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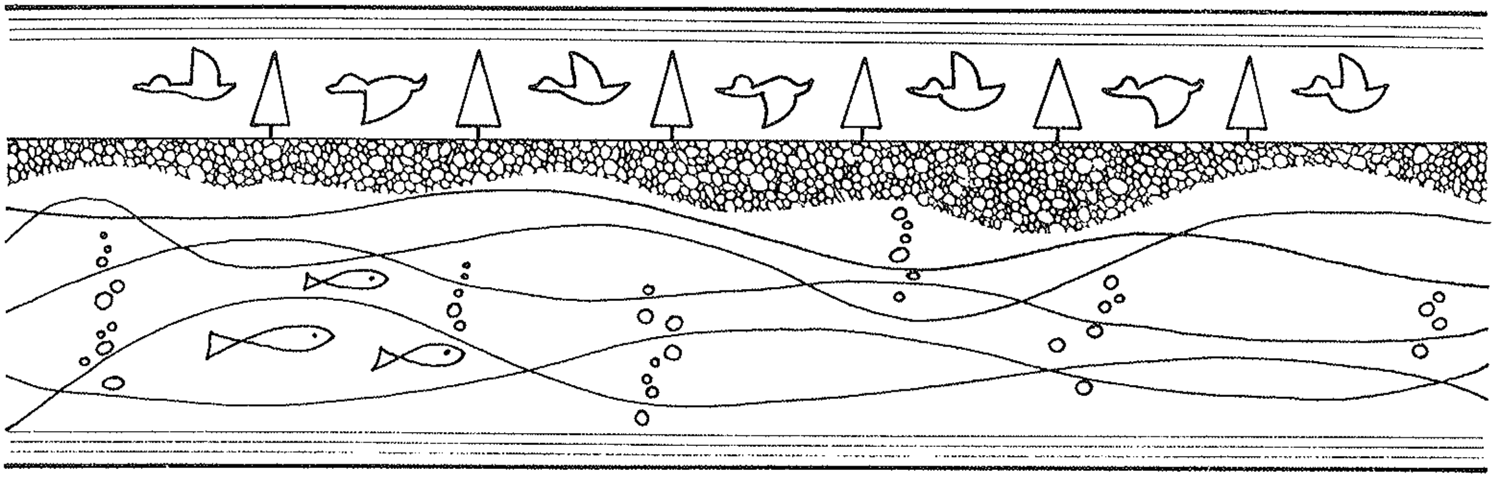

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The Spill Technology Newsletter was started with modest intentions in 1976 to provide a forum for the exchange of information on oil spill countermeasures and other related matters. We now have over 2,600 subscribers in over 40 countries.

To broaden the scope of this newsletter, and to provide more information on industry and foreign activities in the field of oil spill control and prevention, readers are encouraged to submit articles on their work and views in this area.

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INTRODUCTION

The first article of this issue is by Al Allen who proposes that Canola oil be used as a test medium for cold water spill trials. A series of tests were conducted using both Canola and Prudhoe Bay crude oils and the results indicate that the properties may be sufficiently similar to allow one to use Canola for spill testing. This is interesting because in using Canola oil, the environmental damage and opposition to testing would be much less than that for crude oils. The second article is by Rainer Leo and his associates and describes an approach to environmental sensitivity mapping.

CANOLA OIL AS A SUBSTITUTE FOR CRUDE OIL IN COLD WATER SPILL TESTS

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INTRODUCTION

The physical properties and behavioral characteristics of Canola oil (also known as rape seed oil) were assessed and compared with Prudhoe Bay crude oil under a variety of conditions in the cold chambers at the University of Alaska, Anchorage. Emphasis was placed on the feasibility of using this nontoxic vegetable oil for testing containment and recovery equipment in cold climates, focusing on its potential applications involving oleophilic/sorbent recovery systems with or without ice.

Several physical properties of Canola oil and Prudhoe Bay crude oil were determined at controlled temperatures. Specific gravities were measured over temperatures ranging from -23°C to 27°C using standard petroleum hydrometers and were found to vary in a linear fashion (Figure 1). The specific gravity of the Canola oil was approximately 4% higher than that of the crude oil over the indicated temperature range.

The viscosities of the oils were measured at temperatures from -18°C to 27°C. Figure 2 contains plots of the measured viscosities for Canola oil, Prudhoe Bay crude oil and Norman Wells crude oil. The Prudhoe Bay and Norman Wells crude oil viscosity data represented by dashed lines were obtained from Figure 3-18 of the ABSORB Oilspill Contingency Plan (1980). The Canola and Prudhoe Bay crude oil viscosity data shown as solid lines are those determined in this experiment. The pour point of the Canola oil was also examined and was estimated to be -26°C. That of the Prudhoe Bay crude oil, approximately 10% evaporated, is -25°C (ABSORB, 1980).

The interfacial tension between the Canola oil and distilled water at 25°C was found to be 11.1 dynes/cm, while the interfacial tension between Prudhoe Bay crude oil and distilled water was measured as 26.8 dynes/cm. In tests on evaporation rates, there was no measurable weight loss for the Canola oil during the test period. The results for the crude oil are shown in Figure 3.

The behaviour of Canola oil and crude oil in the presence of rope mop fibres, sorbent pads, and ice was examined. All tests were conducted with prepared seawater mixtures (approximately 35 parts per thousand), polypropylene fibres removed from a section of ABSORB's ARCAT* skimming system, small squares of nonwoven polypropylene microfibre, and ice prepared from the same seawater mixtures. The objectives were to assess the oleophilic properties of each of these media while noting the rates of oil uptake and release. A simple oil-and-water shake test was also conducted under warm and cold conditions, to compare the tendencies for Canola oil and crude oil to emulsify with seawater.

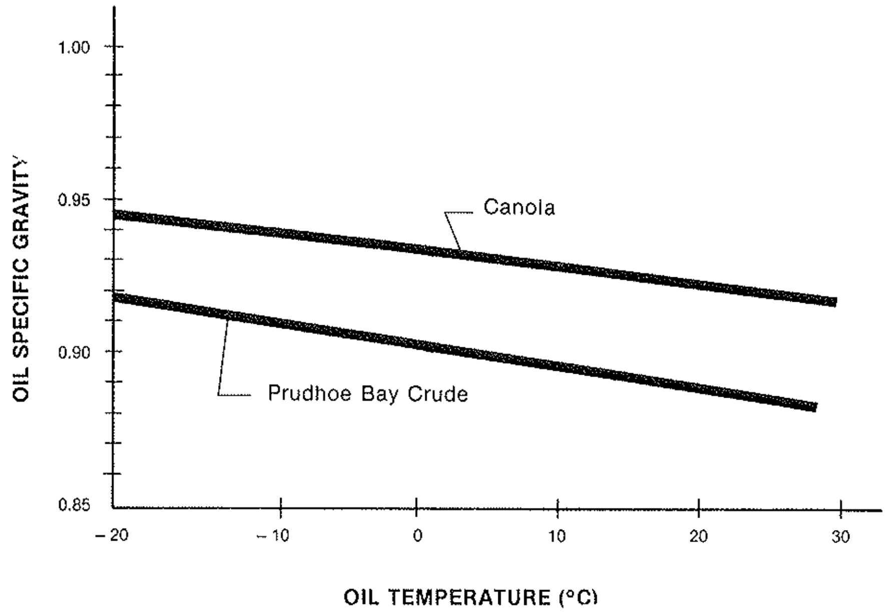

FIGURE 1 SPECIFIC GRAVITY OF CANOLA AND PRUDHOE BAY CRUDE OIL VERSUS TEMPERATURE

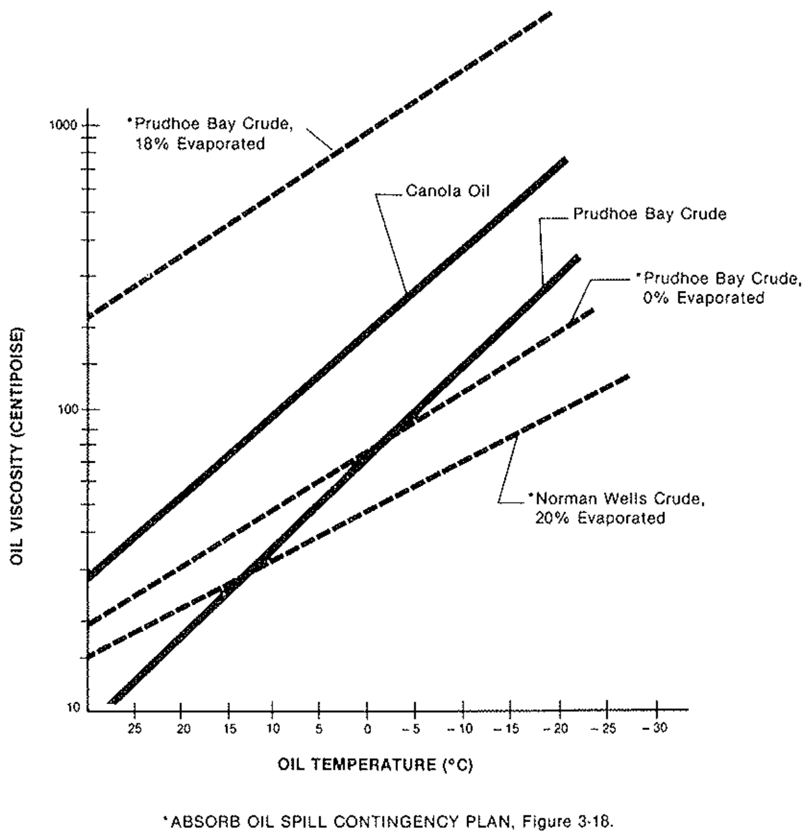

FIGURE 2 CANOLA VISCOSITY VERSUS CRUDE OIL VISCOSITY

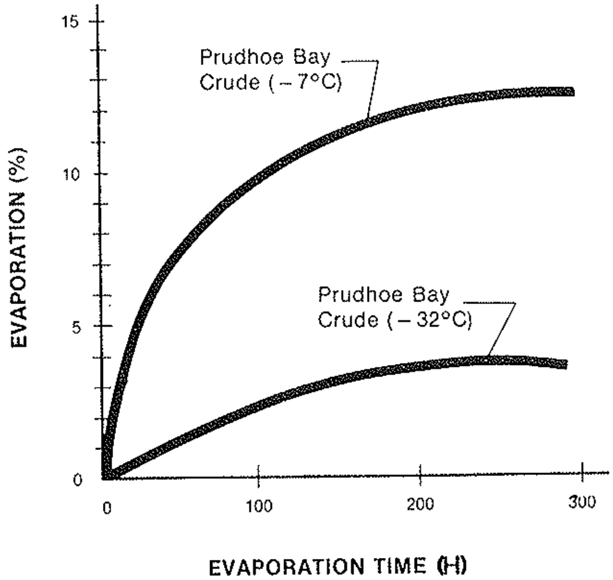

FIGURE 3 MEASURED EVAPORATION OF PRUDHOE BAY CRUDE OIL VERSUS TIME AND TEMPERATURE (Air Speed Variable at ≈2 m/s)

In tests to determine oil adhesion, the rope mop fibres were observed to reach an apparent saturation level within a few seconds. The volumes of oil plus water recovered for crude oil ranged from 1.5 to more than 8 g per dip. Figure 4 illustrates these comparative recovery rates for the two oils showing how the recovered volume in each case increased with decreasing water and air temperatures.

The recovered volume of Canola oil in warm air tests was twice that of crude oil, but only 40-50% greater in cold air tests. These latter tests are more representative of the actual operating conditions a rope mop skimmer might be subjected to during winter and breakup recovery operations on a cleared (ice-free) pool of oil and water. Should such a field test be conducted using Canola oil, these laboratory (cold-room) experiments suggest that the recovered volumes (for a saturated rope mop) would very likely be 40 to 50% greater than the actual volumes had fresh Prudhoe Bay crude oil been used.

The oil-to-water ratios for the recovered volumes was bound to vary between the two oils, as shown in the boxes of Figure 4. The rope mop fibres picked up between 19 and 23% water when used with Canola oil, while the water uptake with crude oil varied between 8 and 10%. Allowing for the lower water contents found in the crude oil test, these tests suggest that a field test with Canola oil and rope mop fibres would likely involve oil recovery rates that are 30 to 40% greater than the actual oil recovery rates had fresh Prudhoe Bay crude oil been used. These comparisons, of course, depend upon a sufficient thickness of oil being available to saturate the rope mop fibres.

Tests involving warm water/warm air and cold water/cold air were also undertaken to evaluate the comparative uptakes of Canola oil and crude oil in sorbent pads. The volumes of oil absorbed by the pads in each of the two tests are shown in Figure 5. The dashed lines are provided only to suggest a possible trend in the oil uptake data for the

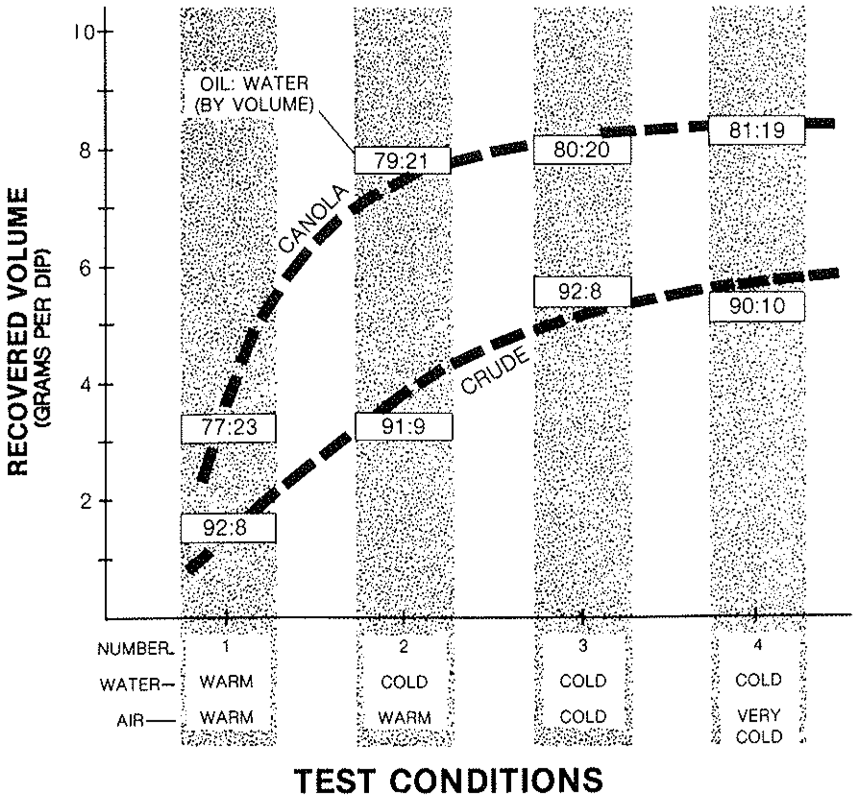

FIGURE 4 ROPE MOP RECOVERY WITH CANOLA AND CRUDE OIL

air/water test conditions being examined. During the 15 second exposure tests, only the warm crude oil in Condition 1 was found to penetrate and saturate each pad (requiring 3 seconds). Whether warm or cold, however, crude oil absorption per pad remained about 1 gram higher than with the Canola. The drop in recovered oil at the colder temperatures is consistent with the expected reductions in penetration with increased viscosities.

When the pads were permitted to saturate, however, the absorbed volumes were nearly the same for crude oil and Canola oil, the amounts increasing with the reduced temperatures. Once saturated at the colder temperatures (requiring about 2 minutes), there was a tendency for more oil to adhere to the outer surfaces of the sorbent.

Ice adhesion tests were conducted with air and water temperatures at or slightly below 0°C. During each test, the cubes of ice were exposed to the oil for 2 minutes. A wire screen was then used to lift the oiled ice above the surface, where it was allowed to drain for 1 minute. The thickness of the oil layer and the condition of the oiled ice were then noted, and a clean batch of ice was placed in the oil. In separate tests, cubes of sea ice were pushed down through the oiled surface, and the degree of oil adhesion to the ice was noted.

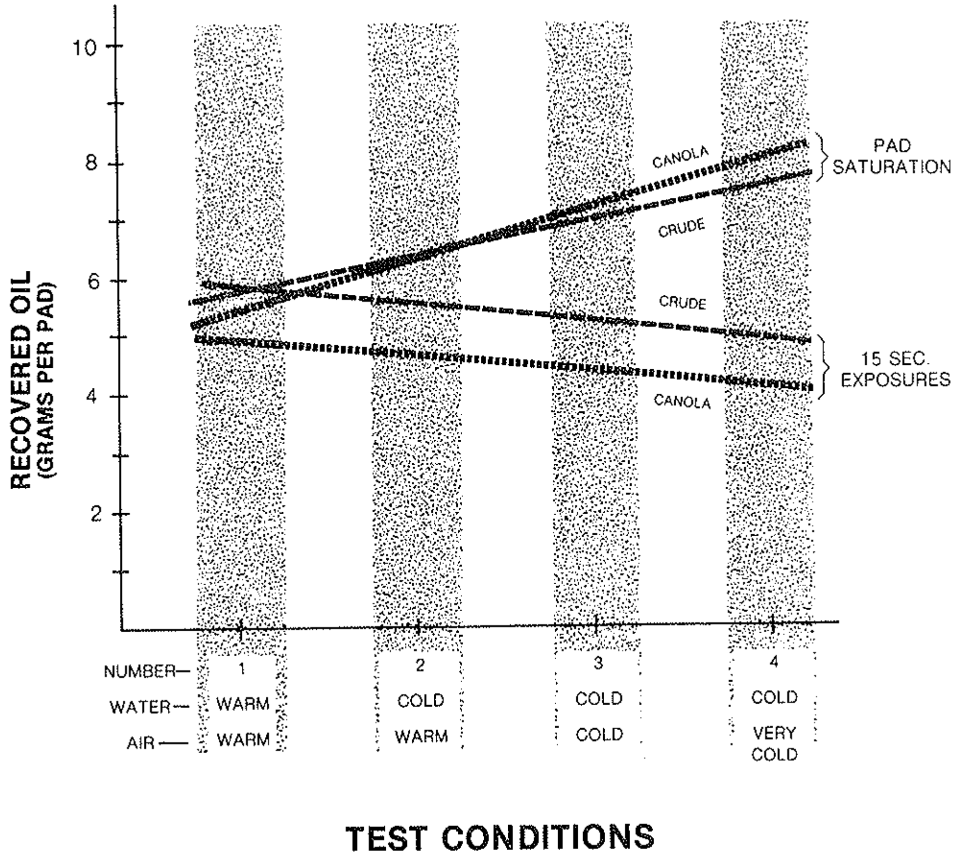

FIGURE 5 SORBENT PAD RECOVERY WITH CANOLA AND CRUDE OIL

Both the Canola oil and the crude oil had the same tendency to coat the sea ice as it was placed through the oil/water interface of each container. The oil would not stick to any portion of the ice surfaces that remained below the oil/water interface; however, the upper surfaces became coated with both oils and remained coated even after removal from the container. The volumes of oil removed during each ice lift were identical for both oils. Because of the reduced air temperatures, the oil in each case remained on the ice, with very minor release until disposed of the following day.

It was noted that neither the Canola nor the crude oil would stick to the sea ice when the ice was pushed completely beneath the oil/water interface. The Canola had a slightly greater tendency to stay on a horizontal underside; however, the slightest agitation of the ice would free it from any remaining oil. This lack of oil adherence to submerged sea ice even after surface coating is of significance in the development of improved oil recovery equipment for use in broken ice.

The comparison of tendencies for Canola and Prudhoe Bay oils to become emulsified by agitation was examined under warm (24°C) and cold (0°C) conditions. The shake test under warm conditions produced water-in-oil emulsions quite unlike those produced during the cold (0°C) test. The results of each test are illustrated in Figure 6. In the warm test with Canola oil, a small water-in-oil emulsion formed immediately after shaking. Canola oil and water gradually separated out of the mixture. In contrast to this stable emulsion, the warm crude oil took up seawater immediately after shaking (i.e., 95% of the content was water-in-oil emulsion), and about 1.5 hours were required for the clear-water volume to return to 40 mL. The nature and extent of water droplet entrainment within the oil could not be assessed visually because of the crude oil's opacity.

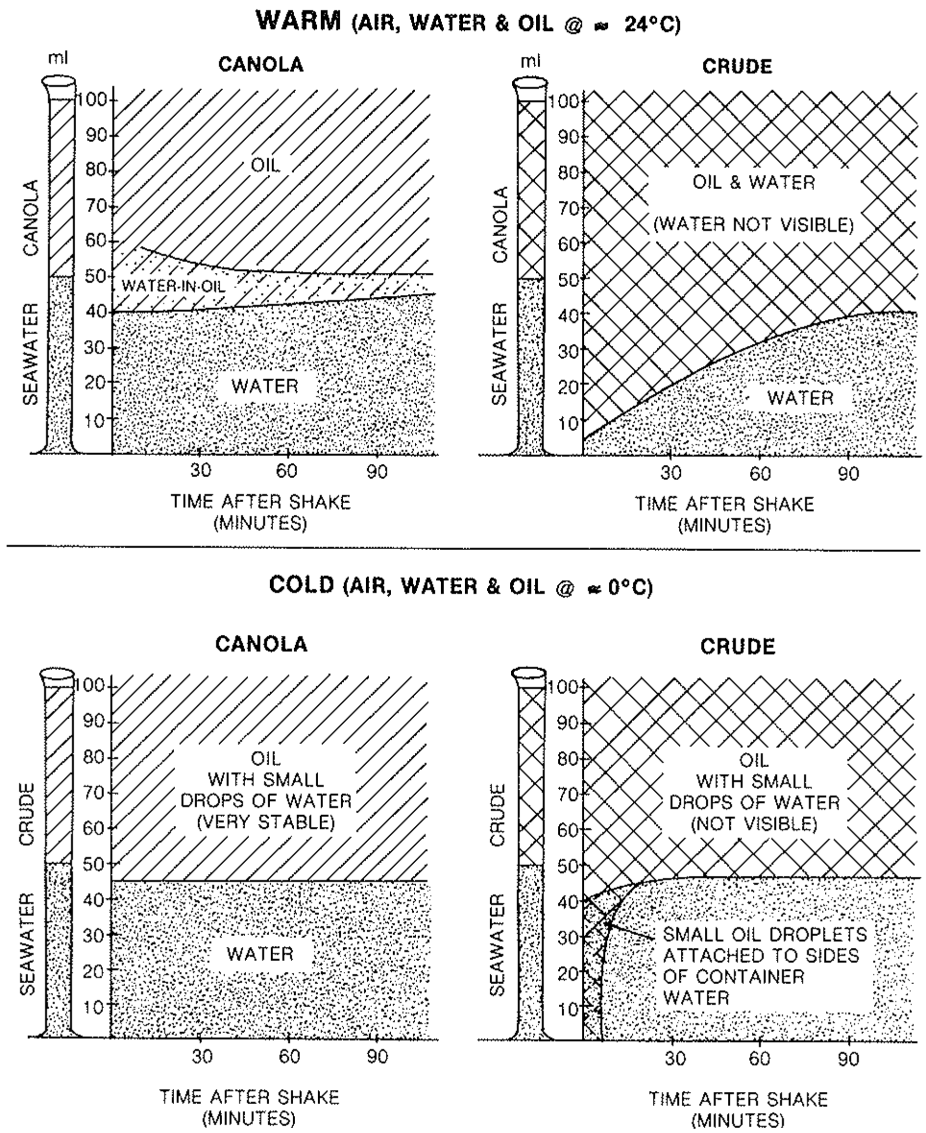

FIGURE 6 EMULSIFICATION TESTS - CANOLA AND CRUDE OIL

During the cold test, both oils revealed a tendency to avoid emulsification. Some of the crude oil broke into small globules within the water column; however, the majority of these globules quickly rose and recombined with the overlying oil layer. Only a few small globules remained for the first 20 minutes attached to the walls of the cylinder in the water column. Shortly after both cylinders were shaken, it was clear that very little water had been entrained in each of the oils. The Canola oil and the crude oil took on approximately 10% of the original water volume as a stable portion of the overlying oil.

The results of these cold-chamber tests suggest that Canola oil can be used as a viable substitute for crude oil during the field testing of certain types of spill control equipment, with or without the presence of broken ice. Observations made during the laboratory tests can be summarized as follows:

(a) The specific gravity and the viscosity of Canola oil vary linearly with temperature. The variation of its viscosity with temperature suggests that Canola oil represents a "medium weight" oil that is comparable to a lightly weathered Prudhoe Bay crude oil (i.e., about 10% evaporated).

(b) The volume of Canola oil used during a spill test will remain unaffected by the usual influence of evaporation.

(c) Canola oil exhibits an affinity for oleophilic surfaces which is quite similar to that of crude oil. Canola oil's greater viscosity (compared to fresh Prudhoe Bay crude oil) results in a 30 to 40% increase in oil recovery rate with saturated rope mop fibres under Arctic air and water temperatures.

(d) Canola oil penetrates the fibres of sorbent pads at a slightly slower rate than does fresh Prudhoe Bay crude oil; however, saturation of the pads can be accomplished within minutes and the recovered volumes of Canola and crude oil are nearly identical.

(e) Canola oil and Prudhoe Bay crude oil have the same tendency to coat the surface of sea ice drawn up through an oil/water interface. Both oils also showed the same tendency to slide off submerged ice surfaces quite rapidly and completely.

(f) Under cold air, water and oil temperatures (0°C), both the Canola and the crude exhibited similar tendencies for emulsification. Each oil took on approximately 10% of its original volume in water globules which did not settle out for several hours following the original 1 minute shake test.

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THE GERMAN APPROACH TO ENVIRONMENTAL SENSITIVITY INDEX MAPPING

Submitted by: Rainer Leo
Bernd Nill
Christian Voigts
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In October 1982, the Federal State of Hamburg awarded a contract to LEO Consult GmbH and ERNO Raumfahrttechnik GmbH, to work out a contingency and alert plan. The content of the contract was - among other items - to

1. complete and integrate the existing alert plan
2. map the banks of the river Elbe and the ports of Hamburg in terms of their relative sensitivity to spilled oil
3. identify major wildlife habitats by season
4. identify areas of socio-economic importance
5. propose primary locations for spill protection and response equipment
6. propose primary locations for intermediate storage, identify treatment plants for recovered oil/water mixtures and oiled soil/vegetation
7. identify access roads (both existing and provisional)
8. present "standard cross-sections" of the banks or quai walls
9. recommend "standard cleanup operations" for the "standard cross-sections"
10. present focal points of response actions
11. recommend an organizational structure for the responsible authority
12. give general informations about oil, its properties and behaviour, and environmental impacts
13. give general information about booms, skimmers, sorbent materials, pumps, etc.

Hamburg, Germany's largest port, is connected with the North Sea by the river Elbe, a river which is influenced by ebb and flood. The banks of the Elbe and the man-made structures of the port area have a total length of approximately 320 kilometres. The Elbe is navigable for vessels with draughts of up to 13 m. In 1982, the import of crude oil by tankers amounted to about 8,300,000 metric tonnes. Import and export of products by tankers, in 1981, was approximately 4,000,000 tonnes. The pipeline connecting Wilhelmshaven with Hamburg was completed in 1982; future amounts of crude oil carried by vessels will therefore decrease significantly.

For fast, cost-effective response to spilled oil, the immediate availability of the following relevant data is very important.

- Responsibilities,
- Communications,
- Response-relevant parameters of the oil spilled,
- Adequacy of manpower and equipment in relation to the type and amount of the spilled oil and to the environment threatened by damages,
- Weather, current, and tidal conditions,
- Safety and health hazards for rescue and cleanup personnel.

As most of these data were not available in Hamburg, it was decided to prepare an oil spill response manual. Volume 1 contains general information about oil, environmental data, impacts of oil, and the alert plan; volume 2 contains environmental sensitivity index maps, "standard cross-section" with recommendations for protection and clean-up operations, and detailed presentation of 162 focal points for response actions.

To help the authorities responsible for combatting oil spills in Hamburg, it was necessary to combine the existing data (mainly telephone numbers of the authority) with the proposed additional data. These additional data, connected with a new structure of organization, included:

- a list of federal, state, and local authorities;
- a list of local and regional cleanup contractors, with lists of their equipment;
- authorities of the neighbour countries (Denmark and the Netherlands) and their equipment;
- physical and chemical properties of various types of oil;
- fate and behaviour of spilled oil under various conditions;
- statistics of import and export of crude oils and products to and from Hamburg and their respective characteristics;
- classification of oils;
- identification of oil on water;
- ecological impacts caused by spilled oil;
- meteorologic and hydraulic conditions;
- prediction of the drift of oil on the river Elbe;
- a list of bridges in Hamburg and their height for vessel passage;
- recommendation for the installation of several strategically chosen local operational centers and their outfit;
- use of and requirements for booms, skimmers, pumps, sorbent materials;
- installation (where and how) of intermediate storage;
- installations for treatment of oil/water mixtures and oiled soil and vegetation;
- standardized cross-sections and recommendations for cleanup operation (what to do, what to avoid).

Volume 2 contains:

- a detailed presentation of 162 focal points for response action;
- a description of two major lines of defense for two highly sensitive areas;
- 11 detailed large-scale maps of the entire Hamburg waterways (Elbe and ports).

Extensive literature review and analysis of all data available was followed by on-site investigations using helicopters, ships and cars. All types of maps available in Hamburg were analyzed and interpreted.

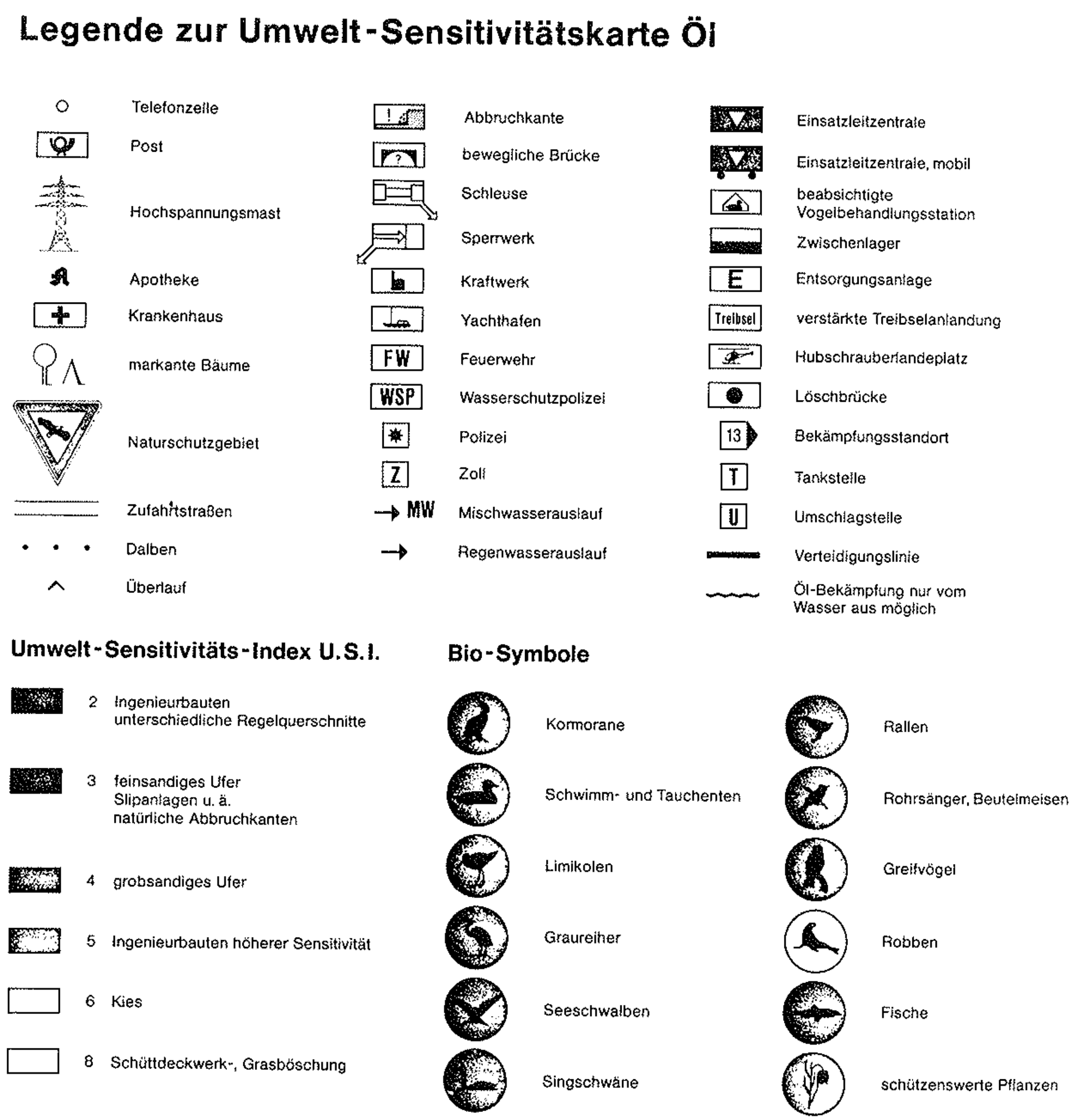
To get more detailed information about the drift of oil on the Elbe and in the ports, three different methods were used:

1. theoretical calculations, using current and tidal data and superposing different wind speeds and directions;

2. intensive investigations at the "Elbe-Modell" (in Rissen near Hamburg, a model of the entire Elbe in the scale 1:500 has been built. Simulation of tides, different current speeds, different amounts of water from upstream is possible with this model). For the most sensitive areas (Heuckenlock, Muhlenberger Loch, and Zollenspieker), detailed investigations using hydrophobic material and model booms were undertaken to find out possibilities for the protection of these areas;

3. to control the results of the model, and to verify the wind's influence, four drift-scenarios were started using modified NOAA drift cards. Six hundred drift cards were placed into the Elbe at each scenario, and were traced during 6 hours by helicopter. After the tracing time, the cards were left in the Elbe to find out where they would drift in the long run. Finders of the drift cards were asked to report the number and the recovery place to LEO Consult, until now, more than 60% of the cards have been reported. Most of them did not move too far from Hamburg: the longest distance reported was approximately 70 kilometers from Hamburg. The findings, results and conclusions are included in volume 1 of the manual.

EXAMPLE OF A SENSITIVITY MAP



EXAMPLE OF A LEGEND FOR A SENSITIVITY MAP