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# An Assessment of Environmental Emergencies Arising from Activities in Antarctica

## **BACKGROUND**

1. Resolution 6 of ACTM XXII requested that COMNAP undertake an assessment of the risks of environmental emergencies arising from activities in Antarctica, including but not limited to an analysis of incidents which have occurred over the past ten years within the Antarctic Treaty area, and the types of future incidents that could occur in connection with operations at stations and bases. The Resolution also requested that the assessment concentrate on facts, data and evaluations, with regard to circumstances leading to and types of environmental damage, the financial magnitude of potential damages and the probable costs of response actions and remedial measures under the circumstances of Antarctica. This working paper summarises the data collected from national operators in response to the attached questionnaire.

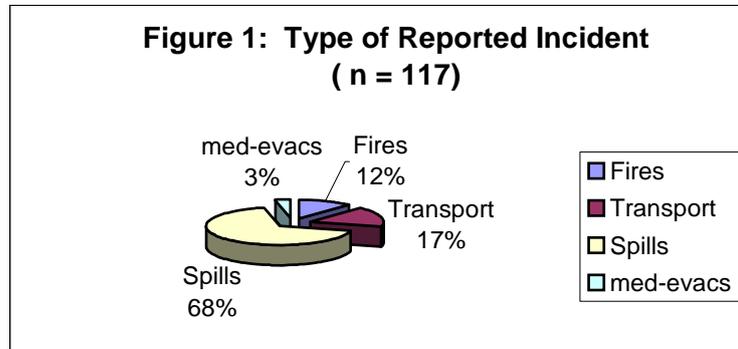
## **SURVEY RESULTS**

2. Seventeen out of the 29 COMNAP members responded to the survey. Of the 17 respondents, 6 countries reported no incidents. The remainder reported 117 incidents over the past ten years (1988-1998) which had the potential to result in adverse environmental effects or require an emergency response. There was some variation in reporting by the various countries. For example, one program reported medical emergencies requiring evacuations as a reportable incident, while other programs did not consider such incidents reportable. Because these reported medical evacuations did not result in any environmental impact, and the remaining programs did not report their medical evacuations, no further discussion of these type of incidents are included in the report.

3. Some programs reported all fuel spills, regardless of volume, while other programs reported only those spills in excess of 200 liters (COMNAP Guidelines for the Reporting of Oil Spill Incidents generally require national Antarctic operators to report fuel spills in excess of 200 liters). Some national programs included fires in their incident reports while others did not. Even with these minor reporting discrepancies, we believe that it provides a useful overview of the incidents that have occurred in the course of operating national programs over the last ten years and can be considered representative of the experience of all national programs.

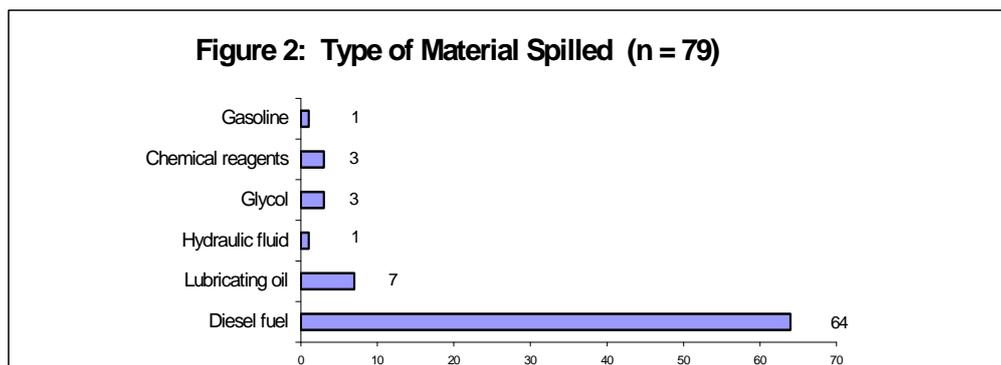
4. The reported incidents can be divided into three major categories (excluding medical emergencies referred to above) as noted in Figure 1:

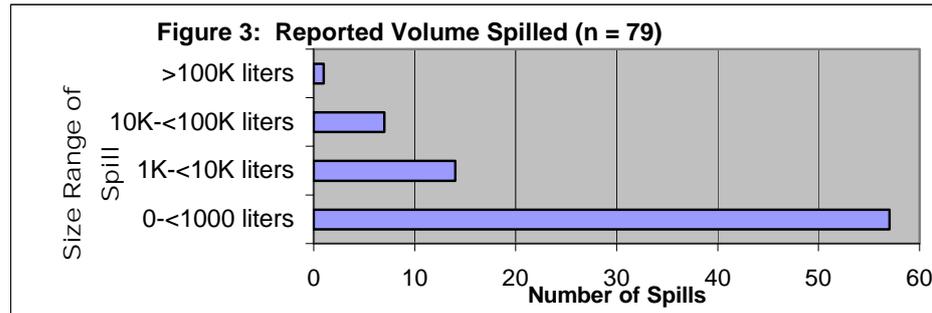
- Liquid Spills (Primarily Petroleum Products)
- Transport accidents involving aircraft, motor vehicles, and vessels
- Fires



5. In 114 out of the 117 incidents reported there were no injuries to Antarctica fauna or flora. Only one incident, a marine fuel spill in 1989, resulted in documented adverse impact on wildlife. Two other marine fuel spills involving smaller volumes than the 1989 incident resulted in no observed injuries to wildlife.

6. The most common type of incident involves liquid spills, which comprise 79 out of the 117 incidents (see Figure 2). Seventy-three of the 79 liquid spills were petroleum products; three involved spills of chemical reagents and three were glycol (antifreeze agent) spills. Of these 79 spills, 57 were volumes of less than 1,000 liters (18 of which were less than 200 liters), 14 involved volumes between 1,000 and 10,000 liters, seven between 10,000 and 100,000 liters, and one spill in excess of 100,000 liters. Fifty-nine of these spills occurred on land, 12 on ice sheets, five on sea ice and three directly into the marine environment (see Figure 3 over-page).





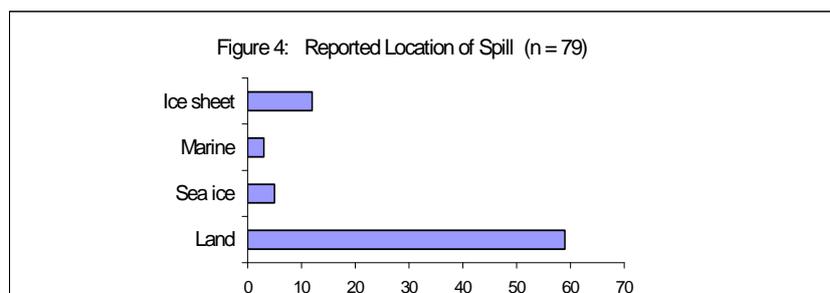
7. The second most frequent type of incident were transportation-related accidents (20 cases), nine of which involved aircraft, one involved a small boat, and the remaining ten involved ground vehicles. In half of the cases it was possible to remove the damaged vehicle/aircraft from the site of the accident. In the remaining half, the vehicles/aircraft were irretrievable.

8. The third most frequent type of incident is fire. Fourteen fire incidents were reported - all but one occurred at permanent stations. Several of the fire incidents were accidental releases of fire extinguishing agents (predominantly halon) with no actual fire. In most cases, fire-damaged equipment or buildings were removed.

9. While some data was provided by national operators on the cost of response action, it was not possible to segregate the costs of damage to facilities or equipment, response action and remediation or to provide accurate estimates. Nevertheless, the estimated cost of response and remediation for each incident was generally reported to be under US\$30,000 (with the exception of the *Bahai Parraiso* incident where the total cost was substantial but not quantified).

## ANALYSIS

10. Approximately 75% of reported spill incidents occurred on land (ice-free areas) as noted in Figure 4 (over-page). Programs reported that they were generally able to take timely response actions to these spills, resulting in effective steps to minimize the migration of the spill and clean up the contaminated area. Research studies in the Arctic and Antarctic have demonstrated that diesel fuels will penetrate the upper soil layer, but will not penetrate down through ice-rich permafrost which can act as an effective barrier to fuel movement. If the spill reaches the interface between the soil layer and the permafrost, it may begin to migrate laterally or down-gradient.<sup>1,2</sup> In many cases, programs were able to recover the contaminated surface layers of soil and backfill the hole with clean soil. In some cases, it was not feasible to excavate remaining contaminated soil without more extensive excavation in the permafrost, which could have resulted in a greater environmental impact



<sup>1</sup> Tumeo, M.A., 1996, Transport of Hydrocarbon Contaminants in Ice and Ice/Soil Systems, Final Project Report # OPP9119559.

than allowing the contaminant to remain in situ. Wildlife was not present at these sites. For these reasons, none of these terrestrial spills resulted in injury to wildlife or any anticipated adverse impact over time.

11. Approximately fifteen percent of the reported spills occurred on the ice sheet. Spills typically percolate rapidly through the compacted snow surface (firn), migrate laterally along ice layers, and may accumulate above the impermeable ice (30 to 120 meters below the surface depending on the location). On ice shelves, studies have shown that such spills percolate almost straight down with little lateral dispersion until the spill reaches the ice firm layer or the water layer below. If the ice sheet is grounded, the spill may move laterally.<sup>3</sup> It is not technically feasible to recover such fuel without major excavations that could cause greater environmental impact than allowing it to remain in place. Since there is no wildlife or flora present in those areas, and because the volume of spills in most cases is relatively small, the spills remain localized and are not considered to pose a significant risk to the environment.

12. Spills onto sea ice comprise approximately six percent of the total number of reported spill incidents. In some cases it has been possible to absorb spilled fuel from the sea ice surface using absorbent materials before it migrates into the water column. Once the spilled material reaches the water, it is very difficult to recover because it rapidly disperses or evaporates. If the spill reaches the water, the potential environmental impacts will vary depending on the quantities spilled, the movement of the spill under the ice, and the presence of wildlife in the affected area.

13. Three marine spills have been reported over the past ten years (4% of reported spills), suggesting that marine fuel spills occur infrequently. Marine spills that occur in the proximity of breeding grounds, rookeries, or significant habitats for a particular species, pose a greater risk to the environment than marine spills that occur at a distance from these more sensitive sites.

14. The largest marine spill on record arose when the *Bahia Parraiso* ran aground off Anvers Island in the Antarctic Peninsula in 1989 when 600,000 litres of fuel began to leak from the hull. Immediately after the incident, Argentine and U.S. response teams recovered over 65,000 litres of fuel from the ship. Within the first week, much of the spilled fuel had dissipated by evaporation and dispersion, reducing the effectiveness of further clean-up efforts. Two years after the incident, Argentina and Netherlands carried out a joint fuel recovery effort to pump out the remaining 148,500 liters of fuel trapped within the tanks of the ship.

15. Shortly after the incident, an international interdisciplinary team of scientists began assessing the long-term impacts of the spill on the local marine ecosystem. According to those studies, the affected area consisted of islands that were breeding sites for species of seabirds and a principal habitat for seals. It took seven years of marine ecosystem studies to distinguish between the environmental impact arising from the spill and the natural variability in species population dynamics. Initially, the spill affected nearly all species in the immediate vicinity. Seven years after the spill, the majority of species had recovered to pre-spill levels while two species continue to demonstrate reduced viability - cormorants and kelp gulls.<sup>4</sup> The other two smaller marine spills reported in the survey resulted in no observed injuries to wildlife.

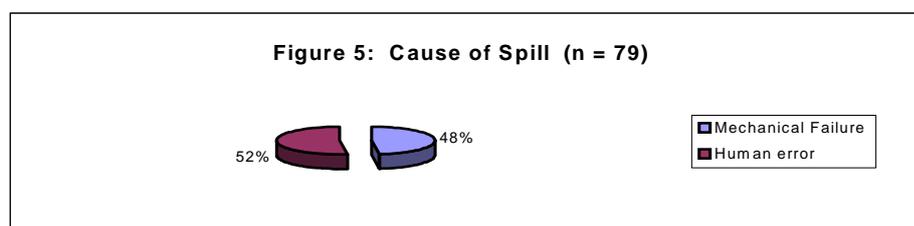
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<sup>2</sup> Zukowski, M.D., and M.A. Tumeo. 1991. Modeling Solute Transport in Ground Water at or Near Freezing. *Ground Water* 29(1):21-25.

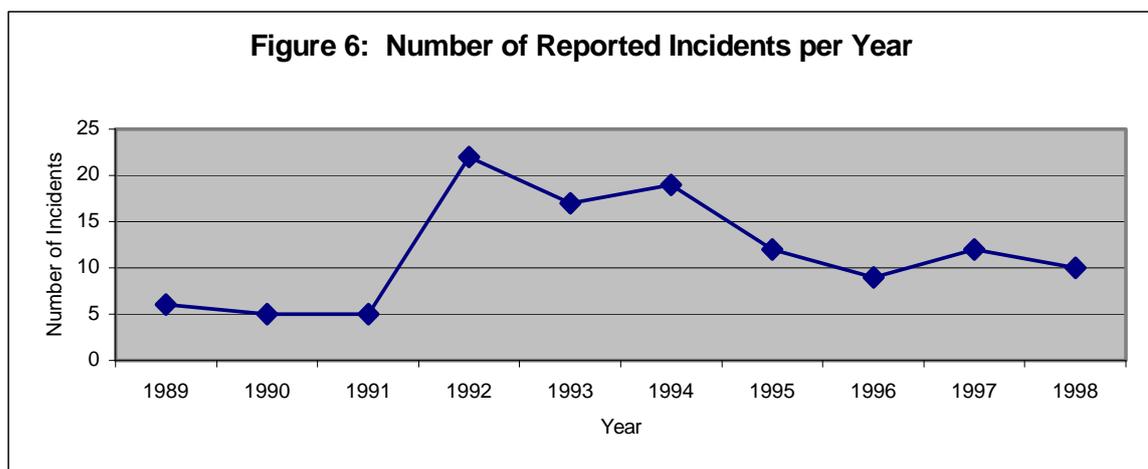
<sup>3</sup> Tumeo, M.A. and M.K. Larson. 1994. *Antarctic Journal of the U.S.* 29(5): 373-374.

<sup>4</sup> Penhale, P.A., Coosen, J., and Marschoff, E.R.. 1997, The Bahia Paraiso: a case study in environmental impact, remediation, and monitoring. In Battaglia, B., Valencia, J. & Walton, D.W.H. eds., *Antarctic communities: species, structure, and survival*. Cambridge: Cambridge University Press, 437-444; Fraser, W.R., and Patterson, D.L., 1997, Human disturbance and long-term changes at Adelie penguin populations: a natural experiment at Palmer Station, Antarctic Peninsula. In Battaglia, B., Valencia, J. & Walton, D.W.H. eds., *Antarctic communities: species, structure, and survival*. Cambridge: Cambridge University Press, 445-452).

16. In examining all of the spill reports included in this survey (Figure 5), approximately 52% were caused by human error (e.g. overfilling tanks, incorrect valve sequences) and 48% were due to mechanical failure (e.g. gasket leaks, fuel bladder leaks, hose failures). It is believed that implementation of the “COMNAP Recommended Procedures for Fuel Oil Transfer at Stations and Bases”, “COMNAP Recommendations for Spill Prevention” and the “Containment of Fuel Oil at Stations and Bases” would have either, prevented many of these spills from occurring, or reduced the size of the spill. The COMNAP Guidelines were developed in 1992 and gradually implemented across national programs in subsequent years. The gradual diminution in the number of reported incidents per year since 1992-1994 time period suggests that these recommendations are being implemented and are effective. (Figure 6). COMNAP recommended the reporting and tracking of spills in 1992; prior to that time many national programs had not implemented any such spill tracking system so that some spills occurring prior to 1992 may not be reported in the survey.



17. In the transport accidents reported, the only release to the environment was from the vehicle’s leaking fuel tanks or engines, typically involving small quantities of petroleum products. In addition, several aircraft and vehicles could not be recovered because they fell into a crevasse or sunk to the sea floor. No impacts on the local environment were noted in any of these incidents.



18. Potential environmental impacts from fires include atmospheric releases of smoke and fire extinguishing materials. Atmospheric releases during these fires were considered insignificant because they involve the combustion of structural materials (e.g. wood) or fuel. Ambient air quality monitoring at several Antarctic stations have indicated that local air quality in the vicinity of these stations is not impacted significantly by normal station operations. It is believed that the incremental increase from such fires to the normal air emission inventory is insignificant. No impacts on the local environment were noted in any of these incidents. Although fires may pose a significant human safety risk, the absence of trees or other combustible vegetation in Antarctica eliminates the possibility of a fire spreading beyond buildings in the immediate vicinity of the station.

## **ENVIRONMENTAL MONITORING OF IMPACTS**

19. COMNAP and SCAR are currently developing a Monitoring Handbook that will provide guidance to national program managers in selecting parameters and methodologies for monitoring impacts from operational activities, including accidental spills with adverse effects on the environment. The Handbook is being developed on the basis of the joint environmental monitoring workshops conducted by COMNAP/SCAR during the last few years. As each national operator develops such monitoring programs it will enhance COMNAP's ability to evaluate the environmental impacts resulting from incidents in the future.

## **CONCLUSIONS**

20. Based on the results of the survey it is concluded that:

- there are minimal adverse environmental impacts resulting from ground or air transport incidents or fires (These events appear to occur infrequently and when they do the magnitude of their impact on the environment is insignificant);
- the most common incidents with the potential to cause the greatest environment impacts are fuel spills;
- most fuel spills in Antarctica are likely to be small and confined to a station or base or the adjoining waters and are unlikely to threaten wildlife;
- fuel spills in the marine environment have a low probability of occurrence but pose a greater magnitude of risk to wildlife than terrestrial or ice sheet spills (Clearly, marine spills in the vicinity of rookeries, breeding grounds or primary habitats for marine mammals or birds pose a higher risk than marine spills in open sea or less sensitive areas); and
- because fuel spills have greatest potential to cause environmental impacts, spill prevention strategies are the most effective tool to minimize potential environmental impacts, followed by emergency preparedness and spill response.

## **RECOMMENDATIONS**

21. It is recommended that:

- Consultative Parties ensure that their national Antarctic agencies implement the COMNAP guidelines on fuel transfer, fuel spill prevention and containment, and emergency response action and contingency planning as required by ATCM XXII Resolution 6 (1998).
- national operators ensure that all fuel handling and storage equipment are maintained in good order and that spill response exercises are held on a regular basis. (These measures will significantly reduce the frequency and magnitude of liquid spills, and thereby minimize environmental impacts); and
- COMNAP continues collecting and collating data annually from all the national programs on incidents with potential adverse effects on the environment arising from national program activities so that COMNAP can periodically reassess the guidelines and revise as necessary, as recommended in Resolution 6 (1998). COMNAP suggests that the ATCM seek comparable information from non-governmental organizations operating in Antarctica so that a more comprehensive database may be assembled

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**ATTACHMENT**

**COMNAP SURVEY QUESTIONNAIRE**

TO: All COMNAP & SCALOP Members

**MNAP NOTICE 175: QUESTIONNAIRE ON ENVIRONMENTAL HAZARDS**

With reference to COMNAP decision in Concepcion (Item 10.3 of the Report), members are requested to report by 21 SEPTEMBER 1998 on environmental hazards that have occurred in Antarctic operations during the last ten years (1987/88 - 1997/98).

Please fill the questionnaire separately for each case, both for incidents that actually occurred and for "near-miss" situations. As indicated by ATCM Decision 3, the purpose is to assess the real risks, therefore, statistics on both occurred events as well as potential accidents should be provided.

The purpose of the analysis will be to report to ATCM on types, frequencies and magnitudes (both in environmental and economic terms) of the environmental risks from accidents in the conduct of national activities. Therefore, although detailed information on dates are requested, this information will only serve to be able to produce statistical summaries for the report. All information will be treated confidentially.

**PLEASE NOTE THAT THIS ANALYSIS HAS BEEN REQUESTED BY THE ATCM TO ASSIST IN DELIBERATIONS ASSOCIATED WITH THE PROPOSED LIABILITY ANNEX. YOUR INPUT IS THEREFORE OF CONSIDERABLE IMPORTANCE.**

In case you have uncertainties on reporting to the Working Group, please contact either Pentti Mälkki or Jack Sayers.

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**ACTION:** Please complete the following questionnaire for all incidents (actual and near-misses) that have occurred during the last 10 years during in conduct of national activities and return to Pentti Malki and Jack Sayers by 21 SEPTEMBER 1998. Use one form for each incident. (The questionnaire has also been attached as a Word document so that responses can be forwarded by fax or mail, if desired)

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**EVENTS/INCIDENTS LEADING TO ENVIRONMENTAL HAZARD**

***1. INFORMATION FOR IDENTIFICATION***

1.1 LOCATION: Latitude  
Longitude

1.2 DATE:

1.3 LOCATION DESCRIPTION (e.g. station, land, glacier ice, sea, etc.):

1.4 NATIONAL OPERATOR/OTHER:

**2. TYPE OF ACCIDENT:**

2.1 OIL SPILL: Type of oil:

Volume of spill:

Description of the Event (i.e. circumstances, weather, cause, details of the accident):

2.2 CHEMICAL SPILL Type of chemical:

Volume of spill:

Description of the Event (i.e. circumstances, weather, cause, details of the accident):

2.3 FIRE Environmental hazard caused:

Description of the Event (i.e. circumstances, weather, cause, details of the accident):

2.4 TRANSPORT ACCIDENT (Air/land transport/transport on glacier/sea transport):

Environmental damage/hazard:

Description of the Event (i.e. circumstances, weather, cause, details of the accident):

2.5 ANY OTHER INCIDENT NOT COVERED ABOVE

Environmental hazard caused:

Description of the Event (i.e. circumstances, weather, cause, details of the accident):

**3. RESPONSE ACTION TAKEN:**

**4. OTHER MEASURES TAKEN (including remediation,etc):**

**5. WAS THE ENVIRONMENT RESTORED TO ITS CONDITION PRIOR TO THE ACCIDENT:**

Yes/No (or other comments)

**6. ESTIMATED COST OF:**

Damage to property:

Response action (i.e. labour, materials,etc.):

Other measures;

**7. WERE THERE INJURIES OR DEATHS TO HUMAN BEINGS:**

Injured persons:

Deaths:

**8. WERE THERE INJURIES OR DEATHS TO WILDLIFE:**

Species and numbers:

**9. ANY OTHER COMMENTS**

(e.g. Potential accidents or incidents that may cause an environmental impact but have not been included in this questionnaire.)

NOTE: The dumping of waste materials (prior to the Madrid Protocol) has not been included as an environmental impact in this survey as such activities were not the results accidents.

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