sources should be made to see if supplies from these sources can be increased The means of doing so may include:

(i) Procuring and pressing into service as many rigs and other well-digging instruments as possible for boring or deepening drinking-water wells, especially in hard rock areas. Highest priority should be given to places where there is known untapped ground water potential and from which people and livestock are tending to migrate. Inter-state transfer of rigs to meet the emergency should be considered An inventory should be kept ready of equipment and transport available in and near drought-prone areas for deepening wells, digging bore and tube wells and for conveying water to the needy areas by truck. If drinking water has to be stored in buckets or other small containers for household use in areas where piped water is normally available, then stocks of containers may have to be provided;

(ii) Repairing hand pumps and pumping sets used to provide drinking water.

In addition to governmental effort, private entrepreneurs might be prepared to transport water over long distances to the affected area for distribution. This method will generally be found appropriate where large establishments such as hotels, hospitals, etc., are in need of supplies for which they can pay.

Serious attention must be paid to the purity of emergency water supplies The most practicable immediate action is to advise the public to boil all drinking water before consumption.

D *Seeds*

In droughts, it is very important to conserve supplies of seeds. Starving people will eat the grains, roots, and tubers which they would normally have saved for planting, but if they do this, there is no possibility of planting the next crop unless seed is introduced from outside.

Procurement and supply of seeds from other countries takes time and all the seed may not arrive in time for the sowing season when a drought is suddenly broken by rains. Besides, such seeds, although occasionally an improvement, must be at least as well-adapted to local conditions of soil, climate and cultivation pattern as are the seeds normally used, if long-term detrimental effects on production and environment are to be avoided.

Although intensive efforts for the conservation of seed stocks are always necessary in times of shortage the only really effective way to prevent people eating seeds is to introduce relief food in good time. As a supplementary measure a government could make the following advance preparations:

(i) *Purchase*. The government may buy up and store some quantity of local seed stocks while they are still available. The seeds can then be released later, and credit facilities offered to the farmers;

(ii) *Seed banks* Banks of untreated seeds, at least of known varieties, grown in rain-fed areas may be built up as part of the food security system. Seeds may be stored until their cut-off dates for sowing and the unused balance released for consumption as food or animal feed. This conversion may involve some financial loss but especially in countries where drought occurs often, it is preferable to searching for seed in times of actual emergency;

(iii) *Help from private sources*. The government may identify progressive farmers, co-operative farms and seed corporations in the locality who could be persuaded to keep more seed stocks than they do in normal times, to be released against government compensation later;

(iv) *Regional co-operation* External assistance from countries in the region with comparable soil and climatic conditions, through the supply of seeds, fertilizers, and pesticides provides immediate relief at short notice and fosters regional co-operation. This possibility could usefully be included in any regional co-operation arrangements which may be negotiated;

(v) *International assistance*. Organizations like FAO (OSRO) mobilize international assistance for the provision of seeds and other agricultural inputs in times of an emergency. In asking for assistance it is imperative to specify variety and application rates used in, and familiar to, the affected area. New varieties or new practices should generally not be introduced during a disaster relief programme. Helpful additional information would include: (*a*) type and variety of seeds in use in the affected area; (*b*) the supplier, if possible; (*c*) growing season in the specific location (rainfall; temperature; length of season); (*d*) any epidemic disease; (*e*) bagging and storage requirements to fit needs; and (*f*) timing to meet the distribution and planting cycle. It should be noted that purchasing seeds normally takes at least three months. FAO (OSRO) entertains emergency assistance requests for agricultural inputs in a prescribed form (see annex VIII.)

Research and training

Research is needed in normal times to develop drought-resistant or -tolerant varieties and suitable farming systems and cropping patterns so as to minimize damage by shortening the vulnerable period of crops. Also, it should promote integrated pest-control that involves the use of resistant varieties. At the research level, methods of training should be adopted which include crop life-saving techniques and alternative cropping patterns, monitoring weather in drought-prone areas and analysis of data on rainfall and its relation to crop production.

E *The survival of livestock in drought/famine*

Remedial measures to save livestock when serious drought conditions prevail depend on the pattern of agricultural and livestock production in the region.

Herds maintained under modern ranch conditions have fewer problems when drought strikes, if good management practices are followed in normal times to achieve the correct grazing intensity

The damage will be significantly higher in arid and semi-arid remote areas of marginal crop and range lands, such as the Sahel, where livestock owners, often nomads, follow traditional practices. The movement of fodder on a large scale to vast desert regions is difficult and uneconomic. Moreover, a relief operation to safeguard animals in a bad year may increase their numbers and their vulnerability and produce more favourable conditions for a new crisis in later years The most effective way to avoid this is to take preventive measures to balance the livestock population with the natural grazing and water resources in a normal year.

To meet periodic crises, however, advance plans based on past experience can be kept ready to give systematic and co-ordinated guidance to herdsmen to reach water points and move in prescribed directions, according to the grazing capacity and water resources of the areas where health protection measures could be provided en route.

Planning should allow for the setting up, at suitable locations, of livestock centres to ensure the survival of at least a breeding nucleus stock: it will be necessary to locate supplies of fodder and concentrates to be transferred to the centres in times of emergency The maintenance in normal times of wells and water pumps in and around the areas identified for the livestock centres would avoid breakdown during critical periods.

The third pattern occurs when livestock farming is an integral part of agricultural operations; this is generally the case in the countries of Asia and the Pacific In most of these areas livestock production is a part of a small farming operation in which a few head of cattle and/or buffalo and other animals are owned by small farmers The animals are allowed to graze and scavenge in fallow lands, roadsides, forests, community village grazing lands, and the like. During the rainy season substantial amounts of fodder of variable quality are available During the dry season there is but scanty natural grazing, and supplements of feed such as crop residues (straw and stovers) and agro-industrial by-products (cakes, brans, pulse by-products, etc.) are given in troughs to the animals.

When only some parts of a region are affected by drought, large numbers of cattle may migrate to unaffected areas. this of course tends to lead to overgrazing and earlier exhaustion of the feed available in those areas also, and thus contributes to a general worsening of the situation. In widespread drought, this kind of problem occurs much less frequently. Inter-regional transport of fodder is both difficult and expensive to organize, and it may well be more beneficial to deal with the problem by more innovative means, making use of non-traditional resources. For example, in a number of countries, fairly substantial quantities of crop residues and agro-industrial by-products are available as livestock feed, especially from areas with assured water supplies. Some of these countries have also investigated the possibility of using many of the unconventional feeds available in the famine-prone areas during actual droughts in order to incorporate them into the feeding systems. In areas with similar patterns of agricultural and livestock production, preparedness plans might usefully include the following:

(i) Schemes of organizing "cattle relief parks" in suitable locations of disaster-prone areas where groups of animals could be housed and fed, depending upon the availability of drinking water and roughage source Provision should be made for veterinary services to vaccinate animals against any prevalent infections and contagious diseases so as to prevent large-scale outbreaks of diseases and mortality;

(ii) Location of sources of fodder in and near the drought-prone areas and a survey of arrangements for transport and storage,

(iii) Formulation during normal times of special animal feeding programmes based on the use of unconventional feed resources available in or near the drought-prone areas which would be useful during periods of fodder scarcity;

(iv) Arrangements for feed formulations using urea-molasses impregnated with poor quality roughages which are valuable in feeding drought-affected animals;

(v) Where migration is allowed from one administrative region to another, preparation of procedures to properly regulate such movement. Quarantine and disease control measures would also have to be made so that the livestock migrating to neighbouring areas do not become a source of conflict or disease;

(vi) Programmes in normal times for the proper management in drought-prone areas of vegetation which survives in a drought. Measures should include the growing of drought-resistant fodder trees and fodder shrubs in drought-prone areas so that feed resources are available during the period of actual disaster;

(vii) In all areas governments must be prepared for unusually heavy calls on the veterinary services. A practical step would be to maintain extra stocks of the needed vaccines and medicines in veterinary centres and outposts in drought-prone areas and to strengthen the staff and transport arrangements when the first signs of possible drought appear.

F. *Medical problems*

In most droughts which have led to famine conditions, deaths from epidemic diseases have outnumbered deaths from starvation. Any infectious disease may assume epidemic proportions in times of famine due to lowered susceptibility or resistance to diseases in the affected population. A good and rapid system of notification of infectious diseases is essential for the medical services to take timely action to control the spread of the disease If famine conditions are forecast, it is better to strengthen the medical units in the affected area and to set up small subsidiary dispensaries in places where hardship is likely to be greatest.

Based on past experience reserves of medicines, drugs, disinfectants, syringes, etc., for simple medical and surgical treatment should be stocked in these units. Extra medical staff would also be needed.

Expenditure on drought relief operations has not solved the basic problem of insulating drought-prone areas from recurring disasters which are the result of ecological damage through prolonged neglect of the environment, destruction of forests and extensive grazing. Indeed there is evidence that over the years the percentage increase in drought disasters has been higher than for any other kind of natural disaster.

When preventive measures are integrated in the long-term physical and economic planning process of a country their capacity to reduce the impact of a drought is considerable Tropical and sub-tropical countries having large drought-prone areas should have more investments in special programmes designed to restore the disturbed ecological balance: for example, through integrated development of agricultural and allied sectors of the rural economy by conservation, development, and use to the optimum extent of land, water, livestock, and human resources

Emphasis should be given to the development of irrigation water supply by means of storage reservoirs, tanks, masonry wells, diversion from rivers and streams and the exploitation of underground water through bore and tube wells. Improving water conveyance to prevent seepage losses and drainage needs attention. Any substantial improvement of crop production in dry land areas depends on improved management to use the rainfall efficiently and to prevent run-off during the rains which causes serious damage by soil erosion. Contour bunding and terracing offer an immediate way to step up agricultural production on large tracts of non-irrigated arable soils.

Uncontrolled felling of trees in catchment areas which affect weather conditions should be prevented, notably in private forests. Encouragement should be given to village forest planting, particularly of quick-growing fuel trees to prevent wind erosion of soil and to provide village fuel supply.

The problems of shifting cultivation, where cultivators have few alternative opportunities, call for research programmes for testing improvements and supplements to such systems of cultivation.

The control of grazing is one of the most difficult agricultural and conservation problems, especially in the desert regions of African countries. These pastoral economies support a large migratory cattle population, far in excess of the available supplies of grazing areas, fodder and feed. Yet the benefits of control are so great that every effort should be made to achieve it in order to keep the number of animals in reasonable relationship with the average fodder and water resources available so that grass, browse plants, and trees may have a chance to make their enormous contribution to the national economy. Dry land pastures should be developed to upgrade the shrinking pasture land.

Basic research would be needed for breeding crops for drought conditions, for early maturation qualities, and for disease and insect resistance so that they can be grown in areas where water supply is limited. Crop planning should take into account the hazards of sudden dry spells and the need to provide fodder for livestock.

Field activities should include multipurpose demonstrations of new techniques, the training of farmers in them, and the supply of suitably improved implements.

The aim of all these programmes should be to maximize agricultural production in years of good rain and to minimize losses when it is unsatisfactory. There are no generally applicable proposals that can be formulated to reach these objectives in any country. In the light of its own experience, local conditions, and resources, each country faced with periodic drought conditions should identify programmes which have the greatest potential to reduce vulnerability to drought and pursue them vigorously as part of its national development plans.

A proper post-disaster evaluation of the effects of drought and the relief measures taken would reveal which development measures should be accorded priority to bring the greatest benefits for the future.

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4. Volcanic eruptions

Large volcanic eruptions are rare events in any single country. Thus, although there may be a general awareness of the devastation which has been caused by cataclysmic eruptions in the past, there is usually also a belief that the next eruption will take place so far in the future that the expenditure of even a small effort on hazard evaluation, monitoring and preparedness activities cannot be justified. At the first signs of reawakening of a volcano close to an important population centre, this attitude will change rapidly: the news media print horror stories of the past; public attention, and especially the concern of the administrative authorities, is focused on the worst possible outcome of the new activity, no matter how minor it may initially be. Political issues and pressures often intervene. Public officials urgently consult local scientists, or specially invited foreign experts, for their opinions on the probable future activity of the volcano. Detailed knowledge of the volcano's earlier historic and prehistoric behaviour is often lacking. In most cases, the local earthquake activity and state of inflation of the volcano will not have been measured recently or regularly. If that is so, then the only scientific opinion that can be given will be one based on general global experience.

In these circumstances, volcanologists will probably find it difficult, and may be unwilling, to evaluate the hazard in a way which is meaningful to government authorities. None the less, a state of emergency will develop, within the public mind even if not by official declaration, and public officials will have difficult decisions to make about the measures which should be taken to protect the lives and property of the population. These measures may include the evacuation of tens of thousands of people for several months. In any country, this will involve enormous social disruption. In a small country, it will cause a serious economic setback regardless of whether or not a destructive eruption follows. If no eruption takes place, but an evacuation has been ordered by the public authorities, criticism can be expected.

Fundamental preparedness actions, therefore will have to include:

(*a*) Clear definition of the responsibility of the volcanologists. Do the civil authorities expect them simply to quantify the hazards (probabilities of occurrence of various types and magnitudes of eruption within specific time intervals such as that required for evacuation)? Or do the government authorities wish volcanologists to go further and say specifically when an evacuation should be called (i.e. to take the responsibility not only for assessing the hazard, but also for setting a standard for public safety)?

(*b*) Establishment of a single, well co-ordinated national or regional team of scientists, selected and appointed in advance of any emergency, to be officially responsible for providing the government with information of the kind indicated in the preceding paragraph;

(*c*) Research into the historic and prehistoric eruptions of the volcano prior to the next emergency (i.e. beginning immediately), so as to have as firm and complete as possible a factual basis for making future hazard assessments;

(*d*) Ensuring that during the course of an eruption, the team gives a single impersonal opinion, updated as often as necessary, on the probabilities of various future events; and

(*e*) Clear definition, in cases where the same team has been assigned the responsibility for recommending when an evacuation should take place, of the terms of reference relating to this, and preferably also the basis for legal protection in the event of errors of judgement. If it has accepted this responsibility, the team should inform itself not only about volcanic activity, but also about the local economic and social implications of an evacuation, co-opting or consulting national experts in these fields as appropriate.

These points can be illustrated by reference to some recent events, in which serious difficulties have arisen over the presentation to the public of contradicting scientific opinions on the probable future course of volcanic activity. A particularly difficult situation of this kind developed during the 1976 eruption in Guadeloupe (Lesser Antilles) in which some of the responsible scientists gave widely diverging predictions on the likely outcome of the eruption. A similar conflict of opinion was reported by the local press before the devastating climax of Mt. St. Helens in 1980: on this occasion, however, the notion that there was no significant hazard remained a minority view expressed by short-term visitors and headline seekers.

When such a clash of scientific opinion occurs and is known to the public, several unfortunate consequences are likely to follow. First, and most important, it leaves the civil authorities without a consensus of expert opinion on the magnitude of the hazard, and obliges them to make a choice based on scientific arguments which they may not properly understand. Second, it makes people doubt the value of scientific monitoring; third, it gives discontented members of the public a basis for querying the decisions of the authorities; and fourth, it can cause friction between the scientists which will distract them from their essential functions of making scientific measurements and assessing them objectively.

Differences of opinion between scientists are almost inevitable on the prediction of future hazards. Civil authorities have often pleaded for a single, impersonal statement from the scientists on every important issue, this statement representing the synthesis of their individual views into a collective judgement. Quantitative estimates of the hazard should be given whenever possible. This not only provides a way of arriving at a compromise between the views of different scientists, but is also a way of indicating the relatively low probability that the worst imaginable scenario will occur.

Quantitative probability statements can be based in the first instance on general global experience, for example by reference tq the known sizes of the areas devastated by glowing avalanches and to the amount of time elapsed between the eruption onset, and the destructive climax. This is illustrated in table 1, which shows that there is a one in two chance that the largest glowing avalanche in an eruption of this type will devastate more than 22 km^2 and will occur more than 24 hours after the onset of the eruption; that there is one in four chance that the largest avalanche will devastate more than 60 km^2 and will occur more than 16 days after the eruption onset, and that the corresponding 1 in 8 probabilities of exceedence are 150 km^2 and 120 days. Hence, when the first (possibly small) glowing avalanche of an eruption has been identified, and if it is decided that the acceptable risk of exceedence is 1 in 16, then it can be calculated from the table that the logical combinations of area and duration will be to evacuate the most vulnerable 22 km^2 of the volcano for 120 days, the area between 22 and 60 km^2 for 16 days, and the area between 60 and 150 km^2 for one day (i.e. 24 hours) after the eruption onset.

TABLE 1

Combination of area and duration of evacuation corresponding to a uniform hazard from glowing avalanche

(Based on data for 20 eruptions, world-wide)

Area		*Duration of evacuation*		*Hazard*
Km^2	*Probability of exceedence*	*Days*	*Probability of exceedence*	*Probability of occurrence*
22	1:2	120	1:8	1:16
60	1:4	16	1:4	1:16
150	1:8	1	1:2	1:16

Reference to general, global experience should be only the first element in hazard evaluation. The second and third elements will be, where available, the evaluation of the particular history and reconstructed prehistory of the volcano, and the interpretation of day-to-day observations during the crisis in progress.

Quantitative statements on hazard will help to define the limits of the scientists' real expertise and appropriate responsibilities. Where the scientists cannot give a specific evaluation of the hazard, civil authorities may feel obliged or entitled to ask them to recommend whether or not to evacuate the population at risk.

The setting of standards for public safety requires decisions to be made on the risk levels at which measures should be taken to protect the population. For the most destructive types of eruption, the only effective protection is evacuation. There is a need to identify first, who will be responsible for making the decision and second, what criteria will be used in arriving at it.

Recent experience in different parts of the world has shown that the responsibility may be shared in any proportion between the earth scientists and the civil authorities. For example, an earth scientist may spontaneously recommend evacuation, as was the case in St. Vincent in 1971. An alternative but similar procedure is that the civil authorities may invite earth scientists to advise on the need for evacuation. This is the standing arrangement, for example, in Indonesia and the Philippines. In the latter country, the National Commission on Volcanology has the appointed responsibility for recommending when and from where to evacuate: and its recommendations go direct to the President. The system has been successful in that during recent eruptions, the periods and areas of evacuation were kept reasonably small whilst loss of life was minimized and the evacuations were readily accepted by the people.

Recent experience has also shown that it is often difficult for the civil authorities to preserve an unbiased perception of acceptable risk. Once a state of emergency has been declared, the safety of the population often becomes the responsibility of a single person. It sometimes happens that under the personal stress which the bearing of such a responsibility entails, and where no clear policy already exists on acceptable risk, he will incline towards a more and more conservative view of what risk should be tolerated. He may accordingly prefer to evacuate a threatened population for several months, no matter at what cost, rather than risk being held responsible for the loss of even a few lives through failing to order an evacuation. In this context, it would be worthwhile to consider what legal liability might confront, and what protection might be desirable for, those people (whether scientists or civil authorities) who assume the responsibility for decisions on acceptable risk.

The detailed requirements of volcanic emergency preparedness planning will differ substantially from one volcano to another, according to the expected types of eruptive activity, to the topography, climate, number and geographic distribution of the population, available escape routes and transports, and various other factors.

For each volcano which represents a significant risk to populated areas, there is a need to plan in detail the routes and means of transport by which people will be evacuated, the points at which the evacuees will be assembled, and the buildings which will be used for their immediate and longer-term shelter. As regards first aid and medical preparedness, the most common problems related to volcanic eruptions are respiratory irritations resulting from the inhalation of volcanic dust. Where strong vertical explosions occur with little warning, large numbers of people may suffer cuts, bruises and fractures caused by falling pebbles and blocks. If glowing avalanches occur and people are caught in the very hot dust cloud around the fringes of one of these avalanches, there will probably be cases of extremely severe burns, both externally, and internally to the throat and lungs.

After an eruption has continued for long enough (several days to weeks) to deposit a thick mantle of fresh, loosely compacted ash and boulders on the flanks of the volcano, there will be a danger that, during periods of heavy rain, this material will be washed into and down the main valleys descending from the volcano, to form mudflows which will inundate and destroy human settlements and the best cultivable land at distances of up to several tens of kilometres. In Japan and Indonesia, successful preparedness measures have been taken by building dykes and catchment ponds in order to confine or divert these mudflows to areas where less damage will occur.

Preparedness measures should also be taken to ensure that during periods of strong vertical eruptions, air traffic is advised of the location and height of the eruption clouds which may reach heights of 20 kilometres and extend for hundreds of kilometres downwind. Arrangements should be made for local volcanic observation teams and meteorological offices in the area to measure the height, density and distance and rate of downwind movement of volcanic ash clouds, and to communicate this information rapidly to regional air traffic control authorities. The International Civil Aviation Organization (ICAO) is engaged on the development of specifications and guidance material in respect of the provision of volcanic ash warnings for aviation interests.

Examination of figure 41 shows that there are two main sequences of duties to be performed, one by the civil authorities and the second by the volcanologists. Each calls for communication and co-operation at appropriate stages between the two groups. Each sequence also involves the acquisition of information and the making of decisions in a specific and logical order. Some of these steps require significant research and cannot be carried out properly at a few days' or weeks' notice once an emergency has developed.

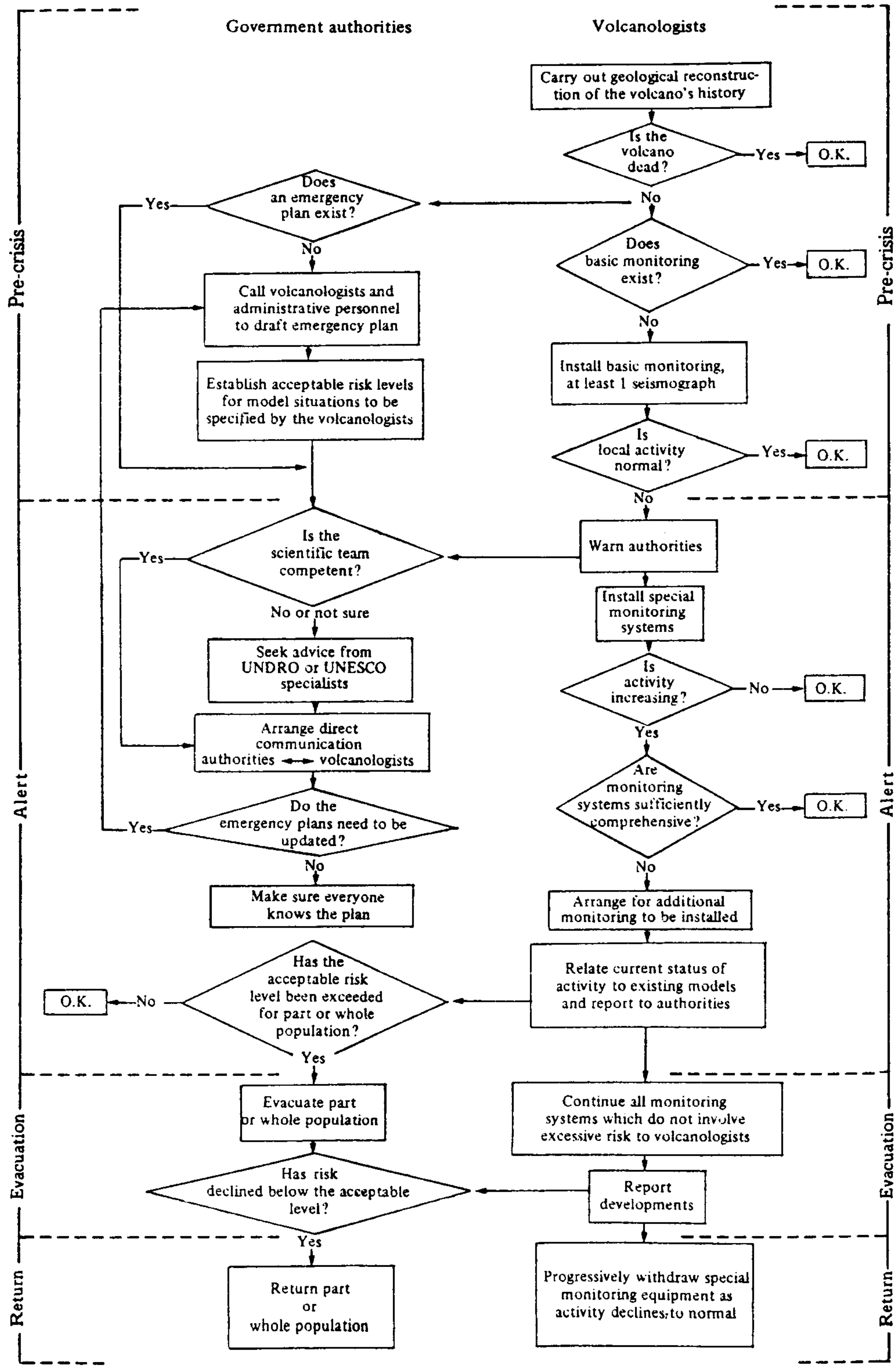
One other aspect of emergency preparedness merits a special word of caution: this is the tendency among many preparedness officials to regard the largest reported historic event as the maximum probable one for the future. With volcanos, this is emphatically not realistic and may lead to a false sense of security. The Mount St. Helens eruption of May 1980 was a dramatic but not a truly major event. It emitted an estimated 0.5 cubic kilometre of fresh volcanic material and devastated an area of 500 square kilometres.[107] The world's biggest historical eruption was that of Tambora, Indonesia, in 1815, which ejected an estimated 80 cubic kilometres of material (160 times that of Mount St. Helens); part of the material remained in the stratosphere long enough to apparently disrupt the world's weather pattern.

Recent and reliable reconstructions of prehistoric volcanic megablasts have shown that the largest of these have reached an order of magnitude greater than in the Tambora eruption. The scale and impact of a really giant eruption of this kind (involving 1,000 cubic kilometres of erupted material and hence with a magnitude 2,000 times greater than that of Mt. St. Helens in 1980) is far beyond the experience of the present population of the world, and beyond the capacity of any emergency service. Such an event would

[107] "The eruptions of Mount St. Helens", by R. W. Decker and B. Decker, *Scientific American*, vol. 244, No 3, pp. 52-64 (1981).

FIGURE 41

Volcanic emergency planning: a flow diagram



After J. Tomblin, *Impact of Science on Society*, vol. 27, no. 1

totally devastate ten thousand square kilometres, and would severely disrupt all human activities in an area of more than a million km^2. In some areas where an event of this scale has occurred within recent geological time, there are now populations of several millions.

Studies of the extent and especially the age of the younger prehistoric deposits from giant eruptions in the world as a whole have led to the realization that eruptions of a scale approaching that of Tambora in 1815, or up to 10 times that size, are by no means rare events: present knowledge, which remains far from complete, indicates a frequency of occurrence of about one per century. Viewed in shorter-term probabilities, this means that there is a one-in-five chance that an event of this scale will occur somewhere in the world every 20 years.

Volcanic eruptions constitute a potential cause of disaster which can be significantly mitigated through preparedness planning. Eruptions differ from other major causes of disaster such as earthquakes, hurricanes and floods, in that they cause total destruction of life and property in relatively small areas which can be easily delineated. More important, there is often a period of weeks or months of clearly recognizable precursors to the first destructive climax. This will give rise to major concern among the population It will also create the possibility, and an obligation, for government authorities to identify and implement those protective measures which are judged to be appropriate, i.e. those which represent the most widely acceptable compromise between reasonable safety and the minimum socio-economic disruption.

5. Hazardous materials accidents

Emergencies involving hazardous substances (which, for the purpose of this section, are taken to include gases and radiation releases) are now increasingly common because there are so many sources, so many uses, so many ways of transporting hazardous materials and so many ways of disposing of them at the end of their useful lives. It is important that the emergency manager should realize that although many of the results of these emergencies require the same kind of response as is provided in other cases (medical care, fire-fighting, evacuation and so on), the means of countering the emergencies may well be different. To take perhaps the most simple example, burning oil is not best extinguished with water. Here, however, the fire services will be aware of the nature of the problem and will be prepared and equipped to deal with it. It is not always practicable, or even possible, for the emergency services to be so prepared and equipped for all the kinds of chemical accidents with which they may be called upon to deal, and it is therefore extremely important that systems should be in place which will allow the rapid flow of technical and scientific information both to and from centres of expertise within and outside the country and those responsible for dealing with the emergency itself. It may well be necessary to supplement this flow of information with specially qualified personnel to advise and assist the emergency services in their work. Such personnel may come from national centres belonging to the government, or they may come from the industry concerned.

Against this considerably simplified background, it is not difficult to see how essential it is to provide for emergency preparedness in industry, government, the scientific community and the emergency services themselves and how the systems so established should be interlinked. Within the United Nations system, the International Programme on Chemical Safety (which operates under the aegis of the World Health Organization, from the WHO's Regional Office for Europe located in Copenhagen, Denmark) is the responsible body so far as the giving of advice and assistance to governments is concerned. A Working Group convened in 1981 at Bilthoven in the Netherlands was organized within the framework of the European Regional Programme on Chemical Safety, and its detailed conclusions and recommendations emphasized this interlinking, as may be seen from the tabulated summary in table 2. Moreover, although the Working Group was particularly concerned with chemical emergencies, much of its advice is equally applicable when other hazardous materials are involved.

TABLE 2

Phase	*Government*	*Industry*	*Scientists*
Hazard analysis	—— Require / perform / assist in making major hazard analysis ——		
Legal measures	—— Co-operate in development of laws and regulations concerning hazardous substances ——		
	Prohibit transport of certain substances over certain routes (at certain times).		Establish short-term emergency exposure tolerable limits for industry workers/emergency services personnel/general public.
Planning, long term	Negotiate with neighbouring countries who may be affected by emergencies at plants near national boundaries and establish a joint plan for "transboundary accidents".	Plan for mutual assistance by provision of equipment and personnel within the same or similar industries.	Maintain national roster of experts and have one of them identified as an international contact in case help is needed in another country.
	Identify sources of expertise within the planning area and establish procedures for obtaining further assistance from outside the area.	Plan for access to industrial centres of expertise. Provide government authorities with toxicological, medical and other relevant information.	Form an international committee of these "contact persons" to meet from time to time to exchange experiences and evaluate control actions taken in major emergencies. Involve social scientists, economists and others in the planning process.
	—— Establish and maintain efficient emergency services ——		
Planning, short term	—— Establish inter-active and compatible emergency plans ——		Provide information relevant to emergency plans.
	Within government emergency plan, provide for co-ordination and co-operation between departments likely to be affected.		
	—— Exercise the plans ——		
	Maintain / provide current information on all potentially hazardous substances in, being transported through, or being disposed of in, the planning area.		Be available at all times at or to data banks and information centres in order to interpret the data on an accident, and Provide fast, reliable information under stress, so that it can be understood and acted upon by non-technical people like firemen and the police.
Post-emergency	—— Require / perform / assist in evaluation of accident and effectiveness of countermeasures adopted ——		
			Help in planning (and executing) detoxification and rehabilitation procedures.

A basic planning document (which has so far been published in an interim version only) is the International Programme on Chemical Safety's "Emergency Response to Chemical Accidents".[108] This classifies the various kinds of emergency and the seriousness of the accident and proposes a model emergency response system. About half the book is devoted to summaries of the various systems of national contingency planning and emergency response in force in Europe.

Emergencies can result from:

(*a*) Disaster/explosion or other unforeseen event (e.g., sabotage, or the effects of natural phenomena) in a plant handling or producing potentially toxic substances;

(*b*) Accidents in storage facilties;

(*c*) Accidents during transport;[109]

(*d*) Misuse, resulting in contamination of foodstuffs, the environment, overdosing of agrochemicals, etc.,

(*e*) Improper waste management, such as uncontrolled dumping, failure in waste management systems or accidents in waste-water treatment plants.

It is suggested that a single emergency may be classified by reference to its effects, or to the degree of involvement of the organizations taking counter-measures, viz.:

(*a*) Environmental health effects:

(i) *Low* contamination of the environment causing minor annoyance, but not requiring extensive remedial measures;

(ii) *Serious* contamination, creating difficulties for man's activities and requiring some protective and/or remedial measures;

(iii) *Dangerous* contamination, limiting some of man's activities;

(iv) *Extremely dangerous* contamination preventing the continuation of man's activities.

(*b*) Duration of adverse effects:

(i) Short-term, from several hours to a few days;

(ii) Long-term, for several weeks or months;

(iii) Almost permanent, expected to last for years.

(*c*) Extent of remedial actions required:

(i) Minor short-term remedies provided by the operator;

(ii) Considerable remedial activities often of long-term character and exceeding the capabilities of the resources available at the local level,

(iii) Considerable long-term rehabilitation of the environment.

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[108] Interim Document No 1—European Co-operation on Environmental Health Aspects of the Control of Chemicals, published by the World Health Organization, Regional Office for Europe Copenhagen, Denmark, 1981

[109] The United Nations Committee of Experts on the Transport of Dangerous Goods has since 1957 made recommendations, based largely on existing regulations and on work undertaken by various organizations, to governments and to international organizations concerned with the regulation of the transport of dangerous goods They cover the following points classification and definition of classes, listing of the principal dangerous goods, packing, marking, labelling and placarding, and shipping documents The adaptation of national and international regulations to the framework of the recommendations will have benefits far beyond those of disaster prevention and preparedness The Third Revised Edition of the recommendations "Transport of Dangerous Goods" is published by the United Nations as document ST/SG/AC 10/1/Rev 3 (1984), and includes recommendations endorsed by the Economic and Social Council of the United Nations in 1983

Alternatively, the classification might be:

(*a*) *Level I (operator).* An accident limited to the confines of one facility and where the effects can be contained and controlled within that area by the operator;

(*b*) *Level II (local/community).* An accident where the effects spread to the public but can be contained by the resources of the operator and the surrounding community, possibly with assistance from the resources of the industry involved. (The majority of transport accidents will fall in this category);

(*c*) *Level III (regional/national).* A larger and more serious accident *or* one of less gravity which occurs at the border between two jurisdictions within one country. It may be handled with the resources available at the regional or national level, as well as those of lower levels;

(*d*) *Level IV (international).* This may be a very large-scale national disaster *or* a unique event requiring for its handling special skills or facilities not available in that country *or* an accident of any gravity whose effects may be felt in a neighbouring (not necessarily adjoining) country. The last type of emergency may be contained using national resources, but its management may be undertaken by an international team established for the purpose. The legislative aspects of responding to "international" emergencies are dealt with in chapter II, section 2, of this volume.

In developing emergency plans, it will be necessary to take into account:

(*a*) The type of operation and its known points of potential failure;

(*b*) The probable character of an accident;

(*c*) The characteristics of the hazardous substance itself;

(*d*) Local conditions, and resources available for dealing with an accident;

(*e*) Probable consequences, both within the boundaries of the facility involved and to the public outside those boundaries, of an accident of different degrees of gravity under different local conditions; and

(*f*) The status and organization of the local/regional/national emergency preparedness machinery and the best means of harmonizing on-site and off-site emergency plans and countermeasures.[110]

It is not the purpose of this volume to discuss preparedness measures which should be taken to deal with Level I accidents, for by definition there is no need at that stage for any action to be taken in respect of the public or the off-site area. However, two points might usefully be made: any incident with the *potential* for causing off-site damage to life or property should be notifiable to the civil authority; and where there exists a threat to life or health among the workers in the employ of the operator who may be called upon to control such an incident, and any resulting injury would require specialized medical treatment, prior arrangements should be made with an appropriately sited and equipped hospital to receive cases at any time.

Notification of an incident need not necessarily be made to the off-site civil emergency authority. It may be sufficient for the Factory Inspectorate or some similar body to be informed.[111] But unless these notifications are made and recorded the identification of points of potential failure in that and similar plants/processes will not be so easily made.

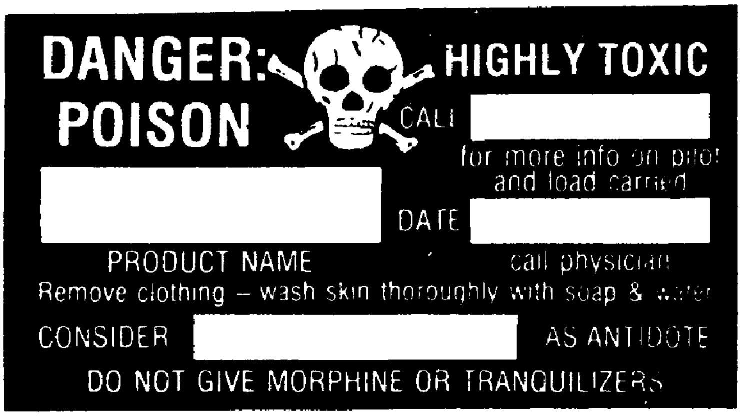
It does not necessarily follow either that hospital treatment must be available in the immediate neighbourhood of the plant. The injury or health detriment caused may be of a kind which would tolerate quite a long delay before treatment: the decision must rest on the circumstances and characteristics of the hazardous substance involved.

[110] Reference may usefully be made to "Planning Guide and Checklist for Hazardous Materials Contingency Plans" published as document FEMA-10/July 1981, by the Federal Emergency Management Agency, Washington, D.C. U.S.A.

[111] Compare, for example, the widespread requirement for notification of all incidents involving aircraft to be made to national civil aviation authorities and, in some cases, to the manufacturer of the aircraft.

An example of a small-scale Level II accident can be found in the crash of a crop-spraying (pesticide-carrying) aircraft. Some of the chemicals involved are highly toxic. In 1982 the Department of Aeronautics in Nebraska, U.S.A., introduced a scheme whereby the pilots of crop-spraying aircraft were encouraged to attach self-adhesive labels to their safety helmets. The labels provided rescuers with information about the name of the chemical, whom to call for further information, the name of an antidote, and other relevant instructions (figure 42). Colour-coding of the labels showed the degree of toxicity of the chemical: red, yellow and green were used for high, moderate and low toxicity respectively.

FIGURE 42



An exhaustive and extremely interesting account of a Level III accident is to be found in an examination of the Mississauga emergency of 1979.[112] In this case, a freight train conveying chemicals was partially derailed and a fire and explosion followed. The result was a major emergency necessitating the evacuation of 217,000 people from the city of Mississauga.

No emergency plan, whatever may be the level or type of accident with which it deals, should ever be regarded as a definitive document, with the only need remaining being that of exercising the plan's provisions at regular and reasonably frequent intervals. In dealing with hazardous substances generally existing plants may introduce new products or new manufacturing processes or keep in storage larger quantities of hazardous substances than hitherto;[113] new plants may be installed in previously safe locations, and old plants may be closed, so removing a hazard from another place, new methods of transport may be introduced; new knowledge generally may become available. There is a need, therefore, for a continuing process of examination of plans, and their modification whenever there is a real change of circumstances. This requirement emphasizes the importance of liaison between operators and off-site authorities, just as it also shows how the specialized activities which may be needed in response to an emergency involving hazardous substances should be undertaken within the framework of the ordinary community/regional/national emergency plan and its organization.

These specialized activities may include monitoring of the environment carried on by the public authorities concerned with the quality of air and water. These authorities should be associated with the planning process, not only because of the post-accident assistance they may be able to render but also because their routine monitoring could even provide the first warning that a release of a hazardous substance has occurred or is occurring. Both the operator and the off-site authority will need to be notified

[112] The Peel Regional Police Force and the Mississauga Evacuation, by J. Scanlon with M. Padgham, published for the Canadian Police College by the Minister of Supply and Services, Canada, 1980.

[113] After the chemical explosion at Salford, U.K., in September 1982, it was ascertained that the fire authority was not aware of the presence of the chemicals, nor, under the then state of the law, was there any requirement for the owner of the premises to notify the authorities.

An important development which affects the prevention of, and preparedness for, possible hazardous substances accidents in Europe has been the adoption, by the Council of the European Communities, of a Directive (82/501/EEC of 24 June 1982) known as the "Seveso Directive". This, when it is fully in force, will have the effect of requiring manufacturers and operators to notify competent national authorities when the natures and quantities of hazardous substances for which they are responsible are of certain kinds and exceed specified amounts; of the locations of the installations and any special dangers arising from that location; of the numbers of persons working on the site; and to give a description of the technological processes involved, the prevention measures taken, and the arrangements for dealing with malfunctions. Furthermore, manufacturers must provide details of their emergency plans and equipment available for on-site use, information necessary for the preparation of off-site plans, and the arrangements for initiating emergency action should it be required. Governments, for their part, are required to set up competent authorities who will receive and evaluate this information, seek any necessary clarification, establish emergency plans for off-site use, and ascertain that the manufacturer continues to perform his duties under the Directive. Governments are also enjoined to inform the public likely to be affected by a major industrial accident of the action they should take if one occurs; and to make this information available also to other governments.

Notifications of accidents, their causes, and the action taken, as well as proposals to alleviate the effects and avoid a recurrence, must be given by manufacturers to governments, and by governments to the European Commission so that the latter may have a comprehensive record and analysis of accidents, to which reference can be made for purposes of disaster prevention.

Post-accident assistance could well require, in addition to the monitoring of concentrations of pollutants, arrangements for alternative supplies of water, or for disposal of wastes—especially wastes which have become polluted because of the accident. Sometimes toxic wastes disposed of in the past, according to the safety standards then in force, may present a hazard as the containers deteriorate with age. Known dumps should be regularly monitored for this reason. Previously unknown dumps are occasionally uncovered in major construction operations, and may be the more difficult to deal with because it may be unclear which hazardous substances have been buried. Illegal dumping is an ever-present threat, difficult to counter or control because it can occur anywhere, often in isolated places at a considerable distance from the source, and without any indication of the nature of the substance itself.[114]

Somewhat similar considerations apply to the establishment of an effective link with public health authorities who are concerned with the purity of food supplies. Pollution after an accident may affect, or may be suspected to have affected, some foods in storage, both in bulk and in the home, or fresh foods in production: conceivably, any point in the food chain may be at risk. Depending on the circumstances of the case, and particularly when one of the primary countermeasures taken has been sheltering rather than evacuation, supplies of uncontaminated foods may have to be provided.

In dealing with hazardous substances generally, access to a reliable information system will be found useful. For chemicals, there are a number of data banks available at the moment, including ECDIN (European Chemicals Data and Information Network), CHEMDATA operated by the National Chemical Emergency Centre, Harwell, United Kingdom (which can provide information in French, German, Italian and Spanish), as well as IRPTC (International Register of Potentially Toxic Chemicals)

Existing data and information systems cannot provide all the information needed in an emergency situation. Information systems can, however, provide a useful service by ensuring the efficient provision of available data on the characteristics of potentially toxic chemicals and also by indicating the areas where information may be unreliable or unavailable, or where additional research may be needed. In the process of

[114] The WHO Regional Office for Europe expects to publish during 1984 further guidance documents including "Safe Processing and Ultimate Disposal of Redundant Products containing or emitting Potentially Toxic Chemicals", "Reclamation and Rehabilitation of Abandoned Toxic Chemical Dumps" and "Rehabilitation following Accidents involving Toxic and Potentially Toxic and Hazardous Chemicals" Advance copies may be obtained by writing to the Regional Office.

contingency planning, there must, therefore, be provision for obtaining required data either from the data bank within the plant or industry or through other regional or national sources.[115]

The assistance provided through information banks and laboratories after an accident may have to be supplemented by expert advice to non-technically-qualified off-site controllers. This advice may come from the operator's own staff, or from other experts, for example the staff of a national regulatory commission for the industry concerned, environmental agencies, and so on There are two points to be considered here. First, while expert advice should be welcomed, the decision-making concerning the implementation of countermeasures should remain the responsibility of the emergency controller. Second, in the early stages of an accident, especially one which happens outside normal working hours, the advice and information from the operator's staff may come from less experienced, more junior or less qualified persons, and the off-site emergency controller must allow for this in deciding how much weight to attach to the counsel he is given. The decision-making process can be demonstrated in schematic and simplified form as shown in figure 43, which was originally designed for use in connection with radiation accidents. For chemical accidents, more detailed flow charts can be found in "Emergency Response to Chemical Accidents" already cited.

HAZARDOUS MATERIALS IN PORTS AND HARBOUR INSTALLATIONS

Accidents in the usually relatively confined spaces of docks, ports and harbours are often associated with, caused or rendered more serious by, the presence of hazardous materials, either in a ship, in storage, or in some industrial process in the port area. The latter case can be illustrated, for example, by purpose-built liquefied natural gas (LNG) terminals. The LNG system consists of a liquefaction plant at the export terminal, a storage unit used before the LNG is loaded into the tanker vessel, the ocean tanker itself, and a regasification plant at the import terminal

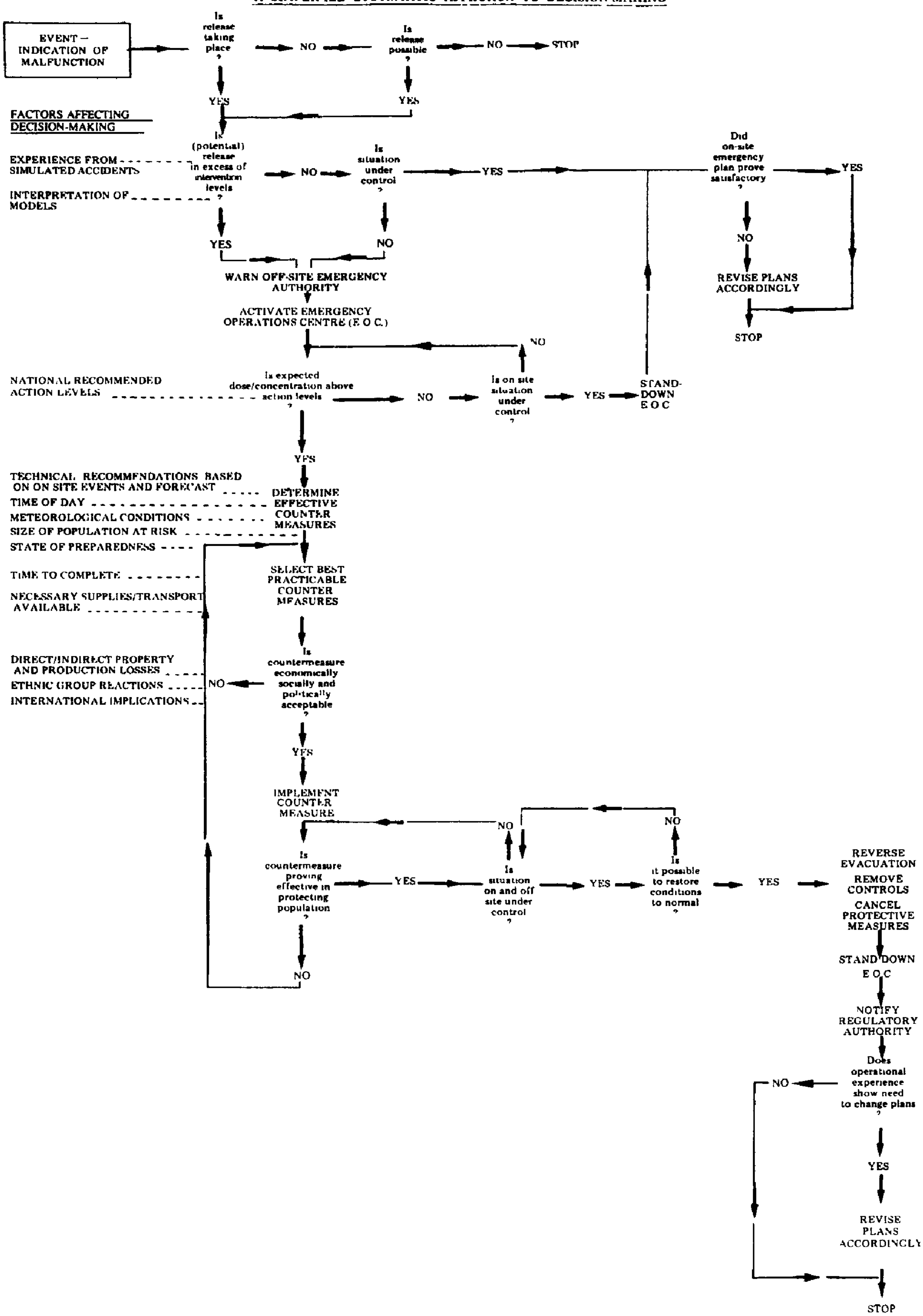
The nature of the hazards makes it unlikely that any warning period will be granted before an accident. The impact will be sudden, and may be devastating in its effects. Moreover, dock areas are in general located in densely populated places (certainly during working hours, and possibly at all times if workers in a port complex live nearby), access roads carry heavy traffic and this may delay or obstruct the passage of emergency vehicles

If a port area is under the control of an authority separate from that responsible for the (local) government of the surrounding area, it may be expected that the port authority will be large enough to dispose of its own fire, ambulance and police services who will be responsible for providing the first assistance in case of emergency. This provision will naturally be governed by the authority's own emergency plan, which should be prepared in association with the (local) government authority and those other agencies from whom assistance may have to be requested. As in all other plans, the arrangements for control and communications, and for the issue of warnings, must be clearly set out. There are two further matters which should be dealt with arrangements for warning, or otherwise communicating with, members of ships' crews who may be unfamiliar with the national language, and for ordering emergency movements of ships within the planning area. The latter may extend to the closing of the port and the banning of entry to it, and powers may have to be provided in order that this can be done. It may also be necessary to contemplate the possibility of beaching ships, and the designation in advance of suitable places where this can be done, would be a wise precaution. It will be seen that the principles of classification of events,

[115] Because events during transport are seen to be those most likely to have consequences affecting the public, chemical manufacturers in the United States agreed in 1971 to found the Chemical Transportation Emergency Center (CHEMTREC) Its services are available at all times to the emergency services to provide information about the nature of the chemical(s) involved and the action which should and should not, be taken in dealing with the initial phase of an emergency If necessary, the shipper is informed by the Center so that further information, and on-site assistance by qualified personnel, can be obtained Among producers mutual aid programmes permit one producer to deal with an emergency involving another producer's product CHEMTREC acts as the communication link for all these programmes Similar arrangements can be found in other countries, with government establishments associated with private programmes to a greater or lesser degree

FIGURE 43

A SIMPLIFIED SYSTEMATIC APPROACH TO DECISION-MAKING



described at the beginning of this section, apply equally well to port disasters. It will be seen too that the port authority, its emergency services (and the local off-site authority, if different) must be continuously aware of the status of the constantly changing hazards as the business of the port is carried on. Joint planning for response to any emergency with effects outside the port authority's boundaries (or even inside them, if the event's size outstrips the resources available there) is essential, and plans must provide for active liaison and exchange of information, and for arrangements for the overall control of any emergency operation.

An excellent and concise summary of the problems likely to be encountered and for which appropriate planning measures should be taken, was given by the President of the Maritime Services Board of New South Wales, Australia, in an address to a Port Disaster Seminar in April 1982[116]

> The following types of incidents are those with which a disaster plan should be concerned
>
> (*a*) Fire;
>
> (*b*) Explosion and/or fire,
>
> (*c*) Escape of toxic gases and liquids,
>
> (*d*) Escape of flammable gases and liquids,
>
> (*e*) Radioactive materials,
>
> (*f*) Collisions and groundings,
>
> (*g*) Spillage of hazardous and dangerous materials,
>
> (*h*) Oil pollution,
>
> (*i*) Natural disasters; and
>
> (*j*) Sabotage.
>
> All these incidents could occur within a harbour or river port area involving any of the following types of vessels:
>
> (*a*) Tankers, carrying chemicals, petroleum products or liquefied gases,
>
> (*b*) General cargo vessels;
>
> (c) Container vessels,
>
> (*d*) Bulk carriers, e g coal, grain, iron ore, phosphates, woodchips,
>
> (*e*) Specialised vessels—roll-on/roll-off car carriers, oil rig tenders, passenger vessels,
>
> (*f*) Harbour and river ferries or tugs, and
>
> (*g*) Naval craft
>
> The incidents can be divided into three categories.
>
> (*a*) "In the stream" including vessels under way, at anchor and at buoy berths;
>
> (*b*) "Alongside", and
>
> (*c*) Outside the port area, where although the original fire/explosion was in the port area, the affected area is much wider.
>
> "In the stream", the type of incident could include,
>
> (*a*) Fire/explosion on a vessel under way or at anchor within the port,
>
> (*b*) Collision/stranding of a vessel within a port, resulting in fire/explosion or spillage of highly flammable hazardous materials into the port waters with additional pollution and/or toxic hazard; and
>
> (*c*) Vessel approaching the port and requiring assistance to combat fire and/or the effects of explosion
>
> The type of incident in the "Alongside" category would include
>
> (*a*) Fire/explosion in a shore installation with or without a vessel alongside;
>
> (*b*) Fire/explosion in a vessel alongside premises while loading/discharging cargo, or

[116] The full text of the address, and the proceedings of the Seminar, were published under the title "Port Disaster Seminar, 26-29 April, 1982", by the Australian Counter Disaster College, Macedon, Victoria, 1982.

(c) Spillage of highly flammable toxic products at shore installations, leading to pollution of the port waterways

Then there are the incidents which could be classified in both these categories.

(a) Fire/explosion while transferring cargo between vessels,

(b) Fire/explosion mishap, involving radioactive material, or

(c) Fire/explosion aboard a vessel under repair or construction

The third category, which is potentially the most serious, is where any of the preceding situations escalates outside the port into residential or industrial areas

It might be useful to remember that when considering the types of vessels which might be involved, "nuclear-powered ships" should be added to the list, this introduces an extra element and the special measures needed to counter radiation accidents are mentioned briefly later in this section.

For the potentially most damaging accidents, such as LNG releases or fires, planning is the more difficult because it has not yet been possible to develop consequence-prediction models which are known to be able to cope with spills which may range up to 150,000 m^3. Although those would be extreme events, in 1981 there were at least 32 LNG tankers with capacities in the 120,000—135,000 m^3 range.[117]

A comprehensive discussion of the whole subject can be found in a Consultative Document "Proposals for Dangerous Substances in Harbour Areas Regulations", published in 1983 by H.M. Stationery Office, London.

RADIATION ACCIDENTS

It is often commonly supposed that nuclear power plants present the only source of danger to the public from radiation accidents. This concept is mistaken, just as it is a mistake to suppose that the declaration of a "nuclear-free zone" will remove all potential danger of this kind from an area so designated. Medical, industrial and research radiation sources exist, as do facilities for nuclear weapons development, and in many, if not most, countries radioactive materials are transported from one place to another, or across a country's territory. Many reported accidents involving the loss of control over radiation sources have occurred in medical and industrial establishments.

None the less, apart from the risks associated with the deliberate explosion of nuclear weapons, it is the risks from possible accidents at nuclear power plants which will largely engage the attention of emergency planners. This applies whether or not the country has such power plants of its own atmospheric (or water-borne) dispersion of radioactive material following an accidental release is no respecter of national boundaries In fact, in countries which do not have nuclear power plants, but which could be at risk from accidents in neighbouring countries, it is all the more essential that preparedness arrangements be in place to expedite the requesting and receiving of specialized international assistance which alone could provide the capability of dealing with the situation. Guidelines for "Mutual Emergency Assistance Arrangements in connection with a Nuclear Accident or Radiological Emergency" have been developed for the International Atomic Energy Agency (IAEA) by an expert group which met in Vienna in April 1983.[118] The IAEA's own Radiation Emergency Assistance Plan was first established in 1959, and is now (1983) being upgraded into a more comprehensive Nuclear Accident Assistance Plan An inventory of the sources and types of assistance available for coping with radiation emergencies has existed since 1963, the last revision was made in 1980 in co-operation with FAO, ILO, WHO and UNDRO, although supplementary information has since been published.[119]

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[117] See "Controlling the Risks from Liquefied Natural Gas", by E Bramonte, in *The Geneva Papers on Risk and Insurance* vol 7, No 23, April 1982, pp 75-88 Published by the Association Internationale pour l Etude de l Economie de l Assurance, Geneva, Switzerland

[118] The guidelines have been published as an Information Circular (INFCIRC 310) by IAEA Reference should be made also to chapter II, section 2 (Legislation) of this volume

[119] TECDOC-237 (1980) and TECDOC-284 (1983), published by IAEA, Vienna.