their unique requirements. The manual is intended to serve as a point of departure, rather than as a set of rigid requirements. Accordingly, Appendix B presents a simplified set of worksheets that are designed to assist generators who are interested in performing only preliminary assessments. These worksheets also provide a useful framework for conducting assessments for small businesses and small quantity generators.

A sample assessment is presented in Appendix C. Appendix D describes waste streams from common industrial operations. Appendix E is a catalog and brief description of waste minimization techniques applicable in a number of common waste-intensive operations. Appendix F is a list of addresses and telephone numbers of state programs for technical assistance in waste minimization. Appendix G presents describes a method for screening and rating potential waste minimization options for further study. Finally, an example of an economic feasibility analysis of a large waste minimization project is presented in Appendix H.



This section discusses factors that are important to the success of a waste minimization program. Because a comprehensive WM program affects many functional groups within a company, the program needs to bring these different groups together to reduce wastes. The formality of the program depends upon the size and complexity of the organization and its waste problems. The program structure must be flexible enough to accommodate unforeseen changes. The developmental activities of a WM program include:

- getting management commitment
- setting WM goals
- staffing the program task force

Getting Management Commitment

The management of a company will support a waste minimization program if it is convinced that the benefits of such a program will outweigh the costs. The potential benefits include economic advantages, compliance with regulations, reduction in liabilities associated with the generation of wastes, improved public image, and reduced environmental impact.

The objectives of a WM program are best conveyed to a company's employees through a formal policy statement or management directive. A company's upper management is responsible for establishing a formal commitment throughout all divisions of the organization. The person in charge of the company's environmental affairs is responsible to advise management of the importance of waste minimization and the need for this formal commitment. An example of a formal policy statement follows:

CORPORATE ENVIRONMENTAL POLICY

[A major chemical company]..."is committed to continue excellence, leadership, and stewardship in protecting the environment. Environmental protection is a primary management responsibility, as well as the responsibility of every employee.

In keeping with this policy, our objective as a company is to reduce waste and achieve minimal adverse impact on the air, water, and land through excellence in environmental control.

The Environmental Guidelines include the following points:

- Environmental protection is a line responsibility and an important measure of employee performance. In addition, every employee is responsible for environmental protection in the same manner he or she is for safety.
- Minimizing or eliminating the generation of waste has been and continues to be a prime consideration in research, process design, and plant operations; and is viewed by management like safety, yield, and loss prevention.
- Reuse and recycling of materials has been and will continue to be given first consideration prior to classification and disposal of waste."

Involve Employees

Although management commitment and direction are fundamental to the success of a waste minimization program, commitment throughout an organization is necessary in order to resolve conflicts and to remove barriers to the WM program. Employees often cause the generation of waste, and they can contribute to the overall success of the program. Bonuses, awards, plaques, and other forms of recognition are often used to provide motivation, and to boost employee cooperation and participation. In some companies, meeting the waste minimization goals is used as a measure for evaluating the job performance of managers and employees.

Cause Champions

Any WM program needs one or more people to champion the cause. These "cause champions" help overcome the inertia present when changes to an existing operation are proposed. They also lead the WM program, either formally or informally. An environmental engineer, production manager, or plant process engineer may be a good candidate for this role. Regardless of who takes the lead, this cause champion must be given enough authority to effectively carry out the program.

Organizing a WM Program: The Program Task Force

The WM program will affect a number of groups within a company. For this reason, a program task force should be assembled. This group should include members of any group or department in the company that has a significant interest in the outcome of the program. Table 2-4 at the end of this section and Worksheet 3 in Appendix A lists departments or groups of a typical manufacturing company that should be involved in the program.

The formality or informality of the WM program will depend on the nature of the company. The program in a large highly structured company will probably develop to be quite formal, in contrast to a small company, or a company in a dynamic industry, where the organizational structure changes frequently.

Table 2-1 lists the typical responsibilities of a WM program task force. It will draw on expertise within the company as required. The scope of the program will determine whether full-time participation is required by any of the team members.

Table 2-1. Responsibilities of the WM Program Task Force

- Get commitment and a statement of policy from management.
- Establish overall WM program goals.
- Establish a waste tracking system.
- Prioritize the waste streams or facility areas for assessment.
- Select assessment teams.
- Conduct (or supervise) assessments.
- Conduct (or monitor) technical/economic feasibility analyses of favorable options.
- Select and justify feasible options for implementation.
- Obtain funding and establish schedule for implementation.
- Monitor (and/or direct) implementation progress.
- Monitor performance of the option, once it is operating.

In a small company, several people at most will be all that are required to implement a WM program. Include the people with responsibility for production, facilities, maintenance, quality control, and waste treatment and disposal on the team. It may be that a single person, such as the plant manager, has all of these responsibilities at a small facility. However, even at a small facility, at least two people should be involved to get a variety of viewpoints and perspectives.

Some larger companies have developed a system in which assessment teams periodically visit different facilities within the company. The benefits result through sharing the ideas and experiences with other divisions. Similar results can be achieved with periodic in-house seminars, workshops, or meetings. A large chemical manufacturer held a corporate-wide symposium in 1986 dealing specifically with waste minimization. The company has also developed other programs to increase company-wide awareness of waste minimization, including an internally published newsletter and videotape.

Setting Goals

The first priority of the WM program task force is to establish goals that are consistent with the policy adopted by management. Waste minimization goals can be qualitative, for example, "a significant reduction of toxic substance emissions into the environment." However, it is better to establish measurable, quantifiable goals, since qualitative goals can be interpreted ambiguously. Quantifiable goals establish a clear guide as to the degree of sucess expected of the program. A major chemical company has adopted a corporate-wide goal of 5% waste reduction per year. In addition, each facility within the company has set its own waste minimization goals.

As part of its general policy on hazardous waste, a large defense contractor has established an ambitious corporate-wide goal of zero discharge of hazardous wastes from its facilities by the end of 1988. Each division within the corporation is given the responsibility and freedom to develop its own program (with intermediate goals) to meet this overall goal. This has resulted in an extensive investigation of procedures and technologies to accomplish source reduction, recycling and resource recovery, and onsite treatment.

Table 2-2 lists the qualities that goals should possess. It is important that the company's overall waste minimization goals be incorporated into the appropriate individual departmental goals.

The goals of the program should be reviewed periodically. As the focus of the WM program becomes more defined, the goals should be changed to reflect any changes. Waste minimization assessments are not intended to be a one-time project. Periodic reevaluation of goals is recommended due to changes, for example, in available technology, raw

Table 2-2. Attributes of Effective Goals

- ACCEPTABLE to those who will work to achieve them.
- FLEXIBLE and adaptable to changing requirements.
- MEASURABLE over time.
- MOTIVATIONAL.
- SUITABLE to the overall corporate goals and mission.
- UNDERSTANDABLE.
- ACHIEVABLE with a practical level of effort.

Source: Pearce and Robinson, Strategic Management (1985)

material supplies, environmental regulations, and economic climate.

Overcoming Barriers

As it sets goals for waste minimization and then defines specific objectives that can be achieved, the program task force should recognize potential barriers. Although waste minimization projects can reduce operating costs and improve environmental compliance, they can lead to conflicts between different groups within the company. Table 2-3 lists examples of jurisdictional conflicts that can arise during the implementation of a waste minimization project.

In addition to jurisdictional conflicts related to these objective barriers, there are attitude-related barriers that can disrupt a WM program. A commonly held attitude is "If it ain't broke, don't fix it!" This attitude stems from the desire to maintain the status quo and avoid the unknown. It is also based on the fear that a new WM option may not work as advertised. Without the commitment to carefully conceive and implement the option, this attitude can become a self-fulfilling prophecy. Management must declare that "It is broke!"

Another attitude-related barrier is the feeling that "It just won't work!" This response is often given when a person does not fully understand the nature of the proposed option and its impact on operations. The danger here is that promising options may be dropped before they can be evaluated. One way to avoid this is to use idea-generating sessions (e.g., brainstorming). This encourages participants to propose a large number of options, which are individually evaluated on their merits.

An often-encountered barrier is the fear that the WM option will diminish product quality. This is particularly common in situations where unused feed materials are recovered from the waste and then recycled back to the process. The deterioration of product quality can be a valid concern if unacceptable concentrations of waste materials build up in the system. The best way to allay this concern is to set up a small-scale demonstration in the facility, or to observe the particular option in operation at another facility.

Table 2-3. Examples of Barriers to Waste Minimization

Production
- A new operating procedure will reduce waste but may also be a bottleneck that decreases the overall production rate.
- Production will be stopped while the new process equipment is installed.
- A new piece of equipment has not been demonstrated in a similar service. It may not work here.

Facilities/Maintenance
- Adequate space is not available for the installation of new equipment.
- Adequate utilities are not available for the new equipment.
- Engineering or construction manpower will not be available in time to meet the project schedule.
- Extensive maintenance may be required.

Quality Control
- More intensive QC may be needed.
- More rework may be required.

Client Relations/Marketing
- Changes in product characteristics may affect customer acceptance.

Inventory
- A program to reduce inventory (to avoid material deterioration and reprocessing) may lead to stockouts during high product demand.

Finance
- There is not enough money to fund the project.

Purchasing
- Existing stocks (or binding contracts) will delay the replacement of a hazardous material with a non-hazardous substitute.

Environmental
- Accepting another plant's waste as a feedstock may require a lengthy resolution of regulatory issues.

Waste Treatment
- Use of a new nonhazardous raw material will adversely impact the existing wastewater treatment facility.

Planning and Organization Summary

Table 2-4 provides a summary of the steps involved in planning and organizing a waste minimization program.

Assessment Worksheets

Appendix A includes a set of worksheets for use in planning and carrying out a waste minimization assessment, and implementing the selected options. Worksheet 1 summarizes the entire assessment procedure. Worksheets 2 and 3 are used to record the organization of the WM program task force and the

individual assessment teams, respectively. Worksheet 3 includes a list of functions and departments that should be considered when organizing the assessment teams.

Table 2-4. Planning and Organization Activities Summary

SETTING UP THE PROGRAM

Get management commitment to:

- Establish waste minimization as a company goal.
- Establish a waste minimization program to meet this goal.
- Give authority to the program task force to implement this program.

Set overall goals for the program. These goals should be:

- ACCEPTABLE to those who will work to achieve them.
- FLEXIBLE to adapt to changing requirements.
- MEASURABLE over time.
- MOTIVATIONAL.
- SUITABLE to the overall corporate goals.
- UNDERSTANDABLE.
- ACHIEVABLE with a practical level of effort.

STAFFING THE PROGRAM TASK FORCE

Find a "cause champion", with the following attributes:

- Familiar with the facility, its production processes, and its waste management operations.
- Familiar with the people.
- Familiar with quality control requirements.
- Good rapport with management.
- Familiar with new production and waste management technology.
- Familiar with WM principles and techniques, and environmental regulations.
- Aggressive managerial style.

Get people who know the facility, processes, and procedures.

Get people from the affected departments or groups.

- Production.
- Facilities/Maintenance.
- Process Engineering.
- Quality Control.
- Environmental.
- Research and Development.
- Safety/Health.
- Marketing/Client Relations.
- Purchasing.
- Material Control/Inventory.
- Legal.
- Finance/Accounting.
- Information Systems.

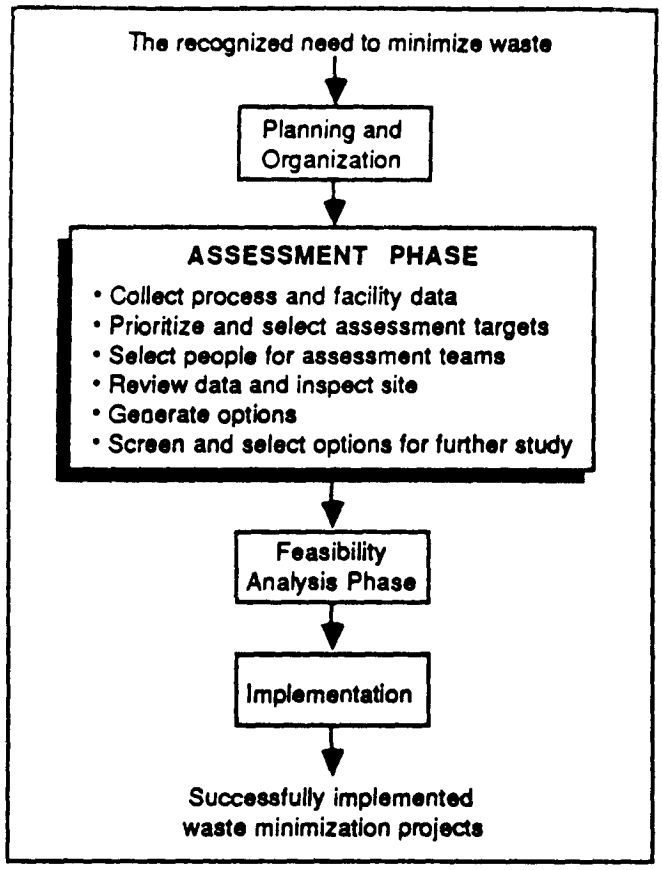
GETTING COMPANY-WIDE COMMITMENT

Incorporate the company's WM goals into departmental goals.

Solicit employee cooperation and participation.

Develop incentives and/or awards for managers and employees.

Section 3
Assessment Phase



The purpose of the assessment phase is to develop a comprehensive set of waste minimization options, and to identify the attractive options that deserve additional, more detailed analysis. In order to develop these WM options, a detailed understanding of the plant's wastes and operations is required. The assessment should begin by examining information about the processes, operations, and waste management practices at the facility.

Collecting and Compiling Data

The questions that this information gathering effort will attempt to answer include the following:

- What are the waste streams generated from the plant? And how much?
- Which processes or operations do these waste streams come from?
- Which wastes are classified as hazardous and which are not? What makes them hazardous?
- What are the input materials used that generate the waste streams of a particular process or plant area?
- How much of a particular input material enters each waste stream?
- How much of a raw material can be accounted for through fugitive losses?
- How efficient is the process?
- Are unnecessary wastes generated by mixing otherwise recyclable hazardous wastes with other process wastes?
- What types of housekeeping practices are used to limit the quantity of wastes generated?
- What types of process controls are used to improve process efficiency?

Table 3-1 lists information that can be useful in conducting the assessment. Reviewing this information will provide important background for understanding the plant's production and maintenance processes and will allow priorities to be determined. Worksheets 4 through 10 in Appendix A can be used to record the information about site characteristics, personnel, processes, input materials, products, and waste streams. Worksheets S2 through S6 in Appendix B are designed to record the same information, but in a more simplified approach.

Waste Stream Records

One of the first tasks of a waste minimization assessment is to identify and characterize the facility waste streams. Information about waste streams can come from a variety of sources. Some information on waste quantities is readily available from the completed hazardous waste manifests, which include the description and quantity of hazardous waste shipped to a TSDF. The total amount of hazardous waste shipped during a one-year period, for example, is a convenient means of measuring waste generation and waste reduction efforts. However, manifests often lack such information as chemical analysis of the waste, specific source of the waste, and the time period during which the waste was generated. Also, manifests do not cover wastewater effluents, air emissions, or nonhazardous solid wastes.

Other sources of information on waste str eams include biennial reports and NPDES (National Pollutant

Table 3-1. Facility Information for WM Assessments

Design Information
- Process flow diagrams
- Material and heat balances (both design balances and actual balances) for
  - production processes
  - pollution control processes
- Operating manuals and process descriptions
- Equipment lists
- Equipment specifications and data sheets
- Piping and instrument diagrams
- Plot and elevation plans
- Equipment layouts and work flow diagrams

Environmental Information
- Hazardous waste manifests
- Emission inventories
- Biennial hazardous waste reports
- Waste analyses
- Environmental audit reports
- Permits and/or permit applications

Raw Material/Production Information
- Product composition and batch sheets
- Material application diagrams
- Material safety data sheets
- Product and raw material inventory records
- Operator data logs
- Operating procedures
- Production schedules

Economic Information
- Waste treatment and disposal costs
- Product, utility, and raw material costs
- Operating and maintenance costs
- Departmental cost accounting reports

Other Information
- Company environmental policy statements
- Standard procedures
- Organization charts

Discharge Elimination System) monitoring reports. These NPDES monitoring reports will include the volume and constituents of wastewaters that are discharged. Additionally, toxic substance release inventories prepared under the "right to know" provisions of SARA Title III, Section 313 (Superfund Amendment and Reauthorization Act) may providevaluable information on emissions into all environmental media (land, water, and air).

Analytical test data available from previous waste evaluations and routine sampling programs can be helpful if the focus of the assessment is a particular chemical within a waste stream.

Flow Diagrams and Material Balances

Flow diagrams provide the basic means for identifying and organizing information that is useful for the assessment. Flow diagrams should be prepared to identify important process steps and to identify sources where wastes are generated. Flow diagrams are also the foundation upon which material balances are built.

Material balances are important for many WM projects, since they allow for quantifying losses or emissions that were previously unaccounted for Also, material balances assist in developing the following information:

- baseline for tracking progress of the WM efforts
- data to estimate the size and cost of additional equipment and other modifications
- data to evaluate economic performance

In its simplest form, the material balance is represented by the mass conservation principle:

Mass in = Mass out + Mass accumulated

The material balance should be made individually for all components that enter and leave the process. When chemical reactions take place in a system, there is an advantage to doing "elemental balances" for specific chemical elements in a system.

Material balances can assist in determining concentrations of waste constituents where analytical test data is limited. They are particularly useful where there are points in the production process where it is difficult (due to inaccessibility) or uneconomical to collect analytical data. A material balance can help determine if fugitive losses are occurring. For example, the evaporation of solvent from a parts cleaning tank can be estimated as the difference between solvent put into the tank and solvent removed from the tank.

To characterize waste streams by material balance can require considerable effort. However, by doing so, a more complete picture of the waste situation results. This helps to establish the focus of the WM activities and provides a baseline for measuring performance. Appendix D lists potential sources of waste from specific processes and operations.

Sources of Material Balance Information

By definition, the material balance includes both materials entering and leaving a process. Table 3-2 lists potential sources of material balance information.

Table 3-2. Sources of Material Balance Information

- Samples, analyses, and flow measurements of feed stocks, products, and waste streams
- Raw material purchase records
- Material inventories
- Emission inventories
- Equipment cleaning and validation procedures
- Batch make-up records
- Product specifications
- Design material balances
- Production records
- Operating logs
- Standard operating procedures and operating manuals
- Waste manifests

Material balances are easier, more meaningful, and more accurate when they are done for individual units, operations, or processes. For this reason, it is important to define the material balance envelope properly. The envelope should be drawn around the specifc area of concern, rather than a larger group of areas or the entire facility. An overall material balance for a facility can be constructed from individual unit material balances. This effort will highlight interrelationships between units and will help to point out areas for waste minimization by way of cooperation between different operating units or departments.

Pitfalls in Preparing Material Balances

There are several factors that must be considered when preparing material balances in order to avoid errors that could significantly overstate or understate waste streams. The precision of analytical data and flow measurements may not allow an accurate measure of the stream. In particular, in processes with very large inlet and outlet streams, the absolute error in measurement of these quantities may be greater in magnitude than the actual waste stream itself. In this case, a reliable estimate of the waste stream cannot be obtained by subtracting the quantity of hazardous material in the product from that in the feed.

The time span is important when constructing a material balance. Material balances constructed over a shorter time span require more accurate and more frequent stream monitoring in order to close the balance. Material balances performed over the duration of a complete production run are typically the easiest to construct and are reasonably accurate. Time duration also affects the use of raw material purchasing records and onsite inventories for calculating input material quantities. The quantities of materials *purchased* during a specific time period may not necessarily equal the quantity of materials *used* in production during the same time period, since purchased materials can accumulate in warehouses or stockyards.

Developing material balances around complex processes can be a complicated undertaking, especially if recycle streams are present. Such tasks are usually performed by chemical engineers, often with the assistance of computerized process simulators.

Material balances will often be needed to comply with Section 313 of SARA (Superfund Amendment and Reauthorization Act of 1986) in establishing emission inventories for specific toxic chemicals. EPA's Office of Toxic Substances (OTS) has prepared a guidance manual entitled Estimating Releases and Waste Treatment Efficiencies for the Toxic Chemicals Inventory Form (EPA 560/4-88-02). The OTS manual contains additional information for developing material balances for the listed toxic chemicals. The information presented in this manual applies to a WM assessment when the material balances are for individual operations being assessed rather than an overall facility, when the variations in flow over time is accounted for, and when the data is used from separate streams rather than from aggregate streams.

Tracking Wastes

Measuring waste mass flows and compositions is something that should be done periodically. By tracking wastes, seasonal variations in waste flows or single large waste streams can be distinguished from continual, constant flows. Indeed, changes in waste generation cannot be meaningfully measured unless the information is collected both before and after a waste minimization option is implemented. Fortunately, it is easier to do material balances the second time, and gets even easier as more are done because of the "learning curve" effect. In some larger companies, computerized database systems have been used to track wastes. Worksheets 9 and 10 in Appendix A (and Worksheet S6 in Appendix B) provide a means of recording pertinent waste stream characteristics.

Prioritizing Waste Streams and/or Operations to Assess

Ideally, all waste streams and plant operations should be assessed. However, prioritizing the waste streams and/or operations to assess is necessary when available funds and/or personnel are limited. The WM assessments should concentrate on the most important waste problems first, and then move on to the lower priority problems as the time, personnel, and budget permit.

Setting the priorities of waste streams or facility areas to assess requires a great deal of care and attention, since this step focuses the remainder of the

assessment activity. Table 3-3 lists important criteria to consider when setting these priorities.

Table 3-3. Typical Considerations for Prioritizing Waste Streams to Assess

- Compliance with current and future regulations.
- Costs of waste management (treatment and disposal).
- Potential environmental and safety liability.
- Quantity of waste.
- Hazardous properties of the waste (including toxicity, flammability, corrosivity, and reactivity).
- Other safety hazards to employees.
- Potential for (or ease of) minimization.
- Potential for removing bottlenecks in production or waste treatment.
- Potential recovery of valuable by-products.
- Available budget for the waste minimization assessment program and projects.

Worksheet 10 in Appendix A (Worksheet S6 in Appendix B) provides a means for evaluating waste stream priorities for the remainder of the assessment.

Small businesses, or large businesses with only a few waste generating operations should assess their entire facility. It is also beneficial to look at an entire facility when there are a large number of similar operations. Similarly, the implementation of good operating practices that involve procedural or organizational measures, such as soliciting employee suggestions, awareness-building programs, better inventory and maintenance procedures, and internal cost accounting changes, should be implemented on a facility-wide basis. Since many of these options do not require large capital expenditures, they should be implemented as soon as practical.

Selecting the Assessment Teams

The WM program task force is concerned with the whole plant. However, the focus of each of the assessment teams is more specific, concentrating on a particular waste stream or a particular area of the plant. Each team should include people with direct responsibility and knowledge of the particular waste stream or area of the plant. Table 3-4 presents four examples of teams for plants of various sizes in different industries.

In addition to the internal staff, consider using outside people, especially in the assessment and implementation phases. They may be trade association representatives, consultants, or experts from a different facility of the same company. In large multi-division companies, a centralized staff of experts at the corporate headquarters may be available. One or more "outsiders" can bring in new ideas and provide an objective viewpoint. An outsider also is more likely to counteract bias brought about by "inbreeding", or the "sacred cow" syndrome, such as when an old process area, rich in history, undergoes an assessment.

Table 3-4. Examples of WM Assessment Teams

1. Metal finishing department in a large defense contractor.
   - Metal finishing department manager
   - Process engineer responsible for metal finishing processes
   - Facilities engineer responsible for metal finishing department*
   - Wastewater treatment department supervisor
   - Staff environmental engineer

2. Small pesticide formulator.
   - Production manager*
   - Environmental manager
   - Maintenance supervisor
   - Pesticide industry consultant

3. Cyanide plating operation at a military facility.
   - Internal assessment team
     - Environmental coordinator*
     - Environmental engineer
     - Electroplating facility engineering supervisor
     - Metallurgist
     - Materials science group chemist
   - Outside assessment team
     - Chemical engineers (2)
     - Environmental engineering consultant
     - Plating chemistry consultant

4. Large offset printing facility.
   - Internal assessment team
     - Plant vice president
     - Film processing supervisor
     - Pressroom supervisor
   - Outside assessment team
     - Chemical engineers (2)*
     - Environmental scientist
     - Printing industry technical consultant

* - Team leader

Outside consultants can bring a wide variety of experience and expertise to a waste minimization assessment. Consultants may be especially useful to smaller companies who may not have in-house expertise in the relevant waste minimization techniques and technologies.

Production operators and line employees must not be overlooked as a source of WM suggestions, since they possess firsthand knowledge and experience with the process. Their assistance is especially useful in assessing operational or procedural changes, or in equipment modifications that affect the way they do their work.

"Quality circles" have been instituted by many companies, particularly in manufacturing industries, to

improve product quality and production efficiency. These quality circles consist of meetings of workers and supervisors, where improvements are proposed and evaluated. Quality circles are beneficial in that they involve the production people who are closely associated with the operations, and foster participation and commitment to improvement. Several large companies that have quality circles have used them as a means of soliciting successful suggestions for waste minimization.

Site Inspection

With a specific area or waste stream selected, and with the assessment team in place, the assessment continues with a visit to the site. In the case where the entire assessment team is employed at the plant being assessed, the team should have become very familiar with the specific area in the process of collecting the operating and design data. The members of the assessment team should familiarize themselves with the site as much as possible. Although the collected information is critical to gaining an understanding of the processes involved, seeing the site is important in order to witness the actual operation. For example, in many instances, a process unit is operated differently from the method originally described in the operating manual. Modifications may have been made to the equipment that were not recorded in the flow diagrams or equipment lists.

When people from outside of the plant participate in the assessment, it is recommended that a formal site inspection take place. Even when the team is made up entirely of plant employees, a site inspection by all team members is helpful after the site information has been collected and reviewed. The inspection helps to resolve questions or conflicting data uncovered during the review. The site inspection also provides additional information to supplement that obtained earlier.

When the assessment team includes members employed outside of the plant, the team should prepare a list of needed information and an inspection agenda. The list can be presented in the form of a checklist detailing objectives, questions and issues to be resolved, and/or further information requirements. The agenda and information list are given to the appropriate plant personnel in the areas to be assessed early enough before the visit to allow them to assemble the information in advance. Of course, it may be that the assessment team members themselves are in the best position to collect and compile much of the data. By carefully thinking out the agenda and needs list, important points are less likely to be overlooked during the inspection. Table 3-5 presents useful guidelines for the site inspection.

Table 3-5. Guidelines for the Site Inspection

- Prepare an agenda in advance that covers all points that still require clarification. Provide staff contacts in the area being assessed with the agenda several days before the inspection.
- Schedule the inspection to coincide with the particular operation that is of interest (e.g., make-up chemical addition, bath sampling, bath dumping, start-up, shutdown, etc.).
- Monitor the operation at different times during the shift, and if needed, during all three shifts, especially when waste generation is highly dependent on human involvement (e.g., in painting or parts cleaning operations).
- Interview the operators, shift supervisors, and foremen in the assessed area. Do not hesitate to question more than one person if an answer is not forthcoming. Assess the operators' and their supervisors' awareness of the waste generation aspects of the operation. Note their familiarity (or lack thereof) with the impacts their operation may have on other operations.
- Photograph the area of interest, if warranted. Photographs are valuable in the absence of plant layout drawings. Many details can be captured in photographs that otherwise could be forgotten or inaccurately recalled at a later date.
- Observe the "housekeeping" aspects of the operation. Check for signs of spills or leaks. Visit the maintenance shop and ask about any problems in keeping the equipment leak-free. Assess the overall cleanliness of the site. Pay attention to odors and fumes.
- Assess the organizational structure and level of coordination of environmental activities between various departments.
- Assess administrative controls, such as cost accounting procedures, material purchasing procedures, and waste collection procedures.

In performing the site inspection the assessment team should follow the process from the point where raw materials enter the area to the point where the products and the wastes leave the area. The team should identify the suspected sources of waste. This may include the production process; maintenance operations; storage areas for raw materials, finished product, and work-in-process. Recognize that the plant's waste treatment area itself may also offer opportunities to minimize waste. This inspection often results in forming preliminary conclusions about the causes of waste generation. Full confirmation of these conclusions may require additional data collection, analysis, and/or site visits.

Generating WM Options

Once the origins and causes of waste generation are understood, the assessment process enters the creative phase. The objective of this step is to generate a comprehensive set of WM options for further consideration. Following the collection of data and site inspections, the members of the team will have begun to identify possible ways to minimize waste in the assessed area. Identifying potential options relies both on the expertise and creativity of the team members. Much of the requisite knowledge may come from their education and on-the-job experience, however, the use of technical literature, contacts, and other sources is always helpful. Some sources of background information for waste minimization techniques are listed in Table 3-6.

Table 3-6. Sources of Background Information on WM Options

Trade associations
As part of their overall function to assist companies within their industry, trade associations generally provide assistance and information about environmental regulations and various available techniques for complying with these regulations. The information provided is especially valuable since it is industry-specific.

Plant engineers and operators
The employees that are intimately familiar with a facility's operations are often the best source of suggestions for potential WM options.

Published literature
Technical magazines, trade journals, government reports, and research briefs often contain information that can be used as waste minimization options.

State and local environmental agencies
A number of states and local agencies have, or are developing, programs that include technical assistance, information on industry-specific waste minimization techniques, and compiled bibliographies. Appendix E provides a list of addresses for state and federal programs for WM assistance.

Equipment vendors
Meetings with equipment vendors, as well as vendor literature, are particularly useful in identifying potential equipment-oriented options. Vendors are eager to assist companies in implementing projects. Remember, though, that the vendor's job is to sell equipment.

Consultants
Consultants can provide information about WM techniques. Section 2 discusses the use of consultants in WM programs. A consultant with waste minimization experience in your particular industry is most desirable.

Waste Minimization Options

The process for identifying options should follow a hierarchy in which source reduction options are explored first, followed by recycling options. This hierarchy of effort stems from the environmental desirability of source reduction as the preferred means of minimizing waste. Treatment options should be considered only after acceptable waste minimization techniques have been identified.

Recycling techniques allow hazardous materials to be put to a beneficial use. Source reduction techniques avoid the generation of hazardous wastes, thereby eliminating the problems associated with handling these wastes. Recycling techniques may be performed onsite or at an offsite facility designed to recycle the waste.

Source reduction techniques are characterized as good operating practices, technology changes, material changes, or product changes. Recycling techniques are characterized as use/reuse techniques and resource recovery techniques. These techniques are described below:

Source Reduction: Good Operating Practices

Good operating practices are procedural, administrative, or institutional measures that a company can use to minimize waste. Good operating practices apply to the human aspect of manufacturing operations. Many of these measures are used in industry largely as efficiency improvements and good management practices. Good operating practices can often be implemented with little cost and, therefore, have a high return on investment. These practices can be implemented in all areas of a plant, including production, maintenance operations, and in raw material and product storage. Good operating practices include the following:

- Waste minimization programs
- Management and personnel practices
- Material handling and inventory practices
- Loss prevention
- Waste segregation
- Cost accounting practices
- Production scheduling

Management and personnel practices include employee training, incentives and bonuses, and other programs that encourage employees to conscientiously strive to reduce waste. Material handling and inventory practices include programs to reduce loss of input materials due to mishandling, expired shelf life of time-sensitive materials, and proper storage conditions. Loss prevention minimizes

wastes by avoiding leaks from equipment and spills. Waste segregation practices reduce the volume of hazardous wastes by preventing the mixing of hazardous and nonhazardous wastes. Cost accounting practices include programs to allocate waste treatment and disposal costs directly to the departments or groups that generate waste, rather than charging these costs to general company overhead accounts. In doing so, the departments or groups that generate the waste become more aware of the effects of their treatment and disposal practices, and have a financial incentive to minimize their waste. By judicious scheduling of batch production runs, the frequency of equipment cleaning and the resulting waste can be reduced.

Example: Good Operating Practices

A large consumer product company in California adopted a corporate policy to minimize the generation of hazardous waste. In order to implement the policy, the company mobilized quality circles made up of employees representing areas within the plant that generated hazardous wastes. The company experienced a 75% reduction in the amount of wastes generated by instituting proper maintenance procedures suggested by the quality circle teams. Since the team members were also line supervisors and operators, they made sure the procedures were followed.

Source Reduction: Technology Changes

Technology changes are oriented toward process and equipment modifications to reduce waste, primarily in a production setting. Technology changes can range from minor changes that can be implemented in a matter of days at low cost, to the replacement of processes involving large capital costs. These changes include the following:

- Changes in the production process
- Equipment, layout, or piping changes
- Use of automation
- Changes in process operating conditions, such as
  - Flow rates
  - Temperatures
  - Pressures
  - Residence times

Example: Technology Changes

A manufacturer of fabricated metal products cleaned nickel and titanium wire in an alkaline chemical bath prior to using the wire in their product. In 1986, the company began to experiment with a mechanical abrasive system. The wire was passed through the system which uses silk and carbide pads and pressure to brighten the metal. The system worked, but required passing the wire through the unit twice for complete cleaning. In 1987. The company bought a second abrasive unit and installed it in series with the first unit. This system allowed the company to completely eliminate the need for the chemical cleaning bath.

Source Reduction: Input Material Changes

Input material changes accomplish waste minimization by reducing or eliminating the hazardous materials that enter the production process. Also, changes in input materials can be made to avoid the generation of hazardous wastes within the production processes. Input material changes include:

- Material purification
- Material substitution

Example: Input Material Changes

An electronic manufacturing facility of a large diversified corporation originally cleaned printed ciruit boards with solvents. The company found that by switching from a solvent-based cleaning system to an aqueous-based system that the same operating conditions and workloads could be maintained. The aqueous-based system was found to clean six times more effectively. This resulted in a lower product reject rate, and eliminated a hazardous waste.

Source Reduction: Product Changes

Product changes are performed by the manufacturer of a product with the intent of reducing waste resulting from a product's use. Product changes include:

- Product substitution
- Product conservation
- Changes in product composition

Example: Product changes

In the paint manufacturing industry, water-based coatings are finding increasing applications where solvent-based paints were used before. These products do not contain toxic or flammable solvents that make solvent-based paints hazardous when they are disposed of. Also, cleaning the applicators with solvent is not necessary. The use of water-

based paints instead of solvent-based paints also greatly reduces volatile organic compound emissions to the atmosphere.

Recycling: Use and Reuse

Recycling via use and/or reuse involves the return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material.

Example: Reuse

A printer of newpaper advertising in California purchased an ink recycling unit to produce black newspaper ink from its various waste inks. The unit blends the different colors of waste ink together with fresh black ink and black toner to create the black ink. This ink is then filtered to remove flakes of dried ink. This ink is used in place of fresh black ink, and eliminates the need for the company to ship waste ink offsite for disposal. The price of the recycling unit was paid off in 18 months based only on the savings in fresh black ink purchases. The payback improved to 9 months when the costs for disposing of ink as a hazardous waste are included.

Recycling: Reclamation

Reclamation is the recovery of a valuable material from a hazardous waste. Reclamation techniques differ from use and reuse techniques in that the recovered material is not used in the facility, rather it is sold to another company.

Example: Reclamation

A photoprocessing company uses an electrolytic deposition cell to recover silver out of the rinsewater from film processing equipment. The silver is then sold to a small recycler. By removing the silver from this wastewater, the wastewater can be discharged to the sewer without additional pretreatment by the company. This unit pays for itself in less than two years with the value of silver recovered.

The company also collects used film and sells it to the same recycler. The recycler burns the film and collects the silver from the the residual ash. By removing the silver from the ash, the ash becomes nonhazardous.

Appendix E lists many WM techniques and concepts applicable to common waste-generating operations (coating, equipment cleaning, parts cleaning, and materials handling). Additionally, a list of good operating practices is provided.

Methods of Generating Options

The process by which waste minimization options are identified should occur in an environment that encourages creativity and independent thinking by the members of the assessment team. While the individual team members will suggest many potential options on their own, the process can be enhanced by using some of the common group decision techniques. These techniques allow the assessment team to identify options that the individual members might not have come up with on their own. Brainstorming sessions with the team members are an effective way of developing WM options. Most management or organizational behavior textbooks describe group decision techniques, such as brainstorming or the nominal group technique.

Worksheet 11 in Appendix A is a form for listing options that are proposed during an option generation session. Worksheet 12 in Appendix A is used to briefly describe and document the options that are proposed. Worksheets S7 and S8 in Appendix B perform the same function in the simplified set of worksheets.

Screening and Selecting Options for Further Study

Many waste minimization options will be identified in a successful assessment. At this point, it is necessary to identify those options that offer real potential to minimize waste and reduce costs. Since detailed evaluation of technical and economic feasibility is usually costly, the proposed options should be screened to identify those that deserve further evaluation. The screening procedure serves to eliminate suggested options that appear marginal, impractical, or inferior without a detailed and more costly feasibility study.

The screening procedures can range from an informal review and a decision made by the program manager or a vote of the team members, to quantitative decision-making tools. The informal evaluation is an unstructured procedure by which the assessment team or WM program task force selects the options that appear to be the best. This method is especially useful in small facilities, with small management groups, or in situations where only a few options have been generated. This method consists of a discussion and examination of each option.

The weighted sum method is a means of quantifying the important factors that affect waste management at a

particular facility, and how each option will perform with respect to these factors. This method is recommended when there are a large number of options to consider. Appendix G presents the weighted sum method in greater detail, along with an example. Worksheet 13 in Appendix A is designed to screen and rank options using this method.

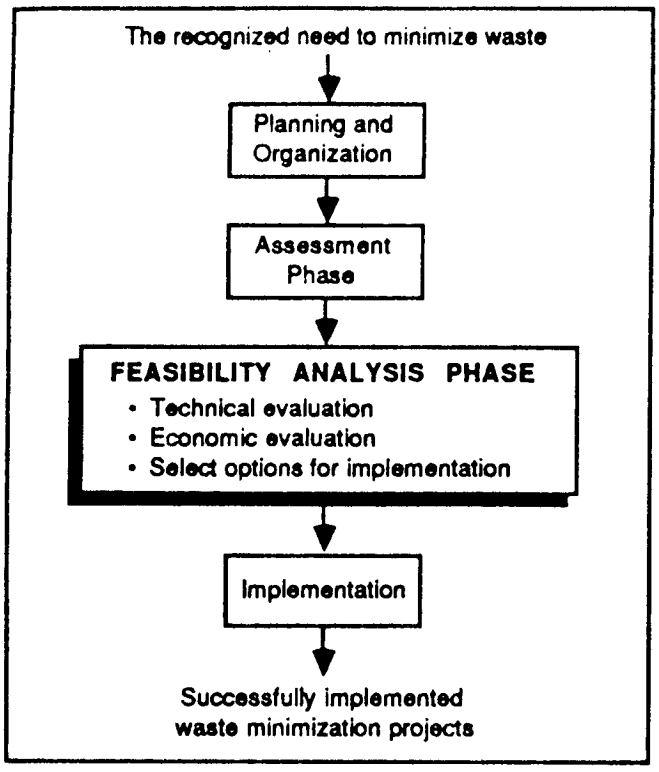
The assessment procedure is flexible enough to allow common group decision-making techniques to be used here. For example, many large corporations currently use decision-making systems that can be used to screen and rank WM options.

No matter what method is used, the screening procedure should consider the following questions.

- What is the main benefit gained by implementing this option? (e.g., economics, compliance, liability, workplace safety, etc.)
- Does the necessary technology exist to develop the option?
- How much does it cost? Is it cost effective?
- Can the option be implemented within a reasonable amount of time without disrupting production?
- Does the option have a good "track record"? If not, is there convincing evidence that the option will work as required?
- Does the option have a good chance of success? (A successfully initiated WM program will gain wider acceptance as the program progresses.)
- What other benefits will occur?

The results of the screening activity are used to promote the successful options for technical and economic feasibility analyses. The number of options chosen for the feasibility analyses depends on the time, budget, and resources available for such a study.

Some options (such as procedural changes) may involve no capital costs and can be implemented quickly with little or no further evaluation. The screening procedure should account for ease of implementation of an option. If such an option is clearly desirable and indicates a potential cost savings, it should be promoted for further study or outright implementation.



The final product of the assessment phase is a list of WM options for the assessed area. The assessment will have screened out the impractical or unattractive options. The next step is to determine if the remaining options are technically and economically feasible.

Technical Evaluation

The technical evaluation determines whether a proposed WM option will work in a specific application. The assessment team should use a "fast-track" approach in evaluating procedural changes that do not involve a significant capital expenditure. Process testing of materials can be done relatively quickly, if the options do not involve major equipment installation or modifications.

For equipment-related options or process changes, visits to see existing installations can be arranged through equipment vendors and industry contacts. The operator's comments are especially important and should be compared with the vendor's claims. Bench-scale or pilot-scale demonstration is often necessary. Often it is possible to obtain scale-up data using a rental test unit for bench-scale or pilot-scale experiments. Some vendors will install equipment on a trial basis, with acceptance and payment after a prescribed time, if the user is satisfied.

The technical evaluation of an option also must consider facility constraints and product requirements, such as those described in Table 4-1. Although an inability to meet these constraints may not present insurmountable problems, correcting them will likely add to the capital and/or operating costs.

Table 4-1. Typical Technical Evaluation Criteria

- Is the system safe for workers?
- Will product quality be maintained?
- Is space available?
- Is the new equipment, materials, or procedures compatible with production operating procedures, work flow, and production rates?
- Is additional labor required?
- Are utilitities available? Or must they be installed, thereby raising capital costs?
- How long will production be stopped in order to install the system?
- Is special expertise required to operate or maintain the new system?
- Does the vendor provide acceptable service?
- Does the system create other environmental problems?

All affected groups in the facility should contribute to and review the results of the technical evaluation. Prior consultation and review with the affected groups (e.g., production, maintenance, purchasing) is needed to ensure the viability and acceptance of an option. If the option calls for a change in production methods or input materials, the project's effects on the quality of the final product must be determined. If after the technical evaluation, the project appears infeasible or impractical, it should be dropped. Worksheet 14 in Appendix A is a checklist of important items to consider when evaluating the technical feasibility of a WM option.

Economic Evaluation

The economic evaluation is carried out using standard measures of profitability, such as payback period, return on investment, and net present value. Each organization has its own economic criteria for selecting projects for implementation. In performing the economic evaluation, various costs and savings must be considered. As in any projects, the cost elements of a WM project can be broken down into capital costs and operating costs. The economic analysis described in this section and in the associated worksheets represents a preliminary, rather than detailed, analysis.

For smaller facilities with only a few processes, the entire WM assessment procedure will tend to be much

Table 4-2. Capital Investment for a Typical Large WM Project

Direct Capital Costs
- Site Development
  - Demolition and alteration work
  - Site clearing and grading
  - Walkways, roads, and fencing
- Process Equipment
  - All equipment listed on flow sheets
  - Spare parts
  - Taxes, freight, insurance, and duties
- Materials
  - Piping and ducting
  - Insulation and painting
  - Electrical
  - Instrumentation and controls
  - Buildings and structures
- Connections to Existing Utilities and Services (water, HVAC, power, steam, refrigeration, fuels, plant air and inert gas, lighting, and fire control)
- New Utility and Service Facilities (same items as above)
- Other Non-Process Equipment
- Construction/Installation
  - Construction/Installation labor salaries and burden
  - Supervision, accounting, timekeeping, purchasing, safety, and expediting
  - Temporary facilities
  - Construction tools and equipment
  - Taxes and insurance
  - Building permits, field tests, licenses

Indirect Capital Costs
- In-house engineering, procurement, and other home office costs
- Outside engineering, design, and consulting Services
- Permitting costs
- Contractors' fees
- Start-up costs
- Training costs
- Contingency
- Interest accrued during construction
  - TOTAL FIXED CAPITAL COSTS

Working Capital
- Raw materials inventory
- Finished product inventory
- Materials and supplies
  - TOTAL WORKING CAPITAL

TOTAL CAPITAL INVESTMENT

Source: Adapted from Perry, Chemical Engineer's Handbook (1985); and Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers (1980).

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less formal. In this situation, several obvious WM options, such as installation of flow controls and good operating practices may be implemented with little or no economic evaluation. In these instances, no complicated analyses are necessary to demonstrate the advantages of adopting the selected WM options.

A proper perspective must be maintained between the magnitude of savings that a potential option may offer, and the amount of manpower required to do the technical and economic feasibility analyses.

Capital Costs

Table 4-2 is a comprehensive list of capital cost items associated with a large plant upgrading project. These costs include not only the fixed capital costs for designing, purchasing, and installing equipment, but also costs for working capital, permitting, training, start-up, and financing charges.

With the increasing level of environmental regulations, initial permitting costs are becoming a significant portion of capital costs for many recycling options (as well as treatment, storage, and disposal options). Many source reduction techniques have the advantage of not requiring environmental permitting in order to be implemented.

Operating Costs and Savings

The basic economic goal of any waste minimization project is to reduce (or eliminate) waste disposal costs and to reduce input material costs. However, a variety of other operating costs (and savings) should also be considered. In making the economic evaluation, it is convenient to use incremental operating costs in comparing the existing system with the new system that incorporates the waste minimization option. ("Incremental operating costs" represent the difference between the estimated operating costs associated with the WM option, and the actual operating costs of the existing system, without the option.) Table 4-3 describes incremental operating costs and savings and incremental revenues typically associated with waste minimization projects.

Reducing or avoiding present and future operating costs associated with waste treatment, storage, and disposal are major elements of the WM project economic evaluation. Companies have tended to ignore these costs in the past because land disposal was relatively inexpensive. However, recent regulatory requirements imposed on generators and waste management facilities have caused the costs of waste management to increase to the point where it is becoming a significant factor in a company's overall cost structure. Table 4-4 presents typical external costs for offsite waste treatment and disposal. In addition to these external costs, there are significant internal costs, including the labor to store and ship out wastes, liability insurance costs, and onsite treatment costs.

Table 4-3. Operating Costs and Savings Associated with WM Projects

Reduced waste management costs.
This includes reductions in costs for:
- Offsite treatment, storage, and disposal fees
- State fees and taxes on hazardous waste generators
- Transportation costs
- Onsite treatment, storage, and handling costs
- Permitting, reporting, and recordkeeping costs

Input material cost savings.
An option that reduces waste usually decreases the demand for input materials.

Insurance and liability savings.
A WM option may be significant enough to reduce a company's insurance payments. It may also lower a company's potential liability associated with remedial clean-up of TSDFs and workplace safety. (The magnitude of liability savings is difficult to determine).

Changes in costs associated with quality.
A WM option may have a positive or negative effect on product quality. This could result in higher (or lower) costs for rework, scrap, or quality control functions.

Changes in utilities costs.
Utilities costs may increase or decrease. This includes steam, electricity, process and cooling water, plant air, refrigeration, or inert gas.

Changes in operating and maintenance labor, burden, and benefits.
An option may either increase or decrease labor requirements. This may be reflected in changes in overtime hours or in changes in the number of employees. When direct labor costs change, then the burden and benefit costs will also change. In large projects, supervision costs will also change.

Changes in operating and maintenance supplies.
An option may result increase or decrease the use of O&M supplies.

Changes in overhead costs.
Large WM projects may affect a facility's overhead costs.

Changes in revenues from increased (or decreased) production.
An option may result in an increase in the productivity of a unit. This will result in a change in revenues. (Note that operating costs may also change accordingly.)

Increased revenues from by-products.
A WM option may produce a by-product that can be sold to a recycler or sold to another company as a raw material. This will increase the company's revenues.

Table 4-4. Typical Costs of Offsite Industrial Waste Management*

Disposal	
Drummed hazardous waste**	
Solids	$75 to $110 per drum
Liquids	$65 to $120 per drum
Bulk waste	
Solids	$120 per cubic yard
Liquids	$0.60 to $2.30 per gallon
Lab packs	$110 per drum
Analysis (at disposal site)	$200 to $300
Transportation	$65 to $85 per hour @ 45 miles per hour (round trip)

* - Does not include internal costs, such as taxes and fees, and labor for manifest preparation, storage, handling, and recordkeeping.

**- Based on 55 gallon drums. These prices are for larger quantities of drummed wastes. Disposal of a small number of drums can be up to four times higher per drum.

For the purpose of evaluating a project to reduce waste quantities, some types of costs are larger and more easily quantified. These include:

- disposal fees
- transportation costs
- predisposal treatment costs
- raw materials costs
- operating and maintenance costs.

It is suggested that savings in these costs be taken into consideration first, because they have a greater effect on project economics and involve less effort to estimate reliably. The remaining elements are usually secondary in their direct impact and should be included on an as-needed basis in fine-tuning the analysis.

Profitability Analysis

A project's profitability is measured using the estimated net cash flows (cash incomes minus cash outlays) for each year of the project's life. A profitability analysis example in Appendix H includes two cash flow tables (Figure H-3 and H-4).

If the project has no significant capital costs, the project's profitability can be judged by whether an operating cost savings occurs or not. If such a project reduces overall operating costs, it should be implemented as soon as practical.

For projects with significant capital costs, a more detailed profitability analysis is necessary. The three standard profitability measures are:

- Payback period
- Internal rate of return (IRR)
- Net present value

The payback period for a project is the amount of time it takes to recover the initial cash outlay on the project. The formula for calculating the payback period on a pretax basis is the following:

$$\text{Payback period (in years)} = \frac{\text{Capital investment}}{\text{Annual operating cost savings}}$$

For example, suppose a waste generator installs a piece of equipment at a total cost of $120,000. If the piece of equipment is expected to save $48,000 per year, then the payback period is 2.5 years.

Payback periods are typically measured in years. However, a particularly attractive project may have a payback period measured in months. Payback periods in the range of three to four years are usually considered acceptable for low-risk investments. This method is recommended for quick assessments of profitability. If large capital expenditures are involved, it is usually followed by more detailed analysis.

The internal rate of return (IRR) and the net present value (NPV) are both discounted cash flow techniques for determining profitability. Many companies use these methods for ranking capital projects that are competing for funds. Capital funding for a project may well hinge on the ability of the project to generate positive cash flows beyond the payback period to realize acceptable return on investment. Both the NPV and IRR recognize the time value of money by discounting the projected future net cash flows to the present. For investments with a low level of risk, an aftertax IRR of 12 to 15 percent is typically acceptable.

Most of the popular spreadsheet programs for personal computers will automatically calculate IRR and NPV for a series of cash flows. Refer to any financial management, cost accounting, or engineering economics text for more information on determining the IRR or NPV. Appendix H presents a profitability analysis example for a WM project using IRR and NPV.

Adjustments for Risks and Liability

As mentioned earlier, waste minimization projects may reduce the magnitude of environmental and safety risks for a company. Although these risks can be identified, it is difficult to predict if problems occur, the nature of the problems, and their resulting magnitude. One way of accounting for the reduction of these risks is to ease the financial performance requirements of the project. For example, the acceptable payback may be lengthened from four to five years, or the required internal rate of return may be lowered from 15 percent to 12 percent. Such adjustments reflect recognition of elements that affect the risk exposure of the company, but cannot be included directly in the analyses. These adjustments are judgmental and necessarily reflect the individual viewpoints of the people evaluating the project for capital funding. Therefore, it is important that the financial analysts and the decision makers in the company be aware of the risk reduction and other benefits of the WM options. As a policy to encourage waste minimization, some companies have set lower hurdle rates for WM projects.

While the profitability is important in deciding whether or not to implement an option, environmental regulations may be even more important. A company operating in violation of environmental regulations can face fines, lawsuits, and criminal penalties for the company's managers. Ultimately, the facility may even be forced to shut down. In this case the total cash flow of a company can hinge upon implementing the environmental project.

Worksheets for Economic Evaluation

Worksheets 15 through 17 in Appendix A are used to determine the economic evaluation of a WM option. Worksheet 15 is a checklist of capital and operating cost items. Worksheet 16 is used to find a simple payback period for an option that requires capital investment. Worksheet 17 is used to find the net present value and internal rate of return for an option that requires capital investment. Worksheet S9 in Appendix B is used to record estimated capital and operating costs, and to determine the payback period in the simplified assessment procedure.

Final Report

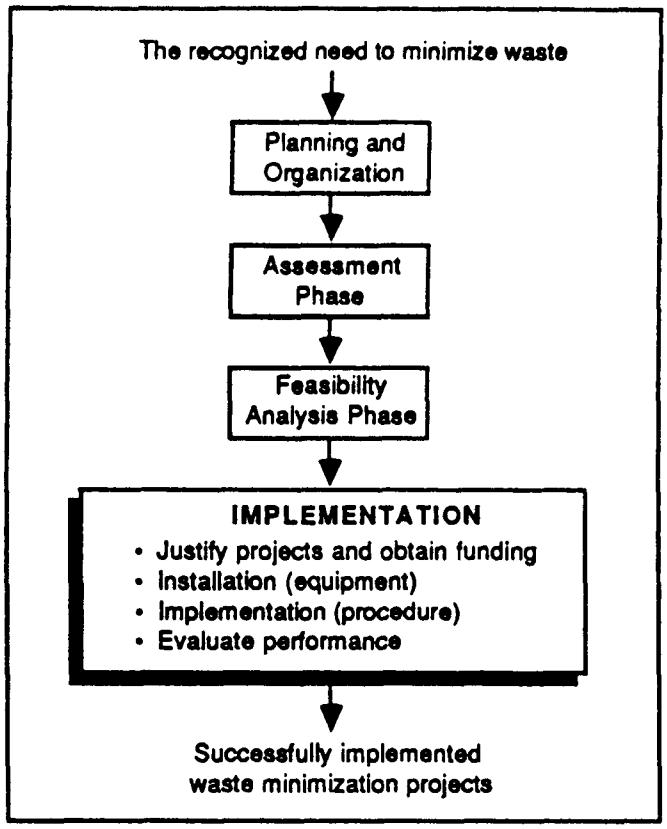
The product of a waste minimization assessment is a report that presents the results of the assessment and the technical and economic feasibility analyses. The report also containes recommendations to implement the feasible options.

A good final report can be an important tool for getting a project implemented. It is particularly valuable in obtaining funding for the project. In presenting the feasibility analyses, it is often useful to evaluate the project under different scenarios. For example, comparing a projects's profitability under optimistic and pessimistic assumptions (such as increasing waste disposal costs) can be beneficial. Sensitivity analyses that indicate the effect of key variables on profitability are also useful.

The report should include not only how much the project will cost and its expected performance, but also how it will be done. It is important to discuss:

- whether the technology is established, with mention of succesful applications;
- the required resources and how they will be obtained;
- estimated construction period;
- estimated production downtime;
- how the performance of the project can be evaluated after it is implemented.

Before the report is finalized, it is important to review the results with the affected departments and to solicit their support. By having department representatives assist in preparing and reviewing the report, the chances are increased that the projects will be implemented. In summarizing the results, a qualitative evaluation of intangible costs and benefits to the company should be included. Reduced liabilities and improved image in the eyes of the employees and the community should be discussed.



The WM assessment report provides the basis for obtaining company funding of WM projects. Because projects are not always sold on their technical merits alone, a clear description of both tangible and intangible benefits can help edge a proposed project past competing projects for funding.

The champions of the WM assessment program should be flexible enough to develop alternatives or modifications. They should also be committed to the point of doing background and support work, and should anticipated potential problems in implementing the options. Above all, they should keep in mind that an idea will not sell if the sponsors are not sold on it themselves.

Obtaining Funding

Waste reduction projects generally involve improvements in process efficiency and/or reductions in operating costs of waste management. However, an organization's capital resources may be prioritized toward enhancing future revenues (for example, moving into new lines of business, expanding plant capacity, or acquiring other companies), rather than toward cutting current costs. If this is the case, then a sound waste reduction project could be postponed until the next capital budgeting period. It is then up to the project sponsor to ensure that the project is reconsidered at that time.

Knowing the level within the organization that has approval authority for capital projects will help in enlisting the appropriate support. In large corporations, smaller projects are typically approved at the plant manager level, medium-size projects at the divisional vice president level, and larger projects at the executive committee level.

An evaluation team made up of financial and technical personnel can ensure that a sponsor's enthusiasm is balanced with objectivity. It can also serve to quell opposing "can't be done" or "if it ain't broke, don't fix it" attitudes that might be encountered within the organization. The team should review the project in the context of:

- past experience in this area of operation
- what the market and the competition are doing
- how the implementation program fits into the company's overall business strategy
- advantages of the proposal in relation to competing requests for capital funding

Even when a project promises a high interal rate of return, some companies will have difficulty raising funds internally for capital investment. In this case, the company should look to outside financing. The company generally has two major sources to consider: private sector financing and government-assisted funding.

Private sector financing includes bank loans and other conventional sources of financing. Government financing is available in some cases. It may be worthwhile to contact your state's Department of Commerce or the federal Small Business Administration for information regarding loans for pollution control or hazardous waste disposal projects. Some states can provide technical and financial assistance. Appendix F includes a list of states providing this assistance and addresses to get information.

Installation

Waste minimization options that involve operational, procedural, or materials changes (without additions or modifications to equipment) should be implemented as soon as the potential cost savings have been determined. For projects involving equipment modifications or new equipment, the installation of a waste minimization project is essentially no different from any other capital improvement project. The phases of the project include planning, design, procurement, and construction.

Worksheet 18 is a form for documenting the progress of a WM project through the implementation phase.

Demonstration and Follow-up

After the waste minimization option has been implemented, it remains to be seen how effective the option actually turns out to be. Options that don't measure up to their original performance expectations may requre rework or modifications. It is important to get warranties from vendors prior to installation of the equipment.

The documentation provided through a follow-up evaluation represents an important source of information for future uses of the option in other facilities. Worksheet 19 is a form for evaluating the performance of an implemented WM option. The experience gained in implementing an option at one facility can be used to reduce the problems and costs of implementing options at subsequent facilities.

Measuring Waste Reduction

One measure of effectiveness for a WM project is the project's effect on the organization's cash flow. The project should pay for itself through reduced waste management costs and reduced raw materials costs. However, it is also important to measure the actual reduction of waste accomplished by the WM project.

The easiest way to measure waste reduction is by recording the quantities of waste generated before and after a WM project has been implemented. The difference, dividied by the original waste generation rate, represents the percentage reduction in waste quantity. However, this simple measurement ignores other factors that also affect the quantity of waste generated.

In general, waste generation is directly dependent on the production rate. Therefore, the ratio of waste generation rate to production rate is a convenient way of measuring waste reduction.

Expressing waste reduction in terms of the ratio of waste to production rates is not free of problems, however. One of these problems is the danger of using the ratio of infrequent large quantities to the production rate. This problem is illustrated by a situation where a plant undergoes a major overhaul involving equipment cleaning, paint stripping, and repainting. Such overhauls are fairly infrequent and are typically performed every three to five years. The decision to include this intermittent stream in the calculation of the waste reduction index, based on the ratio of waste rate to product rate, would lead to an increase in this index. This decision cannot be justified, however, since the infrequent generation of painting wastes is not a function of production rate. In a situation like this, the waste reduction progress should be measured in terms of the ratio of waste quantity or materials use to the square footage of the area painted. In general, a distinction should be made between production- related wastes and maintenance-related wastes and clean-up wastes.

Also, a few waste streams may be inversely proportional to production rate. For example, a waste resulting from outdated input materials is likely to increase if the production rate decreases. This is because the age-dated materials in inventory are more likely to expire when their use in production decreases.

For these reasons, care must be taken when expressing the extent of waste reduction. This requires that the means by which wastes are generated be well understood.

In measuring waste reduction, the total quantity of an individual waste stream should be measured, as well as the individual waste components or characteristics. Many companies have reported substantial reduction in the quanitites of waste disposed. Often, much of the reduction can be traced to good housekeeping and steps taken to concentrate a dilute aqueous waste. Although concentration, as such, does not fall within the definition of waste minimization, there are practical benefits that result from concentrating wastewater streams, including decreased disposal costs. Concentration may render a waste stream easier to recycle, and is also desirable if a facility's current wastewater treatment system is overloaded.

Obtaining good quality data for waste stream quanities, flows, and composition can be costly and time consuming. For this reason, it may be practical, in some instances, to express waste reduction indirectly in terms of the ratio of input materials consumption to production rate. These data are easier to obtain, although the measure is not direct.

Measuring waste minimization by using a ratio of waste quantity to material throughput or product output is generally more meaningful for specific units or operations, rather than for an entire facility. Therefore, it is important to preserve the focus of the WM project when measuring and reporting progress. For those operations not involving chemical reactions, it may be helpful to measure WM progress by using the ratio of input material quantity to material throughput or production rate.

Waste Minimization Assessments for New Production Processes

This manual concentrates on waste minimization assessments conducted in existing facilities. However, it is important that waste minimization principles be applied to new projects. In general, it is easier to avoid waste generation during the research and development or design phase than to go back and modify the process after it has already been installed.

The planning and design team for a new product, production process, or operation should address waste generation aspects early on. The assessment procedure in this manual can be modified to provide a WM review of a product or process in the planning or design phase. The earlier the assessment is performed, the less likely it is that the project will require expensive changes. All new projects should be reviewed by the waste minimization program task force.

A better approach than a pre-project assessment is to include one or more members of the WM program task force on any new project that will generate waste. In this way, the new project will benefit from the "built-in" presence of a WM champion and his or her influence to design the process to minimize waste At a California facility of a major defense contractor, all new projects and modifications to existing facilities and equipment are reviewed by the WM program team. All projects that have no environmental impact are quickly screened and approved. Those projects that do have an environmental impact are assigned to a team member who participates in the project kick-off and review meetings from inception to implementation.

Ongoing Waste Minimization Program

The WM program is a continuing, rather than a one-time effort. Once the highest priority waste streams and facility areas have been assessed and those projects have been implemented, the assessment program should look to areas and waste streams with lower priorities. The ultimate goal of the WM program should be to reduce the generation of waste to the maximum extent achievable. Companies that have eliminated the generation of hazardous waste should continue to look at reducing industrial wastewater discharges, air emissions, and solid wastes.

The frequency with which assessments are done will depend on the program's budget, the company's budgeting cycle (annual cycle in most companies), and special circumstances. These special circumstances might be:

- a change in raw material or product requirements
- higher waste management costs
- new regulations
- new technology
- a major event with undesirable environmental consequences (such as a major spill)

Aside from the special circumstances, a new series of assessments should be conducted each fiscal year.

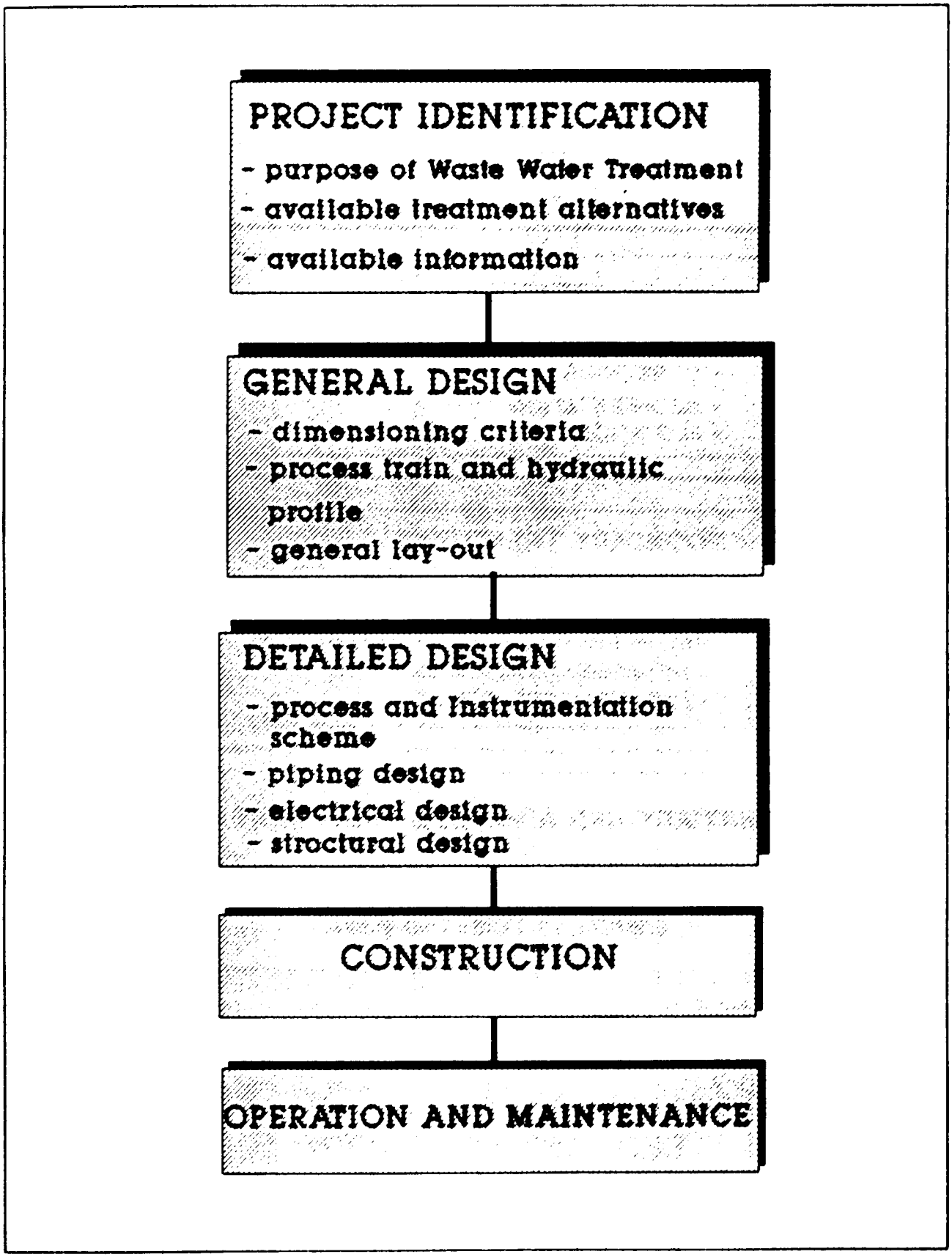
To be truly effective, a philosophy of waste minimization must be developed in the organization. This means that waste minimization must be an integral part of the company's operations. The most successful waste minimization programs to date have all developed this philosophy within their companies.

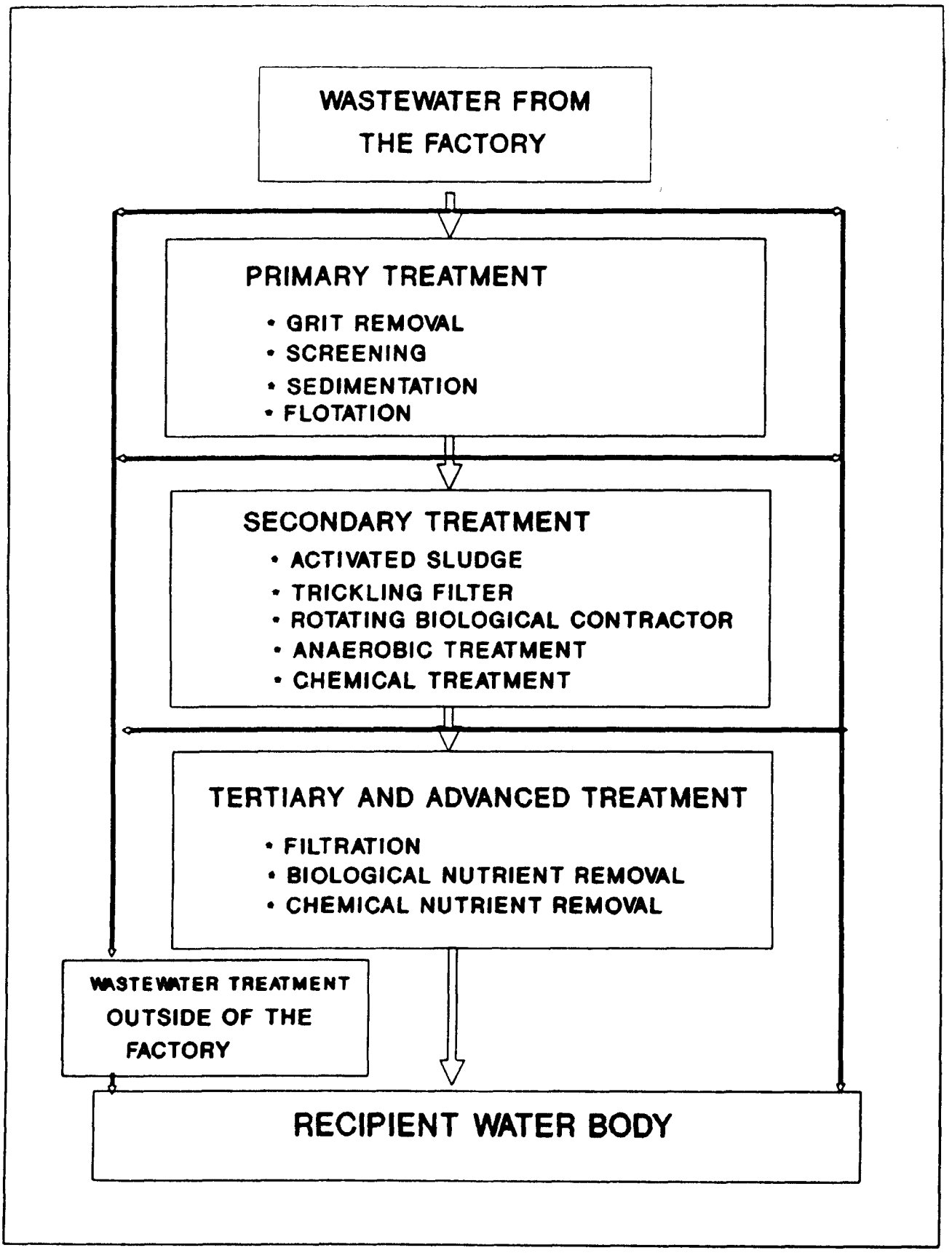
Training Course on Environmental Management in Industry

Planning of Industrial Wastewater Treatment

Tampere, 16 August

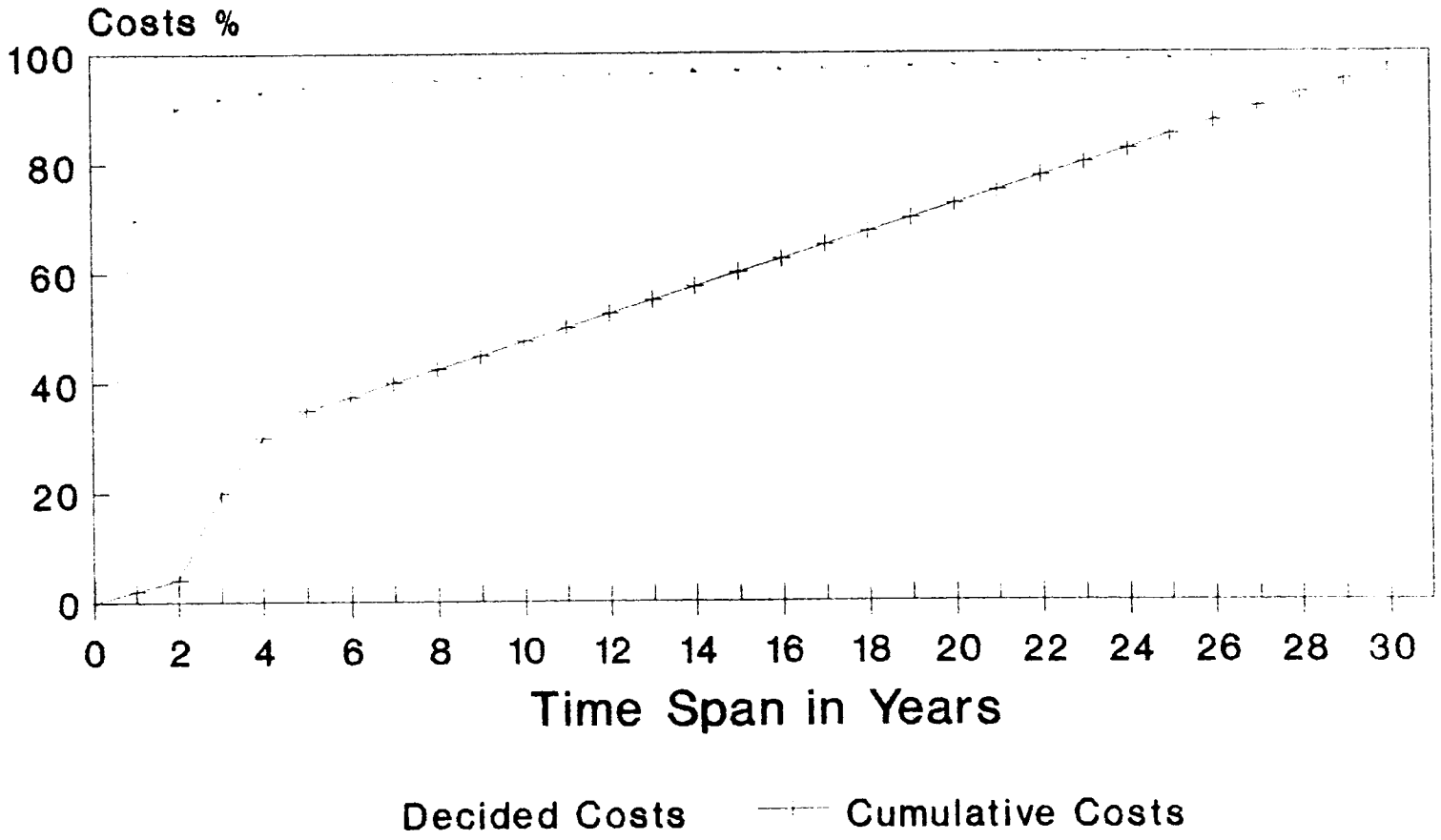
Pertti Keskitalo
Air-Ix Consulting Engineers

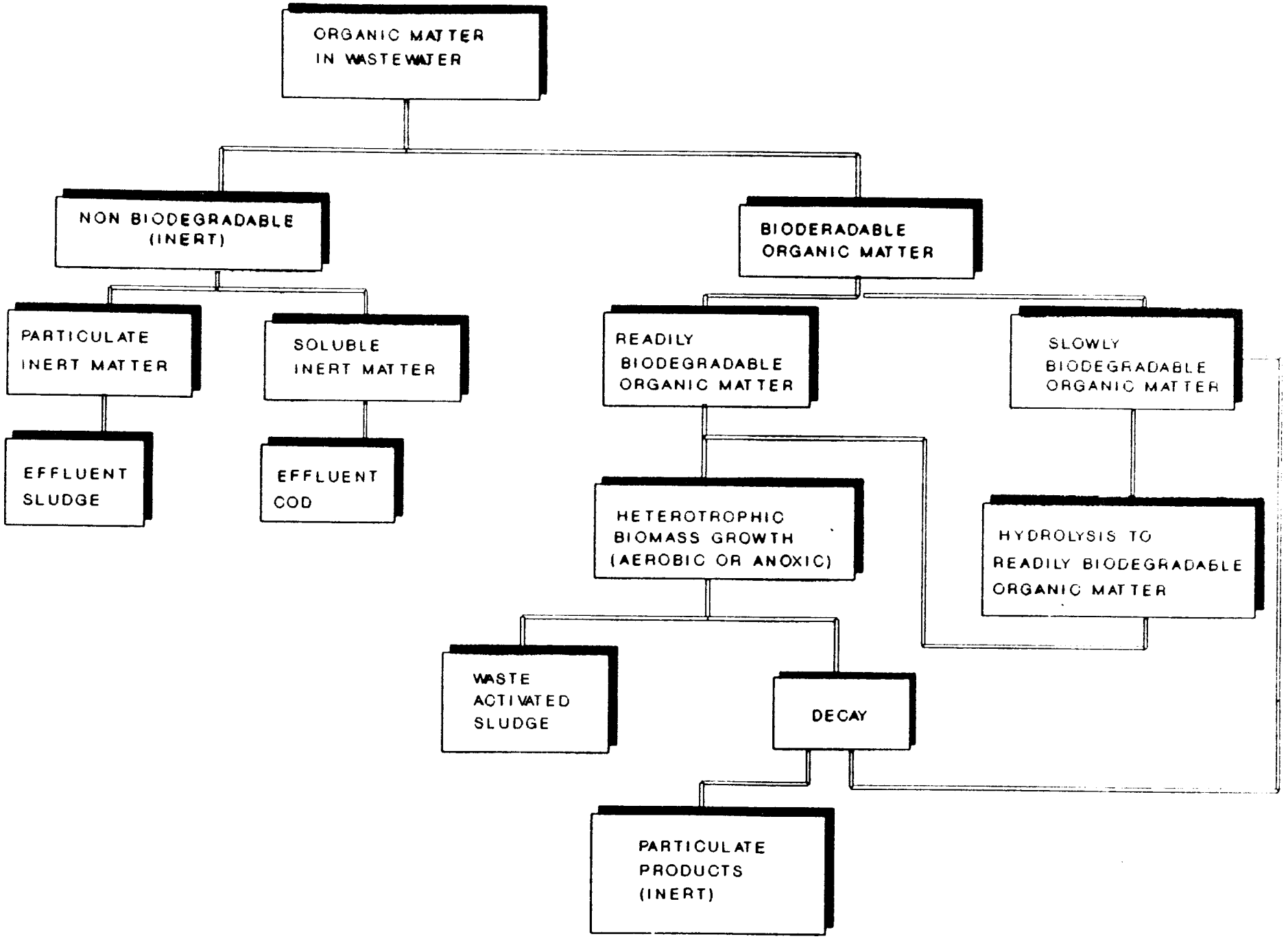

PROJECT IDENTIFICATION
- purpose of Waste Water Treatment
- available treatment alternatives
- available information
GENERAL DESIGN
- dimensioning criteria
- process train and hydraulic profile
- general lay-out
DETAILED DESIGN
- process and instrumentation scheme
- piping design
- electrical design
- structural design
CONSTRUCTION
OPERATION AND MAINTENANCE

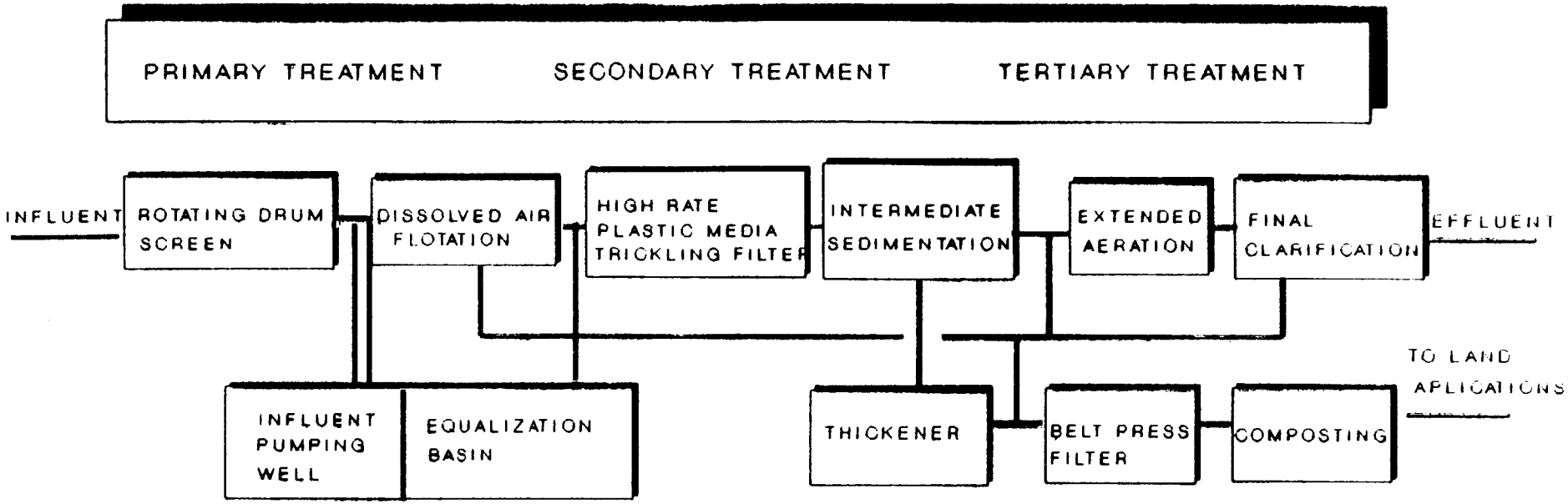

WASTEWATER FROM THE FACTORY
PRIMARY TREATMENT
• GRIT REMOVAL
• SCREENING
• SEDIMENTATION
• FLOTATION
SECONDARY TREATMENT
• ACTIVATED SLUDGE
• TRICKLING FILTER
• ROTATING BIOLOGICAL CONTRACTOR
• ANAEROBIC TREATMENT
• CHEMICAL TREATMENT
TERTIARY AND ADVANCED TREATMENT
• FILTRATION
• BIOLOGICAL NUTRIENT REMOVAL
• CHEMICAL NUTRIENT REMOVAL
WASTEWATER TREATMENT OUTSIDE OF THE FACTORY
RECIPIENT WATER BODY

Cost Comparison

Decided and Cumulative Costs




ORGANIC MATTER IN WASTEWATER
NON BIODEGRADABLE (INERT)
BIODERADABLE ORGANIC MATTER
PARTICULATE INERT MATTER
SOLUBLE INERT MATTER
READILY BIODEGRADABLE ORGANIC MATTER
SLOWLY BIODEGRADABLE ORGANIC MATTER
EFFLUENT SLUDGE
EFFLUENT COD
HETEROTROPHIC BIOMASS GROWTH (AEROBIC OR ANOXIC)
HYDROLYSIS TO READILY BIODEGRADABLE ORGANIC MATTER
WASTE ACTIVATED SLUDGE
DECAY
PARTICULATE PRODUCTS (INERT)



INFLUENT CHARACTERISTICS

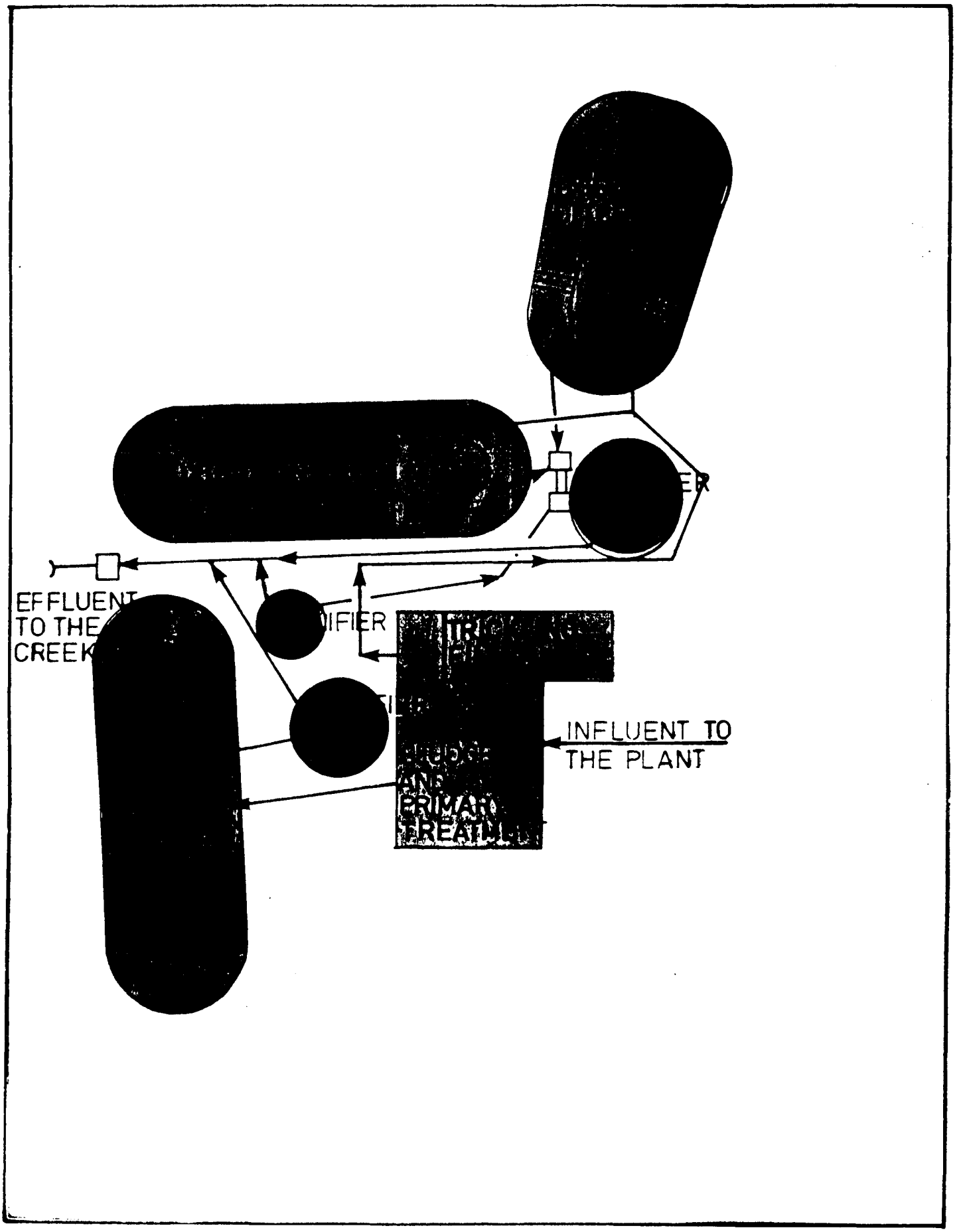
FLOW	≈2600 m3/d
BOD7	≈3500 mg/l
SS	≈1200 mg/l
CREASE	≈1000 mg/l
P	≈16 mg/l

REDUCTION

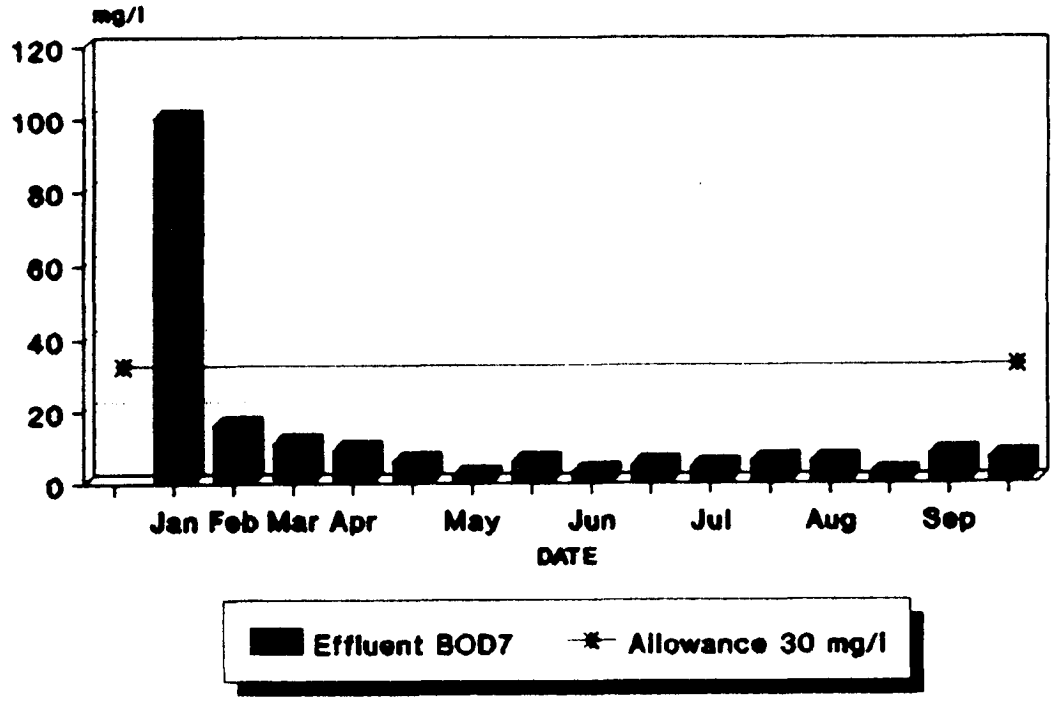
BOD7	99.7 %
SS	98.7 %
P	96-98 %

EFLUENT QUALITY

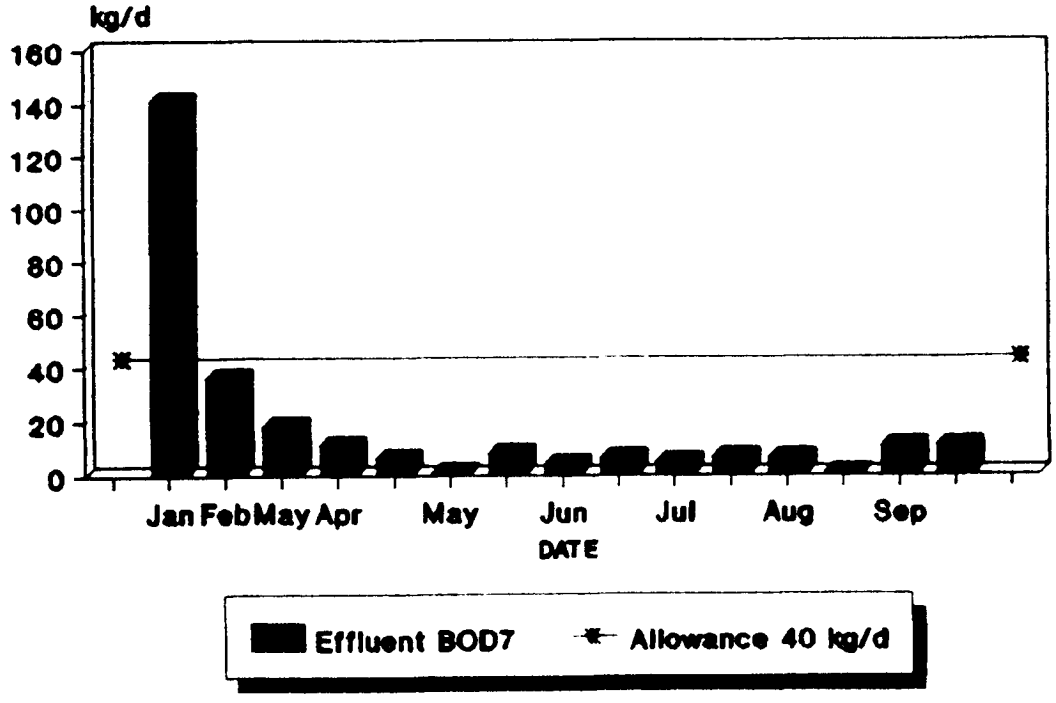
BOD7	10 mg/l
SS	15 mg/l
P	0.2-0.5 mg/l

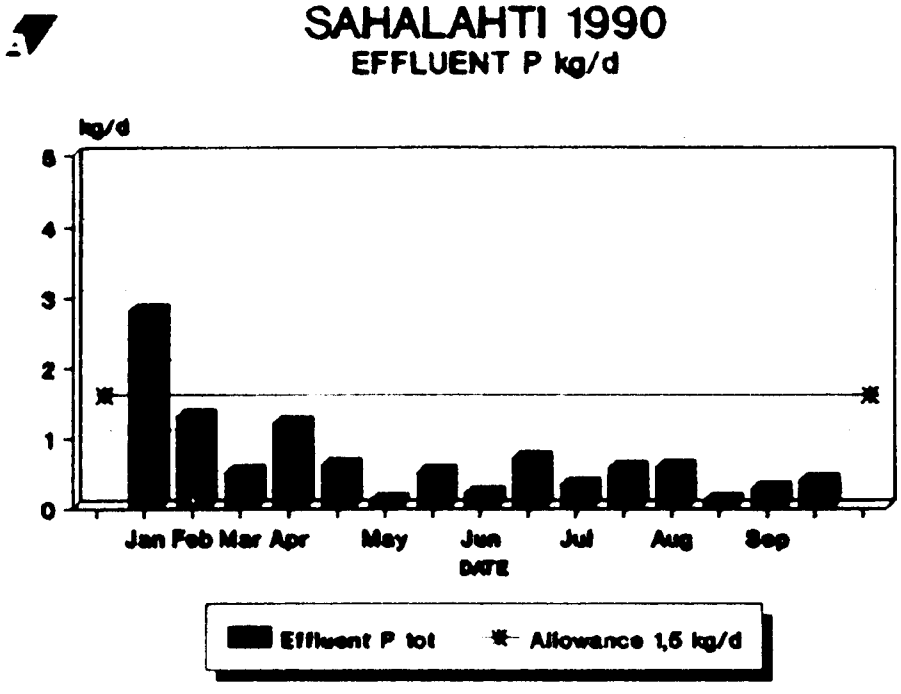

EFFLUENT
TO THE
CREEK
INFLUENT TO
THE PLANT

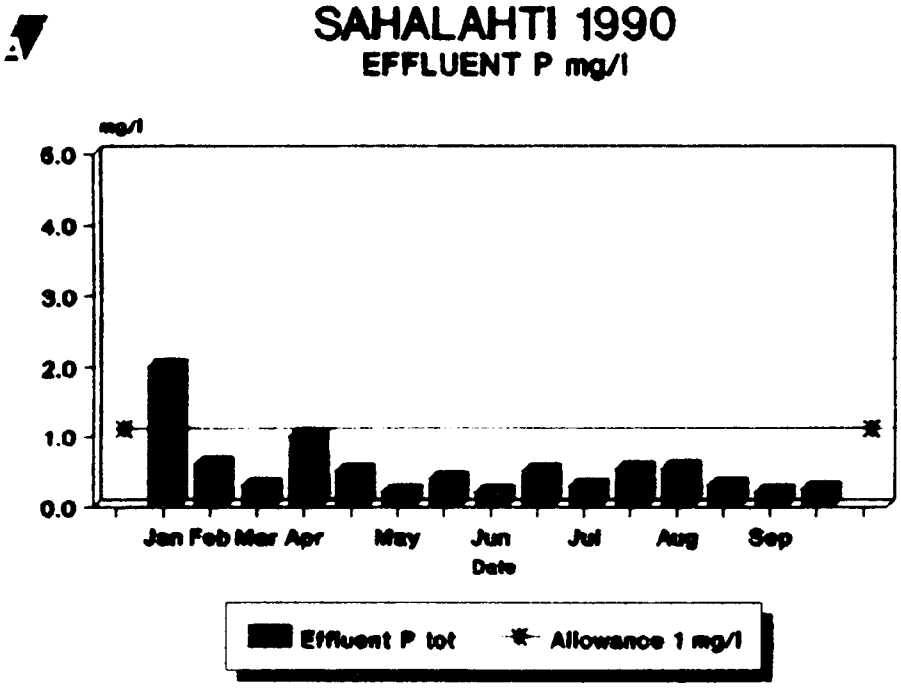
SAHALAHTI 1990
EFFLUENT BOD7 mg/l



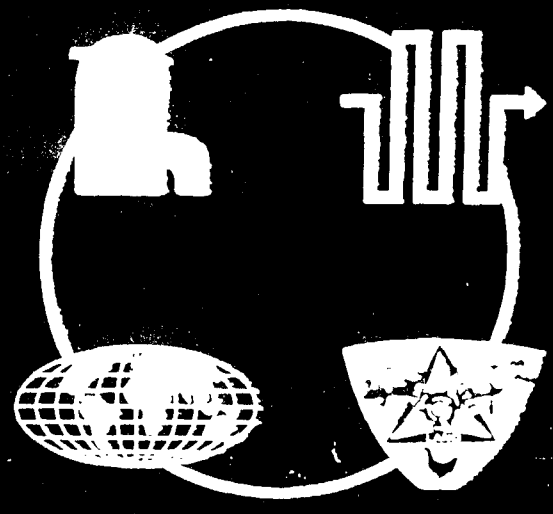
SAHALAHTI 1990
EFFLUENT BOD7 KG/D




SAHALAHTI 1990
EFFLUENT P kg/d
kg/d
5
4
3
2
1
0
Jan Feb Mar Apr May Jun Jul Aug Sep
DATE
Effluent P tot
Allowance 1,5 kg/d


SAHALAHTI 1990
EFFLUENT P mg/l
mg/l
6.0
4.0
3.0
2.0
1.0
0.0
Jan Feb Mar Apr May Jun Jul Aug Sep
Date
Effluent P tot
Allowance 1 mg/l

Agricultural and Food Processing Waste



Proceedings of the
Sixth International Symposium
on Agricultural
and Food Processing Wastes

December 17-18, 1990
Hyatt Regency Chicago in Illinois Center
Chicago, Illinois

American Society of Agricultural Engineers

POULTRY AND VEGETABLE PROCESSING WASTEWATER TREATMENT WITH TWO STAGE DISSOLVED AIR FLOTATION AND BIOLOGICAL PURIFICATION

P. Keskitalo *
Member WPCF and IAWPRC

I. Sundholm *

This paper presents a case study of the design and operation of a wastewater treatment plant for an integrated poultry and food processing facility in Finland. In addition to the industrial wastewater a small amount of municipal wastewater representing one percent of the total influent organic loading is taken to the plant.

The plant failed to meet the limits of its wastewater discharge permit in the mid eighties and renovations became necessary. In addition to the actual need for expanding the treatment process, there were several operation and maintenance problems that had to be solved during the design process.

The first year of operation has proved the general process selection and design successful. With few exceptions the effluent quality has been well below the permit limits. During the tests the BOD and Suspended Solids reduction in flotation were 87 % and 93 % respectively. In normal operation the use of chemicals has been minimized and the reduction has been lower, ranging from 50 to 70 %. Overall reductions of BOD and Phosphorus have been in over 99 and 96 % when the plant is in normal operation.

PROCESS DESIGN AND PLANT LAY-OUT

The treatment process has three different stages. The process flow diagram is presented in Figure 1. The trickling filter and oxidation ditches were originally placed into operation in the mid seventies. Flotation facilities and equalization basin were added to the process train as part of the recent upgrade. Design data for each process unit are given in Table 1.

Dissolved air flotation was selected for primary treatment. The basic principles and operation of dissolved air flotation have been discussed by Zabel (1985). In this project a two stage dissolved air flotation was used to minimize the amount of coagulation and flocculation chemicals.

High-rate trickling filter is used for secondary treatment and it is particularly efficient in treating the readily degradable organic material. The general principles and process kinetics of biological wastewater purification have been discussed by Benefield and Randall (1980), Benefield et al. (1982) and WPCF (1976).

Tertiary treatment is provided in oxidation ditches which operate in the extended aeration mode. Precipitation of phosphorus is achieved by adding ferrous sulphate to the oxidation ditches. Simultaneous precipitation is the prevailing method for phosphorus removal in Finland. Basic studies on simultaneous precipitation and its reaction rates has been done by Viitasaari (1976).

Nitrification can occur in the process if the water temperature is not too low. This may cause some problems because of insufficient alkalinity of the wastewater. Nitrification can be controlled by changing solids retention time in the process. In practice it is possible to have sludge concentrations up to 6000 mg/l MLSS in the oxidated ditches. Principles of biological wastewater treatment and nitrification have been discussed by Henze et al (1986).

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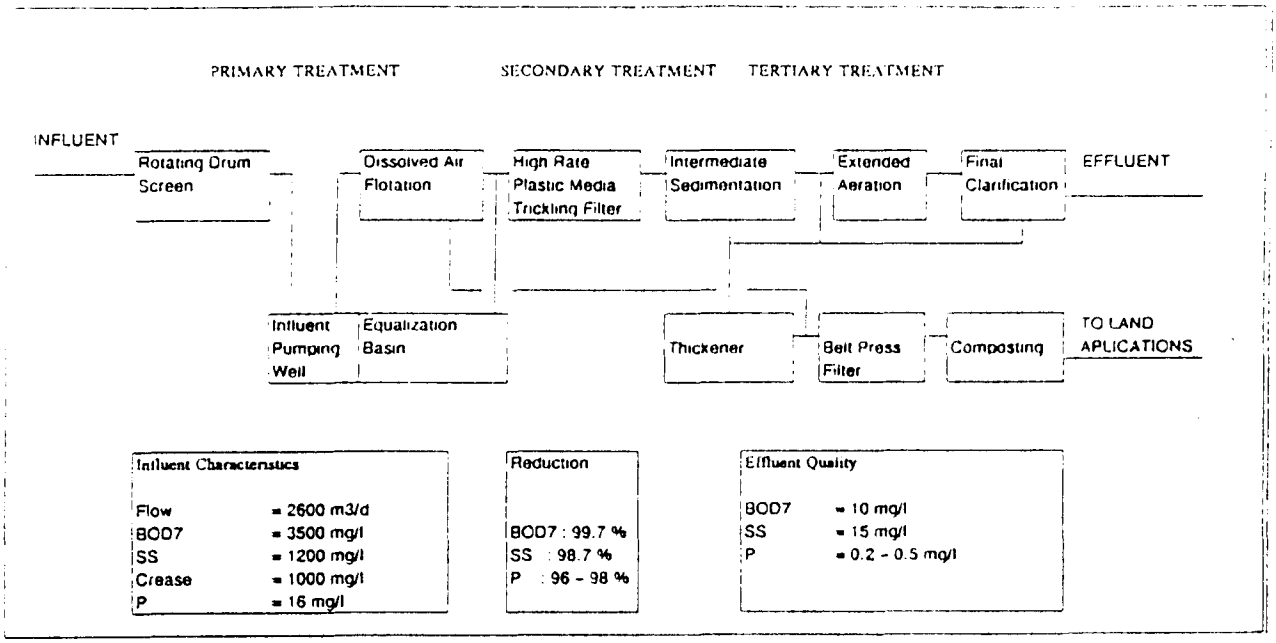

Fig. 1. Process train at Sahalahti wastewater treatment plant. Influent and effluent values are typical under normal plant operation.

Table 1. Design parameters for Sahalahti Wastewater Treatment plant.

Proces unit	Flow m^3/h	Hydraulic loading m/h	BOD load kg/d	BOD red %	Organic loading kg BOD_7/MLSS/d
Flotation	150	8	4000	50	-
Trickling filter	100	-	2000	70	-
Oxidated ditch	100	-	650	94	0.05
Final Clarifier	100	0.6	-	-	-
Effluent	100	-	40	99	-

Plant Lay-out

Plant lay-out is shown in Figure 2. New facilities were layed out next to the existing sludge treatment facilities. This made it possible to have pretreatment, sludge treatment, chemical handling and intermediate sedimentation in same heated working area. The maintenance shop is also in this same area. Also the final clarifiers buildings were insulated and equipped with electrical heaters.

The office and control room were expanded. This area is completely separeated from the process areas to avoid odors in the office laboratory and break room.

Wastewater Characterization

The task croup that was set by IAWPRC (International Association of Water Pollution Researche and Control) has established a very specified mathematical model for single sludge activated sludge system. As staled by Henze et al (1986) organic loading is not a single factor, like for instance BOD_7-load. Different fractions of organic load and their contribution to activated sludge process are presented in Figure 3.

It was found in laboratory studies that 70 % of the ultimate BOD in the incoming wastewater is associated with suspended solids. It was thus possible to remove major part of the slowly degradable organic matter with primary treatment.

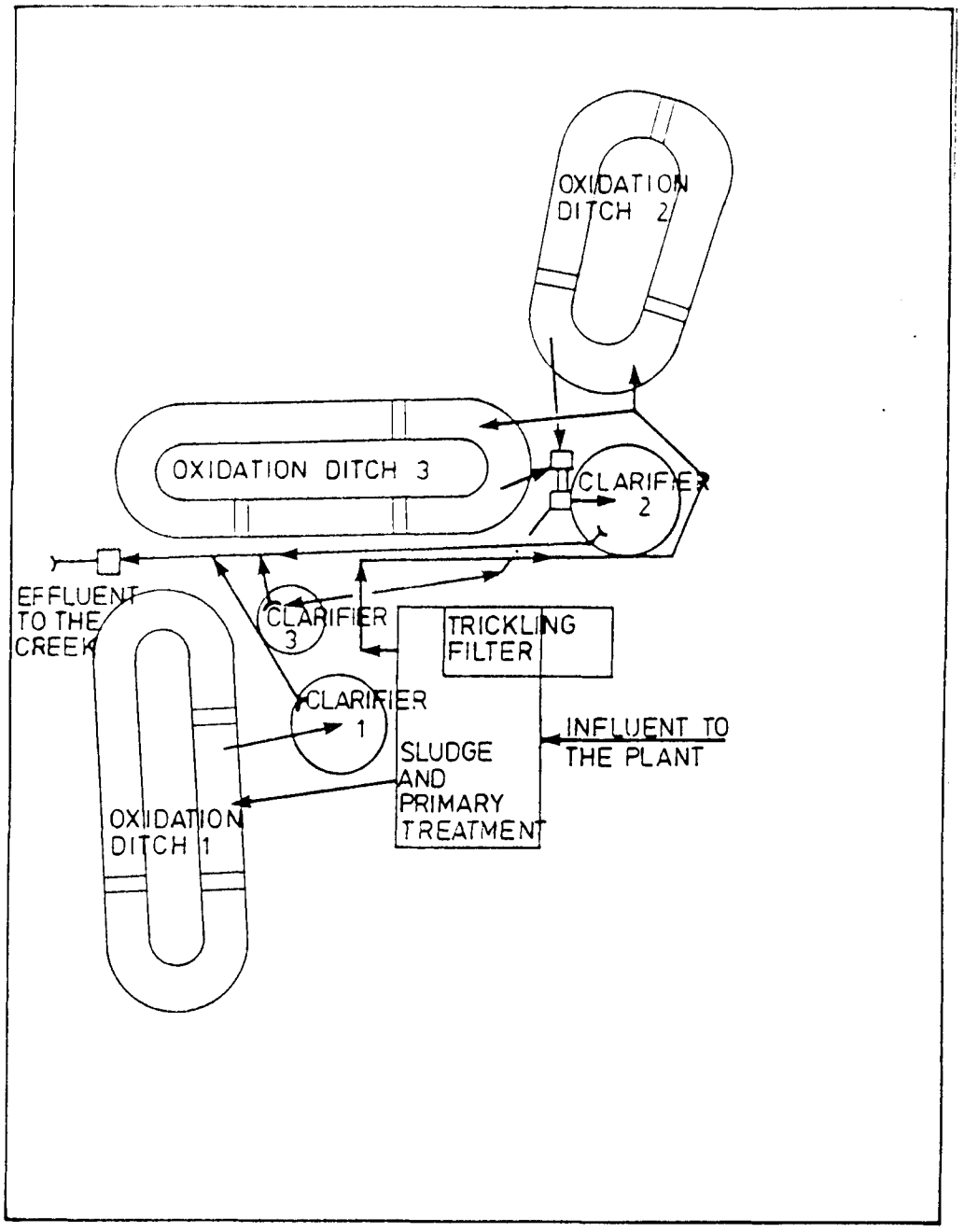

Fig. 2. Lay-out of the Sahalahti Wastewater treatment plant.

Hydraulic Process Design

Many of the problems in plant operation were related to the wide variations of the influent flow. More than 90 % of the daily wastewater flow entered the plant within ten hours. With the new equalization basin it is possbile to alternate the peak flow such that the current flow through the plant is practically constant for twenty hours.

The equalization basin is after the flotation unit. This minimizes the problems of settleable material in equalization basin. Also the transformation of readily degradable particulate organic matter to soluble organics is reduced since most of the particulate matter has been removed in the flotation unit.

PRIMARY TREATMENT AND TWO STAGE DISSOLVED AIR FLOTATION

The primary treatment of the industrial wastewater includes a rotating drum screen, two stage dissolved air flotation and an equalization basin. The screen separates all particles bigger than three millimeters. The screenings are placed into an open container that is taken to the landfill with a farm tractor.

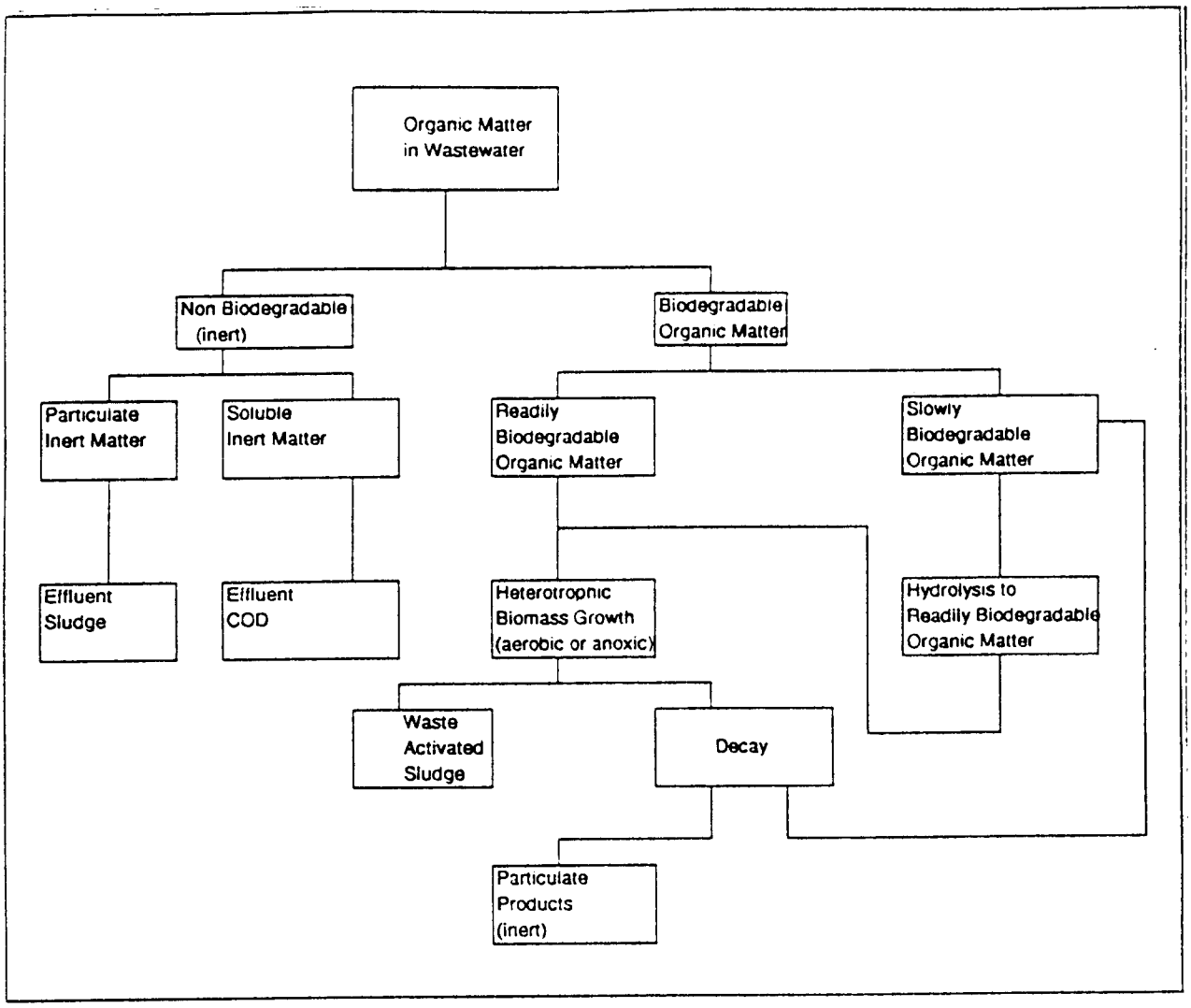

Fig. 3. Characterization of Organic Matter in Wastewater based on the information from Henze et al (1986).

After the screening the wastewater flows to a wet well from which it is pumped to the flotation unit. No chemicals are added in the first flotation stage. The coagulation and flocculation process is enhanced in the second flotation stage by adding alum salts and/or polymer to the wastewater. During the first year of operation only polymer was used. Average dosage has been 0.5 g/m^3. The use of polyelectrolytes has been discussed extensively by Schwoyer (1981). The flotated sudge flows by gravity to a holding tank from where it is pumped to the belt filter press. The general principle of the flotation unit is presented in Figure 4.

Settleable sludge has not caused any major trouble, eventough there is no sludge collecting device in the bottom of the unit. In practise the flotation unit has to be cleaned once a month or so.

The primary coagulant used at the plant is liquid aluminum hydroxidechloride. Special effort was made to minimize the hazards and maintenance work related to the handling of this chemical. The storage tank is located on a lower level and it can be filled by gravity from the transporting vehicle.

Polyelectrolytes are used as flocculating aids. For the time being the need of primary coagulant has been minimal. The cationic polyelectrolyte alone has been very effective especially in removing creasy substances.

The flotation unit is followed by an equalization basin which is the last step of the primary treatment. As the wastewater leaves the flotation unit the constant flow of 60 m^3/h is led to secondary treatment. The rest of the flow goes to the equalization basin and is pumped back to the process during night hours as the influent flow decreases.

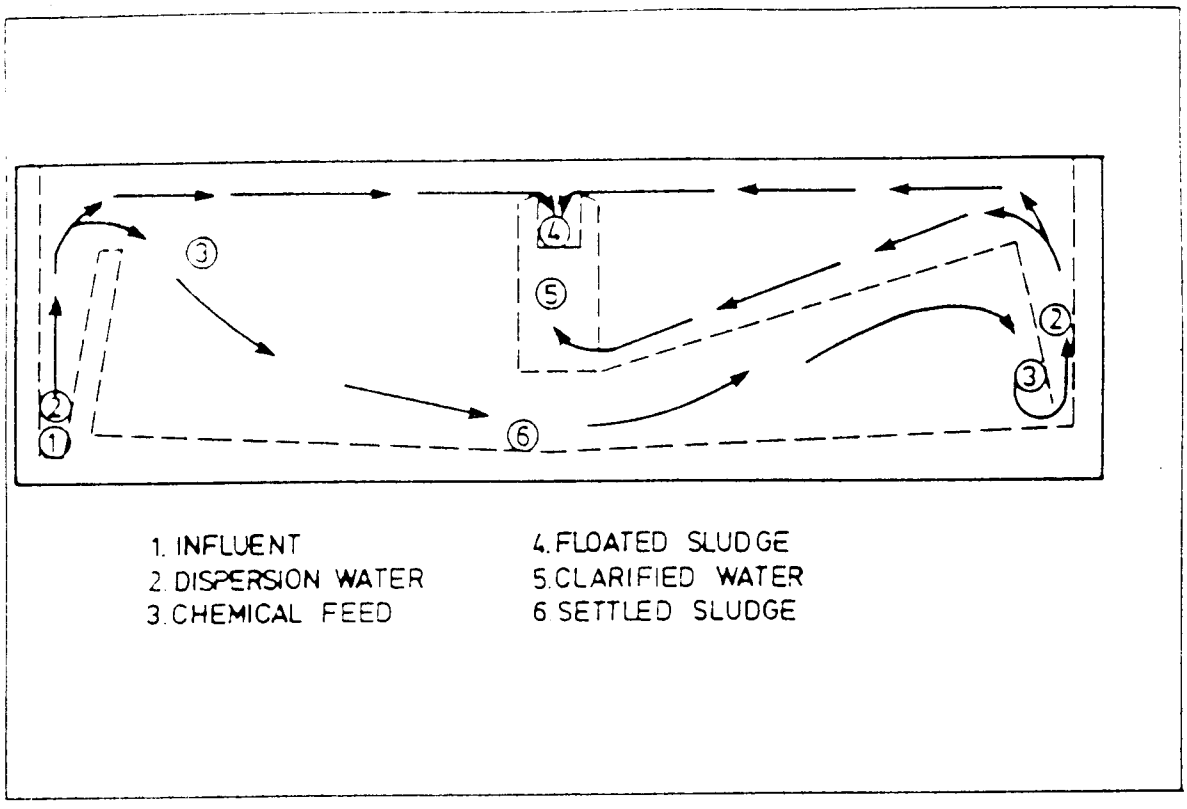

Fig. 4. Operation principle of two stage dissolved air flotation unit.

SECONRADY AND TERTIARY TREATMENT

The equalized flow is led to the trickling filter. The total volume of the palstic media filter is 900 m^3. Design load to the filter is 2.2 $kg/m^3/d$.

In the measurements the average COD-concentration in filter influent has been 990 mg/l. Effluent COD has been 410 mg/l.

The operation of the plant has been controlled once or twice per month by water autohorities. The results of these test between Feb. 90 - June 90 are in Table 2. COD-tests were started in the beginning of July.

Table 2. Influent and effluent suspended solids, BOD_7 and phosphorus concentrations at Sahalahti wastewater treatment plant from February 90 through June 90.

DATE	FLOW	INFLUENT				EFFLUENT			
	m^3/d	SS mg/l	BOD_7 mg/l	COD mg/l	P mg/l	SS mg/l	BOD_7 mg/l	COD mg/l	P mg/l
FEB 22	2320	1320	1500		11	17	16		0.6
MAR 21	1600	1300	2300		13	13	11		0.2
APR 11	1200	2300	3150		14	11	9		1.0
APR 25	1020	2100	2330		13	10	5		0.5
MAY 7	520	540	670		6	7	4		0.3
MAY 24	1400	1300	2500		12	13	6		0.4
JUN 6	1280	2200	3050		11	5	3		0.2
JUN 19	1240	3100	2100		19	20	5		0.5
JUL 4				8300				48	
JUL 9				1800				22	
JUL 11				3300				22	
JUL 31				2300				18	
AVG	1323	1770	2200	3925	12	12	7	20	0.5

For the last six months the MLVSS concentration has been around 2000 mg/l. Higher concentrations would lead to nitrifying process and lime should be added for alkalinity.

OPERATION AND MAINTENANCE

One of the main concerns in design process was to make the operation and maintenance of the plant easier and above all possible in all climate conditions. All the repairs and maintenance had to be done out of doors. When especially in wintertime temperatures are sometimes 40 degrees below zero maintenance work was extremely difficult and even hazardous for plant operators.

To improve the operation and maintenance the following goals were set for the design process:

- all the repair work will be done inside in a room dedicated for these repairs. The size of the room will be such that a bruch aerator can be brought in for repairs.

- general lay-out of the plant will be simplified. All the major operation areas will be under the same roof.

- all the new wastewater and sludge pumps will be dry well assembly pumps.

- control and operation facilities shall be newly designed to give operators adequate room to change clothes, take a shower and include, small kitchen and lunch room, control room and laboratory for daily analyses.

- chemical handling shall be designed to minimize possible hazards for operators and for people delivering the chemicals.

From the very start of the design process these improvements were considered essential. As a working enviroment the wastewater treatment plant has to meet the same high standards as normal Finnish industrial working places do.

RESULTS AND CONCLUSIONS

The first year of operation has proven the selected process train appropriate. With polymer addition of 0.5 g/m^3 it was possible to reduce organic loading 50 - 70 %. Additional reduction can be achieved with coagulant addition to the primary stage.

The operation and maintenance of the trickling filter has become less troublesome. The grease that used to block the distribution system is now removed by the flotation unit. Overall reduction of BOD_7 at trickling filter has been around 70 %.

The organic load to the oxidation ditches has been slightly lower than was estimated. Effluent BOD_7 has been around 10 mg/l. Phosphorus has been bellow 1.0 mg/l and COD 20-40 mg/l.

The first year of operation has also been a year of learning, most of the time through trial and error. The organic loading of the oxidation ditches was significantly reduced by the new flotation unit. Solids retention time in the oxidation ditches increased and nitrifying bacteria population started to grow. The alkalinity of the wastewater is low and there was problems with bulking sludge. It remains to be seen whether the alkalinity will be controlled with lime feed. The other possibility is to keep solids retention time low and prevent nitrification.

The first year has also showed that design criteria should be very conservatively selected. With high strength wastes it is very difficult to estimate the maximum daily load. This is especially true with integrated factories, where the load is coming from several sources. In this case the maximum daily load has been about 50 % higher than estimated. However, both flotation and trickling filters are very effective for cutting high concentrations. The load to the oxidation ditches is only slightly higher when the primary and secondary steps are functioning well.

Design process for an industrial wastewater treatment faarlity should always be

based on thorough understanding of the manufacturing process and the nature of wastewater involved. BOD_7 concentration should not be the only criteria for determining the organic loading. Ultimate BOD and COD should also be determined.

Sufficient training of the plant operators is a must for fluent start up. This is especially true with new and innovative treatment plants. Risk analysis should be carried out already in the design phase to identify the most critical parts of the process. After the identification of critical malfunction situations it is possible to do hands on instructions for these special occasions. This will minimize the affect of process failures to the effluent quality.

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Consulting Aid

Consulting business is unique compared with all other businesses: it does not sell anything materialized but only written reports, drawings or sometimes only a couple of words of advice. Consulting and consulting engineering companies can be divided into two groups:

- Independent consulting companies belonging to FIDIC (the International Federation of Consulting Engineers) through national organizations.
- Engineering departments of separate companies of industrial concerns mainly selling the know-how of these industrial concerns. In addition to design and procurement the package may include supply, erection and supervision of some equipment or processes developed by this industrial company.

Use of Consultants

There are two main approaches to implement an industrial plant or environmental protection measures project:

- to purchase the whole plant as a package, on a "turn-key" basis, or
- to purchase the equipment, assembly, civil works, automation, start-up, etc. in several packages.

In the first alternative the consultant's task may be to prepare documents for tender inquiries, to prepare tender comparisons and assist in negotiations.

Sometimes a department or some persons of the industry which is investing in a project may act just like a consultant or consulting engineering company. They can be assisted by an outside consulting company.

In the second alternative the role of the consultant is much larger. Normally, the consulting companies used here are big engineering companies, independent of suppliers (FIDIC members) or dependant on suppliers. The suitable approach has to be considered case by case: sometimes the know-how of an industrial process is owned by one or two companies in the world. It is logical that these companies tender for the project on a turn-key basis.

Within the larger projects, it may be economically advantageous to buy equipment and other services from several suppliers and contractors. Specially in these cases, the consulting aid may be needed for evaluating tenders, for construction supervision and for overall coordination.

Generally, the consulting aid is needed to design, procure, evaluate, coordinate, supervise and manage.

Selection of the consulting engineer

The client must consider the consulting engineer's technical qualifications, experience, education, training and business acumen, since the choice of the best qualified consultant for a specific assignment ensures optimum results and overall economies for any project.

For smaller projects, it is often unnecessary to carry out a lengthy selection process. As in other professions, consulting engineers are retained e.g. on the basis of referral, general reputation, previous performance with a given client, evidence of their work found in completed projects such as buildings, bridges and factories.

For larger projects, the following is a recognized and recommended procedure for the selection of a consulting engineering firm:

- Using the International Directory of Consulting Engineers section "Types of Services and Fields of Specialization", prepare a list of all consulting engineering firms which appear to be qualified for the specific services required.
- Use the Profile Pages section to select the three or more firms which are the best qualified according to the information presented.
- Write to each of the firms on the selected "long list" giving them a brief description of the project and enquiring about their interest. Refer to the Official List of Members for head office addresses, or to the section listing member firms by province and city.
- From the firms, which have expressed their interest and have sent the references, a "short list" will be selected. The companies selected will be provided with further information and be given an opportunity, by visits to the site or other means, to make a reasonable evaluation of the scope of the work.

The firms, which are still interested in, should provide the client with following information:

- Past experience with projects of a similar nature to that proposed;
- Details about their organization, qualifications and size of staff;
- Ability to complete the assignment within the available time;
- Technical approach and method proposed for the execution of the project; and
- Knowledge of local conditions.

The best qualified consulting engineering firms should be able to design the most economical project. No firm should be asked to engage in competitive bidding. The profession is united in the belief that competitive bidding is neither in the interest of the client nor the consulting engineer.

Once a firm has been selected, an engineering service contract, fee and sanctions are negotiated. Should an agreement not be reached, negotiations should be terminated with the first firm selected, and opened with the second. When a final selection is made, all firms originally selected should be notified.

Consulting Services

The activities of a consulting engineer generally can be grouped:

- Advisory sevices of a continuing nature or for particular projects or problems. These may include advice on management, inspection of production, testing and quality control. They may also include appearances before commissions, boards, courts, or other judicial bodies to give evidence or to submit professional opinions based on engineering knowledge, experience and judgement.
- Preliminary investigations and reports on the feasibility, economic and financial justification, general layout and design, cost estimates and completion time for a given project.
- The preparation of detailed drawings, specifications and contract documents; the analysis of bids and recommendations thereon.
- Supervision of construction, management, and sometimes the initial operation of a project.

- Specialized design and development services. Examples of this type of service are processes and special machinery used in the treatment of raw materials or in manufacturing, and the applications or automatic controls to machinery or equipment. This type of service is sometimes provided to assist the client's own staff. Services may also be provided for the development of inventions and for the registration of patents.

No one project can succeed if there is not a good working atmosphere, confidence and cooperation between the parties involved. Both the client and the consultant have to be flexible and work as a team. The client has to provide the local knowledge, the own experience, and has to be ready to supply all the information needed which can help the project. The consultant has to transmit all the information and know-how for the specific project and be sure that the client gets the best possible training on use of equipment and process.

Training Course on Environment Management in Industry
August 4-25, 1991, Tampere, Finland

STAFF TRAINING

by Sirpa Sandelin
Tampere University of Technology

Industry is facing many problems of growth and change arising from restructuring of economies, market shifts, technological advances and social movements. These changes are making increasing demands on staff in all levels. Training and development is responsibility of all managers, whether or not assisted by training specialists.

The need both to attract and retain staff and equip them with the necessary skills, knowledge and attitudes is an urgent priority. Training is not a luxury. It is essential to survival. Its main objective is to improve the work performance of individuals and groups, thereby promoting personal effectiveness and satisfaction and increasing the efficiency of the organization.

Training makes the utilization of manpower resources more effective - to the benefit of all concerned. It is vitally important that training is provided in a controlled and systematic manner for best results. Training involves steps: assessing, planning, implementing and reviewing (Figure 1).

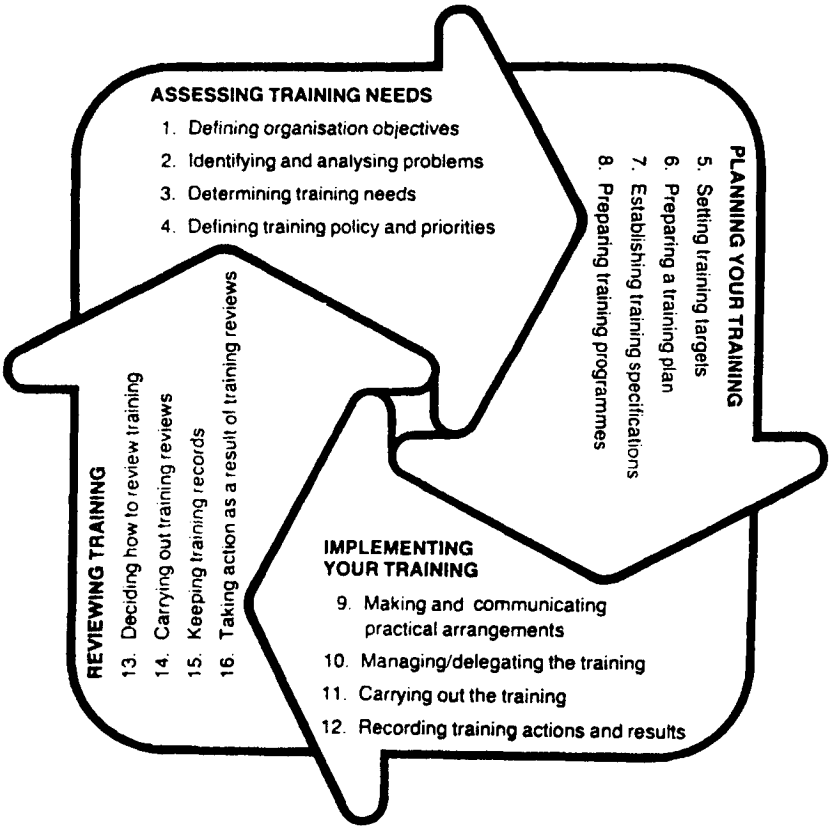

Figure 1. Complete cycle of activities in training.

Assessing

Training is an investment in people. To pay off it must be closely related to the needs of the business and the industry. So it does not make sense to leave training to chance, but to see that it is carefully thought about, planned, carried out and reviewed. Assessing training needs is the important first stage in systematic training. It can be divided into four steps: defining organization objectives, identifying and analysing problems, determining training needs and determining training policy and priorities.

Management should prepare an agreed objective statement of the purposes and aims of their organization. They must be totally committed to achieving the goals stated. In preparing this strategy, the enterprise must assess its present and future plans, general tends and problems.

The basic standards at a mill level concern environmental protection, occupational safety, energy and material economy and product quality. A proper and continuous developing strategy can offer the most rapid and cheapest way to meet demands and orders which mainly are coming outside the mill. However, any in-mill strategy as a written paper with flow charts does not work well if all employees do not know and understand it. In addition, the staff must be motivated to work for it. A continuing training is the only solution to have spirit for the strategy.

All the identification and analysis of problems should be done within guidelines established for each activity, like future plans, marketing, production, maintenance, technical, finance, manpower, personnel, public responsibility, etc.

A training need exists when staff lack knowledge, skills or attitudes required for their present or future job:

- their performance in the present job is below the standard required by the business, e.g. lack of management, technical, organizing or manual skills or knowledge
- changes, like new methods or procedures, reorganization or new machines, take place which affect their present job
- they are or will be chancing jobs, e.g. newcomers, transfers and promotion or career development.

Training should be directed to those priority areas where it can have the greatest effect and produce the best return for the time and money training will involve.

Planning

Responsibility for seeing that the right people with the right training are available at the right time and place lies with senior management. Planning training is the job of management.

Training is not for training's sake. The function of training is to make people more effective so that they make more effective use of materials, means of production and control systems. The essential stage, planning, involves setting training targets, preparing training plans, establishing training specifications and preparing training programmes.

To be effective training must be aimed at achievements in many important target areas:

- priorities: tackle highest first for maximum pay-off, overcome bottlenecks, etc.
- who: select which workers need (NOT the workers who already perform the required skills) and can most benefit from the proposed training
- when: take account of seasonal peaks and lows
- performance: define the standard of performance required and plan the training to achieve it
- time: training period should be long enough to meet the performance level required. You should remember that although knowledge is relatively quick and easy to impart, the practical application of the related skill will take longer to develop. Judgements about the length of a training should be based on estimates of average ability.
- cost: depends on performance and time, an estimation of the costs is needed for every training in order to decide if the training is affordable. Another reason is that it enables management to compare the costs of the proposed training with the need and the likely benefits. It also enables proposals to be put forward to ensure adequate budget allocations.

Once the company knows what training is needed it is possible to make a detailed training plan. It represents the training of specific categories of staff over a stated period of time and may also cover certain key areas of training such as opening a new unit, fire prevention, induction or industrial relations.

Before planning training programmes, job and personal specifications are needed. These two later mentioned define the duties, responsibilities, tasks, knowledge, skills, attitudes, etc., which go to make up a job. Comparison between this information and the knowledge, skills, attitudes, etc., of the intended trainees helps to determine the training gap and therefore forms the foundation for establishing training specifications (Figure 2). Training programmes itemise the content to fill the training gaps in order to achieve the training target.

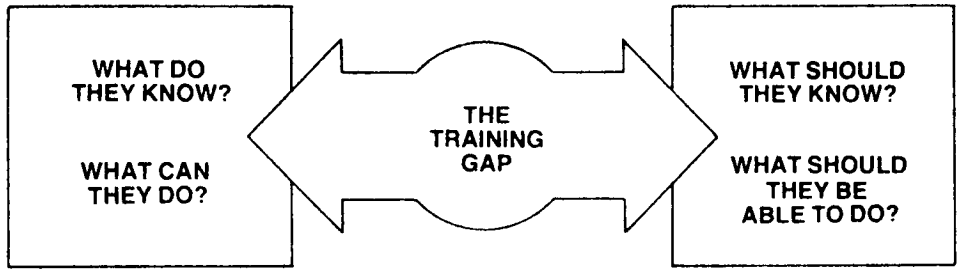

Figure 2. Training gap.

Implementing

It is on-the-job that the results of any training are seen and tested, and it is on-the-job where trainees at all levels need help and guidance in applying what they have learned. Systematic on-the-job training is appropriate for the development of most skills, particular manual and supervisory skills. Much of the training in industry takes place almost entirely on-the-job. Therefore, whether there are concentrated periods of training away from the working place or continuing job instruction while work proceeds, the manager and supervisor are inevitably involved in putting training into practice.

Implementing training involves practical arrangements, managing/delegating the training, carrying out the training and recording training actions and results.

The assessing and planning stages have already sorted out the questions who, what and how. However, there will always be further details to fill in, practical arrangement to be made for the training and its follow-up, and people to be informed.

Sometimes management might need advise and assist from training specialists to carry out their responsibilities for training and developing their subordinates. Supervisors should be involved in such areas as the delivery of on-the-job training, needs assessment and evaluation of training. They have to focus on what are the current and emerging issues to develop and to inspire people and to set standards of actual performance. Supervisors should be given the training necessary to help them perform selection, explanation, expectation, training, inspecting, respecting, retraining, reinspection, enforcement and raising the standards. These tasks can be described as follows:

- select: determine standards that are critical to success and relevant to each person's job
- explain: ensure that everyone understands the standards

- expect: let staff knows that they are expected to meet and even exceed the standards, and that lesser performance is unacceptable
- train: train staff so well that performance will routinely exceed the standards
- inspect: check to see if standards are being met
- respect: if standards are being met, respect your staff enough
- retrain: after re-studying the standards and rewieving the training, retrain as is determined to be necessary
- reinspect: keep informing staff about performance expectations
- raise the standard: holding forth a vision of success, raise the standard, and repeat the foregoing cycle, moving continuously upward by generating momentum for exceeding the standards.

Carrying out the training is a joint responsibility between managers/supervisors and trainees because what happens in day-to-day work before, during and after the more formal training is crucial important to the person being trained. A great deal depends on the commitment and support of supervisors and managers. This support involves:

- showing interest in the progress which a trainee is making
- discussing with the trainee what he/she has learned and how it is to be put into practice
- helping him/her adapt what he/she has learned to the work situation and standards
- regularly reviewing his/her progress and performance at work
- recognising and using his/her new abilities
- looking out for his/her potential future development.

Records concerning the training in general, costs, follow-up, practical difficulties, etc. should be kept after every training event. Recording means some more work and costs, but for management control and review some information is necessary to be recorded.

Reviewing

Training is not complete when the trainees walk out of the classroom. The final test of whether training has been effective for the organization and the individual will be made after every training event. Managers/supervisors and trainees will always have views about how useful and effective any training has been. As part of systematic training, the review stage should be as methodological and objective as possible, so that the company can :

- check how much of its planned training has been carried out in practice

- see in what way the business has benefited from its training
- identify successes and continue them
- pin-point shortcomings and correct them
- note problems that have arisen and correct them.

There are four steps in the reviewing stage: deciding how to review training, carrying out training reviews, keeping training records and taking action as a result of training reviews. Depending on the size of the company, there may be a number of levels at which planned reviews will be carried out. Broadly speaking, it should happen at two levels:

- senior managers and training personnel should review the company's training effort as a whole
- trainees should evaluate training during and after the event.

A thorough review helps to ensure that training has met objectives with effective results, can meet future needs and is kept up-to-date and efficient. Reviewing training will, in most cases, lead to actions to improve future training.

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