EBASCO

REM III PROGRAM

REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES

EPA CONTRACT 68-01-7250

EBASCO SERVICES INCORPORATED

FINAL
REMEDIAL INVESTIGATION/
FEASIBILITY STUDY

VOLUME IV
APPENDICES F - I

BYRON BARREL AND DRUM SITE
BYRON, NEW YORK

JULY 1989
W.A. NO. 161-2LD6

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EPA WORK ASSIGNMENT NUMBER 161-2LD6
UNDER
CONTRACT NUMBER 68-01-7250

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APPENDIX F

TOXICITY PROFILES

ACETONE (Clement Associates, Inc.,)

Health Effects

Acetone has not been tested in a carcinogenicity bioassay but gave negative results in skin painting tests and was not mutagenic in the Ames assay. No studies on animals for teratogenicity or reproductive toxicity have been done, but acetone was negative in a chicken egg injection study for teratogenicity.

Acetone is generally regarded as having a low toxicity and therefore has not been extensively studied. Prolonged inhalation of high concentrations may produce irritation of the respiratory tract, coughing, headache, drowsiness, incoordination, and in severe cases, coma.

In animal studies, rats consuming doses of 18 mg/kg/day for 4 months showed reduced food consumption and growth. In behavioral studies, rats exposed to 14,200 mg/m^3 acetone for 4 hours/day, 5 days/week for 2 weeks showed modified avoidance and escape behavior after one exposure, but no changes after subsequent exposures. At 37,800 mg/m^3, altered responses were noted throughout the 2-week exposure period. No chronic health hazards have been associated with exposure to acetone.

Toxicity to Wildlife and Domestic Animals

The toxicity of acetone to aquatic organisms is low. The LC_{50} value for sunfish was reported to be 14.2 g/liter, and the threshold concentration for immobilization of Daphnia magna was reported to be over 9 g/liter.

No information on the toxicity of acetone to terrestrial wildlife or domestic animals was available.

ARSENIC (Clement Associates, Inc., 1985*)

Health Effects

Arsenic has been implicated in the production of skin cancer in humans. There is also extensive evidence that inhalation of arsenic compounds causes lung cancer in workers. Arsenic compounds cause chromosome damage in animals, and humans exposed to arsenic compounds have been reported to have an elevated

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* References for Appendix F are included in Volume I of this report.

incidence of chromosome aberrations. Arsenic compounds have been reported to be teratogenic, fetotoxic, and embryotoxic in several animal species, and an increased incidence of multiple malformations among children born to women occupationally exposed to arsenic has been reported. Arsenic compounds also cause noncancerous, possibly precancerous, skin changes in exposed individuals. Several cases of progressive polyneuropathy involving motor and sensory nerves and particularly affecting the extremities and myelinated long-axon neurons have been reported in individuals occupationally exposed to inorganic arsenic. Polyneuropathies have also been reported after the ingestion of arsenic-contaminated foods.

Toxicity to Wildlife and Domestic Animals

Various inorganic forms of arsenic appear to have similar levels of toxicity; they all seem to be much more toxic than organic forms. Acute toxicity to adult freshwater animals occurs at levels of arsenic trioxide as low as 812 μg/liter and at levels as low as 40 μg/liter in early life stages of aquatic organisms. Acute toxicity to saltwater fish occurs at levels around 15 mg/liter, while some invertebrates are affected at much lower levels (508 μg/liter). Arsenic toxicity does not appear to increase greatly with chronic exposure, and it does not seem that arsenic is bioconcentrated to a great degree.

Arsenic poisoning is a rare but not uncommon toxic syndrome among domestic animals. Arsenic causes hyperemia and edema of the gastrointestinal tract, hemorrhage of the cardiac serosal surfaces and peritoneum, and pulmonary congestion and edema; and it may cause liver necrosis. Arsenic toxicity to terrestrial wildlife was not reported in the literature reviewed.

BENZENE (Clement Associates, Inc., 1985)

Health Effects

Benzene is a recognized human carcinogen. Several epidemiological studies provided sufficient evidence of a causal relationship between benzene exposure and leukemia in humans. Benzene is a known inducer of aplastic anemia in humans, with a latent period of up to 10 years. It produces leukopenia and thrombocytopenia, which may progress to ancytopenia. Similar adverse effects on the blood-cell-producing system occur in animals exposed to benzene. In both humans and animals, benzene exposure is associated with chromosomal damage, although it is not mutagenic in microorganisms. Benzene was fetotoxic and caused embryo lethality in experimental animals.

Exposure to very high concentrations of benzene [about 20,000 ppm (66,000 mg/m^3) in air] can be fatal within minutes. The prominent signs are central nervous system depression and convulsions, with death usually following as a consequence of cardiovascular collapse. Milder exposure can produce vertigo, drowsiness, headache, nausea, and eventually unconsciousness if exposure continues. Deaths from cardiac sensitization and cardiac arrhythmias have also been reported after exposure to unknown concentrations. Although most benzene hazards are associated with inhalation exposure, dermal absorption of liquid benzene may occur, and prolonged or repeated skin contact may produce blistering, erythema, and a dry, scaly dermatitis.

Toxicity to Wildlife and Domestic Animals

The EC_{50} values for benzene in a variety of invertebrate and vertebrate freshwater aquatic species range from 5,300 µg/liter to 386,000 µg/liter. However, only values for the rainbow trout (5,300 µg/liter) were obtained from a flow-through test and were based on measured concentrations. Results based on unmeasured concentrations in static tests are likely to underestimate toxicity for relatively volatile compounds like benzene. A chronic test with Daphnia magna was incomplete, with no adverse effects observed at test concentrations as high as 98,000 µg/liter.

For saltwater species, acute values for one fish and five invertebrate species range from 10,900 µg/liter to 924,000 µg/liter. Freshwater and saltwater plant species that have been studied exhibit toxic effects at benzene concentrations ranging from 20,000 µg/liter to 525,000 µg/liter.

BENZOIC ACID

Health Effects

Benzoic acid is considered moderately toxic by ingestion and intraperitoneal routes of exposure (Sax and Lewis, 1989). Large oral doses in humans result in gastric pain, nausea, and vomiting (Gosselin et al., 1984). Systemic effects observed following inhalation exposure include dyspnea and allergic dermatitis (Sax and Lewis, 1989). A 67-kilogram man has ingested doses of 50 grams without ill effects.

Toxicity to Wildlife and Domestic Animals

The mean lethal dose in cats and dogs is 2 g/kg (Gosselin et al., 1984). When injected in rats, tremors, convulsions, and death occur (Gosselin et al., 1984).

BIS(2-ETHYLHEXYL)PHTHALATE (Clement Associates, Inc., 1985)

Health Effects

Bis(2-ethylhexyl)phthalate (BEHP) is reported to be carcinogenic in rats and mice, causing increased incidences of hepatocellular carcinomas or neoplastic nodules after oral administration. Its status as a human carcinogen is considered indeterminate by the International Agency for Research on Cancer (IARC). The results of dominant lethal experiments with mice suggest that BEHP is mutagenic when injected intraperitoneally. However, most experiments conducted with microorganisms and mammalian cells have failed to demonstrate genotoxic activity. Teratogenic and fetotoxic effects have been observed in experimental animals after oral and intraperitoneal administration. Other reproductive effects, including testicular changes in rats and mice, have also been reported.

BEHP appears to have a relatively low toxicity in experimental animals. The oral, intraperitoneal, and intravenous LD_{50} values reported for BEHP in rats are 31 g/kg, 30.7 g/kg, and 0.25 g/kg, respectively. BEHP is poorly absorbed through the skin, and no irritant response or sensitizing potential from dermal application has been noted in experimental animals or humans.

Toxicity to Wildlife and Domestic Animals

Acute median effect values ranged from 1,000 to 11,100 mg/liter BEHP for the freshwater cladoceran *Daphnia magna*. The LC_{50} values for the midge, scud, and bluegill all exceeded the highest concentrations tested, which were 18,000, 32,000, and 770,000 mg/liter, respectively. As these values are greater than the water solubility of the chemical, it is unlikely that BEHP will be acutely toxic to organisms in natural waters. In a chronic toxicity test with *Daphnia magna*, significant reproductive impairment was found at the lowest concentration tested, 3 mg/liter. A chronic toxicity value of 8.4 mg/liter was reported for the rainbow trout. No acute or chronic values were reported for saltwater invertebrates or vertebrates. Reported bioconcentration factors for BEHP in fish and invertebrates range from 14 to 2,680.

Although insufficient data were presented to calculate the acute-chronic ratio for BEHP, it is apparently on the order of 100 to 1,000. Therefore, acute exposure to the chemical is unlikely to affect aquatic organisms adversely, but chronic exposure may have detrimental effects on the environment.

BROMODICHLOROMETHANE

Health Effects

No data are available on the toxicity of bromodichloromethane to humans. Medium lethal doses (LD_{50}) for ICR Swiss mice administered bromodichloromethane by gavage were 450 mg/kg and 900 mg/kg for males and females, respectively (Bowman et al., 1978 in EPA, October 1980). Animals that died in groups dosed over 500 to 4,000 mg/kg showed fatty infiltration of livers, pale kidneys, and hemorrhage in the kidneys, adrenals, lungs, and brains. Mice ingesting 300 mg/l in drinking water exhibited dramatic decrease in body weight (Cambell, 1978 in EPA, October 1980).

Female ICR mice exposed to bromodichloromethane by gavage for 90 days at 125 mg/kg daily exhibited a suppression of cellular and humoral immune response indices (Schuller et al., 1978 in

EPA, October 1980). Sanders et al. (1977) observed hepatomegaly and a depression in a reticuloendothelial system functional index in exposed mice (EPA, October 1980). Munson et al. (1977) observed a dose-dependent suppression of hepatic phagocytosis in mice exposed to daily doses by gavage ranging up to 125 mg/kg.

Bromodichloromethane was mutagenic in Salmonella typhimurium assay (Simmonet et al., 1978 in NAS, 1980).

The teratogenicity of bromodichloromethane has not been demonstrated, but some fetal abnormalities were reported in experiments in which mice were exposed to 8,375 mg/m^3 by inhalation for 7 hours/day during gestation days 6 to 15 (Schwetz, et al., 1957 in EPA, October 1980).

Toxicity to Wildlife and Domestic Animals

Data regarding the toxicity of bromodichloromethane to aquatic or terrestrial biota were not available in the literature reviewed.

2-BUTANONE (Clement Associates, Inc.)

Health Effects

MEK has not been adequately tested for carcinogenicity and has produced only equivocal evidence of mutagenicity in a few bacterial assays. MEK has been reported to cause retarded fetal development and some teratogenic effects (acaudia, imperforate anus, and brachygnathia) at air concentrations of 9,000 mg/m^3. MEK is of relatively low toxicity, but at high doses it affects the nervous system and causes irritation of the eyes, nose, and skin. The oral LD_{50} value for the rat was 2,750 mg/kg.

Although MEK is not strongly neurotoxic alone, it apparently strongly potentiates the neurotoxicity of n-hexane, and n-hexanone (methyl n-isobutyl ketone).

Toxicity to Wildlife and Domestic Animals

Only limited information was available on the toxicity of MEK to wildlife. LC_{50} concentrations for two freshwater fishes were around 5,600 µg/liter. MEK was toxic to brine shrimp at LC_{50} levels of 1,950 mg/liter.

No information on the toxicity of MEK to terrestrial wildlife or domestic animals was available.

CADMIUM (Clement Associates, Inc., 1985)

Health Effects

There is suggestive evidence linking cadmium with cancer of the prostate in humans. In animal studies, exposure to cadmium by inhalation caused lung tumors in rats, and exposure by injection produced injection-site sarcomas and/or Leydig-cell tumors. An increased incidence of tumors has not been seen in animals exposed to cadmium orally, but four of the five available studies were inadequate by current standards.

The evidence from a large number of studies on the mutagenicity of cadmium is equivocal, and it has been hypothesized that cadmium is not directly mutagenic but impedes repair. Cadmium is a known animal teratogen and reproductive toxin. It has been shown to cause renal dysfunction in both humans and animals. Other toxic effects attributed to cadmium include immunosuppression (in animals), anemia (in humans), pulmonary disease (in humans), possible effects on the endocrine system, defects in sensory function, and bone damage. The oral LD_{50} in the rat was 225 mg/kg.

Toxicity to Wildlife and Domestic Animals

Laboratory experiments suggest that cadmium may have adverse effects on reproduction in fish at levels present in lightly to moderately polluted waters.

The acute LC_{50} for freshwater fish and invertebrates generally ranged from 100 to 1,000 µg/liter; salmonids are much more sensitive than other organisms. Saltwater species were in general 10-fold more tolerant to the acute effects of cadmium. Chronic tests have been performed and show that cadmium has cumulative toxicity and acute-chronic ratios that range from 66 to 431. Bioconcentration factors were generally less than 1,000 but were as high as 10,000 for some freshwater fish species.

No adverse effects on domestic or wild animals were reported in the studies review.

CARBON DISULFIDE

Health Effects

Toxic effects to humans via inhalation of carbon disulfide have been reported in the literature. Inhalation of 50 mg/m^3 for 7 years was associated with central nervous effects (Registry of Toxic Effects for Chemical Substances (RTECs), 1975 in NAS, 1977). The lowest reported lethal concentration in humans is 4,000 ppm in 30 minutes (RTECs, 1975 in NAS, 1977). Moderate chronic exposure at less than 65 mg/m^3 for several years was reported to cause polyneuropathy (Cooper, 1976 in NAS, 1977).

Oral administration of carbon disulfide in rats produced toxic effects at 1 ppm (Freundt et al., 1974 in NAS, 1977). One ppm in drinking water was nontoxic to rabbits; 70 ppm was lethal (Vinogradov, 1966 in NAS, 1977).

In chronic studies, 6 mg/mg-day produced toxic effects in rats (Paterni et al., 1958 in NAS, 1977). Carbon disulfide applied topically produced a higher incidence of anemia in female than in male rats, and teratogenic effects were observed (Gut, 1969 in NAS, 1977). When rats inhaled carbon disulfide at 10 mg/m^3, abnormalities of the genitourinary and skeletal systems, disturbances of ossification and blood formation, and dystrophic changes in the _________ and kidney were noted (Bariliak et al., 1975 in NAS, 1977).

Carbon disulfide has been demonstrated to cause disturbances in reproduction as well as teratogenic effects in animals when inhaled (NAS, 1977). Bariliak et al. (1975) observed that inhalation of 10 mg/m^3 was lethal to embryos before and after implantation. Bariliak et al. (1975) reported that inhalation of 10 mg/m^3 by male rats before copulation by male rats resulted in embryo lethality (NAS, 1977). Inhalation of 2.2 g/m^3 for 4 hours/day proved embryotoxic if given to females during gestation (Salnikova and Chirkova, 1974). Inhalation of lower concentrations (0.34 mg/l for 210 days) caused disturbances during estrus (Rozcwiski et al., 1973 in NAS, 1977).

Toxicity to Wildlife and Domestic Animals

Data regarding the toxicity of carbon disulfide to aquatic and terrestrial biota were not available in the literature reviewed.

CARBON TETRACHLORIDE (Clement Associates, Inc., 1985)

Health Effects

Carbon tetrachloride was carcinogenic in mice, rats, and hamsters; in all cases liver tumors were induced. In addition, mice also displayed a high incidence of tumors of the adrenal gland. Studies discussed by EPA on the mutagenic and teratogenic effects of carbon tetrachloride and its impact on reproduction are inconclusive. Carbon tetrachloride also causes both liver and kidney damage in animals and humans. One study in which guinea pigs were repeatedly exposed to carbon tetrachloride vapor for several months provided evidence of damage to the optic nerve and degeneration of the myelin sheath of the sciatic nerve.

Toxicity to Wildlife and Domestic Animals

Carbon tetrachloride has been shown to be acutely toxic to aquatic species at concentrations as low as 35 mg/liter. No data on chronic toxicity to aquatic life were reported in the literature reviewed. Fish bioconcentrate carbon tetrachloride by a factor of less than 50. No studies on the toxicity of carbon tetrachloride to domestic animals or terrestrial wildlife were found in the literature reviewed.

CHLOROBENZENE (Clement Associates, Inc., 1985)

Health Effects

A study of the carcinogenicity of chlorobenzene was recently completed by the National Toxicology Program and preliminary results show that chlorobenzene caused neoplastic nodules in the liver of male rats but was not carcinogenic in female rats or in mice.

Occupational studies suggest that chronic exposure to monochlorobenzene vapor may cause blood dyscrasia, hyperlipidemia, and cardiac dysfunction in humans. Like many organic solvents, monochlorobenzene is a central nervous system depressant in overexposed humans, but no chronic neurotoxic effects have been reported. Animals exposed to chlorobenzene have exhibited liver and kidney damage and atrophy of the seminiferous tubules in the testes. The oral LD_{50} value for rats was 2,910 mg/kg.

Toxicity to Wildlife and Domestic Animals

Chlorobenzene was acutely toxic to fish at levels greater than 25 mg/liter and to aquatic invertebrates at levels greater than 10 mg/liter. No chronic studies on the toxicity of chlorobenzene to aquatic life were found in the literature reviewed. Monochlorobenzene was shown to have a bioaccumulation factor of about 1,000 in freshwater species. No studies on terrestrial wildlife or domestic animals were reported in the literature reviewed.

CHLORODIBROMOMETHANE

Health Effects

No data are available on the toxicity of chlorodibromomethane to humans. The oral and lethal dose for female and male Swiss ICR mice are 1,200 mg/kg and 800 mg/kg (NAS, 1980). Deaths occurred from 1 to 5 days after exposure. Effects reported include fatty infiltration of the liver, pale kidneys, and hemorrhaging of the adrenals (NAS, 1980). Chlorodibromomethane is mutagenic in the *Salmonella typhimurium* assay (Simmon et al., 1978).

Toxicity to Wildlife and Domestic Animals

Data regarding the toxicity of chlorodibromomethane to aquatic and terrestrial biota were not available in the literature reviewed.

CHLOROMETHANE (EPA, October 1980)

Health Effects

Chloromethane is a central nervous system depressant. Toxic manifestations of inhalation exposure include blurred vision, headache, nausea, loss of coordination, and personality changes. Systemic poisonings have involved hepatic and renal injury. Recovery is rapid after brief exposures. There are no reports of reproductive toxicity or teratogenicity in humans. Acute toxic effects from inhalation are reported at 1,032 mg/m^3.

Toxicity to Wildlife and Domestic Animals

There is no information available on the toxicity of chloromethane on aquatic life. In animals, a variety of toxic effects have been observed in experimentally exposed animals. Many effects were consistent with human data, suggesting central nervous system involvement and altered metabolism. A 6-hour LC_{50} of 6,500 mg/m^3 is reported for mice.

CHLOROFORM (Clement Associates, Inc., 1985)

Health Effects

Chronic administration of chloroform by gavage is reported to produce a dose-related increase in the incidence of kidney epithelial tumors in rats and a dose-related increase in the incidence of hepatocellular carcinomas in mice. Epidemiological studies suggest that higher concentrations of chloroform and other trihalomethanes in water supplies may be associated with an increased frequency of bladder cancer in humans. However, these results are not sufficient to establish causality. An increased incidence of fetal abnormalities was reported in offspring of pregnant rats exposed to chloroform by inhalation. Oral doses of chloroform that caused maternal toxicity produced relatively mild fetal toxicity in the form of reduced birth weights. There are limited data suggesting that chloroform has mutagenic activity in some test systems. However, negative results have been reported for bacterial mutagenesis assays.

Humans may be exposed to chloroform by inhalation, ingestion, or skin contact. Toxic effects include local irritation of the skin or eyes, central nervous system depression, gastrointestinal irritation, liver and kidney damage, cardiac arrhythmia, ventricular tachycardia, and brachycardia. Death from chloroform overdosing can occur and is attributed to ventricular fibrillation. Chloroform anesthesia can produce delayed death as a result of liver necrosis.

Exposure to chloroform by inhalation, intragastric administration, or intraperitoneal injection produces liver and kidney damage in laboratory animals. The oral LD_{50} and inhalation LC_{LO} values for the rat are 908 mg/kg and 39,000 mg/m^3 per 4 hours, respectively.

CHROMIUM (Clement Associates, Inc., 1985)

Health Effects

The hexavalent form of chromium is of major toxicological importance in higher organisms. A variety of chromate (Cr VI) salts are carcinogenic in rats, and an excess of lung cancer has been observed among workers in the chromate-producing industry. Cr VI compounds can cause DNA and chromosome damage in animals and humans, and Cr (VI) trioxide in teratogenic in the hamster. Inhalation of hexavalent chromium salts causes irritation and inflammation of the nasal mucosa, and ulceration and perforation of the nasal septum. Cr VI also produces kidney damage in animals and humans. The liver is also sensitive to the toxic effects of hexavalent Cr, but apparently less so than the kidneys or respiratory system. Cr III is less toxic than Cr VI; its main effect in humans is a form of contact dermatitis in sensitive individuals.

Toxicity to Wildlife and Domestic Animals

Chromium is an essential nutrient and is accumulated in a variety of aquatic and marine biota, especially benthic organisms, to levels much higher than in ambient water. Levels in biota, however, usually are lower than levels in the sediments. Passage of chromium through the food chain can be demonstrated. The food chain appears to be a more efficient pathway for chromium uptake than direct uptake from seawater.

Water hardness, temperature, dissolved oxygen, species, and age of the test organism all modify the toxic effects of chromium on aquatic life. Cr III appears to be more acutely toxic to fish than Cr VI; the reverse is true in long-term chronic exposure studies.

None of the plants normally used as food or animal feed are chromium accumulators. Chromium absorbed by plants tends to remain primarily in the roots and is poorly translocated to the leaves. There is little tendency for chromium to accumulate along food chains in the trivalent inorganic form. Organic chromium compounds, about which little is known, can have significantly different bioaccumulation tendencies. Little information concerning the toxic effects of chromium on mammalian wildlife and domestic animal species is available.

DDT (Clement Associates, Inc., 1985)

Health Effects

DDT, DDE, and DDD have been shown to be carcinogenic to mice, primarily causing liver tumors, but also causing lung tumors and lymphomas. DDT does not appear to be mutagenic, but it has caused chromosomal damage. There is no evidence that DDT is a teratogen; but it is a reproductive toxin, causing reduced fertility, reduced growth of offspring, and fetal mortality.

Chronic exposure to DDT causes a number of adverse effects, especially to the liver and central nervous system (CNS). DDT induces various microsomal enzymes and therefore probably affects the metabolism of steroid hormones and exogenous chemicals. Other effects on the liver include hypertrophy of the parenchymal cells and increased fat deposition. In the CNS, exposure to DDT causes behavioral effects such as decreased aggression and decreased conditional reflexes. Acute exposure to large doses or chronic exposure to lower doses causes seizures. The oral LD_{50} is between 113 and 450 mg/kg for the rat and is generally higher for other animals.

DDT, DDD, and DDE are bioconcentrated and stored in the adipose tissues of most animals.

Toxicity to Wildlife and Domestic Animals

DDT has been extensively studied in freshwater invertebrates and fishes and is quite toxic to most species. The range of toxicities was 0.18 to 1,800 µg/liter, and the freshwater final acute value for DDT and its isomers was determined by EPA to be 1.1 µg/liter. Saltwater species were somewhat more sensitive to DDT; the saltwater final acute value for the DDT isomers was 0.13 µg/liter. Only one chronic toxicity test on aquatic species was reported. This test indicated that the acute-chronic ratio for DDT might be high (65 in the reported study), but the data were insufficient to allow calculation of a final acute-chronic ratio. DDT, DDD, and DDE are bioconcentrated by a factor of 10^3 to 10^5.

DDT, DDD, DDE and the other persistent organochlorine pesticides are primarily responsible for the great decrease in the reproductive capabilities and consequently in the populations of fish-eating birds, such as the bald eagle, brown pelican, and osprey. DDT has also been shown to decrease the populations of numerous other species of waterbirds, raptors, and passerines significantly.

1,2-DICHLOROETHANE (Clement Associates, Inc., 1985)

Health Effects

1,2-Dichloroethane is carcinogenic in rats and mice, producing a variety of tumors. When administered by gavage, it produced carcinomas of the forestomach and hemangiosarcomas of the circulatory system in male rats; adenocarcinomas of the mammary gland in female rats; lung adenomas in male mice; and lung adenomas, mammary adenocarcinomas, and endometrial tumors in female mice. It is mutagenic when tested using bacterial test systems. Human exposure by inhalation to 1,2-dichloroethane has been shown to cause headache, dizziness, nausea, vomiting, abdominal pain, irritation of the mucous membranes, and liver and kidney dysfunction. Dermatitis may be produced by skin contact. In severe cases, leukocytosis (an excess of white blood cells) may be diagnosed; and internal hemorrhaging and pulmonary edema leading to death may occur. Similar effects are produced in experimental animals.

Toxicity to Wildlife and Domestic Animals

1,2-Dichloroethane is one of the chlorinated ethanes least toxic to aquatic life. For both fresh- and salt-water species, it is acutely toxic at concentrations greater than 118 mg/liter, while chronic toxicity has been observed at 20 mg/liter. 1,2-Dichloroethane is not likely to bioconcentrate, as its steady-state bioconcentration factor was 2 and its elimination half-life was less than 2 days in bluegill.

No information on the toxicity of 1,2-dichloroethane to domestic animals or terrestrial wildlife was available in the literature reviewed.

1,1-DICHLOROETHANE (Clement Associates, Inc., 1985)

Health Effects

Limited toxicological testing of 1,1-dichloroethane has been conducted, although the literature indicates that 1,1-dichloroethane is one of the least toxic of the chlorinated ethanes. An NCI bioassay on 1,1-dichloroethane was limited by poor survival of test animals, but some marginal tumorigenic effects were seen. Inhalation exposure to high doses of 1,1-dichloroethane (over 16,000 mg/m^3) caused retarded fetal development in rats. 1,1-Dichloroethane was not found to be mutagenic using the Ames assay. 1,1-Dichloroethane causes central nervous system depression when inhaled at high concentrations, and evidence suggests that the compound is heptatoxic in humans. Kidney and liver damage was seen in animals exposed to high levels of 1,1-dichloroethane. The oral LD_{50} value in the rat is 725 mg/kg.

Toxicity to Wildlife and Domestic Animals

No information on the toxicity of 1,1-dichloroethane to aquatic species was reported in the literature reviewed. However, the available information on the chloroethanes indicates that toxicity declines with decreases in chlorination and that the 1,1,1-isomer is less active than the 1,1,2-isomer. Therefore, 1,1-dichloroethane is probably no more toxic than 1,2-dichloroethane, which is acutely toxic at levels of 100-500 mg/liter and has a chronic toxicity beginning at about 20 mg/liter.

No information on the toxicity of 1,1-dichloroethane to terrestrial wildlife or domestic animals was found in the sources reviewed.

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1,1-DICHLOROETHENE (Clement Associates, Inc., 1985)

Health Effects

1,1-Dichloroethene caused kidney tumors in males and leukemia in males and females in one study of mice exposed by inhalation, gave equivocal results in other inhalation studies, and gave negative results in rats and mice following oral exposure and in hamsters following inhalation exposure. 1,1-Dichloroethene was mutagenic in several bacterial assays. 1,1-Dichloroethene did not appear to be teratogenic but did cause embryotoxicity and fetotoxicity when administered to rats and rabbits by inhalation. Chronic exposure to oral doses of 1,1-dichloroethene as low as 5 mg/kg/day caused liver changes in rats. Acute exposure to high doses causes central nervous system depression, but neurotoxicity has not been associated with low-level chronic exposure. The oral LD_{50} value for the rat is 1,500 mg/kg, and for the mouse it is 200 mg/kg.

Toxicity to Wildlife and Domestic Animals

1,1-Dichloroethene is not very toxic to freshwater or saltwater species, with acute LC_{50} values generally ranging from 80 to 200 mg/liter. A chronic study in which no adverse effects were observed indicated that the acute-chronic ratio was less than 40; a 13-day study that produced an LC_{50} of 29 mg/liter indicated that the acute-chronic ratio is greater than 4.

No reports of the toxicity of 1,1-dichloroethene to terrestrial wildlife or domestic animals were found in the literature reviewed.

1,2-DICHLOROETHENE (Clement Associates, Inc.)

Health Effects

Very little information concerning exposure only to 1,2-DCE is available. There are no reports of carcinogenic or teratogenic activity by 1,2-DCE in animals or humans. It is reportedly nonmutagenic in a variety of test systems. Like other members of the chlorinated ethene series, 1,2-DCE has anesthetic properties. Exposure to high vapor concentrations has been found to cause nausea, vomiting, weakness, tremor, and cramps in humans. Repeated exposure via inhalation of 800 mg/m^3 (8 hours/day, 5 days/week for 16 weeks) was reported to produce fatty degeneration of the liver in rats. The intraperitoneal injection LD_{50} value for the rat is 7,536 mg/kg.

Although nephrotoxic and cardiac sensitizing effects are associated with exposure to 1,1-DCE, the 1,2-DCE isomers have not been investigated with respect to this type of effect. 1,2-DCE can inhibit aminopyrine demethylation in rat liver microsomes _in vitro_, and it may thus interact with the hepatic drug-metabolizing monooxygenase system.

Toxicity to Wildlife and Domestic Animals

Practically no information concerning the toxicity of 1,2-DCE to wildlife and domestic animals exists. The reported 96-hour LC_{50} value under static conditions is 135,000 µg/liter for the bluegill. Under the same test conditions, the LC_{50} value for 1,1-DCE is 73,900 µg/liter. Recommended criteria for protection of aquatic life are based primarily on data concerning 1,1-DCE.

DI-N-BUTYL PHTHALATE (EPA, October 1980b)

Health Effects

Most of the detailed toxicological studies for phthalates focused on BEHP. There is no evidence of carcinogenicity of DNBP. Rats fed 0.25 percent DNBP in their food experienced no adverse effects after 1 year. A dose of 1.25 percent resulted in death for 50 percent of the test population, while the rest grew normally. Rats exposed by inhalation to concentrations of 0.98 mg/m^3 experienced no behavioral changes or weight, but an increase in gamma globulin was found to be dose-related. The intraperitoneal LD_{50} for rats was found to be 3.05 g/kg.

Toxicity to Wildlife and Domestic Animals

Four fish and two invertebrate species were exposed to DNBP. The LC_{50} values ranged from 730 to 6,470 µg/l. Bluegills were found to be the most sensitive fish and the scud was the most sensitive invertebrate.

ETHYLBENZENE (Clement Associates, Inc., 1985)

Health Effects

Ethylbenzene has been selected by the National Toxicology Program to be tested for possible carcinogenicity, although negative results were obtained in mutagenicity assays in Salmonella typhimurium and Saccharomyces cerevisiae. There is recent animal evidence that ethylbenzene causes adverse reproductive effects. Ethylbenzene is a skin irritant, and its vapor is irritating to the eyes at a concentration of 200 ppm (870 mg/m^3) and above. When experimental animals were exposed to ethylbenzene by inhalation, 7 hours/day for 6 months, adverse effects were produced at concentrations of 600 ppm (2,610 mg/m^3) and above, but not at 400 ppm (1,740 mg/m^3). At 600 ppm, rats and guinea pigs showed slight changes in liver weight, and monkeys and rabbits experienced histopathologic changes in the testes. Similar effects on the liver and kidney were observed in rats fed ethylbenzene at 4-8 and 680 mg/kg/day for 6 months.

Toxicity to Wildlife and Domestic Animals

Ethylbenzene was accurately toxic to freshwater species at levels greater than 32 mg/liter. No chronic toxicity was reported, but the highest test dose (440 µg/liter) was only one-hundredth of the 96-hour LC_{50} for the particular species being tested. No studies on the bioaccumulation of ethylbenzene were reported in the information reviewed, but a bioconcentration factor of 95 was calculated using the log octanol/water partition coefficient. No information on the toxicity of ethylbenzene to domestic animals and terrestrial wildlife was found in the sources reviewed.

ISOPHORONE (ACGIH, 1980)

Health Effects

Exposure in the workplace to isophorone at concentrations of 40 to 400 ppm resulted in eye, nose, and throat irritation, nausea, headache, dizziness, faintness, and inebriation. A time-weighted average threshold limit value of 5 ppm (25 mg/m^3) was recommended to prevent fatigue and malaise. No carcinogenic, mutagenic, or teratogenic effects are reported for humans.

Toxicity to Wildlife and Domestic Animals

No studies on the toxicity of isophorone to domestic animals or wildlife were found in the literature reviewed.

LEAD (Clement Associates, Inc. 1985)

Health Effects

There is evidence that several lead salts are carcinogenic in mice or rats, causing tumors of the kidneys after either oral or parenteral administration. Data concerning the carcinogenicity of lead in humans are inconclusive. The available data are not sufficient to evaluate the carcinogenicity of organic lead compounds or metallic lead. There is equivocal evidence that exposure to lead causes genotoxicity in humans and animals. The available evidence indicates that lead presents a hazard to reproduction and exerts a toxic effect on conception, pregnancy, and the fetus in humans and experimental animals.

Many lead compounds are sufficiently soluble in body fluids to be toxic. Exposure of humans or experimental animals to lead can result in toxic effects in the brain and central nervous system, the peripheral nervous system, the kidneys, and the hematopoietic system. Chronic exposure to inorganic lead by ingestion or inhalation can cause lead encephalopathy, and severe cases can result in permanent brain damage. Lead poisoning may cause peripheral neuropathy in adults and children, and permanent learning disabilities that are clinically undetectable in children may be caused by exposure to relatively low levels. Short-term exposure to lead can cause reversible kidney damage, but prolonged exposure at high concentrations may result in progressive kidney damage and possibly kidney failure. Anemia, due to inhibition of hemoglobin synthesis and a reduction in the life span of circulating red blood cells, is an early manifestation of lead poisoning. Several studies with experimental animals suggest that lead may interfere with various aspects of the immune response.

Toxicity to Wildlife and Domestic Animals

Freshwater vertebrates and invertebrates are more sensitive to lead in soft water than in hard water. At a hardness of about 50 mg/liter $CaCO_3$, the median effect concentrations for nine families range from 140 mg/liter to 236,600 mg/liter. Chronic values for Daphnia magna and the rainbow trout are 12.26 and 83.08 mg/liter, respectively, at a hardness of about 50 mg/liter. Acute-chronic ratios calculated for three freshwater species ranged from 18 to 62. Bioconcentration factors, ranging from 42 for young brook trout to 1,700 for a snail, were reported. Freshwater algae show an inhibition of growth at concentrations about 500 mg/liter.

Acute values for twelve saltwater species range from 476 mg/liter for the common mussel to 27,000 mg/liter for the softshell clam. Chronic exposure to lead causes adverse effects in mysid shrimp at 37 mg/liter, but not at 17 mg/liter. The acute-chronic ratio for this species is 118. Reported bioconcentration factors range from 17.5 for the quahog clam to 2,570 for the blue mussel. Saltwater algae are adversely affected at concentrations as low as 15.8 mg/liter.

Although lead is known to occur in the tissue of many free-living wild animals, including birds, mammals, fishes, and invertebrates, reports of poisoning usually involve waterfowl. There is evidence that lead, at concentrations occasionally found near roadsides and smelters, can eliminate or reduce populations of bacteria and fungi on leaf surfaces and in soil. Many of these microorganisms play key roles in the decomposer food chain.

Cases of lead poisoning have been reported for a variety of domestic animals, including cattle, horses, dogs, and cats. Several types of anthropogenic sources are cited as the source of lead in these reports. Because of their curiosity and their indiscriminate eating habits, cattle experience the greatest incidence of lead toxicity among domestic animals.

LINDANE (EPA, September 1984)

Health Effects

Ingestion of lindane caused liver tumors in mice, but other animal bioassays have been negative or equivocal. Several case histories link the development of aplastic anemia with exposure to lindane alone or in combination with DDT. Lindane is the most acutely toxic isomer of hexachlorocyclohexane and causes stimulation of the central nervous system. Chronic inhalation of lindane in the workplace resulted in liver changes and chronic pancreatitis.

Toxicity to Wildlife and Domestic Animals

Cladocerans are the most resistant organisms tested, with mean LC_{50} values of 460 to 676 µg/l. Crustaceans are the most sensitive, with LC_{50} values of 10 to 48 µg/l. Freshwater fish LC_{50}s range from 2 to 141 µg/l with warmwater fishes generally more tolerant than the coldwater salmonids.

4-METHYLPHENOL

Health Effects

Data regarding the subchronic and chronic oral toxicity of 4-methylphenol (o-cresol) in humans or experimental animals were not available in the literature reviewed. Subchronic inhalation studies indicate that an exposure level of 9 mg o-cresol/m^3, 6 hours/day, 5 days/week for 2 months and then for 4 hours/day, 5 days/week for 2 subsequent months, produced unspecified changes in EKGs in guinea pigs and CNS and blood changes in rats (Uzhdavini et al., 1972 in EPA, September 1984). Rats exposed to a 0.05 mg/m^3 mixture of three cresol isomers for 90 days exhibited CNS excitation, lung protein denaturation, and decreased body weight gain (Kurlyandskiy et al., 1975 in EPA, September, 1984).

Toxicity to Wildlife and Domestic Animals

Regarding the toxicity of 4-methylphenol to aquatic or terrestrial biota were not available in the literature reviewed.

MERCURY (Clement Associates, Inc., 1985)

Health Effects

When administered by intraperitoneal injection, metallic mercury produces implantation site sarcomas in rats. No other studies were found connecting mercury exposure with carcinogenic effects in animals or humans. Several mercury compounds exhibit a variety of genotoxic effects in eukaryotes. In general, organic mercury compounds are more toxic than inorganic compounds. Although brain damage due to prenatal exposure to methylmercury has occurred in human populations, no conclusive evidence is available to suggest that mercury causes anatomical defects in humans. Embryotoxicity and teratogenicity of methylmercury has been reported for a variety of experimental animals. Mercuric chloride is reported to be teratogenic in experimental animals. No conclusive results concerning the teratogenic effects of mercury vapor are available.

In humans, alkyl mercury compounds pass through the blood brain barrier and the placenta very rapidly, in contrast to inorganic mercury compounds. Major target organs are the central and peripheral nervous systems, and the kidney. Methylmercury is particularly hazardous because of the difficulty of eliminating it from the body. In experimental animals, organic mercury compounds can produce toxic effects in the gastrointestinal tract, pancreas, liver, heart, and gonads, with involvement of the endocrine, immunocompetent, and central nervous systems.

Elemental mercury is not highly toxic as an acute poison. However, inhalation of high concentrations of mercury vapor can cause pneumonitis, bronchitis, chest pains, dyspnea, coughing, stomatitis, gingivitis, salivation, and diarrhea. Soluble mercuric salts are highly poisonous on ingestion, with oral LD_{50} values of 20 to 60 mg/kg reported. Mercurous compounds are less toxic when administered orally. Acute exposure to mercury compounds at high concentrations causes a variety of gastrointestinal symptoms and severe anuria with uremia. Signs and symptoms associated with chronic exposure involve the central nervous system and include behavioral and neurological disturbances.

Toxicity to Wildlife and Domestic Animals

The toxicity of mercury compounds has been tested in a wide variety of aquatic organisms. Although methylmercury appears to be more toxic than inorganic mercuric salts, few acute or chronic toxicity tests have been conducted with it. Among freshwater species, the 96-hour LC_{50} values for inorganic mercuric salts range from 0.02 µg/liter for crayfish to 2,000 µg/liter for caddisfly larvae. Acute values for methylmercuric compounds and other mercury compounds are only available for fishes. In rainbow trout, methylmercuric chloride is about ten times more toxic to rainbow trout than mercuric chloride, which is acutely toxic at about 300 µg/liter at 10°C. Methylmercury is the most chronically toxic of the tested compounds, with chronic values for Daphnia magna and brook trout of 1.00 and 0.52 µg/liter, respectively. The acute-chronic ratio for Daphnia magna is 3.2.

Mean acute values for saltwater species range from 3.5 to 1,680 µg/liter. In general, molluscs and crustaceans are more sensitive than fish to the acute toxic effects of mercury. A life-cycle experiment with the mysid shrimp showed that inorganic mercury at a concentration of 1.6 µg/liter significantly influences time of appearance of first brood, time of first spawn, and productivity. The acute-chronic ratio for the mysid shrimp is 2.9.

Chronic dietary exposure of chickens to mercuric chloride at growth inhibitory levels causes immune suppression, with a differential reduction effect on specific immunoglobulins.

METHYLENE CHLORIDE (Clement Associates, Inc., 1985)

Health Effects

Methylene chloride is currently under review by the National Toxicology Program. Preliminary results indicate that it produced an increased incidence of lung and liver tumors in mice and mammary tumors in females and male rats. In a chronic inhalation study, male rats exhibited an increased incidence of sarcomas in the ventral neck region. However, the authors suggested that the relevance and toxicological significance of this finding were uncertain in light of available toxicity data. Methylene chloride is reported to be mutagenic in bacterial test systems. It also has produced positive results in the Fischer rat embryo cell-transformation tests. However, it has been suggested that the observed cell-transforming capability may have been due to impurities in the test material. There is no conclusive evidence that methylene chloride can produce teratogenic effects.

In humans, direct contact with methylene chloride produces eye, respiratory passage, and skin irritation. Mild poisonings due to inhalation exposure produce somnolence, lassitude, numbness and tingling of the limbs, anorexia, and lightheadedness, followed by rapid and complete recovery. More severe poisonings generally involve correspondingly greater disturbances of the central and peripheral nervous systems. Methylene chloride also has acute toxic effects on the heart, including the induction of arrhythmia. Fatalities reportedly due to methylene chloride exposure have been attributed to cardiac injury and heart failure. Methylene chloride is metabolized to carbon monoxide in vivo, and levels of carboxyhemoglobin the blood are elevated after acute exposure. In experimental animals, methylene chloride is reported to cause kidney and liver damage, convulsions, and distal paresis. An oral LD_{50} value of 2,136 mg/kg, and an inhalation LC_{50} value of 88,000 mg/m^3/30 minutes are reported for the rat.

Toxicity to Wildlife and Domestic Animals

Very little information concerning the toxicity of methylene chloride to domestic animals and wildlife exists. Acute values for the freshwater species *Daphnia magna*, the fathead minnow, and the bluegill are 224,000, 193,000 and 224,000 µg/liter, respectively. Acute values for the saltwater species, mysid shrimp and sheepshead minnow, are 256,000 and 331,000 µg/liter, respectively. No data concerning chronic toxicity are available. The 96-hour EC_{50} values for both freshwater and saltwater algae are greater than the highest test concentration, 662,000 µg/liter.

4-METHYL-2-PENTANONE (Clement Associates, Inc.)

Health Effects

No studies on the carcinogenicity, mutagenicity, reproductive toxicity, or teratogenicity of methyl isobutyl ketone were found in the literature reviewed. Kidney damage was observed in rats exposed to 400 mg/m^3 of MIBK for 2 weeks but the damage appeared to be reversible. Methyl isobutyl ketone caused headache, nausea, vomiting, and eye irritation in a number of workers exposed to concentrations of 200 to 2,000 mg/m^3. The oral LD_{50} for MIBK in the rat was 2,080 mg/kg.

Toxicity to Wildlife and Domestic Animals

The only study on the toxicity of methyl isobutyl ketone to wildlife reported that the TL_{50} for brine shrimp was 1,230 mg/liter. MIBK is probably also not very toxic to other aquatic species or to terrestrial animals.

NICKEL (Clement Associates, Inc., 1985)

Health Effects

There is extensive epidemiological evidence indicating excess cancer of the lung and nasal cavity for workers at nickel refineries and smelters, and weaker evidence for excess risk in workers at nickel electroplating and polishing operations. Respiratory tract cancers have occurred in excess at industrial facilities that are metallurgically diverse in their operations. The nickel compounds that have been implicated as having carcinogenic potential are insoluble dusts of nickel subsulfide and nickel oxides, the vapor of nickel carbonyl, and soluble aerosols of nickel sulfate, nitrate, or chloride. Inhalation studies with experimental animals suggest that nickel subsulfide and nickel carbonyl are carcinogenic in rats. Evidence for the carcinogenicity of nickel metal and other compounds is relatively weak or inconclusive. Studies with experimental animals indicate that nickel compounds can also produce various types of malignant tumors in experimental animals after administration by other routes, including subcutaneous, intramuscular, implantation, intravenous, intrarenal, and intrapleural. Carcinogenic potential is not strongly dependent on route or site of administration but appears to be inversely related to the solubility of the compounds in aqueous media. Insoluble compounds, such as nickel dust, nickel sulfide, nickel carbonate, nickel oxide, nickel carbonyl, and nickelocene are carcinogenic, whereas soluble nickel salts such as nickel chloride, nickel sulfate, and nickel ammonium sulfate, are not.

Mammalian cell transformation data indicate that several nickel compounds are mutagenic and can cause chromosomal alterations. The available information is inadequate for assessing teratogenic and reproductive effects of nickel in humans and experimental animals.

Dermatitis and other dermatological effects are the most frequent effects of exposure to nickel and nickel-containing compounds. The dermatitis is a sensitization reaction. Most information regarding acute toxicity of nickel involves inhalation exposure to nickel carbonyl. Clinical manifestations of acute poisoning include both immediate and delayed symptoms. Acute chemical pneumonitis is produced, and death may occur at exposures of 30 ppm (107 mg/m^3) for 30 minutes. Rhinitis, nasal sinusitis, and nasal mucosal injury are among the effects reported among workers chronically exposed to various nickel compounds. Studies with experimental animals suggest that nickel and nickel compounds have relatively low acute and chronic oral toxicity.

Toxicity to Wildlife and Domestic Animals

In freshwater, toxicity depends on hardness; nickel tends to be more toxic in softer water. Acute values for exposure to a variety of nickel salts, expressed as nickel, range from 510 µg/liter for *Daphnia magna* to 46,200 µg/liter for banded killifish at comparable hardness levels. Chronic values range from 14.8 µg/liter for *Daphnia magna* in soft water to 530 µg/liter for the fathead minnow in hard water. Acute-chronic ratios for *Daphnia magna* range from 14 in hard water to 83 in soft water, and are approximately 50 in both hard and soft water for the fathead minnow. Residue data for the fathead minnow indicate a bioconcentration factor of 61. Freshwater algae experience reduced growth at nickel concentrations as low as 100 µg/liter.

Acute values for saltwater species range from 152 µg/liter for mysid shrimp to 350,000 µg/liter for the mummichog. A chronic value of 92.7 µg/liter is reported for the mysid shrimp, which gives an acute-chronic ratio of 5.5 for the species. Reduced growth is seen in saltwater algae at concentrations as low as 1,000 µg/liter. Bioconcentration factors ranging from 299 to 416 have been reported for the oyster and mussel.

POLYCHLORINATED BIPHENYLS (PCBs)
(Clement Associates, Inc., 1985)

Health Effects

In humans exposed to polychlorinated biphenyls (PCBs) (in the workplace or via accidental contamination of food), reported adverse effects include chloracne (a long-lasting, disfiguring skin disease), impairment of liver function, a variety of neurobehavioral and affective symptoms, menstrual disorders, minor birth abnormalities, and probably increased incidence of cancer. Animals experimentally exposed to PCBs have shown most of the same symptoms, as well as impaired reproduction; pathological changes in the liver, stomach, skin, and other organs; and suppression of immunological functions. PCBs are carcinogenic in rats and mice and, in appropriate circumstances, enhance the effects of other carcinogens. Reproductive and neurobiological effects of PCBs have been reported in rhesus monkeys at the lowest dose level tested, 11 mg/kg body weight/day over a period of several months.

Toxicity to Wildlife and Domestic Animals

Polychlorinated biphenyls are bioaccumulated and can be biomagnified. Therefore, their toxicity increases with length of exposure and position of the exposed species on the food chain. The toxicity of the various PCB mixtures is also dependent on their composition. Because of the complexity of PCB toxicity, only general effects will be discussed here.

The 96-hour LC_{50} values for rainbow trout, bluegills, and channel catfish were around 20 mg/liter. The same species exposed for 10 to 20 days had LC_{50} values of about 0.1 mg/liter. Invertebrate species were also adversely affected, with some species having 7-day LC_{50} values as low as 1 mg/liter. In general, juvenile organisms appeared more susceptible to the effects of PCBs than either eggs or adults.

Three primary ways in which PCBs can affect terrestrial wildlife are outright mortality, adversely affecting reproduction, and changing behavior. PCB doses greater than 200 ppm in the diet or 10 mg/kg body weight (bw) caused some mortality in sensitive bird species exposed for several days. Doses around 1,500 ppm (diet) or about 100 mg/kg bw caused extensive mortality in these sensitive species. They generally caused some mortality in all species, with the level being dependent on the length of exposure and the particular PCB mixture. Some mammalian species are especially susceptible to PCBs. For example, mink died when fed as little as 5 ppm in the diet (equivalent to less than 1 mg/kg bw/day). PCBs caused lower egg production; deformities; decreased hatchability, growth, and survival; and some eggshell thinning in reproductive studies on chickens fed doses of 20 ppm in the diet (1 mg/kg bw). Mink fed 1 ppm in the diet (0.2 mg/kg bw) had lower reproductive success, and there are indications that an increased incidence of premature births in some marine animals was linked to PCB exposure. Behavioral effects on wildlife include increased activity, decreased avoidance response, and decreased nesting, all of which could significantly influence survival in the wild.

No toxic effects on domestic animals other than chickens were reported in the sources reviewed, but susceptible species would probably be affected in a similar manner to laboratory animals and wildlife.

POLYCYCLIC AROMATIC HYDROCARBONS
(Clement Associates, Inc., 1985)

Health Effects

The potential for polycyclic aromatic hydrocarbons (PAHs) to induce malignant transformation dominates the consideration of health hazards resulting from exposure, because there often are no overt signs of toxicity until the dose is high enough to produce a high tumor incidence.

No case reports or epidemiological studies concerning the significance of human exposure to individual PAHs are available. However, coal tar and other materials known to be carcinogenic to humans contain PAHs.

PAHs administered by various routes have been found to be carcinogenic in several animal species and to have both local and systemic carcinogenic effects. On oral administration, carcinogenic PAHs produce tumors of the forestomach in mice. Lung tumors are produced in hamsters after intratracheal administration and in mice after intravenous administration. In skin painting experiments with mice, carcinogenic PAHs produced skin carcinomas. Other observed effects include induction of local sarcomas and an increased incidence of lung adenomas in mice following single, subcutaneous injections. Studies in other species, while indicating the PAHs have universal carcinogenic effects, are less complete. Carcinogenic PAHs are reported to be mutagenic in a variety of test systems. The limited available information suggests that PAHs are not very potent teratogens or reproductive toxins.

There is very little information regarding nonmalignant changes caused by exposure to PAHs. Application of carcinogenic PAHs to mouse skin is reported to cause destruction of sebaceous glands, hyperplasia, hyperkeratosis, and ulceration. Many carcinogenic PAHs also have immunosuppressive effects. Subcutaneous injections of some PAHs for several weeks reportedly caused hemolymphatic changes in the lymph nodes in rats. Workers exposed to PAH-containing materials have exhibited chronic dermatitis, hyperkeratoses, and other skin disorders.

Toxicity to Wildlife and Domestic Animals

There is very little information on the environmental toxicity of PAHs; they probably are not very toxic to aquatic organisms.

1,1,2,2-TETRACHLOROETHANE (Clement Associates, Inc., 1985)

Health Effects

1,1,2,2-Tetrachloroethane is a liver carcinogen when administered orally to mice. IARC concludes that there is limited evidence for its carcinogenicity in experimental animals. This compound is mutagenic in at least two bacterial test strains. Administration of 300-400 mg/kg/day to mice during organogenesis is reported to produce embryotoxic effects and slightly increase the incidence of malformations.

1,1,2,2-Tetrachloroethane produces acute and chronic toxic effects in laboratory animals exposed by various routes. Toxic action is primarily on the liver. However, effects on the central nervous system, kidneys, and other tissues are also reported; and acute exposure can be fatal. The oral LD_{50} in rats is 250 mg/kg.

Numerous deaths in humans have been reported, primarily as a result of occupational exposure by ingestion, inhalation, or skin contact. Acute exposure produces central nervous system depression. Chronic effects include hepatotoxicity and gastrointestinal disturbances in addition to central nervous system effects such as tremors, dizziness, headache, paralysis, and polyneuritis.

Toxicity to Wildlife and Domestic Animals

Acute values for freshwater species range from 9,320 μg/liter for an invertebrate species to approximately 20,000 μg/liter for two species of fish. An embryo-larval test conducted with the fathead minnow provides a chronic value of 2,400 μg/liter and an acute-chronic ratio of 8.5 for this species. Among saltwater species, acute values of 9,020 μg/liter for the mysid shrimp and 12,300 μg/liter for the sheepshead minnow are reported. Exposure to 1,1,2,2-tetrachloroethane affects chlorophyll a and cell numbers of algae exposed to approximately 141,000 μg/liter in a freshwater species and 6,300 μg/liter in a saltwater species. The weighted average bioconcentration factor for the edible portion of all freshwater and estuarine aquatic organisms consumed by Americans is 5.0.

TETRACHLOROETHENE (Clement Associates, Inc., 1985)

Health Effects

Tetrachloroethene was found to produce liver cancer in male and female mice when administered orally by gavage. Unpublished gavage studies in rats and mice performed by the National Toxicology Program (NTP) showed heptocellular carcinomas in mice and a slight, statistically insignificant increase in a rare type of kidney tumor. NTP is also conducted an inhalation carcinogenicity study. Elevated mutagenic activity was found in Salmonella strains treated with tetrachloroethene. Delayed ossification of skull bones and sternebrae were reported in offspring of pregnant mice exposed to 2,000 mg/m^3 of tetrachloroethene and 7 hours/day on days 6-15 of gestation. Increased fetal resorptions were observed after exposure of pregnant rats to tetrachloroethene. Renal toxicity and hepatoxicity have been noted following chronic inhalation exposure of rats to tetrachloroethene levels of 1,356 mg/m^3. During the first 2 weeks of a subchronic inhalation study, exposure to concentrations of 1,622 ppm (10,867 mg/m^3) of tetrachloroethene produced signs of central nervous system depression, and cholinergic stimulation was observed among rabbits, monkeys, rats, and guinea pigs.

Toxicity to Wildlife and Domestic Animals

Tetrachloroethene is the most toxic of the chloroethenes to aquatic organisms but is only moderately toxic relative to other types of compounds. The limited acute toxicity data indicated that the LC_{50} value for saltwater and freshwater species were similar, around 10,000 μg/liter; the trout was the most sensitive (LC_{50} = 4,800 μg/liter). Chronic values were 840 and 450 μg/liter for freshwater and saltwater species respectively, and an acute-chronic ratio of 19 was calculated.

No information on the toxicity of tetrachloroethene to terrestrial wildlife or domestic animals was available in the literature reviewed.

TOLUENE (Clement Associates, Inc., 1985)

Health Effects

There is no conclusive evidence that toluene is carcinogenic or mutagenic in animals or humans. The National Toxicological Program is currently conducting an inhalation carcinogenicity bioassay in rats and mice.

Oral administration of toluene at doses as low at 260 mg/kg produced a significant increase in embryonic lethality in mice. Decreased fetal weight was observed at doses as low as 434 mg/kg, and an increased incidence of cleft palate was seen at doses as low at 867 mg/kg. However, other researchers have reported that toluene is embryotoxic but not teratogenic in laboratory animals. There are no accounts of a teratogenic effect in humans being linked to toluene exposure.

Acute exposure to toluene at concentrations of 357-1,500 mg/m^3 produces central nervous system depression and narcosis in humans. However, even exposure to quantities sufficient to produce unconsciousness fails to produce residual organic damage. The rat oral LD_{50} value and inhalation LC_{LO} value are 5,000 mg/kg and 15,000 mg/m^3, respectively. Chronic inhalation exposure to toluene at relatively high concentrations produces cerebellar degeneration and an irreversible encephalopathy in mammals.

Toluene in sufficient amounts appears to have the potential to significantly alter the metabolism and resulting bioactivity of certain chemicals. For example, coadministrations of toluene along with benzene or styrene have been shown to suppress metabolism of the benzene or styrene in rats.

Toxicity to Wildlife and Domestic Animals

Of five freshwater species acutely tested with toluene, the cladoceran Daphnia magna was most resistant. The EC_{50} and LC_{50} values for all species range from 12,700 to 313,000 µg/liter. No chronic tests are available for freshwater species. The two freshwater algal species tested are relatively insensitive to toluene with EC_{50} values of 245,000 µg/liter or greater being reported. For saltwater species, EC_{50} and LC_{50} values range from 3,700 µg/liter for the bay shrimp to 1,050 mg/liter for the Pacific oyster. The chronic value in an embryo-larval test for the sheepshead minnow is reported to be between 3,200 and 7,700 µg/liter, and the acute-chronic ratio is between 55 and 97. In several saltwater algal species and kelp, effects occur at toluene concentrations from 8,000 to more than 433,000 µg/liter.

1,1,2-TRICHLOROETHANE (Clement Associates, Inc., 1985)

Health Effects

1,1,2-Trichloroethane induced heptacellular carcinomas and pheochromocytoma of the adrenal gland in male and female mice but did not produce a significant increase in tumor incidence in male or female rats. It was not mutagenic when tested using the Ames assay. No information was found concerning the reproductive toxicity or teratogenicity of 1,1,2-trichloroethane. No chronic studies were found on the toxicity of 1,1,2-trichloroethane but single doses as low as 400 mg/kg caused liver and kidney damage in dogs. The oral LD_{50} value for 1,1,2-trichloroethane in rats is 835 mg/kg.

Toxicity to Wildlife and Domestic Animals

The acute LC_{50} values for 1,1,2-trichloroethane for freshwater aquatic organisms ranged from 18,000 to 81,700 µg/liter. One chronic test was conducted; this indicated that the acute-chronic ratio for 1,1,2-trichloroethane was around 8.7. No information on the toxicity of 1,1,2-trichloroethane to saltwater species, terrestrial wildlife, or domestic animals was available in the literature reviewed.

1,1,1-TRICHLOROETHANE (Clement Associates, Inc., 1985)

Health Effects

1,1,1-Trichloroethane was retested for carcinogenicity because in a previous study by NCI, early lethality precluded assessment of carcinogenicity. Preliminary results indicate that 1,1,1-TCA increased the incidence of combined hepatocellular carcinomas and adenomas in female mice when administered by gavage. There is evidence that 1,1,1-trichloroethane is mutagenic in Salmonella typhimurium and causes transformation in cultured rat embryo cells. These data suggest that the chemical may be carcinogenic.

Other toxic effects of 1,1,1-TCA are seen only at concentrations well above those likely in an open environment. The most notable toxic effects of 1,1,1-trichloroethane in humans and animals are central nervous system depression, including anesthesia at very high concentrations and impairment of coordination, equilibrium, and judgment at lower concentrations (350 ppm and above); cardiovascular effects, including premature ventricular contractions, decreased blood pressure, and sensitization to epinephrine-induced arrhythmia; and adverse effects on the lungs, liver, and kidneys. Irritation of the skin and mucous membranes resulting from exposure to 1,1,1-trichloroethane has also been reported. The oral LD_{50} value of 1,1,1-trichloroethane in rats is about 11,000 mg/kg.

Toxicity to Wildlife and Domestic Animals

The acute toxicity of 1,1,1-trichloroethane to aquatic species is rather low, with the LC_{50} concentration for the most sensitive species tested being 52.8 mg/l. No chronic toxicity studies have been done on 1,1,1-trichloroethane, but acute-chronic ratios for the other chlorinated ethanes ranged from 2.8 to 8.7. 1,1,1-Trichloroethane was only slightly bioaccumulated with a steady-state bioconcentration factor of nine and an elimination half-life of 2 days.

No information on the toxicity of 1,1,1-trichloroethane to terrestrial wildlife or domestic animals was available in the literature reviewed.

TRICHLOROETHENE (Clement Associates, Inc., 1985)

Health Effects

Trichloroethene is carcinogenic to mice after oral administration, producing hepatocellular carcinomas. It was found to be mutagenic using several microbial assay systems. Trichloroethene does not appear to cause reproductive toxicity or teratogenicity. TCE has been shown to cause renal toxicity, hepatotoxicity, neurotoxicity, and dermatological reactions in animals following chronic exposure to levels greater than 2,000 mg/m^3 for 6 months. Trichloroethene has low acute toxicity; the acute oral LD_{50} value in several species ranged from 6,000 to 7,000 mg/kg.

Toxicity to Wildlife and Domestic Animals

There was only limited data on the toxicity of trichloroethene to aquatic organisms. The acute toxicity to freshwater species was similar in the three species tested, with LC_{50} values of about 50 mg/liter. No LC_{50} values were available for saltwater species. However, a dose of 2 mg/liter caused erratic swimming and loss of equilibrium in the grass shrimp. No chronic toxicity tests were reported.

No information on the toxicity of trichloroethene to domestic animals or terrestrial wildlife was available in the literature reviewed.

VINYL CHLORIDE (Clement Associates, Inc., 1985)

Health Effects

IARC considers vinyl chloride to be a Category I human carcinogen, causing angiosarcomas of the liver and tumors of the brain, lung, and hemolymphopoietic system in humans. Vinyl chloride is carcinogenic in mice, rats, and hamsters; it produces tumors at several sites, including angiosarcomas of the liver, after oral or inhalation exposure. Vinyl chloride, both as a vapor and in solution, is mutagenic in several biological assay systems. In addition, chromosome aberrations including fragments, dicentics and rings, breaks, and gaps have been found in workers occupationally exposed to vinyl chloride. The evidence on its teratogenic and reproductive effects is equivocal. Minor skeletal abnormalities and increased fetal death rates have been observed in the offspring of experimental animals exposed by inhalation to vinyl chloride. In humans, a significant increase in fetal deaths was seen in women whose husbands were exposed to vinyl chloride. Also, an excess number of central nervous system disorders and deformities of the upper alimentary tract, genital organs, and feet were observed in stillborn and live children born in cities with vinyl chloride facilities. However, further research is necessary before the link between vinyl chloride and these observed effects can be positively established.

Acute occupational exposure to high concentrations of vinyl chloride can produce symptoms of narcosis in humans. Respiratory tract irritation, bronchitis, headache, irritability, memory disturbances, and tingling sensations may also occur. Chronic exposure to vinyl chloride is associated with multiple systemic disorders, including a sclerotic syndrome, acro-osteolysis, thrombocytopenia, and liver damage, consisting of damage to parenchymal cells, fibrosis of the liver capsule, periportal fibrosis associated with hepatomegaly, and splenomegaly. Concentrations encountered by workers in industries using or producing vinyl chloride are reportedly quite variable and may range from less than the limit of detection to several grams per cubic meter.

Acute inhalation exposure of experimental animals to high concentrations of vinyl chloride can result in narcosis and death. The 2-hour LC_{50} value for rats is 390 g/m^3. Chronic exposure of experimental animals can result in growth disturbances and histopathological and histochemical lesions in the liver, kidneys, spleen, and lungs.

Toxicity to Wildlife and Domestic Animals

No information is available concerning the toxicity of vinyl chloride to domestic animals or wildlife.

XYLENES (Clement Associates, Inc., 1985)

Health Effects

The National Toxicology Program (NTP) is testing xylene for carcinogenicity by administering it orally to rats and mice. Although the results have not been finalized, it does not appear to be carcinogenic in rats. Results have not been reported for mice. Xylene was found not to be mutagenic in a battery of short-term assays. Xylene was not teratogenic but has caused fetotoxicity in rats and mice. Acute exposure to rather high levels of xylene affect the central nervous system and irritates the mucous membranes. There is limited evidence of effects on other organ systems, but it was not possible to attribute these effects solely to xylene as other solvents were present. The oral LD_{50} value of xylene in rats was 5,000 mg/kg.

Toxicity to Wildlife and Domestic Animals

Xylene adversely affected adult trout at concentrations as low as 3.6 mg/liter in a continuous flow system and trout fry avoided xylene at concentrations greater than 0.1 mg/liter. The LC_{50} value in adult trout was determined to be 13.5 mg/liter. LC_{50} values for other freshwater fish were around 30 mg/liter in a static system, which probably underestimated toxicity. Only a few studies have been done on the toxicity of xylene to saltwater species. These indicated that the m- and o-xylene isomers probably have similar toxicities and are probably less toxic than p-xylene, and that saltwater species are generally more susceptible than freshwater species to the detrimental effects of xylene (LC_{50} = 10 mg/liter for m- and o-xylene and LC_{50} = 2 mg/liter for p-xylene). However, it should be stressed that these generalizations are based on results from limited data.

No information on the toxicity of xylenes to terrestrial wildlife and domestic animals was available in the literature reviewed. However, because of the low acute toxicity of xylenes, it is unlikely that they would be toxic to wild or domestic birds or mammals.

G

APPENDIX G

RISK ASSESSMENT CALCULATIONS

- Dermal Contact
- Accidental Ingestion
- Fugitive Dust Emissions
- Volatile Emissions
- Groundwater Use

Dermal Contact

RISK ASSESSMENT SPREADSHEET - DIRECT DERMAL CONTACT WITH SOIL

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

MAXIMUM-CASE EXPOSURE SCENARIO

RELEVANT EQUATION: DOSE = (C)*(SA)*(AD)*(AF)/(BW)

ASSUMPTIONS:

C	= CONCENTRATION IN SOIL SAMPLE (UG/KG)			
SA	= EXPOSED SURFACE AREA OF SKIN (SQ CM) (SCHAUM, NOVEMBER 1984)	ADULT:	2950	
		CHILD:	2330	
AD	= ADHERENCE FACTOR (MG/SQ CM):		1	
RAF	= RELATIVE ABSORPTION FRACTION (%/DAY)	VOCS:	.1	(ASSUMED)
		BNAS:	.05	(ASSUMED)
		METALS:	.05	(ASSUMED)
BW1	= BODY WEIGHT CHILD (KG):		45	
BW2	= BODY WEIGHT ADULT (KG):		70	
ED	= ADULT EXPOSURE DURATION (YEARS):		40	
EF	= EXPOSURE FREQUENCY (DAYS/YEAR):		30	

DETERMINE CONVERSION FACTORS:

DOSE = (C)*(AF)*(1MG/1000 UG)*(1 KG/1000000 MG)*(SA SQ CM)*(AD MG/SQ CM)*(EF DAYS/YEAR)*(1 YEAR/365 DAYS)/(BW KG)

DOSEchild = (CF1)*(C)*(AF)   CF1 = 4.256e-9
DOSEadult = (CF2)*(C)*(AF)   CF2 = 3.464e-9

0013393

RISK ASSESSMENT SPREADSHEET - DIRECT DERMAL CONTACT WITH SOIL (PAGE TWO)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	C (UG/KG)	ABSORPTION FRACTION	YOUTH DOSE (MG/KG/DAY)	ADULT DOSE (MG/KG/DAY)	RFD (MG/KG/DAY)	CPF (KG-DAY/MG)
ACETONE		.1	0	0	1e-1	
2-BUTANONE		.1	0	0	5e-2	
4-METHYL-2-PENTANONE		.1	0	0	5e-2	
BENZENE		.1	0	0		2.9e-2
ETHYLBENZENE		.1	0	0	1e-1	
TOLUENE		.1	0	0	3e-1	
XYLENES		.1	0	0	2e0	
CHLOROBENZENE		.1	0	0	3e-2	
1,2-DICHLOROBENZENE		.05	0	0	4e-1	
1,4-DICHLOROBENZENE		.05	0	0		2.4e-2
PHENOL		.05	0	0	6e-1	
1,1,2-TRICHLOROETHANE		.1	0	0	4e-2	5.7e-2
1,1,1-TRICHLOROETHANE	2	.1	8.51e-10	6.93e-10	9e-2	
1,2-DICHLORETHANE		.1	0	0		9.1e-2
1,1-DICHLOROETHANE		.1	0	0	1e-1	9.1e-2
TETRACHLOROETHENE	7	.1	2.979e-9	2.425e-9	1e-2	5.1e-2
TRICHLOROETHENE	47	.1	2.000e-8	1.628e-8		1.1e-2
1,1-DICHLOROETHENE		.1	0	0	9e-3	6e-1
CARBON TETRACHLORIDE		.1	0	0	7e-4	1.3e-1
CHLOROFORM	2	.1	8.51e-10	6.93e-10	1e-2	6.1e-3
METHYLENE CHLORIDE		.1	0	0	6e-2	7.5e-3
CHLOROMETHANE		.1	0	0		1.3e-2
BROMODICHLOROMETHANE		.1	0	0		1.3e-1
CHLORODIBROMOMETHANE		.1	0	0	2e-1	8.4e-2
BENZOIC ACID	490	.05	1.043e-7	8.486e-8	4e0	
CARBON DISULFIDE		.1	0	0	1e-1	
BENZO(A)ANTHRACENE	110	.05	2.341e-8	1.905e-8		1.54e-1
BENZO(B)FLUORANTHENE	240	.05	5.107e-8	4.157e-8		9.2e-1
BENZO(A)PYRENE	100	.05	2.128e-8	1.732e-8		1.15e0
POLYCHLORINATED BIPHENYLS		.05	0	0		7.7e0
N-NITROSODIPHENYLAMINE		.05	0	0		4.9e-3
BIS(2-ETHYLHEXYL)PHTHALATE	550	.05	1.170e-7	9.525e-8	2e-2	1.4e-2
DI-N-BUTYLPHTHALATE	67	.05	1.426e-8	1.160e-8	1e-1	
LEAD	2720000	.05	5.788e-4	4.711e-4	1.4e-1	
CHROMIUM	804000	.05	1.711e-4	1.392e-4	1e0	
			0	0		
			0	0		
			0	0		
			0	0		

RISK ASSESSMENT SPREADSHEET - DIRECT DERMAL CONTACT WITH SOIL (PAGE THREE)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
DETERMINE HAZARD INDICES AND CANCER RISK:

CHEMICAL	HAZARD INDEX YOUTH	HAZARD INDEX ADULT	CANCER RISK LIFETIME
ACETONE	0	0	0
2-BUTANONE	0	0	0
4-METHYL-2-PENTANONE	0	0	0
BENZENE	0	0	0
ETHYLBENZENE	0	0	0
TOLUENE	0	0	0
XYLENES	0	0	0
CHLOROBENZENE	0	0	0
1,2-DICHLOROBENZENE	0	0	0
1,4-DICHLOROBENZENE	0	0	0
PHENOL	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0
1,1,1-TRICHLOROETHANE	9.457e-9	7.697e-9	0
1,2-DICHLORETHANE	0	0	0
1,1-DICHLOROETHANE	0	0	0
TETRACHLOROETHENE	2.979e-7	2.425e-7	7.07e-11
TRICHLOROETHENE	0	0	1.02e-10
1,1-DICHLOROETHENE	0	0	0
CARBON TETRACHLORIDE	0	0	0
CHLOROFORM	8.511e-8	6.928e-8	2.41e-12
METHYLENE CHLORIDE	0	0	0
CHLOROMETHANE	0	0	0
BROMODICHLOROMETHANE	0	0	0
CHLORODIBROMOMETHANE	0	0	0
BENZOIC ACID	2.607e-8	2.122e-8	0
CARBON DISULFIDE	0	0	0
BENZO(A)ANTHRACENE	0	0	1.676e-9
BENZO(B)FLUORANTHENE	0	0	2.185e-8
BENZO(A)PYRENE	0	0	1.138e-8
POLYCHLORINATED BIPHENYLS	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	5.852e-6	4.763e-6	7.62e-10
DI-N-BUTYLPHTHALATE	1.426e-7	1.160e-7	0
LEAD	4.134e-3	3.365e-3	0
CHROMIUM	1.711e-4	1.392e-4	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
TOTAL	4.312e-3	3.509e-3	3.585e-8

0013395

RISK ASSESSMENT SPREADSHEET - DIRECT DERMAL CONTACT WITH SOIL

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

AVERAGE-CASE EXPOSURE SCENARIO

RELEVANT EQUATION: DOSE = (C)*(SA)*(AD)*(AF)/(BW)

ASSUMPTIONS:	C	= CONCENTRATION IN SOIL SAMPLE (UG/KG)		
	SA	= EXPOSED SURFACE AREA OF SKIN (SQ CM) (SCHAUM, NOVEMBER 1984)	ADULT:	2950
			CHILD:	2330
	AD	= ADHERENCE FACTOR (MG/SQ CM):		1
	RAF	= RELATIVE ABSORPTION FRACTION (%/DAY)	VOCS:	.1 (ASSUMED)
			BNAS:	.05 (ASSUMED)
			METALS:	.05 (ASSUMED)
	BW1	= BODY WEIGHT CHILD (KG):		45
	BW2	= BODY WEIGHT ADULT (KG):		70
	ED	= ADULT EXPOSURE DURATION (YEARS):		40
	EF	= EXPOSURE FREQUENCY (DAYS/YEAR):		30

DETERMINE CONVERSION FACTORS:

DOSE = (C)*(AF)*(1MG/1000 UG)*(1 KG/1000000 MG)*(SA SQ CM)*(AD MG/SQ CM)*(EF DAYS/YEAR)*(1 YEAR/365 DAYS)/(BW KG)

DOSEchild = (CF1)*(C)*(AF)   CF1 = 4.256e-9
DOSEadult = (CF2)*(C)*(AF)   CF2 = 3.464e-9

RISK ASSESSMENT SPREADSHEET - DIRECT DERMAL CONTACT WITH SOIL (PAGE TWO)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	C (UG/KG)	ABSORPTION FRACTION	YOUTH DOSE (MG/KG/DAY)	ADULT DOSE (MG/KG/DAY)	RFD (MG/KG/DAY)	CPF (KG-DAY/MG)
ACETONE		.1	0	0	1e-1	
2-BUTANONE		.1	0	0	5e-2	
4-METHYL-2-PENTANONE		.1	0	0	5e-2	
BENZENE		.1	0	0		2.9e-2
ETHYLBENZENE		.1	0	0	1e-1	
TOLUENE		.1	0	0	3e-1	
XYLENES		.1	0	0	2e0	
CHLOROBENZENE		.1	0	0	3e-2	
1,2-DICHLOROBENZENE		.05	0	0	4e-1	
1,4-DICHLOROBENZENE		.05	0	0		2.4e-2
PHENOL		.05	0	0	6e-1	
1,1,2-TRICHLOROETHANE		.1	0	0	4e-2	5.7e-2
1,1,1-TRICHLORDETHANE	.0741	.1	3.15e-11	2.57e-11	9e-2	
1,2-DICHLORETHANE		.1	0	0		9.1e-2
1,1-DICHLOROETHANE		.1	0	0	1e-1	9.1e-2
TETRACHLOROETHENE	.2593	.1	1.10e-10	8.98e-11	1e-2	5.1e-2
TRICHLOROETHENE	2	.1	8.51e-10	6.93e-10		1.1e-2
1,1-DICHLOROETHENE		.1	0	0	9e-3	6e-1
CARBON TETRACHLORIDE		.1	0	0	7e-4	1.3e-1
CHLOROFORM	.2593	.1	1.10e-10	8.98e-11	1e-2	6.1e-3
METHYLENE CHLORIDE		.1	0	0	6e-2	7.5e-3
CHLOROMETHANE		.1	0	0		1.3e-2
BROMODICHLOROMETHANE		.1	0	0		1.3e-1
CHLORODIBROMOMETHANE		.1	0	0	2e-1	8.4e-2
BENZOIC ACID	56.67	.05	1.206e-8	9.815e-9	4e0	
CARBON DISULFIDE		.1	0	0	1e-1	
BENZO(A)ANTHRACENE	4.074	.05	8.67e-10	7.06e-10		1.54e-1
BENZO(B)FLUORANTHENE	16	.05	3.405e-9	2.771e-9		9.2e-1
BENZO(A)PYRENE	3.703	.05	7.88e-10	6.41e-10		1.15e0
POLYCHLORINATED BIPHENYLS		.05	0	0		7.7e0
N-NITROSODIPHENYLAMINE		.05	0	0		4.9e-3
BIS(2-ETHYLHEXYL)PHTHALATE	84.81	.05	1.805e-8	1.469e-8	2e-2	1.4e-2
DI-N-BUTYLPHTHALATE	17	.05	3.617e-9	2.944e-9	1e-1	
LEAD	173200	.05	3.685e-5	3.000e-5	1.4e-1	
CHROMIUM	71240	.05	1.516e-5	1.234e-5	1e0	
			0	0		
			0	0		
			0	0		
			0	0		

RISK ASSESSMENT SPREADSHEET - DIRECT DERMAL CONTACT WITH SOIL (PAGE THREE)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
DETERMINE HAZARD INDICES AND CANCER RISK:

CHEMICAL	HAZARD INDEX YOUTH	HAZARD INDEX ADULT	CANCER RISK LIFETIME
ACETONE	0	0	0
2-BUTANONE	0	0	0
4-METHYL-2-PENTANONE	0	0	0
BENZENE	0	0	0
ETHYLBENZENE	0	0	0
TOLUENE	0	0	0
XYLENES	0	0	0
CHLOROBENZENE	0	0	0
1,2-DICHLOROBENZENE	0	0	0
1,4-DICHLOROBENZENE	0	0	0
PHENOL	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0
1,1,1-TRICHLOROETHANE	3.50e-10	2.85e-10	0
1,2-DICHLORETHANE	0	0	0
1,1-DICHLORDETHANE	0	0	0
TETRACHLOROETHENE	1.104e-8	8.982e-9	2.62e-12
TRICHLOROETHENE	0	0	4.35e-12
1,1-DICHLOROETHENE	0	0	0
CARBON TETRACHLORIDE	0	0	0
CHLOROFORM	1.104e-8	8.982e-9	3.13e-13
METHYLENE CHLORIDE	0	0	0
CHLOROMETHANE	0	0	0
BROMODICHLOROMETHANE	0	0	0
CHLORODIBROMOMETHANE	0	0	0
BENZOIC ACID	3.015e-9	2.454e-9	0
CARBON DISULFIDE	0	0	0
BENZO(A)ANTHRACENE	0	0	6.21e-11
BENZO(B)FLUORANTHENE	0	0	1.457e-9
BENZO(A)PYRENE	0	0	4.21e-10
POLYCHLORINATED BIPHENYLS	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	9.023e-7	7.344e-7	1.18e-10
DI-N-BUTYLPHTHALATE	3.617e-8	2.944e-8	0
LEAD	2.632e-4	2.143e-4	0
CHROMIUM	1.516e-5	1.234e-5	0
	0	0	0
	0	0	0
	0	0	0
	0	0	0
TOTAL	2.794e-4	2.274e-4	2.065e-9

Accidental Ingestion

RISK ASSESSMENT SPREADSHEET - ACCIDENTAL INGESTION OF SOIL

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
EXPOSURES THROUGH PICA INGESTION ARE CONSIDERD.
ASSUMPTIONS ARE OUTLINED BELOW.

MAXIMUM-CASE EXPOSURE SCENARIO

REFERENCE: EPA, OCTOBER 1986

RELEVANT EQUATION: *DOSE = (C)*(IR)*(AF)/(BW)*

ASSUMPTIONS: ADOLESCENT AND ADULT RECEPTORS ARE SUBJECT TO EXPOSURE THROUGH THIS ROUTE

C = CONCENTRATION IN SOIL SAMPLE (UG/KG)

IR = AVERAGE SOIL INGESTION RATE (HAWLEY, 1985) (G/DAY) .1

BW = BODY WEIGHT OF ADULT (KG): 70

BW = BODY WEIGHT OF CHILD (KG): 45

DETERMINE CONVERSION FACTOR:

DOSE = (C)*(1)*(1MG/1000 UG)*(1 KG/1000 G)*(IR G/DAY)/(BW KG)

DOSEchild = (CF)*(C) CF1 = 2.222e-9

DETERMINE TIME-WEIGHTED AVERAGE DOSE (FOR LONG TERM CARCINOGENIC RISK)

40 YEARS OF EXPOSURE PER 70 YEAR LIFETIME
30 DAYS OF EXPOSURE/YEAR

TIME WEIGHTING FACTOR (DAYS OF EXPOSURE/YEAR): 8.219e-2
TIME WEIGHTING FACTOR (YEARS OF EXPOSURE /70): 5.714e-1

RISK ASSESSMENT SPREADSHEET - ACCIDENTAL INGESTION OF SOIL (PAGE TWO)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	C (UG/KG)	WEIGHTED CHILD DOSE (MG/KG/DAY)	WEIGHTED ADULT DOSE (MG/KG/DAY)	RFD (MG/KG/DAY)	CPF (KG-DAY/MG)
ACETONE		0	0	1e-1	
2-BUTANONE		0	0	5e-2	
4-METHYL-2-PENTANONE		0	0	5e-2	
BENZENE		0	0		2.9e-2
ETHYLBENZENE		0	0	1e-1	
TOLUENE		0	0	3e-1	
XYLENES		0	0	2e0	
CHLOROBENZENE		0	0	3e-2	
1,2-DICHLOROBENZENE		0	0	4e-1	
1,4-DICHLOROBENZENE		0	0		2.4e-2
PHENOL		0	0	6e-1	
1,1,2-TRICHLOROETHANE		0	0	4e-2	5.7e-2
1,1,1-TRICHLOROETHANE	2	3.65e-10	1.34e-10	9e-2	
1,2-DICHLORETHANE		0	0		9.1e-2
1,1-DICHLOROETHANE		0	0	1e-1	9.1e-2
TETRACHLOROETHENE	7	1.279e-9	4.70e-10	1e-2	5.1e-2
TRICHLOROETHENE	47	8.584e-9	3.153e-9		1.1e-2
1,1-DICHLOROETHENE		0	0	9e-3	6e-1
CARBON TETRACHLORIDE		0	0	7e-4	1.3e-1
CHLOROFORM	2	3.65e-10	1.34e-10	1e-2	6.1e-3
METHYLENE CHLORIDE		0	0	6e-2	7.5e-3
CHLOROMETHANE		0	0		1.3e-2
BROMODICHLOROMETHANE		0	0		1.3e-1
CHLORODIBROMOMETHANE		0	0	2e-1	8.4e-2
BENZOIC ACID	490	8.950e-8	3.288e-8	4e0	
CARBON DISULFIDE		0	0	1e-1	
BENZO(A)ANTHRACENE	110	2.009e-8	7.380e-9		1.54e-1
BENZO(B)FLUORANTHENE	240	4.384e-8	1.610e-8		9.2e-1
BENZO(A)PYRENE	100	1.826e-8	6.710e-9		1.15e0
POLYCHLORINATED BIPHENYLS		0	0		7.7e0
N-NITROSODIPHENYLAMINE		0	0		4.9e-3
BIS(2-ETHYLHEXYL)PHTHALATE	550	1.005e-7	3.690e-8	2e-2	1.4e-2
DI-N-BUTYLPHTHALATE	67	1.224e-8	4.495e-9	1e-1	
LEAD	272000	4.968e-5	1.825e-5	1.4e-1	
CHROMIUM	804000	1.468e-4	5.394e-5	1e0	
		0	0		
		0	0		
		0	0		
		0	0		

100401

RISK ASSESSMENT SPREADSHEET - ACCIDENTAL INGESTION OF SOIL (PAGE THREE)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
DETERMINE HAZARD INDICES AND CANCER RISK:

CHEMICAL	HAZARD INDEX CHILD	CANCER RISK LIFETIME
ACETONE	0	0
2-BUTANONE	0	0
4-METHYL-2-PENTANONE	0	0
BENZENE	0	0
ETHYLBENZENE	0	0
TOLUENE	0	0
XYLENES	0	0
CHLOROBENZENE	0	0
1,2-DICHLOROBENZENE	0	0
1,4-DICHLOROBENZENE	0	0
PHENOL	0	0
1,1,2-TRICHLOROETHANE	0	0
1,1,1-TRICHLOROETHANE	4.059e-9	0
1,2-DICHLORETHANE	0	0
1,1-DICHLOROETHANE	0	0
TETRACHLOROETHENE	1.279e-7	2.40e-11
TRICHLOROETHENE	0	3.47e-11
1,1-DICHLOROETHENE	0	0
CARBON TETRACHLORIDE	0	0
CHLOROFORM	3.653e-8	8.19e-13
METHYLENE CHLORIDE	0	0
CHLOROMETHANE	0	0
BROMODICHLOROMETHANE	0	0
CHLORODIBROMOMETHANE	0	0
BENZOIC ACID	2.237e-8	0
CARBON DISULFIDE	0	0
BENZO(A)ANTHRACENE	0	1.137e-9
BENZO(B)FLUORANTHENE	0	1.481e-8
BENZO(A)PYRENE	0	7.716e-9
POLYCHLORINATED BIPHENYLS	0	0
N-NITROSODIPHENYLAMINE	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	5.023e-6	5.17e-10
DI-N-BUTYLPHTHALATE	1.224e-7	0
LEAD	3.549e-4	0
CHROMIUM	1.468e-4	0
	0	0
	0	0
	0	0
	0	0
TOTAL	5.070e-4	2.424e-8

RISK ASSESSMENT SPREADSHEET - ACCIDENTAL INGESTION OF SOIL

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
EXPOSURES THROUGH PICA INGESTION ARE CONSIDERD.
ASSUMPTIONS ARE OUTLINED BELOW.

AVERAGE-CASE EXPOSURE SCENARIO

REFERENCE: EPA, OCTOBER 1986

RELEVANT EQUATION: DOSE = (C)*(IR)*(AF)/(BW)

ASSUMPTIONS: ADOLESCENT AND ADULT RECEPTORS ARE SUBJECT TO EXPOSURE THROUGH THIS ROUTE

C = CONCENTRATION IN SOIL SAMPLE (UG/KG)

IR = AVERAGE SOIL INGESTION RATE (HAWLEY, 1985) (G/DAY) .1

BW = BODY WEIGHT OF ADULT (KG): 70

BW = BODY WEIGHT OF CHILD (KG): 45

DETERMINE CONVERSION FACTOR:

DOSE = (C)*(1)*(1MG/1000 UG)*(1 KG/1000 G)*(IR G/DAY)/(BW KG)

DOSEchild = (CF)(C)* *CF1 =* 2.222e-9

DETERMINE TIME-WEIGHTED AVERAGE DOSE (FOR LONG TERM CARCINOGENIC RISK)

40 YEARS OF EXPOSURE PER 70 YEAR LIFETIME
30 DAYS OF EXPOSURE/YEAR

TIME WEIGHTING FACTOR (DAYS OF EXPOSURE/YEAR): 8.219e-2
TIME WEIGHTING FACTOR (YEARS OF EXPOSURE /70): 5.714e-1

003409

RISK ASSESSMENT SPREADSHEET - ACCIDENTAL INGESTION OF SOIL (PAGE TWO)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	C (UG/KG)	WEIGHTED CHILD DOSE (MG/KG/DAY)	WEIGHTED ADULT DOSE (MG/KG/DAY)	RFD (MG/KG/DAY)	CPF (KG-DAY/MG)
ACETONE		0	0	1e-1	
2-BUTANONE		0	0	5e-2	
4-METHYL-2-PENTANONE		0	0	5e-2	
BENZENE		0	0		2.9e-2
ETHYLBENZENE		0	0	1e-1	
TOLUENE		0	0	3e-1	
XYLENES		0	0	2e0	
CHLOROBENZENE		0	0	3e-2	
1,2-DICHLOROBENZENE		0	0	4e-1	
1,4-DICHLOROBENZENE		0	0		2.4e-2
PHENOL		0	0	6e-1	
1,1,2-TRICHLOROETHANE		0	0	4e-2	5.7e-2
1,1,1-TRICHLOROETHANE	.0741	1.35e-11	4.97e-12	9e-2	
1,2-DICHLORETHANE		0	0		9.1e-2
1,1-DICHLOROETHANE		0	0	1e-1	9.1e-2
TETRACHLOROETHENE	.2593	4.74e-11	1.74e-11	1e-2	5.1e-2
TRICHLOROETHENE	2	3.65e-10	1.34e-10		1.1e-2
1,1-DICHLOROETHENE		0	0	9e-3	6e-1
CARBON TETRACHLORIDE		0	0	7e-4	1.3e-1
CHLOROFORM	.2593	4.74e-11	1.74e-11	1e-2	6.1e-3
METHYLENE CHLORIDE		0	0	6e-2	7.5e-3
CHLOROMETHANE		0	0		1.3e-2
BROMODICHLOROMETHANE		0	0		1.3e-1
CHLORODIBROMOMETHANE		0	0	2e-1	8.4e-2
BENZOIC ACID	56.67	1.035e-8	3.802e-9	4e0	
CARBON DISULFIDE		0	0	1e-1	
BENZO(A)ANTHRACENE	4.074	7.44e-10	2.73e-10		1.54e-1
BENZO(B)FLUORANTHENE	16	2.922e-9	1.074e-9		9.2e-1
BENZO(A)PYRENE	3.704	6.77e-10	2.49e-10		1.15e0
POLYCHLORINATED BIPHENYLS		0	0		7.7e0
N-NITROSODIPHENYLAMINE		0	0		4.9e-3
BIS(2-ETHYLHEXYL)PHTHALATE	84.81	1.549e-8	5.690e-9	2e-2	1.4e-2
DI-N-BUTYLPHTHALATE	4.037	7.37e-10	2.71e-10	1e-1	
LEAD	173200	3.163e-5	1.162e-5	1.4e-1	
CHROMIUM	71240	1.301e-5	4.780e-6	1e0	
		0	0		
		0	0		
		0	0		
		0	0		

RISK ASSESSMENT SPREADSHEET - ACCIDENTAL INGESTION OF SOIL (PAGE THREE)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
DETERMINE HAZARD INDICES AND CANCER RISK:

CHEMICAL	HAZARD INDEX CHILD	CANCER RISK LIFETIME
ACETONE	0	0
2-BUTANONE	0	0
4-METHYL-2-PENTANONE	0	0
BENZENE	0	0
ETHYLBENZENE	0	0
TOLUENE	0	0
XYLENES	0	0
CHLOROBENZENE	0	0
1,2-DICHLOROBENZENE	0	0
1,4-DICHLOROBENZENE	0	0
PHENOL	0	0
1,1,2-TRICHLOROETHANE	0	0
1,1,1-TRICHLOROETHANE	1.50e-10	0
1,2-DICHLORETHANE	0	0
1,1-DICHLOROETHANE	0	0
TETRACHLOROETHENE	4.736e-9	8.87e-13
TRICHLOROETHENE	0	1.48e-12
1,1-DICHLOROETHENE	0	0
CARBON TETRACHLORIDE	0	0
CHLOROFORM	4.736e-9	1.06e-13
METHYLENE CHLORIDE	0	0
CHLOROMETHANE	0	0
BROMODICHLOROMETHANE	0	0
CHLORODIBROMOMETHANE	0	0
BENZOIC ACID	2.588e-9	0
CARBON DISULFIDE	0	0
BENZO(A)ANTHRACENE	0	4.21e-11
BENZO(B)FLUORANTHENE	0	9.88e-10
BENZO(A)PYRENE	0	2.86e-10
POLYCHLORINATED BIPHENYLS	0	0
N-NITROSODIPHENYLAMINE	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	7.745e-7	7.97e-11
DI-N-BUTYLPHTHALATE	7.374e-9	0
LEAD	2.260e-4	0
CHROMIUM	1.301e-5	0
	0	0
	0	0
	0	0
	0	0
TOTAL	2.398e-4	1.398e-9

Fugitive Dust Emissions

RISK ASSESSMENT SPREADSHEET - INHALATION OF FUGITIVE DUST

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
EXPOSURE THROUGH INHALATION OF FUGITIVE DUST IS CONSIDERED.

MAXIMUM-CASE EXPOSURE SCENARIO

REFERENCES: COWHERD, ET AL., 1984

RELEVANT EQUATIONS:	E10 = 0.83*F*P(U+)*(1-V)/PE/50)**2	F =	30
		V =	0
	UT = U*ln(7/Zo)/0.4	U+ =	23.9
		PE =	110
	P(U+) = 6.7*(U+ - UT)	UT =	7.861296
		A =	400
	R10 = ALPHA*E10*A	PR =	.288
		Fi =	3.425
	X = Q*Fi	BR1 =	10
		BR2 =	20
		AF =	1
	Q = R10/PR	BW1 =	10
		BW2 =	70
	DOSE = X*BR*AF/BW	TW =	.5714286 (40 yr/70 yr)

INTERMEDIATE CALCULATIONS:

P(U+) = 107.4593
E10 = 1.536e-4

RISK ASSESSMENT SPREADSHEET - INHALATION OF FUGITIVE DUST (PAGE TWO)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	C (UG/KG)	ALPHA (MASS FRACTION)	R10 (G/S)	X (UG/M3)	DOSE (MG/KG/DAY) CHILD	DOSE (MG/KG/DAY) ADULT	DOSE (MG/KG/DAY) TIME-WEIGHTED
ACETONE		0	0	0	0	0	0
2-BUTANONE		0	0	0	0	0	0
4-METHYL-2-PENTANONE		0	0	0	0	0	0
BENZENE		0	0	0	0	0	0
ETHYLBENZENE		0	0	0	0	0	0
TOLUENE		0	0	0	0	0	0
XYLENES		0	0	0	0	0	0
CHLOROBENZENE		0	0	0	0	0	0
1,2-DICHLOROBENZENE		0	0	0	0	0	0
1,4-DICHLOROBENZENE		0	0	0	0	0	0
PHENOL		0	0	0	0	0	0
1,1,2-TRICHLOROETHANE		0	0	0	0	0	0
1,1,1-TRICHLOROETHANE	2	2e-9	1.23e-10	1.461e-9	1.46e-12	4.17e-13	2.39e-13
1,2-DICHLORETHANE		0	0	0	0	0	0
1,1-DICHLOROETHANE		0	0	0	0	0	0
TETRACHLOROETHENE	7	7e-9	4.30e-10	5.114e-9	5.11e-12	1.46e-12	8.35e-13
TRICHLOROETHENE	47	4.7e-8	2.887e-9	3.433e-8	3.43e-11	9.81e-12	5.61e-12
1,1-DICHLOROETHENE		0	0	0	0	0	0
CARBON TETRACHLORIDE		0	0	0	0	0	0
CHLOROFORM	2	2e-9	1.23e-10	1.461e-9	1.46e-12	4.17e-13	2.39e-13
METHYLENE CHLORIDE		0	0	0	0	0	0
CHLOROMETHANE		0	0	0	0	0	0
BROMODICHLOROMETHANE		0	0	0	0	0	0
CHLORODIBROMOMETHANE		0	0	0	0	0	0
BENZOIC ACID	490	4.9e-7	3.010e-8	3.579e-7	3.58e-10	1.02e-10	5.84e-11
CARBON DISULFIDE		0	0	0	0	0	0
BENZO(A)ANTHRACENE	110	1.1e-7	6.757e-9	8.036e-8	8.04e-11	2.30e-11	1.31e-11
BENZO(B)FLUORANTHENE	240	2.4e-7	1.474e-8	1.753e-7	1.75e-10	5.01e-11	2.86e-11
BENZO(A)PYRENE	100	1e-7	6.143e-9	7.305e-8	7.31e-11	2.09e-11	1.19e-11
POLYCHLORINATED BIPHENYLS		0	0	0	0	0	0
N-NITROSODIPHENYLAMINE		0	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	550	5.5e-7	3.378e-8	4.018e-7	4.02e-10	1.15e-10	6.56e-11
DI-N-BUTYLPHTHALATE	67	6.7e-8	4.116e-9	4.894e-8	4.89e-11	1.40e-11	7.99e-12
ARSENIC	49100	4.91e-5	3.016e-6	3.587e-5	3.587e-8	1.025e-8	5.856e-9
LEAD	2720000	2.72e-3	1.671e-4	1.987e-3	1.987e-6	5.677e-7	3.244e-7
		0	0	0	0	0	0
		0	0	0	0	0	0
		0	0	0	0	0	0
		0	0	0	0	0	0
		0	0	0	0	0	0

RISK ASSESSMENT SPREADSHEET - INHALATION OF FUGITIVE DUST (PAGE THREE)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE HAZARD INDICES AND CANCER RISKS:

CHEMICAL	DOSE CHILD	DOSE ADULT	DOSE TIME-WEIGHTED	RFD (MG/KG/DAY)	CPF (KG-DAY/MG)	HAZARD INDEX CHILD	HAZARD INDEX ADULT	CANCER RISK ADULT
ACETONE	0	0	0			0	0	0
2-BUTANONE	0	0	0	9e-2		0	0	0
4-METHYL-2-PENTANONE	0	0	0	2e-2		0	0	0
BENZENE	0	0	0		2.9e-2	0	0	0
ETHYLBENZENE	0	0	0			0	0	0
TOLUENE	0	0	0	1e0		0	0	0
XYLENES	0	0	0	4e-1		0	0	0
CHLOROBENZENE	0	0	0	5e-3		0	0	0
1,2-DICHLOROBENZENE	0	0	0	4e-1		0	0	0
1,4-DICHLOROBENZENE	0	0	0			0	0	0
PHENOL	0	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	0		5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	1.46e-12	4.17e-13	2.39e-13	3e-1		4.87e-12	1.39e-12	0
1,2-DICHLORETHANE	0	0	0		9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	0			0	0	0
TETRACHLOROETHENE	5.11e-12	1.46e-12	8.35e-13	1e-1	3.3e-3	5.11e-11	1.46e-11	2.76e-15
TRICHLOROETHENE	3.43e-11	9.81e-12	5.61e-12		1.3e-2	0	0	7.29e-14
1,1-DICHLOROETHENE	0	0	0		1.2e0	0	0	0
CARBON TETRACHLORIDE	0	0	0		1.3e-1	0	0	0
CHLOROFORM	1.46e-12	4.17e-13	2.39e-13		8.1e-2	0	0	1.93e-14
METHYLENE CHLORIDE	0	0	0		1.4e-2	0	0	0
CHLOROMETHANE	0	0	0		6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	0			0	0	0
BENZOIC ACID	3.58e-10	1.02e-10	5.84e-11			0	0	0
CARBON DISULFIDE	0	0	0			0	0	0
BENZO(A)ANTHRACENE	8.04e-11	2.30e-11	1.31e-11		8.17e-2	0	0	1.07e-12
BENZO(B)FLUORANTHENE	1.75e-10	5.01e-11	2.86e-11		4.9e-1	0	0	1.40e-11
BENZO(A)PYRENE	7.31e-11	2.09e-11	1.19e-11		6.1e0	0	0	7.28e-11
POLYCHLORINATED BIPHENYLS	0	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	4.02e-10	1.15e-10	6.56e-11			0	0	0
DI-N-BUTYLPHTHALATE	4.89e-11	1.40e-11	7.99e-12			0	0	0
ARSENIC	3.587e-8	1.025e-8	5.856e-9		5e1	0	0	2.928e-7
LEAD	1.987e-6	5.677e-7	3.244e-7			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
TOTAL						5.60e-11	1.60e-11	2.929e-7

000409

RISK ASSESSMENT SPREADSHEET - INHALATION OF FUGITIVE DUST

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
EXPOSURE THROUGH INHALATION OF FUGITIVE DUST IS CONSIDERED.

AVERAGE-CASE EXPOSURE SCENARIO

REFERENCES: COWHERD, ET AL., 1984

RELEVANT EQUATIONS:	E10 = 0.83*F*P(Ut)*(1-V)/PE/50)**2	F =	30
		V =	0
	UT = U*ln(7/Zo)/0.4	Ut =	23.9
		PE =	110
	P(Ut) = 6.7*(Ut - UT)	UT =	7.861296
		A =	400
	R10 = ALPHA*E10*A	PR =	.288
		Fi =	3.425
	X = Q*Fi	BR1 =	10
		BR2 =	20
		AF =	1
	Q = R10/PR	BW1 =	10
		BW2 =	70
	DOSE = X*BR*AF/BW	TW =	.5714286 (40 yr/70 yr)

INTERMEDIATE CALCULATIONS:

P(Ut) = 107.4593
E10 = 1.536e-4

001410

RISK ASSESSMENT SPREADSHEET - INHALATION OF FUGITIVE DUST (PAGE TWO)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	C (UG/KG)	ALPHA (MASS FRACTION)	R10 (G/S)	X (UG/M3)	DOSE (MG/KG/DAY) CHILD	DOSE (MG/KG/DAY) ADULT	DOSE (MG/KG/DAY) TIME-WEIGHTED
ACETONE		0	0	0	0	0	0
2-BUTANONE		0	0	0	0	0	0
4-METHYL-2-PENTANONE		0	0	0	0	0	0
BENZENE		0	0	0	0	0	0
ETHYLBENZENE		0	0	0	0	0	0
TOLUENE		0	0	0	0	0	0
XYLENES		0	0	0	0	0	0
CHLOROBENZENE		0	0	0	0	0	0
1,2-DICHLOROBENZENE		0	0	0	0	0	0
1,4-DICHLOROBENZENE		0	0	0	0	0	0
PHENOL		0	0	0	0	0	0
1,1,2-TRICHLOROETHANE		0	0	0	0	0	0
1,1,1-TRICHLOROETHANE	.0741	7.41e-11	4.55e-12	5.41e-11	5.41e-14	1.55e-14	8.84e-15
1,2-DICHLORETHANE		0	0	0	0	0	0
1,1-DICHLOROETHANE		0	0	0	0	0	0
TETRACHLOROETHENE	.2593	2.59e-10	1.59e-11	1.89e-10	1.89e-13	5.41e-14	3.09e-14
TRICHLOROETHENE	2	2e-9	1.23e-10	1.461e-9	1.46e-12	4.17e-13	2.39e-13
1,1-DICHLOROETHENE		0	0	0	0	0	0
CARBON TETRACHLORIDE		0	0	0	0	0	0
CHLOROFORM	.2593	2.59e-10	1.59e-11	1.89e-10	1.89e-13	5.41e-14	3.09e-14
METHYLENE CHLORIDE		0	0	0	0	0	0
CHLOROMETHANE		0	0	0	0	0	0
BROMODICHLOROMETHANE		0	0	0	0	0	0
CHLORODIBROMOMETHANE		0	0	0	0	0	0
BENZOIC ACID	56.67	5.667e-8	3.481e-9	4.140e-8	4.14e-11	1.18e-11	6.76e-12
CARBON DISULFIDE		0	0	0	0	0	0
BENZO(A)ANTHRACENE	4.074	4.074e-9	2.50e-10	2.976e-9	2.98e-12	8.50e-13	4.86e-13
BENZO(B)FLUORANTHENE	16	1.6e-8	9.83e-10	1.169e-8	1.17e-11	3.34e-12	1.91e-12
BENZO(A)PYRENE	3.704	3.704e-9	2.28e-10	2.706e-9	2.71e-12	7.73e-13	4.42e-13
POLYCHLORINATED BIPHENYLS		0	0	0	0	0	0
N-NITROSODIPHENYLAMINE		0	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	84.81	8.481e-8	5.210e-9	6.195e-8	6.20e-11	1.77e-11	1.01e-11
DI-N-BUTYLPHTHALATE	4.037	4.037e-9	2.48e-10	2.949e-9	2.95e-12	8.43e-13	4.81e-13
ARSENIC	6182	6.182e-6	3.797e-7	4.516e-6	4.516e-9	1.290e-9	7.37e-10
LEAD	173200	1.732e-4	1.064e-5	1.265e-4	1.265e-7	3.615e-8	2.066e-8
		0	0	0	0	0	0
		0	0	0	0	0	0
		0	0	0	0	0	0
		0	0	0	0	0	0
		0	0	0	0	0	0

001411

RISK ASSESSMENT SPREADSHEET - INHALATION OF FUGITIVE DUST (PAGE THREE)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE HAZARD INDICES AND CANCER RISKS:

CHEMICAL	DOSE CHILD	DOSE ADULT	DOSE TIME-WEIGHTED	RFD (MG/KG/DAY)	CPF (KG-DAY/MG)	HAZARD INDEX CHILD	HAZARD INDEX ADULT	CANCER RISK ADULT
ACETONE	0	0	0			0	0	0
2-BUTANONE	0	0	0	9e-2		0	0	0
4-METHYL-2-PENTANONE	0	0	0	2e-2		0	0	0
BENZENE	0	0	0		2.9e-2	0	0	0
ETHYLBENZENE	0	0	0			0	0	0
TOLUENE	0	0	0	1e0		0	0	0
XYLENES	0	0	0	4e-1		0	0	0
CHLOROBENZENE	0	0	0	5e-3		0	0	0
1,2-DICHLOROBENZENE	0	0	0	4e-1		0	0	0
1,4-DICHLOROBENZENE	0	0	0			0	0	0
PHENOL	0	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	0		5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	5.41e-14	1.55e-14	8.84e-15	3e-1		1.80e-13	5.16e-14	0
1,2-DICHLORETHANE	0	0	0		9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	0			0	0	0
TETRACHLOROETHENE	1.89e-13	5.41e-14	3.09e-14	1e-1	3.3e-3	1.89e-12	5.41e-13	1.02e-16
TRICHLOROETHENE	1.46e-12	4.17e-13	2.39e-13		1.3e-2	0	0	3.10e-15
1,1-DICHLOROETHENE	0	0	0		1.2e0	0	0	0
CARBON TETRACHLORIDE	0	0	0		1.3e-1	0	0	0
CHLOROFORM	1.89e-13	5.41e-14	3.09e-14		8.1e-2	0	0	2.50e-15
METHYLENE CHLORIDE	0	0	0		1.4e-2	0	0	0
CHLOROMETHANE	0	0	0		6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	0			0	0	0
BENZOIC ACID	4.14e-11	1.18e-11	6.76e-12			0	0	0
CARBON DISULFIDE	0	0	0			0	0	0
BENZO(A)ANTHRACENE	2.98e-12	8.50e-13	4.86e-13		8.17e-2	0	0	3.97e-14
BENZO(B)FLUORANTHENE	1.17e-11	3.34e-12	1.91e-12		4.9e-1	0	0	9.35e-13
BENZO(A)PYRENE	2.71e-12	7.73e-13	4.42e-13		6.1e0	0	0	2.69e-12
POLYCHLORINATED BIPHENYLS	0	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	6.20e-11	1.77e-11	1.01e-11			0	0	0
DI-N-BUTYLPHTHALATE	2.95e-12	8.43e-13	4.81e-13			0	0	0
ARSENIC	4.516e-9	1.290e-9	7.37e-10		5e1	0	0	3.687e-8
LEAD	1.265e-7	3.615e-8	2.066e-8			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
	0	0	0			0	0	0
TOTAL						2.07e-12	5.93e-13	3.687e-8

001412

Volatile Emissions

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
INHALATION OF VOLATILES EMITTED FROM CONTAMINATED SOILS ARE CONSIDERED.

MAXIMUM-CASE EXPOSURE SCENARIO

REFERENCES: EPA, SEPTEMBER 1982
TURNER, 1970

RELEVANT EQUATIONS:

INHALATION: DOSE = (C x IR x AF)/BW

WHERE:
- C = DOWNWIND (RECEPTOR) CONCENTRATION (MG/M3)
- IR = INHALATION RATE (M3/DAY)
- AF = ABSORPTION FRACTION (DECIMAL FRACTION)
- BW = BODY WEIGHT (KG)

C = Q/(Pi x SIGMAy x SIGMAz x U)

WHERE:
- Q = VOLATILE CHEMICAL EMISSSION RATE (MG/SEC)
- Pi = 3.14159
- SIGMAy = STD. DEV. OF HORIZ. DISTR. OF CONTAMINANT IN THE PLUME (M)
- SIGMAz = STD. DEV. OF VERT. DISTR. OF CONTAMINANT IN THE PLUME (M)
- U = WIND SPEED (M/SEC)

Q = Di x Csi x A x Pt**(4/3) x Mi/DSC

WHERE:
- Q = EMISSION RATE OF CONTAMINANT I (G/SEC)
- D = DIFFUSION COEFFICIENT OF CONTAMINANT IN AIR (CM2/SEC)
- Cs = SATURATION VAPOR CONCENTRATION OF CONTAMINANT (G/CM3)
- A = EXPOSED SURFACE AREA OF CONTAMINATED SOIL (CM2)
- Pt = TOTAL SOIL POROSITY (DIMENSIONLESS)
- Mi = MOLE FRACTION OF CONTAMINANT IN WASTE (DIMENSIONLESS)
- DSC = EFFECTIVE DEPTH OF SOIL COVER (CM)

Di = [0.001 x T**1.75 x SQRT(1/MWi + 1/MWair)]/[Pair x (Vi**1/3 + Vair**1/3)**2]

WHERE:
- T = AMBIENT TEMPERATURE (K)
- MWi = MOLECULAR WEIGHT OF CONTAMINANT I (G/MOL)
- MWair = MOLECULAR WEIGHT OF AIR (G/MOL)
- Pair = AMBIENT PRESSURE (ATM)
- Vi = MOLECULAR DIFFUSION VOLUME OF CONTAMINANT I (CM3/MOL)
- Vair = MOLECULAR DIFFUSION VOLUME OF AIR (CM3/MOL)

ENTER INPUT PARAMETERS:

INHALATION:

IR1:	20	T:	298	R:	62361
BW1:	70	MWair:	28.8	MWsoil:	60.08
IR2:	10	Vair:	20.1	Pt:	.25
BW2:	10	Pair:	1	DSC:	1
AF:	1	R:	62361		
ED:	40	SIGMAy:	2		
LF:	70	SIGMAz:	2.3		
A:	2e7	U:	2		
Pi:	3.141593				

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL (PAGE TWO)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	CONCENTRATION (UG/KG)	MOLECULAR WEIGHT	Vi (CM3/MOL)	Pv (mm Hg)	Di (CM2/SEC)	Ei (G/S)	C (MG/M3)
ACETONE					0	0	0
2-BUTANONE					0	0	0
4-METHYL-2-PENTANONE					0	0	0
BENZENE					0	0	0
ETHYLBENZENE					0	0	0
TOLUENE					0	0	0
XYLENES					0	0	0
CHLOROBENZENE					0	0	0
1,2-DICHLOROBENZENE					0	0	0
1,4-DICHLOROBENZENE					0	0	0
PHENOL					0	0	0
1,1,2-TRICHLOROETHANE					0	0	0
1,1,1-TRICHLOROETHANE	2	133.41	97	123	8.210e-2	2.057e-7	7.116e-6
1,2-DICHLORETHANE					0	0	0
1,1-DICHLOROETHANE					0	0	0
TETRACHLOROETHENE	7	165.83	111	14	7.620e-2	7.605e-8	2.631e-6
TRICHLOROETHENE	47	131.39	93	57.9	8.367e-2	2.319e-6	8.023e-5
1,1-DICHLOROETHENE					0	0	0
CARBON TETRACHLORIDE					0	0	0
CHLOROFORM	2	119.38	77	150.5	9.125e-2	2.797e-7	9.677e-6
METHYLENE CHLORIDE					0	0	0
CHLOROMETHANE					0	0	0
BROMODICHLOROMETHANE					0	0	0
CHLORODIBROMOMETHANE					0	0	0
BENZOIC ACID	490	122.1	118	7.04e-3	7.618e-2	2.676e-9	9.259e-8
CARBON DISULFIDE					0	0	0
BENZO(A)ANTHRACENE	110	228.3	321	2.2e-8	4.619e-2	1.14e-15	3.94e-14
BENZO(B)FLUORANTHENE	240	252.3	354	5e-7	4.384e-2	5.36e-14	1.85e-12
BENZO(A)PYRENE	100	252	354	5.6e-9	4.384e-2	2.50e-16	8.65e-15
POLYCHLORINATED BIPHENYLS					0	0	0
N-NITROSODIPHENYLAMINE					0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	550	391	473	2e-7	3.736e-2	4.18e-14	1.45e-12
DI-N-BUTYLPHTHALATE	67	278.3	309	1e-5	4.656e-2	3.18e-13	1.10e-11
ARSENIC					0	0	0
LEAD					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0

001415

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL (PAGE THREE)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE HAZARD INDICES:

CHEMICAL	C (MG/M3)	CHILD DOSE (MG/KG/DAY)	ADULT DOSE (MG/KG/DAY)	REFERENCE DOSE INH.	HAZARD INDEX CHILD	HAZARD INDEX ADULT
ACETONE	0	0	0		0	0
2-BUTANONE	0	0	0	9e-2	0	0
4-METHYL-2-PENTANONE	0	0	0	2e-2	0	0
BENZENE	0	0	0		0	0
ETHYLBENZENE	0	0	0		0	0
TOLUENE	0	0	0	1e0	0	0
XYLENES	0	0	0	4e-1	0	0
CHLOROBENZENE	0	0	0	5e-3	0	0
1,2-DICHLOROBENZENE	0	0	0	4e-1	0	0
1,4-DICHLOROBENZENE	0	0	0		0	0
PHENOL	0	0	0		0	0
1,1,2-TRICHLOROETHANE	0	0	0		0	0
1,1,1-TRICHLOROETHANE	7.116e-6	7.116e-6	2.033e-6	3e-1	2.372e-5	6.777e-6
1,2-DICHLORETHANE	0	0	0		0	0
1,1-DICHLOROETHANE	0	0	0		0	0
TETRACHLOROETHENE	2.631e-6	2.631e-6	7.517e-7	1e-1	2.631e-5	7.517e-6
TRICHLOROETHENE	8.023e-5	8.023e-5	2.292e-5		0	0
1,1-DICHLOROETHENE	0	0	0		0	0
CARBON TETRACHLORIDE	0	0	0		0	0
CHLOROFORM	9.677e-6	9.677e-6	2.765e-6		0	0
METHYLENE CHLORIDE	0	0	0		0	0
CHLOROMETHANE	0	0	0		0	0
BROMODICHLOROMETHANE	0	0	0		0	0
CHLORODIBROMOMETHANE	0	0	0		0	0
BENZOIC ACID	9.259e-8	9.259e-8	2.645e-8		0	0
CARBON DISULFIDE	0	0	0		0	0
BENZO(A)ANTHRACENE	3.94e-14	3.94e-14	1.13e-14		0	0
BENZO(B)FLUORANTHENE	1.85e-12	1.85e-12	5.30e-13		0	0
BENZO(A)PYRENE	8.65e-15	8.65e-15	2.47e-15		0	0
POLYCHLORINATED BIPHENYLS	0	0	0		0	0
N-NITROSODIPHENYLAMINE	0	0	0		0	0
BIS(2-ETHYLHEXYL)PHTHALATE	1.45e-12	1.45e-12	4.14e-13		0	0
DI-N-BUTYLPHTHALATE	1.10e-11	1.10e-11	3.14e-12		0	0
ARSENIC	0	0	0		0	0
LEAD	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
TOTAL HAZARD INDEX					5.003e-5	1.429e-5

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL (PAGE FOUR)
BYRON BARREL AND DRUM SITE
MAXIMUM-CASE EXPOSURE SCENARIO
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	C (MG/M3)	TIME-WEIGHTED DOSE (MG/KG/DAY)	POTENCY FACTOR INH.	CANCER RISK
ACETONE	0	0		0
2-BUTANONE	0	0		0
4-METHYL-2-PENTANONE	0	0		0
BENZENE	0	0	2.9e-2	0
ETHYLBENZENE	0	0		0
TOLUENE	0	0		0
XYLENES	0	0		0
CHLOROBENZENE	0	0		0
1,2-DICHLOROBENZENE	0	0		0
1,4-DICHLOROBENZENE	0	0		0
PHENOL	0	0		0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	0
1,1,1-TRICHLOROETHANE	7.116e-6	1.162e-6		0
1,2-DICHLORETHANE	0	0	9.1e-2	0
1,1-DICHLOROETHANE	0	0		0
TETRACHLOROETHENE	2.631e-6	4.296e-7	3.3e-3	1.418e-9
TRICHLOROETHENE	8.023e-5	1.310e-5	1.3e-2	1.703e-7
1,1-DICHLOROETHENE	0	0	1.2e0	0
CARBON TETRACHLORIDE	0	0	1.3e-1	0
CHLOROFORM	9.677e-6	1.580e-6	8.1e-2	1.280e-7
METHYLENE CHLORIDE	0	0	1.4e-2	0
CHLOROMETHANE	0	0	6.3e-3	0
BROMODICHLOROMETHANE	0	0		0
CHLORODIBROMOMETHANE	0	0		0
BENZOIC ACID	9.259e-8	1.512e-8		0
CARBON DISULFIDE	0	0		0
BENZO(A)ANTHRACENE	3.94e-14	6.43e-15	8.17e-2	5.25e-16
BENZO(B)FLUORANTHENE	1.85e-12	3.03e-13	4.9e-1	1.48e-13
BENZO(A)PYRENE	8.65e-15	1.41e-15	6.1e0	8.61e-15
POLYCHLORINATED BIPHENYLS	0	0		0
N-NITROSODIPHENYLAMINE	0	0		0
BIS(2-ETHYLHEXYL)PHTHALATE	1.45e-12	2.36e-13		0
DI-N-BUTYLPHTHALATE	1.10e-11	1.79e-12		0
ARSENIC	0	0	5e1	0
LEAD	0	0		0
	0	0		0
	0	0		0
	0	0		0
	0	0		0
	0	0		0
TOTAL RISK				2.997e-7

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: APRIL 26, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
INHALATION OF VOLATILES EMITTED FROM CONTAMINATED SOILS ARE CONSIDERED.

AVERAGE-CASE EXPOSURE SCENARIO

REFERENCES: EPA, SEPTEMBER 1982
TURNER, 1970

RELEVANT EQUATIONS:

INHALATION: DOSE = (C x IR x AF)/BW

WHERE: C = DOWNWIND (RECEPTOR) CONCENTRATION (MG/M3)
IR = INHALATION RATE (M3/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

C = Q/(Pi x SIGMAy x SIGMAz x U)

WHERE: Q = VOLATILE CHEMICAL EMISSSION RATE (MG/SEC)
Pi = 3.14159
SIGMAy = STD. DEV. OF HORIZ. DISTR. OF CONTAMINANT IN THE PLUME (M)
SIGMAz = STD. DEV. OF VERT. DISTR. OF CONTAMINANT IN THE PLUME (M)
U = WIND SPEED (M/SEC)

Q = Di x Csi x A x Pt**(4/3) x Mi/DSC

WHERE: Q = EMISSION RATE OF CONTAMINANT I (G/SEC)
D = DIFFUSION COEFFICIENT OF CONTAMINANT IN AIR (CM2/SEC)
Cs = SATURATION VAPOR CONCENTRATION OF CONTAMINANT (G/CM3)
A = EXPOSED SURFACE AREA OF CONTAMINATED SOIL (CM2)
Pt = TOTAL SOIL POROSITY (DIMENSIONLESS)
Mi = MOLE FRACTION OF CONTAMINANT IN WASTE (DIMENSIONLESS)
DSC = EFFECTIVE DEPTH OF SOIL COVER (CM)

Di = [0.001 x T**1.75 x SQRT(1/MWi + 1/MWair)]/[Pair x (Vi**1/3 + Vair**1/3)**2]

WHERE: T = AMBIENT TEMPERATURE (K)
MWi = MOLECULAR WEIGHT OF CONTAMINANT I (G/MOL)
MWair = MOLECULAR WEIGHT OF AIR (G/MOL)
Pair = AMBIENT PRESSURE (ATM)
Vi = MOLECULAR DIFFUSION VOLUME OF CONTAMINANT I (CM3/MOL)
Vair = MOLECULAR DIFFUSION VOLUME OF AIR (CM3/MOL)

ENTER INPUT PARAMETERS:

INHALATION:

IR1:	20	T:	298	R:	62361
BW1:	70	MWair:	28.8	MWsoil:	60.08
IR2:	10	Vair:	20.1	Pt:	.25
BW2:	10	Pair:	1	DSC:	1
AF:	1	R:	62361		
ED:	40	SIGMAy:	2		
LF:	70	SIGMAz:	2.3		
A:	2e7	U:	2		
Pi:	3.141593				

001418

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL (PAGE TWO)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE DOSES:

CHEMICAL	CONCENTRATION (UG/KG)	MOLECULAR WEIGHT	Vi (CM3/MOL)	Pv (mm Hg)	Di (CM2/SEC)	Ei (G/S)	C (MG/M3)
ACETONE					0	0	0
2-BUTANONE					0	0	0
4-METHYL-2-PENTANONE					0	0	0
BENZENE					0	0	0
ETHYLBENZENE					0	0	0
TOLUENE					0	0	0
XYLENES					0	0	0
CHLOROBENZENE					0	0	0
1,2-DICHLOROBENZENE					0	0	0
1,4-DICHLOROBENZENE					0	0	0
PHENOL					0	0	0
1,1,2-TRICHLOROETHANE					0	0	0
1,1,1-TRICHLOROETHANE	.0741	133.41	97	123	8.210e-2	7.620e-9	2.637e-7
1,2-DICHLORETHANE					0	0	0
1,1-DICHLOROETHANE					0	0	0
TETRACHLOROETHENE	.2593	165.83	111	14	7.620e-2	2.817e-9	9.746e-8
TRICHLOROETHENE	2	131.39	93	57.9	8.367e-2	9.867e-8	3.414e-6
1,1-DICHLOROETHENE					0	0	0
CARBON TETRACHLORIDE					0	0	0
CHLOROFORM	.2593	119.38	77	150.5	9.125e-2	3.626e-8	1.255e-6
METHYLENE CHLORIDE					0	0	0
CHLOROMETHANE					0	0	0
BROMODICHLOROMETHANE					0	0	0
CHLORODIBROMOMETHANE					0	0	0
BENZOIC ACID	56.67	122.1	118	7.04e-3	7.618e-2	3.09e-10	1.071e-8
CARBON DISULFIDE					0	0	0
BENZO(A)ANTHRACENE	4.074	228.3	321	2.2e-8	4.619e-2	4.22e-17	1.46e-15
BENZO(B)FLUORANTHENE	16	252.3	354	5e-7	4.384e-2	3.57e-15	1.24e-13
BENZO(A)PYRENE	3.704	252	354	5.6e-9	4.384e-2	9.26e-18	3.20e-16
POLYCHLORINATED BIPHENYLS					0	0	0
N-NITROSODIPHENYLAMINE					0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	84.81	391	473	2e-7	3.736e-2	6.45e-15	2.23e-13
DI-N-BUTYLPHTHALATE	4.037	278.3	309	1e-5	4.656e-2	1.91e-14	6.62e-13
ARSENIC					0	0	0
LEAD					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0
					0	0	0

001449

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL (PAGE THREE)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE HAZARD INDICES:

CHEMICAL	C (MG/M3)	CHILD DOSE (MG/KG/DAY)	ADULT DOSE (MG/KG/DAY)	REFERENCE DOSE INH.	HAZARD INDEX CHILD	HAZARD INDEX ADULT
ACETONE	0	0	0		0	0
2-BUTANONE	0	0	0	9e-2	0	0
4-METHYL-2-PENTANONE	0	0	0	2e-2	0	0
BENZENE	0	0	0		0	0
ETHYLBENZENE	0	0	0		0	0
TOLUENE	0	0	0	1e0	0	0
XYLENES	0	0	0	4e-1	0	0
CHLOROBENZENE	0	0	0	5e-3	0	0
1,2-DICHLOROBENZENE	0	0	0	4e-1	0	0
1,4-DICHLOROBENZENE	0	0	0		0	0
PHENOL	0	0	0		0	0
1,1,2-TRICHLOROETHANE	0	0	0		0	0
1,1,1-TRICHLOROETHANE	2.637e-7	2.637e-7	7.533e-8	3e-1	8.788e-7	2.511e-7
1,2-DICHLORETHANE	0	0	0		0	0
1,1-DICHLOROETHANE	0	0	0		0	0
TETRACHLOROETHENE	9.746e-8	9.746e-8	2.785e-8	1e-1	9.746e-7	2.785e-7
TRICHLOROETHENE	3.414e-6	3.414e-6	9.754e-7		0	0
1,1-DICHLOROETHENE	0	0	0		0	0
CARBON TETRACHLORIDE	0	0	0		0	0
CHLOROFORM	1.255e-6	1.255e-6	3.585e-7		0	0
METHYLENE CHLORIDE	0	0	0		0	0
CHLOROMETHANE	0	0	0		0	0
BROMODICHLOROMETHANE	0	0	0		0	0
CHLORODIBROMOMETHANE	0	0	0		0	0
BENZOIC ACID	1.071e-8	1.071e-8	3.059e-9		0	0
CARBON DISULFIDE	0	0	0		0	0
BENZO(A)ANTHRACENE	1.46e-15	1.46e-15	4.17e-16		0	0
BENZO(B)FLUORANTHENE	1.24e-13	1.24e-13	3.53e-14		0	0
BENZO(A)PYRENE	3.20e-16	3.20e-16	9.15e-17		0	0
POLYCHLORINATED BIPHENYLS	0	0	0		0	0
N-NITROSODIPHENYLAMINE	0	0	0		0	0
BIS(2-ETHYLHEXYL)PHTHALATE	2.23e-13	2.23e-13	6.38e-14		0	0
DI-N-BUTYLPHTHALATE	6.62e-13	6.62e-13	1.89e-13		0	0
ARSENIC	0	0	0		0	0
LEAD	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
	0	0	0		0	0
TOTAL HAZARD INDEX					1.853e-6	5.296e-7

001420

RISK ASSESSMENT SPREADSHEET - INHALATION OF VOLATILES EMITTED FROM SOIL (PAGE FOUR)
BYRON BARREL AND DRUM SITE
AVERAGE-CASE EXPOSURE SCENARIO
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	C (MG/M3)	TIME-WEIGHTED DOSE (MG/KG/DAY)	POTENCY FACTOR INH.	CANCER RISK
ACETONE	0	0		0
2-BUTANONE	0	0		0
4-METHYL-2-PENTANONE	0	0		0
BENZENE	0	0	2.9e-2	0
ETHYLBENZENE	0	0		0
TOLUENE	0	0		0
XYLENES	0	0		0
CHLOROBENZENE	0	0		0
1,2-DICHLOROBENZENE	0	0		0
1,4-DICHLOROBENZENE	0	0		0
PHENOL	0	0		0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	0
1,1,1-TRICHLOROETHANE	2.637e-7	4.305e-8		0
1,2-DICHLORETHANE	0	0	9.1e-2	0
1,1-DICHLOROETHANE	0	0		0
TETRACHLOROETHENE	9.746e-8	1.591e-8	3.3e-3	5.25e-11
TRICHLOROETHENE	3.414e-6	5.574e-7	1.3e-2	7.246e-9
1,1-DICHLOROETHENE	0	0	1.2e0	0
CARBON TETRACHLORIDE	0	0	1.3e-1	0
CHLOROFORM	1.255e-6	2.048e-7	8.1e-2	1.659e-8
METHYLENE CHLORIDE	0	0	1.4e-2	0
CHLOROMETHANE	0	0	6.3e-3	0
BROMODICHLOROMETHANE	0	0		0
CHLORODIBROMOMETHANE	0	0		0
BENZOIC ACID	1.071e-8	1.748e-9		0
CARBON DISULFIDE	0	0		0
BENZO(A)ANTHRACENE	1.46e-15	2.38e-16	8.17e-2	1.95e-17
BENZO(B)FLUORANTHENE	1.24e-13	2.02e-14	4.9e-1	9.88e-15
BENZO(A)PYRENE	3.20e-16	5.23e-17	6.1e0	3.19e-16
POLYCHLORINATED BIPHENYLS	0	0		0
N-NITROSODIPHENYLAMINE	0	0		0
BIS(2-ETHYLHEXYL)PHTHALATE	2.23e-13	3.64e-14		0
DI-N-BUTYLPHTHALATE	6.62e-13	1.08e-13		0
ARSENIC	0	0	5e1	0
LEAD	0	0		0
	0	0		0
	0	0		0
	0	0		0
	0	0		0
	0	0		0
TOTAL RISK				2.389e-8

Groundwater Use

RISK ASSESSMENT SPREADSHEET - EXPOSURES THROUGH HOUSEHOLD USE OF GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 5, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET. TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCEANRIO 1 - MAXIMUM CASE

REFERENCES:

- EPA, OCTOBER 1986
- FOSTER, ET AL., 1987
- DONIGIAN, ET AL., NOVEMBER, 1983
- EPA, JULY 29, 1986
- EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION FACTOR =	.0285714
AF:	1		
BW:	70		

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	Tl:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
E0:	40	T:	293
R:	.000082	FR:	10

0012823

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCEANRIO 1 - MAXIMUM CASE
CALCULATE DOSES:

CHEMICAL	CONCENTRATION (MG/L)	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (YAI)	INGESTION DOSE	INHALATION DOSE
ACETONE				0	0	0
2-BUTANONE				0	0	0
4-METHYL-2-PENTANONE				0	0	0
BENZENE	.0005	78.12	5.5e-3	1.8884e1	1.429e-5	9.846e-6
ETHYLBENZENE				0	0	0
TOLUENE	.001	92.13	6.66e-3	1.7521e1	2.857e-5	1.865e-5
XYLENES	.003	106.17	4.33e-3	1.6010e1	8.571e-5	5.230e-5
CHLOROBENZENE	.00025	112.56	3.58e-3	1.5373e1	7.143e-6	4.226e-6
1,2-DICHLOROBENZENE	.000026	147.01	1.93e-3	1.2739e1	7.429e-7	3.792e-7
1.4-DICHLOROBENZENE	.002	147.01	3.1e-3	1.3316e1	5.714e-5	3.022e-5
VINYL CHLORIDE	.00006	62.5	8.14e-2	2.2005e1	1.714e-6	1.315e-6
1.1.2-TRICHLOROETHANE	.0037	133.41	7.42e-4	1.1296e1	1.057e-4	4.894e-5
1.1.1-TRICHLOROETHANE	4.4	133.41	3e-2	1.4983e1	1.257e-1	7.292e-2
1.2-DICHLORETHANE	.00041	98.96	9.14e-4	1.3769e1	1.171e-5	6.361e-6
1.1-DICHLOROETHANE	.29	98.96	4.26e-3	1.6568e1	8.286e-3	5.188e-3
TETRACHLOROETHENE	.082	165.83	1.53e-2	1.3333e1	2.343e-3	1.240e-3
TRICHLOROETHENE	3.3	131.39	9.1e-3	1.4816e1	9.429e-2	5.422e-2
1.1-DICHLOROETHENE	.041	96.94	1.9e-1	1.7700e1	1.171e-3	7.703e-4
CARBON TETRACHLORIDE				0	0	0
CHLOROFORM	.00051	119.38	2.88e-3	1.4693e1	1.457e-5	8.325e-6
METHYLENE CHLORIDE	.0028	84.94	2.03e-3	1.6855e1	8e-5	5.073e-5
CHLOROMETHANE				0	0	0
BROMODICHLOROMETHANE	.00023	163.83	2.41e-3	1.2350e1	6.571e-6	3.272e-6
CHLORODIBROMOMETHANE	.00014	208.3	9.9e-4	9.6499e0	4e-6	1.623e-6
2-CHLOROETHYLVINYLETHER				0	0	0
CARBON DISULFIDE				0	0	0
BENZO(A)ANTHRACENE				0	0	0
BENZO(B)FLUORANTHENE				0	0	0
BENZO(A)PYRENE				0	0	0
POLYCHLORINATED BIPHENYLS				0	0	0
N-NITROSODIPHENYLAMINE	.002	198.2	6.6e-4	8.9856e0	5.714e-5	2.182e-5
BIS(2-ETHYLHEXYL)PHTHALATE				0	0	0
				0	0	0
				0	0	0
CHROMIUM	.479			0	1.369e-2	0
				0	0	0
LEAD	.631			0	1.803e-2	0
				0	0	0
				0	0	0
				0	0	0

001424

RISK ASSESSMENT SPREADSHEET   HOUSEHOLD USE OF GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCEANRIO 1 - MAXIMUM CASE
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2 BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	1.429e-5	9.846e-6			0	0	0
ETHYLBENZENE	0	0	1e-1		0	0	0
TOLUENE	2.857e-5	1.865e-5	3e-1	1e0	9.524e-5	1.865e-5	1.139e-4
XYLENES	8.571e-5	5.230e-5	2e0	4e-1	4.286e-5	1.307e-4	1.736e-4
CHLOROBENZENE	7.143e-6	4.226e-6	3e-2	5e-3	2.381e-4	8.451e-4	1.083e-3
1,2-DICHLOROBENZENE	7.429e-7	3.792e-7	4e-1	4e-1	1.857e-6	9.480e-7	2.805e-6
1,4-DICHLOROBENZENE	5.714e-5	3.022e-5			0	0	0
VINYL CHLORIDE	1.714e-6	1.315e-6			0	0	0
1,1,2-TRICHLOROETHANE	1.057e-4	4.894e-5	4e-2		2.643e-3	0	2.643e-3
1,1,1-TRICHLOROETHANE	1.257e-1	7.292e-2	9e-2	3e-1	1.3968e0	2.431e-1	1.6399e0
1,2-DICHLORETHANE	1.171e-5	6.361e-6			0	0	0
1,1-DICHLOROETHANE	8.286e-3	5.188e-3	1e-1		8.286e-2	0	8.286e-2
TETRACHLORDETHENE	2.343e-3	1.240e-3	1e-2	1e-1	2.343e-1	1.240e-2	2.467e-1
TRICHLOROETHENE	9.429e-2	5.422e-2			0	0	0
1,1-DICHLORDETHENE	1.171e-3	7.703e-4	9e-3		1.302e-1	0	1.302e-1
CARBON TETRACHLORIDE	0	0	7e-4		0	0	0
CHLOROFORM	1.457e-5	8.325e-6	1e-2		1.457e-3	0	1.457e-3
METHYLENE CHLORIDE	8e-5	5.073e-5	6e-2		1.333e-3	0	1.333e-3
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	6.571e-6	3.272e-6			0	0	0
CHLORODIBROMOMETHANE	4e-6	1.623e-6	2e-1		2e-5	0	2e-5
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	5.714e-5	2.182e-5			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
	0	0	3e-4		0	0	0
	0	0	5e-2	1e-4	0	0	0
CHROMIUM	1.369e-2	0	1e0		1.369e-2	0	1.369e-2
	0	0	3.7e-2	1e-2	0	0	0
LEAD	1.803e-2	0	1.4e-3		1.2878e1	0	1.2878e1
	0	0	2e-2		0	0	0
	0	0	1e-3		0	0	0
	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							1.4998e1

001425

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCEANRIO I - MAXIMUM CASE
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	1.429e-5	9.846e-6	2.9e-2	2.9e-2	2.367e-7	1.632e-7	3.999e-7
ETHYLBENZENE	0	0			0	0	0
TOLUENE	2.857e-5	1.865e-5			0	0	0
XYLENES	8.571e-5	5.230e-5			0	0	0
CHLOROBENZENE	7.143e-6	4.226e-6			0	0	0
1,2-DICHLOROBENZENE	7.429e-7	3.792e-7			0	0	0
1,4-DICHLOROBENZENE	5.714e-5	3.022e-5	2.4e-2		7.837e-7	0	7.837e-7
VINYL CHLORIDE	1.714e-6	1.315e-6	2.3e0	2.95e-1	2.253e-6	2.216e-7	2.475e-6
1,1,2-TRICHLOROETHANE	1.057e-4	4.894e-5	5.7e-2	5.7e-2	3.443e-6	1.594e-6	5.037e-6
1,1,1-TRICHLOROETHANE	1.257e-1	7.292e-2			0	0	0
1,2-DICHLORETHANE	1.171e-5	6.361e-6	9.1e-2	9.1e-2	6.091e-7	3.308e-7	9.399e-7
1,1-DICHLOROETHANE	8.286e-3	5.188e-3	9.1e-2		4.309e-4	0	4.309e-4
TETRACHLOROETHENE	2.343e-3	1.240e-3	5.1e-2	3.3e-3	6.828e-5	2.339e-6	7.062e-5
TRICHLOROETHENE	9.429e-2	5.422e-2	1.1e-2	1.3e-2	5.927e-4	4.027e-4	9.954e-4
1,1-DICHLOROETHENE	1.171e-3	7.703e-4	6e-1	1.2e0	4.016e-4	5.282e-4	9.298e-4
CARBON TETRACHLORIDE	0	0	1.3e-1	1.3e-1	0	0	0
CHLOROFORM	1.457e-5	8.325e-6	6.1e-3	8.1e-2	5.079e-8	3.853e-7	4.361e-7
METHYLENE CHLORIDE	8e-5	5.073e-5	7.5e-3	1.4e-2	3.429e-7	4.059e-7	7.487e-7
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	6.571e-6	3.272e-6	1.3e-1		4.882e-7	0	4.882e-7
CHLORODIBROMOMETHANE	4e-6	1.623e-6	8.4e-2		1.92e-7	0	1.92e-7
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	5.714e-5	2.182e-5	4.9e-3		1.6e-7	0	1.6e-7
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
	0	0			0	0	0
	0	0			0	0	0
CHROMIUM	1.369e-2	0			0	0	0
	0	0			0	0	0
LEAD	1.803e-2	0			0	0	0
	0	0		8.4e-1	0	0	0
	0	0			0	0	0
	0	0			0	0	0
TOTAL RISK							2.438e-3

007426

RISK ASSESSMENT SPREADSHEET EXPOSURES THROUGH HOUSEHOLD USE OF GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 5, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET. TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCENARIO 2 - AVERAGE CASE

REFERENCES:
EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW x Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION FACTOR =	.0285714
AF:	1		
BW:	70		

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	Tl:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
ED:	40	T:	293
F:	.000082	FR:	10

00142?

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - AVERAGE CASE
CALCULATE DOSES:

CHEMICAL	CONCENTRATION (MG/L)	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAL)	INGESTION DOSE	INHALATION DOSE
ACETONE				0	0	0
2-BUTANONE				0	0	0
4-METHYL-2-PENTANONE				0	0	0
BENZENE	.000025	78.12	5.5e-3	1.8884e1	7.143e-7	4.923e-7
ETHYLBENZENE				0	0	0
TOLUENE	.00014	92.13	6.66e-3	1.7521e1	4e-6	2.611e-6
XYLENES	.00035	106.17	4.33e-3	1.6010e1	1e-5	6.101e-6
CHLOROBENZENE	.0000417	112.56	3.58e-3	1.5373e1	1.191e-6	7.048e-7
1,2-DICHLOROBENZENE	.0000013	147.01	1.93e-3	1.2739e1	3.714e-8	1.896e-8
1,4-DICHLOROBENZENE	.00001	147.01	3.1e-3	1.3316e1	2.857e-7	1.511e-7
VINYL CHLORIDE	.000003	62.5	8.14e-2	2.2005e1	8.571e-8	6.573e-8
1,1,2-TRICHLOROETHANE	.0001932	133.41	7.42e-4	1.1296e1	5.52e-6	2.555e-6
1,1,1-TRICHLOROETHANE	.3892	133.41	3e-2	1.4983e1	1.112e-2	6.450e-3
1,2-DICHLORETHANE		98.96	9.14e-4	1.3769e1	0	0
1,1-DICHLOROETHANE	.01755	98.96	4.26e-3	1.6568e1	5.014e-4	3.139e-4
TETRACHLOROETHENE	.0041	165.83	1.53e-2	1.3333e1	1.171e-4	6.201e-5
TRICHLOROETHENE	.1665	131.39	9.1e-3	1.4816e1	4.757e-3	2.735e-3
1,1-DICHLOROETHENE	.00525	96.94	1.9e-1	1.7700e1	1.5e-4	9.863e-5
CARBON TETRACHLORIDE				0	0	0
CHLOROFORM	.0000095	119.38	2.88e-3	1.4693e1	2.714e-7	1.551e-7
METHYLENE CHLORIDE		84.94	2.03e-3	1.6855e1	0	0
CHLOROMETHANE				0	0	0
BROMODICHLOROMETHANE	.0000022	163.83	2.41e-3	1.7350e1	6.286e-8	3.130e-8
CHLORODIBROMOMETHANE		208.3	9.9e-4	9.6499e0	0	0
2-CHLOROETHYLVINYLETHER				0	0	0
CARBON DISULFIDE				0	0	0
BENZO(A)ANTHRACENE				0	0	0
BENZO(B)FLUORANTHENE				0	0	0
BENZO(A)PYRENE				0	0	0
POLYCHLORINATED BIPHENYLS				0	0	0
N-NITROSODIPHENYLAMINE	.0002	198.2	6.6e-4	8.9856e0	5.714e-6	2.182e-6
BIS(2-ETHYLHEXYL)PHTHALATE				0	0	0
				0	0	0
				0	0	0
CHROMIUM	.0878			0	2.509e-3	0
				0	0	0
LEAD	.11796			0	3.370e-3	0
				0	0	0
				0	0	0
				0	0	0

824700

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - AVERAGE CASE
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	7.143e-7	4.923e-7			0	0	0
ETHYLBENZENE	0	0	1e-1		0	0	0
TOLUENE	4e-6	2.611e-6	3e-1	1e0	1.333e-5	2.611e-6	1.594e-5
XYLENES	1e-5	6.101e-6	2e0	4e-1	5e-6	1.525e-5	2.025e-5
CHLOROBENZENE	1.191e-6	7.048e-7	3e-2	5e-3	3.971e-5	1.410e-4	1.807e-4
1,2-DICHLOROBENZENE	3.714e-8	1.896e-8	4e-1	4e-1	9.286e-8	4.740e-8	1.403e-7
1,4-DICHLOROBENZENE	2.857e-7	1.511e-7			0	0	0
VINYL CHLORIDE	8.571e-8	6.573e-8			0	0	0
1,1,2-TRICHLOROETHANE	5.52e-6	2.555e-6	4e-2		1.38e-4	0	1.38e-4
1,1,1-TRICHLOROETHANE	1.112e-2	5.450e-3	9e-2	3e-1	1.236e-1	2.150e-2	1.451e-1
1,2-DICHLORETHANE	0	0			0	0	0
1,1-DICHLOROETHANE	5.014e-4	3.139e-4	1e-1		5.014e-3	0	5.014e-3
TETRACHLOROETHENE	1.171e-4	6.201e-5	1e-2	1e-1	1.171e-2	6.201e-4	1.233e-2
TRICHLOROETHENE	4.757e-3	2.735e-3			0	0	0
1,1-DICHLOROETHENE	1.5e-4	9.863e-5	9e-3		1.667e-2	0	1.667e-2
CARBON TETRACHLORIDE	0	0	7e-4		0	0	0
CHLOROFORM	2.714e-7	1.551e-7	1e-2		2.714e-5	0	2.714e-5
METHYLENE CHLORIDE	0	0	6e-2		0	0	0
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	6.286e-8	3.130e-8			0	0	0
CHLORODIBROMOMETHANE	0	0	2e-1		0	0	0
2-CHLOROETHYLVINYLETHER	0	0	4e0		0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	5.714e-6	2.182e-6			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
	0	0	3e-4		0	0	0
	0	0	5e-2	1e-4	0	0	0
CHROMIUM	2.509e-3	0	1e0		2.509e-3	0	2.509e-3
	0	0	3.7e-2		0	0	0
LEAD	3.370e-3	0	1.4e-3		2.4073e0	0	2.4073e0
	0	0	2e-2		0	0	0
	0	0	1e-3		0	0	0
	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							2.5893e0

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RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - AVERAGE CASE
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	7.143e-7	4.923e-7	2.9e-2	2.9e-2	1.184e-8	8.158e-9	1.999e-8
ETHYLBENZENE	0	0			0	0	0
TOLUENE	4e-6	2.611e-6			0	0	0
XYLENES	1e-5	6.101e-6			0	0	0
CHLOROBENZENE	1.191e-6	7.048e-7			0	0	0
1,2-DICHLOROBENZENE	3.714e-8	1.896e-8			0	0	0
1,4-DICHLOROBENZENE	2.857e-7	1.511e-7	2.4e-2		3.918e-9	0	3.918e-9
VINYL CHLORIDE	8.571e-8	6.573e-8	2.3e0	2.95e-1	1.127e-7	1.108e-8	1.237e-7
1,1,2-TRICHLOROETHANE	5.52e-6	2.555e-6	5.7e-2	5.7e-2	1.798e-7	8.323e-8	2.630e-7
1,1,1-TRICHLOROETHANE	1.112e-2	6.450e-3			0	0	0
1,2-DICHLORETHANE	0	0	9.1e-2	9.1e-2	0	0	0
1,1-DICHLOROETHANE	5.014e-4	3.139e-4	9.1e-2		2.607e-5	0	2.607e-5
TETRACHLOROETHENE	1.171e-4	6.201e-5	5.1e-2	3.3e-3	3.414e-6	1.169e-7	3.531e-6
TRICHLOROETHENE	4.757e-3	2.735e-3	1.1e-2	1.3e-2	2.990e-5	2.032e-5	5.022e-5
1,1-DICHLOROETHENE	1.5e-4	9.863e-5	6e-1	1.2e0	5.143e-5	6.763e-5	1.191e-4
CARBON TETRACHLORIDE	0	0	1.3e-1	1.3e-1	0	0	0
CHLOROFORM	2.714e-7	1.551e-7	6.1e-3	8.1e-2	9.46e-10	7.178e-9	8.124e-9
METHYLENE CHLORIDE	0	0	7.5e-3	1.4e-2	0	0	0
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	6.286e-8	3.130e-8	1.3e-1		4.669e-9	0	4.669e-9
CHLORODIBROMOMETHANE	0	0	8.4e-2		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	5.714e-6	2.182e-6	4.9e-3		1.6e-8	0	1.6e-8
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
	0	0			0	0	0
	0	0			0	0	0
CHROMIUM	2.509e-3	0			0	0	0
	0	0			0	0	0
LEAD	3.370e-3	0			0	0	0
	0	0		.84	0	0	0
	0	0			0	0	0
	0	0			0	0	0
TOTAL RISK							1.993e-4

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RISK ASSESSMENT SPREADSHEET   EXPOSURES THROUGH HOUSEHOLD USE OF GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 5, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF
VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCENARIO 3 - RESIDENTIAL WELL RESULTS

REFERENCES:
EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION	.0285714
AF:	1	FACTOR =	
BW:	70		

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	T1:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
ER:	40	T:	293
F:	.000082	FR:	10

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 RESIDENTIAL WELL RESULTS
CALCULATE DOSES:

CHEMICAL	CONCENTRATION (MG/L)	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAL)	INGESTION DOSE	INHALATION DOSE
ACETONE				0	0	0
2 BUTANONE				0	0	0
4-METHYL-2-PENTANONE				0	0	0
BENZENE				0	0	0
ETHYLBENZENE				0	0	0
TOLUENE				0	0	0
XYLENES				0	0	0
CHLOROBENZENE				0	0	0
1,2-DICHLOROBENZENE				0	0	0
1,4-DICHLOROBENZENE				0	0	0
VINYL CHLORIDE				0	0	0
1,1,2-TRICHLOROETHANE				0	0	0
1,1,1-TRICHLOROETHANE				0	0	0
1,2-DICHLOROETHANE				0	0	0
1,1-DICHLOROETHANE				0	0	0
TETRACHLOROETHENE	.00025	165.83	1.53e-2	1.3333e1	7.143e-6	3.781e-6
TRICHLOROETHENE	.00032	131.39	9.1e-3	1.4816e1	9.143e-6	5.257e-6
1,1-DICHLOROETHENE				0	0	0
CARBON TETRACHLORIDE	.0000094	153.82	2.3e-2	1.3918e1	2.686e-7	1.471e-7
CHLOROFORM				0	0	0
METHYLENE CHLORIDE				0	0	0
CHLOROMETHANE				0	0	0
BROMODICHLOROMETHANE				0	0	0
CHLORODIBROMOMETHANE				0	0	0
2-CHLOROETHYLVINYLETHER				0	0	0
CARBON DISULFIDE				0	0	0
BENZO(A)ANTHRACENE				0	0	0
BENZO(B)FLUORANTHENE				0	0	0
BENZO(A)PYRENE				0	0	0
POLYCHLORINATED BIPHENYLS				0	0	0
N-NITROSODIPHENYLAMINE				0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE				0	0	0
DI N-BUTYLPHTHALATE				0	0	0
LEAD	.004			0	1.143e-4	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0

0001432

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 - RESIDENTIAL WELL RESULTS
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	0	0			0	0	0
ETHYLBENZENE	0	0	1e-1		0	0	0
TOLUENE	0	0	3e-1	1e0	0	0	0
XYLENES	0	0	2e0	4e-1	0	0	0
CHLOROBENZENE	0	0	3e-2	5e-3	0	0	0
1,2-DICHLOROBENZENE	0	0	4e-1	4e-1	0	0	0
1,4-DICHLOROBENZENE	0	0			0	0	0
VINYL CHLORIDE	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	4e-2		0	0	0
1,1,1-TRICHLOROETHANE	0	0	9e-2	3e-1	0	0	0
1,2-DICHLORETHANE	0	0			0	0	0
1,1-DICHLORDETHANE	0	0	1e-1		0	0	0
TETRACHLOROETHENE	7.143e-6	3.781e-6	1e-2	1e-1	7.143e-4	3.781e-5	7.521e-4
TRICHLOROETHENE	9.143e-6	5.257e-6			0	0	0
1,1-DICHLOROETHENE	0	0	9e-3		0	0	0
CARBON TETRACHLORIDE	2.68e-7	1.471e-7	7e-4		3.837e-4	0	3.837e-4
CHLOROFORM	0	0	1e-2		0	0	0
METHYLENE CHLORIDE	0	0	[illegible]e-2		0	0	0
CHLOROETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	2e-1		0	0	0
2-CHLOROETHYLVINYLETHER	0	0	4e0		0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0	1e-1		0	0	0
LEAD	1.143e-4	0	1.4e-3		8.163e-2	0	8.163e-2
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
TOTAL HAZARD INDEX							8.277e-2

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RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 - RESIDENTIAL WELL RESULTS
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	0	0	2.9e-2	2.9e-2	0	0	0
ETHYLBENZENE	0	0			0	0	0
TOLUENE	0	0			0	0	0
XYLENES	0	0			0	0	0
CHLOROBENZENE	0	0			0	0	0
1,2-DICHLOROBENZENE	0	0			0	0	0
1,4-DICHLOROBENZENE	0	0	2.4e-2		0	0	0
VINYL CHLORIDE	0	0	2.3e0	2.95e-1	0	0	0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	0	0			0	0	0
1,2-DICHLOROETHANE	0	0	9.1e-2	9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	9.1e-2		0	0	0
TETRACHLOROETHENE	7.143e-6	3.781e-6	5.1e-2	3.3e-3	2.082e-7	7.131e-9	2.153e-7
TRICHLOROETHENE	9.143e-6	5.257e-6	1.1e-2	1.3e-2	5.747e-8	3.905e-8	9.652e-8
1,1-DICHLOROETHENE	0	0	6e-1	1.2e0	0	0	0
CARBON TETRACHLORIDE	2.686e-7	1.471e-7	1.3e-1	1.3e-1	1.995e-8	1.093e-8	3.088e-8
CHLOROFORM	0	0	6.1e-3	8.1e-2	0	0	0
METHYLENE CHLORIDE	0	0	7.5e-3	1.4e-2	0	0	0
CHLOROMETHANE	[illegible]	[illegible]	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	1.3e-1		0	0	0
CHLORODIBROMOMETHANE	0	0	8.4e-2		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	0	0	4.9e-3		0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0			0	0	0
LEAD	1.143e-4	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
	0	0			0	0	0
TOTAL RISK							3.427e-7

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APPENDIX H

FEASIBILITY STUDY CALCULATIONS

Cleanup Goals

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE FIVE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCEANRIO 1 - MAXIMUM CASE
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
CARCINOGENIC RISK 1e-4

CHEMICAL	NUMBER OF CARCINOGENS	TARGET RISK	INGESTIONAL DOSE	GW ACTION LEVEL (MG/L)
ACETONE	0	0	0	0
2-BUTANONE	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0
BENZENE	1	6.667e-6	9.379e-5	3.283e-3
ETHYLBENZENE	0	0	0	0
TOLUENE	0	0	0	0
XYLENES	0	0	0	0
CHLOROBENZENE	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0
1,4-DICHLOROBENZENE	1	6.667e-6	2.778e-4	9.722e-3
VINYL CHLORIDE	1	6.667e-6	2.483e-6	8.691e-5
1,1,2-TRICHLOROETHANE	1	6.667e-6	3.701e-5	1.295e-3
1,1,1-TRICHLOROETHANE	0	0	0	0
1,2-DICHLORETHANE	1	6.667e-6	2.578e-5	9.024e-4
1,1-DICHLOROETHANE	1	6.667e-6	7.326e-5	2.564e-3
TETRACHLOROETHENE	1	6.667e-6	1.165e-4	4.077e-3
TRICHLOROETHENE	1	6.667e-6	1.984e-4	6.943e-3
1,1-DICHLOROETHENE	1	6.667e-6	2.749e-6	9.622e-5
CARBON TETRACHLORIDE	1	6.667e-6	1.815e-5	6.352e-4
CHLOROFORM	1	6.667e-6	4.508e-5	1.578e-3
METHYLENE CHLORIDE	1	6.667e-6	2.254e-4	7.889e-3
CHLOROMETHANE	0	0	0	0
BROMODICHLOROMETHANE	1	6.667e-6	5.128e-5	1.795e-3
CHLORODIBROMOMETHANE	1	6.667e-6	7.937e-5	2.778e-3
2-CHLOROETHYLVINYLETHER	0	0	0	0
CARBON DISULFIDE	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0
BENZO(A)PYRENE	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0
N-NITROSODIPHENYLAMINE	1	6.667e-6	1.361e-3	4.762e-2
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0
MERCURY	0	0	0	0
BARIUM	0	0	0	0
CHROMIUM	0	0	0	0
COPPER	0	0	0	0
LEAD	0	0	0	0
NICKEL	0	0	0	0
VANADIUM	0	0	0	0
ZINC	0	0	0	0
TOTAL	15	.0001		

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE FIVE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO NUMBER 1 - DETERMINE GROUNDWATER CLEAN-UP GOALS (10-6 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
CARCINOGENIC RISK 1e-6

CHEMICAL	NUMBER OF CARCINOGENS	TARGET RISK	INGESTIONAL DOSE	GW ACTION LEVEL (MG/L)
ACETONE	0	0	0	0
2-BUTANONE	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0
BENZENE	1	6.667e-8	9.379e-7	3.283e-5
ETHYLBENZENE	0	0	0	0
TOLUENE	0	0	0	0
XYLENES	0	0	0	0
CHLOROBENZENE	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0
1,4-DICHLOROBENZENE	1	6.667e-8	2.778e-6	9.722e-5
VINYL CHLORIDE	1	6.667e-8	2.483e-8	8.691e-7
1,1,2-TRICHLOROETHANE	1	6.667e-8	3.701e-7	1.295e-5
1,1,1-TRICHLOROETHANE	0	0	0	0
1,2-DICHLORETHANE	1	6.667e-8	2.578e-7	9.024e-6
1,1-DICHLOROETHANE	1	6.667e-8	7.326e-7	2.564e-5
TETRACHLOROETHENE	1	6.667e-8	1.165e-6	4.077e-5
TRICHLOROETHENE	1	6.667e-8	1.984e-6	6.943e-5
1,1-DICHLOROETHENE	1	6.667e-8	2.749e-8	9.622e-7
CARBON TETRACHLORIDE	1	6.667e-8	1.815e-7	6.352e-6
CHLOROFORM	1	6.667e-8	4.508e-7	1.578e-5
METHYLENE CHLORIDE	1	6.667e-8	2.254e-6	7.889e-5
CHLOROMETHANE	0	0	0	0
BROMODICHLOROMETHANE	1	6.667e-8	5.128e-7	1.795e-5
CHLORODIBROMOMETHANE	1	6.667e-8	7.937e-7	2.778e-5
2-CHLOROETHYLVINYLETHER	0	0	0	0
CARBON DISULFIDE	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0
BENZO(A)PYRENE	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0
N-NITROSODIPHENYLAMINE	1	6.667e-8	1.361e-5	4.762e-4
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
TOTAL	15	1e-6		

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE SIX)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO NUMBER 1 - DETERMINE GROUNDWATER CLEAN-UP GOALS (10-6 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
NONCARCIN. RISK = .9

CHEMICAL	NUMBER OF NONCARCINOGENS	TARGET HAZARD INDEX	INGESTIONAL DOSE	GW ACTION LEVEL (MG/L)
ACETONE	0	0	0	0
2-BUTANONE	1	6.429e-2	3.085e-3	1.080e-1
4-METHYL-2-PENTANONE	0	0	0	0
BENZENE	0	0	0	0
ETHYLBENZENE	0	0	0	0
TOLUENE	1	6.429e-2	1.613e-2	5.645e-1
XYLENES	1	6.429e-2	3.174e-2	1.1109e0
CHLOROBENZENE	1	6.429e-2	4.239e-4	1.484e-2
1,2-DICHLOROBENZENE	1	6.429e-2	1.702e-2	5.958e-1
1,4-DICHLOROBENZENE	0	0	0	0
VINYL CHLORIDE	0	0	0	0
1,1,2-TRICHLOROETHANE	1	6.429e-2	2.571e-3	9e-2
1,1,1-TRICHLOROETHANE	1	6.429e-2	4.928e-3	1.725e-1
1,2-DICHLORETHANE	0	0	0	0
1,1-DICHLOROETHANE	1	6.429e-2	6.429e-3	2.25e-1
TETRACHLOROETHENE	1	6.429e-2	6.105e-4	2.137e-2
TRICHLOROETHENE	0	0	0	0
1,1-DICHLOROETHENE	1	6.429e-2	5.786e-4	2.025e-2
CARBON TETRACHLORIDE	1	6.429e-2	4.5e-5	1.575e-3
CHLOROFORM	1	6.429e-2	6.429e-4	2.25e-2
METHYLENE CHLORIDE	1	6.429e-2	3.857e-3	1.35e-1
CHLOROMETHANE	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0
CHLORODIBROMOMETHANE	1	6.429e-2	1.286e-2	4.5e-1
2-CHLOROETHYLVINYLETHER	0	0	0	0
CARBON DISULFIDE	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0
BENZO(A)PYRENE	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
	0	0	0	0
TOTAL	14	9e-1		

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 15, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET. TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)

REFERENCES:

EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

$$DOSE = (C \times IR \times AF)/BW$$

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

$$DOSE = \frac{S \times IR}{BW \times Ra \times 10E6} \times \left(Ds + \frac{EXP(-Ra \times Dt)}{Ra} - \frac{EXP(Ra \times (Ds - Dt))}{Ra}\right)$$

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION FACTOR =	.0285714
AF:	1		
BW:	70		

MODEL PARAMETERS:

Q (CM/YEAR):	25.4
Vd (CM/YEAR):	1500
L (CM):	2300
M (CM):	305
Foc (KG CARBON/KG SOIL):	.0096

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	Tl:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
ED:	40	T:	293
R:	.000082	FP:	10

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RISK ASSESSMENT SPREADSHEET   IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2   DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
CALCULATE DOSES:

CHEMICAL	SOIL CONCENT. (MG/KG)	SOIL-SED. ADS. COEFFIC.	GROUNDWATER CONCENTRATION	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAI)	INGESTION DOSE	INHALATIO DOSE
ACETONE			0	58.08	3.43e-5	2.7584e0	0	0
2-BUTANONE			0			0	0	0
4-METHYL-2-PENTANONE			0			0	0	0
BENZENE			0	78.12	5.5e-3	1.8884e1	0	0
ETHYLBENZENE	.009	1100	.0001088	106.16	6.6e-3	1.6317e1	3.109e-6	1.925e-6
TOLUENE	.53	300	.0234992	92.13	6.66e-3	1.7521e1	6.714e-4	4.382e-4
XYLENES	.2	248	.0107270	106.17	4.33e-3	1.6010e1	3.065e-4	1.870e-4
CHLOROBENZENE			0			0	0	0
1,2-DICHLOROBENZENE			0			0	0	0
1,4-DICHLOROBENZENE			0			0	0	0
VINYL CHLORIDE			0			0	0	0
1,1,2-TRICHLOROETHANE			0	133.41	7.42e-4	1.1296e1	0	0
1,1,1-TRICHLOROETHANE	.039	152	.0034129	133.41	3e-2	1.4983e1	9.751e-5	5.656e-5
1,2-DICHLOROETHANE			0	98.96	9.14e-4	1.3769e1	0	0
1,1-DICHLOROETHANE			0			0	0	0
TETRACHLOROETHENE	.61	364	.0222909	165.83	1.53e-2	1.3333e1	6.369e-4	3.372e-4
TRICHLOROETHENE	.5	126	.0527836	131.39	9.1e-3	1.4816e1	1.508e-3	8.672e-4
1,1-DICHLOROETHENE			0	96.94	1.9e-1	1.7700e1	0	0
CARBON TETRACHLORIDE			0			0	0	0
CHLOROFORM			0			0	0	0
METHYLENE CHLORIDE			0			0	0	0
CHLOROMETHANE			0			0	0	0
BROMODICHLOROMETHANE			0			0	0	0
CHLORODIBROMOMETHANE			0			0	0	0
2-CHLOROETHYLVINYLETHER			0			0	0	0
CARBON DISULFIDE			0			0	0	0
BENZO(A)ANTHRACENE			0			0	0	0
BENZO(B)FLUORANTHENE			0			0	0	0
BENZO(A)PYRENE			0			0	0	0
POLYCHLORINATED BIPHENYLS			0			0	0	0
N-NITROSODIPHENYLAMINE			0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE			0			0	0	0
DI-N-BUTYLPHTHALATE			0	278.3	2.8e-7	1.168e-2	0	0
BARIUM			0			0	0	0
CHROMIUM			0			0	0	0
COPPER			0			0	0	0
LEAD			0			0	0	0
NICKEL			0			0	0	0
VANADIUM			0			0	0	0
ZINC			0			0	0	0

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	0	0			0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6	1e-1		3.109e-5	0	3.109e-5
TOLUENE	6.714e-4	4.382e-4	3e-1	1e0	2.238e-3	4.382e-4	2.676e-3
XYLENES	3.065e-4	1.870e-4	2e0	4e-1	1.532e-4	4.675e-4	6.207e-4
CHLOROBENZENE	0	0	3e-2	5e-3	0	0	0
1,2-DICHLOROBENZENE	0	0	4e-1	4e-1	0	0	0
1,4-DICHLOROBENZENE	0	0			0	0	0
VINYL CHLORIDE	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	4e-2		0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5	9e-2	3e-1	1.083e-3	1.885e-4	1.272e-3
1,2-DICHLORETHANE	0	0			0	0	0
1,1-DICHLOROETHANE	0	0	1e-1		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	1e-2	1e-1	6.369e-2	3.372e-3	6.706e-2
TRICHLOROETHENE	1.508e-3	8.672e-4			0	0	0
1,1-DICHLOROETHENE	0	0	9e-3		0	0	0
CARBON TETRACHLORIDE	0	0	7e-4		0	0	0
CHLOROFORM	0	0	1e-2		0	0	0
METHYLENE CHLORIDE	0	0	6e-2		0	0	0
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	2e-1		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0	1e-1		0	0	0
BARIUM	0	0	5e-2	1e-4	0	0	0
CHROMIUM	0	0	1e0		0	0	0
COPPER	0	0	3.7e-2	1e-2	0	0	0
LEAD	0	0	1.4e-3		0	0	0
NICKEL	0	0	2e-2		0	0	0
VANADIUM	0	0	1e-3		0	0	0
ZINC	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							7.166e-2

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (1E-4 CANCER RISK)
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	0	0	2.9e-2	2.9e-2	0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6			0	0	0
TOLUENE	6.714e-4	4.382e-4			0	0	0
XYLENES	3.065e-4	1.870e-4			0	0	0
CHLOROBENZENE	0	0			0	0	0
1,2-DICHLOROBENZENE	0	0			0	0	0
1,4-DICHLOROBENZENE	0	0	2.4e-2		0	0	0
VINYL CHLORIDE	0	0	2.3e0	2.95e-1	0	0	0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5			0	0	0
1,2-DICHLORETHANE	0	0	9.1e-2	9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	9.1e-2		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	5.1e-2	3.3e-3	1.856e-5	6.358e-7	1.920e-5
TRICHLOROETHENE	1.508e-3	8.672e-4	1.1e-2	1.3e-2	9.479e-6	6.442e-6	1.592e-5
1,1-DICHLOROETHENE	0	0	6e-1	1.2e0	0	0	0
CARBON TETRACHLORIDE	0	0	1.3e-1	1.3e-1	0	0	0
CHLOROFORM	0	0	6.1e-3	8.1e-2	0	0	0
METHYLENE CHLORIDE	0	0	7.5e-3	1.4e-2	0	0	0
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	1.3e-1		0	0	0
CHLORODIBROMOMETHANE	0	0	8.4e-2		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	0	0	4.9e-3		0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0			0	0	0
BARIUM	0	0			0	0	0
CHROMIUM	0	0			0	0	0
COPPER	0	0			0	0	0
LEAD	0	0			0	0	0
NICKEL	0	0		8.4e-1	0	0	0
VANADIUM	0	0			0	0	0
ZINC	0	0			0	0	0
TOTAL RISK							3.512e-5

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FIVE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
CARCINOGENIC RISK 1e-4

CHEMICAL	NUMBER OF CARCINOGENS	TARGET RISK	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	0	0	0	0	0
TOLUENE	0	0	0	0	0
XYLENES	0	0	0	0	0
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	0	0	0	0	0
1,2-DICHLORETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	5e-5	8.736e-4	3.058e-2	8.367e-1
TRICHLOROETHENE	1	5e-5	1.488e-3	5.207e-2	4.933e-1
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	2	1e-4			

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE SIX)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
NONCARCIN. RISK = .9

CHEMICAL	NUMBER OF NONCARCINOGENS	TARGET HAZARD INDEX	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	1	1.8e-1	1.8e-2	6.3e-1	5.2100e1
TOLUENE	1	1.8e-1	4.516e-2	1.5805e0	3.5647e1
XYLENES	1	1.8e-1	8.887e-2	3.1106e0	5.7995e1
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	1	1.8e-1	1.380e-2	4.830e-1	5.5190e0
1,2-DICHLOROETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	1.8e-1	1.710e-3	5.983e-2	1.6373e0
TRICHLOROETHENE	0	0	0	0	0
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	5	9e-1			

0014446

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 15, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET. TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCENARIO 1 - DETERMINE SOIL CLEAN-UP GOALS (10-6 CANCER RISK)

REFERENCES:
EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION FACTOR =	.0285714
AF:	1		
BW:	70		

MODEL PARAMETERS:

Q (CM/YEAR):	25.4
Vd (CM/YEAR):	1500
L (CM):	2300
M (CM):	305
Foc (KG CARBON/KG SOIL):	.0096

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	T1:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
ED:	40	T:	293
R:	.000082	FR:	10

0014447

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 1 - DETERMINE SOIL CLEAN-UP GOALS (10-6 CANCER RISK)
CALCULATE DOSES:

CHEMICAL	SOIL CONCENT. (MG/KG)	SOIL SED. ADS. COEFFIC.	GROUNDWATER CONCENTRATION	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAI)	INGESTION DOSE	INHALATIO DOSE
ACETONE			0	58.08	3.43e-5	2.7584e0	0	0
2-BUTANONE			0			0	0	0
4-METHYL-2-PENTANONE			0			0	0	0
BENZENE			0	78.12	5.5e-3	1.8884e1	0	0
ETHYLBENZENE	.009	1100	.0001088	106.16	6.6e-3	1.6317e1	3.109e-6	1.925e-6
TOLUENE	.53	300	.0234997	92.13	6.66e-3	1.7521e1	6.714e-4	4.382e-4
XYLENES	.7	248	.0107220	106.17	4.33e-3	1.6010e1	3.065e-4	1.870e-4
CHLOROBENZENE			0			0	0	0
1,2-DICHLOROBENZENE			0			0	0	0
1,4-DICHLOROBENZENE			0			0	0	0
VINYL CHLORIDE			0			0	0	0
1,1,2-TRICHLOROETHANE			0	133.41	7.42e-4	1.1296e1	0	0
1,1,1-TRICHLOROETHANE	.039	152	.0034129	133.41	3e-2	1.4983e1	9.751e-5	5.656e-5
1,2-DICHLOROETHANE			0	98.96	9.14e-4	1.3769e1	0	0
1,1-DICHLOROETHANE			0			0	0	0
TETRACHLOROETHENE	.61	364	.0222909	165.83	1.53e-2	1.3333e1	6.369e-4	3.372e-4
TRICHLOROETHENE	.5	126	.0527836	131.39	9.1e-3	1.4816e1	1.508e-3	8.672e-4
1,1-DICHLOROETHENE			0	96.94	1.9e-1	1.7700e1	0	0
CARBON TETRACHLORIDE			0			0	0	0
CHLOROFORM			0			0	0	0
METHYLENE CHLORIDE			0			0	0	0
CHLOROMETHANE			0			0	0	0
BROMODICHLOROMETHANE			0			0	0	0
CHLORODIBROMOMETHANE			0			0	0	0
2-CHLOROETHYLVINYLETHER			0			0	0	0
CARBON DISULFIDE			0			0	0	0
BENZO(A)ANTHRACENE			0			0	0	0
BENZO(B)FLUORANTHENE			0			0	0	0
BENZO(A)PYRENE			0			0	0	0
POLYCHLORINATED BIPHENYLS			0			0	0	0
N-NITROSODIPHENYLAMINE			0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE			0			0	0	0
DI-N-BUTYLPHTHALATE			0	278.3	2.8e-7	1.168e-2	0	0
BARIUM			0			0	0	0
CHROMIUM			0			0	0	0
COPPER			0			0	0	0
LEAD			0			0	0	0
NICKEL			0			0	0	0
VANADIUM			0			0	0	0
ZINC			0			0	0	0

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO I - DETERMINE SOIL CLEAN-UP GOALS (10-6 CANCER RISK)
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	0	0			0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6	1e-1		3.109e-5	0	3.109e-5
TOLUENE	6.714e-4	4.382e-4	3e-1	1e0	2.238e-3	4.382e-4	2.676e-3
XYLENES	3.065e-4	1.870e-4	2e0	4e-1	1.532e-4	4.675e-4	6.207e-4
CHLOROBENZENE	0	0	3e-2	5e-3	0	0	0
1,2-DICHLOROBENZENE	0	0	4e-1	4e-1	0	0	0
1,4-DICHLOROBENZENE	0	0			0	0	0
VINYL CHLORIDE	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	4e-2		0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5	9e-2	3e-1	1.083e-3	1.885e-4	1.272e-3
1,2-DICHLORETHANE	0	0			0	0	0
1,1-DICHLOROETHANE	0	0	1e-1		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	1e-2	1e-1	6.369e-2	3.372e-3	6.706e-2
TRICHLOROETHENE	1.508e-3	8.672e-4			0	0	0
1,1-DICHLOROETHENE	0	0	9e-3		0	0	0
CARBON TETRACHLORIDE	0	0	7e-4		0	0	0
CHLOROFORM	0	0	1e-2		0	0	0
METHYLENE CHLORIDE	0	0	6e-2		0	0	0
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	2e-1		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0	1e-1		0	0	0
BARIUM	0	0	5e-2	1e-4	0	0	0
CHROMIUM	0	0	1e0		0	0	0
COPPER	0	0	3.7e-2	1e-2	0	0	0
LEAD	0	0	1.4e-3		0	0	0
NICKEL	0	0	2e-2		0	0	0
VANADIUM	0	0	1e-3		0	0	0
ZINC	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							7.166e-2

001449

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 1 - DETERMINE SOIL CLEAN-UP GOALS (10-6 CANCER RISK)
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	0	0	2.9e-2	2.9e-2	0	0	0
ETHYLBENZENE	3.109e-6	1.975e-6			0	0	0
TOLUENE	6.714e-4	4.382e-4			0	0	0
XYLENES	3.065e-4	1.970e-4			0	0	0
CHLOROBENZENE	0	0			0	0	0
1,2-DICHLOROBENZENE	0	0			0	0	0
1,4-DICHLOROBENZENE	0	0	2.4e-2		0	0	0
VINYL CHLORIDE	0	0	2.3e0	2.95e-1	0	0	0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5			0	0	0
1,2-DICHLORETHANE	0	0	9.1e-2	9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	9.1e-2		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	5.1e-2	3.3e-3	1.856e-5	6.358e-7	1.920e-5
TRICHLOROETHENE	1.508e-3	8.672e-4	1.1e-2	1.3e-2	9.479e-6	6.442e-6	1.592e-5
1,1-DICHLOROETHENE	0	0	6e-1	1.2e0	0	0	0
CARBON TETRACHLORIDE	0	0	1.3e-1	1.3e-1	0	0	0
CHLOROFORM	0	0	6.1e-3	8.1e-2	0	0	0
METHYLENE CHLORIDE	0	0	7.5e-3	1.4e-2	0	0	0
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	1.3e-1		0	0	0
CHLORODIBROMOMETHANE	0	0	8.4e-2		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	0	0	4.9e-3		0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0			0	0	0
BARIUM	0	0			0	0	0
CHROMIUM	0	0			0	0	0
COPPER	0	0			0	0	0
LEAD	0	0			0	0	0
NICKEL	0	0		8.4e-1	0	0	0
VANADIUM	0	0			0	0	0
ZINC	0	0			0	0	0
TOTAL RISK							3.512e-5

001450

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FIVE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 1 - DETERMINE SOIL CLEAN-UP GOALS (10-6 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
CARCINOGENIC RISK 1e-4

CHEMICAL	NUMBER OF CARCINOGENS	TARGET RISK	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	0	0	0	0	0
TOLUENE	0	0	0	0	0
XYLENES	0	0	0	0	0
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	0	0	0	0	0
1,2-DICHLORETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	5e-5	8.736e-4	3.058e-2	8.367e-1
TRICHLOROETHENE	1	5e-5	1.488e-3	5.207e-2	4.933e-1
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	2	1e-4			

0014451

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE SIX)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 1 DETERMINE SOIL CLEAN-UP GOALS (10-6 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
NONCARCIN. RISK = .9

CHEMICAL	NUMBER OF NONCARCINOGENS	TARGET HAZARD INDEX	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	1	1.8e-1	1.8e-2	6.3e-1	5.2100e1
TOLUENE	1	1.8e-1	4.516e-2	1.5805e0	3.5647e1
XYLENES	1	1.8e-1	8.887e-2	3.1106e0	5.7995e1
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	1	1.8e-1	1.380e-2	4.830e-1	5.5190e0
1,2-DICHLOROETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	1.8e-1	1.710e-3	5.983e-2	1.6373e0
TRICHLOROETHENE	0	0	0	0	0
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	5	9e-1			

0014452

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 15, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET.
TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF
VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCENARIO 3 - DETERMINE SOIL CLEAN-UP GOALS (ARAR-BASED)

REFERENCES:
EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION FACTOR =	.0285714
AF:	1		
BW:	70		

MODEL PARAMETERS:

Q (CM/YEAR):	25.4
Vd (CM/YEAR):	1500
L (CM):	2300
M (CM):	305
Foc (KG CARBON/KG SOIL):	.0096

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	T1:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.516
ED:	40	T:	293
R:	.000082	FR:	10

001453

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 DETERMINE SOIL CLEAN-UP GOALS (ARAR-BASED)
CALCULATE DOSES:

CHEMICAL	SOIL CONCENT. (MG/KG)	SOIL/SED. ADS. COEFFIC.	GROUNDWATER CONCENTRATION	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAL)	INGESTION DOSE	INHALATIO DOSE
ACETONE			0	58.08	3.43e-5	2.7584e0	0	0
2-BUTANONE			0			0	0	0
4-METHYL-2-PENTANONE			0			0	0	0
BENZENE			0	78.12	5.5e-3	1.8884e1	0	0
ETHYLBENZENE	.009	1100	.0001088	106.16	6.6e-3	1.6317e1	3.109e-6	1.925e-6
TOLUENE	.53	300	.0234997	92.13	6.66e-3	1.7521e1	6.714e-4	4.382e-4
XYLENES	.2	248	.0107270	106.17	4.33e-3	1.6010e1	3.065e-4	1.870e-4
CHLOROBENZENE			0			0	0	0
1,2 DICHLOROBENZENE			0			0	0	0
1,4-DICHLOROBENZENE			0			0	0	0
VINYL CHLORIDE			0			0	0	0
1,1,2-TRICHLOROETHANE			0	133.41	7.42e-4	1.1296e1	0	0
1,1,1-TRICHLOROETHANE	.039	152	.0034129	133.41	3e-2	1.4983e1	9.751e-5	5.656e-5
1,2 DICHLOROETHANE			0	98.96	9.14e-4	1.3769e1	0	0
1,1-DICHLOROETHANE			0			0	0	0
TETRACHLOROETHENE	.61	364	.0222909	165.83	1.53e-2	1.3333e1	6.369e-4	3.372e-4
TRICHLOROETHENE	.5	126	.0527836	131.39	9.1e-3	1.4816e1	1.508e-3	8.672e-4
1,1-DICHLOROETHENE			0	96.94	1.9e-1	1.7700e1	0	0
CARBON TETRACHLORIDE			0			0	0	0
CHLOROFORM			0			0	0	0
METHYLENE CHLORIDE			0			0	0	0
CHLOROMETHANE			0			0	0	0
BROMODICHLOROMETHANE			0			0	0	0
CHLORODIBROMOMETHANE			0			0	0	0
2-CHLOROETHYLVINYLETHER			0			0	0	0
CARBON DISULFIDE			0			0	0	0
BENZO(A)ANTHRACENE			0			0	0	0
BENZO(B)FLUORANTHENE			0			0	0	0
BENZO(A)PYRENE			0			0	0	0
POLYCHLORINATED BIPHENYLS			0			0	0	0
N-NITROSODIPHENYLAMINE			0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE			0			0	0	0
DI-N-BUTYLPHTHALATE			0	278.3	2.8e-7	1.168e-2	0	0
BARIUM			0			0	0	0
CHROMIUM			0			0	0	0
COPPER			0			0	0	0
LEAD			0			0	0	0
NICKEL			0			0	0	0
VANADIUM			0			0	0	0
ZINC			0			0	0	0

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 - DETERMINE SOIL CLEAN-UP GOALS (ARAR-BASED)
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	0	0			0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6	1e-1		3.109e-5	0	3.109e-5
TOLUENE	6.714e-4	4.382e-4	3e-1	1e0	2.238e-3	4.382e-4	2.676e-3
XYLENES	3.065e-4	1.870e-4	2e0	4e-1	1.532e-4	4.675e-4	6.207e-4
CHLOROBENZENE	0	0	3e-2	5e-3	0	0	0
1,2-DICHLOROBENZENE	0	0	4e-1	4e-1	0	0	0
1,4-DICHLOROBENZENE	0	0			0	0	0
VINYL CHLORIDE	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	4e-2		0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5	9e-2	3e-1	1.083e-3	1.885e-4	1.272e-3
1,2-DICHLORETHANE	0	0			0	0	0
1,1-DICHLOROETHANE	0	0	1e-1		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	1e-2	1e-1	6.369e-2	3.372e-3	6.706e-2
TRICHLOROETHENE	1.508e-3	8.672e-4			0	0	0
1,1-DICHLOROETHENE	0	0	9e-3		0	0	0
CARBON TETRACHLORIDE	0	0	7e-4		0	0	0
CHLOROFORM	0	0	1e-2		0	0	0
METHYLENE CHLORIDE	0	0	6e-2		0	0	0
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	2e-1		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0	1e-1		0	0	0
BARIUM	0	0	5e-2	1e-4	0	0	0
CHROMIUM	0	0	1e0		0	0	0
COPPER	0	0	3.7e-2	1e-2	0	0	0
LEAD	0	0	1.4e-3		0	0	0
NICKEL	0	0	2e-2		0	0	0
VANADIUM	0	0	1e-3		0	0	0
ZINC	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							7.166e-2

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 - DETERMINE SOIL CLEAN-UP GOALS (ARAR-BASED)
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	0	0	2.9e-2	2.9e-2	0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6			0	0	0
TOLUENE	6.714e-4	4.382e-4			0	0	0
XYLENES	3.065e-4	1.870e-4			0	0	0
CHLOROBENZENE	0	0			0	0	0
1,2-DICHLOROBENZENE	0	0			0	0	0
1,4-DICHLOROBENZENE	0	0	2.4e-2		0	0	0
VINYL CHLORIDE	0	0	2.3e0	2.95e-1	0	0	0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5			0	0	0
1,2-DICHLORETHANE	0	0	9.1e-2	9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	9.1e-2		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	5.1e-2	3.3e-3	1.856e-5	6.358e-7	1.920e-5
TRICHLOROETHENE	1.508e-3	8.672e-4	1.1e-2	1.3e-2	9.479e-6	6.442e-6	1.592e-5
1,1-DICHLOROETHENE	0	0	6e-1	1.2e0	0	0	0
CARBON TETRACHLORIDE	0	0	1.3e-1	1.3e-1	0	0	0
CHLOROFORM	0	0	6.1e-3	8.1e-2	0	0	0
METHYLENE CHLORIDE	0	0	7.5e-3	1.4e-2	0	0	0
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	1.3e-1		0	0	0
CHLORODIBROMOMETHANE	0	0	8.4e-2		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	0	0	4.9e-3		0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0			0	0	0
BARIUM	0	0			0	0	0
CHROMIUM	0	0			0	0	0
COPPER	0	0			0	0	0
LEAD	0	0			0	0	0
NICKEL	0	0		8.4e-1	0	0	0
VANADIUM	0	0			0	0	0
ZINC	0	0			0	0	0
TOTAL RISK							3.512e-5

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FIVE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 3 - DETERMINE SOIL CLEAN-UP GOALS (ARAR-BASED)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:

CHEMICAL	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0
2-BUTANONE	0	0
4-METHYL-2-PENTANONE	0	0
BENZENE	0	0
ETHYLBENZENE	6.8e-1	5.6234e1
TOLUENE	2e0	4.5108e1
XYLENES	4.4e-1	8.2036e0
CHLOROBENZENE	0	0
1,2-DICHLOROBENZENE	0	0
1,4-DICHLOROBENZENE	0	0
VINYL CHLORIDE	0	0
1,1,2-TRICHLOROETHANE	0	0
1,1,1-TRICHLOROETHANE	2e-1	2.2855e0
1,2-DICHLORETHANE	0	0
1,1-DICHLOROETHANE	0	0
TETRACHLOROETHENE	5e-3	1.368e-1
TRICHLOROETHENE	5e-3	4.736e-2
1,1-DICHLOROETHENE	0	0
CARBON TETRACHLORIDE	0	0
CHLOROFORM	0	0
METHYLENE CHLORIDE	0	0
CHLOROMETHANE	0	0
BROMODICHLOROMETHANE	0	0
CHLORODIBROMOMETHANE	0	0
2-CHLOROETHYLVINYLETHER	0	0
CARBON DISULFIDE	0	0
BENZO(A)ANTHRACENE	0	0
BENZO(B)FLUORANTHENE	0	0
BENZO(A)PYRENE	0	0
POLYCHLORINATED BIPHENYLS	0	0
N-NITROSODIPHENYLAMINE	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0
DI-N-BUTYLPHTHALATE	0	0
BARIUM	0	0
CHROMIUM	0	0
COPPER	0	0
LEAD	0	0
NICKEL	0	0
VANADIUM	0	0
ZINC	0	0

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE 5[illegible])

BYRON BARREL AND DRUM SITE

EXPOSURE SCENARIO 3 DETERMINE SOIL CLEAN UP GOALS (ARAR BASED)

DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:

NONCARCIN. RISK = .9

CHEMICAL	NUMBER OF NONCARCINOGENS	TARGET HAZARD INDEX	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	1	1.8e-1	1.8e-2	6.3e-1	5.2100e1
TOLUENE	1	1.8e-1	4.516e-2	1.5805e0	3.5647e1
XYLENES	1	1.8e-1	8.887e-2	3.1106e0	5.7995e1
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	1	1.8e-1	1.380e-2	4.830e-1	5.5190e0
1,2-DICHLORETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	1.8e-1	1.710e-3	5.983e-2	1.6373e0
TRICHLOROETHENE	0	0	0	0	0
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	5	9e-1			

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Soil Impact on Groundwater

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET

CLIENT: EPA	FILE NO.: L725.10	BY: RJH	PAGE 1 OF
SUBJECT: Average Source Concentrations - Area 1 (CLP Results)		CHECKED BY: KCT	DATE: 05/18/88

Objective - Determine average source concentrations for the contaminated soil in the southwestern portion of source area 1. CLP sample results for samples BS-SS043-1, BS-SS038-1, BS-SS021-1, BS-SS035-1, BS-SS028-1, BS-SS042-1 BS-SS029-1, BS-SS025-1, BS-SS026-1, and BS-SS012-1 will be used.

Sample Calculation:

1,1,1-trichloroethane

$$\bar{C} = \frac{89+45+0+66+0+0+0+0+150+10}{10} = 35\ \mu g/kg$$

Similarly, average concentrations may be determined for the remaining volatile analytes.

Chemical	$\bar{C}$ (µg/kg)
ethylbenzene	8
toluene	474
xylenes	178
1,1,1-trichloroethane	35
tetrachloroethene	553
trichloroethene	447

001460

BYRON BARREL & DRUM - SUBSURFACE SOILS

SAMPLE NUMBER:	BS-SS005-1M	BS-SS006-1M	BS-SS007-1M	BS-SS008-1M	BS-SS009-1M	BS-SS011-1M	BS-SS012-1
TRAFFIC REPORT NUMBER:	MOBILE LAB	MOBILE LAB	MOBILE LAB	MOBILE LAB	MOBILE LAB	MOBILE LAB	BQ720
SAMPLING POINT:	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1
LOCATION:	4'	6'	1.5' - 2'	4'	6'	1.5' - 2'	4'
DESCRIPTION:	TP-1	TP-1	TP-2	TP-2	TP-2	TP-2	TP-2
UNITS:	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
DATE SAMPLED:	08/31/88	08/31/88	08/31/88	08/31/88	08/31/88	08/31/88	08/31/88

*** VOLATILES ***

PP	CAS NO	COMPOUND	BS-SS005-1M	BS-SS006-1M	BS-SS007-1M	BS-SS008-1M	BS-SS009-1M	BS-SS011-1M	BS-SS012-1
	67-64-1	ACETONE							
4V	71-43-2	BENZENE	J 10						
86V	108-88-3	TOLUENE					J 143		J 2700
38V	100-41-4	ETHYLBENZENE							
	95-47-6	TOTAL XYLENES							J 1700
11V	71-55-6	1,1,1-TRICHLOROETHANE	J 6		J 158	J 53	J 10	J 223	J 150
14V	79-00-5	1,1,2-TRICHLOROETHANE							
10V	107-06-2	1,2-DICHLOROETHANE							
85V	127-18-4	TETRACHLOROETHENE							J 4400
87V	79-01-6	TRICHLOROETHENE	J 19	J 10	J 1713	J 608	J 312	J 2669	J 2800
30V	156-60-5	TRANS-1,2-DICHLOROETHENE			J 6			J 20	
29V	75-35-4	1,1-DICHLOROETHENE							J 10
44V	75-09-2	METHYLENE CHLORIDE							J 25
33VT	10061-02-6	TRANS-1,3-DICHLOROPROPENE							

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BYRON BARREL & DRUM - SUBSURFACE SOILS

SAMPLE NUMBER:	BS-SS019-1M	BS-SS020-1M	BS-SS021-1	BS-SS021-1M	BS-SS022-1M	BS-SS023-1M	BS-SS024-1M
TRAFFIC REPORT NUMBER:	MOBILE LAB	MOBILE LAB	BQ721	MOBILE LAB	MOBILE LAB	MOBILE LAB	MOBILE LAB
SAMPLING POINT:	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1
LOCATION:	6'	1.5' - 2'	4'	4'	6'	1.5' - 2'	1.5' - 2'
DESCRIPTION:	TP-4	TP-5	TP-5	TP-5	TP-5	TP-6	TP-7
UNITS:	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
DATE SAMPLED:	09/01/88	09/01/88	09/01/88	09/01/88	09/01/88	09/01/88	09/02/88

*** VOLATILES ***

PP	CAS NO	COMPOUND	BS-SS019-1M	BS-SS020-1M	BS-SS021-1	BS-SS021-1M	BS-SS022-1M	BS-SS023-1M	BS-SS024-1M
	67-64-1	ACETONE							
4V	71-43-2	BENZENE							
86V	108-88-3	TOLUENE	J 11		J 1100				
38V	100-41-4	ETHYLBENZENE			J 33				
	95-47-6	TOTAL XYLENES			J 72				
11V	71-55-6	1,1,1-TRICHLOROETHANE							J 35
14V	79-00-5	1,1,2-TRICHLOROETHANE							
10V	107-06-2	1,2-DICHLOROETHANE							
85V	127-18-4	TETRACHLOROETHENE			J 610				
87V	79-01-6	TRICHLOROETHENE			J 660				J 312
30V	156-60-5	TRANS-1,2-DICHLOROETHENE							
29V	75-35-4	1,1-DICHLOROETHENE							
44V	75-09-2	METHYLENE CHLORIDE							
33VT	10061-02-6	TRANS-1,3-DICHLOROPROPENE							

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BYRON BARREL & DRUM - SUBSURFACE SOILS

SAMPLE NUMBER:	BS-SS025-1	BS-SS025-1M	BS-SS026-1	BS-SS026-1M	BS-SS027-1M	BS-SS028-1	BS-SS028-1M
TRAFFIC REPORT NUMBER:	BQ722	MOBILE LAB	BQ724	MOBILE LAB	MOBILE LAB	BQ723	MOBILE LAB
SAMPLING POINT:	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1
LOCATION:	4'	4'	6'	6'	1.5' - 2'	4'	4'
DESCRIPTION:	TP-7	TP-7	TP-7	TP-7	TP-8	TP-8	TP-8
UNITS:	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
DATE SAMPLED:	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88

*** VOLATILES ***

PP	CAS NO	COMPOUND	BS-SS025-1	BS-SS025-1M	BS-SS026-1	BS-SS026-1M	BS-SS027-1M	BS-SS028-1	BS-SS028-1M
	67-64-1	ACETONE	J 270						
4V	71-43-2	BENZENE					J 5		
86V	108-88-3	TOLUENE	J 700		41			65	
38V	100-41-4	ETHYLBENZENE	J 51						
	95-47-6	TOTAL XYLENES						7	
11V	71-55-6	1,1,1-TRICHLOROETHANE			66		J 227		
14V	79-00-5	1,1,2-TRICHLOROETHANE							
10V	107-06-2	1,2-DICHLOROETHANE							
85V	127-18-4	TETRACHLOROETHENE	J 410		30			29	
87V	79-01-6	TRICHLOROETHENE	J 420	J 35	230		J 17	46	
30V	156-60-5	TRANS-1,2-DICHLOROETHENE							
29V	75-35-4	1,1-DICHLOROETHENE							
44V	75-09-2	METHYLENE CHLORIDE	J 66						
33VT	10061-02-6	TRANS-1,3-DICHLOROPROPENE						7	

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BYRON BARREL & DRUM - SUBSURFACE SOILS

SAMPLE NUMBER:			BS-SS029-1	BS-SS029-1A	BS-SS029-1M	BS-SS030-1M	BS-SS031-1M	BS-SS032-1M	BS-SS033-1M
TRAFFIC REPORT NUMBER:			BQ725	BQ726	MOBILE LAB	MOBILE LAB	MOBILE LAB	MOBILE LAB	MOBILE LAB
SAMPLING POINT:			SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1
LOCATION:			6'	6'	6'	1.5' - 2'	4'	6'	1.5' - 2'
DESCRIPTION:			TP-8	DUP TP-8	TP-8	TP-9	TP-9	TP-9	TP-10
UNITS:			UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
DATE SAMPLED:			09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88
*** VOLATILES ***									
PP	CAS NO	COMPOUND							
	67-64-1	ACETONE							
4V	71-43-2	BENZENE							
86V	108-88-3	TOLUENE		33					
38V	100-41-4	ETHYLBENZENE							
	95-47-6	TOTAL XYLENES							
11V	71-55-6	1,1,1-TRICHLOROETHANE	17	45	J 7				
14V	79-00-5	1,1,2-TRICHLOROETHANE							
10V	107-06-2	1,2-DICHLOROETHANE							
85V	127-18-4	TETRACHLOROETHENE	18	12					
87V	79-01-6	TRICHLOROETHENE	37	79	J 11	J 10			
30V	156-60-5	TRANS-1,2-DICHLOROETHENE							
29V	75-35-4	1,1-DICHLOROETHENE							
44V	75-09-2	METHYLENE CHLORIDE							
33VT	10061-02-6	TRANS-1,3-DICHLOROPROPENE							

001464

BYRON BARREL & DRUM - SUBSURFACE SOILS

SAMPLE NUMBER:	BS-SS034-1M	BS-SS035-1	BS-SS035-1M	BS-SS036-1M	BS-SS037-1M	BS-SS038-1	BS-SS038-1M
TRAFFIC REPORT NUMBER:	MOBILE LAB	BQ727	MOBILE LAB	MOBILE LAB	MOBILE LAB	BQ728	MOBILE LAB
SAMPLING POINT:	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1
LOCATION:	4'	6'	6'	8'	1.5' - 2'	4'	4'
DESCRIPTION:	TP-10	TP-10	TP-10	TP-10	TP-0	TP-0	TP-0
UNITS:	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
DATE SAMPLED:	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88

*** VOLATILES ***

PP	CAS NO	COMPOUND	BS-SS034-1M	BS-SS035-1	BS-SS035-1M	BS-SS036-1M	BS-SS037-1M	BS-SS038-1	BS-SS038-1M
	67-64-1	ACETONE							
4V	71-43-2	BENZENE							
86V	108-88-3	TOLUENE		32				47	
38V	100-41-4	ETHYLBENZENE							
	95-47-6	TOTAL XYLENES							
11V	71-55-6	1,1,1-TRICHLOROETHANE						89	
14V	79-00-5	1,1,2-TRICHLOROETHANE						12	
10V	107-06-2	1,2-DICHLOROETHANE							
85V	127-18-4	TETRACHLOROETHENE		8				13	
87V	79-01-6	TRICHLOROETHENE		45				120	J 9
30V	156-60-5	TRANS-1,2-DICHLOROETHENE							
29V	75-35-4	1,1-DICHLOROETHENE						J 2	
44V	75-09-2	METHYLENE CHLORIDE						41	
33VT	10061-02-6	TRANS-1,3-DICHLOROPROPENE							

0001465

BYRON BARREL & DRUM - SUBSURFACE SOILS

			BS-SS039-1M	BS-SS040-1M	BS-SS041-1M	BS-SS042-1	BS-SS042-1M	BS-SS043-1	BS-SS043-1M
TRAFFIC REPORT NUMBER:			MOBILE LAB	MOBILE LAB	MOBILE LAB	8Q729	MOBILE LAB	8Q730	MOBILE LAB
SAMPLING POINT:			SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1	SOURCE 1
LOCATION:			6'	1.5' - 2'	1.5' - 2'	4'	4'	6'	6'
DESCRIPTION:			TP-0	TP-11	TP-12	TP-12	TP-12	TP-12	TP-12
UNITS:			UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG	UG/KG
DATE SAMPLED:			09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88	09/02/88
*** VOLATILES ***									
PP	CAS NO	COMPOUND							
	67-64-1	ACETONE							
4V	71-43-2	BENZENE							
86V	108-88-3	TOLUENE				6		16	
38V	100-41-4	ETHYLBENZENE							
	95-47-6	TOTAL XYLENES							
11V	71-55-6	1,1,1-TRICHLOROETHANE							
14V	79-00-5	1,1,2-TRICHLOROETHANE							
10V	107-06-2	1,2-DICHLOROETHANE							
85V	127-18-4	TETRACHLOROETHENE				J 3		10	
87V	79-01-6	TRICHLOROETHENE	J 8		J 15	13		53	
30V	156-60-5	TRANS-1,2-DICHLOROETHENE							
29V	75-35-4	1,1-DICHLOROETHENE							
44V	75-09-2	METHYLENE CHLORIDE				190		160	
33VT	10061-02-6	TRANS-1,3-DICHLOROPROPENE							

0001466

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 1 OF 2
SUBJECT: Source Loading to Groundwater		CHECKED BY: KCT	DATE: 05/31/88

Average concentration from source area 1 will be used to estimate leachate concentrations and groundwater concentrations.

Leachate concentrations may be estimated using the Freundlich isotherm:

$$C_{leachate} = C_{soil} / Kd$$

where $Kd = foc\ Koc$

$foc = 8.9 \times 10^{-3}$ kg organic carbon / kg soil (Ebasco, May 1989)

Groundwater concentrations may be estimated as

$$Co = \frac{C_{leachate}(Q)(L)}{(m)(Vd)}$$

where: Q is the annual percolation (cm/year)
L is the width of the leachate plume at the water table (cm)
m is the saturated thickness of the aquifer (cm)
Vd is the Darcy groundwater velocity (cm/year)

Source: Donigian, et. al., 1984.

Assumptions Q from Figures 4-3 (Soil Group B) and Figure 4-16 = 10 inches = 25.4 cm
L = 75 feet = 2300 cm (Ebasco, May 1989)
m = 10 feet (length of screen at well MW-1B = 305 cm
Vd = (240 feet/year)(0.2) = 1500 cm/year (Ebasco, May 1989 (Appendix D)). Interstitial pore velocity corrected to Darcy velocity using porosity of 0.2.

001467

NUS 155A REVISED 0285

NUS CORPORATION AND SUBSIDIARIES	STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 2 OF 2
SUBJECT: Source Loading to Groundwater		CHECKED BY: KCT	DATE: 05/31/88

The soil/sediment adsorption coefficient for PCE is 364. (Ebasco, May, 1989: Table 5-1).

Hence, for an average source concentration of ~~610~~ 553 μg/kg

$C_{leachate}$ = (~~610~~ 553 μg/kg)/(364 μg/kg/μg/L)/(9.6x10^{-3} kg/kg)

= ~~175~~ 158 μg/L

The groundwater concentration may be determined as follows:

C_0 = (~~175~~ 158 μg/L)(25.4 cm/year)(2,300 cm)/(1500 cm/year)/(305 cm)

= ~~22~~ 20 μg/L

001488

NUS 155A REVISED 0285

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 15, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET. TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)

REFERENCES:
EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE: C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE: S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION FACTOR =	.0285714
AF:	1		
BW:	70		

MODEL PARAMETERS:

Q (CM/YEAR):	25.4
Vd (CM/YEAR):	1500
L (CM):	2300
M (CM):	305
Foc (KG CARBON/KG SOIL):	.0096

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	T1:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
ED:	40	T:	293
R:	.000082	FR:	10

001489

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
CALCULATE DOSES:

CHEMICAL	SOIL CONCENT. (MG/KG)	SOIL SED. ADS. COEFFIC.	GROUNDWATER CONCENTRATION	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAI)	INGESTION DOSE	INHALATIO DOSE
ACETONE			0	58.08	3.43e-5	2.7584e0	0	0
2-BUTANONE			0			0	0	0
4-METHYL-2-PENTANONE			0			0	0	0
BENZENE			0	78.12	5.5e-3	1.8884e1	0	0
ETHYLBENZENE	.009	1100	.0001088	106.16	6.6e-3	1.6317e1	3.109e-6	1.925e-6
TOLUENE	.53	300	.0234992	92.13	6.66e-3	1.7521e1	6.714e-4	4.382e-4
XYLENES	.2	248	.0107270	106.17	4.33e-3	1.6010e1	3.065e-4	1.870e-4
CHLOROBENZENE			0			0	0	0
1,2-DICHLOROBENZENE			0			0	0	0
1,4-DICHLOROBENZENE			0			0	0	0
VINYL CHLORIDE			0			0	0	0
1,1,2-TRICHLOROETHANE			0	133.41	7.42e-4	1.1296e1	0	0
1,1,1-TRICHLOROETHANE	.039	152	.0034129	133.41	3e-2	1.4983e1	9.751e-5	5.656e-5
1,2-DICHLORETHANE			0	98.96	9.14e-4	1.3769e1	0	0
1,1-DICHLOROETHANE			0			0	0	0
TETRACHLOROETHENE	.61	364	.0222909	165.83	1.53e-2	1.3333e1	6.369e-4	3.372e-4
TRICHLOROETHENE	.5	126	.0527836	131.39	9.1e-3	1.4816e1	1.508e-3	8.672e-4
1,1-DICHLOROETHENE			0	96.94	1.9e-1	1.7700e1	0	0
CARBON TETRACHLORIDE			0			0	0	0
CHLOROFORM			0			0	0	0
METHYLENE CHLORIDE			0			0	0	0
CHLOROMETHANE			0			0	0	0
BROMODICHLOROMETHANE			0			0	0	0
CHLORODIBROMOMETHANE			0			0	0	0
2-CHLOROETHYLVINYLETHER			0			0	0	0
CARBON DISULFIDE			0			0	0	0
BENZO(A)ANTHRACENE			0			0	0	0
BENZO(B)FLUORANTHENE			0			0	0	0
BENZO(A)PYRENE			0			0	0	0
POLYCHLORINATED BIPHENYLS			0			0	0	0
N-NITROSODIPHENYLAMINE			0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE			0			0	0	0
DI-N-BUTYLPHTHALATE			0	278.3	2.8e-7	1.168e-2	0	0
BARIUM			0			0	0	0
CHROMIUM			0			0	0	0
COPPER			0			0	0	0
LEAD			0			0	0	0
NICKEL			0			0	0	0
VANADIUM			0			0	0	0
ZINC			0			0	0	0

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	0	0	5e-2	9e-2	0	0	0
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	0	0			0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6	1e-1		3.109e-5	0	3.109e-5
TOLUENE	6.714e-4	4.382e-4	3e-1	1e0	2.238e-3	4.382e-4	2.676e-3
XYLENES	3.065e-4	1.870e-4	2e0	4e-1	1.532e-4	4.675e-4	6.207e-4
CHLOROBENZENE	0	0	3e-2	5e-3	0	0	0
1,2-DICHLOROBENZENE	0	0	4e-1	4e-1	0	0	0
1,4-DICHLOROBENZENE	0	0			0	0	0
VINYL CHLORIDE	0	0			0	0	0
1,1,2-TRICHLOROETHANE	0	0	4e-2		0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5	9e-2	3e-1	1.083e-3	1.885e-4	1.272e-3
1,2-DICHLORETHANE	0	0			0	0	0
1,1-DICHLOROETHANE	0	0	1e-1		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	1e-2	1e-1	6.369e-2	3.372e-3	6.706e-2
TRICHLOROETHENE	1.508e-3	8.672e-4			0	0	0
1,1-DICHLOROETHENE	0	0	9e-3		0	0	0
CARBON TETRACHLORIDE	0	0	7e-4		0	0	0
CHLOROFORM	0	0	1e-2		0	0	0
METHYLENE CHLORIDE	0	0	6e-2		0	0	0
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	0	0			0	0	0
CHLORODIBROMOMETHANE	0	0	2e-1		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	0	0			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0	1e-1		0	0	0
BARIUM	0	0	5e-2	1e-4	0	0	0
CHROMIUM	0	0	1e0		0	0	0
COPPER	0	0	3.7e-2	1e-2	0	0	0
LEAD	0	0	1.4e-3		0	0	0
NICKEL	0	0	2e-2		0	0	0
VANADIUM	0	0	1e-3		0	0	0
ZINC	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							7.166e-2

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (1E-4 CANCER RISK)
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	0	0			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	0	0	2.9e-2	2.9e-2	0	0	0
ETHYLBENZENE	3.109e-6	1.925e-6			0	0	0
TOLUENE	6.714e-4	4.387e-4			0	0	0
XYLENES	3.065e-4	1.870e-4			0	0	0
CHLOROBENZENE	0	0			0	0	0
1,2-DICHLOROBENZENE	0	0			0	0	0
1,4-DICHLOROBENZENE	0	0	2.4e-2		0	0	0
VINYL CHLORIDE	0	0	2.3e0	2.95e-1	0	0	0
1,1,2-TRICHLOROETHANE	0	0	5.7e-2	5.7e-2	0	0	0
1,1,1-TRICHLOROETHANE	9.751e-5	5.656e-5			0	0	0
1,2-DICHLORETHANE	0	0	9.1e-2	9.1e-2	0	0	0
1,1-DICHLOROETHANE	0	0	9.1e-2		0	0	0
TETRACHLOROETHENE	6.369e-4	3.372e-4	5.1e-2	3.3e-3	1.856e-5	6.358e-7	1.920e-5
TRICHLOROETHENE	1.508e-3	8.672e-4	1.1e-2	1.3e-2	9.479e-6	6.442e-6	1.592e-5
1,1-DICHLOROETHENE	0	0	6e-1	1.2e0	0	0	0
CARBON TETRACHLORIDE	0	0	1.3e-1	1.3e-1	0	0	0
CHLOROFORM	0	0	6.1e-3	8.1e-2	0	0	0
METHYLENE CHLORIDE	0	0	7.5e-3	1.4e-2	0	0	0
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	0	0	1.3e-1		0	0	0
CHLORODIBROMOMETHANE	0	0	8.4e-2		0	0	0
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	0	0	4.9e-3		0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
DI-N-BUTYLPHTHALATE	0	0			0	0	0
BARIUM	0	0			0	0	0
CHROMIUM	0	0			0	0	0
COPPER	0	0			0	0	0
LEAD	0	0			0	0	0
NICKEL	0	0		8.4e-1	0	0	0
VANADIUM	0	0			0	0	0
ZINC	0	0			0	0	0
TOTAL RISK							3.512e-5

0014722

RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE FIVE)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
CARCINOGENIC RISK 1e-4

CHEMICAL	NUMBER OF CARCINOGENS	TARGET RISK	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	0	0	0	0	0
TOLUENE	0	0	0	0	0
XYLENES	0	0	0	0	0
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	0	0	0	0	0
1,2-DICHLORETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	5e-5	8.736e-4	3.058e-2	8.367e-1
TRICHLOROETHENE	1	5e-5	1.488e-3	5.207e-2	4.933e-1
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	2	1e-4			

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RISK ASSESSMENT SPREADSHEET - IMPACT OF SOIL CONTAMINATION ON GROUNDWATER (PAGE SIX)
BYRON BARREL AND DRUM SITE
EXPOSURE SCENARIO 2 - DETERMINE SOIL CLEAN-UP GOALS (10-4 CANCER RISK)
DETERMINE GROUNDWATER AND SOIL ACTION LEVELS:
NONCARCIN. RISK = .9

CHEMICAL	NUMBER OF NONCARCINOGENS	TARGET HAZARD INDEX	INGESTIONAL DOSE	GW CLEAN-UP GOAL (MG/L)	SOIL CLEAN-UP GOAL (MG/KG)
ACETONE	0	0	0	0	0
2-BUTANONE	0	0	0	0	0
4-METHYL-2-PENTANONE	0	0	0	0	0
BENZENE	0	0	0	0	0
ETHYLBENZENE	1	1.8e-1	1.8e-2	6.3e-1	5.2100e1
TOLUENE	1	1.8e-1	4.516e-2	1.5805e0	3.5647e1
XYLENES	1	1.8e-1	8.887e-2	3.1106e0	5.7995e1
CHLOROBENZENE	0	0	0	0	0
1,2-DICHLOROBENZENE	0	0	0	0	0
1,4-DICHLOROBENZENE	0	0	0	0	0
VINYL CHLORIDE	0	0	0	0	0
1,1,2-TRICHLOROETHANE	0	0	0	0	0
1,1,1-TRICHLOROETHANE	1	1.8e-1	1.380e-2	4.830e-1	5.5190e0
1,2-DICHLORETHANE	0	0	0	0	0
1,1-DICHLOROETHANE	0	0	0	0	0
TETRACHLOROETHENE	1	1.8e-1	1.710e-3	5.983e-2	1.6373e0
TRICHLOROETHENE	0	0	0	0	0
1,1-DICHLOROETHENE	0	0	0	0	0
CARBON TETRACHLORIDE	0	0	0	0	0
CHLOROFORM	0	0	0	0	0
METHYLENE CHLORIDE	0	0	0	0	0
CHLOROMETHANE	0	0	0	0	0
BROMODICHLOROMETHANE	0	0	0	0	0
CHLORODIBROMOMETHANE	0	0	0	0	0
2-CHLOROETHYLVINYLETHER	0	0	0	0	0
CARBON DISULFIDE	0	0	0	0	0
BENZO(A)ANTHRACENE	0	0	0	0	0
BENZO(B)FLUORANTHENE	0	0	0	0	0
BENZO(A)PYRENE	0	0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	0	0	0
N-NITROSODIPHENYLAMINE	0	0	0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	0	0	0
DI-N-BUTYLPHTHALATE	0	0	0	0	0
BARIUM	0	0	0	0	0
CHROMIUM	0	0	0	0	0
COPPER	0	0	0	0	0
LEAD	0	0	0	0	0
NICKEL	0	0	0	0	0
VANADIUM	0	0	0	0	0
ZINC	0	0	0	0	0
TOTAL	5	9e-1			

Theoretical Leachate Concentations

001475

CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 1 OF 4
SUBJECT: Theoretical Leachate Concentrations		CHECKED BY: KCT	DATE: 05/31/89

Objective - Estimate leachate concentrations based on soil concentrations and contrast with the land ban requirements.

Approach - The USEPAs Organic Leachate Model (OLM), source concentrations, and water solubilities will be used to estimate leachate concentrations.

Relevant Equation - $C_{leachate} = 2.11 \times 10^{-3} C_{soil}^{0.678} S^{0.373}$

where: $C_{leachate}$ is the leachate concentration (mg/L)
C_{soil} is the soil concentration (mg/kg)
S is the water solubility of the chemical (mg/L)

Reference - EPA, July 1986. "Hazardous Waste: Identification and Listing: Leachate." 51 Federal Register 145, 27061 et seq.

Assumptions - Excavated soils will be staged for offsite disposal from source area 1 and the maintenance building source. Arithmetic average concentrations for positive detections will be representative of staged soil concentrations.

Arithmetic average concentrations are greatest for soils in area 1 and are as follows: ethylbenzene (8 μg/kg); toluene (474 μg/kg); xylenes (178 μg/kg); TCA (35 μg/kg); PCE (553 μg/kg); TCE (447 μg/kg).

CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 2 OF 4
SUBJECT: Theoretical Leachate Concentrations		CHECKED BY: RCT	DATE: 05/31/89

Water solubilities are presented in Table 5-1 in the RI Report for the Byron Barrel and Drum Site and are as follows:

Chemical	Solubility (mg/L)
ethylbenzene	152
toluene	535
xylenes	187
1,1,1-trichloroethane	720
tetrachloroethene	200
trichloroethene	1,100

Sample calculation: (PCE)

$$C_{leachate} = 2.11 \times 10^{-3} (0.553 \text{ mg/kg})^{0.678} (200 \text{ mg/L})^{0.373}$$

$$= 0.010 \text{ mg/L}$$

Similarly, the remaining leachate concentrations may be estimated as:

Chemical	Cleachate (mg/L)
ethylbenzene	0.0005
toluene	0.013
xylenes	0.0046
1,1,1-trichloroethane	0.0025
tetrachloroethene	0.010
trichloroethene	0.017

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CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 3 OF 4
SUBJECT: Theoretical Leachate Concentrations		CHECKED BY: KCT	DATE: 05/31/89

These results may be contrasted to the constituent concentrations in the waste extract in the EPA Regulations on Land Disposal Restrictions (40 CFR 268, Part 268.41):

TABLE CCWE — CONSTITUENT CONCENTRATIONS WASTE EXTRACT

F001—F005 spent solvents	Concentration (in mg/l) Wastewaters containing spent solvents	All other spent solvent wastes
Acetone	0.05	0.59
n-Butyl alcohol	5.0	5.0
Carbon disulfide	1.05	4.81
Carbon tetrachloride	.05	.96
Chlorobenzene	.15	.05
Cresols (and cresylic acid)	2.82	.75
Cyclohexanone	.125	.75
1,2-Dichlorobenzene	.65	.125
Ethyl acetate	.05	.75
* Ethylbenzene	.05	.053
Ethyl ether	.05	.75
Isobutanol	5.0	5.0
Methanol	.25	.75
Methylene chloride	.20	.96
Methyl ethyl ketone	0.05	0.75
Methyl isobutyl ketone	0.05	0.33
Nitrobenzene	0.66	0.125
Pyridine	1.12	0.33
* Tetrachloroethylene	0.079	0.05
* Toluene	1.12	0.33
* 1,1,1-Trichloroethane	1.05	0.41
1,1,2-Trichloro-1,2,2-Trifluorethane	1.05	0.96
* Trichloroethylene	0.062	0.091
Trichlorofluoromethane	0.05	0.96
* Xylene	0.05	0.15

[F001–F005 table amended by 53 FR 31211, August 17, 1988]

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CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 4 OF 4
SUBJECT: Theoretical Leachate Concentrations		CHECKED BY: KCT	DATE: 05/31/89

Comparison of the calculated leachate concentrations with the CCWE standards indicates that soil from the Byron Barrel and Drum Site would not be considered a spent solvent waste.

Chemical	CCWE (mg/L)	OLM Conc. (mg/L)
ethylbenzene	0.053	0.0005
toluene	0.33	0.013
xylenes	0.15	0.0046
1,1,1-trichloroethane	0.41	0.0025
tetrachloroethene	0.05	0.010
trichloroethene	0.091	0.017

Groundwater Recovery System

001480

Groundwater Remediation Design

Assumptions - Avg K = 9.0 ft/day (Geometric mean of slug tests for well's 1B - 10B (excludes 1A, 6B, 11B - 14B) — high & low values within plume area — on-site field, outside plume

Aquifer Thickness - ~20' Avg

Transmissivity - 180 ft^2/day - 1346 gpd/ft

Areas of contamination -

Area A - 500 ft wide x 400 ft deep

Area B - 350 ft wide x 350 ft deep

Natural gradient = .00175

For Area A,

$Q_{nat.} = KiA$, where K, i as above, A = 500'

Q = 157 ft^3/day

= 1174 gpd

Conceptual design - System of pumping wells aligned along edge of field, along downgradient edge of site & within central portion of area of plume.

A) Assuming that system is pumped at a sufficient rate to induce average gradient of .01 along plume perimeter,

$Q_{remediation(R)} = KiA$, where K = 9.0 ft/day

= 3240 ft^3/day   i = .01

~ 17 gpm   A = [(500)(2) + (400)(2)](20) = 36,000 ft^2

System design

Assuming individual drawdown @ each well does not exceed 5',

Q/s = T/1500, where s = 5', T = 1346 gpd/ft (Driscoll, 1986 Pg. 1021)

Q = 4.48 gpm

4 wells @ 4.5 gpm each = 18 gpm

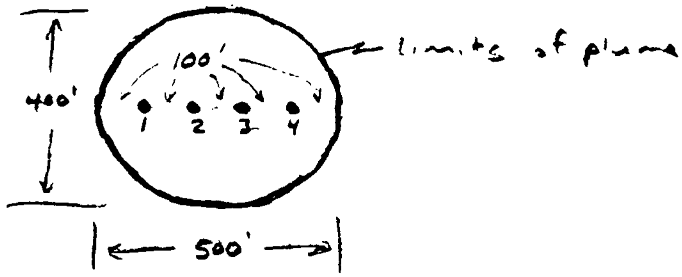
individual drawdowns = 5.01 each

001481

CLIENT: USEPA	FILE NO.: L725	BY: JPD	PAGE 2 OF 4
SUBJECT: BYRON BARREL & DRUM SITE		CHECKED BY: MSC 5/31/89	DATE: 5/30/89

Area A (continued)

System design



Cumulative drawdowns (from distance/drawdown graph)

Well 1 - 5.01' + .7' from well 2 + .2 from well 3 = 5.91'

2 - 5.01 + .7' from well 1 + .7 from well 3 + .2 from well 4 = 6.61'

3 - Same as well 2

4 - Same as well 1

B) Assume perimeter gradient of .015,

$Q_R = KiA$, where $K = 9.0$ ft/day

= 4860 ft³/day   i = .015

= 25 gpm   A = 36,000 ft²

Keeping 4 wells pumping @ 6.25 gpm each, check to see that drawdown does not exceed .5x saturated thickness (.5 x 20' = 10')

Q/s = T/1500, where   Q = 6.25 gpm

s = 7.0 per well   T = 1346 gpd/ft

Cumulative drawdowns (from distance-drawdown graph)

Well 1 - 7.0' + .85' from well 2 + .1' from well 3 = 7.95'

" 2 - 7.0' + .85' from well 1 + .85' from well 3 + .1' from well 4 = 8.8'

" 3 - Same as well 2

" 4 - Same as well 1

Minimum drawdowns between wells (from dist. dd graph)

Between 2 & 3 - 1.6' + 1.6' + .4' + .4' = 4.0'

Between 1 & 2, 3 & 4 - 1.6' + 1.6' + .4' = 3.6'

001482

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET

CLIENT: USEPA	FILE NO.: L725	BY: JPO	PAGE 3 OF 4
SUBJECT: BYRON BARREL & DRUM SITE		CHECKED BY: MZC 5/31/89	DATE: 5/30/89

Area A (continued)

All predicted drawdowns ≤ 10', pumping rates OK

To check capture zone limit (must exceed 200')

Downgradient capture zone limit = $Q/2\pi h \phi V_n$, where $Q = 6.25\,gpm = 1203\,ft^3/day$

(Keely & Tsang, 1983) $h = 20'$

Capture zone = 606' for each well $\phi = .20$

$V_n = Ki/n = \frac{9.0\,ft/day(.00175)}{.20} = .079\,ft/day$

Final system design - 4 wells pumping @ 6.25 gpm each, spaced across the center of the plume area.

Area B System Design

Use same assumptions as w/ Area A

($K = 9.0\,ft/day$, $b = 20'$ $\phi = .20$, Area $= 2\pi r$ ($r = 175'$, $A = 1100\,ft$), induced gradient = .015)

$Q_R = KiA = 9.0\,ft/day(.015)(1100\,ft)(20\,ft)$

$= 2970\,ft^3/day = 15.5\,gpm$

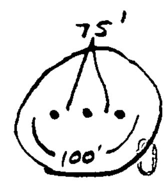
Can use 2 wells pumping @ 7.5 gpm each

Drawdown - $Q/s = T/1500$, $s = 8.4 + 1.0$ (from adj. well) $= 9.4'$

Spacing

Can use 3 wells pumping @ 5.2 gpm each

Max. Drawdown = 5.8' + 1.0 + 1.0 (from adj wells) 7.8'



001483

Area B Design (continued)

- Use 3-well extraction system in preference to 2 well system - more flexibility for adjustment.

Downgradient capture zone must be > 175'

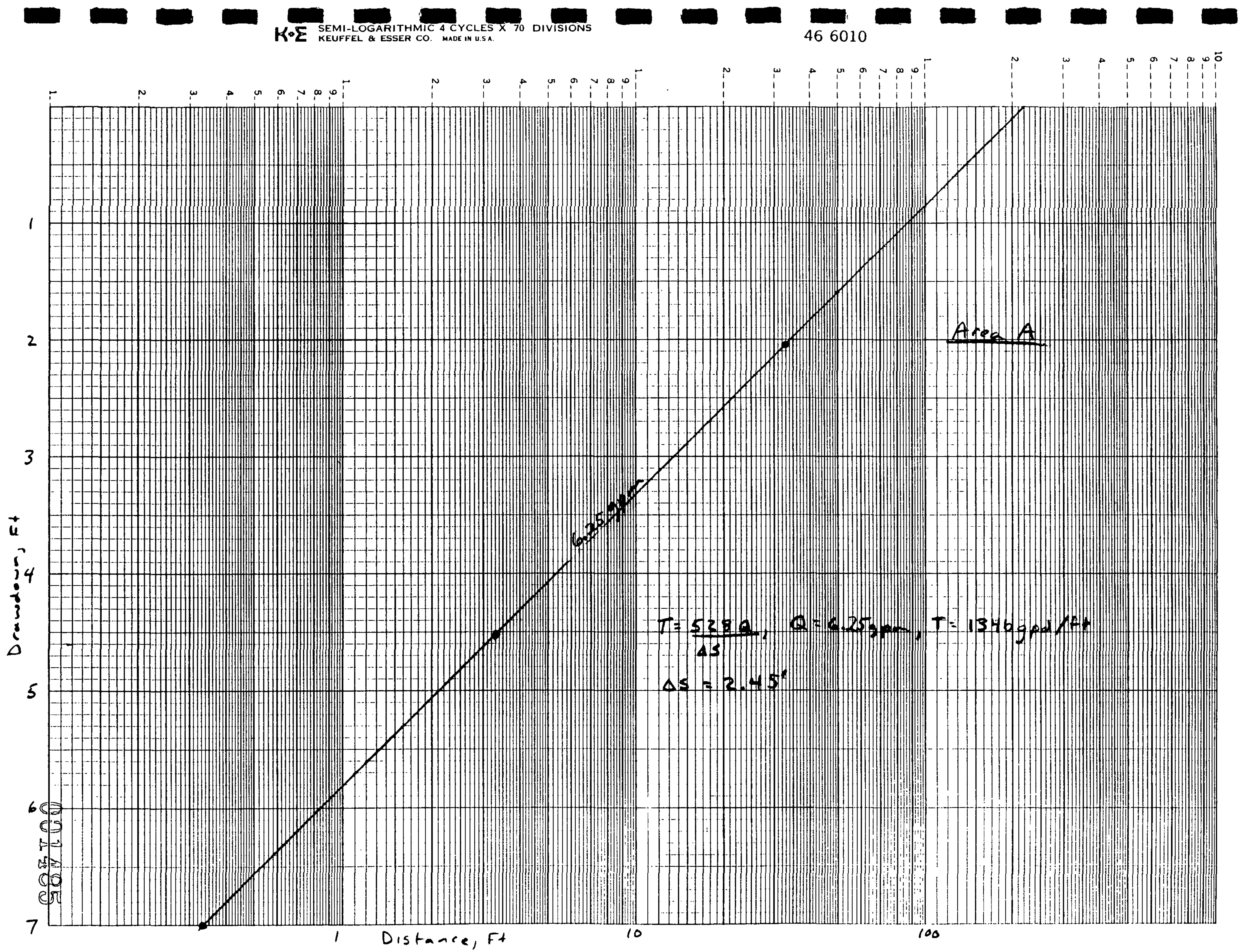
$CZ_{Dg} = Q/2\pi h \phi V_n$, $Q = 1001 ft^3/day, h = 20' \phi = .2, V_n = .08$ ft/day

$= 498'$

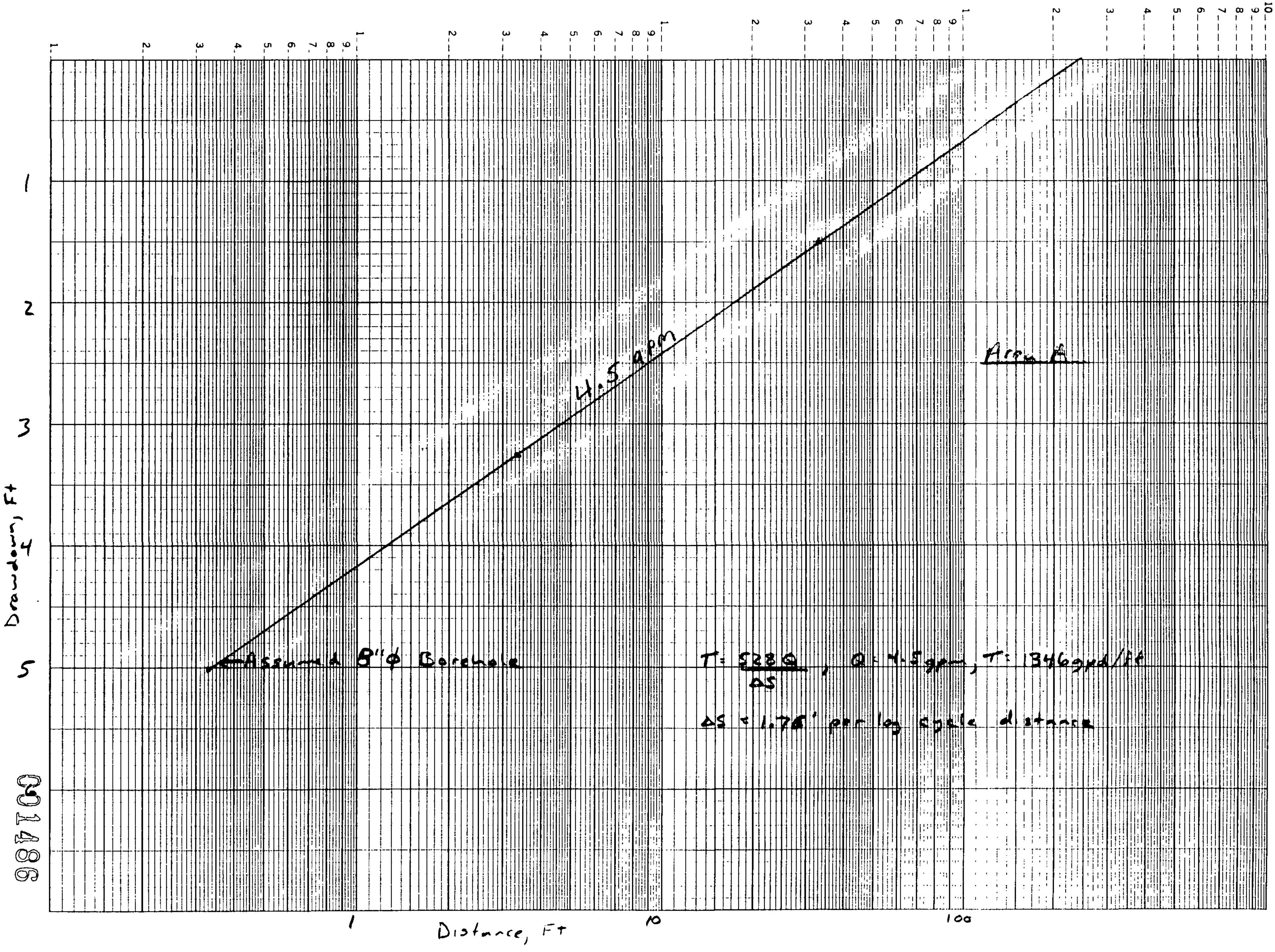
Infiltration Galleries

Galleries will be located within source areas of contamination, upgradient of the extraction wells. Infiltration rates will be ½ the extraction rate, to allow the downgradient portion of the contaminant plume to be drawn back to the extraction wells. Remaining water is to be disposed of offsite.

001484


K+E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6010
Area A
6.25 gpm
T = 528 Q / ΔS, Q = 6.25 gpm, T = 1346 gpd/ft
ΔS = 2.45'
Drawdown, Ft
Distance, Ft
1
10
100

K•E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 6010



K+E SEMI-LOGARITHMIC 4 CYCLES X 70 DIVISIONS
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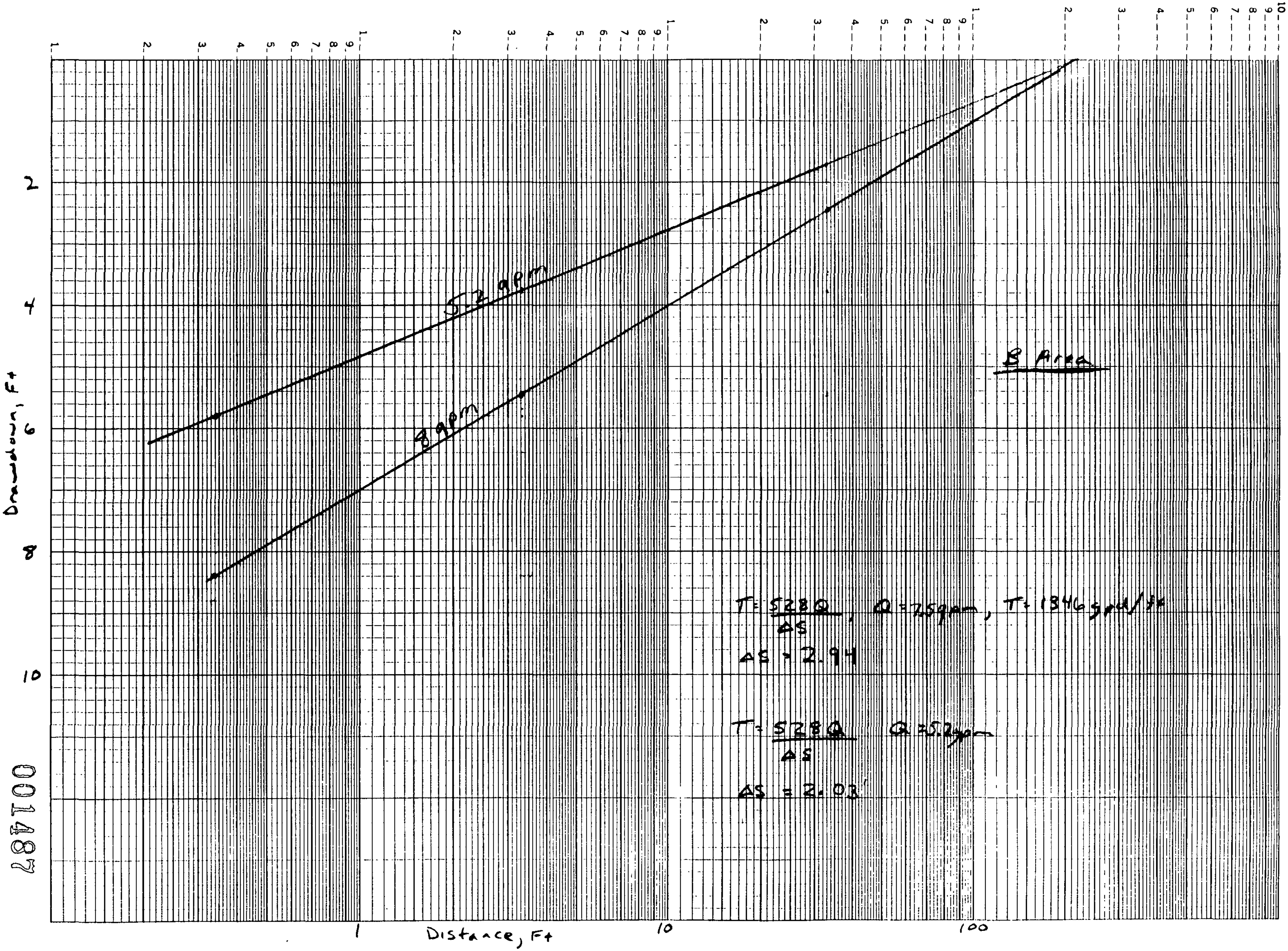
46 6010



Air Stripper Design

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: EPA	FILE NO.: L725	BY: DDB	PAGE OF
SUBJECT: Byron Barrel - Air Stripping Calculations		CHECKED BY: KCT	DATE: 5/22/89

Parameter	Max Conc. (µg/l)	Air stripper discharge *, ***	
		To achieve ARAR A/w: 25; Height: 30'	To Achieve 10^{-6} A/w: 61; Height: 50'
Benzene	0.5	0.001	<0.0001
Toluene	1.0	0.002	<0.0001
Xylene's	3.0	0.007	<0.0001
Chlorobenzene	0.25	0.003	<0.0001
1,2 Dichlorobenzene	0.026	0.002	<0.0001
1,4 Dichlorobenzene	2.0	0.050	0.0001
1,1,2 TCA	3.7	1.1	0.013 **
1,1,1 TCA	4400	2.2	<0.1
1,2 DCA	0.41	0.16	0.0035
1,1 DCA	290	1.2	<0.01
Chloroform	0.51	0.007	<0.0001
Methylene Chloride	2.8	0.14	0.0001
Bromo-dichloromethane	0.23	0.010	<0.0001
Chloro-dibromomethane	0.14	0.066	0.003
Vinyl Chloride	0.06	<0.0001	<0.0001
PCE	82	0.053	<0.001
TCE	3300	3.7 **	<0.05
1,1 DCE	41	0.005	<0.001
N-Nitrodisodiphenyl amine.	2	0.59	0.007

* Haarhoff, J. and Schoeller D, 1988, Theory and Design of Counter Current Packed Aeration Towers, Release 1. Airstrip.

** Limiting parameter for each stripper sizing.

*** Liquid Flux Rate: 20GPM/SF, Water Temp: 50°F, 1" Jaeger Tripack

001489

NUS 155A REVISED 0285

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: Byron Barrel & Drum	FILE NO.: L725	BY: KCT	PAGE 1 OF 2
SUBJECT: Preliminary Air Stripper Designs		CHECKED BY: [signature] (05/31/89)	DATE: 5/24/89

AIR STRIPPER #1 – DISCHARGE TO SURFACE WATER AND DISCHARGE TO GROUNDWATER (ARAR-BASED EFFLUENT LIMITS)

Influent Flow Rate = 44 gpm (max)

Design Parameters (based on "AIRSTRIP" computer program) (Documentation attached)

- Liquid flow rate – 20 gpm/ft²
- water temperature – 50°F
- Tower packing – 1" Jaeger Tripacks
- Air/water ratio – :1
- Packing depth – 30 ft

Column Diameter $\frac{44 \text{ gal}}{\text{min}} \Big| \frac{\text{min-ft}^2}{20 \text{ gal}} = 2.2 \text{ ft}^2$ D = 1.7 ft ⇒ 2 ft ✓

Liquid Loading Rate $\frac{44 \text{ gal}}{\text{min}} \Big| \frac{1 \text{ ft}^3}{7.48 \text{ gal}} = \frac{5.9 \text{ ft}^3}{\text{min}}$ ✓

Gas Loading Rate $\frac{5.9 \text{ ft}^3}{\text{min}} \times 34 = \frac{200 \text{ ft}^3}{\text{min}} \Rightarrow 200$ cfm ✓

<u>Major Design Features</u>

Air flow rate	200 cfm	(need 2 blowers) ✓
Water flow rate	44 gpm ✓	
Diameter	2 ft ✓	
Packing depth	30 ft	(add 10 ft to column for packing support and sprayer) ✓

001490

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: BYRON BARREL & DRUM	FILE NO.: L725	BY: KCT	PAGE 2 OF 2
SUBJECT: PRELIMINARY AIR STRIPPER DESIGNS		CHECKED BY: [signature] (05/31/89)	DATE: 5/24/89

AIR STRIPPER #2 – DISCHARGE TO GROUNDWATER (EFFLUENT LIMITS BASED ON 10^{-6} RISK

Influent flow rate = 44 gpm

Design parameters (based on "AIRSTRIP" computer program) (Documentation Attached)
- Liquid flow rate – 20 gpm/ft^2
- Water temperature – 50°F
- Tower packing – 1" Jaeger Tripacks
- Air/water ratio – 61 : 1
- Packing depth – 50 ft (or 2 columns @ 25 ft)

Column diameter $\frac{44 \text{ gpm}}{} \Big| \frac{1 \text{ ft}^2}{20 \text{ gpm}} = 2.2 \text{ ft}^2$ D ⇒ 2 ft ✓

Liquid loading rate $\frac{44 \text{ gal}}{\text{min}} \Big| \frac{1 \text{ ft}^3}{7.48 \text{ gal}} = \frac{5.9 \text{ ft}^3}{\text{min}}$ ✓

Gas loading rate $(5.9 \text{ ft}^3/\text{min})(61) = 360$ cfm ⇒ 400 cfm ✓

<u>Major Design Features</u> – Use 2 columns in series ✓

Air flow rate	400 cfm	(need 3 blowers) ✓
Water flow rate	44 gpm ✓	
Diameter	2 ft ✓	
Packing depth	25 ft	(add 10 ft for packing support and sprayer) ✓

001491

A I R S T R I P Documentation

Theory and Design
of
Countercurrent Packed Aeration Towers

Johannes Haarhoff & Dave Schoeller

Prepared by NUS Corporation, Pittsburgh PA.

AIRSTRIP Release 1.0 Copyright 1988

TABLE OF CONTENTS

H E N R Y ' S   L A W

In a gas/liquid system, a contaminant will partition itself between the gas and liquid phases. According to Henry's Law, the concentration of the contaminant in the gas above the solution is proportional to the concentration of the contaminant in the solution. Henry's Law is only valid for relatively dilute contaminant concentrations, and for systems which are at equilibrium. The proportionality constant, Henry's constant, is expressed in different forms, depending on the units chosen for expressing the contaminant concentrations. Throughout AIRSTRIP, we will use the following form:

$$A = H * C$$ with

A = contaminant concentration in air (gram per cubic meter)
H = Henry's constant (dimensionless)
C = contaminant concentration in water (gram per cubic meter)

The following alternative form of Henry's Law is commonly encountered in the chemical literature:

$$PP = Ha * MF$$ with

PP = partial pressure of contaminant in air (atmospheres)
Ha = Henry's constant (atmospheres)
MF = mole fraction of contaminant in solution (dimensionless)

This form of Henry's constant is related to the one used in AIRSTRIP by:

$$H = Ha / (Co * R * (T + 273.2)) = 0.219 * Ha / (T + 273.2)$$

Co = molar density of water = 55.6 mole per liter
R = universal gas constant = 0.08206 liter.atm per mole.Kelvin
T = water temperature in degrees Celsius

Like all equilibrium constants, Henry's constant H is strongly influenced by temperature - H increases as the temperature rises. The relationship between H at two different temperatures is:

$$H2 = H1 * 10^{[D / R] * [1 / (T1+273.2) - 1 / (T2+273.2)]}$$

H1 = H at temperature T1 (dimensionless)
H2 = H at temperature T2 (dimensionless)
D = enthalpy change upon dissolution in water (cal / mole)
R = universal gas constant
= 1.987 cal / degrees Kelvin.mole
T = water temperature (degrees Celsius)

001494

EQUILIBRIUM CONDITIONS

In a countercurrent aeration tower, where water flows down from the top and air is pumped up from the bottom, a mass balance on the contaminant yields:

Q(water) * [C(in) - C(out)] = Q(air) * [A(out) - A(in)]

where the C's and the A's are the water and air concentrations of the contaminant, and the Q's are the volumetric flow rates.

Ideally, the contaminant will be completely stripped, or C(out) = 0. The incoming air will be practically contaminant-free, or A(in) = 0. Also, at the top of the tower where outgoing air meets incoming water, the application of Henry's Law yields:

A(out) = H * C(in)

With these substitutions, the mass balance on the contaminant simplifies to:

Q(water) = H * Q(air)

The above expression can be re-arranged to:

H * (A/W ratio) = 1

where A/W ratio is the dimensionless volumetric air/water ratio. The term on the left is also the expression for the stripping factor R.

This simple derivation is only valid for ideal, equilibrium conditions. In practical terms, it gives the minimum A/W ratio that will completely strip the contaminant from the water with an infinitely tall tower. In order to strip a substantial fraction of the contaminant with a tower of reasonable height, a higher A/W ratio (or stripping factor) will be required.

S T R I P P I N G   F A C T O R

The stripping factor R was previously defined by the expression:

$$R = H * (A/W\ ratio)$$

In the screen dealing with "Equilibrium Conditions", R = 1 was derived for the special case when the contaminant was totally stripped in an infinitely tall tower. If R < 1, complete stripping cannot occur, even with an infinitely tall tower. If R > 1, then complete stripping becomes possible with a tower of finite size.

In practice, complete stripping is seldom required and tower height is limited to a few meters. With these conditions, substantial stripping only becomes possible if R > 2. At R < 2, the stripping process is limited by the capacity of the air to carry the contaminant away.

If R > 5, however, there is little to be gained with further increase of the A/W ratio, because stripping will be essentially complete. The ideal design condition, therefore, will exist with the stripping factor somewhere between 2 and 5.

Practical A/W ratios vary from about 5 - 100. Above 100, the energy requirement for pumping the air makes the process uneconomical. The stripping factor is, therefore, limited by the practical A/W ratio. If the Henry's constant H is between about 0.02 and 1.00, the optimum R can be reached simply by adjusting the A/W ratio. If the Henry's constant H is higher than 1.00, then stripping will be essentially complete, even at very low A/W ratios.

If the Henry's constant H is less than about 0.02, the compound is not very volatile and stripping will be become poorer with lower H. In these cases, the designer has no other option than to select the highest practical A/W ratio and to increase the tower height, or consider an alternative process.

M A S S T R A N S F E R E Q U A T I O N

The basic mass transfer equation for countercurrent aeration towers is:

Z = HTU * NTU where Z = tower height
HTU = height of transfer units
NTU = number of transfer units

The following symbols will be used in its derivation:

Q	= volumetric flow rate	H	= Henry's constant
L	= areal liquid loading rate	J	= mass transfer rate per tower volume
w	= unit mass of water	Kla	= mass transfer rate constant
B	= cross-sectional tower area	R	= stripping factor
C	= concentration in water	i	= suffix denoting "in"
A	= concentration in air	o	= suffix denoting "out"
dz	= infinitesimal height incr.	$	= suffix denoting "at equilibrium"

For any infinitesimal tower element of height dz, the mass transfer rate is

J = [Q(water) * dC] / [B * dz]

For the same element, another expression for J is available from the concentration gradient across the water/air interface:

J = Kla * [C$ - C]

(C$ is the water concentration that would have been in equilibrium with the air at that point. The difference between C$ and the actual concentration C provides the driving force for the mass transfer.)

Setting these two expressions equal, and substituting L/w for Q(water)/B, yields the expression at the top of the next screen:

$$dz = \frac{L}{w * Kla} * \frac{dC}{(C\$ - C)}$$

Integration of the left hand term across the tower height simply yields the overall tower height Z. The first factor on the right is unaffected by integration, because it contains nothing that varies over the tower height. This factor is called the HTU (height of transfer units).

The second factor on the right must be integrated between the concentration limits of the contaminant in the water, i.e. from C(in) to C(out). This integration will be developed in a moment. Once integrated, it is called the NTU (number of transfer units). The final expression for the mass transfer equation, in shorthand, becomes:

Z = HTU * NTU

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To simplify the integrand in the expression for the NTU, the term C$ needs to be expressed as a function of the variable C. First apply Henry's Law at the element dz:

$$A = H * C\$$$

Now take a mass balance from the bottom of the tower up to element dz:

$$Q(air) * (A - Ai) = Q(water) * (C - Co)$$

Eliminate A from these two expressions, set Ai = 0 (because the incoming air is contaminant-free), solve for C$, substitute into the integrand and integrate:

$$NTU = \frac{R}{R - 1} * \ln \left\{ \frac{(R - 1) * (Ci / Co) + 1}{R} \right\}$$

T W O - F I L M   T H E O R Y

The Whitman Two-film theory provides a conceptual basis for modeling mass transfer between a liquid and a gas. The bulk liquid and the bulk gas phases are turbulent, but where they meet, there are two laminar layers, one of each phase:

```
))))))))))))))))))))                          !                    ((((((((((((((((((((
))))) turbulent ))))    laminar               !      laminar       (((( turbulent (((((
)))))    air    ))))      air                 !       liquid       ((((   liquid  (((((
))))))))))))))))))))                          !                    ((((((((((((((((((((
```

The transfer of a volatile contaminant from water to air, in terms of this theory, requires two distinctly different steps - diffusion through the laminar layer of water first, and then diffusion through the laminar air layer. The higher the diffusional resistance in either or both of the laminar layers, the lower the overall mass transfer rate.

O V E R A L L   M A S S   T R A N S F E R   C O E F F I C I E N T

In the mass transfer equation, the mass transfer coefficient appeared as the single term Kla. In reality it reflects the combined effects of three quite different parameters, which are (1) the mass transfer properties of the laminar air layer, (2) the mass transfer properties of the laminar water film and (3) the total area of the air/water interface. In this section, the relationship between the overall mass transfer rate constant Kl and the mass transfer rate constants kl and kg (for the laminar water and air films, respectively) will be derived.

CONCENTRATION PROFILE ACROSS THE TWO-FILM INTERFACE

```
|* * * * * * * * * * * * * *.     |                    |                    |
|           C            | *.   |                    |      Bulk Air      |
|                        |   *. | Ai                 |                    |
|                        |      *   _                |                    |
|      Bulk Water        |  Ci  |       *     _      |      A , C$        |
|                        |      |                    * * * * * * * * * * *|
```

Three expressions for the mass transfer rate J follow from the concentration profile just given:

Through the water film :	$J = kl * a * (C - Ci)$	.....(1)
Through the air film :	$J = kg * a * (Ai - A)$	.....(2)
Through both films :	$J = Kl * a * (C - C\$)$	.....(3)

From equations (1) and (3), the following expression can be derived:

$$kl * (C - Ci) = Kl * (C - Ci) + Kl * (Ci - C\$) \quad .....(4)$$

By applying Henry's Law at the interface, and in the bulk air, the following relationship is found:

$$(Ci - C\$) = (Ai - A) / H \quad .....(5)$$

Combine equations (1) and (2) to find another expression for (Ai - A):

$$(Ai - A) = (C - Ci) * kl / kg \quad .....(6)$$

Substitute equation (6) into (5):

$$(Ci - C\$) = (C - Ci) * kl / (H * kg) \quad .....(7)$$

Substitute equation (7) into (4), cancel the (C - Ci) terms and divide through by (Kl * kl) :

$$1 / Kl = 1 / kl + 1 / (H * kg) \quad .....(8)$$

Equation (8) is the final expression for combining the mass transfer rate constants of the water and air films into the overall mass transfer rate constant Kl.

M O D E L I N G   A P P R O A C H E S

The relationship between the different mass transfer rate constants was earlier derived as:

$$1 / Kl = 1 / kl + 1 / (H * kg)$$

For highly volatile contaminants (large H), the contribution of the air film rate constant kg is very small and may be safely ignored. If the contaminant is only slightly volatile (small H), the diffusional resistance in the air layer will obviously become more significant.

The SHERWOOD-HOLLOWAY relationship ignores the effects of the air film and estimates the overall mass transfer coefficient only on the basis of the diffusional resistance in the water film. It will work fine for the highly volatile contaminants, but falls short for the less volatile contaminants.

The ONDA and SHULMAN models are more explicit - they estimate kl, kg and the interfacial area a with three separate correlations, which can be combined into an overall mass transfer coefficient. These relationships are, therefore, valid for a wider range of contaminants, regardless of volatility. The SHULMAN model, however, uses a procedure for estimating the interfacial area which is not amenable to computer applications.

For the SHERWOOD-HOLLOWAY model, the properties of the tower packing are entered as a set of specially derived empirical packing constants, which makes it tough to apply it to a new type of packing. The ONDA and SHULMAN models use packing properties which are relatively easy to measure.

AIRSTRIP uses the ONDA correlations throughout. Their validity has been repeatedly verified by a number of studies reported in the environmental engineering literature. The model has emerged as a standard basis for countercurrent packed tower design.

D E S I G N   T E M P E R A T U R E

Temperature is the single most important factor affecting the performance of stripping towers. It has dramatic effects on two key variables - Henry's constant, and the mass transfer coefficient. The lower the temperature, the slower the mass transfer at the air/water interface. To be on the safe side, stripping towers should be designed for the coldest expected temperature.

The derivation of the mass transfer equation implicitly assumed isothermal operation, i.e. both air and water remain at a common, constant temperature throughout the height of the tower. In practice, however, air and water enter the tower at different temperatures, and the water is cooled by its slight evaporation.

Simple thermodynamics allow us to estimate the effect of widely different air and water temperatures. The heat capacity of water is 75 kJ/mol.K, and that of air 29 kJ/mol.K. A volumetric A/W ratio of 30 (a typical value for full-scale applications) is equivalent to a molar ratio of 0.024.

A heat balance then shows that there will be a 11 degree Celsius change in air temperature for every 0.1 degree Celsius change in water temperature. For even the widest conceivable difference in air and water temperatures, the final equilibrium temperature (assuming it could be reached in the tower) would be within 0.3 degrees Celsius of the incoming water temperature.

Evaporative cooling effects are also very small. At very low air temperature (which are likely to occur during the critical winter months), the moisture-carrying capacity of air is also at its lowest.

For practical purposes, the critical design temperature can, therefore, be assumed to be equal to the coldest expected water temperature.

T R A N S F E R   R A T E   C O N S T A N T   I N   A I R

The ONDA correlation for the mass transfer rate constant kg through the laminar air film is:

```
        kg    =   CON  *  factor 1  *  factor 2  *  factor 3  *  factor 4

       CON    =   constant depending on packing size
  factor 1    =   { G / [ a *  vis(air) ] } ^ (0.7)
  factor 2    =   { vis(air) / [ den(air) * D(air) ] } ^ (1/3)
  factor 3    =   { a * dp } ^ (-2)
  factor 4    =   { a * D(air) }
```

The explanation of symbols and their units appear on the next screen. This correlation was derived with various packing shapes in the gas flow range 0.014 to 1.7 kg/s.m^2, with packing sizes between 4 and 50 mm.

The following symbols were used in the correlation on the previous screen:

kg	=	mass transfer rate constant	(m / s)
CON	=	5.23 if dp > 15 mm or larger	(-)
CON	=	2.00 if dp < 15 mm	(-)
den	=	density	(kg / m^3)
vis	=	absolute viscosity	(kg / m . s)
G	=	areal air loading rate	(kg / m^2 . s)
a	=	total specific packing area	(m^2 / m^3)
D	=	molecular diffusivity of contaminant	(m^2 / s)
dp	=	nominal packing size	(m)

T R A N S F E R   R A T E   C O N S T A N T   I N   W A T E R

The ONDA correlation for the mass transfer rate constant kl through the laminar water film is:

```
kl        =    0.0051  *  factor 1  *  factor 2  *  factor 3  *  factor 4

factor 1  =    { den(water) / [ vis(water) * g ] } ^ (-1/3)
factor 2  =    { L / [ aw * vis(water) ] } ^ (2/3)
factor 3  =    { vis(water) / [ den(water) * D(water) ] } ^ (-1/2)
factor 4  =    { a * dp } ^ (2/5)
```

The explanation of symbols and their units appear on the next screen. This correlation was derived from data collected with various packing shapes such as rings, spheres, rods and saddles. The nominal sizes ranged from 4 to 50 mm, and the liquid loading rate from 0.8 to 43 kg/s.m^2. The accuracy of the estimates is given as plus/minus 20%.

The following symbols were used in the correlation on the previous screen:

kl	=	mass transfer rate constant	(m / s)
den	=	density	(kg / m^3)
vis	=	absolute viscosity	(kg / m . s)
g	=	gravitational acceleration	(9.81 m / s^2)
L	=	areal liquid loading rate	(kg / m^2 . s)
a	=	total specific packing area	(m^2 / m^3)
aw	=	wetted specific packing area	(m^2 / m^3)
D	=	molecular diffusivity of contaminant	(m^2 / s)
dp	=	nominal packing size	(m)

001503

W E T T E D   P A C K I N G   A R E A

The ONDA correlation for the specific interfacial area (wetted packing area) is given by:

```
    aw    =   a * { 1 - exp [ factor 1 * factor 2 * factor 3 * factor 4 ] }

factor 1 =  - 1.45 * [ cst(packing) / st(water) ] ^ (3/4)
factor 2 =  { L / [ a * vis(water) ] } ^ (0.1)
factor 3 =  { L^2 * a / [ den(water)^2 * g ] } ^ (-0.05)
factor 4 =  { L^2 / [ den(water) * st(water) * a ] } ^ (1/5)
```

The explanation of symbols and their units appear on the next screen. This correlation was derived for packing made of different materials such as ceramic. glass, plastic and wax-coated packing. The accuracy of the estimates is plus/minus 20%.

The following symbols were used in the correlation on the previous screen:

```
aw    =   specific wetted packing area          ( m^2 / m^3 )
a     =   total specific packing area           ( m^2 / m^3 )
cst(packing)  =  critical surface tension       ( kg / s^2 )
st(water)     =  surface tension                ( kg / s^2 )
vis   =   absolute viscosity                    ( kg / m . s )
den   =   density                               ( kg / m^3 )
L     =   areal liquid loading rate             ( kg / m^2 . s )
g     =   gravitational acceleration            ( 9.81 m / s^2 )
```

001504

M O L E C U L A R   D I F F U S I V I T Y   I N   A I R

AIRSTRIP uses the estimation method published by Wilke and Lee:

```
              K * T^(3/2) * Mr^(1/2)
    D(air) = ------------------------
                  P * CL^2 * CI

        D   =  molecular diffusivity  (m^2/s)
        K   =  0.0001 * [ 0.00217 - 0.00050 * Mr^(1/2) ]
        T   =  air temperature  (deg K)
        Mr  =  1 / 28.95  +  1 / Mw(contaminant)
        Mw  =  molecular weight  (gram/mol)
        P   =  air pressure  (atmospheres)
        CL  =  characteristic length (also called collision radius)
        CI  =  collision integral
```

The characteristic length is also known as the collision radius and is the arithmetic mean of the molecular radii of air and the contaminant:

```
            CL  =  [ Mr(air) + Mr(contaminant) ] / 0.2      (CL in Angstrom)

            Mr  =  molecular radius  (nm or nanometer)
       Mr(air)  =  0.3711  (nm)
```

The molecular radius of the contaminant (in nm) is separately estimated:

```
       Mr(contaminant)  =  1.18 * [ Vm^(1/3) ]

                    Vm  =  molal volume at boiling point  (liter/mol)
```

The estimation of the collision integral is a multistep calculation:

```
   CI  =  a / (Ts^b)  +  c / exp(Ts*d)  +  e / exp(Ts*f)  +  g / exp(Ts*h)

a = 1.06036        c = 0.19300         e = 1.03587         g = 1.76474
b = 0.15610        d = 0.47635         f = 1.52996         h = 3.89411
```

Ts is a dimensionless intermediate parameter:

```
                 Ts  =  T / { [ E(air) * E(contaminant) ]^(1/2) }

                  T  =  air temperature  (deg K)
                  E  =  function of molecular attraction and Boltzmann constant
             E(air)  =  78.6  (deg K)
     E(contaminant)  =  1.15 * Tb
                 Tb  =  boiling point of contaminant (deg K)
```

M O L E C U L A R   D I F F U S I V I T Y   I N   W A T E R

The molecular diffusivity in water can be calculated with a correlation developed by Wilke and Chang:

$$D(water) = 1.173 * 10^{(-16)} * \frac{(A * Mw)^{0.5} * (T + 273.2)}{vis(water) * Vm^{0.6}}$$

D	=	molecular diffusivity, square meter per second
A	=	association parameter, dimensionless
	=	2.26 for water, according to Hayduk and Laudie
Mw	=	molecular weight of water
	=	18 mole / liter
T	=	water temperature, degrees Celsius
vis	=	absolute viscosity, kilogram per meter.sec
Vm	=	molar volume of the contaminant as a liquid at boiling point, liter per mole

P H Y S I C A L   P R O P E R T I E S   O F   A I R

Density of atmospheric air (expressed in kilogram per cubic meter)

$$= \frac{1.293}{1 + 0.00367 * T} * \frac{P}{101.3}$$

Absolute viscosity of air (expressed in kilogram per meter.sec)

$$= 1.7 * 10^{-7} * (T + 273.2)^{0.818}$$

T = air temperature expressed in degrees Celcius
P = Ambient air pressure expressed in kiloPascal per square meter or kiloPascal

P H Y S I C A L   P R O P E R T I E S   O F   W A T E R

Density of water (expressed in kilogram per cubic meter)

$$= \frac{999.84 + 16.945 * T - 7.9870 * 10^{-3} * T^2 - 4.6171 * 10^{-5} * T^3}{1 + 1.68799 * 10^{-2} * T}$$

Absolute viscosity of water (expressed in kilogram per meter.sec)

$$= 1.7868 * 10^{-3} - 5.8573 * 10^{-5} * T + 1.1951 * 10^{-6} * T^2 - 1.1146 * 10^{-8} * T^3$$

Surface tension of water (expressed in kilogram per second squared)

$$= 7.5583 * 10^{-2} - 1.3143 * 10^{-4} * T - 4.7616 * 10^{-7} * T^2$$

001506

In all three cases, T is the water temperature expressed in degrees Celsius

P R O P E R T I E S O F T O W E R P A C K I N G

The NOMINAL PACKING SIZE roughly corresponds to the overall dimension of a packing piece and is ultimately determined by the manufacturer. AIRSTRIP does not consider nominal sizes smaller than 25 mm, because it is not practical.

The PACKING TYPE relates to the design of the packing, for example RASCHIG and PALL rings, TELLERETTES, BERL and INTALOX saddles, TRIPAC, etc.

The PACKING MATERIAL simply denotes what the packing is made of, and could be glass, ceramic, steel or plastic. AIRSTRIP limits itself to plastic (almost exclusively used for full-scale applications) and ceramic (sometimes used for laboratory studies).

The CRITICAL SURFACE TENSION determines the physical interaction between the packing and the water. It is a function of the packing material only, and not of the packing shape or size. AIRSTRIP uses the following values:

Plastic	0.033 kg/s^2
Ceramic	0.061 kg/s^2

The AIR FRICTION FACTOR determines the pressure gradient when air is pumped through the tower. It is a dimensionless parameter which is used in a standard graphical procedure for determining the air pressure gradient.

A I R P R E S S U R E G R A D I E N T

The air pressure gradient through packed towers is normally read from a set of empirical curves which are reproduced in a number of standard textbooks on chemical engineering. These curves are valid if the air pressure gradient is between 50 and 1200 Pa/m. The curves have recently been digitized into a set of equations, which is used in AIRSTRIP. The multistep computation is tedious and reversed, i.e. it treats the air pressure gradient as the independent variable. The air pressure gradient, therefore, is most easily calculated by iteration.

First calculate the intermediate values F, A0, A1 and A2:

```
F   =   log P        (P is the air pressure gradient in Pa/m)
A0  =  -6.6599  +  4.3077*F  -  1.3503*F^2  +  0.15931*F^3
A1  =   3.0945  -  4.3512*F  +  1.6240*F^2  -  0.20855*F^3
A2  =   1.7611  -  2.3394*F  +  0.8991*F^2  -  0.11597*F^3
```

Calculate the intermediate value E from:

```
E  =  - log [ (A/W) * (S - S^2)^0.5 ]
```

with A/W = dimensionless volumetric air/water ratio
S = dimensionless air/water density ratio

Use the intermediate values A0, A1, A2 and E to calculate M:

```
M  =  10 ^ ( A0 + A1*E + A2*E^2 )
```

Calculate the air flow rate from:

```
Q(air) = {M * [den(water)-den(air)] / [den(air)*Cf*vis(water)^0.1]} ^ 0.5
```

The symbols and units in the preceding equation are:

- Q (air) = mass air loading rate, kg/m^2.s
- M = intermediate value, dimensionless
- den = density kg/m^3
- vis = viscosity kg/m.s
- Cf = dimensionless air friction factor (see "packing properties")

The above calculation sequence is only valid within certain bounds:

1. The air pressure gradient must be between 50 and 1200 Pa/m,
2. (A/W) * (S - S^2)^0.5 must be less than 33, and
3. M must be greater than 0.0015.

T O W E R   F L O O D I N G

Air and water flow in opposite directions through the packed tower. If the air and/or liquid loading rates reach a certain level, there will be insufficient open space in the tower to allow the free and uninterrupted flow of each phase. This will lead to tower flooding, which is an unstable condition characterized by bubbling, surging and water blowout at the top of the tower. This can obviously not be tolerated during regular operation.

The onset of flooding is dependent on the air flow rate, the liquid loading rate and the properties of the packing, which are the same factors that determine the air pressure gradient. Tower flooding is therefore closely related to the air pressure gradient. Flooding will only start if the air pressure gradient exceeds 1200 Pascal per meter.

Tower flooding should not be a concern in full-scale water/wastewater stripping applications. Practical designs usually end up with a pressure gradient of less than 100 Pascal per meter (see "most economical design").

S E L E C T I O N   O F   P A C K I N G   S I Z E

The designer has to consider a number of issues when picking the nominal tower packing size:

- The specific surface area of the packing increases as its size decreases. Smaller packing will result in more efficient mass transfer.
- The air pressure gradient increases as the size decreases. Blower operating costs will be lower for larger packing.
- The chances of tower flooding are higher if a small packing size is used. For small packing, lower air and water loading rates will be necessary.
- Precipitates may form in some applications because of air oxidation. Small packing will clog more rapidly than larger packing.
- Large packing in a small-diameter tower will lead to excessive channeling because of wall effects. A minimum tower diameter of twelve times the packing diameter is one suggested practical rule of thumb.

AIRSTRIP will allow you to appreciate most of these (often conflicting) effects as you play around with different packing sizes. Together with the packing cost data for your specific project, you should be able to determine the feasible size range relatively quickly.

C H A N N E L I N G

Unless special precautions are taken, water will tend to flow down the packing closest to the walls of a packed tower, and the air will tend to flow through the center portion. This phenomenon is known as channeling.

Channeling can be minimized if proper attention is given to the following:

- o A packing size that is not too large (see "Packing Size"),
- o A carefully designed water distribution system at the top of the tower, such as a weir-trough arrangement to ensure an even distribution onto the top of the packing, and
- o The use of of intermediate packing support plates at regular intervals throughout the tower. These support plates should be designed for the redistribution of the water at intervals varying from 3 to 10 times the tower diameter.

S A F E T Y F A C T O R S

The designer can apply safety factors to almost any of the many input parameters. Because the calculation sequence is long and involved, it is not easy to appreciate the effects on eventual cost and removal efficiency if, for example, the water temperature is taken as 3 degrees Celcius below the expected minimum. The most direct way of providing a margin of safety is to simply add additional packing over and above the theoretical minimum height required. The output format of AIRSTRIP is designed to directly show the effect of packing height on removal efficiency.

Although AIRSTRIP does not allow the explicit use of safety factors, you can also apply a safety factor by reducing the Henry's constant - this approach has been reported in the literature. In this case, the contaminant properties must be copied into another disk file and stored with an appropriately reduced Henry's constant.

Two factors may make a stripping tower design safer than theoretical calculations will show:

- o Some stripping of the contaminant will take place while the incoming water is being distributed above the packing and while the outgoing water is being collected below the packing. This stripping is collectively known as the "end effects". There are no mathematical models available for estimating the end effects, because they differ from one design to the next. Unless they are specifically measured and accounted for in a pilot study, they simply form part of the safety factor.
- o It has been reported in the literature that pilot studies on small-diameter towers yield experimental mass transfer coefficients that are lower than those measured in comparable large-diameter towers. Full-scale facilities that are designed on the basis of pilot-scale results, will thus include an inherent safety factor.

MOST ECONOMICAL DESIGN

The published cost optimization studies all concur that the air pressure gradient, more than anything else, determines the total treatment cost. Different optimizations have shown the optimum air pressure gradient to be between 50 and 60 Pa/m. If it is much higher, blower operating costs shoot up sharply; if it is too low, an excessive volume of packing is required.

Total treatment costs are relatively insensitive to small deviations from the optimum design, but costs increase rapidly if design conditions too far away from the optimum are chosen. Treatment costs increase linearly with decreasing temperature - design temperatures should not be chosen with unnecessary conservatism. Tower packing should be selected on the basis of its pressure loss properties rather than on the basis of its capital cost. In general, however, the total treatment cost is more sensitive to the capital cost than to the operating cost. AIRSTRIP does not optimize a design for minimum treatment cost, but does provide all the necessary operating information for the designer to calculate the site-specific optimum design.

PILOT STUDIES

Most parameters in the mass transfer equation are values that are readily available, e.g. air and water flow rates, and influent and effluent contaminant concentrations. The two exceptions are Henry's constant H and the overall mass transfer coefficient Kla. Henry's constant has to be obtained from chemical references, and the mass transfer coefficient from empirical correlations such as those of ONDA. Before these "textbook" values were generally accepted for full-scale applications, designers were virtually compelled to conduct pilot tests for verification.

A pilot tower is normally operated with different combinations of air and water loading and the influent and effluent concentration is measured once steady state is achieved for every combination. With a number of such data points available, a combination of H and Kla can be mathematically found which will give the best agreement between theoretically calculated and experimentally measured values.

AIR POLLUTION

Air stripping does not change or destroy the contaminant, but simply transfers it from the incoming water to the outgoing air. Regulatory agencies will normally require some documentation to prove that air quality standards are not violated by the exhaust air from the stripping tower.

AIRSTRIP will present you with the exhaust air concentration right at the tower, but you will have to estimate the dispersion of the contaminant plume yourself with one of the available two- or three-dimensional dispersion models, specifically for your particular site. In some cases it may be necessary to design an exhaust air scrubber to remove the contaminant before the exhaust air is released into the atmosphere.

Note that the contaminant concentration in the air will be highest when the stripping is most effective. The critical design condition for air pollution is therefore when the water temperature reaches its highest expected level.

THEORETICAL LIMITATIONS

AIRSTRIP is based on theory which is commonly and successfully used in practice. Some assumptions have been implicitly made in the earlier derivations that warrant explicit attention:

- o The contaminant is entirely strippable. Some reports have indicated that there may be an unstrippable contaminant fraction, but no theoretical explanation has been advanced. If the designer wants to incorporate an unstrippable fraction into the mass transfer equation, it is readily done.

- o The contaminant is unreactive. Some compounds, such as carbon dioxide or ammonia, maintain an equilibrium with other chemical species in the water. AIRSTRIP will not be applicable to these contaminants.

- o The ONDA correlations are based on experimental data which was collected with packing 50mm and smaller. They appear to work fairly well for packing up to 75mm, but no explicit verification has been published.

W A T E R   Q U A L I T Y   S T A N D A R D S

In 1986 the US Congress passed a number of amendments to the Safe Drinking Water Act. A total of 83 unregulated contaminants were listed, of which at least 25 had to be regulated by 1991. A large percentage of these contaminants are organic chemicals. The USEPA has subsequently taken a number of steps, and the current (August 1987) position for organic chemicals is:

FINAL STANDARDS:	Trichloroethylene	5 ug/L
	Carbon tetrachloride	5 ug/L
	Vinyl chloride	2 ug/L
	1,2-Dichloroethane	5 ug/L
	Benzene	5 ug/L
	para-Dichlorobenzene	75 ug/L
	1,1-Dichloroethylene	7 ug/L
	1,1,1-Trichloroethane	200 ug/L

CANDIDATES FOR FUTURE REGULATION:

- Dibromomethane
- 2,4-Dinitrotoluene
- Chloroform
- Dibromochloromethane
- Chloromethane
- Bromomethane
- 1,1,1,2-Tetrachloroethane
- o-Chlorotoluene
- Hexachloroethane
- 1,3-Dichloropropene
- Halogenated acids
- Halogenated aldehydes
- Chloropicrin
- 1,3-Dichloropropane
- Bromodichloromethane
- Bromoform
- Bromobenzene
- 1,2,3-Trichloropropane
- 2,2-Dichloropropane
- p-Chlorotoluene
- Hexachlorobutadiene
- Acrylonitrile
- Halogenated alcohols
- Halogenated ketones

NON-CANDIDATES AT PRESENT, BUT MONITORING REQUIRED FOR ALL SYSTEMS:

Chlorobenzene	Chloroethane
m-Dichlorobenzene	o-Dichlorobenzene
trans-1,2-Dichloroethylene	cis-1,2-Dichloroethylene
Dichloromethane	1,1-Dichloroethane
1,1-Dichloropropene	1,2-Dichloropropane
Ethylbenzene	Styrene
1,1,2-Trichloroethane	1,1,2,2-Tetrachloroethane
Tetrachloroethylene	Toluene
p-Xylene	o-Xylene
m-Xylene	
Ethylene dibromide)	monitoring required for
1,2-Dibromo-3-Chloropropane)	vulnerable systems only

NON-CANDIDATES AT PRESENT, BUT MONITORING MAY BE REQUIRED AT STATE LEVEL:

Bromochloromethane	n-Propylbenzene
n-Butylbenzene	Secbutylbenzene
Dichlorodifluoromethane	Tertbutylbenzene
Fluorotrichloromethane	1,2,3-Trichlorobenzene
Hexachlorobutadiene	1,2,4-Trichlorobenzene
Isopropyl benzene	1,2,3-Trimethylbenzene
p-Isopropyltoluene	1,3,5-Trimethylbenzene
Naphthalene	

UNITS OF MEASUREMENT

Air stripping theory is relatively new to sanitary engineering. Most of the theory has been borrowed from the chemical engineering literature and from basic chemistry, with a wide assortment of units as a result. Many of these units have no established equivalents in sanitary engineering yet. Earlier papers in the Journal of the American Water Works Association, for example, utilized metric units, whereas more recent papers have attempted to demetrisize the subject.

There is no question that metric units greatly facilitate the calculations and derivations required for stripping tower design. (If you do not agree with this, try working through the ONDA correlations once with non-metric units!) AIRSTRIP uses metric units internally, and all the formulas and derivations on these screens are given in metric units.

Where well established non-metric equivalents are available, they are accessible through the F10 function key, which acts as a units toggle.

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A C K N O W L E D G M E N T S

During the fall of 1985, an advanced literature review course was offered at Iowa State University which was specifically focused on the theory and practice of air stripping towers. The critical analyses and discussion offered by fellow students, under the direction of Dr. J. L. Cleasby, provided the foundation of this program.

During 1986, a first computer program was developed that was marketed under the name VOCSTRIP, which was the predecessor of AIRSTRIP. VOCSTRIP offered a less flexible design procedure than AIRSTRIP, and did not offer as many screens explaining the underlying theory. Current VOCSTRIP users come from consulting firms, universities, and manufacturing companies, and valuable suggestions were received from these users. Most of these suggestions have been incorporated into this new release.

Any comments or complaints from registered users are welcomed, and should be sent to the address listed under "Customer Support".

C U S T O M E R   S U P P O R T

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AIRSTRIP
3209 Garner Ave.
Ames
IA 50010

In case of an urgent problem,
call between 7 & 10 PM (CST):

(515) 232 - 3476

Inorganics Removal

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 1 OF 4
SUBJECT: GROUNDWATER TREATMENT AVERAGE METAL CONCENTRATIONS IN GROUNDWATER		CHECKED BY: [signature]	DATE: 7/18/89

DETERMINE AVERAGE METAL CONCENTRATIONS (TREATMENT PLANT INFLUENT)
USE AVERAGE VALUES FROM ROUND 3 AND ROUND 4 RI MONITORING
(SOURCE - TABLES 4-6 AND 4-7 FROM RI/FS)

Contaminant	Round 3	Round 4	Average (Influent) - μg/L
aluminum (Al)	NA?	51,000	51,000
arsenic (As)	9.6	2.1	5.9
barium (Ba)	840	870	855
beryllium (Be)	0.9	4.3	2.6
cadmium (Cd)	11	1.8	6.4
calcium (Ca)	420,000	460,000	440,000
chromium (Cr)	40	130	85
cobalt (Co)	31	57	44
copper (Cu)	160	350	255
iron (Fe)	28,000	110,000	69,000
lead (Pb)	97	110	104
magnesium (Mg)	91,000	120,000	105,500
manganese (Mn)	3,900	3,300	3,600
mercury (Hg)	0.07	0.085	0.08
nickel (Ni)	71	120	96
potassium (K)	4,400	11,000	7,700
silver (Ag)	0.3	2.7	1.5
sodium (Na)	11,000	11,000	11,000
vanadium (V)	27	110	69
zinc (Zn)	570	1,300	935

001519

NUS CORPORATION AND SUBSIDIARIES

STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 2 OF 4
SUBJECT: GROUNDWATER TREATMENT NEED FOR METALS REMOVAL - DISCHARGE TO SURFACE WATER		CHECKED BY: [signature]	DATE: 7/18/89

Contaminant	Avg. Influent (ug/L)	NY State Surface Quality Std (1) (ug/L)	NYSDEC Ambient Water Quality Stds (ug/L) (3)	Treatment Req'd ?
aluminum	51,000	-	-	-
arsenic	5.9	360	360	-
barium	855	-	-	-
beryllium	2.6	-	-	-
cadmium	6.4	39 (2)	39 (2)	-
calcium	440,000	-	-	-
chromium	85	9,170 (2)	9,170 (2)	-
cobalt	44	-	(110) (4)	-
copper	255	120 (2)	120 (2)	YES
iron	69,000	300	300	YES
lead	104	1,080 (2)	1,080 (2)	-
magnesium	105,500	-	-	-
manganese	3,600	-	-	-
mercury	0.08	-	(0.2)	-
nickel	96	8,640 (2)	8,640 (2)	-
potassium	7,700	-	-	-
silver	1.5	134 (2)	134 (2)	-
sodium	11,000	-	-	-
vanadium	69	190	190	-
zinc	935	1,735 (2)	1,735 (2)	-

(1) 6 NYCRR 701 Appendix 31, Class D

(2) based on hardness of 763 mg/l (as $CaCO_3$)

(3) NY State DEC Ambient Water Quality Standards and Guidance Values (Memorandum from D.M. Barolo, Director, Division of Water, 7/24/85). Guidance for development of SPDES effluent limitations. Class D

(4) Values in parentheses are guidance values

001520

NUS 155A REVISED 0285

NUS 155A REVISED 0285

NUS CORPORATION AND SUBSIDIARIES

STANDARD CALCULATION SHEET

CLIENT: USEPA Region II | FILE NO.: L725 | BY: KCT | PAGE 3 OF 4

SUBJECT: GROUNDWATER TREATMENT NEED FOR METALS REMOVAL - DISCHARGE TO RECHARGE BASIN | CHECKED BY: [signature] | DATE: 7/18/89

Contaminant	Avg. Influent (µg/L)	NYSDOH MCL (1)	NYSDOH Stds - Source of Water Supply (2)	NY State Groundwater Quality Standard (3)	NYSDEC Ambient Water Quality Stds (4)	Treatment Required
aluminum	51,000	–	–	–	–	–
arsenic	5.9	50	50	25	25	–
barium	855	1,000	1,000	1,000	1,000	–
beryllium	2.6	–	–	–	(3)(5)	–
cadmium	6.4	10	10	10	10	–
calcium	440,000	–	–	–	–	–
chromium	85	50	50	50	50	Yes
cobalt	44	–	–	–	–	–
copper	255	1,000	<200	1,000	1,000	Yes
iron	69,000	300	–	300	300	Yes
lead	104	50	50	25	25	Yes
magnesium	105,500	–	–	–	35,000	Yes
manganese	3,600	300	–	300	300	Yes
mercury	0.08	2	5	2	2	–
nickel	96	–	–	–	–	–
potassium	7,700	–	–	–	–	–
silver	1.5	50	50	50	50	–
sodium	11,000	–	<20,000	–	–	–
vanadium	69	–		–	–	–
zinc	935	5,000	<300	5,000	5,000	Yes

(1) 10 NYCRR, Subpart 5-1

(2) 10 NYCRR Part 170

(3) NYCRR Part 173, Class GA

(4) Barcelo Memo 7/24/85

(5) Values in parentheses are guidance levels, Class GA

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 4 OF 4
SUBJECT: GROUNDWATER TREATMENT - SUMMARY OF INFLUENT AND EFFLUENT CONCENTRATIONS (µg/L)		CHECKED BY: [signature]	DATE:

Influent - Average of values for metals detected during sampling rounds 3 and 4

Effluent - Lowest value based on discharge to surface water or groundwater (recharge basins) (pgs 2 & 3 of this calculation)

Contaminant	Assumed Influent	Assumed Acceptable Effluent	
aluminum	51,000	-	
arsenic	5.9	25	
barium	855	1,000	
beryllium	2.6	3	
cadmium	6.4	10	
calcium	440,000	-	
chromium	85	50	*
cobalt	44	110	
copper	255	120	*
iron	69,000	300	*
lead	104	25	*
magnesium	105,500	35,000	*
manganese	3,600	300	*
mercury	0.08	0.2	
nickel	96	8,640	
potassium	7,700	-	
silver	1.5	50	
sodium	11,000	20,000	
vanadium	69	190	
zinc	935	300	*

\- no standards or criteria available

* basis for design (removal required) - treat using hydroxide precipitation, include filtration as "polishing" to remove excess solids from clarifier effluent.

001522

NUS CORPORATION AND SUBSIDIARIES			*STANDARD CALCULATION SHEET*
CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 1 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: RJH	DATE: 7-19-89

DETERMINE SLUDGE PRODUCTION RATES AND HYDROXIDE (OH^-) REQUIREMENTS FOR HYDROXIDE PRECIPITATION OF HEAVY METALS

Influent Contaminants	Average Concentration (mg/l)
aluminum	51
barium	0.855
chromium	0.085
copper	0.255
iron	69
lead	0.104
magnesium	105.5
manganese	3.6
nickel	0.096
potassium	7.7
zinc	0.935

* Other inorganics are present at low concentrations (< 0.1 mg/l) and would not influence chemical usage or sludge production significantly

Influent flow rate = 44 gpm = 63,360 gpd

Assume that sludge produced will be 2.5% solids

001523

NUS 155A REVISED 0285

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 2 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

Aluminum

$$\frac{51\ mg\ Al}{\ell} \cdot \frac{3.785\ \ell}{gal} \cdot \frac{63{,}360\ gal}{day} \cdot \frac{1\ lb}{454{,}000\ mg} = \frac{27\ lb\ Al}{day}$$

$Al(OH)_3$ produced

$$\frac{27\ lb\ Al}{day} \cdot \frac{78\ gm/mole\ Al(OH)_3}{27\ gm/mole\ Al} = \frac{78\ lb\ Al(OH)_3}{day}$$

sludge produced @ 2.5% solids

$$\frac{78\ lb}{day} \cdot \frac{gal}{8.34\ lb} \cdot \frac{}{0.025} = \frac{374\ gal}{day}$$

OH^- required

$$\frac{78\ lb\ Al(OH)_3}{day} \cdot \frac{51\ gm/mole\ OH}{78\ gm/mole\ Al(OH)_3} = \frac{51\ lb\ OH^-}{day}$$

Barium

$$\frac{0.855\ mg\ Ba}{\ell} = \frac{0.5\ lb\ Ba}{day}$$

$Ba(OH)_2$ produced

$$\frac{0.5\ lb\ Ba}{day} \cdot \frac{171\ gm/mole\ Ba(OH)_2}{137\ gm/mole\ Ba} = \frac{0.6\ lb\ Ba(OH)_2}{day}$$

sludge produced

$$\frac{0.6\ lb}{day} \cdot \frac{gal}{8.34\ lb} \cdot \frac{}{0.025} = \frac{3\ gal}{day}$$

OH^- required

$$\frac{0.6\ lb\ Ba(OH)_2}{day} \cdot \frac{34\ gm/mole\ OH}{171\ gm/mole\ Ba(OH)_2} = \frac{0.12\ lb\ OH^-}{day}$$

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 3 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

Chromium

$$\frac{0.085\ mg\ Cr}{l} = \frac{0.04\ lb\ Cr}{day}$$

$Cr(OH)_3$ produced
$$\frac{0.04\ lb\ Cr}{day} \cdot \frac{103\ gm/mole\ Cr(OH)_3}{52\ gm/mole\ Cr} = \frac{0.08\ lb\ Cr(OH)_3}{day}$$

sludge produced
$$\frac{0.08\ lb}{day} \cdot \frac{gal}{8.34\ lb} \cdot \frac{}{0.025} = \frac{0.4\ gal}{day}$$

OH^- required
$$\frac{0.08\ lb\ Cr(OH)_3}{day} \cdot \frac{51\ gm/mole\ OH}{103\ gm/mole\ Cr(OH)_3} = \frac{0.04\ lb\ OH^-}{day}$$

Copper

$$0.255\ mg\ Cu/L = 0.13\ lb\ Cu/day$$

$Cu(OH)_2$ produced
$$\frac{0.13\ lb\ Cu}{day} \cdot \frac{98\ gm/mole\ Cu(OH)_2}{64\ gm/mole\ Cu} = \frac{0.2\ lb\ Cu(OH)_2}{day}$$

sludge produced
$$\frac{0.2\ lb}{day} \cdot \frac{gal}{8.34\ lb} \cdot \frac{}{0.025} = \frac{1\ gal}{day}$$

OH required
$$\frac{0.2\ lb\ Cu(OH)_2}{day} \cdot \frac{34\ gm/mole\ OH}{98\ gm/mole\ Cu(OH)_2} = \frac{0.07\ lb\ OH^-}{day}$$

Iron $69\ mg/l = 36\ lb\ Fe/day$

$Fe(OH)_3$ produced
$$\frac{36\ lb\ Fe}{day} \cdot \frac{107\ gm\ Fe(OH)_3/mole}{56\ gm\ Fe/mole} = \frac{69\ lb\ Fe(OH)_3}{day}$$

sludge produced
$$\frac{69\ lb}{day} \cdot \frac{gal}{8.34\ lb} \cdot \frac{}{0.025} = \frac{331\ gal}{day}$$

OH^- required
$$\frac{69\ lb\ Fe(OH)_3}{day} \cdot \frac{51\ gm\ OH/mole}{107\ gm\ Fe(OH)_3/mole} = \frac{33\ lb\ OH^-}{day}$$

001525

NUS CORPORATION AND SUBSIDIARIES

STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 4 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: RJH	DATE: 7-19-89

Lead 0.104 mg/l = 0.05 lb Pb/day

$Pb(OH)_2$ produced $\frac{0.05 \text{ lb Pb}}{\text{day}} \Big| \frac{241 \text{ gm } Pb(OH)_2/\text{mole}}{207 \text{ gm Pb/mole}} = \frac{0.06 \text{ lb } Pb(OH)_2}{\text{day}}$

sludge produced $\frac{0.06 \text{ lb}}{\text{day}} \Big| \frac{\text{gal}}{8.34 \text{ lb}} \Big| \frac{}{0.025} = \frac{0.3 \text{ gal}}{\text{day}}$

OH^- required $\frac{0.06 \text{ lb } Pb(OH)_2}{\text{day}} \Big| \frac{34 \text{ gm OH/mole}}{241 \text{ gm } Pb(OH)_2/\text{mole}} = \frac{0.008 \text{ lb } OH^-}{\text{day}}$

Magnesium 105.5 mg/l = 56 lb/day

$Mg(OH)_2$ produced $\frac{56 \text{ lb Mg}}{\text{day}} \Big| \frac{58 \text{ gm } Mg(OH)_2/\text{mole}}{24 \text{ gm Mg/mole}} = \frac{135 \text{ lb } Mg(OH)_2}{\text{day}}$

sludge produced $\frac{135 \text{ lb}}{\text{day}} \Big| \frac{\text{gal}}{8.34 \text{ lb}} \Big| \frac{}{0.025} = \frac{647 \text{ gal}}{\text{day}}$

OH^- required $\frac{135 \text{ lb } Mg(OH)_2}{\text{day}} \Big| \frac{34 \text{ gm OH/mole}}{58 \text{ gm } Mg(OH)_2/\text{mole}} = \frac{79 \text{ lb } OH^-}{\text{day}}$

Manganese 3.6 mg/l = 1.9 lb/day

$Mn(OH)_2$ produced $\frac{1.9 \text{ lb Mn}}{\text{day}} \Big| \frac{89 \text{ gm } Mn(OH)_2/\text{mole}}{55 \text{ gm Mn/mole}} = \frac{3.1 \text{ lb } Mn(OH)_2}{\text{day}}$

sludge produced $\frac{3.1 \text{ lb}}{\text{day}} \Big| \frac{\text{gal}}{8.34 \text{ lb}} \Big| \frac{}{0.025} = \frac{15 \text{ gal}}{\text{day}}$

OH^- required $\frac{3.1 \text{ lb } Mn(OH)_2}{\text{day}} \Big| \frac{34 \text{ gm OH/mole}}{89 \text{ gm } Mn(OH)_2/\text{mole}} = \frac{1.2 \text{ lb } OH^-}{\text{day}}$

NUS CORPORATION AND SUBSIDIARIES — STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L 725	BY: KCT	PAGE 5 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

Nickel 0.096 mg/l = 0.05 lb/day

$Ni(OH)_2$ produced $\frac{0.05 \text{ lb Ni}}{\text{day}} \left| \frac{93 \text{ gm } Ni(OH)_2/\text{mole}}{59 \text{ gm Ni/mole}} \right. = \frac{0.08 \text{ lb } Ni(OH)_2}{\text{day}}$

sludge produced $\frac{0.08 \text{ lb}}{\text{day}} \left| \frac{\text{gal}}{8.34 \text{ lb}} \right| \frac{}{0.025} = \frac{0.4 \text{ gal}}{\text{day}}$

OH^- required $\frac{0.08 \text{ lb } Ni(OH)_2}{\text{day}} \left| \frac{34 \text{ gm OH/mole}}{93 \text{ gm } Ni(OH)_2/\text{mole}} \right. = \frac{0.03 \text{ lb } OH^-}{\text{day}}$

Potassium 7.7 mg/l = 4.1 lb/day

KOH produced $\frac{4.1 \text{ lb K}}{\text{day}} \left| \frac{56 \text{ gm KOH/mole}}{39 \text{ gm K/mole}} \right. = \frac{5.9 \text{ lb KOH}}{\text{day}}$

sludge produced $\frac{5.9 \text{ lb}}{\text{day}} \left| \frac{\text{gal}}{8.34 \text{ lb}} \right| \frac{}{0.025} = \frac{28 \text{ gal}}{\text{day}}$

OH^- required $\frac{5.9 \text{ lb KOH}}{\text{day}} \left| \frac{17 \text{ gm } OH^-/\text{mole}}{56 \text{ gm KOH/mole}} \right. = \frac{1.8 \text{ lb } OH^-}{\text{day}}$

Zinc 0.935 mg/l = 0.49 lb/day

$Zn(OH)_2$ produced $\frac{0.49 \text{ lb Zn}}{\text{day}} \left| \frac{99 \text{ gm } Zn(OH)_2/\text{mole}}{65 \text{ gm Zn/mole}} \right. = \frac{0.75 \text{ lb } Zn(OH)_2}{\text{day}}$

sludge produced $\frac{0.75 \text{ lb}}{\text{day}} \left| \frac{\text{gal}}{8.34 \text{ lb}} \right| \frac{}{0.025} = \frac{3.6 \text{ gal}}{\text{day}}$

OH^- required $\frac{0.75 \text{ lb } Zn(OH)_2}{\text{day}} \left| \frac{34 \text{ gm OH/mole}}{99 \text{ gm } Zn(OH)_2/\text{mole}} \right. = \frac{0.26 \text{ lb } OH^-}{\text{day}}$

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 6 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

Total sludge production @ 2.5% solids = 1,404 gpd

Al	374 gpd	Mg	647 gpd
Ba	3 gpd	Mn	15 gpd
Cr	0.4 gpd	Ni	0.4 gpd
Cu	1 gpd	K	28 gpd
Fe	331 gpd	Zn	3.6 gpd
Pb	0.3 gpd		

Total OH^- requirement = 167 lb/day

Al	51 lb/day	Mg	79 lb/day
Ba	0.12 lb/day	Mn	1.2 lb/day
Cr	0.04 lb/day	Ni	0.03 lb/day
Cu	0.07 lb/day	K	1.8 lb/day
Fe	33 lb/day	Zn	0.26 lb/day
Pb	0.008 lb/day		

NaOH requirement $\frac{167 \text{ lb OH}}{\text{day}} \Big| \frac{40 \text{ gm NaOH/mole}}{17 \text{ gm OH/mole}} = \frac{393 \text{ lb NaOH}}{\text{day}}$

use 50% NaOH (12.5 lb/gal)

$$\frac{393 \text{ lb NaOH}}{\text{day}} \Big| \frac{\text{gal}}{12.5 \text{ lb}} = \frac{31 \text{ gal}}{\text{day}} \text{ 50\% NaOH}$$

H_2SO_4 dosage to lower pH following hydroxide precipitation
assume dosage of 200 mg/l of 66° Baume H_2SO_4

$$\frac{200 \text{ mg}}{l} \Big| \frac{44 \text{ gal}}{\text{min}} \Big| \frac{3.785 \, l}{\text{gal}} \Big| \frac{1440 \text{ min}}{\text{day}} \Big| \frac{1 \text{ lb}}{454{,}000 \text{ mg}} \Big| \frac{1 \text{ gal}}{15 \text{ lb } H_2SO_4} = \frac{7 \text{ gal } H_2SO_4}{\text{day}}$$

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NUS 155A REVISED 0285

NUS CORPORATION AND SUBSIDIARIES — STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L 725	BY: KCT	PAGE 7 OF 7
SUBJECT: Heavy Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

Determine volume of dewatered sludge for disposal

Total sludge production 1404 gpd @ 2.5% solids

Assume dewatered sludge @ 30% solids (81 lb/ft^3)

$$\frac{1404\ \text{gal}}{\text{day}} \left| \frac{8.34\ \text{lb}}{\text{gal}} \right| \frac{0.025\ \text{lb dry solids}}{\text{lb sludge}} = \frac{293\ \text{lb dry solids}}{\text{day}}$$

$$\frac{293\ \text{lb dry solids}}{\text{day}} \left| \frac{1\ \text{lb sludge cake}}{0.3\ \text{lb dry solids}} \right| \frac{\text{ft}^3}{81\ \text{lb sludge cake}} = \frac{12\ \text{ft}^3\ \text{sludge cake}}{\text{day}}$$

NUS CORPORATION AND SUBSIDIARIES — STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 1 OF 3
SUBJECT: Treatment Plant Cost Items for Metal Removal (Design is for cost estimation purposes only)		CHECKED BY: [signature]	DATE: 7-19-89

1. EQUALIZATION (WET WELL) - assume 30 min detention time (DT)

   - V = (44 gpm)(30 min) = 1320 gal (176 ft³) ⇒ 1500 GAL

   assume cylindrical tank with h = D

   $V = \frac{\pi D^3}{4} = 176 \text{ ft}^3$ D = 6 ft   H = 6 ft + 2 ft freeboard (FB) = 8 ft

   - mixer 1/2 HP per 1000 gal   USE ~~1/2~~ 3/4 HP MIXER

2. RAW WATER FEED PUMPS
   - same as effluent pumps 44 gpm ($2000 M, $400 L)

3. REACTION TANK (MIXING TANK) - assume 5 min DT

   - V = (44 gpm)(5 min) = 220 gal ⇒ 250 GAL

   - mixer 1/8 HP

4. NaOH FEED SYSTEM   50% NaOH - 31 gal/day
   feed from drums

   pump 31 gal/day ÷ 24 = 1.3 gph ⇒ say 2 gph

5. pH control system - need 2

6. FLOCCULATION TANK assume 20 min DT

   V = (44 gpm)(20 min) = 880 gal ⇒ 1000 GAL

001530

CLIENT: USEPA Region II	FILE NO.: L725	BY: KCT	PAGE 2 OF 3
SUBJECT: Treatment Plant - Cost Items for Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

7. POLYMER FEED SYSTEM assume 0.5 mg/l dosage

$$\frac{0.5\,mg}{l} \cdot \frac{44\,gal}{min} \cdot \frac{3.785\,l}{gal} \cdot \frac{lb}{454{,}000\,mg} \cdot \frac{1440\,min}{day} = 0.26\ lb/day \quad (0.01\ lb/hr)$$

feed @ 1% solution $\frac{0.01\,lb}{hr} \cdot \frac{100\,lb}{1\,lb} \cdot \frac{gal}{8.34\,lb} = 0.12\ gph \Rightarrow 0.2\ gph$

8. CLARIFIER

assume overflow rate of 600 gpd/ft² min DT = 2 hrs

$$\frac{44\,gal}{min} \cdot \frac{1440\,min}{day} \cdot \frac{ft^2\text{-}day}{600\,gal} = 106\ ft^2 \qquad D = 12\ ft$$

$$\frac{44\,gal}{min} \cdot 2\,hr \cdot \frac{60\,min}{hr} \cdot \frac{ft^3}{7.48\,gal} = 706\ ft^3$$

$$Depth = \frac{706\,ft^3}{106\,ft^2} = 7\ ft + 2'\ FB = 9\ ft$$ ⇒ SAY 12 FT (allow extra sludge capacity)

9. SLUDGE PUMPS

Sludge produced at 1404 gpd ~ 1gpm

pump out 1 day sludge volume in 1 hr (60 min)

Q = 25 gpm

10. pH ADJUSTMENT TANK - assume same as REACTION TANK

V = 220 gal 1/8 HP MIXER SAY 250 GAL

11. ACID FEED SYSTEM - 7 gpd - feed from drums/carboys/etc

pumps - 0.12 gph

001531

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: USEPA Region II	FILE NO.: L 725	BY: KCT	PAGE 3 OF 3
SUBJECT: Treatment Plant - Cost Items for Metal Removal		CHECKED BY: [signature]	DATE: 7-19-89

12. AIR STRIPPER FEED PUMPS – same as effluent pumps

44 gpm ($2000 M / $400 L)

13. SAND FILTERS assume loading rate of 3 gpm/ft², need 2

$\frac{44 \text{ gpm}}{} \Big| \frac{ft^2}{3 \text{ gpm}} = 15 \text{ ft}^2$ use 4' ⌀ or 4'⌀ filter

Backwash tank backwash rate 100 gal/ft² x 15 ft² = 1500 gal

Backwash pumps ~~rate~~ 15 gpm/ft² x 15 ft² = 225 gpm

Filter feed pumps 44 gpm – same as other feed pumps

14. Vapor Phase Carbon Adsoption ⇒ NEED

15. GAC system (as per Calgon)
 Mob $50,000
 Demob 15,000

 Lease unit 4700/mo = 56,400/yr (YR 1→2)
 Carbon $144,000/yr (YR 1 – 2) (14 lb/1000 gal)

16. GAC feed pumps – same as other 44 gpm pumps

17. Filter Press – same as Douglassville ($65,000 M / $16,000 labor)
 Feedpumps $4000 M / $600 L

001532

NUS CORPORATION AND SUBSIDIARIES — STANDARD CALCULATION SHEET

CLIENT: USEPA Region 2	FILE NO.: L725	BY: KCT	PAGE 1 OF 1
SUBJECT: Equipment Summary - Additional Cost Items Based on Draft FS Comments		CHECKED BY: [signature]	DATE: 7-19-89

Item	Qty	Comments
Equalization Tank	1	1500 GAL
Equalization Tank Mixer	1	3/4 HP
Raw Water Feed Pumps	2	44 GPM ($2000 M, $400 L)
Mixing Tank	1	250 GAL
Mixing Tank Mixer	1	1/8 HP
NaOH Feed Pumps	2	2 GPH
pH Control System	2	
Flocculation Tank	1	1000 GAL
Polymer Feed System	1	0.2 GPH
Clarifier	1	12 FT DIAM
Sludge Pumps	2	25 GPM
pH Adjustment Tank	1	250 GAL
pH Adjustment Tank Mixer	1	1/8 HP
Acid Feed Pumps	2	0.2 GPH
Air Stripper Feed Pumps	2	44 GPM ($2000 M, $400 L)
Vapor Phase Carbon Adsorption	1	
Filter Feed Pumps	2	44 GPM ($2000 M, $400 L)
Sand Filters	2	4' SQ OR 4' DIAM
Backwash Tank	1	1500 GAL
Backwash Pumps	2	225 GPM
Carbon Adsorption System - Mobilization		($50,000 SUB) (Leased Units)
Demobilization		($15,000 SUB) (Leased Units)
Carbon Adsorption Feed Pumps	2	44 GPM ($2000 M, $400 L)
Filter Press	1	($65,000 M, $16,000 L)
Filter Press Feed Pumps	2	($4000 M, $600 L)

001533

NUS CORPORATION AND SUBSIDIARIES	STANDARD CALCULATION SHEET

CLIENT: USEPA REGION II	**FILE NO.:** L725	**BY:** KCT	**PAGE** 1 **OF** 1
SUBJECT: ADDITIONAL ANNUAL COSTS FOR TREATMENT BASED ON DRAFT FS COMMENTS		**CHECKED BY:** [signature]	**DATE:** 7-19-89

				Present Worth #1	Present Worth #2
50% NaOH	31 gal/day	=	11,315 gal/yr	YR 1-20	YR 1-30
Polymer	0.26 lb/day	=	95 lb/yr	YR 1-20	YR 1-30
66° Be' H_2SO_4	7 gal/day	=	2,555 gal/yr	YR 1-20	YR 1-30
* Lease Carbon Adsorption System			$56,400/yr	YR 1-2	YR 1-2
* Granular Activated Carbon			$144,000/yr	YR 1-2	YR 1-2
* Vapor Phase Carbon				YR 1-20	YR 1-30
Sludge Hauling & Disposal				YR 1-20	YR 1-30

12 ft^3 dewatered sludge/day - 165 yd^3/yr (hazardous waste)

* Vendor quote (CALGON)

001534

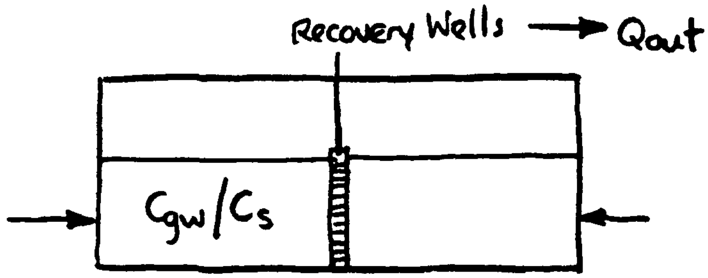
NUS 155A REVISED 0285

Aquifer Restoration Times

NUS CORPORATION AND SUBSIDIARIES			STANDARD CALCULATION SHEET
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 1 OF 9
SUBJECT: Time to Achieve Aquifer Restoration		CHECKED BY: KCT	DATE: 6-10-89

Objective - determine theoretical aquifer restoration times based on maximum contaminant concentrations, ARARs and risk-based cleanup goals, partitioning between soil and groundwater, and aquifer pumping times

Approach - a simplified mass balance approach will be used to estimate restoration times, as follows:



Accumulation = Mass In − Mass Out

Accumulation (removal) = change in mass with respect to time: dM/dt

Mass in = 0 (assume that groundwater outside the contaminated zone has no contaminants, furthermore concentrations in water from recharge basins are negligible after treatment ≈ 0)

Mass out = $Q_{out} \times C_{gw}$

Assumptions: Groundwater concentrations in the contaminated portions of the aquifer are homogenous and equal to the maximum observed concentrations.

Equilibrium partitioning between the solid and aqueous aquifer matrices is reversible and instantaneous.

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The contaminant mass in the aquifer at time t=0 consists of the total mass in the water and the total mass in the soil. The mass in the water is as follows:

$$Mass_w = \theta V C_{gw}$$

where: θ is the porosity of the aquifer matrix (decimal fraction)
V is the total volume of contaminated groundwater and saturated subsurface soil (liters)
C_{gw} is the groundwater concentration of the contaminant of interest (μg/liter)

The mass in the soil may be determined as follows:

$$Mass_s = (1-\theta) V C_s \rho_s$$

where: C_s is the soil concentration of the contaminant of interest (μg/kg)
ρ_s is the density of the soil (kg/liter)

The soil concentration and the water concentration may be equated using a partition coefficient (kd) as follows:

$$C_s = Kd C_w = f_{oc} \cdot K_{oc} \cdot C_w$$

where: f_{oc} is the fractional organic carbon content of the soil (kg organic carbon/kg soil)
K_{oc} is the soil/sediment adsorption coefficient (μg/kg organic carbon / μg/liter water)

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Therefore, the mass balance may be expressed as:

$$\text{Removal} = \frac{dM}{dt} = -QC_{gw}$$

$$\Rightarrow \frac{d\left[\theta V C_{gw} + (1-\theta)V\rho_s f_{oc} K_{oc} C_{gw}\right]}{dt} = -QC_{gw}$$

Since V, θ, ρ_s, foc, and Koc are constants, the ordinary derivative may be expressed as:

$$\left[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}\right]\frac{dC_{gw}}{dt} = -QC_{gw}$$

Separation of variables yields:

$$\frac{1}{C_{gw}} \cdot \frac{dC_{gw}}{dt} = \frac{-Q}{\left[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}\right]}$$

Integrating with respect to time:

$$\int \frac{1}{C_{gw}} \frac{dC_{gw}}{dt}\, dt = \int \frac{-Q}{\left[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}\right]}\, dt$$

Yields:

$$\ln C_{gw} = \frac{-Q}{\left[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}\right]}\, t + K$$

where: K is a constant of integration

initial condition @ $t=0$ $C = C_o$ (initial concen.)

001538

Solving for Cgw yields:

$$C_{gw} = \exp\left[\frac{-Qt}{[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}]} + K\right]$$

$$= \exp[K] \exp\left[\frac{-Qt}{[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}]}\right]$$

$$= \hat{K} \exp\left[\frac{-Qt}{[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}]}\right]$$

Imposing the initial condition yields:

$$C_{gw} = C_o \exp\left[\frac{-Qt}{[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}]}\right]$$

The time to achieve restoration can be estimated by taking the natural logarithm of both sides.

$$\ln\left[\frac{C_{gw}}{C_o}\right] = -Qt/[\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}]$$

Therefore:

$$(1) \quad t = \frac{\ln\left[\frac{C_{gw}}{C_o}\right][\theta V + (1-\theta)V\rho_s f_{oc} K_{oc}]}{-Q}$$

where t is the time to achieve a specified cleanup goal (C_{gw}) given an initial concentration of C_o.

001539

NUS CORPORATION AND SUBSIDIARIES			STANDARD CALCULATION SHEET
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 5 OF 9
SUBJECT: Time to Achieve Aquifer Restoration		CHECKED BY: KCT	DATE: 6-10-89

The total volume of the contaminant plumes (V) may be determined as follows:

Source Area 1 - Assumptions

Plume is elliptical in shape.
Major axis (a) = 225 feet
Minor axix (b) = 150 feet

$$\text{Area} = \pi ab = \pi(225)(150) = 106029 \text{ ft}^2$$

Saturated thickness = 20 feet

$$V = (20\text{ft})(106029\text{ft}^2) = 2{,}120{,}580 \text{ ft}^3$$

$$V = \frac{2{,}120{,}580 \text{ ft}^3 \mid 28.32 \text{ liters}}{\mid \text{ft}^3} = 5.05 \times 10^7 \text{ liters}$$

Maintenance Building Source - Assumptions

Plume is circular in shape.
Radius = 150 ft

$$\text{Area} = \pi R^2 = \pi(150)^2 = 70685.8 \text{ ft}^2$$

$$V = 20\text{ft}(70685.8 \text{ ft}^2) = 1413716.7 \text{ ft}^3$$

$$V = \frac{1413716.7 \text{ ft}^3 \mid 28.32 \text{ liters}}{\mid \text{ft}^3} = 4.00 \times 10^7 \text{ liters}$$

$$V_{TOTAL} = 5 \times 10^7 \text{ liters} + 4 \times 10^7 \text{ liters}$$

$$\approx 1 \times 10^8 \text{ liters.}$$

Additional Assumptions:

Θ (porosity) = 0.2 (liters H_2O / liter aquifer)
ρ_s (density) = 2 (Kg soil / liter soil)
foc = 9.6×10^{-3} (Kg org. carbon / kg soil) (based on TOC results)
Koc values are summarized in Table 5-1 of the RI (Volume I)
Q = 44 gpm = 167 liters H_2O / min (recovery well system design)

Sample Calculation:

Compound of interest = 1,1,1-trichloroethane

Maximum Concentration (C_0) = 4,400 µg/liter
Target Concentration (C_{gw}) = 200 µg/liter (MCL)
Koc = 152 µg/kg org. carbon / µg/liter H_2O

Input parameters for Eqn 1 are as follows:

$$\Theta V = \frac{0.2 \text{ liters } H_2O}{\text{liter aquifer}} \Big| 1\times10^8 \text{ liters aquifer} = 2.0\times10^7 \text{ liters } H_2O$$

$$(1-\Theta)V\rho_s K_{oc} f_{oc} = \frac{0.8 \text{ liters soil}}{\text{liters aquifer}} \Big| 1\times10^8 \text{ liters aquifer} \Big| \frac{2 \text{ Kg soil}}{\text{liter soil}} \Big| \frac{9.6\times10^{-3} \text{ Kg org carbon}}{\text{Kg soil}} \cdot \frac{152 \text{ µg/kg org carbon}}{\text{µg/liter } H_2O} = 2.335\times10^8 \text{ liters } H_2O$$

$$t = -\ln\left[\frac{200 \text{ µg/liter}}{4{,}400 \text{ µg/liter}}\right]\left[(2.0\times10^7 + 2.335\times10^8) \text{ liters } H_2O\right] \Big/ 167 \frac{\text{liters}}{\text{min}}$$

$$= 4.69\times10^6 \text{ min}$$

$$= \frac{4.69\times10^6 \text{ min}}{} \Big| \frac{\text{hour}}{60 \text{ min}} \Big| \frac{\text{day}}{24 \text{ hour}} \Big| \frac{\text{year}}{365 \text{ days}} = 8.9 \text{ years}$$

001541

NUS CORPORATION AND SUBSIDIARIES			STANDARD CALCULATION SHEET
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 7 OF 9
SUBJECT: Time to Achieve Aquifer Restoration		CHECKED BY: KCT	DATE: 6-10-89

Time Required to remove the remaining contaminants is summarized in the attached spreadsheet.

In addition, the residual concentrations after a 20-year operational period (time to meet the cleanup goal for PCE) are also summarized.

The attached risk assessment spreadsheet shows that the incremental cancer risk for these concentrations is 8×10^{-5} which satisfies the requirement that risks are less than 1×10^{-4}.

As shown on the spreadsheet requiring attainment of concentrations corresponding to a 10^{-6} risk, it would require approximately 90 years.

001542

Determine Aquifer Restoration Times

Site Name: Byron Barrel and Drum
Date: June 1989

Relevant Equation:

t = -{V*[n + (1-n)pKd}/Q * ln[Cgw/Co]

Where: t is the time to achieve remediation (minutes)
V is the total volume of the contaminated aquifer (liters)
n is the porosity of the aquifer matrix (decimal fraction)
p is the bulk density of the soil matrix (kg/liter)
Foc is the fractional inorganic carbon content of the soil (kg/kg)
Koc is the soil/sediment adsorption coefficient of the contaminant (ug/kg/ug/l)
Q is the recovery well pumping rate (l/min)
Ccu is the groundwater cleanup goal (ug/l)
Co is the groundwater concentration at t = 0 (ug/l)

Enter Input Parameters:

V = 1e8
n = .2
p = 2
Foc = .0096
Q = 167

Enter Contaminant Specific Information:

Contaminant	Co (ug/l)	Ccu (ug/l)	Koc (ug/kg/ug/l)	t (min)	t (years)
benzene	.5	5	65	0	0
bromodichloromethane	.23	100	84	0	0
2-butanone	3000	170	17	7.9262e5	1.508031
carbon tetrachloride	290	100	439	4.4265e6	8.421888
chlorobenzene	.25	488	330	0	0
chlorodibromomethane	.14	100	84	0	0
chloroform	.51	100	44	0	0
1,2-dichlorobenzene	.026	620	1700	0	0
1,4-dichlorobenzene	2	75	1700	0	0
1,1-dichloroethane	290	5	30	1.6067e6	3.056832
1,2-dichloroethane	.41	5	14	0	0
1,1-dichloroethene	41	7	65	1.2685e6	2.413399
methylene chloride	2.8	100	8.8	0	0
N-nitrosodiphenylamine	2	4.9	648	0	0
tetrachloroethene	82	5	364	9.7001e6	18.45529
toluene	1	5	300	0	0
1,1,1-trichloroethane	4400	200	152	4.6916e6	8.926128
1,1,2-trichloroethane	3.7	5	56	0	0
trichloroethene	3300	5	126	8.3014e6	15.79406
vinyl chloride	.06	2	8.2	0	0
xylenes	3	440	248	0	0

Time to Achieve Restoration for Most Difficult Contaminant: 18.5 (years)

001543

Determine Residual Concentrations After T Years of Operation:

T = 20

Chemical	Residual Concentration (ug/l)
benzene	2.173e-7
bromodichloromethane	1.761e-6
2-butanone	8.78e-14
carbon tetrachloride	2.3137e1
chlorobenzene	8.931e-3
chlorodibromomethane	1.072e-6
chloroform	1.006e-9
1,2-dichlorobenzene	1.334e-2
1,4-dichlorobenzene	1.0263e0
1,1-dichloroethane	8.41e-10
1,2-dichloroethane	1.75e-19
1,1-dichloroethene	1.782e-5
methylene chloride	5.01e-23
N-nitrosodiphenylamine	3.549e-1
tetrachloroethene	3.9563e0
toluene	2.596e-2
1,1,1-trichloroethane	4.3212e0
1,1,2-trichloroethane	2.381e-7
trichloroethene	8.874e-1
vinyl chloride	2.44e-25
xylenes	3.763e-2

RISK ASSESSMENT SPREADSHEET - EXPOSURES THROUGH HOUSEHOLD USE OF GROUNDWATER

SITE NAME: BYRON BARREL AND DRUM SITE
LOCATION: BYRON, NEW YORK
DATE: MAY 5, 1989

HAZARD INDICES AND INCREMENTAL CANCER RISKS ARE CALCULATED BY THIS SPREADSHEET. TWO EXPOSURE ROUTES ARE CONSIDERED: INGESTION OF GROUNDWATER AND INHALATION OF VOLATILES DURING SHOWERING. ASSUMPTIONS ARE OUTLINED BELOW.

DETERMINE RESIDUAL RISK AFTER ATTAINMENT OF ARARS

REFERENCES:
EPA, OCTOBER 1986
FOSTER, ET AL., 1987
DONIGIAN, ET AL., NOVEMBER, 1983
EPA, JULY 29, 1986
EPA, NOVEMBER 27, 1985

INGESTION: DOSE = (C x IR x AF)/BW

WHERE:
C = GROUNDWATER CONCENTRATION (MG/L)
IR = INGESTION RATE (LITERS/DAY)
AF = ABSORPTION FRACTION (DECIMAL FRACTION)
BW = BODY WEIGHT (KG)

INHALATION: DOSE = (S x IR)/(BW X Ra X 10E6) X (Ds + EXP(-Ra X Dt)/Ra - EXP(Ra X (Ds - Dt))/Ra)

WHERE:
S = VOLATILE ORGANIC CHEMICAL GENERATION RATE (UG/CUBIC METER/MIN)
IR = INHALATION RATE (LITERS/SEC)
Ds = SHOWER DURATION (MIN)
Ra = AIR EXCHANGE RATE (1/MIN)
Dt = TOTAL DURATION IN SHOWER ROOM (MIN)
BW = BODY WEIGHT (KG)

ENTER INPUT PARAMETERS:

INGESTION: ADULT EXPOSURE

IR:	2	CONVERSION	.0285714
AF:	1	FACTOR =	
BW:	70		

INHALATION: ADULT EXPOSURE

IR:	20	d:	1
BW:	70	Ts:	2
Ds:	15	Tl:	293
Dt:	20	Ts:	318
Ra:	.0083	M1:	.982
SV:	12	M2:	.616
ED:	40	T:	293
R:	.000082	FR:	10

0015455

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE TWO)
BYRON BARREL AND DRUM SITE
DETERMINE RESIDUAL RISK AFTER ATTAINMENT OF ARARS
CALCULATE DOSES:

CHEMICAL	CONCENTRATION (MG/L)	MOLECULAR WEIGHT	HENRYS LAW CONSTANT	MASS TRANSFER COEFFICIENT (KAl)	INGESTION DOSE	INHALATION DOSE
ACETONE				0	0	0
2-BUTANONE	8.78e-17	72.1	2.08e-5	1.5760e0	2.51e-18	1.89e-19
4-METHYL-2-PENTANONE				0	0	0
BENZENE	2.17e-10	78.12	5.5e-3	1.8884e1	6.21e-12	4.28e-12
ETHYLBENZENE				0	0	0
TOLUENE	2.596e-5	92.13	6.66e-3	1.7521e1	7.417e-7	4.841e-7
XYLENES	3.763e-5	106.17	4.33e-3	1.6010e1	1.075e-6	6.560e-7
CHLOROBENZENE	8.931e-6	112.56	3.58e-3	1.5373e1	2.552e-7	1.510e-7
1,2-DICHLOROBENZENE	1.334e-5	147.01	1.93e-3	1.2739e1	3.811e-7	1.946e-7
1,4-DICHLOROBENZENE	1.026e-3	147.01	3.1e-3	1.3316e1	2.932e-5	1.551e-5
VINYL CHLORIDE	2.44e-28	62.5	8.14e-2	2.2005e1	6.97e-30	5.35e-30
1,1,2-TRICHLOROETHANE	2.38e-10	133.41	7.42e-4	1.1296e1	6.80e-12	3.15e-12
1,1,1-TRICHLOROETHANE	4.321e-3	133.41	3e-2	1.4983e1	1.235e-4	7.161e-5
1,2-DICHLORETHANE	1.75e-22	98.96	9.14e-4	1.3769e1	5e-24	2.72e-24
1,1-DICHLOROETHANE	8.41e-13	98.96	4.26e-3	1.6568e1	2.40e-14	1.50e-14
TETRACHLOROETHENE	3.956e-3	165.83	1.53e-2	1.3333e1	1.130e-4	5.984e-5
TRICHLOROETHENE	8.874e-4	131.39	9.1e-3	1.4816e1	2.535e-5	1.458e-5
1,1-DICHLOROETHENE	1.782e-8	96.94	1.9e-1	1.7700e1	5.09e-10	3.35e-10
CARBON TETRACHLORIDE	2.314e-2	153.82	2.3e-2	1.3918e1	6.611e-4	3.620e-4
CHLOROFORM	1.01e-12	119.38	2.88e-3	1.4693e1	2.87e-14	1.64e-14
METHYLENE CHLORIDE	5.01e-26	84.94	2.03e-3	1.6855e1	1.43e-27	9.08e-28
CHLOROMETHANE				0	0	0
BROMODICHLOROMETHANE	1.761e-9	163.83	2.41e-3	1.2350e1	5.03e-11	2.51e-11
CHLORODIBROMOMETHANE	1.072e-9	208.3	9.9e-4	9.6499e0	3.06e-11	1.24e-11
2-CHLOROETHYLVINYLETHER				0	0	0
CARBON DISULFIDE				0	0	0
BENZO(A)ANTHRACENE				0	0	0
BENZO(B)FLUORANTHENE				0	0	0
BENZO(A)PYRENE				0	0	0
POLYCHLORINATED BIPHENYLS				0	0	0
N-NITROSODIPHENYLAMINE	3.549e-4	198.2	6.6e-4	8.9856e0	1.014e-5	3.872e-6
BIS(2-ETHYLHEXYL)PHTHALATE				0	0	0
MERCURY				0	0	0
BARIUM				0	0	0
CHROMIUM				0	0	0
COPPER				0	0	0
LEAD				0	0	0
NICKEL				0	0	0
VANADIUM				0	0	0
ZINC				0	0	0

001546

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE THREE)
BYRON BARREL AND DRUM SITE
DETERMINE RESIDUAL RISK AFTER ATTAINMENT OF ARARS
CALCULATE HAZARD INDICES:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	REFERENCE DOSE ING.	REFERENCE DOSE INH.	HAZARD IND. ING.	HAZARD IND. INH.	HAZARD INDEX
ACETONE	0	0	1e-1		0	0	0
2-BUTANONE	2.51e-18	1.89e-19	5e-2	9e-2	5.02e-17	2.10e-18	5.23e-17
4-METHYL-2-PENTANONE	0	0	5e-2	2e-2	0	0	0
BENZENE	6.21e-12	4.28e-12			0	0	0
ETHYLBENZENE	0	0	1e-1		0	0	0
TOLUENE	7.417e-7	4.841e-7	3e-1	1e0	2.472e-6	4.841e-7	2.956e-6
XYLENES	1.075e-6	6.560e-7	2e0	4e-1	5.376e-7	1.640e-6	2.178e-6
CHLOROBENZENE	2.552e-7	1.510e-7	3e-2	5e-3	8.506e-6	3.019e-5	3.870e-5
1,2-DICHLOROBENZENE	3.811e-7	1.946e-7	4e-1	4e-1	9.529e-7	4.864e-7	1.439e-6
1,4-DICHLOROBENZENE	2.932e-5	1.551e-5			0	0	0
VINYL CHLORIDE	6.97e-30	5.35e-30			0	0	0
1,1,2-TRICHLOROETHANE	6.80e-12	3.15e-12	4e-2		1.70e-10	0	1.70e-10
1,1,1-TRICHLOROETHANE	1.235e-4	7.161e-5	9e-2	3e-1	1.372e-3	2.387e-4	1.611e-3
1,2-DICHLORETHANE	5e-24	2.72e-24			0	0	0
1,1-DICHLOROETHANE	2.40e-14	1.50e-14	1e-1		2.40e-13	0	2.40e-13
TETRACHLOROETHENE	1.130e-4	5.984e-5	1e-2	1e-1	1.130e-2	5.984e-4	1.190e-2
TRICHLOROETHENE	2.535e-5	1.458e-5			0	0	0
1,1-DICHLOROETHENE	5.09e-10	3.35e-10	9e-3		5.657e-8	0	5.657e-8
CARBON TETRACHLORIDE	6.611e-4	3.620e-4	7e-4		9.444e-1	0	9.444e-1
CHLOROFORM	2.87e-14	1.64e-14	1e-2		2.87e-12	0	2.87e-12
METHYLENE CHLORIDE	1.43e-27	9.08e-28	6e-2		2.39e-26	0	2.39e-26
CHLOROMETHANE	0	0			0	0	0
BROMODICHLOROMETHANE	5.03e-11	2.51e-11			0	0	0
CHLORODIBROMOMETHANE	3.06e-11	1.24e-11	2e-1		1.53e-10	0	1.53e-10
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0	1e-1		0	0	0
BENZO(A)ANTHRACENE	0	0			0	0	0
BENZO(B)FLUORANTHENE	0	0			0	0	0
BENZO(A)PYRENE	0	0			0	0	0
POLYCHLORINATED BIPHENYLS	0	0			0	0	0
N-NITROSODIPHENYLAMINE	1.014e-5	3.872e-6			0	0	0
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	2e-2		0	0	0
MERCURY	0	0	3e-4		0	0	0
BARIUM	0	0	5e-2	1e-4	0	0	0
CHROMIUM	0	0	1e0		0	0	0
COPPER	0	0	3.7e-2	1e-2	0	0	0
LEAD	0	0	1.4e-3		0	0	0
NICKEL	0	0	2e-2		0	0	0
VANADIUM	0	0	1e-3		0	0	0
ZINC	0	0	2e-1		0	0	0
TOTAL HAZARD INDEX							9.579e-1

RISK ASSESSMENT SPREADSHEET - HOUSEHOLD USE OF GROUNDWATER (PAGE FOUR)
BYRON BARREL AND DRUM SITE
DETERMINE RESIDUAL RISK AFTER ATTAINMENT OF ARARS
CALCULATE INCREMENTAL CANCER RISK:

CHEMICAL	INGESTION DOSE	INHALATION DOSE	POTENCY FACTOR ING.	POTENCY FACTOR INH.	CANCER RISK ING.	CANCER RISK INH.	CANCER RISK
ACETONE	0	0			0	0	0
2-BUTANONE	2.51e-18	1.89e-19			0	0	0
4-METHYL-2-PENTANONE	0	0			0	0	0
BENZENE	6.21e-12	4.28e-12	2.9e-2	2.9e-2	1.03e-13	7.09e-14	1.74e-13
ETHYLBENZENE	0	0			0	0	0
TOLUENE	7.417e-7	4.841e-7			0	0	0
XYLENES	1.075e-6	6.560e-7			0	0	0
CHLOROBENZENE	2.552e-7	1.510e-7			0	0	0
1,2-DICHLOROBENZENE	3.811e-7	1.946e-7			0	0	0
1,4-DICHLOROBENZENE	2.932e-5	1.551e-5	2.4e-2		4.021e-7	0	4.021e-7
VINYL CHLORIDE	6.97e-30	5.35e-30	2.3e0	2.95e-1	9.16e-30	9.01e-31	1.01e-29
1,1,2-TRICHLOROETHANE	6.80e-12	3.15e-12	5.7e-2	5.7e-2	2.22e-13	1.03e-13	3.24e-13
1,1,1-TRICHLOROETHANE	1.235e-4	7.161e-5			0	0	0
1,2-DICHLORETHANE	5e-24	2.72e-24	9.1e-2	9.1e-2	2.6e-25	1.41e-25	4.01e-25
1,1-DICHLOROETHANE	2.40e-14	1.50e-14	9.1e-2		1.25e-15	0	1.25e-15
TETRACHLOROETHENE	1.130e-4	5.984e-5	5.1e-2	3.3e-3	3.294e-6	1.128e-7	3.407e-6
TRICHLOROETHENE	2.535e-5	1.458e-5	1.1e-2	1.3e-2	1.594e-7	1.083e-7	2.677e-7
1,1-DICHLOROETHENE	5.09e-10	3.35e-10	6e-1	1.2e0	1.75e-10	2.30e-10	4.04e-10
CARBON TETRACHLORIDE	6.611e-4	3.620e-4	1.3e-1	1.3e-1	4.911e-5	2.689e-5	7.600e-5
CHLOROFORM	2.87e-14	1.64e-14	6.1e-3	8.1e-2	1.00e-16	7.60e-16	8.60e-16
METHYLENE CHLORIDE	1.43e-27	9.08e-28	7.5e-3	1.4e-2	6.13e-30	7.26e-30	1.34e-29
CHLOROMETHANE	0	0	1.3e-2	6.3e-3	0	0	0
BROMODICHLOROMETHANE	5.03e-11	2.51e-11	1.3e-1		3.74e-12	0	3.74e-12
CHLORODIBROMOMETHANE	3.06e-11	1.24e-11	8.4e-2		1.47e-12	0	1.47e-12
2-CHLOROETHYLVINYLETHER	0	0			0	0	0
CARBON DISULFIDE	0	0			0	0	0
BENZO(A)ANTHRACENE	0	0	1.54e-1	8.17e-2	0	0	0
BENZO(B)FLUORANTHENE	0	0	9.2e-1	4.9e-1	0	0	0
BENZO(A)PYRENE	0	0	1.15e0	6.1e0	0	0	0
POLYCHLORINATED BIPHENYLS	0	0	7.7e0		0	0	0
N-NITROSODIPHENYLAMINE	1.014e-5	3.872e-6	4.9e-3		2.839e-8	0	2.839e-8
BIS(2-ETHYLHEXYL)PHTHALATE	0	0	1.4e-2		0	0	0
MERCURY	0	0			0	0	0
BARIUM	0	0			0	0	0
CHROMIUM	0	0			0	0	0
COPPER	0	0			0	0	0
LEAD	0	0			0	0	0
NICKEL	0	0		8.4e-1	0	0	0
VANADIUM	0	0			0	0	0
ZINC	0	0			0	0	0
TOTAL RISK							8.011e-5

Determine Aquifer Restoration Times (10-6 Risk)

Site Name: Byron Barrel and Drum
Date: June 1989

Relevant Equation:

$$t = -(V*[n + (1-n)pKd)/Q * \ln[Cgw/Co]$$

Where:
- t is the time to achieve remediation (minutes)
- V is the total volume of the contaminated aquifer (liters)
- n is the porosity of the aquifer matrix (decimal fraction)
- p is the bulk density of the soil matrix (kg/liter)
- Foc is the fractional inorganic carbon content of the soil (kg/kg)
- Koc is the soil/sediment adsorption coefficient of the contaminant (ug/kg/ug/l)
- Q is the recovery well pumping rate (l/min)
- Ccu is the groundwater cleanup goal (ug/l)
- Co is the groundwater concentration at t = 0 (ug/l)

Enter Input Parameters:

V =	1e8
n =	.2
p =	2
Foc =	.0096
Q =	167

Enter Contaminant Specific Information:

Contaminant	Co (ug/l)	Ccu (ug/l)	Koc (ug/kg/ug/l)	t (min)	t (years)
benzene	.5	3.28e-2	65	1.9549e6	3.719339
bromodichloromethane	.23	1.795e-2	84	2.2760e6	4.330320
2-butanone			17	0	0
carbon tetrachloride	290	6.352e-3	439	4.4606e7	84.86619
chlorobenzene			330	0	0
chlorodibromomethane	.14	2.778e-2	84	1.4433e6	2.746019
chloroform	.51	1.578e-2	44	1.8229e6	3.468138
1,2-dichlorobenzene			1700	0	0
1,4-dichlorobenzene	2	9.722e-2	1700	4.7644e7	90.64626
1,1-dichloroethane	290	2.564e-2	30	3.6931e6	7.026516
1,2-dichloroethane	.41	9.024e-3	14	9.4845e5	1.804507
1,1-dichloroethene	41	9.622e-4	65	7.6496e6	14.55394
methylene chloride	2.8	7.889e-2	8.8	7.1635e5	1.362921
N-nitrosodiphenylamine	2	4.762e-1	648	8.7250e6	16.60015
tetrachloroethene	82	4.077e-2	364	2.6377e7	50.18492
toluene			300	0	0
1,1,1-trichloroethane			152	0	0
1,1,2-trichloroethane	3.7	1.295e-2	56	3.5898e6	6.829846
trichloroethene	3300	6.943e-2	126	1.3770e7	26.19873
vinyl chloride	.06	8.691e-4	8.2	8.2651e5	1.572515
xylenes			248	0	0

Time to Achieve Restoration for Most Difficult Contaminant: 90.6 (years)

Air Emissions

NUS CORPORATION AND SUBSIDIARIES			STANDARD CALCULATION SHEET
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 1 OF 2
SUBJECT: Air Emissions - Stripper		CHECKED BY: KCT	DATE: 05/31/89

Objective - determine the theoretical emission rate from air strippers.

Assumptions - Influent concentrations are the maximum observed values, as follows:

Chemical	Influent Concentration (μg/L)
benzene	0.5
bromodichloromethane	0.23
chlorobenzene	0.25
chlorodibromomethane	0.14
chloroform	0.51
1,2-dichlorobenzene	0.026
1,4-dichlorobenzene	2.0
1,1-dichloroethane	290
1,2-dichloroethane	0.41
1,1-dichloroethene	41
methylene chloride	2.8
N-nitrosodiphenylamine	2.0
tetrachloroethene	82
toluene	1.0
1,1,1-trichloroethane	4,400
1,1,2-trichloroethane	3.7
trichloroethene	3,300
vinyl chloride	0.06
xylenes	3.0
2-butanone	600
carbon tetrachloride	290
total	9,020

001551

NUS CORPORATION AND SUBSIDIARIES	STANDARD CALCULATION SHEET

CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 2 OF 2
SUBJECT: Air Emissions - Stripper		CHECKED BY: KCT	DATE: 05/31/89

The influent flow rate to the stripper was estimated as 44 gallons/minute. Assuming a removal efficiency of 100%, worst-case air emission rates may be determined as follows:

$$Q_{air} = \frac{44 \text{ gallons}}{\text{min}} \left| \frac{9{,}020 \, \mu g}{\text{liter}} \right| \frac{\text{liter}}{3.785 \text{ gal}} \left| \frac{60 \text{ min}}{\text{hr}} \right| \frac{g}{1 \times 10^{6} \, \mu g} \left| \frac{\text{lb}}{454 \, g} \right.$$

$$= 0.014 \text{ lbs/hr}$$

001552

NUS CORPORATION AND SUBSIDIARIES			STANDARD CALCULATION SHEET
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 1 OF 2
SUBJECT: Emission Rates - Air Strippers		CHECKED BY: KCT	DATE: 7-15-89

Objective - determine stack concentrations for air strippers.

Chemical	Influent Concen. (ug/L)	Effluent Concen. (ug/L)	
		Stripper #1	Stripper #2
benzene	0.5	0.0005	<0.0001
bromodichloromethane	0.23	0.0032	<0.0001
chlorobenzene	0.25	0.0013	<0.0001
chlorodibromomethane	0.14	0.043	0.003
chloroform	0.51	0.0026	<0.0001
1,2-dichlorobenzene	0.026	0.0009	<0.0001
1,4-dichlorobenzene	2.0	0.02	0.0001
1,1-dichloroethane	290	0.5	<0.01
1,2-dichloroethane	0.41	0.095	0.0035
1,1-dichloroethene	41	0.004	<0.001
methylene chloride	2.8	0.041	0.0001
N-nitrosodiphenylamine	2.0	0.2	0.007
tetrachloroethene	82	0.04	<0.001
toluene	1.0	0.0012	<0.0001
1,1,1-trichloroethane	4,400	1.7	<0.1
1,1,2-trichloroethane	3.7	0.56	0.013
trichloroethene	3,300	2.3	<0.05
vinyl chloride	0.06	<0.0001	<0.0001
xylenes	3.0	0.004	<0.0001
2-butanone	600	570	550
carbon tetrachloride	290	<0.0001	<0.0001

Pertinent information for air strippers:

Stripper	Water Flow Rate (gpm)	Air Flow Rate (cfm)
#1	44	200
#2	44	400

CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 2 OF 2
SUBJECT: Emission Rates - Air Strippers		CHECKED BY: KCT	DATE: 7-15-89

Sample Calculation:

Mass emitted from air stripper #1 (benzene):

$$\frac{44\ \text{gal}}{\text{min}} \left| \frac{\text{liter}}{3.785\ \text{gal}} \right| 0.5\ \mu g/L - 0.0005\ \mu g/L \ = \ \frac{5.81\ \mu g}{\text{min}}$$

Stack concentration:

$$\frac{5.81\ \mu g}{\text{min}} \left| \frac{\text{min}}{200\ ft^3} \right| \frac{ft^3}{0.02832\ m^3} = 1.03\ \mu g/m^3$$

Chemical	Stack Concentration ($\mu g/m^3$) Stripper #1	Stripper #2
benzene	1.03	0.51
bromodichloromethane	0.47	0.24
chlorobenzene	0.51	0.26
chlorodibromomethane	0.20	0.14
chloroform	1.04	0.52
1,2-dichlorobenzene	0.05	0.03
1,4-dichlorobenzene	4.06	2.05
1,1-dichloroethane	594	298
1,2-dichloroethane	0.65	0.42
1,1-dichloroethene	84.1	42.1
methylene chloride	5.66	2.87
N-nitrosodiphenylamine	3.69	2.05
tetrachloroethene	168	84
toluene	2.05	1.03
1,1,1-trichloroethane	9,030	4,520
1,1,2-trichloroethane	6.44	3.78
trichloroethene	6,770	3,390
vinyl chloride	0.12	0.06
xylenes	6.15	3.08
2-butanone	61.5	51.3
carbon tetrachloride	595	298

001554

NUS CORPORATION AND SUBSIDIARIES		STANDARD CALCULATION SHEET	
CLIENT: USEPA Region II	FILE NO.: L725	BY: RJH	PAGE 1 OF 1
SUBJECT: Air Emissions - Thermal Desorption		CHECKED BY: KCT	DATE: 05/31/89

Objective - determine theoretical emission rate from the low temperature thermal desorption unit.

Assumptions - throughput = 6 tons/hour

Concentrations = the maximum observed subsurface soil concentrations (Table 4-4,5 in the RI Report).

Chemical	Concentration (ug/kg)
acetone	270
benzene	19
toluene	2,700
ethylbenzene	51
xylenes	1,700
1,1,1-trichloroethane	551
1,1,2-trichloroethane	12
tetrachloroethene	4,400
trichloroethene	2,800
1,1-dichloroethene	10
1,2-dichloroethene	22
methylene chloride	190
1,3-dichloropropene	7
total	12,730 µg/kg

Assuming a removal efficiency of 100%, a worst-case emission rate may be determined, as follows:

$$Q_{air} = \frac{12{,}730\ \mu g}{kg} \left| \frac{6\ tons}{hr} \right| \frac{2{,}000\ lbs}{ton} \left| \frac{kg}{2.2\ lbs} \right| \frac{g}{1\times10^{6}\ \mu g} \left| \frac{lb}{454\ g} \right.$$

$$= 0.15\ lbs/hr$$

001555

NUS 155A REVISED 0285

In-situ Vapor Extraction

001556

NUS CORPORATION AND SUBSIDIARIES — STANDARD CALCULATION SHEET

CLIENT: US EPA II BYRON BARREL AND DRUM	FILE NO.: L725	BY: KCT	PAGE 1 OF 2
SUBJECT: IN-SITU VAPOR EXTRACTION		CHECKED BY: [signature]	DATE: 6/7/88

1. Calculate total pounds of contaminants in subsurface soils – use analytical results from Source Area 1 (CLP data for maintenance building source not available) Fig 4-4 from RI Report

ug/kg

Test Pit	TCE	TCA	PCE	DCE
TP 0	120	89	13	2
TP 2	2,800	150	4,400	10
TP 5	660	<5	610	<5
TP 7	325	<5	220	<5
TP 8	63	<5	24	<5
TP 10	45	<5	8	<5
TP 12	13	<5	3	<5
Arith. Avg.	575	34	754	<5
Cleanup Goals ARAR	47	–	140	–
10^{-6}	4.9	–	8.4	–

TCE $\frac{0.575\,mg}{kg} \cdot 4100\,yd^3 \cdot \frac{27\,ft^3}{yd^3} \cdot \frac{100\,lb}{ft^3} \cdot \frac{kg}{2.2\,lb} \cdot \frac{gm}{1000\,mg} \cdot \frac{lb}{454\,gm}$

= 6.4 lb

PCE $\frac{0.754\,mg/kg}{0.575\,mg/kg} \cdot 6.4\,lb = 8.4\,lb$

2. Calculate % removal required to meet ARAR & 10^{-6} goals

ARARs TCE $(575-47) \div 575 = 91\%$ PCE 81 %

10^{-6} TCE 99% PCE 99 %

001557

NUS CORPORATION AND SUBSIDIARIES			STANDARD CALCULATION SHEET
CLIENT: USEPA II Byron Barrel & Drum	FILE NO.: L725	BY: KCT	PAGE 2 OF 2
SUBJECT: IN-SITU VAPOR EXTRACTION		CHECKED BY: [signature]	DATE: 6/7/88

3. Determine extraction and injection (passive) wells

Place 1 extraction well at center of each source area. Depth would be to water table (~ 8 ft). Place 4 passive air injection wells around perimeter of each source area. Need to cap source area 1. Building floor is sufficiently impermeable, so no cap or dismantling required.

4. Time to achieve cleanup (Midwest Water Resource, 1987)

for 90 % removal - need 1 pore air volume/day for 90 days
for 99 % removal - need 1 pore air volume/day for 180 days

pore volume $\frac{4{,}100\ yd^3\ soil \mid 27\ ft^3 \mid 0.2\ porosity}{\mid yd^3 \mid} = 22{,}140\ ft^3$

$\frac{22{,}140\ ft^3}{1440\ min} = 16\ cfm \Rightarrow$ blower size

5. Pounds of contaminants to be absorbed onto carbon

assume 100% removal TCE + PCE = 6.4 + 8.4 = 14.8 lb ⇒ say 20 lb

A carbon column won't be needed - disposable vapor-phase carbon adsorption cannisters to be used.

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APPENDIX I

COST ESTIMATES

• Alternative 1

No Action with Monitoring

BRYON BARREL & DRUM SITE
Bryon, New York
No Action With Monitoring
Alternative No. 1
Post Remedial Monitoring
(O&MBBD1)

Annual Costs

ITEM	ITEM $ ANNUAL SAMPLING	ITEM $ ANNUAL SAMPLING	NOTES
1. Sampling	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Analysis	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
3. Reporting	950.00	950.00	20 manhours per annual report plus other direct costs.
4. Analysis Review		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	13550.00	33550.00	Post Remedial monitoring will be performed annually for years 1 thru 30

BYRON BARREL & DRUM SITE
Bryon, New York
No Action With Monitoring
Alternative No. 1
(PWABBD1)
265

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	0											
2. O & M COSTS	---	13.6										
3. ANNUAL COSTS	0	13.6	13.6	13.6	13.6	33.6	13.6	13.6	13.6	13.6	33.6	13.6
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	0	13	12	12	11	26	10	10	9	9	21	8

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	13.6	13.6	13.6	33.6	13.6	13.6	13.6	13.6	33.6	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	8	7	7	16	6	6	6	5	13	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	265

• <u>Alternative 2</u>

Deed and Groundwater Use Restrictions

BYRON BARREL & DRUM SITE
Bryon, New York
Deed And Groundwater Use Restrictions
Alternative No. 2
(BBDS1a)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Cost Sub.	Total Cost Mat.	Total Cost Labor	Total Cost Equip.	Total Direct Cost	Comments
1) Implement Institutional Controls		LS	10000.00				10000				10000	
							10000	0	0	0	10000	
Burden @ 13% of Labor Cost									0		0	
Labor @ 15% of Labor Cost									0		0	
Material @ 5% of Material Cost								0			0	
Subcontract @ 10% of Sub. Cost							1000				1000	
Total Direct Cost							11000	0	0	0	11000	
Indirects @ 75% of Total Direct Labor Cost									0		0	
Profit @ 10% Total Direct Cost											1100	
Total Field Cost											12100	
Contingency @ 20% of Total Field Cost											2420	
TOTAL COST THIS PAGE											14520	

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BRYON BARREL & DRUM SITE
Bryon, New York
Deed And Groundwater Use Restrictions
Alternative No. 2
Post Remedial Monitoring
(O&MBBD1a)

Annual Costs

ITEM	ITEM $ ANNUAL SAMPLING	ITEM $ ANNUAL SAMPLING	NOTES
1. Sampling	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Analysis	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
3. Reporting	950.00	950.00	20 manhours per annual report plus other direct costs.
4. Analysis Review		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	13550.00	33550.00	Post Remedial monitoring will be performed annually for years 1 thru 30

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BYRON BARREL & DRUM SITE
Bryon, New York
Deed And Groundwater Use Restrictions
Alternative No. 2
(PWABBD1a)
279

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	14.5											
2. O & M COSTS	---	13.6										
3. ANNUAL COSTS	14.5	13.6	13.6	13.6	13.6	33.6	13.6	13.6	13.6	13.6	33.6	13.6
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	15	13	12	12	11	26	10	10	9	9	21	8

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	13.6	13.6	13.6	33.6	13.6	13.6	13.6	13.6	33.6	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	8	7	7	16	6	6	6	5	13	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	279

0015667

• Alternative 3

Deed Restrictions
Groundwater Pumping, Treatment, and Discharge to Surface Water

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3
(BBDS2S)

SUMMARY

Item	Sub.	Mat.	Labor	Equip.	
1) EQUIPMENT	91400	278850	55900	0	426150
2) PIPING & INSTRUMENTATION	0	68438	51569	12370	132377
3) FOUNDATION & STRUCTURAL	11520	16065	29750	1785	59120
4) ELECTRICAL	0	78800	59000	0	137800
	102920	442153	196219	14155	755447
Burden @ 13% of Labor Cost			25508		25508
Labor @ 15% of Labor Cost			29433		29433
Material @ 5% of Material Cost		22108			22108
Subcontract @ 10% of Sub. Cost	10292				10292
Total Direct Cost	113212	464261	251160	14155	842788
Indirects @ 75% of Total Direct Labor Cost			188370		188370
Profit @ 10% Total Direct Cost					84279
Total Field Cost					1115437
Contingency @ 20% of Total Field Cost					223087
Engineering @ 15% of Total Field Cost					167316
Total Cost This Page					1505840

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3
(BBDS2)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
EQUIPMENT												
1) Extraction Wells	140	LF	160.00				22400				22400	7 @ 20'
2) Extraction Well Pumps	4			1500.00	400.00			6000	1600		7600	2 @ 18 gpm 2 @ 26 gpm
3) Equalization Tank	1			2500.00	500.00			2500	500		3000	1500 gal
4) Equalization Tank Mixer - 3/4 HP	1			1750.00	400.00			1750	400		2150	
5) Raw Water Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
6) Rapid Mix Tank	1			600.00	200.00			600	200		800	250 gal
7) Rapid Mix Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
8) Caustic Soda Feed Pumps	2			1000.00	200.00			2000	400		2400	3 gph
9) Flocculation Tank	1			6000.00	1500.00			6000	1500		7500	1000gal
10) Polymer Feed System	1			2000.00	400.00			2000	400		2400	0.2 gph
11) Clarifier	1			32400.00	4800.00			32400	4800		37200	12' dia
12) Sludge Transfer Pumps	2			4500.00	600.00			9000	1200		10200	25 gpm
13) PH Adjust Tank	1			600.00	200.00			600	200		800	250 gal
14) PH Adjust Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
15) Acid Feed Pumps	2			1000.00	200.00			2000	400		2400	0.2 gph
16) Air Stripper Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
17) Air Stripping System incl. Stripping Tower, Packing, Blowers	1			25000.00	12500.00			25000	12500		37500	44 gpm
18) Vapor Phase Carbon Adsorption System	1		4000.00				4000				4000	
19) Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
20) Sand Filters	2			40000.00	4000.00			80000	8000		88000	4' dia
21) Backwash Tank	1			2500.00	500.00			2500	500		3000	1500 gal
22) Backwash Pumps	2			4000.00	600.00			8000	1200		9200	225 gpm
23) Carbon Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
24) Carbon Filters (Leased)	1		65000.00				65000				65000	Mob/Demob
25) Sludge Tank	1			2500.00	500.00			2500	500		3000	1500 gal
26) Filter Press Feed Pumps	2			4000.00	600.00			8000	1200		9200	
27) Filter Press	1			65000.00	16000.00			65000	16000		81000	
28) Effluent Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
							91400	278850	55900	0	426150	

001570

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3
(BBDS2)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
PIPING & INSTRUMENTATION												
1) Extraction Wells to Treatment Plant												
A) Piping												
a) 1"	140	LF		6.00	3.75	.15		840	525	21	1386	
b) 1-1/2"	1100	LF		6.00	3.75	.15		6600	4125	165	10890	
c) 2"	100	LF		5.60	4.00	.15		560	400	15	975	
B) Excavation, Backfill, Compaction												
a) 2' wide x 4' deep	1200	LF		.75	4.62	4.14		900	5544	4968	11412	
C) Pipe Bedding												
a) 2' wide (1 Layer)	1200	LF		1.12	1.55			1344	1860		3204	
D) Revegetation	12	MSF		54.00	11.20	10.20		648	134	122	905	
2) Equal. Tank to Mix Tank - 2"	100	LF		13.00	7.00			1300	700		2000	
3) Mix Tank to Floc Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
4) Floc Tank to Clarifier - 4"	100	LF		26.00	14.00			2600	1400		4000	
5) Caustic Soda Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
6) PH Control System	2			5000.00	2000.00			10000	4000		14000	
7) Clarifier Sludge Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
8) Clarifier to PH Adjust Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
9) Acid Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
10) PH Adjust Tank to Air Strip Sump - 4"	100	LF		26.00	14.00			2600	1400		4000	
11) Standpipe to Air Stripper - 2"	50	LF		13.00	7.00			650	350		1000	
12) Air Piping												
a) 4"	100	LF		26.00	14.00			2600	1400		4000	
13) Air Stripper to Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
14) Filter Backwash Piping - 4"	200	LF		26.00	14.00			5200	2800		8000	
15) Filter to Carbon Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
16) Filtrate Return Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
17) Effluent Piping - 2"	1650	LF		5.60	4.00	.15		9240	6600	248	16088	
a) Excavation, Backfill, Compaction	1650	LF		.75	4.62	4.14		1238	7623	6831	15692	
b) Pipe Bedding	1650	LF		1.12	1.55			1848	2558		4406	
18) Plug Valves												
a) 1/2"	8			45.00	25.00			360	200		560	
b) 1"	4			60.00	30.00			240	120		360	
c) 2"	28			120.00	50.00			3360	1400		4760	
19) Check Valves												
a) 1/2"	4			60.00	25.00			240	100		340	
a) 2"	14			150.00	50.00			2100	700		2800	
20) Butterfly Valves												
a) 4"	4			80.00	70.00			320	280		600	
							0	68438	51569	12370	132376	

001521

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3
(BBDS2)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
FOUNDATION & STRUCTURAL												
1) Equalization Tank Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
2) Rapid Mix Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
3) Flocculation Tank Foundation	5	CY		135.00	250.00	15.00		675	1250	75	2000	
4) Clarifier Foundation	20	CY		135.00	250.00	15.00		2700	5000	300	8000	
5) PH Adjust Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
6) Air Stripper Foundation	15	CY		135.00	250.00	15.00		2025	3750	225	6000	
7) Sand Filter Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
8) Carbon Filter Foundation	30	CY		135.00	250.00	15.00		4050	7500	450	12000	
9) Control Building	288	SF	40.00				11520				11520	
10) Control Building Foundation	22	CY		135.00	250.00	15.00		2970	5500	330	8800	
11) Filter Press Support	5	CY		135.00	250.00	15.00		675	1250	75	2000	
							11520	16065	29750	1785	59120	
ELECTRICAL												
1) Motor Starters												
a) #1	32			1000.00	450.00			32000	14400		46400	
2) Disconnect Switches	32			200.00	75.00			6400	2400		8800	
3) Feeder Cable	1200	FT		1.00	1.50			1200	1800		3000	
4) Conduit, Cable, Control												
a) #1	32			350.00	450.00			11200	14400		25600	
5) Grounding		LS		8000.00	8000.00			8000	8000		16000	
6) Miscellaneous Wiring		LS		16000.00	16000.00			16000	16000		32000	
7) Outdoor Lighting		LS		4000.00	2000.00			4000	2000		6000	
							0	78800	59000	0	137800	

BYRON BARREL & DRUM SITE
Bryon, New York
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3
(O&MBBD2a)

Annual Costs - (24 hr/day - 365 days/year)

ITEM	QTY	UNIT	UNIT$	ITEM $	NOTES
1. Energy					
a. Electric	241696	Kw-hr	.085	$20544	Treatment Plant
2. Maintenance				$32600	3% of Capital Cost
3. Operator	1.5	EA	40000.00	$60000	1 Operator - 1st Shift
4. Chemicals					
a) Caustic Soda	71	TON	300.00	$21300	50%
b) Polymer	95	LB	3.50	$333	
c) Sulfuric Acid	20	TON	150.00	$3000	66 Baume
5. Vapor Phase Carbon					
a) Replacement				$3000	
b) Hauling	1	LD	1400.00	$1400	
c) Incineration	.5	TON	250.00	$125	Bridgeport N.J.
6. Sludge Disposal					
a) Hauling	9	LD	240.00	$2160	
b) Disposal	180	TON	188.00	$33840	Model City, N.Y.
7. Carbon Filter					
a) Rental				$56400	Year No. 1 & 2 Only
b) Carbon Replaceme				$144000	Year No. 1 & 2 Only
TOTAL ANNUAL COSTS				$378702	Years 1 and 2
TOTAL ANNUAL COSTS				$178302	Years 3 thru 20

001573

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3 (Present Worth No. 1)
Post Remedial Monitoring
(O&MBBD2)

Annual Costs

ITEM	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 1 THRU 20	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 1 THRU 20	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 21 THRU 30	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 21 THRU 30	NOTES
1. Sampling	3000.00	3000.00	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Sampling	9600.00	9600.00	.00	.00	1 effluent sample, 8 manhours per sampling period(monthly) plus travel, living & sample shipping costs.
3. Analysis	9600.00	9600.00	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
4. Analysis	28800.00	28800.00	.00	.00	3 samples per sampling period (monthly) (inc. blank and duplicate) Volatile Organics
5. Reporting	950.00	950.00	950.00	950.00	20 manhours per annual report plus other direct costs.
6. Reporting	2400.00	2400.00	.00	.00	4 manhours per monthly report plus other direct costs.
7. Analysis Review		20000.00		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	54350.00	74350.00	13550.00	33550.00	Post Remedial monitoring will be performed monthly & annually as noted for years 1 thru 30

BYRON BARREL & DRUM SITE
Bryon, New York
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 3
Present Worth No. 1
(PWABBD2)
4874

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	1505.8											
2. O & M COSTS	---	433.1										
3. ANNUAL COSTS	1505.8	433.1	433.1	232.7	232.7	252.7	232.7	232.7	232.7	232.7	252.7	232.7
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	1506	412	393	201	192	198	174	165	158	150	155	136

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	232.7	232.7	232.7	252.7	232.7	232.7	232.7	232.7	252.7	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	130	123	118	122	107	101	97	92	95	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	4874

• <u>Alternative 4</u>

Soil Capping
Groundwater Pumping, Treatment, and Discharge to Surface Water

BRYON BARREL & DRUM SITE
Bryon, New York
Capping, Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4
(BBDS3S)

SUMMARY

Item	Sub.	Mat.	Labor	Equip.	
1) EQUIPMENT	91400	278850	55900	0	426150
2) PIPING & INSTRUMENTATION	0	68438	51569	12370	132377
3) FOUNDATION & STRUCTURAL	11520	16065	29750	1785	59120
4) ELECTRICAL	0	78800	59000	0	137800
5) CAPPING	18000	17418	26034	47682	109134
	120920	459571	222253	61837	864581
Burden @ 13% of Labor Cost			28893		28893
Labor @ 15% of Labor Cost			33338		33338
Material @ 5% of Material Cost		22979			22979
Subcontract @ 10% of Sub. Cost	12092				12092
Total Direct Cost	133012	482550	284484	61837	961882
Indirects @ 75% of Total Direct Labor Cost			213363		213363
Profit @ 10% Total Direct Cost					96188
Total Field Cost					1271434
Contingency @ 20% of Total Field Cost					254287
Engineering @ 15% of Total Field Cost					190715
Total Cost This Page					1716435

001577

BRYON BARREL & DRUM SITE
Bryon, New York
Capping, Extraçtion, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4
(BBDS3)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
EQUIPMENT												
1) Extraction Wells	140	LF	160.00				22400				22400	7 @ 20'
2) Extraction Well Pumps	4			1500.00	400.00			6000	1600		7600	2 @ 18 gpm 2 @ 26 gpm
3) Equalization Tank	1			2500.00	500.00			2500	500		3000	1500 gal
4) Equalization Tank Mixer - 3/4 HP	1			1750.00	400.00			1750	400		2150	
5) Raw Water Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
6) Rapid Mix Tank	1			600.00	200.00			600	200		800	250 gal
7) Rapid Mix Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
8) Caustic Soda Feed Pumps	2			1000.00	200.00			2000	400		2400	3 gph
9) Flocculation Tank	1			6000.00	1500.00			6000	1500		7500	1000gal
10) Polymer Feed System	1			2000.00	400.00			2000	400		2400	0.2 gph
11) Clarifier	1			32400.00	4800.00			32400	4800		37200	12' dia
12) Sludge Transfer Pumps	2			4500.00	600.00			9000	1200		10200	25 gpm
13) PH Adjust Tank	1			600.00	200.00			600	200		800	250 gal
14) PH Adjust Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
15) Acid Feed Pumps	2			1000.00	200.00			2000	400		2400	0.2 gph
16) Air Stripper Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
17) Air Stripping System incl. Stripping Tower, Packing, Blowers	1			25000.00	12500.00			25000	12500		37500	44 gpm
18) Vapor Phase Carbon Adsorption System	1		4000.00				4000				4000	
19) Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
20) Sand Filters	2			40000.00	4000.00			80000	8000		88000	4' dia
21) Backwash Tank	1			2500.00	500.00			2500	500		3000	1500 gal
22) Backwash Pumps	2			4000.00	600.00			8000	1200		9200	225 gpm
23) Carbon Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
24) Carbon Filters (Leased)	1		65000.00				65000				65000	Mob/Demob
25) Sludge Tank	1			2500.00	500.00			2500	500		3000	1500 gal
26) Filter Press Feed Pumps	2			4000.00	600.00			8000	1200		9200	
27) Filter Press	1			65000.00	16000.00			65000	16000		81000	
28) Effluent Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
							91400	278850	55900	0	426150	

0015278

BRYON BARREL & DRUM SITE
Bryon, New York
Capping, Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4
(BBDS3)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
PIPING & INSTRUMENTATION												
1) Extraction Wells to Treatment Plant												
A) Piping												
a) 1"	140	LF		6.00	3.75	.15		840	525	21	1386	
b) 1-1/2"	1100	LF		6.00	3.75	.15		6600	4125	165	10890	
c) 2"	100	LF		5.60	4.00	.15		560	400	15	975	
B) Excavation, Backfill, Compaction												
a) 2' wide x 4' deep	1200	LF		.75	4.62	4.14		900	5544	4968	11412	
C) Pipe Bedding												
a) 2' wide (1 Layer)	1200	LF		1.12	1.55			1344	1860		3204	
D) Revegetation	12	MSF		54.00	11.20	10.20		648	134	122	905	
2) Equal. Tank to Mix Tank - 2"	100	LF		13.00	7.00			1300	700		2000	
3) Mix Tank to Floc Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
4) Floc Tank to Clarifier - 4"	100	LF		26.00	14.00			2600	1400		4000	
5) Caustic Soda Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
6) PH Control System	2			5000.00	2000.00			10000	4000		14000	
7) Clarifier Sludge Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
8) Clarifier to PH Adjust Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
9) Acid Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
10) PH Adjust Tank to Air Strip Sump - 4"	100	LF		26.00	14.00			2600	1400		4000	
11) Standpipe to Air Stripper - 2"	50	LF		13.00	7.00			650	350		1000	
12) Air Piping												
a) 4"	100	LF		26.00	14.00			2600	1400		4000	
13) Air Stripper to Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
14) Filter Backwash Piping - 4"	200	LF		26.00	14.00			5200	2800		8000	
15) Filter to Carbon Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
16) Filtrate Return Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
17) Effluent Piping - 2"	1650	LF		5.60	4.00	.15		9240	6600	248	16088	
a) Excavation, Backfill, Compaction	1650	LF		.75	4.62	4.14		1238	7623	6831	15692	
b) Pipe Bedding	1650	LF		1.12	1.55			1848	2558		4406	
18) Plug Valves												
a) 1/2"	8			45.00	25.00			360	200		560	
b) 1"	4			60.00	30.00			240	120		360	
c) 2"	28			120.00	50.00			3360	1400		4760	
19) Check Valves												
a) 1/2"	4			60.00	25.00			240	100		340	
a) 2"	14			150.00	50.00			2100	700		2800	
20) Butterfly Valves												
a) 4"	4			80.00	70.00			320	280		600	
							0	68438	51569	12370	132376	

001579

BRYON BARREL & DRUM SITE
Bryon, New York
Capping, Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4
(BBDS3)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
FOUNDATION & STRUCTURAL												
1) Equalization Tank Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
2) Rapid Mix Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
3) Flocculation Tank Foundation	5	CY		135.00	250.00	15.00		675	1250	75	2000	
4) Clarifier Foundation	20	CY		135.00	250.00	15.00		2700	5000	300	8000	
5) PH Adjust Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
6) Air Stripper Foundation	15	CY		135.00	250.00	15.00		2025	3750	225	6000	
7) Sand Filter Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
8) Carbon Filter Foundation	30	CY		135.00	250.00	15.00		4050	7500	450	12000	
9) Control Building	288	SF	40.00				11520				11520	
10) Control Building Foundation	22	CY		135.00	250.00	15.00		2970	5500	330	8800	
11) Filter Press Support	5	CY		135.00	250.00	15.00		675	1250	75	2000	
							11520	16065	29750	1785	59120	
ELECTRICAL												
1) Motor Starters												
a) #1	32			1000.00	450.00			32000	14400		46400	
2) Disconnect Switches	32			200.00	75.00			6400	2400		8800	
3) Feeder Cable	1200	FT		1.00	1.50			1200	1800		3000	
4) Conduit, Cable, Control												
a) #1	32			350.00	450.00			11200	14400		25600	
5) Grounding		LS		8000.00	8000.00			8000	8000		16000	
6) Miscellaneous Wiring		LS		16000.00	16000.00			16000	16000		32000	
7) Outdoor Lighting		LS		4000.00	2000.00			4000	2000		6000	
							0	78800	59000	0	137800	
CAPPING												
1) Dismantle Building	250000	CF			.06	.08			15000	20000	35000	
2) Filter Fabric	2222	SY		1.20	.30			2666	667		3333	
3) Synthetic Membrane	20000	SF	.90				18000				18000	50 mil
4) Sand - 12"	741	CY		7.50	2.70	7.43		5558	2001	5506	13064	20 mi. R.T.
a) Place & Spread	741	CY			.63	.57			467	422	889	
5) Clean Soil - 30"	1852	CY		3.50	2.70	7.43		6482	5000	13760	25243	20 mi. R.T.
a) Place, Spread & Compact	1852	CY			.84	2.67			1556	4945	6501	Sheepsfoot Roller
6) Topsoil - 6"	370	CY		6.00	2.70	7.43		2220	999	2749	5968	20 mi. R.T.
a) Place & Spread	370	CY			.63	.57			233	211	444	
7) Revegetation	20	MSF		24.60	5.60	4.45		492	112	89	693	
							18000	17418	26034	47682	109134	

BYRON BARREL & DRUM SITE
Bryon, New York
Capping, Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4
(O&MBBD3a)

Annual Costs - (24 hr/day - 365 days/year)

ITEM	QTY	UNIT	UNIT$	ITEM $	NOTES
1. Energy					
a. Electric	241696	Kw-hr	.085	$20544	Treatment Plant
2. Maintenance				$37300	3% of Capital Cost
3. Operator	1.5	EA	40000.00	$60000	1 Operator - 1st Shift
4. Chemicals					
a) Caustic Soda	71	TON	300.00	$21300	50%
b) Polymer	95	LB	3.50	$333	
c) Sulfuric Acid	20	TON	150.00	$3000	66 Baume
5. Vapor Phase Carbon					
a) Replacement				$3000	
b) Hauling	1	LD	1400.00	$1400	
c) Incineration	.5	TON	250.00	$125	Bridgeport N.J.
6. Sludge Disposal					
a) Hauling	9	LD	240.00	$2160	
b) Disposal	180	TON	188.00	$33840	Model City, N.Y.
7. Carbon Filter					
a) Rental				$56400	Year No. 1 & 2 Only
b) Carbon Replaceme				$144000	Year No. 1 & 2 Only
TOTAL ANNUAL COSTS				$383402	Years 1 and 2
TOTAL ANNUAL COSTS				$183002	Years 3 thru 20

BRYON BARREL & DRUM SITE
Bryon, New York
Capping, Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4 (Present Worth No. 1)
Post Remedial Monitoring
(O&MBBD3)

Annual Costs

ITEM	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 1 THRU 20	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 1 THRU 20	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 21 THRU 30	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 21 THRU 30	NOTES
1. Sampling	3000.00	3000.00	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Sampling	9600.00	9600.00	.00	.00	1 effluent sample, 8 manhours per sampling period(monthly) plus travel, living & sample shipping costs.
3. Analysis	9600.00	9600.00	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
4. Analysis	28800.00	28800.00	.00	.00	3 samples per sampling period (monthly) (inc. blank and duplicate) Volatile Organics
5. Reporting	950.00	950.00	950.00	950.00	20 manhours per annual report plus other direct costs.
6. Reporting	2400.00	2400.00	.00	.00	4 manhours per monthly report plus other direct costs.
7. Analysis Review		20000.00		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	54350.00	74350.00	13550.00	33550.00	Post Remedial monitoring will be performed monthly & annually as noted for years 1 thru 30

001582

BYRON BARREL & DRUM SITE
Bryon, New York
Capping, Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 4
Present Worth No. 1
(PWABBD3)
5143

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	1716.4											
2. O & M COSTS	---	437.8										
3. ANNUAL COSTS	1716.4	437.8	437.8	237.4	237.4	257.4	237.4	237.4	237.4	237.4	257.4	237.4
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	1716	417	397	205	195	202	177	169	161	153	158	139

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	237.4	237.4	237.4	257.4	237.4	237.4	237.4	237.4	257.4	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	132	126	120	124	109	104	99	94	97	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	5143

• Alternative 5

Soil Excavation and Offsite Disposal
Groundwater Pumping, Treatment, and Discharge to Surface Water

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
(BBDS4S)

SUMMARY

Item	Sub.	Mat.	Labor	Equip.	
1) EQUIPMENT	91400	278850	55900	0	426150
2) PIPING & INSTRUMENTATION	0	68438	51569	12370	132377
3) FOUNDATION & STRUCTURAL	11520	16065	29750	1785	59120
4) ELECTRICAL	0	78800	59000	0	137800
5) OFFSITE DISPOSAL	1317736	17062	34138	70609	1439545
	1420656	459215	230357	84764	2194992
Burden @ 13% of Labor Cost			29946		29946
Labor @ 15% of Labor Cost			34554		34554
Material @ 5% of Material Cost		22961			22961
Subcontract @ 10% of Sub. Cost	142066				142066
Total Direct Cost	1562722	482176	294857	84764	2424518
Indirects @ 75% of Total Direct Labor Cost			221143		221143
Profit @ 10% Total Direct Cost					242452
Total Field Cost					2888113
Contingency @ 20% of Total Field Cost					577623
Engineering @ 15% of Total Field Cost					433217
Total Cost This Page					3898952

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
(BBDS4)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
EQUIPMENT												
1) Extraction Wells	140	LF	160.00				22400				22400	7 @ 20'
2) Extraction Well Pumps	4			1500.00	400.00			6000	1600		7600	2 @ 18 gpm 2 @ 26 gpm
3) Equalization Tank	1			2500.00	500.00			2500	500		3000	1500 gal
4) Equalization Tank Mixer - 3/4 HP	1			1750.00	400.00			1750	400		2150	
5) Raw Water Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
6) Rapid Mix Tank	1			600.00	200.00			600	200		800	250 gal
7) Rapid Mix Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
8) Caustic Soda Feed Pumps	2			1000.00	200.00			2000	400		2400	3 gph
9) Flocculation Tank	1			6000.00	1500.00			6000	1500		7500	1000gal
10) Polymer Feed System	1			2000.00	400.00			2000	400		2400	0.2 gph
11) Clarifier	1			32400.00	4800.00			32400	4800		37200	12' dia
12) Sludge Transfer Pumps	2			4500.00	600.00			9000	1200		10200	25 gpm
13) PH Adjust Tank	1			600.00	200.00			600	200		800	250 gal
14) PH Adjust Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
15) Acid Feed Pumps	2			1000.00	200.00			2000	400		2400	0.2 gph
16) Air Stripper Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
17) Air Stripping System incl. Stripping Tower, Packing, Blowers	1			25000.00	12500.00			25000	12500		37500	44 gpm
18) Vapor Phase Carbon Adsorption System	1		4000.00				4000				4000	
19) Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
20) Sand Filters	2			40000.00	4000.00			80000	8000		88000	4' dia
21) Backwash Tank	1			2500.00	500.00			2500	500		3000	1500 gal
22) Backwash Pumps	2			4000.00	600.00			8000	1200		9200	225 gpm
23) Carbon Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
24) Carbon Filters (Leased)	1		65000.00				65000				65000	Mob/Demob
25) Sludge Tank	1			2500.00	500.00			2500	500		3000	1500 gal
26) Filter Press Feed Pumps	2			4000.00	600.00			8000	1200		9200	
27) Filter Press	1			65000.00	16000.00			65000	16000		81000	
28) Effluent Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
							91400	278850	55900	0	426150	

001586

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
(BBDS4)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
PIPING & INSTRUMENTATION												
1) Extraction Wells to Treatment Plant												
A) Piping												
a) 1"	140	LF		6.00	3.75	.15		840	525	21	1386	
b) 1-1/2"	1100	LF		6.00	3.75	.15		6600	4125	165	10890	
c) 2"	100	LF		5.60	4.00	.15		560	400	15	975	
B) Excavation, Backfill, Compaction												
a) 2' wide x 4' deep	1200	LF		.75	4.62	4.14		900	5544	4968	11412	
C) Pipe Bedding												
a) 2' wide (1 Layer)	1200	LF		1.12	1.55			1344	1860		3204	
D) Revegetation	12	MSF		54.00	11.20	10.20		648	134	122	905	
2) Equal. Tank to Mix Tank - 2"	100	LF		13.00	7.00			1300	700		2000	
3) Mix Tank to Floc Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
4) Floc Tank to Clarifier - 4"	100	LF		26.00	14.00			2600	1400		4000	
5) Caustic Soda Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
6) PH Control System	2			5000.00	2000.00			10000	4000		14000	
7) Clarifier Sludge Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
8) Clarifier to PH Adjust Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
9) Acid Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
10) PH Adjust Tank to Air Strip Sump - 4"	100	LF		26.00	14.00			2600	1400		4000	
11) Standpipe to Air Stripper - 2"	50	LF		13.00	7.00			650	350		1000	
12) Air Piping												
a) 4"	100	LF		26.00	14.00			2600	1400		4000	
13) Air Stripper to Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
14) Filter Backwash Piping - 4"	200	LF		26.00	14.00			5200	2800		8000	
15) Filter to Carbon Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
16) Filtrate Return Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
17) Effluent Piping - 2"	1650	LF		5.60	4.00	.15		9240	6600	248	16088	
a) Excavation, Backfill, Compaction	1650	LF		.75	4.62	4.14		1238	7623	6831	15692	
b) Pipe Bedding	1650	LF		1.12	1.55			1848	2558		4406	
18) Plug Valves												
a) 1/2"	8			45.00	25.00			360	200		560	
b) 1"	4			60.00	30.00			240	120		360	
c) 2"	28			120.00	50.00			3360	1400		4760	
19) Check Valves												
a) 1/2"	4			60.00	25.00			240	100		340	
a) 2"	14			150.00	50.00			2100	700		2800	
20) Butterfly Valves												
a) 4"	4			80.00	70.00			320	280		600	
							0	68438	51569	12370	132376	

001587

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
(BBDS4)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
FOUNDATION & STRUCTURAL												
1) Equalization Tank Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
2) Rapid Mix Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
3) Flocculation Tank Foundation	5	CY		135.00	250.00	15.00		675	1250	75	2000	
4) Clarifier Foundation	20	CY		135.00	250.00	15.00		2700	5000	300	8000	
5) PH Adjust Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
6) Air Stripper Foundation	15	CY		135.00	250.00	15.00		2025	3750	225	6000	
7) Sand Filter Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
8) Carbon Filter Foundation	30	CY		135.00	250.00	15.00		4050	7500	450	12000	
9) Control Building	288	SF	40.00				11520				11520	
10) Control Building Foundation	22	CY		135.00	250.00	15.00		2970	5500	330	8800	
11) Filter Press Support	5	CY		135.00	250.00	15.00		675	1250	75	2000	
							11520	16065	29750	1785	59120	
ELECTRICAL												
1) Motor Starters												
a) #1	32			1000.00	450.00			32000	14400		46400	
2) Disconnect Switches	32			200.00	75.00			6400	2400		8800	
3) Feeder Cable	1200	FT		1.00	1.50			1200	1800		3000	
4) Conduit, Cable, Control												
a) #1	32			350.00	450.00			11200	14400		25600	
5) Grounding		LS		8000.00	8000.00			8000	8000		16000	
6) Miscellaneous Wiring		LS		16000.00	16000.00			16000	16000		32000	
7) Outdoor Lighting		LS		4000.00	2000.00			4000	2000		6000	
							0	78800	59000	0	137800	
OFFSITE DISPOSAL												
1) Dismantle Building	250000	CF			.06	.08			15000	20000	35000	
2) Excavate Contaminated Soil	4100	CY			.80	1.50			3280	6150	9430	
3) Hauling - 20 CY Truck	14760	MI	4.00				59040				59040	60 mi.
4) Disposal Landfill	6642	TON	188.00				1248696				1248696	Model City, N.Y.
5) Closure Testing		LS	10000.00				10000				10000	
6) Backfill New Soil	4100	CY		3.50	2.70	7.43		14350	11070	30463	55883	20 mi. R.T.
a) Place, Spread & Compact	4100	CY			.84	2.67			3444	10947	14391	Sheepsfoot Roller
7) Topsoil - 6"	370	CY		6.00	2.70	7.43		2220	999	2749	5968	20 mi. R.T.
a) Place & Spread	370	CY			.63	.57			233	211	444	
8) Revegetation	20	MSF		24.60	5.60	4.45		492	112	89	693	
							1317736	17062	34138	70609	1439545	

BYRON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
(O&MBBD4a)

Annual Costs - (24 hr/day - 365 days/year)

ITEM	QTY	UNIT	UNIT$	ITEM $	NOTES
1. Energy					
a. Electric	241696	Kw-hr	.085	$20544	Treatment Plant
2. Maintenance				$85700	3% of Capital Cost
3. Operator	1.5	EA	40000.00	$60000	1 Operator - 1st Shift
4. Chemicals					
a) Caustic Soda	71	TON	300.00	$21300	50%
b) Polymer	95	LB	3.50	$333	
c) Sulfuric Acid	20	TON	150.00	$3000	66 Baume
5. Vapor Phase Carbon					
a) Replacement				$3000	
b) Hauling	1	LD	1400.00	$1400	
c) Incineration	.5	TON	250.00	$125	Bridgeport N.J.
6. Sludge Disposal					
a) Hauling	9	LD	240.00	$2160	
b) Disposal	180	TON	188.00	$33840	Model City, N.Y.
7. Carbon Filter					
a) Rental				$56400	Year No. 1 & 2 Only
b) Carbon Replaceme				$144000	Year No. 1 & 2 Only
TOTAL ANNUAL COSTS				$431802	Years 1 and 2
TOTAL ANNUAL COSTS				$231402	Years 3 thru 20

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
Post Remedial Monitoring
(O&MBBD4)

Annual Costs

ITEM	ITEM $ MONTHLY & ANNUAL SAMPLING	ITEM $ MONTHLY & ANNUAL SAMPLING	NOTES
1. Sampling	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Sampling	9600.00	9600.00	1 effluent sample, 8 manhours per sampling period(monthly) plus travel, living & sample shipping costs.
3. Analysis	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
4. Analysis	28800.00	28800.00	3 samples per sampling period (monthly) (inc. blank and duplicate) Volatile Organics
5. Reporting	950.00	950.00	20 manhours per annual report plus other direct costs.
6. Reporting	2400.00	2400.00	4 manhours per monthly report plus other direct costs.
7. Analysis Review		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	54350.00	74350.00	Post Remedial monitoring will be performed monthly & annually as noted for years 1 thru 30

BYRON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Offsite Disposal
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 5
Present Worth No. 1
(PWABBD4)
7929

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	3899											
2. O & M COSTS	---	486.2										
3. ANNUAL COSTS	3899	486.2	486.2	285.8	285.8	305.8	285.8	285.8	285.8	285.8	305.8	285.8
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	3899	463	441	247	235	240	213	203	193	184	188	167

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	285.8	285.8	285.8	305.8	285.8	285.8	285.8	285.8	305.8	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	159	151	144	147	131	125	119	113	115	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	7929

001591

- Alternative 6

Soil Excavation and Thermal Treatment
Groundwater Pumping, Treatment, and Discharge to Surface Water

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal Treatment, Onsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
(BBDS5S)

SUMMARY

Item	Sub.	Mat.	Labor	Equip.	
1) EQUIPMENT	91400	278850	55900	0	426150
2) PIPING & INSTRUMENTATION	0	68438	51569	12370	132377
3) FOUNDATION & STRUCTURAL	11520	16065	29750	1785	59120
4) ELECTRICAL	0	78800	59000	0	137800
5) THERMAL TREATMENT	1006300	2712	28029	51093	1088134
	1109220	444865	224248	65248	1843581
Burden @ 13% of Labor Cost			29152		29152
Labor @ 15% of Labor Cost			33637		33637
Material @ 5% of Material Cost		22243			22243
Subcontract @ 10% of Sub. Cost	110922				110922
Total Direct Cost	1220142	467108	287037	65248	2039536
Indirects @ 75% of Total Direct Labor Cost			215278		215278
Profit @ 10% Total Direct Cost					203954
Total Field Cost					2458767
Contingency @ 20% of Total Field Cost					491753
Engineering @ 15% of Total Field Cost					368815
Total Cost This Page					3319336

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal Treatment, Onsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
(BBDS5)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
EQUIPMENT												
1) Extraction Wells	140	LF	160.00				22400				22400	7 @ 20'
2) Extraction Well Pumps	4			1500.00	400.00			6000	1600		7600	2 @ 18 gpm 2 @ 26 gpm
3) Equalization Tank	1			2500.00	500.00			2500	500		3000	1500 gal
4) Equalization Tank Mixer - 3/4 HP	1			1750.00	400.00			1750	400		2150	
5) Raw Water Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
6) Rapid Mix Tank	1			600.00	200.00			600	200		800	250 gal
7) Rapid Mix Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
8) Caustic Soda Feed Pumps	2			1000.00	200.00			2000	400		2400	3 gph
9) Flocculation Tank	1			6000.00	1500.00			6000	1500		7500	1000gal
10) Polymer Feed System	1			2000.00	400.00			2000	400		2400	0.2 gph
11) Clarifier	1			32400.00	4800.00			32400	4800		37200	12' dia
12) Sludge Transfer Pumps	2			4500.00	600.00			9000	1200		10200	25 gpm
13) PH Adjust Tank	1			600.00	200.00			600	200		800	250 gal
14) PH Adjust Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
15) Acid Feed Pumps	2			1000.00	200.00			2000	400		2400	0.2 gph
16) Air Stripper Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
17) Air Stripping System incl. Stripping Tower, Packing, Blowers	1			25000.00	12500.00			25000	12500		37500	44 gpm
18) Vapor Phase Carbon Adsorption System	1		4000.00				4000				4000	
19) Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
20) Sand Filters	2			40000.00	4000.00			80000	8000		88000	4' dia
21) Backwash Tank	1			2500.00	500.00			2500	500		3000	1500 gal
22) Backwash Pumps	2			4000.00	600.00			8000	1200		9200	225 gpm
23) Carbon Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
24) Carbon Filters (Leased)	1		65000.00				65000				65000	Mob/Demob
25) Sludge Tank	1			2500.00	500.00			2500	500		3000	1500 gal
26) Filter Press Feed Pumps	2			4000.00	600.00			8000	1200		9200	
27) Filter Press	1			65000.00	16000.00			65000	16000		81000	
28) Effluent Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
							91400	278850	55900	0	426150	

001594

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal Treatment, Onsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
(BBDS5)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
PIPING & INSTRUMENTATION												
1) Extraction Wells to Treatment Plant												
A) Piping												
a) 1"	140	LF		6.00	3.75	.15		840	525	21	1386	
b) 1-1/2"	1100	LF		6.00	3.75	.15		6600	4125	165	10890	
c) 2"	100	LF		5.60	4.00	.15		560	400	15	975	
B) Excavation, Backfill, Compaction												
a) 2' wide x 4' deep	1200	LF		.75	4.62	4.14		900	5544	4968	11412	
C) Pipe Bedding												
a) 2' wide (1 Layer)	1200	LF		1.12	1.55			1344	1860		3204	
D) Revegetation	12	MSF		54.00	11.20	10.20		648	134	122	905	
2) Equal. Tank to Mix Tank - 2"	100	LF		13.00	7.00			1300	700		2000	
3) Mix Tank to Floc Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
4) Floc Tank to Clarifier - 4"	100	LF		26.00	14.00			2600	1400		4000	
5) Caustic Soda Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
6) PH Control System	2			5000.00	2000.00			10000	4000		14000	
7) Clarifier Sludge Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
8) Clarifier to PH Adjust Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
9) Acid Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
10) PH Adjust Tank to Air Strip Sump - 4"	100	LF		26.00	14.00			2600	1400		4000	
11) Standpipe to Air Stripper - 2"	50	LF		13.00	7.00			650	350		1000	
12) Air Piping												
a) 4"	100	LF		26.00	14.00			2600	1400		4000	
13) Air Stripper to Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
14) Filter Backwash Piping - 4"	200	LF		26.00	14.00			5200	2800		8000	
15) Filter to Carbon Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
16) Filtrate Return Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
17) Effluent Piping - 2"	1650	LF		5.60	4.00	.15		9240	6600	248	16088	
a) Excavation, Backfill, Compaction	1650	LF		.75	4.62	4.14		1238	7623	6831	15692	
b) Pipe Bedding	1650	LF		1.12	1.55			1848	2558		4406	
18) Plug Valves												
a) 1/2"	8			45.00	25.00			360	200		560	
b) 1"	4			60.00	30.00			240	120		360	
c) 2"	28			120.00	50.00			3360	1400		4760	
19) Check Valves												
a) 1/2"	4			60.00	25.00			240	100		340	
a) 2"	14			150.00	50.00			2100	700		2800	
20) Butterfly Valves												
a) 4"	4			80.00	70.00			320	280		600	
							0	68438	51569	12370	132376	

001595

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal Treatment, Onsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
(BBDS5)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
FOUNDATION & STRUCTURAL												
1) Equalization Tank Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
2) Rapid Mix Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
3) Flocculation Tank Foundation	5	CY		135.00	250.00	15.00		675	1250	75	2000	
4) Clarifier Foundation	20	CY		135.00	250.00	15.00		2700	5000	300	8000	
5) PH Adjust Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
6) Air Stripper Foundation	15	CY		135.00	250.00	15.00		2025	3750	225	6000	
7) Sand Filter Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
8) Carbon Filter Foundation	30	CY		135.00	250.00	15.00		4050	7500	450	12000	
9) Control Building	288	SF	40.00				11520				11520	
10) Control Building Foundation	22	CY		135.00	250.00	15.00		2970	5500	330	8800	
11) Filter Press Support	5	CY		135.00	250.00	15.00		675	1250	75	2000	
							11520	16065	29750	1785	59120	
ELECTRICAL												
1) Motor Starters												
a) #1	32			1000.00	450.00			32000	14400		46400	
2) Disconnect Switches	32			200.00	75.00			6400	2400		8800	
3) Feeder Cable	1200	FT		1.00	1.50			1200	1800		3000	
4) Conduit, Cable, Control												
a) #1	32			350.00	450.00			11200	14400		25600	
5) Grounding		LS		8000.00	8000.00			8000	8000		16000	
6) Miscellaneous Wiring		LS		16000.00	16000.00			16000	16000		32000	
7) Outdoor Lighting		LS		4000.00	2000.00			4000	2000		6000	
							0	78800	59000	0	137800	
THERMAL TREATMENT												
1) Dismantle Building	250000	CF			.06	.08			15000	20000	35000	
2) Excavate Contaminated Soil	4100	CY			.80	1.50			3280	6150	9430	
3) Thermal Treatment	6642	TON	150.00				996300				996300	
4) Closure Testing		LS	10000.00				10000				10000	
5) Backfill Treated Soil	4100	CY			1.21	2.67			4961	10947	15908	1 mi. R.T.
a) Place, Spread & Compact	4100	CY			.84	2.67			3444	10947	14391	Sheepsfoot Roller
6) Topsoil - 6"	370	CY		6.00	2.70	7.43		2220	999	2749	5968	20 mi. R.T.
a) Place & Spread	370	CY			.63	.57			233	211	444	
7) Revegetation	20	MSF		24.60	5.60	4.45		492	112	89	693	
							1006300	2712	28029	51093	1088134	

BYRON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal treatment, Onsite Disposal
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
(O&MBBD5a)

Annual Costs - (24 hr/day - 365 days/year)

ITEM	QTY	UNIT	UNIT$	ITEM $	NOTES
1. Energy					
a. Electric	241696	Kw-hr	.085	$20544	Treatment Plant
2. Maintenance				$49600	3% of Capital Cost
3. Operator	1.5	EA	40000.00	$60000	1 Operator - 1st Shift
4. Chemicals					
a) Caustic Soda	71	TON	300.00	$21300	50%
b) Polymer	95	LB	3.50	$333	
c) Sulfuric Acid	20	TON	150.00	$3000	66 Baume
5. Vapor Phase Carbon					
a) Replacement				$3000	
b) Hauling	1	LD	1400.00	$1400	
c) Incineration	.5	TON	250.00	$125	Bridgeport N.J.
6. Sludge Disposal					
a) Hauling	9	LD	240.00	$2160	
b) Disposal	180	TON	188.00	$33840	Model City, N.Y.
7. Carbon Filter					
a) Rental				$56400	Year No. 1 & 2 Only
b) Carbon Replaceme				$144000	Year No. 1 & 2 Only
TOTAL ANNUAL COSTS				$395702	Years 1 and 2
TOTAL ANNUAL COSTS				$195302	Years 3 thru 20

BRYON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal Treatment, Onsite Disposal
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
Post Remedial Monitoring
(O&MBBD5)

Annual Costs

ITEM	ITEM $ MONTHLY & ANNUAL SAMPLING	ITEM $ MONTHLY & ANNUAL SAMPLING	NOTES
1. Sampling	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Sampling	9600.00	9600.00	1 effluent sample, 8 manhours per sampling period(monthly) plus travel, living & sample shipping costs.
3. Analysis	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
4. Analysis	28800.00	28800.00	3 samples per sampling period (monthly) (inc. blank and duplicate) Volatile Organics
5. Reporting	950.00	950.00	20 manhours per annual report plus other direct costs.
6. Reporting	2400.00	2400.00	4 manhours per monthly report plus other direct costs.
7. Analysis Review		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	54350.00	74350.00	Post Remedial monitoring will be performed monthly & annually as noted for years 1 thru 30

BYRON BARREL & DRUM SITE
Bryon, New York
Excavation Contaminated Soil, Thermal Treatment, Onsite Disposal
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 6
Present Worth No. 1
(PWABBD5)
6899

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	3319.3											
2. O & M COSTS	---	450.1										
3. ANNUAL COSTS	3319.3	450.1	450.1	249.7	249.7	269.7	249.7	249.7	249.7	249.7	269.7	249.7
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	3319	428	408	216	206	211	186	178	169	161	166	146

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	249.7	249.7	249.7	269.7	249.7	249.7	249.7	249.7	269.7	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	139	132	126	130	114	109	104	99	102	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	6899

• Alternative 7

In-Situ Soil Vapor Extraction
Groundwater Pumping, Treatment, and Discharge to Surface Water

BRYON BARREL & DRUM SITE
Bryon, New York
In-situ Soil Vapor Extraction
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7
(BBDS7S)

SUMMARY

Item	Sub.	Mat.	Labor	Equip.	
1) EQUIPMENT	91400	278850	55900	0	426150
2) PIPING & INSTRUMENTATION	0	68438	51569	12370	132377
3) FOUNDATION & STRUCTURAL	11520	16065	29750	1785	59120
4) ELECTRICAL	0	78800	59000	0	137800
5) IN-SITU SOIL VAPOR EXTRACTION	149000	1295	1310	3737	155342
	251920	443448	197529	17892	910789
Burden @ 13% of Labor Cost			25679		25679
Labor @ 15% of Labor Cost			29629		29629
Material @ 5% of Material Cost		22172			22172
Subcontract @ 10% of Sub. Cost	25192				25192
Total Direct Cost	277112	465620	252837	17892	1013462
Indirects @ 75% of Total Direct Labor Cost			189628		189628
Profit @ 10% Total Direct Cost					101346
Total Field Cost					1304436
Contingency @ 20% of Total Field Cost					260887
Engineering @ 15% of Total Field Cost					195665
Total Cost This Page					1760988

001801

BRYON BARREL & DRUM SITE
Bryon, New York
In-situ Soil Vapor Extraction
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7
(BBDS7)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
EQUIPMENT												
1) Extraction Wells	140	LF	160.00				22400				22400	7 @ 20'
2) Extraction Well Pumps	4			1500.00	400.00			6000	1600		7600	2 @ 18 gpm 2 @ 26 gpm
3) Equalization Tank	1			2500.00	500.00			2500	500		3000	1500 gal
4) Equalization Tank Mixer - 3/4 HP	1			1750.00	400.00			1750	400		2150	
5) Raw Water Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
6) Rapid Mix Tank	1			600.00	200.00			600	200		800	250 gal
7) Rapid Mix Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
8) Caustic Soda Feed Pumps	2			1000.00	200.00			2000	400		2400	3 gph
9) Flocculation Tank	1			6000.00	1500.00			6000	1500		7500	1000gal
10) Polymer Feed System	1			2000.00	400.00			2000	400		2400	0.2 gph
11) Clarifier	1			32400.00	4800.00			32400	4800		37200	12' dia
12) Sludge Transfer Pumps	2			4500.00	600.00			9000	1200		10200	25 gpm
13) PH Adjust Tank	1			600.00	200.00			600	200		800	250 gal
14) PH Adjust Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
15) Acid Feed Pumps	2			1000.00	200.00			2000	400		2400	0.2 gph
16) Air Stripper Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
17) Air Stripping System incl. Stripping Tower, Packing, Blowers	1			25000.00	12500.00			25000	12500		37500	44 gpm
18) Vapor Phase Carbon Adsorption System	1		4000.00				4000				4000	
19) Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
20) Sand Filters	2			40000.00	4000.00			80000	8000		88000	4' dia
21) Backwash Tank	1			2500.00	500.00			2500	500		3000	1500 gal
22) Backwash Pumps	2			4000.00	600.00			8000	1200		9200	225 gpm
23) Carbon Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
24) Carbon Filters (Leased)	1		65000.00				65000				65000	Mob/Demob
25) Sludge Tank	1			2500.00	500.00			2500	500		3000	1500 gal
26) Filter Press Feed Pumps	2			4000.00	600.00			8000	1200		9200	
27) Filter Press	1			65000.00	16000.00			65000	16000		81000	
28) Effluent Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
							91400	278850	55900	0	426150	

BRYON BARREL & DRUM SITE
Bryon, New York
In-situ Soil Vapor Extraction
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7
(BBDS7)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
PIPING & INSTRUMENTATION												
1) Extraction Wells to Treatment Plant												
A) Piping												
a) 1"	140	LF		6.00	3.75	.15		840	525	21	1386	
b) 1-1/2"	1100	LF		6.00	3.75	.15		6600	4125	165	10890	
c) 2"	100	LF		5.60	4.00	.15		560	400	15	975	
B) Excavation, Backfill, Compaction												
a) 2' wide x 4' deep	1200	LF		.75	4.62	4.14		900	5544	4968	11412	
C) Pipe Bedding												
a) 2' wide (1 Layer)	1200	LF		1.12	1.55			1344	1860		3204	
D) Revegetation	12	MSF		54.00	11.20	10.20		648	134	122	905	
2) Equal. Tank to Mix Tank - 2"	100	LF		13.00	7.00			1300	700		2000	
3) Mix Tank to Floc Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
4) Floc Tank to Clarifier - 4"	100	LF		26.00	14.00			2600	1400		4000	
5) Caustic Soda Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
6) PH Control System	2			5000.00	2000.00			10000	4000		14000	
7) Clarifier Sludge Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
8) Clarifier to PH Adjust Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
9) Acid Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
10) PH Adjust Tank to Air Strip Sump - 4"	100	LF		26.00	14.00			2600	1400		4000	
11) Standpipe to Air Stripper - 2"	50	LF		13.00	7.00			650	350		1000	
12) Air Piping												
a) 4"	100	LF		26.00	14.00			2600	1400		4000	
13) Air Stripper to Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
14) Filter Backwash Piping - 4"	200	LF		26.00	14.00			5200	2800		8000	
15) Filter to Carbon Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
16) Filtrate Return Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
17) Effluent Piping - 2"	1650	LF		5.60	4.00	.15		9240	6600	248	16088	
a) Excavation, Backfill, Compaction	1650	LF		.75	4.62	4.14		1238	7623	6831	15692	
b) Pipe Bedding	1650	LF		1.12	1.55			1848	2558		4406	
18) Plug Valves												
a) 1/2"	8			45.00	25.00			360	200		560	
b) 1"	4			60.00	30.00			240	120		360	
c) 2"	28			120.00	50.00			3360	1400		4760	
19) Check Valves												
a) 1/2"	4			60.00	25.00			240	100		340	
a) 2"	14			150.00	50.00			2100	700		2800	
20) Butterfly Valves												
a) 4"	4			80.00	70.00			320	280		600	
							0	68438	51569	12370	132376	

0016033

BRYON BARREL & DRUM SITE
Bryon, New York
In-situ Soil Vapor Extraction
Extraction, Onsite Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7
(BBDS7)

			Unit Cost				Total				Total Direct Cost	
Item	Qty	Unit	Sub.	Mat.	Labor	Equip.	Sub.	Mat.	Labor	Equip.		Comments
FOUNDATION & STRUCTURAL												
1) Equalization Tank Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
2) Rapid Mix Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
3) Flocculation Tank Foundation	5	CY		135.00	250.00	15.00		675	1250	75	2000	
4) Clarifier Foundation	20	CY		135.00	250.00	15.00		2700	5000	300	8000	
5) PH Adjust Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
6) Air Stripper Foundation	15	CY		135.00	250.00	15.00		2025	3750	225	6000	
7) Sand Filter Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
8) Carbon Filter Foundation	30	CY		135.00	250.00	15.00		4050	7500	450	12000	
9) Control Building	288	SF	40.00				11520				11520	
10) Control Building Foundation	22	CY		135.00	250.00	15.00		2970	5500	330	8800	
11) Filter Press Support	5	CY		135.00	250.00	15.00		675	1250	75	2000	
							11520	16065	29750	1785	59120	
ELECTRICAL												
1) Motor Starters												
a) #1	32			1000.00	450.00			32000	14400		46400	
2) Disconnect Switches	32			200.00	75.00			6400	2400		8800	
3) Feeder Cable	1200	FT		1.00	1.50			1200	1800		3000	
4) Conduit, Cable, Control												
a) #1	32			350.00	450.00			11200	14400		25600	
5) Grounding		LS		8000.00	8000.00			8000	8000		16000	
6) Miscellaneous Wiring		LS		16000.00	16000.00			16000	16000		32000	
7) Outdoor Lighting		LS		4000.00	2000.00			4000	2000		6000	
							0	78800	59000	0	137800	
IN-SITU SOIL VAPOR EXTRACTION												
1) Mobilization		LS	100000.00		.06	.08	100000				100000	
2) Vapor Extraction Treatment With Carbon Disposal		LS	30000.00		.80	1.50	30000				30000	
3) Demobilization		LS	10000.00				10000				10000	
4) Capping (Source Area)												
a) Clean Soil - 12"	370	CY		3.50	2.70	7.43		1295	999	2749	5043	
b) Place, Spread & Compact	370	CY			.84	2.67			311	988	1299	
c) Synthetic Membrane	10000	SF	.90				9000				9000	
							149000	1295	1310	3737	155342	

BYRON BARREL & DRUM SITE
Bryon, New York
In-situ Soil Vapor Extraction
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7
(O&MBBD7a)

Annual Costs - (24 hr/day - 365 days/year)

ITEM	QTY	UNIT	UNIT$	ITEM $	NOTES
1. Energy					
a. Electric	241696	Kw-hr	.085	$20544	Treatment Plant
2. Maintenance				$38300	3% of Capital Cost
3. Operator	1.5	EA	40000.00	$60000	1 Operator - 1st Shift
4. Chemicals					
a) Caustic Soda	71	TON	300.00	$21300	50%
b) Polymer	95	LB	3.50	$333	
c) Sulfuric Acid	20	TON	150.00	$3000	66 Baume
5. Vapor Phase Carbon					
a) Replacement				$3000	
b) Hauling	1	LD	1400.00	$1400	
c) Incineration	.5	TON	250.00	$125	Bridgeport N.J.
6. Sludge Disposal					
a) Hauling	9	LD	240.00	$2160	
b) Disposal	180	TON	188.00	$33840	Model City, N.Y.
7. Carbon Filter					
a) Rental				$56400	Year No. 1 & 2 Only
b) Carbon Replaceme				$144000	Year No. 1 & 2 Only
TOTAL ANNUAL COSTS				$384402	Years 1 and 2
TOTAL ANNUAL COSTS				$184002	Years 3 thru 20

001605

BRYON BARREL & DRUM SITE
Bryon, New York
In-situ Soil Vapor Extraction,
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7 (Present Worth No. 1)
Post Remedial Monitoring
(O&MBBD7)

Annual Costs

ITEM	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 1 THRU 20	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 1 THRU 20	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 21 THRU 30	ITEM $ MONTHLY & ANNUAL SAMPLING YEARS 21 THRU 30	NOTES
1. Sampling	3000.00	3000.00	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Sampling	9600.00	9600.00	.00	.00	1 effluent sample, 8 manhours per sampling period(monthly) plus travel, living & sample shipping costs.
3. Analysis	9600.00	9600.00	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
4. Analysis	28800.00	28800.00	.00	.00	3 samples per sampling period (monthly) (inc. blank and duplicate) Volatile Organics
5. Reporting	950.00	950.00	950.00	950.00	20 manhours per annual report plus other direct costs.
6. Reporting	2400.00	2400.00	.00	.00	4 manhours per monthly report plus other direct costs.
7. Analysis Review		20000.00		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	54350.00	74350.00	13550.00	33550.00	Post Remedial monitoring will be performed monthly & annually as noted for years 1 thru 30

001809

BYRON BARREL & DRUM SITE
Bryon, New York
In-Situ Soil Vapor Extraction
Extraction, Groundwater Treatment,
Discharge To Surface Water
Alternative No. 7
Present Worth No. 1
(PWABBD7)
5200

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	1761											
2. O & M COSTS	---	438.8										
3. ANNUAL COSTS	1761	438.8	438.8	238.4	238.4	258.4	238.4	238.4	238.4	238.4	258.4	238.4
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	1761	418	398	206	196	203	178	170	161	154	159	139

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	238.4	238.4	238.4	258.4	238.4	238.4	238.4	238.4	258.4	13.6	13.6	13.6
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	133	126	120	124	109	104	99	94	97	5	5	4

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	13.6	33.6	13.6	13.6	13.6	13.6	33.6	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	4	10	4	4	3	3	8	5200

- <u>Alternative 8</u>

In-Situ Soil Flushing
Groundwater Pumping, Treatment, and
Discharge to Subsurface Water

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Groundwater (ARARS)
Alternative No. 8A
(BBDS6AS)

SUMMARY

Item	Sub.	Mat.	Labor	Equip.	
1) EQUIPMENT	91400	278850	55900	0	426150
2) PIPING & INSTRUMENTATION	0	77402	63773	17518	158693
3) FOUNDATION & STRUCTURAL	11520	46165	75194	108645	241524
4) ELECTRICAL	0	78800	59000	0	137800
	102920	481217	253867	126163	964167
Burden @ 13% of Labor Cost			33003		33003
Labor @ 15% of Labor Cost			38080		38080
Material @ 5% of Material Cost		24061			24061
Subcontract @ 10% of Sub. Cost	10292				10292
Total Direct Cost	113212	505278	324950	126163	1069603
Indirects @ 75% of Total Direct Labor Cost			243712		243712
Profit @ 10% Total Direct Cost					106960
Total Field Cost					1420275
Contingency @ 20% of Total Field Cost					284055
Engineering @ 15% of Total Field Cost					213041
Total Cost This Page					1917372

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
EQUIPMENT												
1) Extraction Wells	140	LF	160.00				22400				22400	7 @ 20'
2) Extraction Well Pumps	4			1500.00	400.00			6000	1600		7600	2 @ 18 gpm 2 @ 26 gpm
3) Equalization Tank	1			2500.00	500.00			2500	500		3000	1500 gal
4) Equalization Tank Mixer - 3/4 HP	1			1750.00	400.00			1750	400		2150	
5) Raw Water Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
6) Rapid Mix Tank	1			600.00	200.00			600	200		800	250 gal
7) Rapid Mix Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
8) Caustic Soda Feed Pumps	2			1000.00	200.00			2000	400		2400	3 gph
9) Flocculation Tank	1			6000.00	1500.00			6000	1500		7500	1000gal
10) Polymer Feed System	1			2000.00	400.00			2000	400		2400	0.2 gph
11) Clarifier	1			32400.00	4800.00			32400	4800		37200	12' dia
12) Sludge Transfer Pumps	2			4500.00	600.00			9000	1200		10200	25 gpm
13) PH Adjust Tank	1			600.00	200.00			600	200		800	250 gal
14) PH Adjust Tank Mixer - 1/4 HP	1			1500.00	200.00			1500	200		1700	
15) Acid Feed Pumps	2			1000.00	200.00			2000	400		2400	0.2 gph
16) Air Stripper Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
17) Air Stripping System incl. Stripping Tower, Packing, Blowers	1			25000.00	12500.00			25000	12500		37500	44 gpm
18) Vapor Phase Carbon Adsorption System	1		4000.00				4000				4000	
19) Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
20) Sand Filters	2			40000.00	4000.00			80000	8000		88000	4' dia
21) Backwash Tank	1			2500.00	500.00			2500	500		3000	1500 gal
22) Backwash Pumps	2			4000.00	600.00			8000	1200		9200	225 gpm
23) Carbon Filter Feed Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
24) Carbon Filters (Leased)	1		65000.00				65000				65000	Mob/Demob
25) Sludge Tank	1			2500.00	500.00			2500	500		3000	1500 gal
26) Filter Press Feed Pumps	2			4000.00	600.00			8000	1200		9200	
27) Filter Press	1			65000.00	16000.00			65000	16000		81000	
28) Effluent Pumps	2			2000.00	400.00			4000	800		4800	44 gpm
							91400	278850	55900	0	426150	

001310

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Groundwater (ARARS)
Alternative No. 8A
(BBDS6A)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
PIPING & INSTRUMENTATION												
1) Extraction Wells to Treatment Plant												
A) Piping												
a) 1"	140	LF		6.00	3.75	.15		840	525	21	1386	
b) 1-1/2"	1100	LF		6.00	3.75	.15		6600	4125	165	10890	
c) 2"	100	LF		5.60	4.00	.15		560	400	15	975	
B) Excavation, Backfill, Compaction												
a) 2' wide x 4' deep	1200	LF		.75	4.62	4.14		900	5544	4968	11412	
C) Pipe Bedding												
a) 2' wide (1 Layer)	1200	LF		1.12	1.55			1344	1860		3204	
D) Revegetation	12	MSF		54.00	11.20	10.20		648	134	122	905	
2) Equal. Tank to Mix Tank - 2"	100	LF		13.00	7.00			1300	700		2000	
3) Mix Tank to Floc Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
4) Floc Tank to Clarifier - 4"	100	LF		26.00	14.00			2600	1400		4000	
5) Caustic Soda Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
6) PH Control System	2			5000.00	2000.00			10000	4000		14000	
7) Clarifier Sludge Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
8) Clarifier to PH Adjust Tank - 4"	100	LF		26.00	14.00			2600	1400		4000	
9) Acid Feed Piping - 1/2"	100	LF		3.25	1.75			325	175		500	
10) PH Adjust Tank to Air Strip Sump - 4"	100	LF		26.00	14.00			2600	1400		4000	
11) Standpipe to Air Stripper - 2"	50	LF		13.00	7.00			650	350		1000	
12) Air Piping												
a) 4"	100	LF		26.00	14.00			2600	1400		4000	
13) Air Stripper to Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
14) Filter Backwash Piping - 4"	200	LF		26.00	14.00			5200	2800		8000	
15) Filter to Carbon Filter - 2"	100	LF		13.00	7.00			1300	700		2000	
16) Filtrate Return Piping - 2"	200	LF		13.00	7.00			2600	1400		4000	
17) Effluent Piping - 2"	2850	LF		5.60	4.00	.15		15960	11400	428	27788	
a) Excavation, Backfill, Compaction	2850	LF		.75	4.62	4.14		2138	13167	11799	27104	
b) Pipe Bedding	2850	LF		1.12	1.55			3192	4418		7610	
18) Plug Valves												
a) 1/2"	8			45.00	25.00			360	200		560	
b) 1"	4			60.00	30.00			240	120		360	
c) 2"	28			120.00	50.00			3360	1400		4760	
19) Check Valves												
a) 1/2"	4			60.00	25.00			240	100		340	
a) 2"	14			150.00	50.00			2100	700		2800	
20) Butterfly Valves												
a) 4"	4			80.00	70.00			320	280		600	
							0	77402	63773	17518	158692	

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Groundwater (ARARS)
Alternative No. 8A
(BBDS6A)

Item	Qty	Unit	Unit Cost Sub.	Unit Cost Mat.	Unit Cost Labor	Unit Cost Equip.	Total Sub.	Total Mat.	Total Labor	Total Equip.	Total Direct Cost	Comments
FOUNDATION & STRUCTURAL												
1) Equalization Tank Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
2) Rapid Mix Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
3) Flocculation Tank Foundation	5	CY		135.00	250.00	15.00		675	1250	75	2000	
4) Clarifier Foundation	20	CY		135.00	250.00	15.00		2700	5000	300	8000	
5) PH Adjust Tank Foundation	3	CY		135.00	250.00	15.00		405	750	45	1200	
6) Air Stripper Foundation	15	CY		135.00	250.00	15.00		2025	3750	225	6000	
7) Sand Filter Foundation	8	CY		135.00	250.00	15.00		1080	2000	120	3200	
8) Carbon Filter Foundation	30	CY		135.00	250.00	15.00		4050	7500	450	12000	
9) Control Building	288	SF	40.00				11520				11520	
10) Control Building Foundation	22	CY		135.00	250.00	15.00		2970	5500	330	8800	
11) Filter Press Support	5	CY		135.00	250.00	15.00		675	1250	75	2000	
12) Dismantle Building	250000	CF			.06	.08			15000	20000	35000	
13) Recharge Basin												
a) Hauling	8600	CY		3.50	2.70	7.43		30100	23220	63898	117218	20 mi. R.T.
b) Place, Spread & Compact	8600	CY			.84	2.67			7224	22962	30186	Sheepsfoot Roller
							11520	46165	75194	108645	241524	
ELECTRICAL												
1) Motor Starters												
a) #1	32			1000.00	450.00			32000	14400		46400	
2) Disconnect Switches	32			200.00	75.00			6400	2400		8800	
3) Feeder Cable	1200	FT		1.00	1.50			1200	1800		3000	
4) Conduit, Cable, Control												
a) #1	32			350.00	450.00			11200	14400		25600	
5) Grounding		LS		8000.00	8000.00			8000	8000		16000	
6) Miscellaneous Wiring		LS		16000.00	16000.00			16000	16000		32000	
7) Outdoor Lighting		LS		4000.00	2000.00			4000	2000		6000	
							0	78800	59000	0	137800	

001612

BYRON BARREL & DRUM SITE
Bryon, New York
Extraction, Groundwater Treatment,
Discharge To Groundwater (ARARS)
Alternative No. 8A
(O&MBBD6a)

Annual Costs - (24 hr/day - 365 days/year)

ITEM	QTY	UNIT	UNIT$	ITEM $	NOTES
1. Energy					
a. Electric	241696	Kw-hr	.085	$20544	Treatment Plant
2. Maintenance				$40400	3% of Capital Cost
3. Operator	1.5	EA	40000.00	$60000	1 Operator - 1st Shift
4. Chemicals					
a) Caustic Soda	71	TON	300.00	$21300	50%
b) Polymer	95	LB	3.50	$333	
c) Sulfuric Acid	20	TON	150.00	$3000	66 Baume
5. Vapor Phase Carbon					
a) Replacement				$3000	
b) Hauling	1	LD	1400.00	$1400	
c) Incineration	.5	TON	250.00	$125	Bridgeport N.J.
6. Sludge Disposal					
a) Hauling	9	LD	240.00	$2160	
b) Disposal	180	TON	188.00	$33840	Model City, N.Y.
7. Carbon Filter					
a) Rental				$56400	Year No. 1 & 2 Only
b) Carbon Replaceme				$144000	Year No. 1 & 2 Only
TOTAL ANNUAL COSTS				$386502	Years 1 and 2
TOTAL ANNUAL COSTS				$186102	Years 3 thru 20

BRYON BARREL & DRUM SITE
Bryon, New York
Extraction, Onsite Groundwater Treatment,
Discharge To Groundwater (ARARS)
Alternative No. 8A
Post Remedial Monitoring
(O&MBBD6)

Annual Costs

ITEM	ITEM $ MONTHLY & ANNUAL SAMPLING	ITEM $ MONTHLY & ANNUAL SAMPLING	NOTES
1. Sampling	3000.00	3000.00	5 monitoring & 5 residential well samples, 40 manhours per sampling period(annual) plus travel, living & sample shipping costs.
2. Sampling	9600.00	9600.00	3 effluent sample, 8 manhours per sampling period(monthly) plus travel, living & sample shipping costs.
3. Analysis	9600.00	9600.00	12 samples per sampling period (annual) (inc. blank and duplicate) Volatile Organics
4. Analysis	48000.00	48000.00	5 samples per sampling period (monthly) (inc. blank and duplicate) Volatile Organics
5. Reporting	950.00	950.00	20 manhours per annual report plus other direct costs.
6. Reporting	2400.00	2400.00	4 manhours per monthly report plus other direct costs.
7. Analysis Review		20000.00	Analysis Review performed for years 5,10,15,20,25,30
TOTAL ANNUAL COST	73550.00	93550.00	Post Remedial monitoring will be performed monthly & annually as noted for years 1 thru 20

001614

BYRON BARREL & DRUM SITE
Bryon, New York
Extraction, Groundwater Treatment,
Discharge To Groundwater (ARARS)
Alternative No. 8A
(PWABBD6a)
5572

PRESENT WORTH ANALYSIS

COST/YEAR COST OCCURS ($000'S)

COST COMPONENT	0	1	2	3	4	5	6	7	8	9	10	11
1. CAPITAL COST	1917.4											
2. O & M COSTS	---	460.1										
3. ANNUAL COSTS	1917.4	460.1	460.1	259.7	259.7	279.7	259.7	259.7	259.7	259.7	279.7	259.7
4. ANNUAL DISCOUNT RATE=5%	1	.952	.907	.864	.823	.784	.746	.711	.677	.645	.614	.585
PRESENT WORTH =	1917	438	417	224	214	219	194	185	176	168	172	152

	12	13	14	15	16	17	18	19	20	21	22	23
O & M COSTS	259.7	259.7	259.7	279.7	259.7	259.7	259.7	259.7	279.7	0	0	0
ANNUAL DISCOUNT RATE=5%	.557	.53	.505	.481	.458	.436	.416	.396	.377	.359	.342	.326
PRESENT WORTH =	145	138	131	135	119	113	108	103	105	0	0	0

	24	25	26	27	28	29	30	TOTAL PRESENT WORTH (000'S)
O & M COSTS	0	0	0	0	0	0	0	
ANNUAL DISCOUNT RATE=5%	.31	.295	.281	.268	.255	.243	.231	
PRESENT WORTH =	0	0	0	0	0	0	0	5572