SAFETY IN NUCLEAR POWER PLANTS

All countries which export nuclear power reactor systems have national design codes and standards specifically developed for the nuclear industry. To assist the industrially developing countries who are currently importing nuclear technology, the IAEA has over the past ten years developed Nuclear Safety Standards for nuclear power plants in several disciplines, including design. These Standards form part of the Agency's programme of Safety Standards and Regulations covering not only nuclear power plants, but such things as Basic Safety Standards for Radiation Protection, Regulations for the Safe Transport of Radioactive Materials, and so on. They have been promulgated by the IAEA following the consensus of experts drawn from its 110 Member States; they thus represent the combined experience of the entire international nuclear community.

The construction of nuclear power plants proceeds under the very strict supervision of inspectors from the vendors of reactor plant equipment, the architect-engineer, the operator (licensee), the regulatory body and expert consultants Here too, in order to supplement the work of national authorities, the IAEA has developed safety guides for quality control in the manufacture of plant components as well as during construction of the plants themselves.

To complement the work undertaken in establishing safety standards for design and construction, the Agency has now almost completed production of the corresponding standards for the operation of nuclear power plants. Because the key to the prevention of nuclear accidents rests with the operating organization, increased emphasis has been given to independent evaluation of plant operations and detailed scrutiny of past incidents at plants throughout the world. The IAEA sends teams of experts in a variety of disciplines related to the design, construction and operation of nuclear power plants to those Member States who request help of this kind. Further, the Agency is instituting a worldwide Incident Reporting System so that the lessons learned from incidents can be shared by plant operators everywhere.

EMERGENCY PREPAREDNESS

The "defence in depth" concept, that is to say the multiple barriers between radioactive materials and man and the environment, has historically governed the development of nuclear power technology and the practical uses of nuclear energy. The application of this concept has, in general, resulted in an excellent record of nuclear safety Nevertheless, these multiple barriers have been breached in some accidents, and this has, on occasion, led to radiological exposures to plant personnel and radioactive contamination of the environment. Although no member of the general public has ever received more than minimal exposure, in some of the accidents that are a matter of historical record, the potential for more serious consequences did exist.

The last bulwark in the "defence in depth" concept is an adequate emergency planning and preparedness programme to support nuclear power plants and other nuclear facilities using large quantities of radioactive materials.

Even though the prime responsibility for safety at a nuclear facility rests with the operator, the off-site authorities can and should be prepared to assist the operators as well as to deal with the off-site consequences themselves This assistance may be as simple as the preparation of a list of hospitals and major radio-therapy centres which might be called upon to provide radiological advice and assistance in case of radioactive contamination of people. On the other hand, off-site authorities may be called upon to provide enhanced facilities for environmental monitoring, to delineate contaminated areas and assess the amount of radiation to which people are exposed. In some circumstances, it may be necessary for them to arrange for the use of aircraft equipped with appropriate instrumentation.

Information about the projected, and later actual, extent of contamination and exposure to radiation is vitally necessary for the taking of effective countermeasures in all three phases of a radiation accident. These phases are generally defined as.

(*a*) *Early Phase*, which extends from the time when it is realized that off-site irradiation of the public may occur, to a few hours after the release begins;

(*b*) *Intermediate Phase*, which may last for several days after the majority of the potential release has already occurred, and

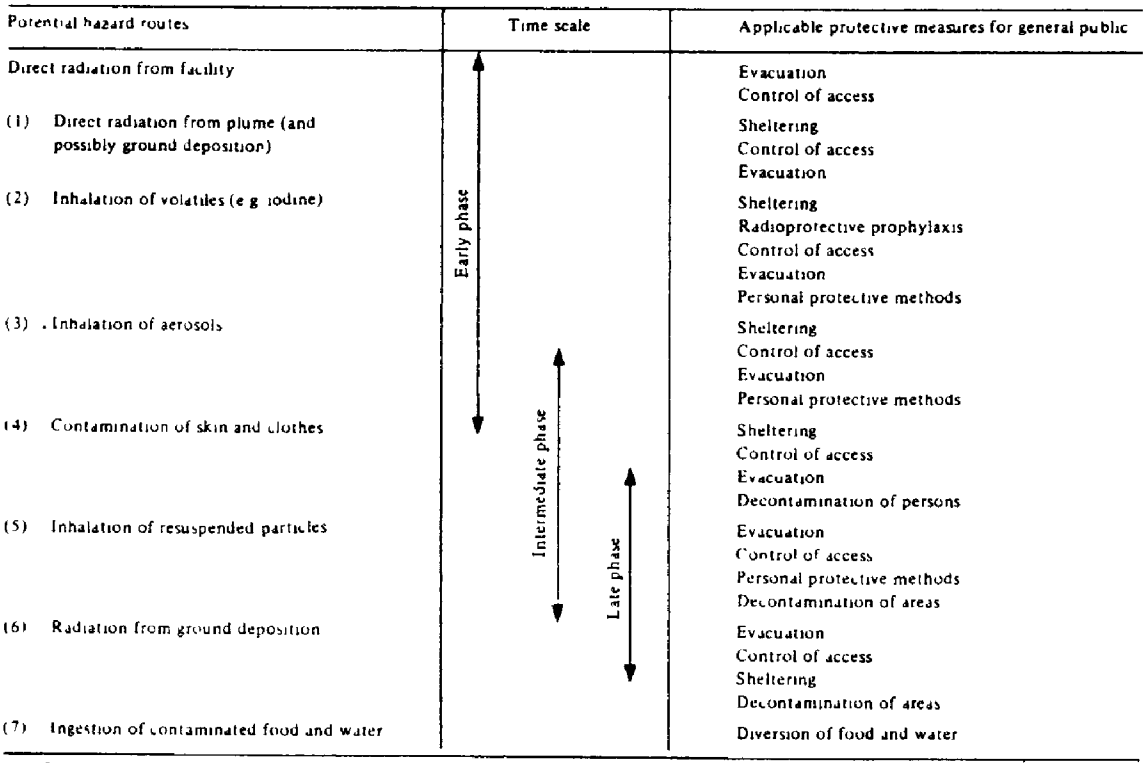
(*c*) *Late Phase*, when decisions are made about a return to normal off-site conditions.

The countermeasures applicable to each phase, and for which prior planning is necessary, are shown in figure 44, and a summary of the risks, difficulties and costs associated with each is given in tabular form in table 3. In the application of any countermeasure, the social cost and risk of its use should be less than those of the radiation dose averted.

Decisions on the introduction of any countermeasure will be conditioned by several factors, including the characteristics of the site and the installation, and a projection of the accident sequence. For each countermeasure, there should be defined lower and upper levels of dose: doses below the lower level are very unlikely to justify, for the purpose of radiological protection, the introduction of the countermeasure, whereas if the upper level is (projected to be) reached the countermeasure is almost certain to have been applied or attempted. Intervention levels will normally be set within the dose range so defined, but national authorities may set them outside that range for special population groups or to take account of localized, possibly transient, factors. Examples of Intervention Levels in various countries are to be found in IAEA publications, and a general guide has been produced by the Commission of the European Communities.[120]

FIGURE 44

RELEVANCE OF PROTECTION MEASURES TO PARTICULAR HAZARDS



NOTES 1 Medical care may be required in any of the time-scale phases, and should be implemented by competent authorities when and if necessary

2 The use of stored animal feeds to limit the uptake of radionuclides by domestic animals in the food chain can be applicable in any of the time-scale phases.

Source "Planning for Off-Site Response to Radiation Accidents in Nuclear Facilities", Safety Series No 55, published by International Atomic Energy Agency Vienna 1981

[120] "Radiological Protection Criteria for Controlling Doses to the Public in the event of Accidental Releases of Radioactive Material", published by the Commission's Health and Safety Directorate, Luxembourg, 1982.

TABLE 3

Countermeasures—their risks, difficulties and costs

Countermeasure	*Practical*	*Social*	*Technical*	*Cost*
Sheltering	Few. Most people will be in or near some kind of building which can afford protection	For periods of over 12 h, problems of feeding, hygiene and medical care may arise. Over 24 hrs, orderly evacuation may be more appropriate		No direct costs. Indirect costs associated with loss of production etc.
Radio-protective prophylaxis	Distribution *must* be made rapidly, and certainly within 6 h after intake of radio-active iodine		Relatively minor side-effects may occur in a few people Protection is against irradiation of the thyroid gland only	Low. Cost should not preclude the use of this protective measure
Control of access and egress	——— Possibility of traffic accidents due to congestion ——— ——— Family disruption ———			Provision of manpower to enforce the measure
Evacuation	——— Possibility of traffic accidents[a] ———		Problems associated with continuous-process industrial plants, care of farm livestock, policing of abandoned property	High, including costs of alternative accommodation, transport, food supply, etc
	Evacuation of the elderly, the sick, children, prisons and other institutions	Family disruption		
Personal protective measures	Special storage and maintenance of the more elaborate equipment	Apart from simple measures for respiratory protection, not applicable to the general public	Training necessary for use of "supplied air" equipment and in wearing and removal of (possibly contaminated) protective clothing.	Purchase of equipment
Decontamination of persons	Decontamination should take place *before* sheltering and *after* evacuation (if the area evacuated was already contaminated)		Storage facilities needed for decontamination wastes	Provision of field decontamination facilities (? reduce cost by using military sources)
Medical care			Training for medical personnel likely to be required to treat irradiated persons	
Diversion of food and water supplies	Change of diet may produce side-effects Supply, transport and distribution of uncontaminated food and water	Ethnic difficulties if certain foods are no longer available	Decision on whether to allow only marginally contaminated supplies to be used	Direct cost of distribution. Value of food destroyed
Decontamination of areas	Exposure of personnel to inhalation, ingestion and external irradiation Need to provide protective clothing Need to remove very large quantities of surface earth. Washing down of very large buildings and possibly very long lengths of road surfaces		Storage/disposal of radio-active wastes	Very high direct cost for machinery, equipment and personnel Indirect costs due to loss of use of property

[a] It has been suggested that it might be possible to calculate values for the risk of death and injury from motor vehicle accidents using historical data from major evacuations not associated with radiation accidents and statistical results on average road accidents. To study the balance between radiation risk and protective action risk, values of $2 \times 3 \times 10^{-8}$ death per man × km and $3 \times 4 \times 10^{-7}$ injury per man × km are proposed in a paper "Evacuation Risks – A Tentative Approach for Quantification" by M. C. Bastien, M. Dumas, J. Laporte and N. Parmentier, Institut de Protection et de Sureté Nucléaire, 92260 Fontenay aux Roses, France.

From the point of view of the preparedness planner, the most immediately relevant of the comprehensive series of publications being issued by the Nuclear Safety Standards Programme of the IAEA are:

Safety Series No. 55	Planning for Off-site Response to Radiation Accidents in Nuclear Facilities (1981);
Safety Series No. 50-SG-G6	Preparedness of Public Authorities for Emergencies at Nuclear Power Plants (1982);
Safety Series No. 50-SG-O6	Preparedness of the Operating Organization (Licensee) for Emergencies at Nuclear Power Plants (1982); and
IAEA-TECDOC-262	Emergency Response Planning for Transport Accidents Involving Nuclear Materials (1982)

and the reader is referred to these handbooks for detailed guidance and instruction on all aspects and implications of planning for radiation accidents. The International Institue for Applied Systems Analysis held an international workshop in January 1980 on the subject "Planning for Rare Events: Nuclear Accident Preparedness and Management" and the proceedings were published as No. 14 in the IIASA Proceedings Series.[121]

For an example of the kind of planning measures to be taken in respect of smaller incidents occuring away from nuclear power plants and other major establishments, reference might also usefully be made to the United Kingdom's "National Arrangements for Dealing with Incidents involving Radioactivity" (the NAIR scheme).[122] These are designed for cases in which the police or fire services are likely to be the first authorities to be notified, as they would almost certainly be for transport accidents or the finding of suspected radioactive material. The arrangements provide for the obtaining of technical advice and assistance from certain named establishments (selection having been made according to the place where the incident has occurred), and enable people who have been, or may have been, contaminated by or exposed to radioactivity to get specialist medical attention. An example of the instructions given to police officers is shown in figure 45 on page 141.

INFORMING THE PUBLIC

(see also chapter II, sections 6 and 7)

The proper handling of the public relations aspects of a radiation accident is most important if undue apprehension is to be prevented, and to eliminate the danger of minor incidents being raised in the public mind to the status of "catastrophes". While technical staff are not usually accustomed to providing prompt, simple, complete, and informative responses to queries from the media, these attributes must be developed or spokesmen with these skills must be identified, so that the public will have a basic awareness of the relative significance of a radiation emergency.

If the public are properly informed in simple words, they will generally react quite logically when faced with a potentially hazardous situation Good public and press relations start before an accident happens by developing openness and trust through facility tours, informal contacts, and responding to requests for information. Local liaison committees can be very helpful since the general public are still not very knowledgeable about the relative degree of hazards from nuclear activities and, indeed, often seem uninterested in receiving or acquiring knowledge about modern technology. It is desirable that continuing efforts should be made to dispel the impressions created by the often inaccurate anti-nuclear power propaganda nowadays so widely disseminated. Particularly is this so since members of the public may come to be persuaded to the mistaken belief that it is impossible to counter effectively the results of any radiation accident. Once that belief becomes widely implanted, it of itself reduces the chances of effective action

[121] Published by Pergamon Press, Oxford, England, 1981

[122] Home Office Circular No ES 7/1972 of 5 December, 1972

because it destroys public confidence in the ability of the authorities to provide protection, and encourages non-co-operation with any countermeasures which may be ordered.

The fundamental message to be transmitted is: nuclear power plants are sited, designed, built and operated according to stringent safety standards. In the event of any malfunction, multiple barriers have to be breached before there is any danger of the general public's being exposed to any radiation at all. If any such exposure should be about to occur, or have occurred, then countermeasures appropriate to the level of exposure are available and will be implemented by trained staff whose efforts on behalf of the public will be the more effective if the public co-operate and do not disregard the instructions they are given.

CONCLUSION

The production, transport, storage, use and disposal of hazardous materials generally are nowadays governed by international agreements and regulations developed by, among others, the International Maritime Organization, the International Civil Aviation Organization and the International Atomic Energy Agency. National legislation and regulations reflect or supplement the provisions of international requirements To the extent that the rules are observed, the likelihood of a serious accident can be reduced, although never eliminated entirely. The fact that serious accidents fall into the category of low frequency events does not lessen the need for effective and careful planning to deal with them.

FIGURE 45

INCIDENTS INVOLVING RADIOACTIVE MATERIALS
Instructions to police officers

1 Notify your police control point IMMEDIATELY. They will arrange for the necessary technical advice and help Include in your report.

(*a*) The location and nature of the incident, and

(*b*) As much information as you can obtain from vehicle drivers, labels, etc about the nature and quantities of the radioactive materials and the name, address and telephone number of the consignor

2 Try to rescue anyone trapped in the wreckage and remove anyone injured with as little contact as possible Take any measures necessary to save life, including removal of *seriously injured* people to hospital (You should inform the ambulance driver of the nature and quantity of the radioactive material if you know it) Minor casualties and persons who may be contaminated but are not seriously injured should be left until expert help or advice arrives

3 If there is a fire, call the fire brigade, who have special instructions for dealing with fires involving radioactive materials

4 Keep the general public as far from the scene as practicable, until a qualified person has made a survey and indicated demarcation boundaries

5 Keep to a minimum the contact of all helpers with anything that may have been contaminated

6 Keep apart all who have had possible contact with radioactive material until they can be examined further (This does not bar the removal of seriously injured people to hospital—see instruction 2)

7 Divert traffic from the scene of the incident

8 Do not allow anyone to eat, drink or smoke in the area

9 Remember that vehicle drivers and escorts may have special instructions about what to do in the event of an accident If so, help them carry them out THEIR instructions will over-ride THESE instructions in the event of conflict

10 Do not try to do too much prior to the arrival of expert help or advice

11 Do not relax supervision until the experts have given clearance

6. Marine Pollution

Pollution of the sea or other navigable waters, whether by oil or some other noxious substance, can, and increasingly often does, have severe economic and environmental impact. It is however rare that the pollution itself, as opposed to the causative agent, produces a disaster with immediate effects upon large numbers of human beings. It may well be that the collision between ships, fire, explosion or shipwreck which leads to the pollution will also cause casualties and create emergency needs for the survivors. This in itself demonstrates the advisability of there being, at the least, an organizational linkage between the normal national emergency services and the specialized technical services which will be needed to deal with the pollution problem *per se* Moreover, oil spills, and especially those of crude oil, spread very rapidly over the surface of the water.[123] The containment/clean-up operation should therefore be started as rapidly as practicable, and preferably within minutes of the incident's being reported This need for speed leaves no time for discussion of the best organization to be established.

It is particularly at the international level that there occurs a fundamental difference in principle between the treatment of oil pollution emergencies and those which have other causes. In the case of oil pollution, international assistance, if it becomes necessary and if all that is necessary cannot be provided under any existing regional agreement, will be of a specialized kind and will be co-ordinated (at the request of governments) by the International Maritime Organization of the United Nations (IMO). Only if the direct or indirect effects upon human beings assume the character of a disaster beyond the capability of the national government(s) will UNDRO become involved—and again, only then at the request of that government or those governments The justification for including this section in this volume lies in the need for emergency planners generally to recognize the existence of the organizational linkage mentioned, and to have, if they are responsible for areas in which there is a threat to the coast line environment, some idea of the technical aspects of the operation. The text which follows owes much to the IMO's "Manual on Oil Pollution".[124]

ASSESSMENT OF THE THREAT

Given that a government has decided that the nature of the threat to the marine and coastline environment justifies the establishment of an emergency organization equipped to deal with pollution, then the planning authority must establish:

(*a*) The sites at which oil or noxious substances are handled in sufficient quantity to present a significant pollution risk (e g tank farms, pipeline terminals, refineries and chemical complexes),

(*b*) The quantities and frequency with which these materials are handled within the different ports and facilities.

(*c*) The volume of shipping, particularly tankers, into the country's ports and along its coasts;

(*d*) Areas and activities of particular sensitivity to the ecology such as fisheries, wildlife, waterfowl and other beneficial uses of marine resources: and

(*e*) The oceanographic, meteorological and geographic characteristics of the area in order to forecast the effects of environmental factors, such as current and wind, upon a spill

CO-ORDINATION OF RESPONSE

The justification for organizational linkage between the emergency services and those particularly responsible and equipped for dealing with pollution has already been noted. Where there are widespread

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[123] An accepted formula for the spreading of oil in a circular field shows that 1 m^3 of Middle East crude oil would, ten minutes after being spilled cover a circle of 48m diameter with a thickness of 0 5mm, spreading after 100 minutes to 110m diameter with a thickness of 100um (P C Blokker 'Spreading and evaporation of petroleum products on water', Antwerp, 1964)

[124] This is published in four sections I—Prevention (revised edition 1983), II—Contingency planning (1978), III—Salvage (1983), and IV—Practical information on means of dealing with oil spillages (revised edition 1980) All may be obtained from the IMO, 4 Albert Embankment, London SE1 7SR, England

effects on human beings, it will be normal to deal with these first, but certain services, like search and rescue for example, may be involved with pollution aspects as well. Ideally, therefore, there should be one authority responsible for overall control. Where this is not practicable, liaison between the various services will have to be carried on in a jointly-staffed emergency operations centre.

Assistance can be expected also from the industry involved. Where the pollution is being or can be contained in a limited area, a government's role may be confined to ensuring that the industry's own emergency plans are adequate Where however the damage is more general, the use of the industry's resources will have to be integrated with the emergency services' own operation.

An effective, interlocking organizational scheme will ensure not only the best use of all available resources, the means of obtaining external help should it be necessary, and a clearly understood command structure, but also that the organization itself will be sufficiently flexible to be used in all situations from a small local incident to a major international event.

GOVERNMENT AUTHORITY FOR INTERVENTION

Consideration should be given to the powers, expertise and equipment necessary to enable a government to intervene in an incident which threatens imminent and serious harm to the country's interests—for instance, by hazard to life, loss of amenity, or harm to fisheries or wildlife. Attention is drawn to the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, and to the Protocol Relating to Intervention on the High Seas in Cases of Marine Pollution by Substances other than Oil, 1973.

BASIC PLANNING CRITERIA

The government must decide upon the organization to be adopted and the functional responsibilities of the agencies operating within that organization Following from those decisions, the government should ensure that:

(*a*) Account is taken both in planning and in operations of the relative sensitivity of different areas of water or stretches of coastline, and that provision is made for determining relative priorities if more than one area should require attention at the same time;

(*b*) Appropriate arrangements exist for consultation by all anti-pollution agencies with organizations representing fisheries and wildlife interests, during both planning and operations,

(*c*) There are adequate lines of communication with shipowners, insurance interests, oil and chemical companies, manufacturers of clean-up equipment, mechanical recovery devices and other materials to ensure that their resources can be made immediately available,

(*d*) Suitable arrangements are concluded with masters of ships and captains of aircraft for any oil or chemical spills caused or sighted to be reported to a specified agency which in turn will be responsible for passing the report to those who must assess it and take any necessary action;[1-5]

[1-5] IMO resolution A 447(XI) on Interim Guidelines for Reporting Incidents involving Harmful Substances applies to pollution incidents (or threat of incident) caused by any ship within 200 miles of the nearest land and all loaded tankers, loaded chemical tankers and any other ship of 10,000 gross tons and above, wherever they may be The report should be transmitted by the Master of the ship without delay, in the following manner

(*a*) To the nearest appropriate coast radio station preceded by the safety signal (if the incident affects the safety of navigation) or by the urgency signal (if it affects the safety of ship or persons),

(*b*) In a standard format on appropriate frequencies, in the bands 405-525kHz, 1605-2850 kHz or 156-174 MHz.

(*c*) On the most appropriate HF coast radio station or relevant maritime satellite communication system, if the ship is not within reach of an MF or VHF coast radio station.

(*d*) When the ship is within or near an area where a ship movement reporting system has been established to the designated shore station of that system

Reports on incidents should contain the information set out in Article IV of Protocol I to the 1973 MARPOL Convention

In order that as many countries as possible may benefit from the lessons learned by coastal and flag States in dealing with spillages of 100 tons or more a report on the results of the investigation into the incident in the form recommended by IMO (document MEPC VII 19, Annex III) should be forwarded to IMO by the Administration(s) concerned

(*e*) Arrangements for providing information to political authorities and to the media are adequate, and do not interfere with operations;[126]

(*f*) Arrangements exist for training in the relevant techniques for combating pollution, and that personnel concerned can take advantage of these facilities;

(*g*) The plans are exercised from time to time (at short notice) to discover any weaknesses, or need for change or updating, so as to ensure an adequate state of preparedness in participating agencies,

(*h*) There are adequate means of contacting everyone likely to be involved in dealing with an incident—whether with the pollution aspect or any other—at whatever time it might occur;

(*i*) All operations and exercises are analysed so that lessons may be learned and disseminated to all concerned, and plans revised as necessary; and

(*j*) Adequate provision is made for training and operating costs, as well as for post-operation recovery of expenditure from any organization held responsible for the pollution. Recovery may be effected under the International Convention on Civil Liability for Oil Pollution Damage, 1969, and the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971, and/or the voluntary TOVALOP and CRISTAL schemes [127]

COMMAND STRUCTURE

Whether operations are to be (or, according to the scale of the pollution, need to be) directed at national, regional or local level the command structure must be clear to all concerned. There may be no requirement for a separate organization; even if there is, it may be neither practicable nor realistic to designate full-time personnel for it. Where pollution of the coastline is the problem, units from local authorities or the military may be quite capable of doing what is necessary, acting within the structure established.[128] For pollution at sea, however, an on-scene commander with appropriate qualifications is obviously necessary, and he must be supported by correspondingly qualified control staff on shore, capable of appreciating technical matters as well as of organizing the logistical aspects of the operation Figure 46 on page 145 shows the structure used in Canada.

RESOURCES

The methods employed to deal with a spill will naturally determine the kind and quantity of the resources needed, methods adopted will vary according to:

(*a*) The properties of the pollutant;[129]

(*b*) The location of the spill and any environmental considerations;

(*c*) The size of the spill, and

(*d*) Meteorological, hydrographic (and in some countries, ice) conditions.

When planning for material resources, it will be necessary to:

(*a*) Identify the types of equipment, materials and systems required, and select the most appropriate for the task,

(*b*) Choose between acquisition/ownership and borrowing or hire from others.[130]

[126] See also chapter II, section 7

[127] Tanker Owners' Voluntary Agreement concerning Liability for Oil Pollution Damage Contract Regarding Interim Supplement to Tanker Liability for Oil Pollution

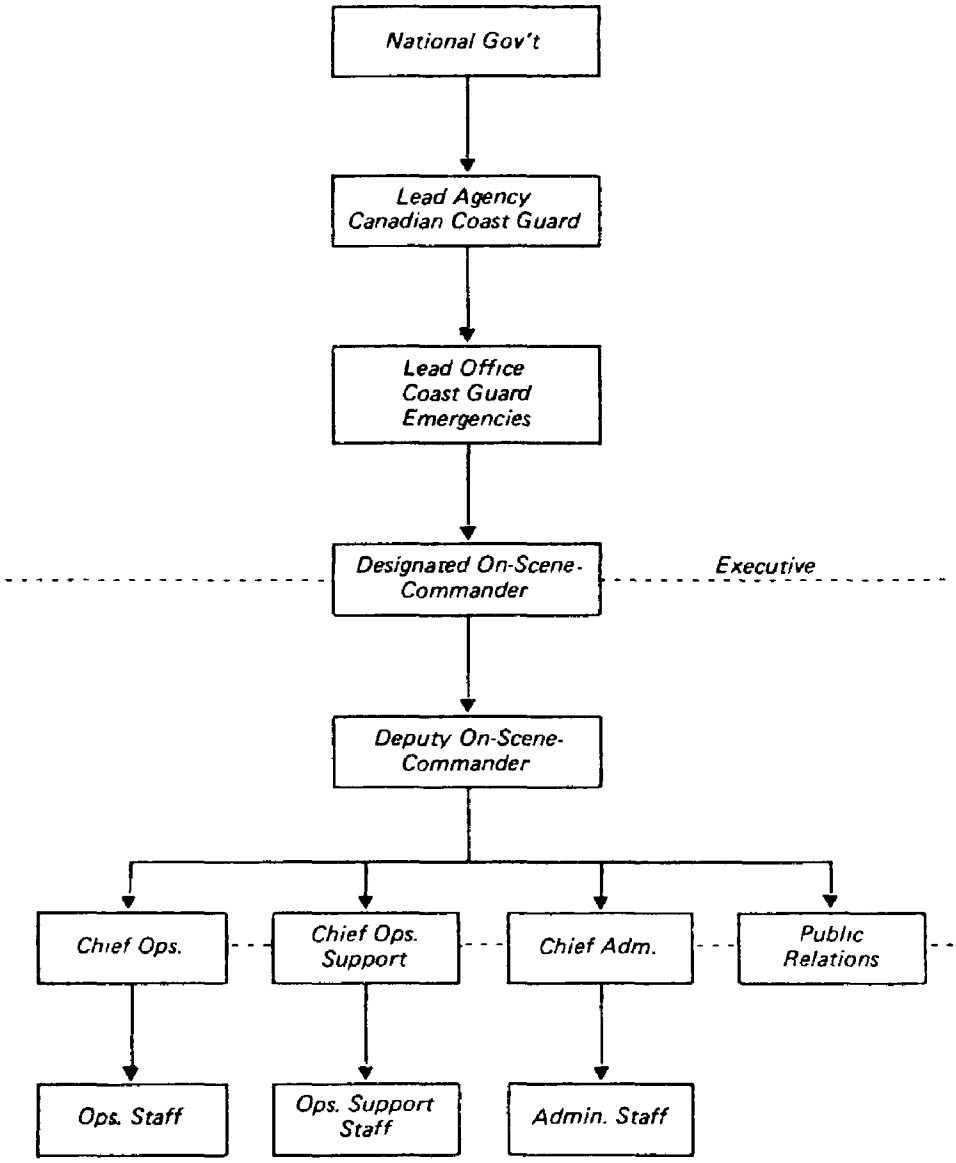
[128] Experience in Humberside, United Kingdom, after a major oil spill in September 1983 showed clearly the need for a single co-ordinating authority and a joint Emergency Operations Centre

[129] As remarked in chapter III, section 5, precise information about the characteristics of the polluting agent is essential if correct decisions are to be made about its handling

[130] A combination of these two methods may be practicable, e g arranging to borrow highly specialized equipment from industry to supplement the more general-purpose items owned by the Government or emergency authority

FIGURE 46

Canadian Organization Chart of the command structure for a major clean-up operation



(*c*) Arrange for storage, and maintenance in good working order;

(*d*) Provide back-up during an incident, and repair and replenishment afterwards, and

(*e*) Consider the use of general purpose equipment, such as highways department items for cleaning beaches of oil.

For personnel resources, planning should take account of the need for.

(*a*) Control staff,

(*b*) Communications operators,

(*c*) Ships' and boats' crews;

(*d*) Operators and maintenance staff for heavy equipment;

(*e*) General labourers, and possibly

(*f*) Specialist advisers and

(*g*) Aerial reconnaissance and spraying.

In all these groups, provision should be made for obtaining reliefs, in case the operation should be prolonged.

Adequate dedicated communications (ship/shore, and inter-organization) must be planned for, and equipment acquired beforehand.

The kinds of materials and equipment commonly used for dealing with coastline contamination vary according to the characteristics of the coastline itself, as shown in table 4. Although the first priority must always be to try, by means of containment and clean-up at sea, to prevent the oil's reaching the shore, this aim is not always possible to achieve—and naturally cannot be achieved if the spill itself occurs, for example, at a tanker terminal during discharging of cargo. (It is for this reason that a trained group should always be available, prepared to take immediate action should a spill occur in such circumstances. It may then be possible to limit, or even avert altogether, damage to the environment.)

When oil pollution is caused by a tanker accident, quick salvage may be the best way to minimize damage to the marine environment. The national contingency plan should contain information on where and how resources for this purpose may be obtained. This will especially concern vessels and equipment that might not be at hand at salvage companies, such as:

(*a*) Barges, lighters and coastal tankers;

(*b*) Air-deliverable emergency lightening pumps; and

(*c*) Whale fenders.

CLEAN-UP POLICY[131]

Before clean-up and restoration operations are initiated, there will have to be considered and evaluated a number of socio-economic, ecological and aesthetic factors.

Containment or protective booms may be used to reduce to a minimum the contamination of particularly sensitive stretches of coastline, especially bay areas. Booms may indeed be constructed from sorbent material which can be replaced periodically, but these, as well as sorbents spread along the shore, will vary in effectiveness according to the type of oil and the climatic conditions. In sheltered areas with light wave action the building of dykes or ditches along the water line may be a good approach to the problem

Oil may of course disperse naturally over a period of time, and this may be acceptable if the contaminated area is neither economically important nor especially biologically sensitive A decision not to initiate expensive operations might be justified, for example, in the case of rock or cliff coastlines; although sheltered pocket beaches (small bays) often found in such areas might need treatment.

The areas in which contamination has occurred, and the time in the tidal cycle at which it took place, are also matters which have to be taken into account Deposition at high tide reduces the possibility of rapid natural dispersion, especially if the coastline is gently shelving rather than steep. Some sands absorb oil under any conditions, and others only when they are dry The depth of penetration is conditioned by the viscosity of the oil and the nature of the substrate.

[131] Reference could usefully be made to "The Basics of Oil Spill Clean-up" by M F Fingas, W S Duval and G B Stevenson, published by the Environmental Emergency Branch of the Environmental Protection Service Environment Canada 1979, from which the gist of this section is taken

TABLE 4

Coastline restoration methods

Coastline Type	Chemical Dispersants*	Hydraulic High-Pressure	Hydraulic Low-Pressure	Steam Cleaning	Sandblasting	Mixing	Mechanical Removal	Manual Removal	Sorbents	Burning	Cropping
Rock Surfaces	+	+	R	+	+	o	o	R	+	o	+
Man-made Structures	+	R	R	R	R	o	o	R	+	o	o
Unresistant or Unconsolidated Cliffs	o	x	x	x	x	o	x	x	x	o	o
Coarse Sediment Beaches	+	+	+	x	x	+	+	R	+	x	o
Sand Beaches	+	x	x	x	x	+	R	R	R	x	o
Inter-tidal Coarse Sediments	+	+	+	+	x	+	+	R	+	x	o
Inter-tidal Mud	+	x	x	x	x	x	x	+	+	x	o
Inter-tidal Sand	+	x	x	x	x	x	+	+	+	x	o
Marshes	x	x	R	x	x	o	x	R	+	+	+

R = Recommended += Useful in some instances x=Not recommended o=Not applicable

*Chemical dispersants are used only in low-sensitivity environments and require approval of appropriate Government agencies.

In general terms, the degree of biological sensitivity of different types of coastline is:

Most sensitive..... Marshes and lagoons
Sheltered areas (pocket beaches)
Exposed beaches
Mud and sand flats
Least sensitive..... Exposed rocks or cliffs

Unfortunately the areas most sensitive to oil pollution are also those most sensitive to other kinds of damage from the methods of clean-up usually employed. Chemical dispersants should not be used without the specific approval of the authority concerned; high-pressure hydraulic dispersion tends to damage flora and fauna on rock surfaces; low-pressure hydraulic dispersion avoids that problem, but on sandy beaches actually promotes further penetration of the oil. Steam cleaning and sandblasting are normally restricted to use on man-made structures, such as harbour walls, or rock areas where no ecological harm would result.

Removal of oil and contaminated sand and other material, and/or the mixing of residual contamination after mechanical or other removal methods have been used, with substrate material, are labour-intensive methods, (supplemented, where the surface is suitable, by mechanical equipment) which are reasonably rapid and reasonably likely to do no, or only an insignificant amount of, ecological damage. Specialized types of mechanical equipment have been developed for these tasks. Where removal is the chosen method, large-scale transport arrangements will have to be made to convey the oil and contaminated material to places where it can be treated for re-use, destroyed, or otherwise disposed of.

For marsh, cutting of contaminated vegetation, or actual burning of the oil, may be resorted to, as well as the use of (preferably synthetic) sorbents to soak up the oil.

NOTICE TO SHIPPING

The government may deem it desirable to take steps, by means of informative radio broadcasts, by the stationing of guard ships, or some other effective method, to warn other vessels of a pollution incident, so as to avoid their hindering the operations, or running into danger themselves.

INTERNATIONAL PLANNING

Where two or more countries share a common interest in a particular sea area, it will be helpful, and possibly essential, to make mutually satisfactory preparatory arrangements to deal with pollution incidents. These arrangements may be informal, but well-understood, or they may take the form of a bilateral or regional agreement.

Whatever arrangements are decided upon, they should at the least contain information about, or be based upon:

(*a*) The resources which either (any) party may be able to provide;

(*b*) The identity of a point of contact in each government and the means of communication in case of need;

(*c*) The action to be taken on the occurrence of incidents and the sighting of spills, when these are likely to affect other parties, whether they are participants in the agreement or not; and

(*d*) Experiences in combating spills and in related research and development programmes.

It may be appropriate to draw up a joint plan with or without joint response to an incident. In this case, the plan should specify:

(*a*) The division of responsibility between parties. This may be based on geographical areas, methods of dealing with incidents, etc.;

(*b*) The harmonization of national plans and philosophies to facilitate any joint response;

(*c*) The means of activating the joint plan.

(*d*) Arrangements for the control of the operation This might fall to the party in whose zone of responsibility the incident occurs, or it may be that one party has especially good facilities for control;

(*e*) The control of national resources. The choice will be between.

(i) Each party retaining tactical control of its own resources under the overall co-ordination of the lead government, and

(ii) Parties placing the required resources at the tactical disposal of the lead government;

and the selection may be different depending upon whether the incident took place in international or territorial waters;

(*f*) Pre-arrangements for clearance by customs and immigration authorities for the entry, trans-shipment or transit of necessary clean-up equipment, material and personnel, and

(*g*) The means and channels of communication between national authorities, including arrangements for the co-ordination of releases to the news media and general public relations matters.

On the other hand, a simple mutual assistance arrangement may be favoured. Any party would be able to seek the loan of equipment and/or personnel from any other Even then, it should be clearly understood whether the resources would be placed absolutely at the disposal of the requesting government, or whether they would remain under the tactical control of the sending government.

Financing

Whatever kind of arrangements are entered into, there must be a clear understanding as to the financing of the operation and the recovery of expenditure thereafter Subject to local circumstances, in any joint operation each participating government should normally be responsible for financing its own share and equally for recovering that expenditure from the polluter

Liability

Participants in a formal agreement should consider the question of liability. In a joint operation in international waters, it might be wise for parties to renounce all claims against one another based on death or injury to personnel, or loss or damage to equipment, arising in connection with the assistance operation—except where such death, injury, loss or damage was caused by wilful misconduct or gross negligence In a joint operation in territorial waters, it might be expected that the Government having jurisdiction would bear all risks and claims arising in the course of the assistance operation and—again with the exception of wilful misconduct or gross negligence—hold the assisting Government and its personnel harmless in case of any claims or liabilities in connection with the assistance. Formal provisions for the settlement of disputes should also be considered in the agreement.

7. Forest and bush fires

The damage which major forest fires can cause has been remarked upon earlier in this volume, in connection with the making of arrangements for mutual international assistance [1] Economic losses in circumstances which obtain in the virtually uninhabited forested areas of parts of the United States and Canada are serious enough, and warrant the provision of fire-fighting resources as a measure of disaster preparedness Much greater justification exists for similar provisions in places where forested areas are inhabited more densely or where they border upon towns and cities—often on or near the coast—which to

[1] See chapter II section 2

some extent rely upon the presence of wooded areas as part of their attraction to tourists and holiday-makers, or of their raison d'être as centres in which important timber-utilizing industries are carried on.

There are of course a number of long-term measures which can be taken to reduce the risk of forest fires, or ensure that they can be dealt with more rapidly before they have time to spread. These measures include

(*a*) Careful selection of varieties of trees when reforestation is undertaken, so that the least vulnerable trees are planted.

(*b*) Routine and regular clearance of undergrowth and brushwood, particularly around habitations, and in the creation of fire-breaks, either through a forest or enclosing vulnerable and important installations of various kinds;

(*c*) Building of access roads, emergency reservoirs, etc., to facilitate the task of fire-fighting units;

(*d*) Surveillance by means of ground patrols, or from watch-towers or aircraft;

(*e*) The designation of areas in which camping or the lighting of fires by the public can be permitted, and

(*f*) Public education in the causes and dangers of forest fires.

Where the danger to human life is the first consideration, and economic consequences, although important, are secondary, the resources available for fire-fighting are likely to be of four kinds

(*a*) Professional—the fire brigades or departments of urban areas,

(*b*) Amateur—local manpower which may be mobilized as individual volunteers, or as a volunteer corps;

(*c*) Military—manpower which may or may not be trained specifically in fire-fighting but which nevertheless operates as a formed and disciplined corps; and

(*d*) Aeronautical—aircraft (usually military) equipped for water-bombing.

These resources will probably be supplemented and assisted by existing communications networks, including those of organizations like the police which, although not directly involved in the actual fighting of fires, will inevitably be required to take other action ranging from the control of traffic to the protection of abandoned property

PUBLIC WARNINGS

It will almost certainly be possible to gain some short-term advance warning of conditions likely to increase the likelihood of outbreaks of fire, through the local/regional/national meteorological service. The dissemination of knowledge of these conditions can be undertaken by television, radio, and (if conditions prevail over a period of time) by newspapers. These warnings can be reinforced by notices placed in prominent positions on roads and tracks giving access to, or passing through, the forest or bush areas at risk, as well as in permanent camping grounds and caravan parks. A typical notice of this kind is illustrated in figure 47 its effectiveness will remain only so long as the public know they can rely upon its being kept up-to-date Nothing can be more calculated to destroy the public's confidence than a notice indicating an extreme fire risk when it has been raining steadily for three days

Consciousness of the existence of the risk can be instilled by the permanent display of eye-catching posters or notices, like those shown in figures 48 and 49. A "character", such as Smokey Bear used in similar notices in the United States, with whom children can identify or feel sympathy is often very effective in displays of this kind. Moreover, this usage can help to remove the sense of authoritarianism from notices forbidding the lighting of fires (except possibly in designated places) and so increase the degree of public compliance

FIGURE 47

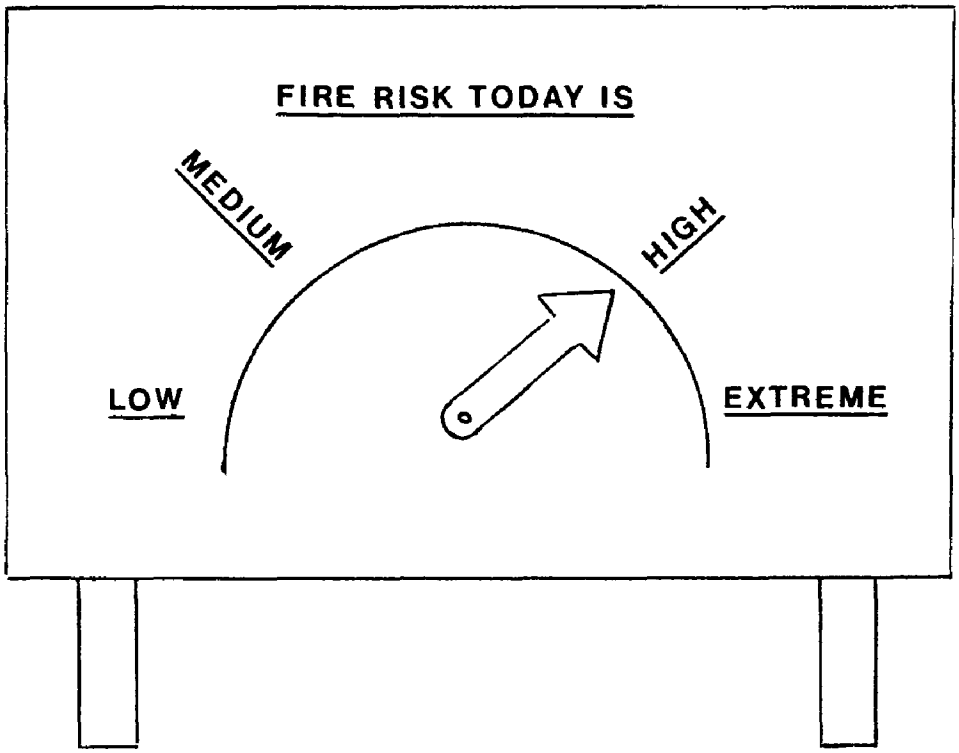
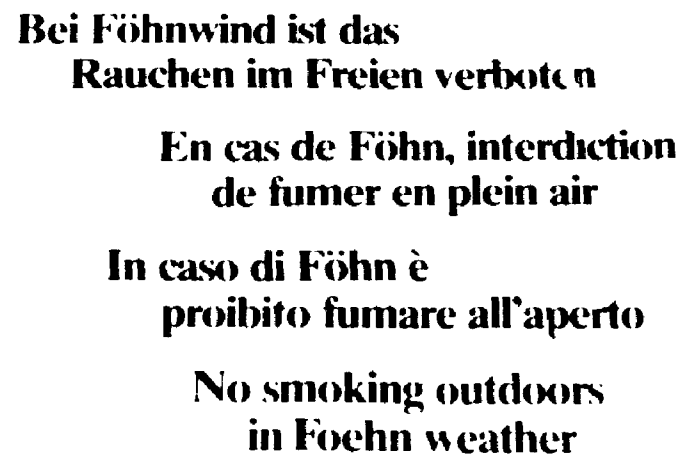


FIGURE 48

FIGURE 49



BASIC PLANNING CONSIDERATIONS

Investigation into the causes of previous fires is perhaps the most fundamental method of preparedness for, or even prevention of, possible future events. If it is known how fires started, attention can be given to removing or nullifying that cause; if it is known where fires started, it may be possible to control access to those places; if it is known when fires started, attention can be given to periods of particular danger. Knowledge of when and where may well lead to knowledge of how, if the cause is not immediately apparent from other evidence.

Given the diverse kinds of human resources available, a pre-season co-ordination meeting between the fire services, the meteorological service, the police, the local authorities in the area at risk, and the military (who may not necessarily be locally based) is advisable to review, probably in the light of past experience, arrangements for mobilization of assistance, and to ensure that all possible resources are in fact known and their state of readiness assured. Meetings of this kind would normally be called by the authority responsible for emergency planning in the area, for forest fire-fighting is by no means the sole responsibility of the fire services alone.

Co-ordination of resources implies also preparation for co-ordination of operations through whatever chain of command is usual in the country concerned. An important factor—especially important when the use of water-bombing aircraft is a possibility—is the use by all concerned of maps of the same scale, marked with the same grid, so that any risk of confusion of location will be practically eliminated. "All concerned" here means adjacent local authorities throughout the area or region, as well as the fire, police, military and aeronautical services. These maps can be kept permanently marked with the locations of static resources, airstrips which can be used by reconnaissance as well as by water-bombing aircraft, stretches of water suitable for in-flight replenishment by those aircraft,[133] camping sites from which people may have to be evacuated, etc.

It may be possible to arrange for specialized training in forest fire-fighting for some officials who are likely to be called upon to take operational command of fire-fighting units. In some countries, such as France, courses for this purpose are held at training establishments.

[133] For Canadair CL-215 aircraft, French practice requires a length between two 15 metre obstacles of 3,850 metres, and that the clear area of water should have a length of 1,900 metres, a width of 100 metres and a minimum depth of 2 metres.

DEVELOPMENT OF AN OPERATION ORDER[134]

The pre-season co-ordination and planning meeting, to which reference has been made, will do well to aim at achieving written agreement on:

A. *Mobilization*

(*a*) Methods of calling out the various resources which are available

(i) Under immediate control;

(ii) From national government authorities; and

(*b*) The means to be adopted to ensure their appropriate logistic support, including the particular needs of the types of aircraft likely to be employed in an operation; and

(*c*) Whether reimbursement of any kind will have to be made for their services.

B. *Communications*

Allocation of frequencies to be used by military, police, fire services, *et al*, as well as by the emergency operations centre itself.

C. *Command*

Elaboration of a command structure consonant with national practice and, so far as practicable, with that adopted for other kinds or emergency.

D. *Meteorological information*

Means of obtaining, and use of, long- and short-term weather predictions and forecasts, including specialized information concerning the operation of water-bombing aircraft, in particular, where these can be expected to be operating near the coast, information regarding the sea-state, and wind speed and direction, since these are important when in-flight replenishment will be undertaken

E. *Use of Military Assistance*

Establishment of priorities for the mobilization of military (ground-based) assistance Planning in France envisages the possible use of three kinds of units.

(*a*) A unit whose sole purpose is that of providing skilled and fully-trained help to the civil protection authorities, and which operates at the disposition of the Ministry of the Interior;

(*b*) Units whose personnel have basic training in forest fire-fighting, and whose staffs know about problems of command and liaison during such operations, and

(*c*) Ordinary Army units, some equipped with heavy machinery like bulldozers (for creating fire-breaks, access tracks, etc.) These units must be assisted by trained advisers from the professional fire services, allocated to them for the duration of the operation

INITIATION OF OPERATIONAL PLAN

Routine (twice daily) analysis of the meteorological conditions and forecast will provide the basis for deciding whether to initiate one or more stages of the operational plan Forecasts can be classified as follows:

[134] Based on circulars issued by the Direction de la Securité Civile, Ministère de l'Intérieur, Paris

(*a*) Immediate (e.g. in the morning, for the remainder of the day);

(*b*) Very short-term (in the evening, for the following day);

(*c*) Short-term (for the next 2 to 3 days);

(*d*) Medium-term (for the next 3 to 8 days);

(*e*) Long-term (for the next 8 to 15 days);

and their reliability will of course decrease as the forecast period lengthens.

Total reliance cannot however be placed upon these forecasts as the sole basis for decision-making. The weather situation may be too complex, and other considerations may for one reason or another carry greater weight. Normally, the meteorological services should be able to provide daily forecasts of wind direction and speed, temperature and hours of sunshine (or degree of overcast). A model for risk assessment based on meteorological data is shown in figure 50.

FIGURE 50

Model for assessment of forest fire risk using meteorological data

Wind / Vapour Pressure	0 - 20 km/h	20 - 40 km/h	>40 km/h
>100 mm	Low	Low	Low
> 50 mm <100 mm	Low	Medium	Medium
> 30 mm < 50 mm	Medium	High	Extreme
< 30 mm	High	Extreme	Extreme

Source: Ministere de l Interieur Paris annexes to circular MIN INT/CAB 80-227 of 12 June 1980

The plan would normally call for the first alert to be sent to those in charge of the various services which it would be necessary to mobilize, taking account of the need for each service to have a permanent point of contact available at any time, day, night, weekend or public holiday, and its own means of mustering a sufficient presence at such times.

Increased surveillance of forested areas would be called for in proportion to the degree of risk, in order to enable very early location of outbreaks of fire, and thus increase the chances of their being contained.

More ground patrols, both mobile and stationary (watch-towers), would be supplemented by aerial reconnaissance, both civil and military. It may be desirable to lay down in advance the routes which mobile ground patrols should follow.

Small teams of trained fire-fighters equipped to take immediate action should if practicable be stationed at points no further than 10-15 minutes' travel[135] from any point in the areas assigned to them to protect. These teams should not represent more than 40 per cent of the trained manpower available: the remainder should be held in reserve to act if the situation becomes more serious, and pending the arrival of further reinforcements, together with their logistical support, from the sources already described.

Provisions for evacuation of certain sites and locations may have to be implemented. This may require the use of public warning systems whose significance should have been communicated to the public as part of the educational programme mentioned earlier in this section.[136] Emergency shelter may be difficult to find for evacuees if the fire has occurred near a popular holiday area. Hotels may well be full already, and unless those evacuated have relatives or friends able to take them in, it may be necessary to plan for the use of public buildings, military facilities, and/or tented accommodation.[137]

It would be usual for notice of the initiation of the plan to be given to the next higher regional or national authority, as well as to any authority external to the chain of command who may be required to send assistance, at the same time as alerts are sent to operational commanders. This would enable contingency action to be started at the higher level in order to accelerate the arrival of reinforcements should they be required.

LEGAL SANCTIONS

It is not unknown for property owners in an area where there is normally a high risk of forest or bush fire to commit the offence of arson, either to start a fire or to spread one which has already begun, in order to claim insurance for their destroyed or damaged property. The temptation to do so may be the greater if there has been a long period of drought which has reduced farm incomes and perhaps created a state of bankruptcy, or the imminent danger thereof. Generally it is not difficult to detect signs of deliberate fire-raising of this kind, but professional fire-fighters should be warned to look out for such signs and insurance companies alerted to make thorough investigations before paying claims in suspected cases. Criminal prosecutions may also have to be brought if the evidence of arson is sufficiently definite to stand scrutiny in a court of law. Here, conviction would usually rule out any possibility of a successful insurance claim's being made.

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[135] The actual distance will vary according to the type of terrain to be crossed.

[136] See also chapter II, section 7

[137] For a fuller discussion of the problems of planning for evacuation, see chapter II, section 10.