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Public Health Assessment
Reich Farm, Dover Township, Ocean County, NJ

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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
BEHP	bis(2-ethylhexyl) phthalate
CACCCC	Citizens' Action Committee on Childhood Cancer Cluster
CCE	carbon/chloroform extractable
CCl4/IR	carbon tetrachloride extraction/infrared absorption
CREG	Cancer Risk Evaluation Guideline
DTBH	Dover Township Board of Health
DTML	Dover Township Municipal Landfill
EMEG	Environmental Media Evaluation Guide
ESD	Explanation of Significant Difference
HSL	Hazardous Substance List
IARC	International Agency for Research on Cancer
MRL	minimal risk level
ND	not detected
NIEHS	National Institute for Environmental Health Sciences
NJDEP	New Jersey Department of Environmental Protection
NJDHSS	New Jersey Department of Health and Senior Services
MCL	maximum contaminant level
OCHD	Ocean County Health Department
PCE	perchloroethylene (tetrachloroethylene)
PHAP	Public Health Action Plan
PHRP	Public Health Response Plan
ppb	parts per billion
ppm	parts per million
RF	Reich Farm
RfD	reference dose
RI/FS	Remedial Investigation/Feasibility Study
RMEG	Reference Dose Media Evaluation Guide
ROD	Record of Decision
SAN trimer	styrene-acrylonitrile trimer
SVOC	semi-volatile organic chemical
TCE	trichloroethylene
TCL	Target Compound List
TOC	total organic carbon
TRWC	Toms River Water Company
UCC	Union Carbide Corporation
USEPA	United States Environmental Protection Agency
UWTR	United Water Toms River

UWTR	United Water Toms River
VOC	volatile organic chemical

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Summary

In response to concerns of the Dover Township community regarding an increased incidence of childhood cancers, the New Jersey Department of Health and Senior Services (NJDHSS) and the Agency for Toxic Substances and Disease Registry (ATSDR) developed a Public Health Response Plan to organize and conduct public health investigations. In addition to evaluating the chemical and radiological quality of the community water supply and analyzing New Jersey State Cancer Registry statistics, the NJDHSS and the ATSDR initiated Public Health Assessments for two National Priorities List sites which are located in Dover Township: Reich Farm (RF; CERCLIS #NJD980529713) and Ciba-Geigy Corporation (CERCLIS #NJD001502517). Based upon information collected by the NJDHSS and the ATSDR during health assessment activities for the RF site, and a high level of community concern, the NJDHSS and the ATSDR also began a Public Health Assessment to evaluate the public health issues associated with the Dover Township Municipal Landfill (CERCLIS #NJD980771570). The Public Health Assessments provide a review of environmental health issues and evaluate past and current human exposure pathways associated with these sites.

Bulk and drummed chemical wastes originating at the Union Carbide Corporation (UCC) facility in Bound Brook, New Jersey were deposited, by a waste hauler contracted by the UCC, at both the RF site and the DTML in late 1971. Wastes at the RF site have migrated through groundwater and impacted private and community water supply wells with volatile and semi-volatile organic chemicals. While private well contamination is documented as early as 1974, contamination of certain wells at the Parkway well field of the community water supply was not documented until 1986. However, hydrologic models predict that contaminated groundwater may have reached the Parkway well field beginning some time in the period 1976 to 1981.

The chemical composition of the groundwater contamination in the past is not well characterized, but a variety of chemicals including trichloroethylene (TCE), tetrachloroethylene (PCE), and a previously unknown material -- styrene-acrylonitrile (SAN) trimer -- have been found in the plume. Although a toxicological evaluation of levels of exposure to known contaminants did not suggest that adverse health effects are likely, this evaluation is based on limited historical environmental data. Much uncertainty exists concerning the composition, levels, and toxicologic characteristics of past exposure to contaminated private and community water supplies. Therefore, although it cannot be documented, the public health significance of past exposures related to the Reich Farm site may have been greater than is apparent from the toxicological evaluation of the levels of known contaminants performed in the Public Health Assessment.

The Reich Farm site is therefore considered by the ATSDR and the NJDHSS to have represented a **public health hazard because of past exposures**. This determination is based on the following considerations, taken together: 1) the presence of completed exposure pathways in the past (through private and community water supplies) to volatile organic chemicals (including PCE and TCE) and other chemicals, to a potentially large exposed population; 2) epidemiological studies in other communities suggesting that exposure to TCE and PCE may increase the risk of certain childhood cancers and adverse neurological effects; and 3) the presence of an excess of childhood cancers in the community.

Current conditions indicate that exposure to contaminants from the RF site is no longer occurring. The exposure pathway through private well use was interrupted by the establishment of a well restriction zone, and there is no indication that private wells are still in use for potable purposes in the area above the RF plume. The exposure pathway through the community water supply has been interrupted by the diversion and treatment of contaminated water from wells #26 and #28 at the Parkway well field, and the recent installation of treatment for well #29, which has shown sporadic RF-related contamination. (Treatment was also extended to the nearby well #22 as a precaution.) However, treated output from wells #26 and #28 may be pumped into the community water supply in times of high water demand. Containment of the RF-related groundwater plume through effective management of the Parkway well field is critical to ensure that currently unaffected wells remain so. In addition, proper operation of the treatment systems in place is necessary to reduce or eliminate the entry of RF-related contaminants into the distribution system. On-going water monitoring is needed to document the effectiveness of well field management and treatment systems. For these reasons, the ATSDR and the NJDHSS are categorizing the RF site as **no apparent public health hazard under present conditions**. Should NJDHSS or ATSDR become aware of information indicating that RF-related exposure is still occurring, or if private wells are still in use in the plume area, this determination will be reconsidered.

Further epidemiologic and toxicologic evaluations are warranted in order to evaluate the public health significance of past risks posed by the site. The NJDHSS and the ATSDR are conducting an epidemiologic study of childhood cancer in Dover Township. This Public Health Assessment supports the consideration of exposure pathways related to the RF site in that study. In addition, a working group of Federal and State public health and environmental agencies is coordinating the development of toxicologic studies of styrene-acrylonitrile trimer to understand better the public health implications of completed exposure pathways at the RF site.

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Purpose and Health Issues

As part of the Public Health Response Plan (PHRP) developed by New Jersey Department of Health and Senior Services (NJDHSS) and the Agency for Toxic Substances and Disease Registry (ATSDR) for the Dover Township Childhood Cancer Investigation (NJDHSS/ATSDR, 1996), this Public Health Assessment will document and evaluate the public health significance of human exposure pathways associated with the Reich Farm (RF) site.

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Background

Demography and Land Use

The RF site (CERCLIS #NJD980529713) is located in Dover Township, Ocean County, New Jersey (see inset), 500 feet east of New Jersey State Highway 9 and 1,000 feet south of Church Rd. The RF site occupies an area of approximately three acres, with an additional 12 acres included within the scope of past remedial investigations. The site lies 8.4 miles west of the Atlantic Ocean, with the elevation of the site ranging from 65 to 80 feet above mean sea level. The site slopes slightly toward the southwest, and there are wooded areas to the north and east. Soils at the RF site are sandy with minimal loose topsoil, and exhibit a relatively high percolation rate as compared to other soils in the State. The environs of the site are primarily light commercial and residential. There are one story structures immediately adjacent to the site occupied by active businesses.

The Kirkwood-Cohansey geologic formation which underlies the RF site, is characterized by sand with clay and gravel lenses, and ranges to a depth of approximately 200 feet. The Cohansey is the shallower aquifer associated with this formation, with the water table at the site found at a depth of approximately 30 feet below grade. There is a direct hydraulic connection between the Cohansey and the deeper Kirkwood water bearing formation. Estimates by the United States Environmental Protection Agency (USEPA) of the rate of groundwater flow in the area of the RF range from 0.93 feet per day (340 feet per year) to 1.6 feet per day (580 feet per year) (NUS, 1986; Ebasco, 1988a). The Kirkwood-Cohansey aquifer is extensively utilized as a potable water source in the area of the RF site by both private and community supply wells. Groundwater in the area of the RF site is acidic (median pH = 5.3), and exhibits a relatively high concentration of dissolved iron and manganese.

Population demographics based upon the 1990 census have been prepared by the ATSDR using area-proportion spatial analysis, and are presented in Figure 1 (see Appendix for figures). ATSDR estimates that within a one mile radius of the RF site, there is a population of approximately 3,700 persons, and 240 housing units.

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Site History

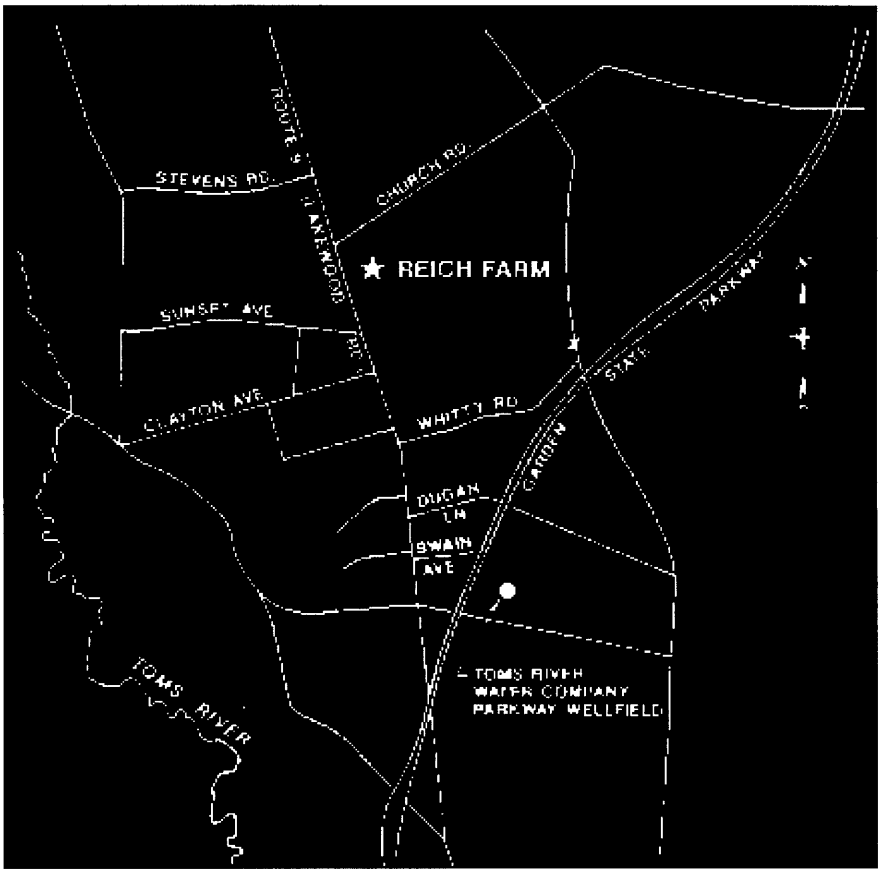
In early 1971, the Union Carbide Corporation (UCC) entered into a contract with an independent waste removal contractor to transport 55 gallon drums of chemical wastes from the Bound Brook facility to the Dover Township Municipal Landfill (DTML) for disposal (Ghassemi, 1976). Between March and December 1971, 5,000 to 6,000 drums labeled as containing organic wash solvents, still bottoms, and residues from the manufacture of plastics and resins were removed from the UCC facility by the contractor for disposal. These wastes were reported to contain aromatic hydrocarbons, phenols, halogenated aliphatic hydrocarbons, polymeric resins and unspecified petrochemicals (Ghassemi, 1976). Table 1 (see Appendix for tables) lists general descriptions of UCC wastes found on the RF site.

In August 1971, the waste removal contractor leased a portion of the RF property from the owner on the premise of storing empty drums on the site. In December 1971, the owners of the RF property noticed unusual chemical odors emanating from the portion of the property leased to the waste removal contractor. Visual inspection revealed the presence of drummed chemical wastes and trenches where bulk chemical wastes had been discharged (NUS, 1986). On December 15, 1971, UCC was notified by the owner of the RF property of the presence of thousands of drums bearing UCC labels on the RF site. The waste removal contractor had illegally deposited approximately 4,500 drums on the RF site without the knowledge of the property owner or the UCC. Upon notification of the presence of their drums on the RF property, the UCC immediately terminated their agreement with the waste hauler.

Of the 5,000 to 6,000 drums removed by the waste removal contractor, only some 4,500 were reportedly accounted for on the RF property. Approximately 10% of the drums located on the RF property were partially or completely empty, suggesting that contained wastes were discharged on-site (NUS, 1986). The remainder of the drums removed from the UCC facility were assumed by the USEPA to have been deposited in the DTML, or possibly were emptied on the RF site after which the empty drums were salvaged (Ghassemi, 1976). Figure 2 presents the relative locations of the RF and the DTML.

The RF property owners and the Dover Township Board of Health (DTBH) initiated a court action requesting that UCC remove the drums from the RF property. From February through April 1972, the UCC performed an initial removal of most of the drums on the RF site back to the UCC Bound Brook Facility (Ghassemi, 1976; NUS, 1986). At this time, drums were also taken by the UCC to locations in and out of State for burial or incineration. In June 1974, approximately 51 additional drums and approximately 1,100 cubic yards of contaminated soil were removed from the RF site by the UCC and transferred

to the Kin-Buc Landfill in Edison, New Jersey (Ghassemi, 1976; NUS, 1986). In addition, 37 UCC drums were discovered stored in two trailer trucks (belonging to the contracted waste hauler) which were parked in Dover Township (at Brookside Drive and Brier Avenue). These drums were also removed by the UCC.



Deposition of wastes at the RF site resulted in contamination of the underlying Cohansey aquifer. Beginning in 1974, approximately 2 years after the discovery of drums on the site, off-site migration of contaminated groundwater resulted in the condemnation of 148 private wells in the Pleasant Plains section of Dover Township, and a DTBH ordinance restricting the use of private wells in the area (see Figure 3). This contamination was identified as associated with the RF site by the USEPA and the NJDEP (Ghassemi, 1976; NJDEP, 1974). In addition, site-related contamination subsequently affected the Parkway well field of the community water purveyor (the Toms River Water Company, later United Water Toms River) located approximately one mile from the RF site (see inset). The chronology of the RF site's impact on both private and community water supplies, and the resultant public health implications are discussed in the "Environmental Contamination" and "Public Health Implications" sections of this Public Health Assessment.

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Health Assessment Activity Summary

The ATSDR conducted a Public Health Assessment of the RF site in April 1989 (ATSDR, 1989a), and concluded that the RF site represented ". . .a potential public health concern because of potential exposure to hazardous substances at levels that may result in adverse health effects over time." This conclusion was based upon a potential human exposure pathway to various volatile organic compounds, semi-volatile organic compounds, and heavy metals through oral and/or dermal exposure to contaminated groundwater. More recent evaluations of the data confirm this conclusion with respect to site-related volatile and semi-volatile compounds, but not with respect to ingestion of heavy metals, which do not appear to be site-related. A comprehensive evaluation of human exposure pathways is presented in the "Pathways Analysis" section of this Public Health Assessment.

The 1989 Public Health Assessment further concluded that the remedial actions proposed in the USEPA's Record of Decision (ROD) for the RF site appear to be protective of the public health (USEPA, 1988). Subsequent to the release of the Public Health Assessment, the USEPA issued an Explanation of Significant Difference (ESD) for remedies regarding the RF site as discussed in the 1985 Remedial Investigation/Feasibility Study (RI/FS) (NUS, 1985a). The ESD (USEPA, 1995), which presented a modification to the originally selected remedy for groundwater contamination, was not reviewed by the ATSDR.

The 1989 Public Health Assessment recommended that private wells in areas potentially affected by the RF site be monitored. This recommendation was satisfied as part of the activities performed for the present Public Health Assessment. The NJDHSS and the ATSDR have reviewed private well data associated with the Pleasant Plains section of Dover

Township (the area denoted in the 1974 well restriction ordinance; proximal to the RF site; see Figure 3). Areas near the DTML (the Silverton Road Groundwater Investigation and the Silverton Private Well Contamination Investigation) are evaluated in a separate Public Health Assessment. In addition, in support of this Public Health Assessment, the NJDHSS and the ATSDR have conducted an exposure investigation of potentially affected private potable wells in Dover Township to determine current groundwater quality (see Figure 4). The nature and extent of groundwater contamination in the RF study area and consequent public health implications are discussed in the "Environmental Contamination", "Pathways Analysis" and "Public Health Implications" sections of this Public Health Assessment.

In the 1989 Public Health Assessment, the ATSDR did not make a specific recommendation for follow-up health study activities, citing insufficient human exposure data. The document further stated that should data become available suggesting that human exposure to hazardous substances is occurring at a level of public health significance, the site would be evaluated for follow-up health studies. Based in part on findings related to the development of this Public Health Assessment, and in response to concerns regarding childhood cancer incidence in Dover Township, the NJDHSS and the ATSDR are currently conducting an epidemiologic study of childhood cancer in Dover Township which will consider relevant completed human exposure pathway information including, but not limited to, the RF site.

In October 1993, the ATSDR released a Lead Initiative Summary Report (ATSDR, 1993a). This report did not identify a RF site-related lead hazard associated with groundwater. The report concluded that lead levels detected in private wells, which were cited in the ATSDR's 1989 Public Health Assessment, were the result of corrosion of household plumbing by acidic groundwater, or an unidentified circumstance at individual residences. The Lead Initiative Summary Report recommended additional groundwater monitoring for lead.

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Site Visits

As part of the activities conducted in support of this Public Health Assessment, staff of the NJDHSS and the ATSDR performed multiple visits of the RF site and other locations within Dover Township during 1996, 1997, 1998, and 1999.

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Community Concerns

The discovery of contamination at the RF site and the consequent impact to area groundwater quality have resulted in a high level of community concern and media attention over the years. Residents of Dover Township have also expressed concern about the incidence of childhood cancer in the community. In the summer of 1995, the ATSDR asked the NJDHSS to perform an analysis of childhood cancer statistics for the township. The NJDHSS found an elevated occurrence of certain childhood cancers.

Community concerns about this finding led the ATSDR and the NJDHSS to formulate a multi-activity Public Health Response Plan (PHRP) in June 1996 (NJDHSS/ATSDR, 1996). The PHRP included an updating and reevaluation of information on childhood cancer incidence and assessments of environmental issues of concern to the community. Originally included in the PHRP were Public Health Assessments of the RF site and the Ciba-Geigy Corporation site (CERCLIS #NJD001502517); subsequently, the NJDHSS and the ATDSR added a third Public Health Assessment for the DTML site (CERCLIS #NJD980771570). The PHRP also included a Public Health Consultation, performed jointly with the NJDEP, that evaluates extensive water quality testing data from the community water system in Dover Township.

Other activities of the PHRP are the development of a community and health professionals education program (see "Public Health Action Plan" section), compilation of a compendium of environmental contamination sources in Dover Township, and inclusion of New Jersey in a multi-state study of brain cancer incidence in proximity to National Priorities List sites.

Since March 1996, the NJDHSS and the ATSDR have participated in monthly public meetings of the Citizens Action Committee on Childhood Cancer Cluster (CACCCC) in order to discuss progress toward implementation of the PHRP, cancer incidence, environmental sampling data, and community concerns related to the on-going investigation.

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Statement of Issues

Based upon past and current data on the RF site, and other environmental concerns communicated to the NJDHSS and the ATSDR, this Public Health Assessment will address the following issues:

Exposure Pathways Associated With Private Wells

This Public Health Assessment will evaluate the potential public health significance of past and present exposure pathways associated with private well water quality in areas of Dover Township near the RF site.

Exposure Pathways Associated With Community Water System Wells

Several wells in the United Water Toms River's Parkway well field have been, and continue to be, impacted by RF

site-related contamination. This Public Health Assessment will evaluate the potential public health significance of exposure pathways associated with these community water supply wells.

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Discussion

This Discussion will review the history of remedial activities conducted in relation to the RF site and the findings of investigations of environmental contamination. Based on these findings, an analysis of exposure pathways will be presented. The Discussion will conclude with an assessment of the public health implications of completed exposure pathways.

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Remedial History

Subsequent to the unauthorized deposition of wastes on the RF property, the UCC removed all visible drums in 1972. In addition, buried drums and 1,100 cubic yards of contaminated soils were removed in 1974 under the supervision of the NJDEP. In 1982, the USEPA included the RF site on the National Priorities List of sites being remediated under the Superfund program.

A Remedial Investigation (RI) was performed for the RF site by the NUS Corporation for the USEPA in 1986 (NUS, 1986; NUS, 1985a; NUS, 1985b). A supplemental Remedial Investigation and Feasibility Study (RI/FS) was completed for the RF site by the Ebasco Corporation in 1988 (Ebasco, 1988a; Ebasco, 1988b; Ebasco, 1988c). The remedial investigations confirmed the presence of on-site soil and on-site and off-site groundwater contamination (see "Environmental Contamination" section below). Goals of the remedial actions were listed as reduction of volatile organic compounds (VOCs) in groundwater (for example, trichloroethylene to less than 1 part per billion, or ppb), reduction of VOCs to less than 1 part per million (ppm) in soils, reduction of bis(2-ethylhexyl) phthalate (BEHP) to less than 10 ppm in soils, and prevention of contaminant transport from soils to groundwater.

In response to the discovery of contamination of certain wells at the Parkway well field, the TRWC installed a packed tower aeration (air stripper) treatment system for the output of two wells (#26 and #28) at the well field in 1988, as a treatment method to remove VOC contamination.

In September 1988, the USEPA issued a Record of Decision (ROD) for the RF site describing the selected remedy for the contaminated soils and groundwater (USEPA, 1988). The ROD specified additional soil and groundwater sampling to further delineate contaminants, the excavation and thermal desorption of VOCs and semi-volatile organic compounds (SVOCs) from contaminated soils, and the installation of a groundwater pumping, treatment, and re-injection system designed to remove VOCs. The excavation and treatment of over 14,000 cubic yards of contaminated soils was completed by the USEPA in May 1995.

Subsequent to the ROD, the UCC conducted predesign activities from 1991 to 1993 (Malcolm Pirnie, 1992; Malcolm Pirnie, 1993). The predesign groundwater evaluation led the USEPA to a reevaluation of the state of the groundwater contamination. It was determined that a contaminant plume existed which extended beyond the RF site's boundary, which consequently made on-site pumping, treatment, and re-injection of groundwater unfeasible.

The contaminant plume was documented as extending to the Parkway well field of the United Water Toms River (UWTR) community water supplier (formerly Toms River Water Company, or TRWC). The plume was estimated to have been approximately 400 feet wide at the RF site, and approximately 1,500 feet wide at the Parkway well field. In 1993, the centroid of the plume was estimated to be 700 feet up-gradient of the Parkway well field, with 50 percent of the contaminant mass in the aquifer estimated to be 4,000 feet south of the RF site in the vicinity of Dugan Lane, approximately 1,000 feet up-gradient of the Parkway well field. The high rate of pumpage at the Parkway well field was influencing the movement and spatial distribution of the contaminant plume (see Figure 8).

In September 1995, the USEPA issued an Explanation of Significant Difference (ESD) which modified the groundwater remedy selected in the 1988 ROD (USEPA,1995). This document presented USEPA's decision to abandon plans for an up-gradient groundwater treatment system. Instead, the existing Parkway well field wells and treatment system would continue to be used to capture and treat the groundwater plume emanating from the RF site. In addition, the treated groundwater would not be re-injected, but instead would continue to be distributed to the community water supply, dependent upon water quality meeting Federal and State drinking water standards. Based upon the predesign evaluation (Malcolm Pirnie, 1993), the USEPA concluded that air stripping alone was necessary to meet New Jersey's drinking water standards. As part of the ESD, the UCC agreed to finance the operation and maintenance of the UWTR air stripper and committed to a program of effectiveness monitoring for the treatment system at the well field.

In 1996, RF site-related non-target semi-volatile compounds were discovered by the NJDEP (in conjunction with the laboratories of the USEPA and the NJDHSS) in water from two wells (#26 and #28) of the Parkway well field (see "Environmental Contamination" section below). As a result, the entire Parkway well field was temporarily taken out of service in November 1996. The treatment system for wells #26 and #28 was then enhanced to include activated carbon contactors for the removal of organic chemicals. Wells #26 and #28 (and a new well #26B installed in late June 1999) are considered to be controlling the RF plume, with their effluent being treated and pumped to waste. (In times of high water demand, treated output from wells #26 and #28 may be pumped to the Parkway well field point of entry.) Well #29 has also

shown evidence of sporadic contamination by the RF plume. In response to detected contamination in this well in July 1998 (see "Environmental Contamination" section below), the State of New Jersey provided for the construction of additional activated carbon treatment for well #29 and the nearby well #22. Treatment was initiated in June 1999, with treated water entering the UWTR distribution system.

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Environmental Contamination

Environmental contamination concerns at the RF site have included on-site soils and both on-site and off-site groundwater contamination (Table 2). Air contamination may have occurred during the dumping of materials at the site, as evidenced by odor complaints at the time (Ghassemi, 1976), and during site investigation and removal activities; however, no off-site air contamination data have been generated during remedial investigations. Surface water contamination has not been an issue at the RF site. The nearest surface water feature to the RF site is the Toms River located nearly two miles to the southeast.

Historic information on groundwater contamination related to the RF site is sparse. Much of the data that exist were generated using analytical methods that were non-specific indicators of organic chemical contamination, and little documentation remains on the sampling procedures and quality of the analytical data. Nonetheless, these data are presented in detail below in order to provide as complete a historic perspective as possible on the potential for RF-related contamination of groundwater in Dover Township. Groundwater Investigations: 1974 to 1976

In early 1974, approximately two years after the deposition and discovery of the chemical wastes at the Reich Farm, residents of three properties proximal to the site began to notice abnormal tastes and odors in their well water. The Dover Township Board of Health (DTBH) recommended that homeowners submit samples of their water to private laboratories for analysis. Subsequent analysis indicated that one of the wells was contaminated with unspecified levels of toluene and the other two with phenolic compounds. In addition, the DTBH received a similar complaint concerning a well next to the DTML where subsequent testing revealed the presence of phenolic compounds. These wells were condemned, and in two cases were replaced by deeper wells whose quality was found to be satisfactory (Ghassemi, 1976).

As a result of these initial complaints, the Ocean County Health Department (OCHD) initiated a wider survey of potable wells in the area during the period from March through June 1974. Analysis was performed by the New Jersey Department of Health (now NJDHSS) Laboratory in Trenton. The analysis method employed detected total organic compounds through ether extraction. (Organic compounds were adsorbed on activated carbon; the carbon was then dried and eluted with ether to recover and quantify the adsorbed organic chemicals.) As indicated in Table 3, concentrations of total (ether extractable) organic compounds were reported to range from not detected (ND) to over 21,000 ppb. At the time of the analysis, there existed no Federal or State standards regarding ether extractable compounds in potable water supplies. Ghassemi (1976) concluded, "However, such extractable organics are not naturally occurring and should not be in the water."

During the period from June 19 through July 30, 1974, the USEPA analyzed additional samples of private wells in the area near the RF site, and TRWC public supply wells (#20 at Indian Head and #26 at the Parkway well field). Activated carbon filters were installed at six selected locations. After saturation, the filters were collected and transported to the USEPA laboratory in Cincinnati, Ohio for determination of chloroform extractables. Table 4 presents the summary of this investigation. Analysis indicated the presence of carbon /chloroform extractable compounds (CCE) ranging from 100 to 1,200 ppb. Only one sample, from a private residence located due south of the RF site on Lakewood Ave., exceeded the U.S. Public Health Service drinking water standard of 700 ppb for CCE in effect in 1974.

On July 11, 1974, the USEPA obtained four additional samples for organic chemical analysis by a gas chromatograph/mass spectrophotometer method in the USEPA laboratory in Edison, New Jersey. This analysis showed no contamination (at a method detection limit of 0.1 ppb) in the Toms River Water Company well # 22, or in wells supplying the Ocean County Agricultural Building and the North Dover School. The well at the Lakewood Ave. private residence noted in Table 4 (with CCEs at 1,200 ppb) was found to contain toluene at 12 ppb and styrene at 30 ppb. Although there were no standards for these chemicals at the time, the levels are below current drinking water maximum contaminant levels (MCLs) or ATSDR comparison values (1,000 ppb for toluene and 100 ppb for styrene).

During the periods from July 31 through August 27, and October 12 through November 9, 1974, the NJDEP and the USEPA conducted a sampling program of private wells within one to 1.5 miles of the RF site. Analyses were performed by the New Jersey Department of Health (now NJDHSS) Laboratory in Trenton and the USEPA Laboratory in Edison, utilizing the carbon tetrachloride extraction/infrared absorption (CCl_4/IR) method. The method was calibrated using an equivolume blend of seven likely contaminants (Ghassemi, 1976). Table 5 summarizes the results of this sampling episode. The July 31, 1974 samples showed anomalously high levels, which were not confirmed with repeated samples at the same locations taken one week later; these data are not presented in Table 5. Results from private wells in the area ranged from not detected to 1,900 ppb. The highest level was found in the same private well that had the highest CCE level and that contained toluene and styrene. However, the overall pattern of contamination could not be attributed to the Reich Farm site alone (Ghassemi, 1976; NUS, 1986).

In June 1974, the DTBH had requested the assistance of the NJDEP (Bureau of Potable Water) in determining the nature and extent of groundwater contamination in the Pleasant Plains section of Dover Township. After review of the above data, the recurrent reports of taste and odor problems associated with some private wells, and the documentation of hazardous chemical waste dumping at the Reich Farm site, the NJDEP concluded that a groundwater contamination problem existed in

portions of Pleasant Plains. The Bureau of Potable Water directed the Township of Dover to take action to protect the public health on July 30, 1974. The DTBH, on September 16, 1974, passed an ordinance which forbade the use of groundwater within a designated area of Pleasant Plains.

In December 1974, the NJDEP issued a report entitled "Final Report -- Delineation of Extent of Groundwater Contamination, Pleasant Plains Section of Dover Township, Ocean County, N.J." (NJDEP, 1974). This report delineated areas of groundwater contamination into three zones and set requirements for private well usage in an area including and expanding beyond the area denoted by the DTBH (Figure 3). Zone I was classified as "Contaminated" and was condemned as a source of water for any purpose; no new wells were permitted to be installed in this area, and all existing and new homes were to connect to the TRWC supply service. Zone II was designated as a "Questionable Area," and included those areas which were perceived as susceptible to future contamination based upon their location with regard to groundwater movement. The NJDEP recommended that a well monitoring program be established for Zone II wells and all new wells were to utilize the Kirkwood aquifer. Zone III was designated as "Uncontaminated," and included those areas thought to be not likely to become contaminated based upon information available at the time. A total of 148 wells in Zone I were condemned and ordered capped. Area residents and public facilities relied upon water tanker trucks and bottled water for a period of approximately six months while the infrastructure for community water supplies was completed (Ghassemi, 1976).

Of the analytical methods discussed above, results from the gas chromatography/mass spectrophotometry method are likely to be most reliable and interpretable. As noted above, interpreting results of the other early groundwater analyses is difficult because: 1) there is little information on sampling procedures employed; 2) the analytical tests are not chemical-specific; 3) there is considerable variation in results from the same location over short periods of time; and 4) the different extraction techniques represent different fractions of the compounds potentially present.

Nonetheless, the data generated by these methods may provide useful information regarding water quality. The laboratory manual Standard Methods (1965 edition) states, in reference to the carbon chloroform extraction (CCE) method, ". . .where concentrations of 200 mg/l [micrograms per liter, equivalent to ppb] have been found, the taste and odor of the water have nearly always been poor." Although the CCE method does not determine the total organic content of the water (due to the escape of the lighter volatile compounds in the carbon drying process, variability to the degree which compounds are adsorbed onto the charcoal, and solubility of specific compounds in the solute), mass recovery ranges from 50 to 90 percent. The CCE method was described as useful for ". . .revealing stress on water from most industrial contaminants, particularly synthetic chemicals." Finally, Standard Methods indicated that clean surface and groundwater will usually contain only 25 to 50 mg/l of CCE (APHA, 1965). In 1960, the CCE method was described as capable of recovering nitriles, 60 to 70 percent of phenolic compounds, substituted nitrobenzenes, aromatic ethers, hydrocarbons, and chlorinated insecticides (Ettinger, 1960). This source evaluated CCE values above 200 mg/l as a useful criterion for chemical pollution of a watershed, and maintained that above this level, consideration be given to alternative water sources and adoption of treatment procedures designed to remove organic contaminants. Another reference source at that time stated that clean water will exhibit less than 25 to 50 mg/l of CCEs, and water known to be polluted with industrial wastes will commonly contain CCEs in the hundreds and sometimes thousands of micrograms per liter (Middleton and Lichtenberg, 1960). With reference to values generated by the CCl4/IR method, Ghassemi (1976) notes that the USEPA Region II Chief of Laboratories at the time considered 1,000 ppb to constitute reason for suspicion of organic chemical contamination.

Newspaper accounts from the period report that two of the TRWC supply wells at the Parkway well field sampled during the July to November 1974 investigation exhibited "phenol" contamination at a maximum level of 42 ppb, while TRWC supply well #20 located at Indian Head Road was reported to have exhibited "phenol" contamination at 6 ppb (APP, 1975a; APP, 1975b). In March 1976, "phenol" was detected in nine of fifteen private potable wells approximately 4,000 feet down-gradient of the RF site in the area of Dugan Lane. "Phenol" concentrations were reported to have ranged from 10 to 5,900 ppb (NUS, 1986). These wells were ordered closed by the DTBH. The test for "phenol" is sensitive to a variety of phenolic compounds (such as phenol itself, ortho- and meta-substituted phenols, and some para-substituted phenols), so the specific chemical composition cannot be determined from this test. No additional information was available for evaluation by the ATSDR or the NJDHSS regarding the analytical methods employed for these sampling events. The "Pathway Analysis" and "Public Health Implications" sections of this Public Health Assessment evaluate the public health significance of the data presented above.

Groundwater Investigations: USEPA Remedial Investigations, 1986 to 1993

The 1989 Public Health Assessment by ATSDR reviewed the soil and groundwater data collected for the 1986 and 1988 RI reports (ATSDR, 1989a). Table 2 and Figures 5, 6 and 7 present summaries from the 1986 and 1988 RIs of hazardous substance list (HSL) and target compound list (TCL) contaminants detected in on-site soils and groundwater. The USEPA identified public health risks associated with the migration of ethylbenzene, chlorobenzene, trichloroethylene (TCE), tetrachloroethylene (perchloroethylene, or PCE), and bis(2-ethylhexyl)phthalate (BEHP) into groundwater (Ebasco, 1988b).

Table 6 summarizes data collected by the USEPA in 1986 and 1987 regarding off-site groundwater quality in eight private wells in the Pleasant Plains area and TRWC community supply wells at the Parkway and Indian Head well fields (NUS, 1986; Ebasco, 1988b). One private well (RW-7), located just up-gradient from the RF site, exhibited contamination with VOCs. PCE, carbon tetrachloride and bromoform exceeded health-based comparison values, while 1,1,1-trichlorethane and chloroform did not (Table 6). (See the appendix for a description of health-based comparison values). An initial report of contamination in another private well was not confirmed in a duplicate or re-sample (Ebasco, 1988c; ATSDR, 1989a).

Three of the Parkway well field wells (#26, #27 and #28) also showed evidence of VOC contamination with TCE, PCE and

benzene (Table 6). A sample from Parkway well #23 contained N-nitrosodiphenylamine, a contaminant also found in one on-site monitoring well, at a level near the health-based comparison value. On the basis of the data from on-site and off-site wells, ATSDR identified TCE, PCE, N-nitrosodiphenylamine, and BEHP as contaminants of concern in off-site groundwater in 1989 (ATSDR, 1989a).

Newspaper accounts from November 1987 reported that in July 1987, TRWC Parkway well #26 contained TCE at 13 mg/l, and TRWC Indian Head well #20 showed TCE at 1 mg/l, 1,1,1-trichloroethane at 0.6 mg/l, chlorobenzene at 0.5 mg/l and benzene at 0.2 mg/l (APP, 1987a; OCO, 1987a).

As part of the predesign activities conducted by Malcolm Pirnie on behalf of the UCC, TRWC community water supply wells and two TRWC monitoring wells (at Dugan Lane and at Swain Ave.) were sampled in 1990 and 1991 (Table 7). Samples of untreated water from TRWC wells #26 and #28, and a sample from well #29, exhibited contamination by volatile organic contaminants at or exceeding health-based comparison values; well #22 did not show signs of contamination. TCE was found at 120 mg/l at the Swain Ave. well, and at 33 mg/l in well #26. Lower levels of 1,2-dichloroethane, 1,1,1-trichloroethane, and PCE were also found in the Swain Ave. well and in well #26. Wells #28 and #29 contained TCE at 1 and 3 mg/l, respectively. At the time of this sampling, the output of wells #26 and #28 was being treated by packed tower aeration (air stripping), while the output of well #29 was not being treated. These wells were intercepting the RF groundwater plume.

The "Pathways Analysis" and "Public Health Implications" sections of this Public Health Assessment evaluate the public health significance of the data presented in the Phase I and II Predesign Report.

Groundwater Investigations: 1996 to 1998

As part of the activities conducted for this Public Health Assessment, and in support of other activities denoted in the PHRP for the Dover Township Childhood Cancer Investigation, the NJDHSS and the ATSDR initiated an exposure investigation in 1996. In an effort to supplement existing data on groundwater quality, the NJDHSS sampled private wells in the Township in 1997. The analyses of private wells, soils and sediments will be summarized in a separate document. In addition, together with the NJDEP, the NJDHSS extensively sampled and analyzed the chemical and radiological quality of the community water system between 1996 and 1998. A separate Health Consultation will provide a complete review of analytical data for all UWTR wells and points of entry in this period. However, information from the private well and community water supply testing that is related to the RF site is also presented here.

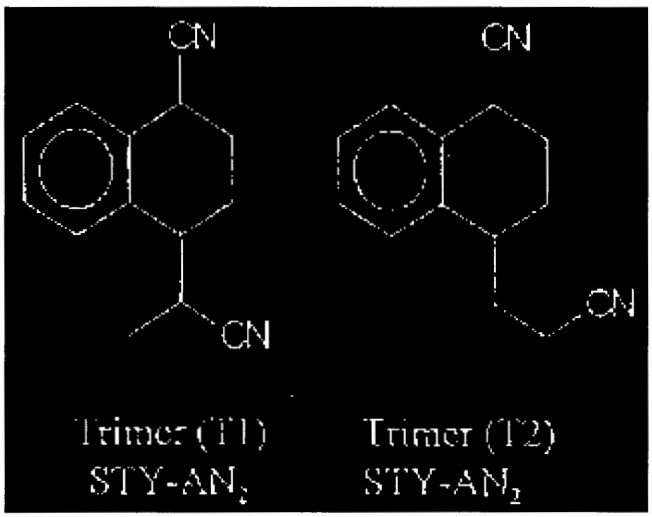
Private Wells

A total of 54 private wells were sampled by the NJDHSS from February through May 1997. Of these, twenty were located in areas pertinent to the RF and DTML health assessment study areas (Figure 4). Analyses were performed utilizing USEPA Methods 524.2, 525.2 and 625 for organic chemicals, and other standard methods appropriate for heavy metals, gross alpha and beta activity (900.0, 903.0), general chemistry, and dissolved oxygen. Of the twenty wells sampled, four contained chloroform in the range of 0.4 to 4.0 mg/l, below the ATSDR comparison value (cancer risk evaluation guide: 6 mg/l) and the MCL of 100 mg/l for trihalomethanes, a group of chemicals to which chloroform belongs. Chloroform is not considered to be a RF site-related contaminant.

Eighteen of the 20 wells also contained lead (range: 1.5 to 27.4 mg/l) (NJDHSS, 1996-1999, Volumes 68 to 81). The presence of lead is most likely a result of corrosion of household plumbing by acidic groundwater, and is not considered to be RF-related. Samples from several private wells exceeded the MCL for gross alpha activity (15 pCi/l). Gross alpha activity was determined to be due to radium species (isotopes 224, 226 and 228) in groundwater. The presence of radium in the Cohansey aquifer is a phenomenon not associated with the RF site, and is common to many areas of southern New Jersey. The public health significance of lead and radium in these private wells will be discussed in the separate summary of the exposure investigation.

Parkway Well Field Public Supply Wells

Beginning in 1996, public supply wells of the Parkway well field have undergone extensive testing. Analyses have been performed utilizing USEPA Methods 524.2, 525.2 and 625 for organic chemicals, and other standard methods appropriate for heavy metals, and radiological activity (900.0, 903.0).



In 1996, laboratory scientists at NJDEP noticed the possible presence of an unknown non-target semi-volatile compound in samples from well #26, the Parkway point of entry, and nearby distribution system samples. Further investigation by the NJDEP revealed the presence of the unknown compound in data generated by previous investigations of the groundwater quality at the Parkway well field. Extensive efforts by laboratory scientists at the NJDEP, the USEPA and the NJDHSS identified the unknown material as compound as a mixture of isomers of 4-cyano-1,2,3,4-tetrahydro-a-methyl-naphthalene-acetonitrile (THNA; labeled T1 in the inset) and 4-cyano-1,2,3,4-tetrahydro-1-naphthalene-propionitrile (THNP; labeled T2 in the inset), now collectively known as styrene-acrylonitrile (SAN) trimer. These closely related compounds are formed as by-products of the styrene-acrylonitrile co-polymerization process. Wastes from UCC's use of this process were deposited at the RF site in 1971.

The initial estimate of SAN trimer concentration in well #26 was 6 mg/l (NJDHSS, 1996-1999, Volumes 39 to 41). Subsequent tests, specifically calibrated for SAN trimer measurement, have shown concentration ranges of 3 to 5 mg/l in well #26. Lesser amounts have been detected repeatedly in well #28, and sporadically in well #29. Analytical data showed that the treatment system in place in 1996 at the Parkway well field (air stripping) was ineffective at removing SAN trimer.

During the period 1996 to 1998, TCE was found in the untreated water from wells #26 and #28 in the range of 2 to 8 mg/l, and sporadically in well #29 at up to 2 mg/l (NJDHSS, 1996-1999). Other volatile organic chemicals, including PCE and 1,1,1-trichloroethane, have also been found consistently in wells #26 and #28. These data will be fully described in the separate Public Health Consultation.

Other organic chemicals may yet be identified in the RF groundwater plume. The NJDEP has established a committee of laboratory scientists to examine recent and past analytical data to determine if there are additional non-target compounds that can be identified.

The "Pathways Analysis" and "Public Health Implications" sections of this Public Health Assessment evaluate the public health significance of the Parkway well field water quality data generated from 1996 to 1998.

Other Data

The UCC continues to monitor groundwater contamination associated with the RF site. On-site and off-site monitoring wells were sampled in May 1997, with split samples provided to the NJDHSS Environmental Laboratory. These data were reviewed by the NJDHSS and found to be consistent with previous data describing groundwater quality. A summary of these data is being prepared as a separate document by NJDHSS.

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Pathways Analysis

To determine whether residents of Dover Township were or are currently being exposed to contaminants migrating from the RF site, the NJDHSS and the ATSDR evaluate the environmental and human components that lead to exposure. An exposure pathway consists of five elements: (1) a source of contamination; (2) transport through an environmental medium; (3) a point of human exposure; (4) a route of human exposure; and (5) a receptor population.

The ATSDR and the NJDHSS classify exposure pathways into three groups: (1) completed pathways, that is, those in which it is likely that some persons in the receptor population were exposed, are being exposed, or will be exposed; (2) potential pathways, that is, those in which exposure might have occurred, may be occurring, or may yet occur; and (3) eliminated pathways, that is, those which can be eliminated from consideration because one of the five elements is missing and will never be present, or in which no contaminants of concern can be identified. Completed or potential pathways may be interrupted by remedial actions.

Private Wells

The NJDHSS and the ATSDR have determined that a completed human exposure pathway to RF-related groundwater contaminants existed in the past through the domestic use of private wells. Exposure to some members of the population may have occurred through ingestion, inhalation or dermal contact, depending on water use patterns and volatility of contaminants.

The presence of contaminants is documented in private wells as early as 1974. Non-specific methods indicated the existence of contamination of unknown composition. However, the USEPA did find toluene (12 ppb), and styrene (30 ppb) in a well at one private residence in July 1974, using a method capable of detecting specific volatile organic compounds. These compounds were found in the material dumped at the RF site, and the private well is in an area now known to be in the path of the RF groundwater plume.

The specific locations affected, and the time of impact, is dependent upon the flow of groundwater, contaminant characteristics, and the location of wells relative to the path of the RF groundwater plume. Exposure through private wells is believed to have been interrupted in 1975 when wells were ordered sealed and community water supplies became available, although compliance with the directive met with some resistance (Ghassemi, 1976). There were an estimated 148 homes with private wells in the area designated as contaminated (Zone I) by NJDEP. While the number of wells actually contaminated by RF is not known, the total number of persons potentially associated with this exposure pathway is estimated to be approximately 370 (148 residences times 2.5 persons per residence) (ATSDR, 1992).

Private wells continuing to exhibit contamination potentially related to the RF plume were reported after 1975, including nine wells with "phenols" in 1976 in the vicinity of Dugan Lane, south of the RF site. The duration of this exposure to phenolic compounds for persons using these wells is not known. The pathway was interrupted when the wells were ordered closed by the DTBH.

The specific chemical characteristics of the past private well exposure pathway cannot be determined from existing data. However, based on monitoring well data, the NJDHSS and the ATSDR have determined that a completed human exposure pathway to a variety of VOCs and SVOCs in groundwater existed in the past through domestic use of private well water in the vicinity of the RF site. The VOCs include TCE, PCE, 1,1,1-trichloroethane, toluene, styrene, benzene and others. The SVOCs include the SAN trimer, BEHP, and possibly others.

In general, the private well exposure pathway has been interrupted by the establishment of a well restriction zone and related well closure actions in the Pleasant Plains area. There is no indication that private wells are still in use in the area known to be above the RF groundwater contamination plume.

(It should be noted that an Ocean County ordinance passed in 1987 requires private potable wells to be tested for a variety of possible contaminants including volatile organic chemicals, when new and at the time of property transfer. This requirement provides an additional mechanism for the detection of local groundwater contamination problems and the interruption of exposure pathways.)

Public Wells (Parkway Well Field)

The NJDHSS and the ATSDR have determined that, for some members of the population, a completed human exposure pathway to RF-related groundwater contaminants existed in the past through the community water supply. Contaminants from the RF were discharged to groundwater and were later drawn into supply wells at the Parkway well field, and then pumped into the community water distribution system. The duration of this exposure pathway is unknown. The travel time of groundwater from below the RF site to the Parkway well field has not been established. Estimates by NJDEP and UCC (Malcolm Pirnie, 1992) have ranged between approximately five and 10 years, indicating that contaminants from the site may have reached the well field beginning some time in the period 1976 to 1981.

The chemical composition of past exposures cannot be determined, although since 1986 the following chemicals have been identified in the RF groundwater plume and in Parkway well field wells: TCE, PCE, 1,1,1-trichloroethane, benzene, toluene, 1,2-dichloroethane, chlorobenzene and the SAN trimer. Other chemicals may still be identified.

In 1986, there were not yet any federal or State MCLs established for TCE or other VOCs, although the NJDEP had established an interim guidance level of 2 mg/l for TCE, above which remedial action was recommended. To achieve this level (and to reduce exposure through this pathway), water from contaminated Parkway wells was blended with water from other wells in the Parkway well field with the intention of introducing the water into the point of entry at no more than 2 mg/l of TCE. However, according to newspaper reports at the time, samples at the Toms River Nursery School (located near the point of entry for the Parkway well field) taken subsequent to blending showed 3 mg/l of TCE (OCO, 1987b). In addition, further sampling by the TRWC showed TCE levels above 2 mg/l at Toms River High School North, and Intermediate West, with lower levels at North Dover and West Dover Elementary Schools (APP, 1987b). Subsequent to these tests, the TRWC closed the Parkway well field's Cohansey wells and began the planning and installation of a packed tower aeration system (air stripper) for wells # 26 and #28; the air stripper was installed and in operation by May 1988. This action served to interrupt the pathway for volatile organic chemicals.

However, this effort to interrupt the exposure pathway was not effective at reducing SVOCs, since semi-volatile chemicals

are not removed by air stripping. In 1996, following the discovery of the SAN trimer, wells #26 and #28 were diverted from the water supply. An activated carbon treatment system has been installed for these wells; the treated effluent is primarily being pumped to waste. In June 1999, another activated carbon treatment system was installed to protect against sporadic RF-related contamination in well #29; treatment was also extended to the nearby well #22 as a precaution. Thus, the completed exposure pathway to VOCs and SVOCs from Parkway well field wells is now interrupted and should now be considered only a potential pathway. To ensure continued interruption of the exposure pathway, it is necessary to effectively manage the well field to contain the RF plume, and to properly operate and monitor the treatment systems now in place.

In 1986, well #23 had been found to contain 8 ppb of N-nitrosodiphenylamine. In the late 1980s and early 1990s, wells #23, # 25 and #27 at the Parkway well field were closed and sealed by TRWC. These actions would have served to eliminate exposure pathways associated with these wells.

The total number of persons associated with the completed exposure pathway through the community water supply in the past is difficult to determine. Exposure potential is dependent upon the dynamics of the water system during the period in question, and the location of potentially affected residences relative to the point of entry within the water system. Because the Parkway well field is a major source of water for the community water system, the number of exposed persons was potentially large.

A summary of exposure pathways associated with private wells and community water supply wells at the Parkway well field is presented in the following table:

Completed Human Exposure Pathways Associated with Reich Farm

Pathway Name	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population	Contaminants (Time Documented)
Private Wells	Reich Farm plume	Groundwater	Residences and other locations with private water supplies	Ingestion, dermal contact, inhalation	Residents (Estimated 370 persons at time of well closures in 1974 and 1975)	TOC (1974 to 1975) "Phenols"(1976) VOCs/SVOCs(1986)
Community Water Supply	Reich Farm plume	Groundwater	Residences and other locations served by water from Parkway well field of the community water supply	Ingestion, dermal contact, inhalation	Residents receiving water from Parkway well field(Number unknown)	VOCs/SVOCs(1986 and 1987) VOCs/SAN Trimer(1996)

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Public Health Implications

The public health implications of the completed exposure pathways in the past will now be considered. Several contaminants were confirmed to be present in water from private wells and community water supply wells at levels above health-based comparison values. (See the appendix for definitions and uses of comparison values.) The NJDHSS and the ATDSR have further evaluated the public health significance of past exposures to these contaminants through an examination of relevant toxicologic and epidemiologic information. In addition, this section will include a brief summary of the findings of an analysis of childhood cancer incidence data for Dover Township.

Childhood Cancer Incidence in Dover Township

The NJDHSS and the ATSDR reviewed cancer incidence data in the period 1979 to 1995 for Dover Township, as part of the Public Health Response Plan. Findings are fully described in a separate Public Health Consultation by the NJDHSS and the ATSDR (NJDHSS/ATSDR, 1997). Dover Township was the only municipality in Ocean County in which overall childhood cancer incidence (ages up to 19 years) was statistically elevated. Ninety cases were observed in the 17-year period, compared to 67 that would have been expected if childhood cancer rates were the same in the township as in the entire State of New Jersey. Leukemia incidence was elevated in Dover Township, particularly in females under the age of five years. In the Toms River section of the township, overall childhood cancer was elevated (24 observed vs. 14 expected). Both leukemia and brain/central nervous system cancers were elevated, with the excess occurring primarily in female children under age five.

Toxicologic and Epidemiologic Evaluation

Before actions were taken in the mid-1970s to interrupt the private well exposure pathway, it is clear that many wells in the Pleasant Plains section of Dover Township were contaminated with organic chemicals, as evidenced by the TOC, CCE, CCl4/IR and "phenol" analytical results from the 1970s. However, the specific compounds and the levels that persons were exposed to through the use of water from their private wells is not known, although complaints of abnormal tastes and odors indicate substantial contamination levels. Much uncertainty exists as to the public health significance of past exposures through consumption of contaminated private well water.

In 1986, one private well (RW-7), located just up-gradient from the RF-site, had levels of PCE, carbon tetrachloride and bromoform exceeding, but similar to, the health-based comparison values. A toxicological evaluation of these contaminants, taken on an individual basis, would not indicate that an adverse health effect (carcinogenic or non-carcinogenic) is likely from past exposure to persons consuming water from RW-7 (ATSDR, 1990; ATSDR, 1994a; ATSDR, 1997a).

As seen from Tables 6 and 7, several contaminants have been detected in untreated raw water samples from the TRWC community water supply wells. Those contaminants detected at or above health-based comparison values include TCE, PCE, 1,2-dichloroethane, benzene and N-nitrosodiphenylamine. In addition, persons were exposed in the past through this pathway to SAN trimer and possibly other organic constituents of unknown composition and toxicological significance. With the exception of TCE in well #26 in 1990 (33 mg/l), the levels of the contaminants detected are generally only slightly above their respective health-based comparison values. However, it is important to note that this measured level is not reflective of the actual concentration a household in the TRWC distribution system would receive because of the installation of the air stripping treatment to remove VOCs in 1988, the blending of water from several wells at the Parkway well field, and the mixing of water within the distribution system from other well fields. For these reasons, a toxicological evaluation of the known contaminants, taken on an individual basis, would not indicate that an adverse health effect (carcinogenic or non-carcinogenic) is likely from past exposures to persons consuming well water from the Parkway well field (ATSDR, 1989; ATSDR, 1994b; ATSDR, 1997a; ATSDR, 1997b; ATSDR, 1997c).

It should be noted that toxicologic evaluations of individual chemicals do not take into account the potential for adverse health effects from the combined exposure to mixtures of these contaminants, although research on the toxicity of mixtures indicates that adverse health effects are unlikely when the mixture components are present at levels well below their individual toxicologic thresholds (Bond et al., 1997; Groton et al., 1997; Seed et al., 1995; and Yang et al., 1989). Because documented contaminant levels indicate that the exposures were well below their respective individual toxicologic thresholds, the toxicological evidence suggests that exposures to combinations of known contaminants detected in private wells and in untreated water from the Parkway well field are not likely to lead to adverse health effects.

However, it is clear from the previous discussions in the Environmental Contamination and Pathways Analysis sections that the water from private wells and the Parkway well field, and subsequently individual households using the water from the system, were contaminated with organic contaminants of an undetermined nature and level in the past. Therefore, much uncertainty exists as to the public health significance of past exposures through consumption of contaminated water. In order to help evaluate the public health significance of human exposure pathways associated with community water supply wells, the ATSDR is developing a model of the UWTR/TRWC water system which will enable a more accurate evaluation of the patterns of distribution associated with the wells. The ATSDR and the NJDHSS will use this model in further public health evaluations of water sources from various points of entry in the distribution system.

The public health significance of the pathway associated with exposure to SAN trimer cannot be fully evaluated at this time (ATSDR, 1997e). However, there are some preliminary toxicological information regarding the toxicity of the SAN trimer. In 1996, when the SAN trimer was first recognized to be present in the community water supply, nothing was known about the toxicology of this material. Since that time, UCC has sponsored genetic toxicology assays and short-term toxicologic testing. SAN trimer was found to be mutagenic in two strains of Salmonella and induced chromosomal aberrations in Chinese hamster ovary (CHO) cells, but there was no evidence of mutagenicity in two other assays. The lethal single dose (LD50) was estimated to be 440 and 590 mg/kg in male and female rats. A two-week repeat dosing study showed that daily dose of 300 mg/kg were lethal to rats, while doses of 150 mg/kg resulted in a variety of toxic effects including lethargy, tremors, anemia, and increased liver weight. No adverse effects were observed at 75 mg/kg under the conditions of this test.

No determination about the toxicity of long-term exposure to lower levels of SAN trimer can be made from this limited set of data from these short-term, very high dose studies. Plans for further toxicological testing are being coordinated by the USEPA and a working group of scientists from the National Institute of Environmental Health Sciences, ATSDR, NJDEP, and NJDHSS, with input from UCC and a consultant to the OCHD. The results of these on-going toxicological studies may provide additional information to further the understanding of the public health implications of past exposures to this contaminant through consumption of community or private water supplies.

The available analyses of water from private and public water samples indicates that VOCs (primarily TCE and PCE) were the most consistently detected contaminants. For this reason and because of the uncertainty in the historical levels of contamination of private wells and the Parkway well field, a discussion of the current scientific knowledge regarding the public health implications of these contaminants is presented below.

Effects of TCE and PCE in Adults

The effects of exposure to TCE and PCE have been evaluated in scientific studies for their possible impact upon adult human health. TCE and PCE are classified as probable human carcinogens by the International Agency for Research on Cancer (IARC, 1995) based on the weight of evidence from laboratory animal experiments and limited human epidemiologic studies.

Laboratory animals have been exposed to these chemicals via contaminated air, drinking water, and food. The results of these studies indicate that the nervous system and liver, and to a lesser degree the kidney and heart, are the primary organs of adult animals affected by these VOCs (ATSDR, 1997a; ATSDR, 1997c). Following long-term, high level exposure, TCE has been shown to produce liver cancer in mice and kidney and testicular tumors in rats (ATSDR, 1997c; IARC, 1995). Chronic,

high level PCE exposure produces liver cancer in mice and kidney tumors and mononuclear cell leukemia in rats (ATSDR, 1997a; IARC, 1995). The exposure levels needed to cause these adverse impacts in laboratory animals are many times higher than exposure levels that could have occurred through the use of contaminated drinking water (ATSDR, 1997a; ATSDR, 1997c).

Epidemiological studies of occupationally-exposed workers suggest an association between long-term inhalation exposure to high levels of TCE and increased risk of liver and biliary tract cancer and non-Hodgkin's lymphoma (IARC, 1995; ATSDR, 1997c). Increased risks of esophageal cancer, cervical cancer, and non-Hodgkin's lymphoma have been observed in workers exposed to high levels of PCE (IARC, 1995; ATSDR, 1997a). Participants in the ATSDR TCE Exposure Subregistry (approximately 4,300 individuals with exposure to TCE in drinking at levels ranging from 2 to 19,000 mg/l for as long as 18 years) have reported a variety of health problems at rates above national averages (ATSDR, 1993b). However, only the rate for strokes was reported to increase with increasing concentration of TCE in drinking water. Results from the Subregistry have not documented any increased occurrence of cancer in the study population (ATSDR, 1993b).

Effects of TCE and PCE in Children and the Fetus

Children may be particularly susceptible to the toxic effects of chemicals; fetuses may also be sensitive to toxic effects if the chemicals can cross the placental barrier. Recent epidemiologic studies suggest that fetal exposure to VOCs in drinking water could result in adverse health effects. The NJDHSS evaluated the effects of VOCs in drinking water on birth outcomes in an area of northern New Jersey (Bove et al., 1995). This exploratory study found that maternal residence during pregnancy in areas with TCE-contaminated drinking water was associated with an increased risk of birth defects of the neural tube and oral cleft. Exposure to PCE during pregnancy was associated with an increased risk of oral cleft defects. The authors concluded that their study by itself cannot determine whether the drinking water contaminants caused the reported adverse birth outcomes.

A recent ATSDR study of exposure to VOCs in drinking water and occurrence of adverse pregnancy outcomes was conducted for residents of the U.S. Marine Corps Base at Camp LeJeune, North Carolina (ATSDR, 1997d). The researchers reported a significantly decreased mean birth weight and increased small for gestational age babies for two potentially susceptible subgroups: infants of mothers older than 35 years of age and infants of mothers with histories of fetal death. However, length of exposures to VOCs was not known for the entire period during which pregnancy outcomes were evaluated. Therefore, this study provides limited evidence for a causal relationship between exposure to VOCs and the reproductive and developmental effects evaluated.

A study of childhood leukemia conducted in Woburn, Massachusetts, concluded that the incidence of childhood leukemia was associated with the mother's potential for exposure to water from specific wells contaminated with TCE and PCE, particularly for exposure during pregnancy (MDPH, 1997). The study did not find any association between the development of childhood leukemia and the child's exposure to contaminated water after birth. The Woburn study should be interpreted with caution, however, since small numbers of study subjects led to imprecise estimates of risk. A study by the NJDHSS found a statistically elevated rate of childhood leukemia in towns served by community water supplies contaminated with TCE and PCE in the years 1979 to 1987 (before current drinking water regulations had been implemented), compared to towns without a history of such contamination (Cohn et al., 1994). Overall, the associations drawn from these limited epidemiological data in humans are suggestive, yet inconclusive, that exposure to these VOCs through drinking water may cause birth defects or childhood leukemia in children exposed while a fetus. ATSDR and others are conducting or sponsoring research to clarify this possible relationship.

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Conclusions

Hazard Category for the Reich Farm Site

Based on a weight-of-evidence analysis of the health and environmental information compiled, each Public Health Assessment assigns a hazard category (see Appendix) in response to the public health risk posed by the site being evaluated. Each category relates to a set of additional actions or interventions that may be considered by the ATSDR, the NJDHSS or other public health agencies, as well as recommendations for further action to the USEPA, NJDEP or other environmental agencies.

The Reich Farm site is considered by the ATSDR and the NJDHSS to have represented a public health hazard because of past exposures. This determination is based on the following considerations, taken together: 1) the presence of completed exposure pathways in the past (through private and community water supplies) to VOCs (including PCE and TCE) and other chemicals, to a potentially large population; 2) epidemiologic studies from other communities suggesting that exposure to TCE and PCE may increase the risk of certain childhood cancers and adverse neurological effects; and 3) the presence of an excess of childhood cancers in the community.

Much uncertainty exists concerning the composition, levels and toxicologic characteristics of past exposure to contaminated private and community water supplies. Although the toxicological evaluation performed for this Public Health Assessment did not suggest that adverse health effects from documented past exposures to contaminated drinking water (through private wells or the community water supply) were likely, this evaluation is based on limited historical environmental data. Therefore, although it cannot be documented, the public health significance of past exposures related to the Reich Farm site

may have been greater than is apparent from the toxicological evaluation of the known levels of contaminants performed in the Public Health Assessment. For the reasons above, further evaluation and follow up actions are warranted in order to evaluate the public health significance of past risks posed by the site.

Current conditions indicate that exposure to contaminants from the RF site is no longer occurring. The exposure pathway through private well use was interrupted by the establishment of a well restriction zone, and there is no indication that private wells are still in use for potable purposes in the area above the RF plume. The exposure pathway through the community water supply has been interrupted by the diversion and treatment of contaminated water from wells #26 and #28 at the Parkway well field, and the recent installation of treatment for well #29. However, treated output from wells #26 and #28 may be pumped into the community water supply in times of high water demand. Containment of the RF-related groundwater plume through effective management of the Parkway well field is critical to ensure that currently unaffected wells remain so. In addition, proper operation of the treatment systems in place is necessary to reduce or eliminate the entry of RF-related contaminants into the distribution system. On-going water monitoring is needed to document the effectiveness of well field management and treatment systems. For these reasons, the ATSDR and the NJDHSS are categorizing the RF site as no apparent public health hazard under present conditions. Should NJDHSS or ATSDR become aware of information indicating that RF-related exposure is still occurring, or if private wells are still in use in the plume area, this determination will be reconsidered.

Past completed human exposure pathways associated with the Reich Farm are of sufficient public health significance to warrant further epidemiological evaluation of childhood cancer incidence in Dover Township. Also, because there is uncertainty about the toxicity of unusual RF site-related contaminants now found in the groundwater plume (SAN trimer), further toxicological evaluation is needed.

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Recommendations

Cease/Reduce Exposure Recommendations

Reich Farm

The ATSDR and the NJDHSS recommend routine sampling of all shallow Cohansey Aquifer wells of the Parkway well field at an appropriate interval to ensure the groundwater plume remains delineated, controlled, and does not impact the currently unaffected public supply wells. Monitoring (at appropriate intervals) of the effectiveness of treatment systems now in place is necessary to ensure that RF site-related contaminants are not introduced into the community water distribution system.

The groundwater plume associated with the RF site is of public health concern, and merits continuation of the well restriction zone (with respect to the Cohansey aquifer) in the Pleasant Plains area of Dover Township.

Site Characterization Recommendations

Reich Farm

The ATSDR and the NJDHSS were unable to locate and review the original data reports related to the groundwater investigations in the early 1970s. Information regarding this sampling (such as quality assurance/quality control, sampling and analytical test methods, and sampling notes) should it exist, could clarify the public health significance of historical data regarding groundwater contamination. The NJDHSS and the ATSDR should review such information, or any other data relevant to the characterization of past exposure, for public health significance if it becomes available.

Public Health Recommendations

Based upon review of completed human exposure pathways at the RF site, and in conjunction with the concerns of the community regarding the incidence of childhood cancer, consideration of RF-related exposure pathways in the on-going epidemiologic investigation by the NJDHSS and the ATSDR is warranted. Estimates of exposure to water though this pathway should include the use of private wells and community water supply wells. To account for the complex dynamics of a community water system, water system models should be employed to trace the flow of water from the Parkway well field to points in the distribution system.

The ATSDR and NJDHSS recommend that toxicity testing of the SAN trimer continue to be pursued, particularly for its potential to be carcinogenic.

The Public Health Action Plan (PHAP) for the Reich Farm Site contains a description of the actions to be taken at or in the vicinity of the site. The purpose of the PHAP is to ensure that this Public Health Assessment not only identifies public health hazards, but provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR and NJDHSS to follow up on this plan to ensure its implementation. ATSDR will provide an annual follow-up to this PHAP, outlining the actions completed and those in progress. This report will be placed in repositories that contain copies of this Public Health Assessment, and will be provided to persons who request it. The public health actions taken or to be implemented are as follows:

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Public Health Actions Undertaken by NJDHSS/ATSDR:

Reich Farm

1. The NJDHSS and the ATSDR have evaluated available information to determine the public health significance of past and present human exposure pathways associated with the Reich Farm Site.

2. The NJDHSS and the ATSDR, in cooperation with the NJDEP, have conducted an extensive program of sampling of the UWTR community water supply. Results of samples from wells at the the Parkway well field led to the discovery of previously uncharacterized contaminants entering the distribution system and subsequent remedial actions.

3. NJDHSS acquired and conducted analyses of split samples of monitoring wells associated with the RF site. These data have been reviewed and will be summarized by NJDHSS in a separate document.

4. In cooperation with the USEPA, the ATSDR (Division of Toxicology) and the NJDHSS have participated in an on-going working group to review initial toxicity testing data and draft protocols for further testing of SAN trimer.

General

1. Results of private well analysis have been communicated to participants in the groundwater phase of the exposure investigation. The NJDHSS has provided assistance in interpreting data where necessary. In addition, the NJDHSS has provided recommendations for minimizing exposure, and educational material regarding the health issues associated with exposure to lead and radiological activity to the appropriate participants.

2. The NJDHSS and the ATSDR have prepared a Public Health Consultation describing a review and analysis of childhood cancer incidence data for Dover Township during the period 1979 to 1995.

3. The NJDHSS and the ATSDR (Division of Health Studies) are conducting an epidemiologic study of childhood cancers in Dover Township. The study will examine whether environmental exposures (including but not limited to completed pathways associated with the RF) and other risk factors are associated with the incidence of these diseases.

4. The ATSDR is developing a community water supply distribution system model which will be used in the epidemiologic study to estimate past exposure to water from the Parkway and other points of entry.

5. The ATSDR (Division of Health Education and Promotion) and the NJDHSS have implemented a variety of physician and community education initiatives in Dover Township as part of the Public Health Response Plan, including:

Health Care Provider Education

- The NJDHSS distributed to physicians approximately 100 Resource Guides for Health Care Providers in Ocean County.

- The NJDHSS developed and distributed a series of Health Care Provider Updates to approximately 430 physicians and physician groups and 30 school nurses in the area. The first Update in the series (August 1996) reviewed the Public Health Response Plan. A survey of educational needs was sent with the first Update; 77 physicians responded to the survey, with 33 requesting additional informational materials. Physicians were most interested in professional seminars and patient education materials on general pollution issues. Five additional Health Care Provider Updates have been completed and distributed by the NJDHSS: information on the Ciba-Geigy and Reich Farm Health Public Health Assessments, the initial results of the community water supply investigation, cancer incidence statistics, and the epidemiological study protocol.

Community Education

- Health Care Provider Updates and Resource Guides have been made available to area residents upon request.

- A one-year progress report of the Dover Township Childhood Cancer investigation has been developed and distributed (September 1997) by the NJDHSS for concerned citizens. The ATSDR issued a the second progress report of the investigation in May 1998.

Public Health Actions Planned By NJDHSS/ATSDR:

Reich Farm

1. The ATSDR and the NJDHSS will continue to review water quality data associated with the Parkway well field generated during future sampling episodes for public health significance, and recommend or take appropriate

mitigative public health actions if necessary.

2. In cooperation with the USEPA, the NIEHS and the NJDEP, the NJDHSS and the ATSDR will review the public health significance of exposure to the SAN trimer upon availability of relevant toxicological data.

General

1. The NJDHSS will contact local health officials and community leaders to assess the need for future community educational activity. Site specific educational materials will be prepared and disseminated as necessary. Periodically, new Progress Reports and Health Care Provider Updates will be developed an distributed.

2. The ATSDR and the NJDHSS will reevaluate and revise this Public Health Action Plan (PHAP) as warranted. New environmental, toxicological, health outcome data, or the results of implementing the above proposed actions may determine the need for additional actions at the RF site by the NJDHSS and/or the ATSDR.

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Certification

This Public Health Assessment was prepared by the New Jersey Department of Health and Senior Services (NJDHSS) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the Public Health Assessment was begun.

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Technical Project Officer
Superfund Site Assessment Branch (SSAB)
Division of Health Assessment and Consultation (DHAC)
ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this Public Health Assessment and concurs with its findings.

Richard E. Gillig
Acting Chief, SSAB, DHAC

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Appendix: Description of Comparison Values

Description of Comparison Values

ATSDR's comparison values are media-specific concentrations that are considered to be "safe" under default conditions of exposure. They are used as screening values in the preliminary identification of site-specific chemical substances that the health assessor has selected for further evaluation of potential health effects.

Generally, a chemical is selected for evaluation because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's comparison values. However, it cannot be emphasized strongly enough that comparison values are not thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. Indeed, the whole purpose behind highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems before they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not solely on environmental concentrations.

Screening values based on non-cancer effects are generally based on the level at which no health adverse health effects (or the lowest level associated with health effects) found in animal or (less often) human studies, and include a cumulative margin of safety (variously called safety factors, uncertainty factors, and modifying factors) that typically range from 10-fold to 1,000-fold or more. By contrast, cancer-based screening values are usually derived by linear extrapolation with statistical models from animal data obtained at high exposure doses, because human cancer incidence data for very low levels of exposure are rarely available. Cancer risk estimates are intended to represent the upper limit of risk, based on the available data.

Listed and described below are the types of comparison values that the ATSDR and the NJDHSS used in this Public Health Assessment:

Cancer Risk Evaluation Guides (CREGs) are estimated concentrations of contaminants in an environmental medium (such as drinking water) that are expected to cause no more than one excess cancer case for every million persons who are continuously exposed to the concentration for an entire lifetime (equaling a risk of 1 x 10-6). These concentrations are calculated from the USEPA's cancer slope factors, which indicate the relative potency of carcinogenic chemicals. Only chemicals that are known or suspected of being carcinogenic have CREG comparison values.

Environmental Media Evaluation Guides (EMEGs) and Reference Dose Media Evaluation Guides (RMEGs) are estimates of chemical concentrations in an environmental medium (such as drinking water) that are not likely to cause an appreciable risk of deleterious, non-cancer health effects, for fixed durations of exposure. These guides may be developed for special sub-populations such as children. EMEGs are based on ATSDR's minimal risk level (MRL) while RMEGs are based on the USEPA's reference dose (RfD).

Other health-based guides may also be used as comparison values, including drinking water maximum contaminant levels (MCLs) established by the USEPA or the NJDEP.

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Appendix: ATSDR Public Health Hazard Categories

ATSDR's Interim Public Health Hazard Categories

Category / Definition	Data Sufficiency	Criteria
A. Urgent Public Health Hazard This category is used for sites where short-term exposures (< 1 yr) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have in the future, an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards.
B. Public Health Hazard This category is used for sites that pose a public health hazard due to the existence of long-term exposures (> 1 yr) to hazardous substance or conditions that could result in adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR has judged sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have in the future, an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical or safety hazards.
C. Indeterminate Public Health Hazard This category is used for sites in which "critical" data are insufficient with regard to extent of exposure and/or toxicologic properties at estimated exposure levels.	This determination represents a professional judgement that critical data are missing and ATSDR has judged the data are insufficient to support a decision. This does not necessarily imply all data are incomplete; but that some additional data are required to support a decision.	The health assessor must determine, using professional judgement, the "criticality" of such data and the likelihood that the data can be obtained and will be obtained in a timely manner. Where some data are available, even limited data, the health assessor is encouraged to the extent possible to select other hazard categories and to support their decision with clear narrative that explains the limits of the data and the rationale for the decision.
D. No Apparent Public Health HazardThis category is used for sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.	This determination represents a professional judgement based on critical data which ATSDR considers sufficient to support a decision. This does not necessarily imply that the available data are complete; in some cases additional data may be required to confirm or further support the decision made.	Evaluation of available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in any adverse impact on human health.
E: No Public Health Hazard This category is used for sites that, because of the absence of exposure, do NOT pose a public health hazard.	Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are now occurring, and none are likely to occur in the future	

* Such as environmental and demographic data; health outcome data; exposure data; community health concerns information; toxicologic, medical, and epidemiologic data; monitoring and management plans.

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