USEPA 1993

RM2 EXIT BRIEFING ON

CHLORINATED PARAFFINS AND OLEFINS

September 1, 1993

Chlorinated Paraffins and Olefins RM2
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Summary

The RM2 investigation looked at both ecological risks, the major concern, and human health risks.

The *ecological* assessment was advanced in four areas. *First*, it was established that the substances of greatest concern are *short chain* (C_{10-13}) chlorinated paraffins (CPs) *and* Olefins (CP/Os). Olefins (C_{12}) were added when it was discovered that they are also used in metalworking fluids, and are essentially indistinguishable from CPs in toxicity, persistence, use and disposal.

Second, the investigation determined that virtually all ecologically significant releases of CP/Os to the environment are from metalworking operations discharging to water -- and that all of those releases are contained in the water fraction of water soluble cutting fluids discharged to water after separation from the oil phase.

Third, the hazard analysis was revised based on new toxicity and bioconcentration studies, and on policy decisions by OPPT Division Directors, yielding the following values.

1. Lowest level of concern concentration:........0.03 μg/l
2. Mid-level of concern concentration:..............0.11 μg/l
3. Highest level of concern concentration:.........0.7 μg/l
4. Most likely range of concern:..............0.11 to 0.7 μg/l
5. NOEC:..1.0 to 5.0 μg/l
6. GMATC:..3 to 7 μg/l
7. LOEC:.. 8.9 μg/l

Fourth, in-house analysis of Survey data covering sales of short chain water soluble cutting fluids in major markets suggests that CP/Os pose relatively low ecological risk. The analysis estimates that 186, or 75 percent, of 248 localities within the four States that consume the greatest amounts of metalworking fluids have in-stream concentrations below the lowest level of concern (0.03 μg/l); 28 fall within the low range of concern (0.03 < 0.11 μg/l); 26 within the "most likely" range of concern (0.11 < 0.7 μg/l); five between the upper bound of the level of concern and the lowest estimated No Observed Effect Concentration (0.7 < 1.0 μg/l); and two within, and one just above, the low range of the estimated NOEC (1.0 < 3.0 μg/l), and at or below the lowest estimated Geometric Maximum Acceptable Toxicant Concentration. Fourteen percent fell within or above the "most likely" level of concern. These estimates do not consider the relative insolubility of CP/Os. Taking partitioning from the water column to sediment into account reduces these estimated in-stream concentrations by 14 to 56 percent.

An aquatic simulation model projects low probability of any effect to any trophic level at a water concentration of 1.0 μg/l, a level exceeded in only three of the 248 localities. An economic benefits model applied to these results estimates that reducing CP concentrations from the hypothetical 1.0 μg/l level to zero in Galveston Bay, the highest risk area modelled, would achieve annual gains ranging from $100,000 to $5,600,000, with expected values, under the two most likely assumptions, of $1,700,000 and $1,000,000.

There are some ***human health concerns***, particularly among metalworkworkers. Based upon a number of "high end" exposure assumptions, there may be as many as 157 U.S. excess lifetime cancer cases. The investigation also concluded that there may be an *individual* excess lifetime cancer risk as high as 5×10^{-4}, in a few of the highest in-stream concentration areas, among indigent people who subsist primarily upon fish they catch. Although the nature of the population at risk raises an "environmental equity" concern, the small number of people involved renders the *population* risk negligible. There may also be a lifetime *individual* excess cancer risk as high as 10^{-3} among a very small population of workers employed in manufacturing resinous long chain CPs.

Although unevaluated in this assessment, CP/Os in metalworking fluids also pose two potential exposures to dioxin/furans. The first is to metalworkers as a result of using chlorinated fluids at high temperatures; the second is to the general population as a result of incinerating spent fluids.

Finland, The Netherlands and The United Kingdom recently completed assessments of CPs. Each concluded that CPs probably pose little risk in their countries. Finland and The Netherlands recommended additional research to develop more release information. An impending assessment in Canada may recommend defining CPs as "toxic". A 1991 Swedish proposal to phase out use of CPs in Europe, voted on this past June, was not adopted.

Five options were considered for closing the RM2 investigation. Irrespective of the option selected, it is recommended that OPPT (a) refer the occupational risk to OSHA, (b) refer the dioxin issues to EPA's Dioxin Workgroup, and (c) advise Region 5 of the subsistence fish-eater risk. The options are:

Option 1: Close with no further action.

Option 2: Negotiate voluntary agreements with industry to: (1) promote pollution prevention practices by reducing use of short chain CPs, and reducing discharges to water; and (2) conduct research -- especially surface water monitoring and sediment toxicity testing -- to address remaining uncertainties.

Option 3: List on TRI and close with no further action.

Option 4: List on TRI, seek funding from the Water Office to monitor CP/Os in high use areas, and add CP/Os to the Master Testing List (MTL).

Option 5: Regulate aggressively with information-gathering, public notification, and restrictive authorities of SARA §313 and TSCA §§4, 8 and 6 to discourage use of short chain CP/Os in metalworking fluids.

Option four is recommended. It is also suggested that a "metalworking fluid" cluster be added to the Design for the Environment/Use Cluster hopper for a start in FY 94 or 95.

I. Overview and Background

This report is in four parts. This first part provides general background information. The second addresses ecological risks posed to aquatic life from concentrations of CPs in surface water resulting from industrial releases. This was the major concern emerging from RM1. The third part covers carcinogenic risks to human health. This was believed to be a minor concern at RM1 exit, but has now assumed somewhat greater importance. The fourth part presents risk reduction options and recommendations.

Significant Milestones

1977:	CPs nominated for testing by ITC.
1982:	Testing agreement between OTS and Consortium published.
1983:	§8(e) Notice submitted by Consortium based on testing results.
1985:	HERD ecological hazard and risk assessments completed.
1985:	OTS Decision Memorandum recommending monitoring.
1988:	OTS-initiated monitoring of Sugar and Tinkers Creeks completed.
7-3-91:	RM1 Decisions: (Ref.# 9) Enter RM2; approach industry to (a) request better information about releases; (b) present the rationale for additional testing; (c) clarify whether industry agreed to treat test results on most toxic category of CPs as applicable to all CPs; and (d) pursue pollution prevention remedies.
9-16-91	Initial meeting with Chlorinated Paraffins Industry Association (CPIA) to discuss Letters of Concern.
6-18-92:	Proposal received from CPIA offering to (a) conduct a Survey of Formulators to obtain better information on releases, and (b) continue and expand on-going efforts to promote pollution prevention and waste minimization.
6-25-92:	OPPT ECMR Decision: Follow-up on CPIA proposal.
6-21-93:	CPIA Survey of Formulators received.

Physical-Chemical Data (Ref.#s 7 and 47)

Chemical name:	Chlorinated Paraffins
Molecular Formula:	$C_{10-14}H_{17-21}Cl_{5-9}$
CAS Number:	63449-39-8
Molecular Weight:	411 for $C_{12}H_{19}Cl_7$
Log P:	5.47-7.30 (M for C_{10-13} Cl 63% Cl)(6.32 GAvg)
Water Solubility:	95-470 μg/l (M)

Production and Uses (Ref.#s 10, 21 and 34)

1992 domestic sales were in the neighborhood of 65 million pounds (Ref.# 34). Taking exports and inventories into account, this is in line with production figures reported by CP producers for the years 1987 through 1990. Demand is expected to remain relatively stable over the foreseeable future. All, or virtually all CP/Os are produced by four companies: Occidental Petroleum, with plant capacity of 90 million lbs.; Keil Chemical Division of Ferro Corp, with plant capacity of 50 million lbs.; Dover Chemical, with 40 million; and Argus Division of Witco Corp., with 12 million.

Roughly half of all CPs produced are used as extreme pressure additives in metalworking cutting fluids; another 20 percent as primary and secondary plasticizers in plastics; 12 percent as flame retardants in rubber; nine percent in paint; six percent as plasticizers in adhesives, caulks and sealants; and three percent in miscellaneous other uses.

Fate and Transport (Ref.# 20)

CP/Os that are incinerated are destroyed (although dioxin may be formed in the process). For the remainder, the high soil organic carbon partition coefficient and low water solubility results in strong sorption to soils and sediment. Consequently, CP/Os that are landfilled are assumed unlikely to migrate or leach to groundwater. Releases to water therefore probably constitute essentially the only source of ecologically significant exposures. Because of their insolubility, the bulk of CP/Os released to water are expected to partition to suspended solids and sediment. Other potential sources are volatilization from land and water, and air particulate dispersion. The likelihood of transfer from solids and sediments is unknown.

Releases (Ref.#s 21 and 44)

About 55 percent of all CP/Os released to the U.S. environment are discharged to water, less than one percent is released to air, and the remaining 44 percent is recycled, incinerated or landfilled where, for the reasons noted above, they are unlikely to create environmental exposures. Metalworking fluid end-users are responsible for virtually all releases to water.

End-user releases of short chain CP/Os to water are comprised almost entirely of those remaining in the water phase of water-soluble cutting fluids, after the water has been separated from the oil prior to discharge. All "straight" (non-water-soluble) oils and the oil phase of all water soluble oils are believed to be recycled, incinerated or landfilled.

Substitutes (Ref.#s 10 and 21)

Only general information has been found on substitutes for CPs. Substitutes for use in cutting fluids is the primary concern, because metalworking accounts for almost all releases to water and most occupational exposures. Possible substitutes in this area include chlorinated fats, fatty acids and esters, sulfurized additives, chlorosulfurized additives, phosphate thiophosphate additives, overbased sulfonate salts, oil soluble borates, lead compounds, and cryogenic fluids. Most sources agree that while substitutes are available for CP/Os in some metalworking applications, in general they are not entirely satisfactory.

II. Ecological Risk.

Strategy

The RM2 ecological investigation assessed the magnitude of risk posed by CPs in circumstances in which that risk is believed to be both most likely and most severe. Based on information generated before and during RM2, it was determined that those circumstances arise when various forms of aquatic life, the most sensitive organisms, are exposed to short chain CPs, the most toxic form, in areas where metalworking operations, the major source of releases, are most heavily concentrated. Focussing the investigation in this manner permitted a realistic assessment of the greatest ecological risks likely to occur. The two major tasks in this effort were to (a) obtain agreement on the magnitude of the hazard, and (b) develop estimates of in-stream concentrations in those geographic localities in which the greatest amounts of CP/Os are released.

Substances of concern

The RM1 analysis (Ref.# 8) concluded that the greatest risk was posed by short chain CPs with 58% chlorination. Based on confirmation by the Division Directors of CCD, HERD and CSRAD (Ref.# 32) that these were the substances of greatest concern, the RM2 investigation concentrated on short chain ($C_{10\text{-}13}$) CPs. Conversations with CP producers revealed that olefins (chain length C_{12}) are also used in metalworking fluids. Since olefins are structurally similar to CPs, there is no reason to believe they are less toxic than short chain CPs: they were therefore included.

Hazard

Chronic toxicity drove the CP/O ecological assessment. CCD, HERD and CSRAD Division Directors reviewed analyses of the hazard (Ref.#s 25 and 28) and revised the estimates that emerged from RM1 to the values shown below.

	RM1 Exit	RM2
Levels of concern	0.006-0.01 μg/l	0.03-0.7, closer to 0.7 μg/l
LOEC	0.6 μg/l	8.9 μg/l
NOEC	Not found	1.0-5.0, closer to 5.0 μg/l
Estimated NOEC	≈ 0.1 μg/l	Not applicable
GMATC[a]	1.2 to 2.4 μg/l	3 to 7, closer to 7 μg/l
Margins of exposure	60-100	10-100, closer to 10

[a]Geometric Maximum Acceptable Toxicant Concentration: the square root of the product of the LOEC and NOEC.

Estimates derived from the Division Director conclusions yield the following significant hazard and concern numbers:

1. Lowest level of concern concentration:[a].....0.03 μg/l
2. Mid-level of concern concentration:[b]............0.1 μg/l
3. Highest level of concern concentration:[c]......0.7 μg/l
4. Most likely range of concern:[d]..........0.11 to 0.7 μg/l
5. NOEC:...1.0 to 5.0 μg/l
6. GMATC:... 3 to 7 μg/l
7. LOEC:.. 8.9 μg/l

[a] Lowest GMATC/highest MOE = 3/100.
[b] Mid-range GMATC/mid-range MOE = 5/45.
[c] Highest GMATC/lowest MOE = 7/10.
[d] Greater weight given to high end GMATC, low end MOE.

Regulations (Ref.# 19)

Regulations under the Clean Water Act prohibit any releases of used oil to water that (1) cause a sheen to appear on the surface, (2) violate applicable water quality standards, or (3) cause sludge or emulsion to be deposited beneath the surface of the water or on adjoining shorelines. Indirect dischargers must meet POTW-imposed restrictions on the concentrations of "Fats, Oil and Grease" (FOG) allowed in facility effluent. These restrictions are typically in the 50 to 250 ppm range. The highest found by the Workgroup, in Detroit, is 2,000 ppm. Even this highest level, however, precludes discharges with oil content above 0.2 percent.

In September of 1992, concluding a series of proposals and promulgations that commenced in 1978, OSWER promulgated a final rule (Ref.# 19) entitled *Identification and Listing of Hazardous Waste; Recycled Used Oil Management Standards*. That rule stipulates that:

1. To encourage recycling, EPA will *not* list *recycled* used oil as hazardous waste.

2. Recycling includes reuse for any purpose, including oil being re-refined or being processed into fuel.

3. All used oil is presumed recyclable; therefore neither the generator nor anyone else who handles the oil, *prior to the person who ultimately decides that the oil is <u>not</u> recyclable*, is required to take that possibility into account.

4. Used oil *disposal* (as opposed to recycling) must be done in compliance with all applicable regulations, including the requirement to determine whether the used oil exhibits any characteristic and, if it does, to manage it as hazardous waste. No characteristic determination is required for used oil that is *recycled.*

5. There is a rebuttable presumption that any oil -- including oil that might otherwise be recycled -- containing more than 1,000 ppm of halogens, is oil that has been mixed with chlorinated hazardous waste, and must therefore be treated as hazardous waste.

6. Because metalworking fluids to which chlorinated extreme pressure additives (i.e., CP/Os) have been added may exceed the 1,000 ppm halogen limit without having been mixed with hazardous waste, there is a conditional exemption for such fluids from the rebuttable presumption. Specifically, *metalworking fluid end-users who enter into a tolling agreement with used oil refiners/processors to re-refine and return the oil for further use are not required to rebut.*

Releases

The number and diversity of metalworking operations made it infeasible to acquire direct CP/O release data from end-users. Based upon restrictions imposed under CWA and RCRA, described above, the RM2 analysis assumed that no metalworking fluid end-user can legally discharge, directly or indirectly, any "straight" oil, or the oil fraction of any water soluble oils. Almost all CP/Os released to water are therefore assumed to be those remaining in the water phase of CP/O-bearing spent water-soluble oils after separation and treatment prior to discharge.

It is also assumed, because of the RCRA exemption described in # 6, above, that metalworking fluid end-users now have a powerful incentive to establish tolling arrangements with professional processor/refiners to periodically pick up, reclaim and return for recycled use, *all* used oils containing CP/Os.

Exposures: Monitoring (Refs.# 1, 20 and 35)

Concentrations of CP/Os in water has been the critical information gap throughout OPPT's assessment. Until the results of the Survey discussed in the next section became available, a few monitoring studies -- completed in the late 1970s and mid 1980s -- provided the best estimates of the distribution and concentrations of CPs in water. The most comprehensive work was done in the British Isles in 1980 by Campbell and McConnell. They detected short and intermediate chain (C_{10-20}) CPs above 0.5 $\mu g/l$ in three of 18 observations in marine water -- but with one observation, in the outer Hebrides, as high as 4.0 $\mu g/l$. In freshwater *remote* from industry, they found concentrations above 0.5 $\mu g/l$ in one of 16 observations, but in freshwater *proximate* to industry they found concentrations above 0.5 $\mu g/l$ in *16* of 25 observations -- with one as high 6.0 $\mu g/l$. These findings suggest that short chain CPs *may* be atmospherically transported long distances, but *will be* found consistently, and in higher concentrations, near the sources of discharge.

OPPT's 1986 monitoring of Sugar Creek, near Dover Chemical's manufacturing facility, found concentrations of short chain CPs at 0.21 μg/l in particulates in water at the outfall, and 0.3 μg/l in particulates in water *up*stream from the outfall. The latter is suspected to have resulted from overflows from a now-closed lagoon. Monitoring of a metalworking fluid end-user on Tinkers Creek, did not detect CPs in either filtered water or particulates. This is believed to be due to the difficulty of detecting CPs in complex mixtures of halogenated organics.

Short chain CPs were detected in the Houston Ship Channel in 1978 at levels ranging from less than 1.0 μg/l to one measurement at 1.5 μg/l. The highest concentrations were found in 1977 near a Diamond Shamrock facility on the Grand River, where concentrations were as high as 3.0 μg/l in the stream both above and below the plant.

The existing monitoring work has three drawbacks. First, the analytical limits of detection and quantitation have been in the vicinity of 0.2 and 0.5 μg/l, respectively -- both falling within the "most likely" range of the current levels of concern, but above the low range. Second, the RM2 release assessment (Ref.# 21) indicates that the highest in-stream concentrations will be found in areas with extensive metalworking fluid *end-users*: none of the monitoring work expressly targeted those areas. Third, the data are now quite old: during the interim, in response to new regulations, changes may have occurred in disposal practices.

Exposures: CPIA Survey of Formulators

To fill this void, the RM1 exit decisions instructed the RM2 investigation to obtain better information from industry on CP releases . In response, the four CP producers each provided detailed manufacturing process information. In addition, following a series of discussions with members of the RM2 Workgroup, CPIA volunteered (Ref.# 14) to conduct a survey of CP/O metalworking fluid formulators. The RM2 investigation had by that time determined that virtually all ecologically significant releases of CP/Os occur as a result of discharges of spent short chain water soluble cutting fluids. The purpose of the Survey, therefore, was to obtain data from metalworking fluid *formulators* reflecting:

1. the amount of short-chain (C_{10-13} without regard to chlorination) CP/Os used in metalworking fluids in 1991;

2. the proportion that went into *water-soluble* metalworking fluids; and

3. the amounts of CP/O-bearing water-soluble metalworking fluids *sold* in the major geographic markets.

It was anticipated that when the Survey data were received, EETD would use assumptions, awareness of technologies and practices, and models, to estimate how much of the CP/Os entering major markets ultimately found their way into specific bodies of water, and the resulting in-stream concentrations.

The survey results were received (Ref.# 38) on June 21st. More than 70 percent of estimated total domestic sales of short chain CP/O-bearing water-soluble metalworking fluids were reported. Thirty-nine percent of estimated total domestic sales were reported to have been sold in the four highest consumption States: Michigan, Ohio, Indiana and Illinois. The in-house analysis therefore focussed on these four States. In order to estimate CP/O concentrations in specific bodies of water, EETD required sales data identified at the city level. Forty-two percent of total reported sales in the four highest consumption States were reported by city. These city-specific data, covering 178 cities, were therefore used by EETD, as described above, to estimate:

1. the amounts of CP/Os released to individual POTWs, assuming 90 percent removal via pre-discharge separation and treatment (Ref.# 44);

2. the amounts released from those POTWs, assuming an additional 90 percent removal (Ref.# 45 and 52); and

3. the resulting concentrations in particular streams, based upon flow rates.

The analysis reflects the best current estimate of CP/O in-stream concentrations in areas with the *highest* concentrations. Uncertainties nevertheless remain including, among the more prominent, the following.

1. The assumption that all water soluble oils are separated and treated before discharge is based primarily upon inferences drawn from regulatory requirements.

2. There is no information on the likelihood or extent of illegal disposal of spent oil.

3. The analysis does not account for any adverse impacts that may result from concentrations of CP/Os in *sediment*.

4. The Survey did not achieve complete coverage. Some of the fluids reported sold in the four States that were not reported by city may, in fact, have gone to cities for which sales *were* reported.[1]

5. No adjustment was made for any destruction of CP/Os that may occur during metalworking operations.

6. Metalworking facilities' pre-discharge CP/O removal efficiency may be better or worse than 90 percent, but is more likely to be better.

7. In the absence of removal efficiency data for CPs, removal efficiency estimates for "Fats, oil and grease" were used as surrogates. There are no empirical data to determine the validity of this assumption.

8. Some double-counting occurred. The total volume of CP/O releases reported for cities served by more than one POTW was attributed to each POTW.

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[1] In attempting to adjust for this possible source of error, by pro-rating the unreported sales on the basis of population distribution, we found that sales *reported* by city matched almost precisely what would have been predicted on the basis of population distribution.

Risk Characterization

Screening Results (Ref.#s 45 and 51)

Initial risk estimation results are presented in Figure I, which shows the number and proportion of localities estimated to have in-stream concentrations below, within and above the three "levels of concern". As shown, 186 localities[2], or 75 percent of the total, are estimated to have in-stream concentrations below the lowest level of concern (0.03 μg/l): 62, or 25 percent, were above that level. Of those 62, 28 fell within the low range of concern (0.03 < 0.11 μg/l); 26 within the "most likely" range of concern (0.11 < 0.7 μg/l); five between the upper bound of the level of concern and the lowest estimated No Observed Effect Concentration (0.7 < 1.0 μg/l); and two within, and one just above, the low range of the estimated NOEC (1.0 < 3.0 μg/l), and at or below the lowest estimated Geometric Maximum Acceptable Toxicant Concentration. All together, 14 percent of the total fell within or above the "most likely" level of concern.

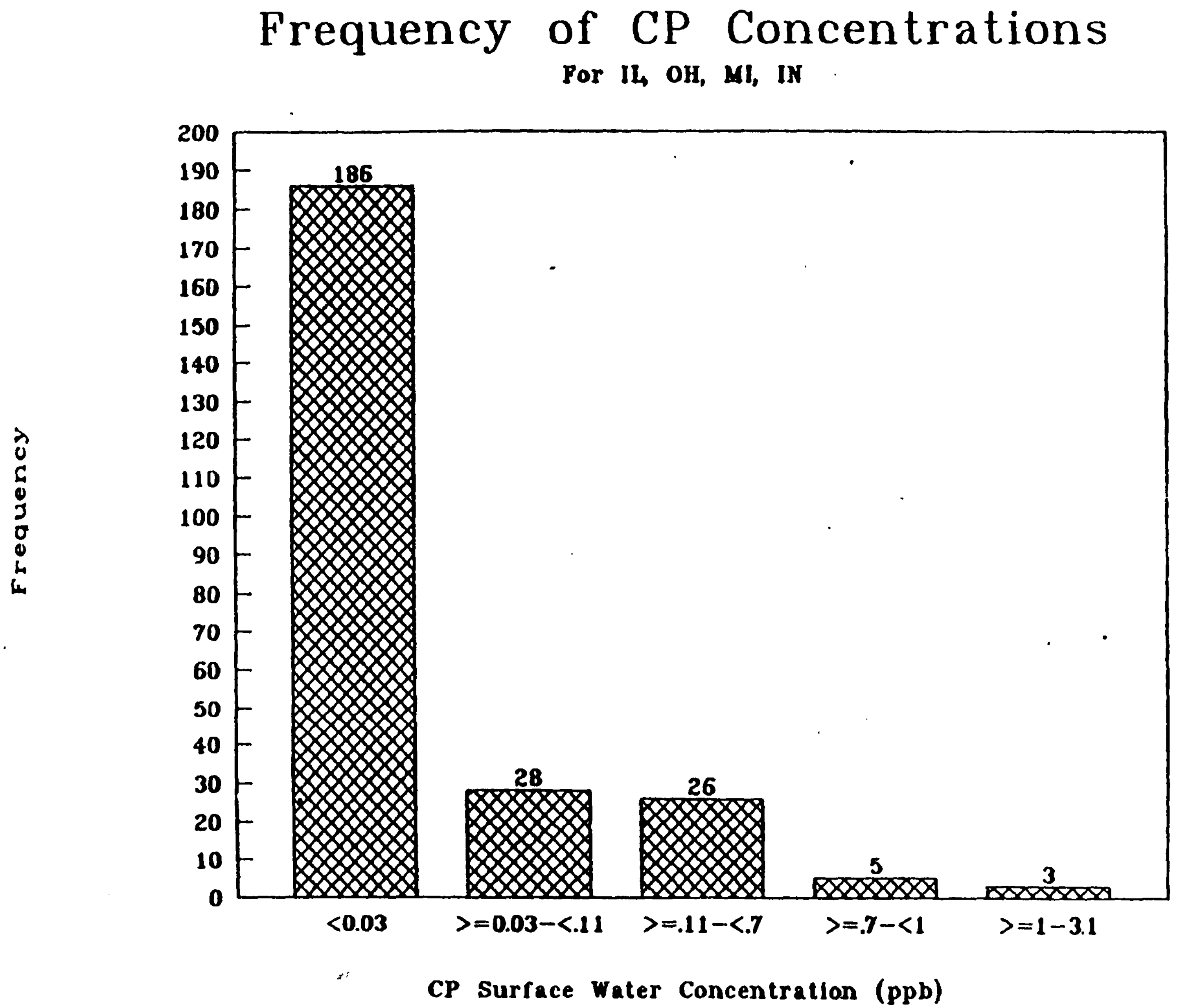
EXAMS II Results (Ref.#s 45 and 52)

The results described above, and reflected in Figure I, do not take into account the insolubility of CP/Os. In order to assess the impact of partitioning from the water column to sediments, the EXAMS II surface water model was used. Time and resource constraints precluded applying EXAMS II to all 178 cities, but it was applied to the two cities with the highest in-stream CP/O concentrations, and to three of the remaining that fell within the highest 62.

City	Pre-partitioning estimated concentration	Post-partitioning estimated concentration
Romeo, MI	3.12 μg/l	1.77 μg/l
Warren, MI	2.91 μg/l	2.49 μg/l
Adrian, MI	0.30 μg/l	0.06 μg/l
Bremen, IN	0.11 μg/l	0.08 μg/l
Seymour, IN	0.035 μg/l	0.03 μg/l

EXAMS II consistently predicted lower CP/O water column concentrations, due to removal of CP/Os via adsorption to sediments and volatilization, than those estimated in the screening results. Reductions in concentrations ranged from 14 to 56 percent.

[2] The total number of localities add up to more than the 178 cities for which data were reported because several cities were serviced by more than one POTW. In those instances the total amount of CP/Os released from that city was attributed to each receiving POTW.



Frequency of CP Concentrations
For IL, OH, MI, IN
Frequency
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
186
28
26
5
3
<0.03
>=0.03-<.11
>=.11-<.7
>=.7-<1
>=1-3.1
CP Surface Water Concentration (ppb)

Figure I

CASM Results (Ref.# 33)

To characterize the extent and probability of impacts from CP/O exposures, and provide some indication of the ecological significance, EEB applied the *Comprehensive Aquatic Simulation Model* (CASM) to three hypothetical concentrations -- 10, 5 and 1 μg/l. CASM is a complex multi-species model which represents the direct and indirect effects of toxic substance exposures to algal biomass, invertebrates, forage fish and top predator fish populations in a typical northern lake ecosystem. It does not take into account the potential effects on exposure to bioconcentration. Forage fish and top predators, especially, could be receiving higher CP/O exposures than CASM predicts by ingesting aquatic invertebrates and fish with CP/O residues. CASM may therefore not provide a conservative estimate of ecological risk.

Figures two through four, on the following pages, show the projected results at 10, 5 and 1 μg/l, respectively. Figure two shows that at 10 μg/l, there would be major losses -- a 50 percent reduction in forage fish, for example, is virtually certain. Figure three indicates that damage would also be significant at 5 μg/l, with about a 40 percent probability of 25 percent reductions in both forage and predator fish and among invertebrates.

At 1 μg/l (Figure 4) CASM projects a low probability of any effect to any trophic level. There is near zero probability of 50 percent or greater loss at any trophic level. There is about a 17 percent probability of a 25 percent loss of forage fish, and about a five percent probability of a reduction of that magnitude in algal biomass. The probability of 25 percent reductions in invertebrates or predator fish approaches zero.

Economic Assessment (Ref.#s 22)

EETD/RIB applied an economic benefits model to the results of the CASM analysis in order to estimate the value of reducing CP concentrations from each of the three hypothetical levels to zero in three areas -- the Houston Ship Channel in Texas, the Schuylkill River in Pennsylvania, and Sugar Creek in Ohio. At the hypothetical concentration of 1 μg/l -- a level higher than estimated to be present in the waters of all but three of the 248 localities in the Survey -- the economic benefits model estimates annual gains ranging from $100,000 to $5,600,000 in Galveston Bay, the highest risk area modelled, with expected values, under the two most likely assumptions, of $1,700,000 and $1,000,000. The estimated expected annual benefits of reducing hypothetical concentrations from 1 μg/l to zero in the Schuylkill River and Sugar Creek were $16,400 and $471, respectively.

Figure II

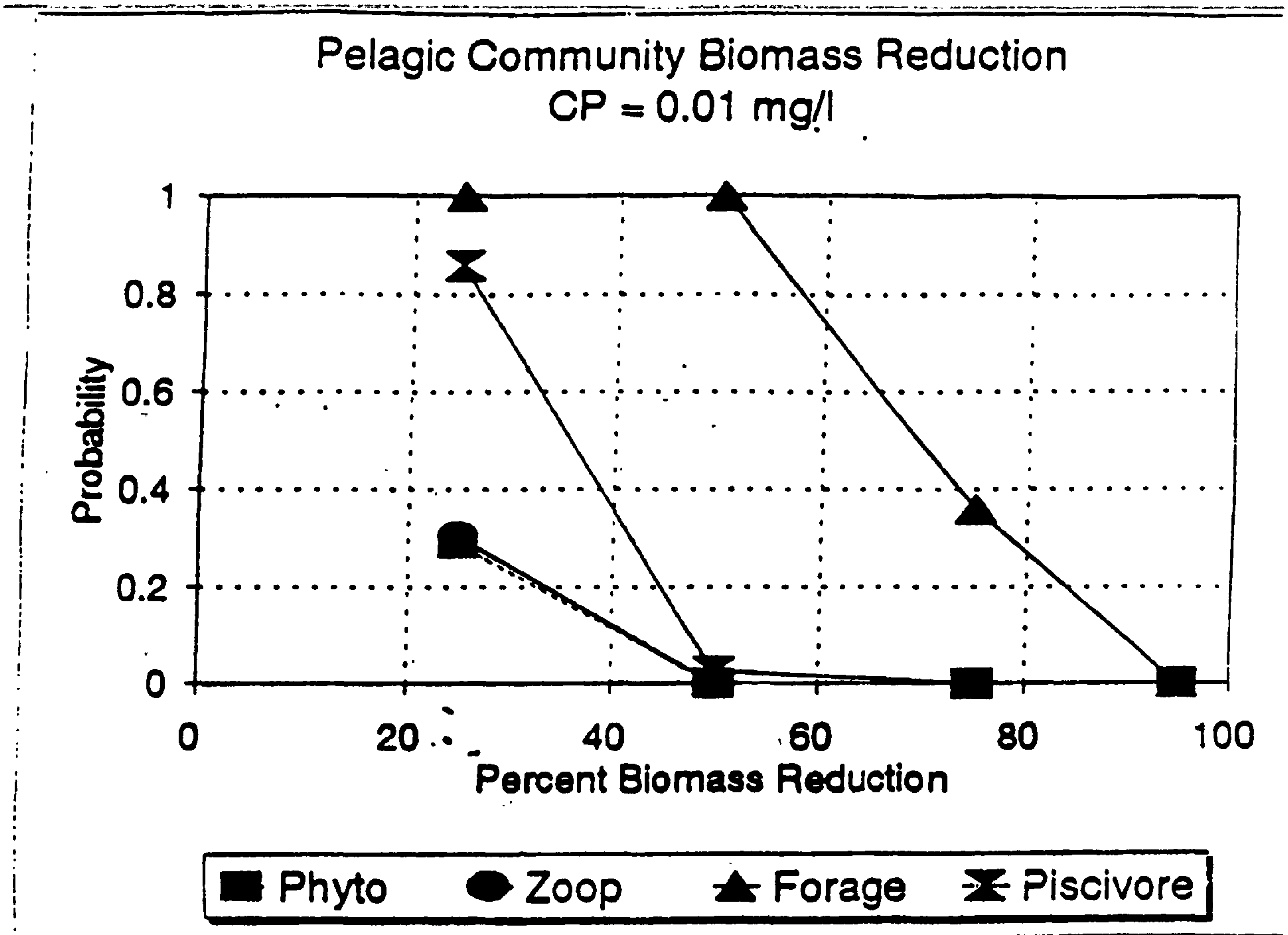


Figure 9. Biomass reduction in four trophic levels at 10 ppb exposure

Figure III

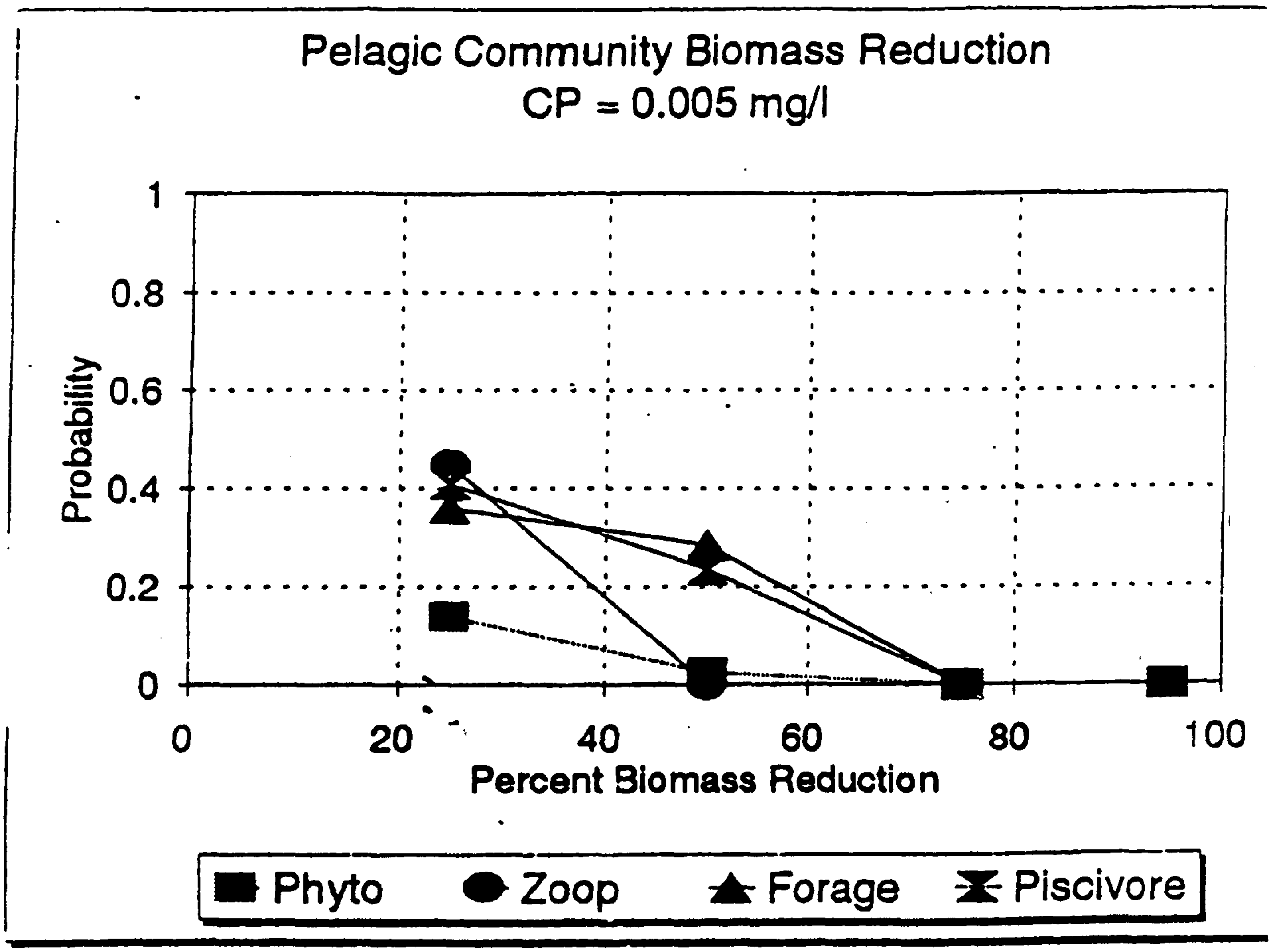


Figure 8. Biomass reduction in four trophic levels at 5 ppb exposure

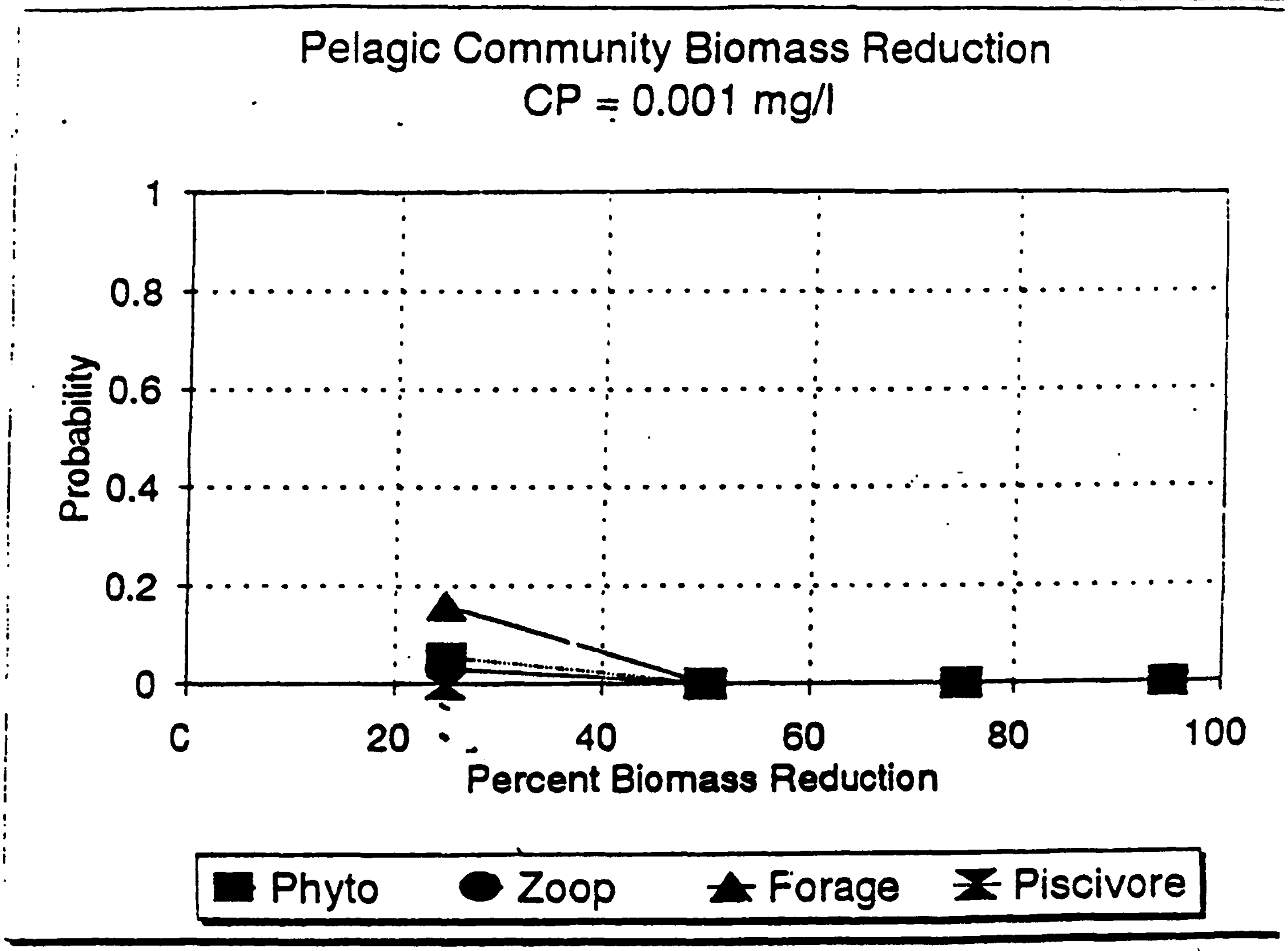


Figure 7. Biomass reductions in four trophic levels at 1 ppb exposure

Foreign Government Assessments (Ref.#s 6, 12, 18 and 40)

Environmental Agencies in Finland (Ref.# 6), The Netherlands (Ref.# 12) and The United Kingdom (Ref.# 18) have recently completed assessments of risks posed by CPs.

In brief, all three countries concluded that CPs were unlikely to pose much of a problem, if any, in their respective countries; Finland and The Netherlands felt that more information was needed on releases to the environment, and recommended efforts to generate it; none recommended restrictive regulation.

The Netherlands document, and in all probability the Finnish and U.K. documents as well, were prepared in order to inform discussion about a proposal to abandon use of CPs in Europe. In 1991 Sweden placed a proposal before the working group on diffuse sources of the Paris Commission (PARCOM) to phase out CPs by the signatory nations over a three to ten year period. It is unclear what the practical consequences would be if that proposal were adopted, since PARCOM is not believed to be a UNEP, EC or other governmental authority. In any event, the proposal was voted on and *not* adopted at a joint meeting of the Oslo and Paris Commissions held in Berlin on June 14-19, 1993. It may be reconsidered at the next meeting, a year from now. (Ref.# 40)

Appendix 1 presents quotes from the three assessments reflecting conclusions reached by each Agency in eleven areas: (1) overall level of concern; (2) general state of knowledge; (3) regulations and recommendations; (4) ecological toxic thresholds; (5) surface water concentrations; (6) transportation in the environment; (7) persistence and degradation; (8) substances of concern; (9) dioxin formation; (10) sources of release; and (11) production and use.

Canada is also investigating potential risks posed by CPs. Environment Canada is expected to publish a final assessment within the next few weeks. That assessment may conclude that chlorinated paraffins may be present in the Canadian environment at levels which could have an immediate or long-term harmful effect on the environment. If such a determination is made, chlorinated paraffins would then be defined as "toxic" under the provisions of the Canadian Environmental Protection Act (CEPA), Section 11(a). Substances so defined are placed on Schedule 1 of the Act, for consideration for possible development of regulations to control any aspect of their life cycle, from the research and development stage through manufacture, use, storage, transport and ultimate disposal.

Further Research

This section discusses eight additional fact-finding activities that might be undertaken to address issues about which there is insufficient information to permit definitive conclusions. The eight efforts are listed below from high to low in order of their perceived importance. The discussion following the listing presents a brief rationale for each activity and, in some instances, provides cost estimates and recommendations as to who might undertake the work.

1. Monitor for CP/Os in the water column in high consumption areas identified in the Survey;

2. Test for effects of CP/O concentrations in sediment to benthic organisms;

3. Ascertain the potential for forming dioxin during metalworking;

4. Characterize spent oil disposal technologies and practices among metalworking operations;

5. Test for chronic effects of short and intermediate chain CPs on fish;

6. Evaluate the potential for adverse effects in terrestrial and avian species;

7. Assess potential long-range distribution of CP/Os via atmospheric and/or aquatic transport; and

8. Evaluate the potential for dioxin formation during incineration of spent oil.

1. Monitoring (Refs.# 37 and 42)

The highest priority is to obtain monitoring data to corroborate or refute the findings of the Survey. Unless and until such monitoring is conducted, the uncertainties discussed earlier will limit confidence in conclusions drawn from the Survey. Those conclusions may either under or overstate the actual risk.

One problem with past monitoring has been that the level of quantification for CPs has been at about 0.5 $\mu g/l$ in relatively clean water, whereas the need is to quantify concentrations occurring in highly complex waters at about 0.1 $\mu g/l$, the low end of the most likely level of concern. To this end, CMD has recently spent about $20,000 to determine the feasibility of sampling and analyzing at the lower level. This work is currently on hold pending an OPPT decision to go forward. CMD estimates that another $30,000 to $40,000 will be required to field test the new procedures in relatively clean and highly contaminated waters, prior to monitoring those areas of the country where metalworking fluids are used most extensively. The actual monitoring program will cost considerably more.

It is recommended that the Office of Water be asked to conduct the monitoring program as a component of EPA's Contaminated Sediment Management Strategy.

2. Sediment toxicity testing (Ref.#s 2, 36 and 46)

Because no suitable protocol existed at the time, the testing agreement negotiated by OTS with the Consortium of chlorinated paraffins producers in 1982 did not call for testing the effects of CP concentrations in *sediment*. All assessments of the effects of CP/Os on aquatic life are therefore based upon CP/Os in the *water column*. The concern is heightened by the fact that CP/O concentrations in sediment are two to three orders of magnitude higher than in the water column.

HERD has now identified and provided test protocols (Ref.# 46) that are suitable for determining acute and chronic effects of sediment concentrations of CP/Os on freshwater, estuarine and marine amphipods. The American Society for Testing and Materials as well as the EPA Research Lab in Newport, Oregon, has been involved in developing these protocols. The cost of administering a 28 day chronic test is in the range of $30,000 to $40,000. In addition, the protocols would need to be modified somewhat for use with CP/Os, and would have to be written to conform to OPPT validation parameters and reporting requirements.

It is recommended that sediment toxicity testing be added to the Master Testing List (MTL).

3. Investigating Formation of Dioxin During Metalworking (Ref.# 13)

Inadvertent production of dioxins or furans in the course of using CP/O-bearing cutting fluids is a concern. Dioxin/furans may be generated when chlorinated substances are heated to 200° centigrade in an oxygenated environment. All three conditions are met during metalworking with CP/O-bearing fluids.

While the details have not been worked out, it would be possible to analyze samples of original and spent oil from a few worksites that employ varying technologies, to ascertain whether, and if so in what amounts, dioxin/furans are produced.

It is recommended that this potentially serious concern be brought to the attention of the Agency's Dioxin Workgroup.

4. Characterizing End-User Disposal Technologies and Practices

Although almost all releases of CP/Os to water occur at metalworking facilities, no effort has yet been made to determine how, and with what removal efficiency, these operations treat their spent cutting fluids. This information is important for two reasons.

First, the RM2 analysis relies heavily upon assumptions made about the proportion of CP/Os in the original fluid that remains in the water phase after separation and treatment. This probably varies from one operation to another, depending upon size, capitalization, function of the facility, and other factors. Second, establishing realistic waste minimization goals will require knowing the amount of CP/O removal that is typically achieved and theoretically possible.

5. Fish Toxicity Testing (Ref.#s 3, 5, 25, 27, 28 and 46)

This concern also arises from testing conducted by the producers' Consortium. During the depuration phase of a Trout Bioconcentration Test, all of the fish died that had been previously exposed to 15.0 μg/l for 168 days, and several died that had been exposed to 3.0 μg/l. This unexpected event raised concern that traditional chronic toxicity testing may have failed to detect the true threshold simply because the fish were not exposed long enough. Mitigating this concern to some extent is the fact that when the Consortium extended an on-going trout *growth* study in which the nominal concentration was also 3.0 μg/l -- in order to determine if the effects would be repeated -- no mortalities occurred, even though the dosages and durations were essentially the same.

HERD has identified a full life cycle fish protocol (Ref.# 46), which also contains a partial life cycle protocol as an addendum, that is suitable to address this concern. The full life cycle test is preferred, and would cost about $150,000 to $200,000 to administer, with an additional $75,000 to $100,000 needed to analyze the results. The partial life cycle could be administered for $50,000 to $100,000, with the same analytical costs. HERD/EEB has contracted to have testing guidelines drafted for both protocols: drafts are expected by the end of the year.

6. Assessing Potential Effects on Terrestrial and Avian Life (Ref.#s 1, 31 and 49)

This concern arises primarily from monitoring conducted in 1980 by Campbell and McConnell (Ref.# 1) in the U.K. and in 1992 by the Institute of Environmental Research in Stockholm (Ref.# 31), in both of which CP concentrations were found in a variety of terrestrial and avian species. This has raised concern that the same situation may prevail in the U.S., and has prompted the suggestion that monitoring of wildlife be undertaken here. No cost estimates have been developed.

One consideration that lends this a somewhat lower priority than the concerns expressed above is a comparison (Ref.# 49) of the residue levels found in animal tissue by both studies, with toxicity threshold levels found for animals in the literature. That comparison found the residue levels to be at least an order of magnitude lower than the toxicity thresholds.

7. Determining Distribution of CP/Os via Atmospheric and/or Aquatic Transport (Ref.#s 1 and 31)

This concern arises primarily from the Swedish work discussed above, and has led to the suggestion to monitor the environment in areas remote from industry in order to determine the presence of CP/Os. Again, no cost estimates have been developed.

The same consideration also applies here; namely, there is no evidence that environmental concentrations found anywhere except in water near industrial discharges pose any risk.

8. Assessing Potential for Dioxin Formation during Incineration of Waste Oil (Ref.# 13)

It is recommended that this concern also be brought to the attention of the Agency's Dioxin Workgroup.

III. Human Health Risk (Ref.#s 47, 48, 50, 51, 52 and 53)

Metalworkers

Cancer is the predominant human health hazard. There is no developmental toxicity risk, and the reproductive toxicity tests were inadequate to use. The major risks arise from exposures of metalworkers via inhalation of CPs in mist generated during use. There is a moderate concern for this risk, and a much lower concern for dermal exposures.

Combining risks to metalworkers from inhalation and dermal exposures yields a high end estimated upper bound of 157 U.S. excess lifetime cancer deaths.

More than 300,000 metalworkers may be exposed. Projected excess cancer cases from inhalation exposures to just the short chain CPs could be as high as one to two cases per year (or 110 cases per work lifetime) in an estimated occupational subpopulation of 160,000 workers. Exposures to the intermediate and long chain CPs are each expected to yield less than an average of one excess cancer case per year -- or as high as 28 cases per work lifetime for the intermediate chain and two for the long chain in estimated subpopulations of 41,900 and 185,000, respectively.

Risks from dermal exposures are estimated to be low because absorption is low. Risks from dermal exposures, however, are added to the inhalation risk to give a composite risk. The high end estimated risk from dermal exposures to short chain CPs is 17 lifetime excess cases which, added to the 110 for inhalation of short chain CPs and the 30 for inhalation of intermediate and long chain CPs, yields a total upper bound estimate of 157 lifetime excess cancer cases among metalworkers due to exposures to CPs.

The following exposure assumptions make this a high end estimate.

1. The number of workers exposed are derived from the National Occupational Exposure Survey. These are high-end estimates.

2. Exposures to CPs were derived from surrogate data collected by OSHA on oil mist exposure during metalworking operations. All metalworking fluids were assumed to contain 10 percent CPs. This assumption is probably an overestimate.

3. The oil mist inhalation exposures are based on actual monitoring data collected by OSHA over a 13-year period. OSHA compliance data may be biased toward the high end since they are predominantly from inspections resulting from employee complaints, or inspections of facilities targeted because of high exposures.

4. The use of personal protective equipment is unknown. In the absence of data, it was assumed protective equipment is not used.

The upper bound estimate of 157 excess lifetime cancer cases is based upon an assumed mist inhalation exposure to CPs of 1.2 mg/day. It should be noted that exposures at the OSHA oil mist PEL of 5.0 mg/m^3, under the same assumption of ten percent CP content, would be 5.0 mg/day, and would thus yield higher risks.

Subsistence Fisheaters

There is a possibility of potential cancer risks to subsistence fisheaters (indigent people whose diet consists primarily of fish they catch and eat). Modeled data indicate *individual* upper bound cancer risks could be as high as 5×10^{-4} in the highest in-stream concentration areas. The size of the populations at risk in these areas is unknown, but certainly too low to pose more than a negligible *population* risk. In addition, the model used to estimate CP releases by end-users does not take into account any possible destruction of CPs which may occur during use. The *nature* of the population (i.e., indigent) makes this a potential "environmental equity" concern.

Manufacture of Resinous Long Chain CPs

There may be an *individual* lifetime excess cancer risk as high as 10^{-3} among a very small population of workers employed in manufacturing resinous long chain CPs.

IV. Options and Recommendations

Five options were considered for closing the RM2 investigation. Irrespective of the option selected, *it is recommended that OPPT (a) refer the occupational risk to OSHA, (b) refer the dioxin issues to EPA's Dioxin Workgroup, and (c) advise Region 5 of the subsistence fish-eater risk.* These three recommendations are not separately and repetitively enumerated in the following option descriptions.

Option 1: **Close with no further action.**

Pros:

a. Action is reasonably consistent with RM2 findings.

b. *Immediately* and *definitively* closes CP/O investigation.

c. Frees OPPT resources for other purposes.

d. Avoids awkwardness of rulemaking without a strong risk case.

e. Objections from external groups are unlikely.

Cons:

a. Does nothing to reduce releases of substances known to be toxic, persistent and bioaccumulative.

b. Residual questions regarding risk remain unanswered.

c. Substances satisfying TRI criteria remain unlisted.

Option 2: **Negotiate voluntary agreements with industry to (1) promote pollution prevention practices to reduce use of short chain CPs, and to reduce discharges of CP/Os to water and, (2) conduct research -- especially surface water monitoring and sediment toxicity testing -- to address uncertainties remaining after RM2.**

Pros:

a. Accommodates concern that CP/Os are present at levels of concern in a few localities.

b. Addresses residual questions regarding risk.

c. Avoids awkwardness of rulemaking without a strong risk case.

d. Based on Survey experience, Industry may be amenable. Holding TRI listing and other steps in abeyance provides additional incentive.

Cons:

a. Leaves CP/O investigation open.

b. Requires additional OPPT resources.

c. Negotiations may not be successful.

d. Substances satisfying TRI criteria remain unlisted.

e. Voluntary written agreements may be unenforceable.

f. Voluntary agreements may yield information of uncertain quality.

Option 3: **List on TRI and close with no further action.**

Pros:

a. *Immediately* and *definitively* closes CP/O investigation.

b. TRI listing will discourage use of CP/Os.

c. Satisfies concern for listing substances that meet TRI criteria.

d. Avoids awkwardness of *risk-based* rulemaking without a strong risk case.

e. OPPT resources are freed for other purposes.

Cons:

a. Other than listing, does nothing to reduce releases of substances known to be toxic, persistent and bioaccumulative.

b. Residual questions regarding risk remain unanswered.

c. Industry may object to listing on grounds that Survey results suggest relatively little risk.

d. Industry may ask why they were encouraged to conduct the Survey -- as a potential alternative to TRI listing -- if the decision to list was to be based solely upon hazard, without regard to the Survey results ("fair play" issue).

Option 4: **List on TRI, seek funding from the Water Office to monitor CP/Os in high use areas, and add CP/Os to the Master Testing List (MTL).**

Pros:

a. TRI listing will discourage use of CP/Os.

b. Satisfies concern for listing substances that meet TRI criteria.

c. Potentially addresses residual questions regarding risk.

d. Avoids awkwardness of *risk-based* rulemaking without a strong risk case.

Cons:

a. Leaves CP/O investigation open.

b. Industry may object to listing on grounds that Survey results suggest relatively little risk.

c. Industry may raise "fair play" issue.

d. OW may be unwilling to fund monitoring.

Option 5: **Regulate aggressively with information-gathering, public notification, and restrictive authorities of SARA §313 and TSCA §§4, 8 and 6 in order to discourage use of short chain CP/Os in metalworking fluids.**

Pros:

a. Effectively and immediately closes the investigatory phase.

b. Aggressive actions will effectively discourage use of CP/Os.

c. Addresses residual questions regarding risk.

d. Results of promulgated regulations are enforceable.

e. Satisfies concern for listing substances that meet TRI criteria.

Cons:

a. Justifications for risk-based rulemakings could be hard to establish.

b. Results would take longer to achieve via rulemaking than under voluntary agreements.

c. Rulemakings would consume more OPPT resources than any of the other options.

d. Industry may object to listing on grounds that Survey results suggest relatively little risk.

e. Industry may raise the "fair play" issue.

Recommendation

Option 4: List on TRI, seek funding from the Water Office to monitor CP/Os in high use areas, and add CP/Os to the MTL. Refer the occupational risk to OSHA, and the dioxin issues to EPA's Dioxin Workgroup, and advise Region 5 of the subsistence fish-eater risk.

Discussion

TRI Listing

Listing on TRI is recommended because CP/Os satisfy the listing criteria. Although CPIA and ILMA will be unhappy about the fact that they were encouraged to undertake the Survey of Formulators (which they proposed as an alternative to listing) without being informed that the listing decision would be based solely upon hazard -- and therefore would not take the Survey results into account -- the principle of listing all substances that satisfy the TRI criteria is overriding. While this principle is considered paramount, it should be recognized that listing under these circumstances may diminish industry's enthusiasm for additional voluntary efforts.

Monitoring

As discussed earlier, eight areas were identified in which additional research could be considered. Of these, the two most important are (1) monitoring surface waters in areas with high in-stream concentrations to corroborate or refute the findings of the Survey; and (2) conducting tests to determine the toxic effects of CP/O concentrations in sediment.

There are theoretically four ways to obtain the monitoring: (1) request industry to undertake it voluntarily; (2) require industry to undertake it under a TSCA §4 rule; (3) fund it out of OPPT; or (4) ask OW to fund it. The likelihood that industry would voluntarily agree to monitoring -- without at least the credible threat of a §4 rule -- is diminished by the decision to list on TRI. A §4 test rule is conceivable, but OPPT may be unwilling to invest the necessary resources and effort. Funding the effort out of OPPT is also unlikely. While OPPT has spent about $20,000 to determine the *feasibility* of this monitoring effort, and an additional $30,000 to 40,000 will be requested for this purpose, the cost of the actual monitoring (estimated at several hundred thousand dollars) is prohibitively expensive for OPPT. That leaves the fourth possibility, of funding by OW. EETD is currently exploring whether OW can be induced to conduct this monitoring, or use their authorities to have States do so, in conjunction with EPA's Contaminated Sediment Management Strategy.

Master Testing List

The two most likely means of obtaining the sediment toxicity testing are either a voluntary agreement by industry to test, or a §4 test rule. For the reasons noted above, a voluntary undertaking seems unlikely. It is therefore recommended that CP/Os be added to the MTL.

Referral to OSHA

The most significant potential human health risk is occupational. In the absence of reliable hard data, several "high end" assumptions were applied to yield the possibility that as many as 157 excess lifetime cancer cases could occur among metalworkers. The number of cases would be much higher, moreover, if metalworkers were operating at OSHA's mist PEL. For this reason, it is recommended that the referral be strongly worded and emphatic (although not so emphatic as a §9(a) referral). Nevertheless, in view of the many other hazards associated with metalworking fluids, and their complicated nature, no referral -- regardless of how emphatic -- is likely to trigger any CP-specific action by OSHA nor, indeed, any oil mist-specific action. The question then arises as to OPPT's responsibility. One possible answer is discussed below, in the subsection entitled *Metalworking Fluid Cluster.*

Referral to Region 5

The only *potential* general population risk is to "subsistence" fish eaters -- indigent people whose primary source of food is the fish they catch. This is primarily an "environmental equity" concern. The highest estimated upper bound *individual* excess lifetime cancer risk is on the order of 5.0×10^{-4}. This is in the city estimated in the Survey as having one of the highest in-stream CP/O concentrations in the country: most other cities have far lower concentrations. When this highest individual risk is multiplied by any believable estimate of the numbers of people that might be involved, the *population* risks become negligible. Since most of the cities in question fall within the north central region, it is recommended that Region 5 be notified of the potential problem.

Referrals to Agency Dioxin Workgroup

Dioxin/furans may be generated when chlorinated substances are heated to 200° centigrade in an oxygenated environment. Since CP/O-bearing cutting fluids are by definition chlorinated substances, the possibility of inadvertently producing dioxins or furans occurs whenever the temperature of these fluids is elevated to 200°. That possibility arises in two situations: during use as cutting fluids and during incineration of spent fluids. Production during use poses a risk to metalworkers, while incineration may add to the general population risk created by incinerating chlorinated substances. It is recommended that both concerns be referred to EPA's Dioxin Workgroup, as the most appropriate body to address them.

Interchangeability of Elements within Options

Each of the five options lays out a broad approach, ranging from what is close to a pure "drop" through (a) negotiated voluntary agreements; (b) listing on SARA §313; (c) listing plus in-house monitoring and rule-generated testing; and, finally, to (d) aggressive regulation under multiple authorities. While it is possible to "mix and match" elements from different options to some extent, each option basically reflects a different judgment about (a) the degree of risk; (b) the importance of reducing that risk; (c) the importance of obtaining more information about the risk; (d) the importance of listing CP/Os on TRI; and (e) the value of fostering industry's interest in voluntary promoting good stewardship, waste minimization and further research. Given the risk case, a "presents or will present" finding could be hard to make. Rulemaking under Option Five may therefore be largely limited to listing on TRI and information-gathering. In this light, Option Four can be viewed as a "do-able" sub-set of Option Five, with built-in mechanisms to determine whether the game is worth the candle. Option Three reflects an opinion that the game is *not* worth the candle *if* OPPT and/or OW have to expend significant extrtamural or FTE resources. Option Two would seek to induce industry to undertake both risk reduction and information-gathering efforts, but such cooperation may be hard to come by if, as in Options Three through Five, CP/Os are listed. Option One is essentially a drop with an *emphatic* referral to OSHA.

Metalworking Fluid Cluster

The CP/O investigation has historically focussed primarily upon ecological risks, and the options presented largely reflect that concern. The recent RM2 finding that there may be significant *occupational* risks raises the question of the appropriate OPPT response. A referral OSHA is straightforward but is frankly unlikely to move that Administration to do anything they would not have done anyway. Assuming that whatever OSHA did was considered inadequate -- and further assuming that OPPT considers itself responsible for reducing the residual *occupational* risk -- what should the Office do?

One possibility would be to enter "metalworking fluids", *qua* metalworking fluids, into the Design for the Environment (DfE)/Use Cluster hopper, for a possible start in FY 94 or 95. The arguments for this include:

1. the CP/O investigation could be closed;

2. many components in metalworking fluids pose human health risks, and CPs are probably not the most significant;

3. solutions to occupational exposures may entail remedies other than eliminating constituent parts; and

4. listing CP/Os on TRI would not be a disadvantage, because (a) OPPT would not be focusing exclusively upon CP/Os, and (b) the Office would be negotiating agreements with metalworking fluid formulators and end-users, rather than CP/O producers.

Appendix 1: Foreign Assessments

Selected Quotes in Eleven Topic Areas Culled from Assessments of Chlorinated Paraffins by Environmental Agencies in Finland (Ref.# 6), The Netherlands (Ref.# 12) and The United Kingdom (Ref.# 18)

Overall level of Concern

Finland:

"It may be concluded that the environmental hazard caused by CPs in Finland is rather small." (p. 36)

The Netherlands:

"Environmental concentrations in the Netherlands are expected not to exceed (maximum permissible concentrations)". (p. IV)

"Based on scanty information on exposure and effect levels it is concluded that chlorinated paraffins do not seem to present a significant risk to humans or ecosystems in The Netherlands." (p. 43)

"In spite of the lack of data, the risk of chlorinated paraffins at the present assumed level of emissions is considered small, if present at all." (p.41)

The United Kingdom:

"Chlorinated paraffins are generally of moderate toxicity to aquatic organisms and are unlikely to cause problems in aquatic ecosystems unless spills of the chemical occur. Short chain length paraffins with a low level of chlorination do pose a hazard to aquatic invertebrates." (Summary)

"Chlorinated paraffins are, generally, only moderately toxic to aquatic organisms but in certain cases, such as *Daphnia magna*, do pose a definable hazard during usage. Temporary risk to aquatic organisms is possible from large spills." (p. 39)

"The levels of chlorinated paraffins found in waters close to industry could cause potential effects in fish over a long period of exposure." (p. 39)

General State of Knowledge

Finland:

"The occurrence of CPs in the environment is still limited and consequently, no risk conclusions can be drawn" (p.16).

The Netherlands:

"Information on the effects of chlorinated paraffins is scarce whereas data on exposure in The Netherlands are lacking. This lack of information seriously hampers a sound risk evaluation." (p. 40)

The United Kingdom:

"The information on chlorinated paraffins is fairly comprehensive except for a lack of information atmospheric levels." (p. 39)

Regulations and Recommendations

Finland:

"Without any data on the presence of CPs in the Finnish biota and on the basis of limited information obtained from the recent literature survey, it is impossible to draw any definite conclusions on the hazardous effects or the degree of accumulation of CPs in the Finnish environment. However, due to the relatively small consumption and the low water solubility of the CPs, the environmental hazards would seem to be rather small. On the other hand, CPs are one of the many harmful sources of chlorinated products. Therefore, the following studies are recommended to be done the near future:

- Measurements of dioxin formation in steel industry and, if needed, investigations of dioxine sources.
- Measurements of Adsorbable Organic Halogens (AOX) in effluents and sediments near some metal, plastic and paint factories and, if needed, investigation of the sources of chlorinated substances.
- Measurements of AOX in leachates from landfills and, if needed, identification of the main chlorinated compounds.
- Studies of pH dependency of chlorinated substances in leachates." (pp. 34-35)

The Netherlands:

"There are no standards and guidelines for chlorinated paraffins in force in The Netherlands. (p. 2)

"Chlorinated paraffins are not considered 'black-list' substances or 'priority substances', but have been placed on the list of 'attention substances'." (p. 2)

"...since chlorinated paraffins are rather toxic (especially those with a short carbon chain and a high chlorine content) and may be persistent under natural conditions, these compounds may need further attention. In order to indicate the potential exposure it is recommended to make an inventory of the use and associated release of (short chain) chlorinated paraffins in The Netherlands, and preferably in Europe." (p. 43)

The United Kingdom:

"Chlorinated paraffins, as organohalogen compounds, have been identified by the Commission of the European Communities as being potential List II candidates, as defined under the Dangerous Substances Directive."

"Chlorinated paraffins, as organohalogen compounds, have also been identified by the Commission of the European Communities as being potential List I candidates, as defined under the Protection of Groundwater Against Pollution Caused by Certain Dangerous Substances Directive."

"The UK Environmental Protection...Regulations 1991 has identified chlorinated paraffins, as halogenated compounds, as a risk group of substances for release into land and the air."

"Chlorinated paraffins were identified as one of the priority substances for the discussion at the Fourth International Conference on the Protection of the North Sea." (p. 1)

Ecological Toxic Thresholds

Finland:

"There is limited information on the behavior and effects of CPs on aquatic biota." (p. 31)

The Netherlands:

"For the aquatic environment a tentative maximum permissible concentration of 1 $\mu g.l^{-1}$ has been derived for the shorter chain grades ($C \leq 17$), based on LC50-values for crustaceans which appear to much more sensitive than fish." (p. 40)

The United Kingdom:

"Long term studies with rainbow trout have shown mortality to occur at 10μg/l after 47 days for Cereclor 42 and at 10μg/l after 71 days for Chlorez 700." (p. 38)

In a continuous flow experiment over 21 days, complete mortality of *Daphnia magna* occurred at 16.3μg/l within 6 days. A static study led to a calculated 48 hour EC_{50} for immobilization of 550μg/l. Comparing the figure at which complete mortality occurred with the measured water concentrations used...it can be seen the LC_{100} /concentration ratio is of the order 32.6 for the general case and 2.72 for the worst case data." (p. 38)

Water Concentrations

Finland:

"In Finland, no data is available on the degree of CP contamination of lakes and rivers, sediments, fish and mammals." (p. 33)

"It may be assumed that, due to their low water solubility and pattern of use, only small amounts of CPs reach the aquatic environment with industrial effluents." (pp. 33-34)

The Netherlands:

"No figures for the occurrence of CPs in the Dutch environment have been found." (p. IV)

"The predicted concentration in The Netherlands was estimated to be far below the detection limit: about 0.001 $\mu g.l^{-1}$, corresponding to about 0.007 $\mu g.l^{-1}$ in surface water containing 30 mg of suspended matter per l." (p. 11)

The United Kingdom:

"Half the (marine) waters (sampled by Campbell and McConnell in 1980) show C_{10-20} chlorinated paraffins at 0.5-4 μg/l...chlorinated paraffin levels in non-marine and fresh waters in industry free areas...range from 0-1μg/l...(levels in) waters receiving industrial/domestic effluent are 1-6μg/l." (p. 16)

Transportation in the Environment

Finland:

"Chlorinated paraffins are non-volatile and highly lipophilic, which restricts their transportation in the environment. Since they are easily adsorbed to suspended solids in industrial effluents, they are likely to be found in sediments near the discharge point." (p. 19)

The Netherlands:

"... it is concluded that advective transport and transformation of chlorinated paraffins may play a relatively important role." (p. 10)

"Campbell and McConnell stated that because of the involatility the CPs cannot be transported and dispersed by atmospheric air movements and assumed that transport by water probably is the only large-scale dispersion mechanism. This contradicts with the McKay model calculations in this report, indicating that advective import and export through air is very important. It also is disagreement with their (Campbell & McConnell's) suggestion that the concentrations of chlorinated paraffins in sediments (up to 1.0 $mg.kg^{-1}$) in remoter areas may be due to atmospheric transport of chlorinated paraffins from the source area." (p. 13)

The United Kingdom:

"No experimental data could be found, in the literature, for distribution of chlorinated paraffins in the environment. " (p. 13)

"Products containing chlorinated paraffins are likely to be disposed of to landfills and to a lesser extent by incineration. The latter process should result in complete destruction of chlorinated paraffin material because of its relatively low thermal stability. Removal from products in landfills by leaching is likely to be slow..." (pp. 7-8)

"...low water solubility and tight binding to sediment would suggest that chlorinated paraffins probably are not leached through soils at appreciable rates." (p. 9)

"...because of the low vapor pressure and low thermal stability (destroyed before volatilized), evaporation and atmospheric transport probably have a very small role in the distribution of chlorinated paraffins in the environment." (p. 9)

Persistence and Degradation

Finland:

"An extensive study was taken up by Zitko & Arsenault on the biodegradation of CPs in the estuarine sediments. They observed that degradation is maximal in sediments under anaerobic conditions." (p. 19)

"The longer the carbon chain, the slower the biodegradation." (p. 19)

The Netherlands:

"Information on the persistence and bioconcentration is scanty. CPs are expected to (bio)degrade in sediment and soil, whereas secondary photolysis in the atmosphere cannot be ruled out. Reported calculated half-life times are approx. 5 days and 1 day, respectively. However, the actual half-life times in the natural environment will be much lower. The biodegradation rate has been shown to decrease with increasing carbon length and chlorine content. (p. IV)

The United Kingdom:

"...it would appear that chlorinated paraffins do not undergo hydrolysis, oxidation or otherwise react at significant rates under ambient temperature and relatively neutral conditions. Thus it would appear that these compounds are fairly chemically stable under environmental conditions.

* * *

However, the chlorinated paraffins can be catalytically dehydrochlorinated in the presence of iron oxides as well as other inorganic compounds and the possibility of this process occurring in nature seems quite feasible. Unfortunately, no experimental data are available on the chemical stability of chlorinated paraffins under simulated environmental conditions." (p. 11)

"Chlorinated paraffins were found to degrade under both aerobic and anaerobic conditions. Biodegradation occurred more rapidly under anaerobic conditions. It was concluded that extensive biodegradation, in the environment, could be envisaged for chlorinated paraffin grades containing less 50% Cl." (p. 13)

"Biodegradation was...found to be dependent on the structure of the compound being tested as well as the degree of chlorination. Shorter chain length paraffins with low levels of chlorination were found to be degraded rapidly and completely. Biodegradation occurred more rapidly under anaerobic conditions than under aerobic conditions. (Summary)

Substances of Concern

Finland:

"It is believed that short chain CPs cause toxic and physiological effects at lower exposure rates than do long chain CPs." (p. 32)

The Netherlands:

"The toxicity of CPs is inversely related to chain length. Therefore in risk evaluation the attention has primarily been focused on the shorter chain grades." (p.IV)

"The bioconcentration factor decreases with increasing molecular weight and decreasing lipophilicity; short-chain CPs with a high level of chlorination show the highest accumulation/retention potential. However, the relatively low levels found in higher organisms do not indicate the occurrence of biomagnification." (p. IV)

The United Kingdom:

"There appear to be differences between short and long chain chlorinated paraffins and also differences also occur due to degree of chlorination of a particular paraffin. LC_{50} values in fish are lowest for short chain length paraffins with a low level of chlorination. It was found that short chain length paraffins (C_{10-13}) with a low level chlorination had the highest uptake in the bleak." (p. 39)

Dioxin Formation

Finland:

"The total emission of dioxins from Finnish incineration plants is about 3 g y^{-1}. * * * The dioxin emissions are not caused only by CPs but also by other chlorine containing wastes." (p. 34)

The Netherlands:

No references.

The United Kingdom:

No references.

Sources of Release

Finland:

"Due to lack of measurements, the route of chlorinated paraffins (CPs) to the Finnish environment are not yet known. Consumption patterns and the low water solubility of CPs suggest that the main part of CPs are bound to products or end up at landfills. (p. 36)

"The routes of CPs into the Finnish environment are not very well known. It may be assumed that, due to their low water solubility and pattern of use, only small amounts of CPs reach the aquatic environment with industrial effluents. Furthermore, due to their low solubility in water, CPs are rapidly accumulated in sediments and possibly also in biota. A greater part is brought to landfills where paints, plastics, cutting oils and other wastes are deposited. Leaching of CPs from landfills is believed to be a slow process. However, there have been no thorough studies on leaching of CPs from landfills. Minor quantities of CP-containing wastes are incinerated in the waste treatment plant in Riihimëki and Turku, and some cutting oils in scraps end up in the steel industry in Finland." (p. 34)

"It is believed that during waste incineration CPs, due to their low thermal stability, will not escape as exhaust gases. CPs decompose at temperatures between 300 and 400 °C whereas the decomposition temperature of PCBs is about 800 ° C." (p. 28)

The Netherlands:

"...no emission data on CPs in the Netherlands are available. * * * The major emissions are likely to occur through use and disposal of products containing chlorinated paraffins." (p. IV)

The United Kingdom:

"Chlorinated paraffins are released to the environment mainly as a result of consumption and disposal losses. No release figures were available for the UK." (Summary)

"The major environmental release of chlorinated paraffins comes from the use and disposal of products which contain them. This occurs through use, through disposal to landfill, or through discarded lubricant oils being washed into watercourses." (p. 8)

Production and Use

Finland:

"No chlorinated paraffins are produced in Finland." (p.20) [The major use (68 percent) in Finland is in special paper production. Only four percent is used in cutting fluids.] (pp. 22-23)

The Netherlands:

"In the Netherlands no production of CPs takes place. The major application in the Netherlands is their use as a secondary plasticizer for PVC. Other applications are plasticizer, lubricants and flame retardants applied in paints, coatings, rubber, oils, etc.

[In The Netherlands use of CPs as a secondary plasticizer in PVC accounts for 70 percent of total consumption.] (p. 4)]

The United Kingdom:

"Only one plant produces chlorinated paraffins in the United Kingdom at Runcorn, Cheshire. The annual production of chlorinated paraffins in the UK is approximately 50kT." (Summary)

"The main use for chlorinated paraffins in the UK is currently as a secondary plasticizer for flexible PVC." (p. 6)

"Non PVC applications of CPs are numerous and diverse, but can be summarized as utilizing their properties as plasticisers, lubricants and flame retardants..." (p. 6)

"One important factor is that about 50% of the chlorinated paraffins used as extreme-pressure additives belong to the group that is most environmentally hazardous, i.e., the group having a chain length of $C_{10\text{-}13}$." (p. 6)

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