WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Draft Environmental Impact Statement

Cleanup Standards

Technical Appendices

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CONTENTS

APPENDIX A

Hazardous Substances

Hazardous substance is defined in the Model Toxics Control Act, RCW 70.105D.020(5), as:

> (a) Any dangerous or extremely hazardous waste as defined in RCW 70.105.010 (5) and (6), or any dangerous or extremely dangerous waste designated by rule pursuant to chapter 70.105 RCW;
>
> (b) Any hazardous substance as defined in RCW 70.105.010(14) or any hazardous substance as defined by rule pursuant to chapter 70.105 RCW;
>
> (c) Any substance that, on March 1, 1989, is a hazardous substance under section 101(14) of the federal cleanup law, 42 U.S.C. Sec. 9601(14);
>
> (d) Petroleum or petroleum products; and
>
> (e) Any substance or category of substances, including solid waste decomposition products, determined by the director by rule to present a threat to human health or the environment if released into the environment.
>
> The term hazardous substance does not include any of the following when contained in an underground storage tank from which there is not a release: Crude oil or any fraction thereof or petroleum, if the tank is in compliance with all applicable federal, state, and local law.

The following is the list of hazardous substances under section 101(14) of the federal cleanup law, 42 U.S.C. Sec. 9601(14), as of March 1, 1989.

LIST OF HAZARDOUS SUBSTANCES UNDER THE MODEL TOXICS CONTROL ACT.

Hazardous Substance	Chemical Abstracts Number
Acenaphthene	83329
Acenaphthylene	208968
Acetaldehyde	75070
Acetaldehyde, chloro-	107200
Acetaldehyde, trichloro-	75876
Acetamide, N-(aminothioxomethyl)-	591082
Acetamide, N-(4-ethoxyphenyl)-	62442
Acetamide, N-9H-fluoren-2-yl-	53963
Acetamide, 2-fluoro-	640197
Acetic acid	64197
Acetic acid, ethyl ester	141786
Acetic acid, fluoro-, sodium salt	62748
Acetic acid, lead salt	301042
Acetic acid, thallium(I) salt	563688
Acetic anhydride	108247
Acetimidic acid, N-[(methylcarbamoyl)oxy]thio- methyl ester	16752775
Acetone	67641
Acetone cyanohydrin	75865
Acetonitrile	75058
3-(alpha-Acetonylbenzyl)-4-hydroxycoumarin and salts	81812
Acetophenone	98862
2-Acetylaminofluorene	53963
Acetyl bromide	506967
Acetyl chloride	75365
1-Acetyl-2-thiourea	591082
Acrolein	107028
Acrylamide	79061
Acrylic acid	79107
Acrylonitrile	107131
Adipic acid	124049
Alanine, 3-[p-bis(2-chloroethyl)amino]phenyl-, L-	148823
Aldicarb	116063
Aldrin	309002
Allyl alcohol	107186
Allyl chloride	107051
Aluminum phosphide	20859738
Aluminum sulfate	10043013
2-Amino-1-methyl benzene	95534
4-Amino-1-methyl benzene	106490
5-(Aminomethyl)-3-isoxazolol	2763964
4-Aminopyridine	504245
Amitrole	61825
Ammonia	7664417
Ammonium acetate	631618
Ammonium benzoate	1863634
Ammonium bicarbonate	1066337
Ammonium bichromate	7789095
Ammonium bifluoride	1341497
Ammonium bisulfite	10192300
Ammonium carbamate	1111780
Ammonium carbonate	506876
Ammonium chloride	12125029
Ammonium chromate	7788989
Ammonium citrate, dibasic	3012655
Ammonium fluoborate	13826830
Ammonium fluoride	12125018
Ammonium hydroxide	1336216
Ammonium oxalate	6009707 5972736 14258492
Ammonium picrate	131748
Ammonium silicofluoride	16919190
Ammonium sulfamate	7773060
Ammonium sulfide	12135761
Ammonium sulfite	10196040
Ammonium tartrate	14307438 3164292
Ammonium thiosulfate	7783188
Ammonium vanadate	7803556

Amyl acetate	628637
iso-Amyl acetate	123922
sec-Amyl acetate	626380
tert-Amyl acetate	625161
Aniline	62533
Anthracene	120127
ANTIMONY AND COMPOUNDS	N.A.
Antimony (b)	7440360
Antimony pentachloride	7647189
Antimony potassium tartrate	28300745
Antimony tribromide	7789619
Antimony trichloride	10025919
Antimony trifluoride	7783564
Antimony trioxide	1309644
Aroclor 1016	12674112
Aroclor 1221	11104282
Aroclor 1232	11141165
Aroclor 1242	53469219
Aroclor 1248	12672296
Aroclor 1254	11097691
Aroclor 1260	11096825
ARSENIC AND COMPOUNDS	N.A.
Arsenic (b)	7440382
Arsenic acid	1327522
	7778394
Arsenic disulfide	1303328
Arsenic(III) oxide	1327533
Arsenic(V) oxide	1303282
Arsenic pentoxide	1303282
Arsenic trichloride	7784341
Arsenic trioxide	1327533
Arsenic trisulfide	1303339
Arsine, diethyl-	692422
Asbestos (c)	1332214
Auramine	492808
Azaserine	115026
Aziridine	151564
Azirino(2',3':3,4)pyrrolo(1,2-a)indole-4,7-dione,6-amino-8-[((aminocarbonyl)oxy) methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methyl-	50077
Barium cyanide	542621
Benz[j]aceanthrylene, 1,2-dihydro-3-methyl-	56495
Benz[c]acridine	225514
3,4-Benzacridine	225514
Benzal chloride	98873
Benz[a]anthracene	56553
1,2-Benzanthracene	56553
1,2-Benzanthracene, 7,12-dimethyl-	57976
Benzenamine	62533
Benzenamine, 4,4'-carbonimidoylbis (N,N-dimethyl-	492808
Benzenamine, 4-chloro-	106478
Benzenamine, 4-chloro-2-methyl-, hydrochloride	3165933
Benzenamine, N,N-dimethyl-4-phenylazo-	60117
Benzenamine, 4,4'-methylenebis(2-chloro-	101144
Benzenamine, 2-methyl-, hydrochloride	636215
Benzenamine, 2-methyl-5-nitro-	99558
Benzenamine, 4-nitro-	100016
Benzene	71432
Benzene, 1-bromo-4-phenoxy-	101553
Benzene, chloro-	108907
Benzene, chloromethyl-	100447
Benzene, 1,2-dichloro-	95501
Benzene, 1,3-dichloro-	541731
Benzene, 1,4-dichloro-	106467
Benzene, dichloromethyl-	98873
Benzene, 2,4-diisocyanatomethyl-	584849
	91087
	26471625
Benzene, dimethyl	1330207
m-Benzene, dimethyl	108383
o-Benzene, dimethyl	95476
p-Benzene, dimethyl	106423
Benzene, hexachloro-	118741
Benzene, hexahydro-	110827
Benzene, hydroxy-	108952

Benzene, methyl-	108883
Benzene, 1-methyl-2,4-dinitro-	121142
Benzene, 1-methyl-2,6-dinitro-	606202
Benzene, 1,2-methylenedioxy-4-allyl-	94597
Benzene, 1,2-methylenedioxy-4-propenyl-	120581
Benzene, 1,2-methylenedioxy-4-propyl-	94586
Benzene, 1-methylethyl-	98828
Benzene, nitro-	98953
Benzene, pentachloro-	608935
Benzene, pentachloronitro-	82688
Benzene, 1,2,4,5-tetrachloro-	95943
Benzene, trichloromethyl-	98077
Benzene, 1,3,5-trinitro-	99354
Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-, ethyl ester	510156
1,2-Benzenedicarboxylic acid anhydride	85449
1,2-Benzenedicarboxylic acid, [bis(2-ethylhexyl)] ester	117817
1,2-Benzenedicarboxylic acid, dibutyl ester	84742
1,2-Benzenedicarboxylic acid, diethyl ester	84662
1,2-Benzenedicarboxylic acid, dimethyl ester	131113
1,2-Benzenedicarboxylic acid, di-n-octyl ester	117840
1,3-Benzenediol	108463
1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]-	51434
Benzenesulfonic acid chloride	98099
Benzenesulfonyl chloride	98099
Benzenethiol	108985
Benzidine	92875
1,2-Benzisothiazolin-3-one,1,1-dioxide, and salts	81072
Benzo[a]anthracene	56553
Benzo[b]fluoranthene	205992
Benzo[k]fluoranthene	207089
Benzo[j,k]fluorene	206440
Benzoic acid	65850
Benzonitrile	100470
Benzo[ghi]perylene	191242
Benzo[a]pyrene	50328
3,4-Benzopyrene	50328
p-Benzoquinone	106514
Benzotrichloride	98077
Benzoyl chloride	98884
1,2-Benzphenanthrene	218019
Benzyl chloride	100447
BERYLLIUM AND COMPOUNDS	N.A.
Beryllium (b)	7440417
Beryllium chloride	7787475
Beryllium dust (b)	7440417
Beryllium fluoride	7787497
Beryllium nitrate	13597994 7787555
alpha - BHC	319846
beta - BHC	319857
delta - BHC	319868
gamma - BHC	58899
2,2'-Bioxirane	1464535
(1,1'-Biphenyl)-4,4'diamine	92875
(1,1'-Biphenyl)-4,4'diamine,3,3'dichloro-	91941
(1,1'-Biphenyl)-4,4'diamine,3,3'dimethoxy-	119904
(1,1'Biphenyl)-4,4'-diamine,3,3'-dimethyl-	119937
Bis(2-chloroethoxy) methane	111911
Bis (2-chloroethyl) ether	111444
Bis(2-chloroisopropyl) ether	108601
Bis(chloromethyl) ether	542881
Bis(dimethylthiocarbamoyl) disulfide	137268
Bis(2-ethylhexyl)phthalate	117817
Bromine cyanide	506683
Bromoacetone	598312
Bromoform	75252
4-Bromophenyl phenyl ether	101553
Brucine	357573
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-	87683
1-Butanamine, N-butyl-N-nitroso-	924163
Butanoic acid, 4-[bis(2-chloroethyl)amino]benzene-	305033
1-Butanol	71363
2-Butanone	78933

2-Butanone peroxide	1338234
2-Butenal	123739
	4170303
2-Butene, 1,4-dichloro-	764410
Butyl acetate	123864
iso-Butyl acetate	110190
sec-Butyl acetate	105464
tert-Butyl acetate	540885
n-Butyl alcohol	71363
Butylamine	109739
iso-Butylamine	78819
sec-Butylamine	513495
	13952846
tert-Butylamine	75649
Butyl benzyl phthalate	85687
n-Butyl phthalate	84742
iso-Butyric acid	79312
Cacodylic acid	75605
CADMIUM AND COMPOUNDS	N.A.
Cadmium (b)	7440439
Cadmium acetate	543908
Cadmium bromide	7789426
Cadmium chloride	10108642
Calcium arsenate	7778441
Calcium arsenite	52740166
Calcium carbide	75207
Calcium chromate	13765190
Calcium cyanide	592018
Calcium dodecylbenzene sulfonate	26264062
Calcium hypochlorite	7778543
Camphene, octachloro-	8001352
Captan	133062
Carbamic acid, ethyl ester	51796
Carbamic acid, methylnitroso-, ethyl ester	615532
Carbamide, N-ethyl-N-nitroso-	759739
Carbamide, N-methyl-N-nitroso-	684935
Carbamide, thio-	62566
Carbamimidoselenoic acid	630104
Carbamoyl chloride, dimethyl-	79447
Carbaryl	63252
Carbofuran	1563662
Carbon bisulfide	75150
Carbon disulfide	75150
Carbonic acid, dithallium (I) salt	6533739
Carbonochloridic acid, methyl ester	79221
Carbon oxyfluoride	353504
Carbon tetrachloride	56235
Carbonyl chloride	75445
Carbonyl fluoride	353504
Chloral	75876
Chlorambucil	305033
CHLORDANE (TECHNICAL MIXTURE AND METABOLITES)	N.A.
Chlordane	57749
Chlordane, technical	57749
CHLORINATED BENZENES	N.A.
CHLORINATED ETHANES	N.A.
CHLORINATED NAPHTHALENE	N.A.
CHLORINATED PHENOLS	N.A.
Chlorine	7782505
Chlorine cyanide	506774
Chlornaphazine	494031
Chloroacetaldehyde	107200
CHLOROALKYL ETHERS	N.A.
p-Chloroaniline	106478
Chlorobenzene	108907
4-Chloro-m-cresol	59507
p-Chloro-m-cresol	59507
Chlorodibromomethane	124481
1-Chloro-2,3-epoxypropane	106898
Chloroethane	75003
2-Chloroethyl vinyl ether	110758
Chloroform	67663
Chloromethyl methyl ether	107302
beta-Chloronaphthalene	91587
2-Chloronaphthalene	91587

2-Chlorophenol	95578
o-Chlorophenol	95578
4-Chlorophenyl phenyl ether	7005723
1-(o-Chlorophenyl)thiourea	5344821
3-Chloropropionitrile	542767
Chlorosulfonic acid	7790945
4-Chloro-o-toluidine, hydrochloride	3165933
Chlorpyrifos	2921882
Chromic acetate	1066304
Chromic acid	11115745
	7738945
Chromic acid, calcium salt	13765190
Chromic sulfate	10101538
CHROMIUM AND COMPOUNDS	N.A.
Chromium (b)	7440473
Chromous chloride	10049055
Chrysene	218019
Cobaltous bromide	7789437
Cobaltous formate	544183
Cobaltous sulfamate	14017415
COKE OVEN EMISSIONS	N.A.
COPPER AND COMPOUNDS	N.A.
Copper (b)	7440508
Copper cyanide	544923
Coumaphos	56724
Creosote	8001589
Cresols	1319773
m-Cresols	108394
o-Cresols	95487
p-Cresols	106445
Cresylic acid	1319773
m-Cresols	108394
o-Cresols	95487
p-Cresols	106445
Crotonaldehyde	123739
	4170303
Cumene	98828
Cupric acetate	142712
Cupric acetoarsenite	12002038
Cupric chloride	7447394
Cupric nitrate	3251238
Cupric oxalate	5893663
Cupric sulfate	7758987
Cupric sulfate ammoniated	10380297
Cupric tartrate	815827
CYANIDES	N.A.
Cyanides (soluble cyanide salts), not elsewhere specified	57125
Cyanogen	460195
Cyanogen bromide	506683
Cyanogen chloride	506774
1,4-Cyclohexadienedione	106514
Cyclohexane	110827
Cyclohexanone	108941
1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro-	77474
Cyclophosphamide	50180
2,4-D Acid	94757
2,4-D Acid	94757
2,4-D Esters	94111
2,4-D Esters	94791
2,4-D Esters	94804
2,4-D Esters	1320189
2,4-D Esters	1928387
2,4-D Esters	1928616
2,4-D Esters	1929733
2,4-D Esters	2971382
2,4-D Esters	25168267
2,4-D Esters	53467111
2,4-D, salts and esters	94757
2,4-D, salts and esters	94757
Daunomycin	20830813
DDT AND METABOLITES	N.A.
DDD	72548
4,4'-DDD	72548
DDE	72559

4,4'-DDE	72559
DDT	50293
4,4'-DDT	50293
Decachlorooctahydro-1,3,4-metheno-2H-cyclobuta[c,d]-pentalen-2-one	143500
Diallate	2303164
Diamine	302012
Diaminotoluene	95807
	496720
	823405
	25376458
Diazinon	333415
Dibenz[a,h]anthracene	53703
1,2:5,6-Dibenzanthracene	53703
Dibenzo[a,h]anthracene	53703
1,2:7,8-Dibenzopyrene	189559
Dibenz[a,i]pyrene	189559
1,2-Dibromo-3-chloropropane	96128
Dibutyl phthalate	84742
Di-n-butyl phthalate	84742
Dicamba	1918009
Dichlobenil	1194656
Dichlone	117806
S-(2,3-Dichloroallyl) diisopropylthiocarbamate	2303164
3,5-Dichloro-N-(1,1-dimethyl-2-propynyl)benzamide	23950585
Dichlorobenzene (mixed)	25321226
1,2-Dichlorobenzene	95501
1,3-Dichlorobenzene	541731
1,4-Dichlorobenzene	106467
m-Dichlorobenzene	541731
o-Dichlorobenzene	95501
p-Dichlorobenzene	106467
DICHLOROBENZIDINE	N.A.
3,3'-Dichlorobenzidine	91941
Dichlorobromomethane	75274
1,4-Dichloro-2-butene	764410
Dichlorodifluoromethane	75718
Dichlorodiphenyl dichloroethane	72548
Dichlorodiphenyl trichloroethane	50293
1,1-Dichloroethane	75343
1,2-Dichloroethane	107062
1,1-Dichloroethylene	75354
1,2-trans-Dichloroethylene	156605
Dichloroethyl ether	111444
2,4-Dichlorophenol	120832
2,6-Dichlorophenol	87650
2,4-Dichlorophenoxyacetic acid, salts and esters	94757
Dichlorophenylarsine	696286
Dichloropropane	26638197
1,1-Dichloropropane	78999
1,3-Dichloropropane	142289
1,2-Dichloropropane	78875
Dichloropropane - Dichloropropene (mixture)	8003198
Dichloropropene	26952238
2,3-Dichloropropene	78886
1,3-Dichloropropene	542756
2,2-Dichloropropionic acid	75990
Dichlorvos	62737
Dieldrin	60571
1,2:3,4-Diepoxybutane	1464535
Diethylamine	109897
Diethylarsine	692422
1,4-Diethylene dioxide	123911
O,O-Diethyl S-[2-(ethylthio)ethyl]phosphorodithioate	298044
N,N'-Diethylhydrazine	1615801
O,O-Diethyl S-methyl dithiophosphate	3288582
Diethyl-p-nitrophenyl phosphate	311455
Diethyl phthalate	84662
O,O-Diethyl O-pyrazinyl phosphorothioate	297972
Diethylstilbestrol	56531
1,2-Dihydro-3,6-pyridazinedione	123331
Dihydrosafrole	94586
Diisopropyl fluorophosphate	55914
Dimethoate	60515
3,3'-Dimethoxybenzidine	119904

Dimethylamine	124403
Dimethylaminoazobenzene	60117
7,12-Dimethylbenz[a]anthracene	57976
3,3'-Dimethylbenzidine	119937
alpha,alpha-Dimethylbenzylhydroperoxide	80159
3,3-Dimethyl-1-(methylthio)-2-butanone,O-[(methylamino)carbonyl] oxime	39196184
Dimethylcarbamoyl chloride	79447
1,1-Dimethylhydrazine	57147
1,2-Dimethylhydrazine	540738
O,O-Dimethyl O-p-nitrophenyl phosphorothioate	298000
Dimethylnitrosamine	62759
alpha,alpha-Dimethylphenethylamine	122098
2,4-Dimethylphenol	105679
Dimethyl phthalate	131113
Dimethyl sulfate	77781
Dinitrobenzene (mixed)	25154545
m-Dinitrobenzene	99650
o-Dinitrobenzene	528290
p-Dinitrobenzene	100254
4,6-Dinitro-o-cresol and salts	534521
4,6-Dinitro-o-cyclohexylphenol	131895
Dinitrophenol	25550587
2,5-Dinitrophenol	329715
2,6-Dinitrophenol	573568
2,4-Dinitrophenol	51285
Dinitrotoluene	25321146
3,4-Dinitrotoluene	610399
2,4-Dinitrotoluene	121142
2,6-Dinitrotoluene	606202
Dinoseb	88857
Di-n-octyl phthalate	117840
1,4-Dioxane	123911
DIPHENYLHYDRAZINE	N.A.
1,2-Diphenylhydrazine	122667
Diphosphoramide, octamethyl-	152169
Dipropylamine	142847
Di-n-propylnitrosamine	621647
Diquat	85007
	2764729
Disulfoton	298044
2,4-Dithiobiuret	541537
Dithiopyrophosphoric acid, tetraethyl ester	3689245
Diuron	330541
Dodecylbenzenesulfonic acid	27176870
ENDOSULFAN AND METABOLITES	N.A.
Endosulfan	115297
alpha - Endosulfan	959988
beta - Endosulfan	33213659
Endosulfan sulfate	1031078
Endothall	145733
ENDRIN AND METABOLITES	N.A.
Endrin	72208
Endrin aldehyde	7421934
Epichlorohydrin	106898
Epinephrine	51434
Ethanal	75070
Ethanamine, 1,1-dimethyl-2-phenyl-	122098
Ethanamine, N-ethyl-N-nitroso-	55185
Ethane, 1,2-dibromo-	106934
Ethane, 1,1-dichloro-	75343
Ethane, 1,2-dichloro-	107062
1,2-Ethanediylbiscarbamodithioic acid	111546
Ethane, 1,1,1,2,2,2-hexachloro-	67721
Ethane, 1,1'-[methylenebis(oxy)]bis(2-chloro-	111911
Ethanenitrile	75058
Ethane, 1,1'-oxybis-	60297
Ethane, 1,1'-oxybis(2-chloro-	111444
Ethane, pentachloro-	76017
Ethane, 1,1,1,2-tetrachloro-	630206
Ethane, 1,1,2,2-tetrachloro-	79345
Ethanethioamide	62555
Ethane, 1,1,2-trichloro-	79005
Ethane, 1,1,1-trichloro-2,2-bis(p-methoxyphenyl)-	72435
Ethanol, 2,2'-(nitrosoimino)bis-	1116547

Ethanone, 1-phenyl-	98862
Ethanoyl chloride	75365
Ethenamine, N-methyl-N-nitroso-	4549400
Ethene, chloro-	75014
Ethene, 2-chloroethoxy-	110758
Ethene, 1,1-dichloro-	75354
Ethene, 1,1,2,2-tetrachloro-	127184
Ethene, trans-1,2-dichloro-	156605
Ethion	563122
2-Ethoxyethanol	110805
Ethyl acetate	141786
Ethyl acrylate	140885
Ethylbenzene	100414
Ethyl carbamate (Urethan)	51796
Ethyl cyanide	107120
Ethyl 4,4'-dichlorobenzilate	510156
Ethylene dibromide	106934
Ethylene dichloride	107062
Ethylene glycol monoethyl ether	110805
Ethylene oxide	75218
Ethylenebis(dithiocarbamic acid)	111546
Ethylenediamine	107153
Ethylenediamine tetraacetic acid (EDTA)	60004
Ethylenethiourea	96457
Ethylenimine	151564
Ethyl ether	60297
Ethylidene dichloride	75343
Ethyl methacrylate	97632
Ethyl methanesulfonate	62500
Famphur	52857
Ferric ammonium citrate	1185575
Ferric ammonium oxalate	2944674 55488874
Ferric chloride	7705080
Ferric fluoride	7783508
Ferric nitrate	10421484
Ferric sulfate	10028225
Ferrous ammonium sulfate	10045893
Ferrous chloride	7758943
Ferrous sulfate	7720787 7782630
Fluoranthene	206440
Fluorene	86737
Fluorine	7782414
Fluoroacetamide	640197
Fluoroacetic acid, sodium salt	62748
Formaldehyde	50000
Formic acid	64186
Fulminic acid, mercury(II)salt	628864
Fumaric acid	110178
Furan	110009
Furan, tetrahydro-	109999
2-Furancarboxaldehyde	98011
2,5-Furandione	108316
Furfural	98011
Furfuran	110009
D-Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)-	18883664
Glycidylaldehyde	765344
Guanidine, N-nitroso-N-methyl-N'-nitro-	70257
Guthion	86500
HALOETHERS	N.A.
HALOMETHANES	N.A.
HEPTACHLOR AND METABOLITES	N.A.
Heptachlor	76448
Heptachlor epoxide	1024573
Hexachlorobenzene	118741
Hexachlorobutadiene	87683
HEXACHLOROCYCLOHEXANE (all isomers)	608731
Hexachlorocyclohexane (gamma isomer)	58899
Hexachlorocyclopentadiene	77474
1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,endo-1,4:5,8-dimethanonaphthalene	72208
1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,	60571

8a-octahydro-endo,exo-1,4:5,8-dimethanonaphthalene	
Hexachloroethane	67721
Hexachlorohexahydro-endo,endo-dimethanonaphthalene	465736
1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-endo,endo-dimethanonaphthalene	465736
1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-endo,exo-dimethanonaphthalene	309002
Hexachlorophene	70304
Hexachloropropene	1888717
Hexaethyl tetraphosphate	757584
Hydrazine	302012
Hydrazine, 1,2-diethyl-	1615801
Hydrazine, 1,1-dimethyl-	57147
Hydrazine, 1,2-dimethyl-	540738
Hydrazine, 1,2-diphenyl-	122667
Hydrazine, methyl-	60344
Hydrazinecarbothioamide	79196
Hydrochloric acid	7647010
Hydrocyanic acid	74908
Hydrofluoric acid	7664393
Hydrogen cyanide	74908
Hydrogen fluoride	7664393
Hydrogen phosphide	7803512
Hydrogen sulfide	7783064
Hydroperoxide, 1-methyl-1-phenylethyl-	80159
Hydrosulfuric acid	7783064
Hydroxydimethylarsine oxide	75605
2-Imidazolidinethione	96457
Indeno(1,2,3-cd)pyrene	193395
Isobutyl alcohol	78831
Isocyanic acid, methyl ester	624839
Isophorone	78591
Isoprene	78795
Isopropanolamine dodecylbenzene sulfonate	42504461
Isosafrole	120581
3(2H)-Isoxazolone, 5-(aminomethyl)-	2763964
Kelthane	115322
Kepone	143500
Lasiocarpine	303344
LEAD AND COMPOUNDS	N.A.
Lead (b)	7439921
Lead acetate	301042
Lead arsenate	7784409 7645252 10102484
Lead chloride	7758954
Lead fluoborate	13814965
Lead fluoride	7783462
Lead iodide	10101630
Lead nitrate	10099748
Lead phosphate	7446277
Lead stearate	7428480 1072351 52652592 56189094
Lead subacetate	1335326
Lead sulfate	15739807 7446142
Lead sulfide	1314870
Lead thiocyanate	592870
Lindane	58899
Lithium chromate	14307358
Malathion	121755
Maleic acid	110167
Maleic anhydride	108316
Maleic hydrazide	123331
Malononitrile	109773
Melphalan	148823
Mercaptodimethur	2032657
Mercuric cyanide	592041
Mercuric nitrate	10045940
Mercuric sulfate	7783359
Mercuric thiocyanate	592858
Mercurous nitrate	10415755 7782867

MERCURY AND COMPOUNDS	N.A.
Mercury	7439976
Mercury, (acetato-O)phenyl-	62384
Mercury fulminate	628864
Methacrylonitrile	126987
Methanamine, N-methyl-	124403
Methane, bromo-	74839
Methane, chloro-	74873
Methane, chloromethoxy-	107302
Methane, dibromo-	74953
Methane, dichloro-	75092
Methane, dichlorodifluoro-	75718
Methane, iodo-	74884
Methane, oxybis(chloro-	542881
Methane, tetrachloro-	56235
Methane, tetranitro-	509148
Methane, tribromo-	75252
Methane, trichloro-	67663
Methane, trichlorofluoro-	75694
Methanesulfenyl chloride, trichloro-	594423
Methanesulfonic acid, ethyl ester	62500
Methanethiol	74931
4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-	76448
Methanoic acid	64186
4,7-Methanoindan, 1,2,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-	57749
Methanol	67561
Methapyrilene	91805
Methomyl	16752775
Methoxychlor	72435
Methyl alcohol	67561
2-Methylaziridine	75558
Methyl bromide	74839
1-Methylbutadiene	504609
Methyl chloride	74873
Methyl chlorocarbonate	79221
Methyl chloroform	71556
3-Methylcholanthrene	56495
4,4'-Methylenebis(2-chloroaniline)	101144
2,2'-Methylenebis(3,4,6-trichlorophenol)	70304
Methylene bromide	74953
Methylene chloride	75092
Methylene oxide	50000
Methyl ethyl ketone	78933
Methyl ethyl ketone peroxide	1338234
Methyl hydrazine	60344
Methyl iodide	74884
Methyl isobutyl ketone	108101
Methyl isocyanate	624839
2-Methyllactonitrile	75865
Methylmercaptan	74931
Methyl methacrylate	80626
N-Methyl-N'-nitro-N-nitrosoguanidine	70257
Methyl parathion	298000
4-Methyl-2-pentanone	108101
Methylthiouracil	56042
Mevinphos	7786347
Mexacarbate	315184
Mitomycin C	50077
Monoethylamine	75047
Monomethylamine	74895
Naled	300765
5,12-Naphthacenedione, (8S-cis)-8-acetyl-10-[3-amino-2,3,6-trideoxy-alpha-L-lyxo-hexopyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-	20830813
Naphthalene	91203
Naphthalene, 2-chloro-	91587
1,4-Naphthalenedione	130154
2,7-Naphthalenedisulfonic acid, 3,3'-[(3,3'-dimethyl-(l,1'-biphenyl)-4,4'-diyl)-bis(azo)]bis(5-amino-4-hydroxy)-tetrasodium salt	72571
Naphthenic acid	1338245
1,4-Naphthoquinone	130154

alpha-Naphthylamine	134327
beta-Naphthylamine	91598
1-Naphthylamine	134327
2-Naphthylamine	91598
2-Naphthylamine, N,N-bis(2-chloroethyl)-	494031
alpha-Naphthylthiourea	86884
NICKEL AND COMPOUNDS	N.A.
Nickel (b)	7440020
Nickel ammonium sulfate	15699180
Nickel carbonyl	13463393
Nickel chloride	7718549 37211055
Nickel cyanide	557197
Nickel(II) cyanide	557197
Nickel hydroxide	12054487
Nickel nitrate	14216752
Nickel sulfate	7786814
Nickel tetracarbonyl	13463393
Nicotine and salts	54115
Nitric acid	7697372
Nitric oxide	10102439
p-Nitroaniline	100016
Nitrobenzene	98953
Nitrogen dioxide	10102440 10544726
Nitrogen(II) oxide	10102439
Nitrogen(IV) oxide	10102440 10544726
Nitroglycerine	55630
NITROPHENOLS	N.A.
Nitrophenol (mixed)	25154556
m-Nitrophenol	554847
o-Nitrophenol	88755
p-Nitrophenol	100027
o-Nitrophenol	88755
p-Nitrophenol	100027
2-Nitrophenol	88755
4-Nitrophenol	100027
2-Nitropropane	79469
NITROSAMINES	N.A.
N-Nitrosodi-n-butylamine	924163
N-Nitrosodiethanolamine	1116547
N-Nitrosodiethylamine	55185
N-Nitrosodimethylamine	62759
N-Nitrosodiphenylamine	86306
N-Nitrosodi-n-propylamine	621647
N-Nitroso-N-ethylurea	759739
N-Nitroso-N-methylurea	684935
N-Nitroso-N-methylurethane	615532
N-Nitrosomethylvinylamine	4549400
N-Nitrosopiperidine	100754
N-Nitrosopyrrolidine	930552
Nitrotoluene	1321126
m-Nitrotoluene	99081
o-Nitrotoluene	88722
p-Nitrotoluene	99990
5-Nitro-o-toluidine	99558
5-Norbornene-2,3-dimethanol,1,4,5,6,7,7-hexachloro ,cyclic sulfite	115297
Octamethylpyrophosphoramide	152169
Osmium oxide	20816120
Osmium tetroxide	20816120
7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid	145733
1,2-Oxathiolane, 2,2-dioxide	1120714
2H-1,3,2-Oxazaphosphorine,2-[bis(2-chloroethyl) amino] tetrahydro-2-oxide	50180
Oxirane	75218
Oxirane, 2-(chloromethyl)-	106898
Paraformaldehyde	30525894
Paraldehyde	123637
Parathion	56382
Pentachlorobenzene	608935
Pentachloroethane	76017
Pentachloronitrobenzene	82688
Pentachlorophenol	87865

1,3-Pentadiene	504609
Perchloroethylene	127184
Phenacetin	62442
Phenanthrene	85018
Phenol	108952
Phenol, 4-chloro-3-methyl-	59507
Phenol, 2-chloro-	95578
Phenol, 2-cyclohexyl-4,6-dinitro-	131895
Phenol, 2,4-dichloro-	120832
Phenol, 2,6-dichloro-	87650
Phenol, 2,4-dimethyl-	105679
Phenol, 2,4-dinitro-6-(1-methylpropyl)-	88857
Phenol, 2,4-dinitro-6-methyl-, and salts	534521
Phenol, 2,4-dinitro-	51285
Phenol, 4-nitro-	100027
Phenol, pentachloro-	87865
Phenol, 2,3,4,6-tetrachloro-	58902
Phenol, 2,4,5-trichloro-	95954
Phenol, 2,4,6-trichloro-	88062
Phenol, 2,4,6-trinitro-, ammonium salt	131748
Phenyl dichloroarsine	696286
1,10-(1,2-Phenylene)pyrene	193395
Phenylmercuric acetate	62384
N-Phenylthiourea	103855
Phorate	298022
Phosgene	75445
Phosphine	7803512
Phosphoric acid	7664382
Phosphoric acid, diethyl p-nitrophenyl ester	311455
Phosphoric acid, lead salt	7446277
Phosphorodithioic acid, O,O-diethyl S-(ethylthio), methyl ester	298022
Phosphorodithioic acid, O,O-diethyl S-methyl ester	3288582
Phosphorodithioic acid, O,O-dimethyl S-[2(methylamino)-2-oxoethyl] ester	60515
Phosphorofluoridic acid, bis(1-methylethyl) ester	55914
Phosphorothioic acid, O,O-diethyl O-(p-nitrophenyl) ester	56382
Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester	297972
Phosphorothioic acid, O,O-dimethyl O-[p-[(dimethylamino)-sulfonyl] phenyl] ester	52857
Phosphorus	7723140
Phosphorus oxychloride	10025873
Phosphorus pentasulfide	1314803
Phosphorus sulfide	1314803
Phosphorus trichloride	7719122
PHTHALATE ESTERS	N.A.
Phthalic anhydride	85449
2-Picoline	109068
Plumbane, tetraethyl-	78002
POLYCHLORINATED BIPHENYLS (PCBs)	1336363
Polychlorinated Biphenyls (PCBs)	12674112
Polychlorinated Biphenyls (PCBs)	11104282
Polychlorinated Biphenyls (PCBs)	11141165
Polychlorinated Biphenyls (PCBs)	53469219
Polychlorinated Biphenyls (PCBs)	12672296
Polychlorinated Biphenyls (PCBs)	11097691
Polychlorinated Biphenyls (PCBs)	11096825
POLYNUCLEAR AROMATIC HYDROCARBONS	N.A.
Potassium arsenate	7784410
Potassium arsenite	10124502
Potassium bichromate	7778509
Potassium chromate	7789006
Potassium cyanide	151508
Potassium hydroxide	1310583
Potassium permanganate	7722647
Potassium silver cyanide	506616
Pronamide	23950585
1-Propanal, 2,3-epoxy-	765344
Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime	116063
1-Propanamine	107108
1-Propanamine, N-propyl-	142847
Propane, 1,2-dibromo-3-chloro-	96128

Propane, 2-nitro-	79469
Propane, 2,2'-oxybis(2-chloro-	108601
1,3-Propane sultone	1120714
Propanedinitrile	109773
Propanenitrile	107120
Propanenitrile, 3-chloro-	542767
Propanenitrile, 2-hydroxy-2-methyl-	75865
1,2,3-Propanetriol, trinitrate-	55630
1-Propanol, 2,3-dibromo-, phosphate (3:1)	126727
1-Propanol, 2-methyl-	78831
2-Propanone	67641
2-Propanone, 1-bromo-	598312
Propargite	2312358
Propargyl alcohol	107197
2-Propenal	107028
2-Propenamide	79061
Propene, 1,3-dichloro-	542756
1-Propene, 1,1,2,3,3,3-hexachloro-	1888717
2-Propenenitrile	107131
2-Propenenitrile, 2-methyl-	126987
2-Propenoic acid	79107
2-Propenoic acid, ethyl ester	140885
2-Propenoic acid, 2-methyl-, ethyl ester	97632
2-Propenoic acid, 2-methyl-, methyl ester	80626
2-Propen-1-ol	107186
Propionic acid	79094
Propionic acid, 2-(2,4,5-trichlorophenoxy)-	93721
Propionic anhydride	123626
n-Propylamine	107108
Propylene dichloride	78875
Propylene oxide	75569
1,2-Propylenimine	75558
2-Propyn-1-ol	107197
Pyrene	129000
Pyrethrins	121299 121211 8003347
4-Pyridinamine	504245
Pyridine	110861
Pyridine, 2-[(2-(dimethylamino)ethyl)-2-thenylamino]-	91805
Pyridine, hexahydro-N-nitroso-	100754
Pyridine, 2-methyl-	109068
Pyridine, (S)-3-(1-methyl-2-pyrrolidinyl)-, and salts	54115
4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo-	56042
Pyrophosphoric acid, tetraethyl ester	107493
Pyrrole, tetrahydro-N-nitroso-	930552
Quinoline	91225
RADIONUCLIDES	N.A.
Reserpine	50555
Resorcinol	108463
Saccharin and salts	81072
Safrole	94597
SELENIUM AND COMPOUNDS	N.A.
Selenious acid	7783008
Selenium (b)	7782492
Selenium dioxide	7446084
Selenium disulfide	7488564
Selenium oxide	7446084
Selenourea	630104
L-Serine, diazoacetate (ester)	115026
SILVER AND COMPOUNDS	N.A.
Silver (b)	7440224
Silver cyanide	506649
Silver nitrate	7761888
Silvex	93721
Sodium	7440235
Sodium arsenate	7631892
Sodium arsenite	7784465
Sodium azide	26628228
Sodium bichromate	10588019
Sodium bifluoride	1333831
Sodium bisulfite	7631905
Sodium chromate	7775113

Sodium cyanide	143339
Sodium dodecylbenzene sulfonate	25155300
Sodium fluoride	7681494
Sodium hydrosulfide	16721805
Sodium hydroxide	1310732
Sodium hypochlorite	7681529
	10022705
Sodium methylate	124414
Sodium nitrite	7632000
Sodium phosphate, dibasic	7558794
	10039324
	10140655
Sodium phosphate, tribasic	7601549
	7758294
	7785844
	10101890
	10124568
	10361894
Sodium selenite	10102188
	7782823
4,4'-Stilbenediol, alpha,alpha'-diethyl-	56531
Streptozotocin	18883664
Strontium chromate	7789062
Strychnidin-10-one, and salts	57249
Strychnidin-10-one, 2,3-dimethoxy-	357573
Strychnine and salts	57249
Styrene	100425
Sulfur hydride	7783064
Sulfur monochloride	12771083
Sulfur phosphide	1314803
Sulfur selenide	7488564
Sulfuric acid	7664939
	8014957
Sulfuric acid, dimethyl ester	77781
Sulfuric acid, thallium(I) salt	7446186
	10031591
2,4,5-T acid	93765
2,4,5-T amines	2008460
	1319728
	3813147
	6369966
	6369977
2,4,5-T esters	93798
	1928478
	2545597
	25168154
	61792072
2,4,5-T salts	13560991
2,4,5-T	93765
TDE	72548
1,2,4,5-Tetrachlorobenzene	95943
2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD)	1746016
1,1,1,2-Tetrachloroethane	630206
1,1,2,2-Tetrachloroethane	79345
Tetrachloroethene	127184
Tetrachloroethylene	127184
2,3,4,6-Tetrachlorophenol	58902
Tetraethyl lead	78002
Tetraethyl pyrophosphate	107493
Tetraethyldithiopyrophosphate	3689245
Tetrahydrofuran	109999
Tetranitromethane	509148
Tetraphosphoric acid, hexaethyl ester	757584
THALLIUM AND COMPOUNDS	N.A.
Thallic oxide	1314325
Thallium (b)	7440280
Thallium(I) acetate	563688
Thallium(I) carbonate	6533739
Thallium(I) chloride	7791120
Thallium(I) nitrate	10102451
Thallium(III) oxide	1314325
Thallium(I) selenide	12039520
Thallium(I) sulfate	7446186
	10031591
Thioacetamide	62555

Thiofanox	39196184
Thioimidodicarbonic diamide	541537
Thiomethanol	74931
Thiophenol	108985
Thiosemicarbazide	79196
Thiourea	62566
Thiourea, (2-chlorophenyl)-	5344821
Thiourea, 1-naphthalenyl-	86884
Thiourea, phenyl-	103855
Thiram	137268
Toluene	108883
Toluenediamine	95807
	496720
	823405
	25376458
Toluene diisocyanate	584849
	91087
	26471625
o-Toluidine	95534
p-Toluidine	106490
o-Toluidine hydrochloride	636215
Toxaphene	8001352
2,4,5-TP acid esters	32534955
2,4,5-TP acid	93721
1H-1,2,4-Triazol-3-amine	61825
Trichlorfon	52686
1,2,4-Trichlorobenzene	120821
1,1,1-Trichloroethane	71556
1,1,2-Trichloroethane	79005
Trichloroethene	79016
Trichloroethylene	79016
Trichloromethanesulfenyl chloride	594423
Trichloromonofluoromethane	75694
Trichlorophenol	25167822
2,3,4-Trichlorophenol	15950660
2,3,5-Trichlorophenol	933788
2,3,6-Trichlorophenol	933755
2,4,5-Trichlorophenol	95954
2,4,6-Trichlorophenol	88062
3,4,5-Trichlorophenol	609198
2,4,5-Trichlorophenol	95954
2,4,6-Trichlorophenol	88062
2,4,5-Trichlorophenoxyacetic acid	93765
Triethanolamine dodecylbenzene sulfonate	27323417
Triethylamine	121448
Trimethylamine	75503
sym-Trinitrobenzene	99354
1,3,5-Trioxane, 2,4,6-trimethyl-	123637
Tris(2,3-dibromopropyl) phosphate	126727
Trypan blue	72571
Unlisted Hazardous Wastes Characteristic of Corrosivity	N.A.
Unlisted Hazardous Wastes Characteristic of EP Toxicity	N.A.
Arsenic D004	N.A.
Barium D005	N.A.
Cadmium D006	N.A.
Chromium D007	N.A.
Lead D008	N.A.
Mercury D009	N.A.
Selenium D010	N.A.
Silver D011	N.A.
Endrin D012	N.A.
Lindane D013	N.A.
Methoxychlor D014	N.A.
Toxaphene D015	N.A.
2,4-D D016	N.A.
2,4,5-TP D017	N.A.
Unlisted Hazardous Wastes Characteristic of Ignitability	N.A.
Unlisted Hazardous Wastes Characteristic of Reactivity	N.A.
Uracil, 5-[bis(2-chloroethyl)amino]-	66751
Uracil mustard	66751

Uranyl acetate	541093
Uranyl nitrate	10102064
	36478769
Vanadic acid, ammonium salt	7803556
Vanadium(V) oxide	1314621
Vanadium pentoxide	1314621
Vanadyl sulfate	27774136
Vinyl acetate	108054
Vinyl chloride	75014
Vinylidene chloride	75354
Warfarin	81812
Xylene (mixed)	1330207
m-Benzene, dimethyl	108383
o-Benzene, dimethyl	95476
p-Benzene, dimethyl	106423
Xylenol	1300716
Yohimban-16-carboxylic acid,11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-, methyl ester	50555
ZINC AND COMPOUNDS	N.A.
Zinc (b)	7440666
Zinc acetate	557346
Zinc ammonium chloride	52628258
	14639975
	14639986
Zinc borate	1332076
Zinc bromide	7699458
Zinc carbonate	3486359
Zinc chloride	7646857
Zinc cyanide	557211
Zinc fluoride	7783495
Zinc formate	557415
Zinc hydrosulfite	7779864
Zinc nitrate	7779886
Zinc phenolsulfonate	127822
Zinc phosphide	1314847
Zinc silicofluoride	16871719
Zinc sulfate	7733020
Zirconium nitrate	13746899
Zirconium potassium fluoride	16923958
Zirconium sulfate	14644612
Zirconium tetrachloride	10026116

F001

The following spent halogenated solvents used in degreasing and sludges from the recovery of these solvents in degreasing operations:

(a) Tetrachloroethylene	127184
(b) Trichloroethylene	79016
(c) Methylene chloride	75092
(d) 1,1,1-Trichloroethane	71556
(e) Carbon tetrachloride	56235
(f) Chlorinated fluorocarbons	N.A.

F002

The following spent halogenated solvents and the still bottoms from the recovery of these solvents:

(a) Tetrachloroethylene	127184
(b) Methylene chloride	75092
(c) Trichloroethylene	79016
(d) 1,1,1-Trichloroethane	71556
(e) Chlorobenzene	108907
(f) 1,1,2-Trichloro-1,2,2-trifluoroethane	76131
(g) o-Dichlorobenzene	95501
(h) Trichlorofluoromethane	75694

F003

The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents:

(a) Xylene (mixed)	1330207
(b) Acetone	67641
(c) Ethyl acetate	141786
(d) Ethylbenzene	100414
(e) Ethyl ether	60297

(f) Methyl isobutyl ketone	108101
(g) n-Butyl alcohol	71363
(h) Cyclohexanone	108941
(i) Methanol	67561

F004
The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents:

(a) Cresols/Cresylic acid	1319773
(b) Nitrobenzene	98953

F005
The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents:

(a) Toluene	108883
(b) Methyl ethyl ketone	78933
(c) Carbon disulfide	75150
(d) Isobutanol	78831
(e) Pyridine	110861

F006
Wastewater treatment sludges from electroplating operations except from the following processes: (1) sulfuric acid anodizing of aluminum, (2) tin plating on carbon steel, (3) zinc plating (segregated basis) on carbon steel, (4) aluminum or zinc-aluminum plating on carbon steel, (5) cleaning /stripping associated with tin, zinc and aluminum plating on carbon steel, and (6) chemical etching and milling of aluminum

F007
Spent cyanide plating bath solutions from electroplating operations (except for precious metals electroplating spent cyanide plating bath solutions)

F008
Plating bath sludges from the bottom of plating baths from electroplating operations where cyanides are used in the process (except for precious metals electroplating plating bath sludges)

F009
Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process (except for precious metals electroplating spent stripping and cleaning bath solutions)

F010
Quenching bath sludge from oil baths from metal heat treating operations where cyanides are used in the process (except for precious metals heat-treating quenching bath sludges)

F011
Spent cyanide solutions from salt bath pot cleaning from metal heat treating operations (except for precious metals heat treating spent cyanide solutions from salt bath pot cleaning)

F012
Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process (except for precious metals heat treating quenching wastewater treatment sludges)

F019
Wastewater treatment sludges from the chemical conversion coating of aluminum

F020
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri-or-tetrachlorophenol, or of intermediates used to produce their pesticide derivatives. (This listing does not include wastes from the production of hexachlorophene from highly purified 2,4,5-trichlorophenol.)

F021
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of pentachlorophenol, or of intermediates used to produce its derivatives.

F022
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzenes under alkaline conditions.

F023
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri- and tetrachlorophenols. (This listing does not include wastes from equipment used only for the production or use of hexachlorophene from highly purified 2,4, 5-trichlorophenol.)

F024
Wastes, including but not limited to distillation residues, heavy ends, tars, and reactor cleanout wastes, from the production of chlorinated aliphatic hydrocarbons, having carbon content from one to five, utilizing free radical catalyzed processes. (This listing does not include light ends, spent filters and filter aids, spent dessicants(sic), wastewater, wastewater treatment sludges, spent catalysts, and wastes listed in Section 261.32.)

F026
Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzene under alkaline conditions.

F027
Discarded unused formulations containing tri-, tetra-, or pentachlorophenol or discarded unused formulations containing compounds derived from these chlorophenols. (This listing does not include formulations containing hexachlorophene synthesized from prepurified 2,4,5-trichlorophenol as the sole component.)

F028
Residues resulting from the incineration or thermal treatment of soil contaminated with EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027.

K001
Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol

K002
Wastewater treatment sludge from the production of chrome yellow and orange pigments

K003
Wastewater treatment sludge from the production of molybdate orange pigments

K004
Wastewater treatment sludge from the production of zinc yellow pigments

K005
Wastewater treatment sludge from the production of chrome green pigments

K006
Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated)

K007
Wastewater treatment sludge from the production of iron blue pigments

K008
Oven residue from the production of chrome oxide green pigments

K009
Distillation bottoms from the production of acetaldehyde from ethylene

K010
Distillation side cuts from the production of acetaldehyde from ethylene

K011
Bottom stream from the wastewater stripper in the production of acrylonitrile

K013
Bottom stream from the acetonitrile column in the production of acrylonitrile

K014
Bottoms from the acetonitrile purification column in the production of acrylonitrile

K015
Still bottoms from the distillation of benzyl chloride

K016
Heavy ends or distillation residues from the production of carbon tetrachloride

K017
Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin

K018
Heavy ends from the fractionation column in ethyl chloride production

K019
Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production

K020
Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production

K021
Aqueous spent antimony catalyst waste from fluoromethanes production

K022
Distillation bottom tars from the production of phenol/acetone from cumene

K023
Distillation light ends from the production of phthalic anhydride from naphthalene

K024
Distillation bottoms from the production of phthalic anhydride from naphthalene

K025
Distillation bottoms from the production of nitrobenzene by the nitration of benzene

K026
Stripping still tails from the production of methyl ethyl pyridines

K027
Centrifuge and distillation residues from toluene diisocyanate production

K028
Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane

K029
Waste from the product steam stripper in the production of 1,1,1-trichloroethane

K030
Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene

K031
By-product salts generated in the production of MSMA and cacodylic acid

K032
Wastewater treatment sludge from the production of chlordane

K033
Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane

K034
Filter solids from the filtration of hexachlorocyclopentadiene in the production of chlordane

K035
Wastewater treatment sludges generated in the production of creosote

K036
Still bottoms from toluene reclamation distillation in the production of disulfoton

K037
Wastewater treatment sludges from the production of disulfoton

K038

Wastewater from the washing and stripping of phorate production

K039
Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate

K040
Wastewater treatment sludge from the production of phorate

K041
Wastewater treatment sludge from the production of toxaphene

K042
Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T

K043
2,6-dichlorophenol waste from the production of 2,4-D

K044
Wastewater treatment sludges from the manufacturing and processing of explosives

K045
Spent carbon from the treatment of wastewater containing explosives

K046
Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds.

K047
Pink/red water from TNT operations

K048
Dissolved air flotation (DAF) float from the petroleum refining industry

K049
Slop oil emulsion solids from the petroleum refining industry

K050
Heat exchanger bundle cleaning sludge from the petroleum refining industry

K051
API separator sludge from the petroleum refining industry

K052
Tank bottoms (leaded) from the petroleum refining industry

K060
Ammonia still lime sludge from coking operations

K061
Emission control dust/sludge from the primary production of steel in electric furnaces

K062
Spent pickle liquor from steel finishing operations

K069
Emission control dust/sludge from secondary lead smelting

K071
Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used

K073
Chlorinated hydrocarbon waste from the purification step of the diaphragm cell process using graphite anodes in chlorine production

K083
Distillation bottoms from aniline extraction

K084
Wastewater treatment sludges generated during the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds

K085
Distillation or fractionation column bottoms from the production of chlorobenzenes

K086
Solvent washes and sludges, caustic washes and sludges, or water washes and sludges from cleaning tubs and equipment used in the formulation of ink from pigments, driers, soaps, and stabilizers containing chromium and lead

K087
Decanter tank tar sludge from coking operations

K093
Distillation light ends from the production of phthalic anhydride from ortho-xylene

K094
Distillation bottoms from the production of phthalic anhydride from ortho-xylene

K095
Distillation bottoms from the production of 1,1,1-trichloroethane

K096
Heavy ends from the heavy ends column from the production of 1,1,1-trichloroethane

K097
Vacuum stripper discharge from the chlordane chlorinator in the production of chlordane

K098
Untreated process wastewater from the production of toxaphene

K099
Untreated wastewater from the production of 2,4-D

K100
Waste leaching solution from acid leaching of emission control dust/sludge from secondary lead smelting

K101
Distillation tar residues from the distillation of aniline-based compounds in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds

K102
Residue from the use of activated carbon for decolorization in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds

K103
Process residues from aniline extraction from the production of aniline

K104
Combined wastewater streams generated from nitrobenzene/aniline chlorobenzenes

K105
Separated aqueous stream from the reactor product washing step in the production of chlorobenzenes

K106
Wastewater treatment sludge from the mercury cell process in chlorine production

K111
Product washwaters from the production of dinitrotoluene via nitration of toluene.

K112
Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitrotoluene.

K113
Condensed liquid light ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.

K114
Vicinals from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.

K115
Heavy ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene.

K116
Organic condensate from the solvent recovery column in the production of toluene diisocyanate via phosgenation of toluenediamine.

K117
Wastewater from the reaction vent gas scrubber in the production of ethylene bromide via bromination of ethene.

K118
Spent absorbent solids from purification of ethylene dibromide in the production of ethylene dibromide.

K123
Process wastewater (including supernates, filtrates, and washwaters) from the production of ethylenebisdithiocarbamic acid and its salts.

K124
Reactor vent scrubber water from the production of ethylenebisdithiocarbamic acid and its salts.

K125
Filtration, evaporation, and centrifugation solids from the production of ethylenebisdithiocarbamic acid and its salts.

K126
Baghouse dust and floor sweepings in milling and packaging operations from the production or formulation of ethylenebisdithiocarbamic acid and its salts.

K136
Still bottoms from the purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene.

COMMENTS/NOTES:

(a) - indicates the statutory source defined by 1, 2, 3 or 4 below.
1 - indicates that the statutory source for designation of this hazardous substance under CERCLA is Clean Water Act Section 311(6)(4).
2 - indicates that the statutory source for designation of this hazardous substance under CERCLA is Clean Water Act Section 307(a).
3 - indicates that the statutory source for designation of this hazardous substance under CERCLA is Clean Air Act Section 112.
4 - indicates that the statutory source for designation of this hazardous substance under CERCLA is RCRA Section 3001.
(b) - no reporting of releases of this hazardous substance is required if the diameter of the pieces of the solid metal released is equal to or exceeds 100 micrometers (0.004 inches).
(c) - limited to friable forms only.

APPENDIX B

Washington Hazardous Waste Sites

In 1988, Ecology began operating the Site Management Information System (SMIS), a database system designed to compile information on all sites identified as potential hazardous waste sites in the state. SMIS is maintained within Ecology's Toxics Cleanup Program (formerly the Hazardous Waste Investigations and Cleanup Program).

SMIS tracks such information as a site's location, owner and operator, affected media (air, water, soil), types of contaminants, how the contamination occurred, and the stage of investigation or cleanup. When the hazard ranking system is fully operational, a site's hazard ranking score will also be included in the database. Inclusion in the list does not establish a person's liability for cleanup costs.

The SMIS database included a total of 725 known and suspected hazardous waste sites as of 1 October 1989. The number of sites in each category follows:

Federal lead National Priorities List sites	32 sites
State lead National Priorities List sites	12 sites
Confirmed state sites	224 sites
Potential state sites	253 sites
Long term monitoring sites	20 sites
Sites with completed cleanup or no contamination	184 sites
	725 sites

Of the 725 sites, 204 sites either were fully cleaned up, are cleaned up and subject to long term monitoring, or were not contaminated. The remaining 521 sites, which are possibly subject to the proposed cleanup standards, are listed. Sites in the "potential state sites" category have been marked with an asterix. These are not confirmed sites and, upon further investigation, the Department may determine that no cleanup action is required.

Reports available from SMIS:

Site Management Information System Fact Sheet

Provides summaries by site category, ownership type, (public or private), and waste management practice (drum, landfill, tank, etc.).

Affected Media and Contaminants

Includes site name, location, site category, county, city, affected media (ground water, surface water, air, soil, sediments, drinking water), contaminants (pesticides, metals, dioxins, etc.), and waste management practice.

To request a standard report, a "Request for Public Records Report" form must be completed. Contact the Public Records Coordinator in the Toxics Cleanup Program, Department of Ecology, MAIL STOP PV-11, Olympia, Washington 98504, or telephone (206) 438-3000.

WASHINGTON HAZARDOUS WASTE SITES

County	Site Name
Adams	Burlington Northern (Othello)
	CMC Real Estate (Othello)
	Soil and Crop
	WWT Batum Facility
Asotin	*Asotin County Landfill
Benton	Benitz Farm Dump
	*Eastgate Park
	*General Chemical
	Hanford - 100-Area [U.S Department of Energy (DOE)]
	Hanford - 1110-Area (DOE)
	Hanford - 200-Area (DOE)
	Hanford - 300-Area (DOE)
	*Hicks Road Dump
	*US Ecology, Inc.
Chelan	Cascade Helicopter
	*Cashmere Landfill
	*Chelan County Landfill
	*Dryden Landfill
	Holden Mine Tailing/Wenatchee
Clallam	Clearwater Correction Center - [Department of Natural Resources (DNR)]
	Daishowa American Company, Ltd.
	Lincoln Square Apartments
	Pen Ply (ITT Rayonier)
Clark	Aerowest
	ALCOA-Vancouver
	ALCOA-Vancouver-PCB
	Allied Chemical Corporation
	ARCO Service Station #6211
	ARCO Station #948
	*Automotive Services, Inc.
	*Bill Wallway
	*Boomsnub Corporation
	*Borden Chemical-Ink Division
	*Carborundum Company
	*Carter Berry, Inc.
	*Cascade Tempering
	*Circle C Landfill
	Columbia Marine Lines
	*Columbia Pest Control Dump
	*English Pit
	*Fort Vancouver Plywood
	Frontier Hard Chrome, Inc.
	*GATX Terminals Corporation

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Clark (continued)	* George Sellinger Site
	* International Paper Company
	L & C Deli
	*Larch Mountain DNR
	Leichner Brothers Landfill
	Lone Star Diesel
	McCall Oil
	McClary Columbia Corporation
	Pacific Northwest Plating
	*Pacific Woodtreating Corporation
	*Pendleton Woolen Mills
	*Port of Vancouver
	*Robertson's Paint Shop
	*Seaport Chemical
	Tidewater Barge Lines, Inc.
	DOE-Bonneville Power Administration Ross Complex
	*Vancouver Gas Manufacturing
	*Vancouver Ice & Fuel
	*Vanrich Casting
	*Woody's 4x4
Cowlitz	*Binn and Sons dumpsite
	*Coal Creek Disposal
	*Cowlitz County SLF
	*Doug Peacock Logging Company
	*Gearhardt Gardens
	International Paper (IP) Site C
	IP Site B-Longview
	*IP Site C-Longview
	Kalama Chemical, Inc.
	*Kalama Dump S
	*N.B. Gardner
	Olympia Pipeline Company
	*Ostrander Rock disposal site
	*PCB Drum Kalama
	*Radakovich Landfill
	Reynolds Metals-Longview
	Reynolds-Longview-PCB
	West Coast/Mobil Oil Company
Douglas	*E. Wenatchee/Dependable Disposal
	Inland Air Service
Ferry	*Hecla Knob Hill Mine
Franklin	Pasco Landfill
	Port of Pasco
Grant	*Grant Company-Ephrata Landfill 1
	*Grant dangerous waste site
	Old Larson Air Force Base (AFB)
	*Washington Army National Guard Shop #2

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Grays Harbor	Aberdeen Landfill/sanitation
	Amanda Park-private well
	*Berg's Marine Construction & Repair
	Hoquiam Municipal Landfill
	Most Western Laundry
	*Roderick Timber Company
	*South Union Landfill
	*T.J. Spradin, Inc.
	*Washington Army National Guard Shop #1
	Weyerhaeuser Paper Company
Island	*Cultus Bay Landfill
	*Freeland Landfill
	*Hastie Lake Landfill
	*Oak Harbor Landfill
	U.S. Navy-NAS Whidbey Island Ault
	U.S. Navy-NAS Whidbey Island Seaplan
	*U.S. Navy-NAS Whidbey Island
Jefferson	Naval Undersea Warfare Station
	Olympic Testing Laboratory
	Port Townsend gas manufacturing site
King	*6th Avenue South Landfill
	*ABC Metal Finishing, Inc.
	*Ace Galvanizing, Inc.
	*Acme Plating Works
	Advance Electroplating
	*Airco Welding Products
	Alaska Pacific Fisheries
	*American Can Company
	American Tar Company
	*And-All Electrochrome, Inc.
	ARCO-Tank Farm
	*Asahipen American, Inc.
	*Ash Grove Cement West, Inc.
	*Asko Processing, Inc.
	*Bahnmiler Autobody Shop
	*Ballestrasse Logging
	*Bayside Disposal Company
	*Belle Field Landfill
	*Bellevue Plating Company, Inc.
	*Black Nugget mine-NE/creek
	*Black Nugget mine-Rock Tunn
	*Black Nugget mine-SW/creek
	Burlington Northern Railroad Roundhouse Site
	*Boeing Company-Auburn
	*Boeing Company-Kent Space Center
	Boeing Company-North Field
	Boeing Company-North Field JP4 tanks
	Boeing Company-Renton
	Boeing Company-Isaacson/Thompson

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
King (continued)	*Bow Lake Landfill
	Bronson Way Texaco
	*Cabot Industry
	Cedar Falls Landfill
	Cedar Hills Landfill
	Champion International-Ballard mill
	Chemcentral Solvents Company
	*Chemical Processors, Inc.
	*Chemical Processors, Inc.
	*Chromium, Inc.
	*Coal Creek Development Corporation
	Custom Circuit Technology
	DOT Landfill
	*Duvall Landfill
	*Duwamish River-Boeing pit 2
	Duwamish Shipyard, Inc.
	*Eastgate abandoned landfill
	*Enumclaw Landfill
	*Factoria pit (Sunset Park)
	*Federal Way Landfill
	First Avenue Bridge Landfill
	*Four Tek Industries
	Gas Works Park (Washington Natural Gas)
	*General Disposal Corporation
	*Genesee Landfill
	Golden Penn Oil Company
	*Guardsman Products, Inc.
	*Haller Lake Landfill
	Harbor Avenue Landfill
	Harbor Island
	Houghton Landfill
	H.P. Construction/Arrow Transportation
	Industrial office complex
	*Industrial Plating Corporation
	*Inland Transporation Company
	*Interbay old landfill
	J.H. Baxter & Company, Inc.
	*Jarvie Paint Manufacturing Co.
	Kent Highlands Landfill
	Kenworth Truck Company
	*King 4 Coal Company mine, A
	Lake Union drydock
	Lake Washington School District
	*Landsburg Mine-Rogers Seam
	LIDCO
	Lindal property
	*Lockheed Shipbuilding Company Yard 1
	Longview Fibre Company
	*L-Bar Products, Inc.
	*Magnolia Fertilizer
	Malarkey Asphalt Company
	Maralco

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
King (continued)	Marine Vacuum Service, Inc.
	*Mastercraft Metal Finishing
	*Meridian Landfill
	*Metal Laundry, Inc.
	Metro Lake Union facility
	*METRO-central operating base
	Midway Landfill
	Mobil bulk facility-Renton
	Mobile Truck Service
	Monterey Apartments site
	MST Chemicals, Inc.
	*Newcastle mine-timber shoot
	*Newcastle mine-air vent
	Non-Ferrous Metals, Inc.
	Northwest Cooperage Company, Inc.
	*N.C. Machinery
	*Olympic Steamship Company, Inc.
	PACCAR
	*Pacific Chemical & Cleaning Co.
	*Pacific Chemical
	*Pacific Landfill
	*Pacific Marine Environmental Lab.
	*Pacific Molasses Company
	*Palmer Coking Coal Company
	Petersen site
	Precision Engineering
	*Puget Sound Tug & Barge
	Queen City Farms
	Queen City Farms
	Quendall Terminals
	Ravenna Landfill
	*Redondo oil pit
	*Reichhold Chemical
	*Renton Highlands Landfill
	*Renton Junction Landfill
	*Rhone-Poulenc, Inc.
	Rose Hill Village Center
	Seafab Metal Corporation
	*Seattle City Light storage
	Seattle Cooperage
	Seattle Iron & Metals
	*Seattle Steel, Inc.
	*Seattle, Port of-Leckenby Co.
	Seattle, Port of-Terminal 5
	Seattle, Port of-Terminal 30
	Shell, Old-Terminal 18/Port of Seattle
	Shell-tank farm
	*Sinclair & Valentine, L.P.
	*Southpark Landfill
	Sternoff Metals
	Sternoff Metals Corporation
	*Strip mine No. 3

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
King (continued)	Sundstrand Data Control, Inc.
	S. 96th Street ditch
	Texaco Marketing & Refining-HI
	Todd Shipyards
	*Tyee Lumber & Manufacturing
	Union Station site
	*United Construction Supply
	*Universal Manufacturing Corporation
	Unocal-Seattle Marketing Terminal
	Value Plating & Metal Pol??
	*Washington Natural Gas-Seattle plant
	*Washington Natural Gas
	*Wesmar Company, Inc.
	Western Processing Company, Inc.
	*Western Tank Properties, Inc.
	*Weyerhaeuser Seattle laboratory
	*Williams Lake
	Wyckoff Company-West Seattle
	Zandt Brass Foundry
Kitsap	Bainbridge Island Landfill
	Bangor Ordnance Disposal
	*Constitution Avenue Landfill
	Eagle Harbor (Wyckoff)
	Hansville Landfill
	Naval Undersea Warfare Engineering Station
	*Pioneer Quarry site-proposed
	Strandley/Manning site
	*U.S. Environmental Protection Agency-Manchester Lab.
	*U.S. Naval Hospital-Bremerton
	*U.S. Naval Supply Center-Drmo Yard
	U.S. Naval Supply Center
	*U.S. Navy-Bangor Submarine Base
	*U.S. Navy-Jackson Park Landfill
	*U.S. Navy-Puget Sound shipyard
	*U.S. Navy-Camp Wesely Harris
	*VIP Landfill
	*Wyckoff Company-Bainbridge Island
Kittitas	Mid-State Aviation
Lewis	American Crossarm & Conduit
	Centralia Landfill
	Cummings Oil Company, Inc.
	Grange Supply-Chehalis
	*Morrie's Garage
	Packwood Lumber Company
	Ross Electric of Washington-Coal Creek
	Ross Electric-Logan Hill
	Utility Transformer Service
	*Washington Army National Guard Shop #4

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Mason	*Goose Lake *Mason County Landfill *Shelton Landfill *Simpson Timber Company Unocal Station (Shelton)
Okanogan	*Alder Mill Arden's Country Store *Canamera Milling & Smelting Oroville dump Silver Mountain Mine Tonasket Post & Rail *USDOI-BLM Kaaba Texas Mine
Pacific	*Dale Richey *Old Baleville Weyco-Raymond Weyerhaeuser Truck Shop
Pierce	*Airo Services, Inc. *Aladdin Plating Company, Inc. Allied Chemical-Tacoma Works *Alpine Plating American Lake Gardens American Plating American Surplus Sales Company ASARCO *Associated Military *Brazier Forest Industry Buffalo Don Murphy-Waller R B&L Woodwaste Fill Cascade Pole Company (McFarland) Cascade Timber #1 Cascade Timber #2 *Cascade Timber #3 Chemical Processors, Inc. Chemical Processors, Inc.-Parcel A *Commencement Bay-Deep waters Commencement Bay-Nearshore/Tideflats Commencement Bay-S. Tacoma Channel Commencement Bay-Ruston/Vashon Coski industrial dump Don Oline landfill DuPont/Weyco D Street Petroleum *Edward & Dorothy Dorman Fife Mobil Station *Flash 1 Hour Photo *General Electric General Metals *General Plastics Kaiser Aluminum & Chemical Corporation

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Pierce (continued)	Lakewood/Ponders Corner
	*Landscaping by Pat Boring
	Lilyblad Petroleum, Inc.
	*Lincoln Avenue landfill
	*Lincoln Avenue ditch
	Louisiana Pacific
	Manke Lumber Company-Sumner pit
	*McChord AFB (12 sites)
	*McChord Custom Cleaners
	McChord (former Wash Rack Site 54)
	McNeil Island
	*Murray Pacific #1
	Murray Pacific #2
	Music Machine, The
	*National Oil dumpsite
	*North Tacoma Landfill
	*Northern Auto Electric Rebuild
	*NW Monitor Molded Products
	*Occidental Chemical-Alexander Avenue
	*Occidental Chemical-Marine View Drive
	Occidental Chemical-Dauphne site
	Occidental Chemical-Petarcik site
	Overall Laundry Services
	Parkland Cleaners
	*Pederson Oil Company
	Pennwalt Corporation
	Petroleum Reclaiming Service
	*Ponders Auto Parts, Inc.
	Portac
	*PRI Northwest
	*Puget Sound Oil Company
	Puget Sound Power & Light
	*Purdy Landfill
	Reichhold Chemical, Inc.
	Rosch property
	*S & W Sand and Gravel Company
	*Simpson
	*South Hill Tire Rentals
	Stauffer Chemical Supply
	*Tacoma Boatbuilding Company
	Tacoma Landfill
	Tacoma Spur-24th and A
	Tacoma Swamp
	Tacoma Tar Pits
	TAM Engineering Corporation
	Thun Field Landfill
	*U.S. Gypsum Company
	*Union Pacific Railroad-Tunnel
	U.S. Army-Fort Lewis Landfill #5
	*U.S. Air Force-McChord AFB, Bldg 792
	U.S. Air Force-McChord AFB, Area A
	U.S. Air Force-McChord AFB, Area C

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Pierce (continued)	*U.S. Air Force-McChord AFB, Area D
	U.S. Air Force-McChord AFB, Area E
	*U.S. Air Force-McChord AFB, Bldg 1173
	U.S. Army-Ft. Lewis Logistics Center
	*Washington Natural Gas
	Wasser Winters
	Well 12A
Skagit	*Butler Hill Lagoon
	EDB 2
	Impact Industries-sulfur pile
	*LTV Energy Products
	Mt. Vernon gasoline spill
	Northwest Petrochemical Corporation
	*PM Northwest dump
	*Sakuma Bros Birdsview Berry
	*Texaco Puget Sound offsite
Skamania	*U.S. Army Corps of Engineers Hamilton Island Landfill
Snohomish	*Arlington/Marysville Landfill
	*Biringer Berry Farm
	*Boeing Commercial Airplane-Everett
	*Boeing Company-Tulalip test site
	*Bryant Landfill
	DFSP Mukilteo tank farm
	*Everett City Landfill
	Everett Tire Fire
	Go East Corporation landfill site
	*J.H. Baxter & Company-Arlington
	*Lake Goodwin Landfill
	*Maltby Warehouse & Field
	Monroe Landfill
	Pallister Paint
	*Simpson Paper Company-pulp plant
	Sisco Landfill
	*Snohomish Landfill
	*Union Oil of California
	U.S.-Defense Fuel Supply Point
	*Verax Chemical Company
	Wallace River Park Well
	Weyerhaeuser-Lumber mill E
Spokane	Alaska Steel and Supply
	*Aluminum Recycling Corporation
	American Tar Company
	Argonne Road
	Geiger Station
	General Electric-old site
	Greenacres Landfill
	Inland Empire Plating
	*Inland Metals, Inc.

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Spokane (continued)	Inland Pit
	Kaiser Aluminum & Chemical Corporation
	*Marshall Landfill
	Mica Landfill
	North Market Street
	Northside Landfill
	Spokane International Airport Business Park
	Spokane junk yard
	U.S. Air Force-Fairchild AFB
Stevens	Dawn Mining Company Mill Ponds
	L-Bar Products
	*Midnight Mine
Thurston	C.B. Bumper Company, Inc.
	Cascade Pole, Inc.-McFarland
	Cedar Creek Corrections (DNR)
	C.B. Bumper Company
	EDB 1
	*German Car Service
	J&B Exterminators
	J.R. Setina Manufacturing
	Lacey Compounds (DNR)
	*O'Brien property
	Pacific Powder Company
	*Puget Sound Power & Light
	Restover Truck Stop
	Treasure Chest
	Unocal Station (Olympia)
	USDA Pacific Northwest Forest Range Experiment
	*DOE-Bonneville Power Administration-Olympia Substation
	Weyerhaeuser Co-Box Plant
	*Wolph's Second Hand Store
	*Wood Fabricators
Walla Walla	Walla Walla Farmers Cooperative
Whatcom	Acme/LUSTs
	*Bellingham-old city dump
	*Cedarville Landfill
	EDB
	*Everson Goshen Disposal
	Georgia Pacific Corporation
	*J. Downing private well
	*Kenmar Company, Inc.
	*Lummi Indian Reservation dump
	*Lummi Shore dump
	*Meadowdale Waster Association well
	*Murray Chris-Craft Cruisers-W
	*Newhalem dump
	Northwest Pipeline Corporation-Sumas
	Northwest Transformer-salvage

WASHINGTON HAZARDOUS WASTE SITES (Continued)

County	Site Name
Whatcom (continued)	Northwest Transformer-downtown
	*Northwest Transformer-Goodwin
	Oeser Cedar
	*Olivine Ash Landfill
	R.G. Haley International Corporation
	*Sumas River dump
	Thermal Reduction Landfill
Whitman	Palouse Producers
	Washington State University Landfill
Yakima	*Cameron - Yakima, Inc.
	*Central Engineering & Machine
	Cliff's Battery Service
	*CMX Corporation
	Crop King
	*Evergreen Products
	FMC-Farm Machine Corporation
	Frank Wear Cleaners
	Irwin Research & Development
	Johnny's Texaco
	*Paxton Sales Corporation
	Richardson Airways, Inc.
	*Shields Bag & Printing Company
	Sunnyside municipal well
	USDA-pesticide laboratory
	Woods Industries #1
	*Woods Industries #2
	Yakima Agricultural Research Laboratory
	*Yakima Old City Landfill
	Yakima Plating
	*Yakima Valley Spray Company]
	Zwight Logging

*Sites in the "potential state sites" category have been marked with an asterix. These are not confirmed sites and, upon further investigaton, the Department may determine that no cleanup action is required.

APPENDIX C

Site Management Information System

Summary Tables

TABLE C-1. SELECTED CONTENTS OF THE SITE MANAGEMENT INFORMATION SYSTEM (SMIS)

Site Location	address zip code county latitude, longitude township, range, section Ecology region
Site Status	A = National Priorities List (NPL), federal lead B = NPL, state lead C1 = state list, confirmed hazardous substances C2 = state list, potential hazardous substances L = state list, long-term monitoring M = state list, free of contamination N = state list, cleanup completed under other statutes D = state list, cleanup completed under MTCA or RCW 70.105B
Affected Media	ground water/surface water/air/soil/sediment
Contaminants	halogenated organic compounds metals - priority pollutant metals - other polychlorinated biphenyl (PCB) mixtures pesticides petroleum products phenolic compounds nonchlorinated solvents dioxin polycyclic aromatic hydrocarbon (PAH) compounds reactive wastes corrosive wastes radioactive wastes conventional contaminants, organic conventional contaminants, inorganic (each coded as confirmed, suspected, or blank/absent)
Waste Management Practices	chemical laboratory drum impoundment improper handling land application landfill pesticide application pesticide disposal spill storm drain tank unknown (up to three practices can be coded for a site)
Site Activity	standard industrial classification categories

TABLE C-2. INVENTORY OF SITES BY COUNTY AND SELECTED CONTAMINANT CLASS[a]

		Contaminant Class							
County	Total Number of Sites	Halogenated Organic Compounds	Priority Pollutant Metals	PCB Mixtures	Pesticides	Petroleum Products	Phenolic Compounds	Nonchlorinated Solvents	PAH Compounds
Adams	4	2	2	0	2	3	0	0	0
Asotin	1	0	0	0	0	0	0	0	1
Benton	9	0	4	0	4	0	0	4	0
Chelan	5	0	1	0	3	0	0	0	0
Clallam	4	1	0	1	0	4	0	0	0
Clark	39	6	18	1	2	13	4	8	7
Cowlitz	17	2	10	1	1	4	3	5	1
Douglas	2	0	0	0	2	0	0	0	0
Ferry	1	0	1	0	0	1	0	0	0
Franklin	2	2	2	0	0	1	0	0	0
Grant	4	0	0	0	1	1	0	2	0
Grays Harbor	10	3	5	1	0	5	3	5	2
Island	7	1	2	1	1	1	0	2	0
Jefferson	3	1	2	0	0	1	0	1	1
King	154	43	87	23	27	66	26	43	38
Kitsap	18	5	9	6	2	5	5	4	3
Kittitas	1	0	0	0	1	0	0	0	0
Lewis	10	0	1	4	1	8	2	3	3
Mason	5	2	2	2	2	4	3	2	3
Okanogan	7	1	4	0	1	1	1	0	0
Pacific	4	1	2	0	0	1	1	0	0
Pierce	94	33	49	13	13	44	13	16	24
Skagit	9	0	2	0	1	2	1	0	0
Skamania	1	0	1	1	0	1	1	0	1
Snohomish	22	1	9	4	1	11	3	4	3
Spokane	18	8	7	5	3	6	2	2	3
Stevens	3	0	2	0	0	0	0	0	0
Thurston	20	3	5	1	5	13	3	1	1
Walla Walla	1	0	0	0	1	0	0	0	0
Whatcom	22	0	5	7	6	4	2	2	0
Whitman	2	1	1	1	1	2	1	1	1
Yakima	22	10	5	0	10	3	0	4	0
TOTALS	**521**	**126**	**238**	**72**	**91**	**205**	**74**	**109**	**92**

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[a] SMIS database summary (October 1989).

TABLE C-3. INVENTORY OF SITES WITH POTENTIAL CONTAMINATION BY MEDIA[a]

County	Total Number of Sites	Ground Water		Surface Water		Air		Soil		Sediment		Drinking Water	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Adams	4	4	100	1	25	0	0	4	100	1	25	1	25
Asotin	1	0	0	0	0	0	0	0	0	0	0	0	0
Benton	9	8	89	6	67	0	0	8	89	2	22	4	44
Chelan	5	5	100	3	60	0	0	4	80	3	60	3	60
Clallam	4	4	100	3	75	1	25	4	100	2	50	1	25
Clark	39	25	64	13	33	3	8	35	90	6	15	7	18
Cowlitz	17	15	88	11	65	1	6	16	94	3	18	4	24
Douglas	2	2	100	1	50	0	0	2	100	0	0	2	100
Ferry	1	0	0	1	100	0	0	0	0	0	0	0	0
Franklin	2	2	100	1	50	0	0	2	100	0	0	1	50
Grant	4	4	100	1	25	0	0	1	25	0	0	2	50
Grays Harbor	10	7	70	7	70	1	10	9	90	5	50	2	20
Island	7	5	71	3	43	0	0	4	57	1	14	4	57
Jefferson	3	2	67	3	100	0	0	3	100	1	33	0	0
King	154	105	67	77	49	30	19	113	72	46	29	24	15
Kitsap	18	12	67	9	50	3	17	12	67	5	28	6	33
Kittitas	1	1	100	0	0	0	0	1	100	1	100	1	100
Lewis	10	9	90	7	70	2	20	10	100	5	50	2	20
Mason	5	4	80	3	60	1	20	4	80	2	40	3	60
Okanogan	7	7	100	6	86	2	29	7	100	4	57	4	57
Pacific	4	2	50	2	50	0	0	3	75	0	0	1	25
Pierce	94	71	76	49	52	5	5	87	93	27	29	29	31
Skagit	9	6	67	4	44	1	11	4	44	2	22	6	67
Skamania	1	1	100	1	100	0	0	1	100	1	100	1	100
Snohomish	22	19	86	14	64	4	18	14	64	3	14	8	36
Spokane	18	13	72	7	39	4	22	15	83	1	6	10	56
Stevens	3	2	67	3	100	1	33	1	33	0	0	1	33
Thurston	20	14	70	12	60	1	5	18	90	2	10	6	30
Walla Walla	1	1	100	0	0	0	0	1	100	0	0	0	0
Whatcom	22	17	77	7	32	2	9	15	68	5	23	16	73
Whitman	2	2	100	1	50	0	0	2	100	1	50	0	0
Yakima	22	22	100	10	45	2	9	20	91	6	27	16	73
TOTALS:	**521**	**391**	**75**	**266**	**51**	**64**	**12**	**420**	**80**	**135**	**26**	**165**	**32**

[a] SMIS database summary (October 1989).

TABLE C-4. POTENTIAL GROUND WATER CONTAMINATION BY SELECTED CONTAMINANT CLASS AND LOCATION[a]

		Contaminant Class							
County	Total Number of Sites	Halogenated Organic Compounds	Priority Pollutant Metals	PCB Mixtures	Pesticides	Petroleum Products	Phenolic Compounds	Nonchlorinated Solvents	PAH Compounds
Adams	4	2	2	0	2	3	0	0	0
Asotin	1	0	0	0	0	0	0	0	0
Benton	9	0	4	0	4	0	0	4	0
Chelan	5	0	1	0	3	0	0	0	0
Clallam	4	1	0	1	0	4	0	0	0
Clark	39	5	12	0	1	9	3	7	4
Cowlitz	17	2	9	0	1	4	3	5	1
Douglas	2	0	0	0	2	0	0	0	0
Ferry	1	0	0	0	0	0	0	0	0
Franklin	2	2	2	0	0	1	0	0	0
Grant	4	0	0	0	1	1	0	2	0
Grays Harbor	10	2	3	1	0	4	2	4	2
Island	7	1	2	1	1	1	0	2	0
Jefferson	3	1	2	0	0	1	0	1	0
King	154	38	65	18	22	58	23	33	34
Kitsap	18	4	9	4	2	5	5	4	3
Kittitas	1	0	0	0	1	0	0	0	0
Lewis	10	0	1	3	1	8	2	3	3
Mason	5	2	2	2	2	3	3	2	3
Okanogan	7	1	4	0	1	1	1	0	0
Pacific	4	1	1	0	0	1	1	0	0
Pierce	94	31	41	10	12	31	13	16	19
Skagit	9	0	2	0	1	2	1	0	0
Skamania	1	0	1	1	0	1	1	0	1
Snohomish	22	1	8	3	1	11	3	4	2
Spokane	18	8	6	2	3	5	2	2	3
Stevens	3	0	1	0	0	0	0	0	0
Thurston	20	1	4	1	3	9	3	0	1
Walla Walla	1	0	0	0	1	0	0	0	0
Whatcom	22	0	5	6	6	3	1	1	0
Whitman	2	1	1	1	1	2	1	1	1
Yakima	22	10	5	0	10	3	0	4	0
TOTALS	**521**	**114**	**193**	**54**	**82**	**171**	**68**	**95**	**77**
TOTAL SITES (all media)		**126**	**238**	**72**	**91**	**205**	**74**	**109**	**92**
PERCENT GROUND WATER		**90**	**81**	**75**	**90**	**83**	**92**	**87**	**84**

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[a] SMIS database summary (October 1989).

TABLE C-5. POTENTIAL SOIL CONTAMINATION BY SELECTED CONTAMINANT CLASS AND LOCATION[a]

County	Total Number of Sites	Contaminant Class							
		Halogenated Organic Compounds	Priority Pollutant Metals	PCB Mixtures	Pesticides	Petroleum Products	Phenolic Compounds	Nonchlorinated Solvents	PAH Compounds
Adams	4	2	2	0	2	3	0	0	0
Asotin	1	0	0	0	0	0	0	0	0
Benton	9	0	4	0	4	0	0	4	0
Chelan	5	0	1	0	3	0	0	0	0
Clallam	4	1	0	1	0	4	0	0	0
Clark	39	6	16	1	2	12	4	7	6
Cowlitz	17	2	10	1	1	4	3	4	1
Douglas	2	0	0	0	2	0	0	0	0
Ferry	1	0	0	0	0	0	0	0	0
Franklin	2	2	2	0	0	1	0	0	0
Grant	4	0	0	0	0	1	0	1	0
Grays Harbor	10	2	4	1	0	4	2	4	2
Island	7	1	2	1	1	1	0	2	0
Jefferson	3	1	2	0	0	1	0	1	1
King	154	38	71	21	22	60	21	35	34
Kitsap	18	5	7	6	2	5	4	3	3
Kittitas	1	0	0	0	1	0	0	0	0
Lewis	10	0	1	4	1	8	2	3	3
Mason	5	2	2	2	2	3	2	2	2
Okanogan	7	1	4	0	1	1	1	0	0
Pacific	4	1	2	0	0	1	1	0	0
Pierce	94	30	49	12	11	43	12	16	24
Skagit	9	0	1	0	0	0	1	0	0
Skamania	1	0	1	1	0	1	1	0	1
Snohomish	22	1	6	4	1	8	3	4	3
Spokane	18	8	7	5	3	6	2	2	3
Stevens	3	0	1	0	0	0	0	0	0
Thurston	20	3	4	1	5	12	3	1	1
Walla Walla	1	0	0	0	1	0	0	0	0
Whatcom	22	0	5	7	3	4	2	2	0
Whitman	2	1	1	1	1	2	1	1	1
Yakima	22	8	4	0	10	3	0	3	0
TOTALS	**521**	**115**	**209**	**69**	**79**	**188**	**65**	**95**	**85**
TOTAL SITES (all media)		**126**	**238**	**72**	**91**	**205**	**74**	**109**	**92**
PERCENT SOIL		**91**	**88**	**96**	**87**	**92**	**88**	**87**	**92**

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[a] SMIS database summary (October 1989).

TABLE C-6. INVENTORY OF SITES BY STANDARD INDUSTRIAL CLASSIFICATION CATEGORY AND BY COUNTY[a,b]

		Standard Industrial Classification										
County	Number of Sites	Metal Mining	Coal Mining	Lumber and Wood Products	Wood Preserving	Chemicals and Allied Products	Pesticides and Agricultural Chemicals	Petroleum and Coal Products	Primary Metals	Electro-plating	Landfills	Military Operations
Adams	4	0	0	0	0	0	1	0	0	0	0	0
Asotin	1	0	0	0	0	0	0	0	0	0	1	0
Benton	9	0	0	0	0	1	0	0	0	0	7	0
Chelan	5	1	0	0	0	0	1	0	0	0	3	0
Clallam	4	0	0	0	0	0	0	0	0	0	0	0
Clark	39	0	0	0	1	2	1	0	1	3	3	0
Cowlitz	17	0	0	2	0	1	0	0	1	0	8	0
Douglas	2	0	0	0	0	0	1	0	0	0	1	0
Ferry	1	1	0	0	0	0	0	0	0	0	0	0
Franklin	2	0	0	0	0	0	0	1	0	0	1	0
Grant	4	0	0	0	0	0	0	0	0	0	2	1
Grays Harbor	10	0	0	2	0	0	0	0	0	0	5	1
Island	7	0	0	0	0	0	0	0	0	0	4	0
Jefferson	3	0	0	0	0	0	0	0	0	0	0	1
King	154	0	9	4	3	9	0	9	8	14	31	0
Kitsap	18	0	0	0	1	0	0	0	0	0	5	4
Kittitas	1	0	0	0	0	0	1	0	0	0	0	0
Lewis	10	0	0	0	1	0	0	1	0	0	2	1
Mason	5	0	0	0	0	0	0	1	0	0	2	0
Okanogan	7	4	0	0	0	0	0	0	0	0	2	0
Pacific	4	0	0	0	0	0	0	0	0	0	1	0
Pierce	94	0	0	6	3	5	0	7	1	2	20	1
Skagit	9	0	0	0	0	2	0	0	0	0	1	0
Skamania	1	0	0	0	0	0	0	0	0	0	1	0
Snohomish	22	0	0	2	1	0	0	1	0	0	8	1
Spokane	18	0	0	0	0	0	0	2	1	1	5	0
Stevens	3	1	0	0	0	0	0	1	1	0	1	0
Thurston	20	0	0	1	3	1	1	1	0	1	1	0
Walla Walla	1	0	0	0	0	0	1	0	0	0	0	0
Whatcom	22	0	0	1	1	1	0	0	0	0	7	0
Whitman	2	0	0	0	0	0	0	1	0	0	1	0
Yakima	22	0	0	1	0	1	7	0	0	1	1	0
Totals	521	7	9	19	14	23	14	25	14	22	124	10

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[a] SMIS database summary (October 1989).

[b] SIC codes:

10	metal mining
12	coal mining
24 (excluding 2491)	lumber and wood products
2491	wood preserving
28 (excluding 287, 2879)	chemicals and allied products
287, 2879, 7	pesticides and agricultural chemicals
29	petroleum and coal products
33	primary metals
347, 3471	electroplating
4953G	landfills
9711	military operations

TABLE C-7. RELATIONSHIPS BETWEEN STANDARD INDUSTRIAL CLASSIFICATION CATEGORIES AND CONTAMINANT CLASSES[a]

		Contaminant Class							
Standard Industrial Classification Category	Total Number of Sites	Halogenated Organic Compounds	Priority Pollutant Metals	PCB Mixtures	Pesticides	Petroleum Products	Phenolic Compounds	Nonchlorinated Solvents	PAH Compounds
Metal mining	7	0	7	0	0	1	0	0	0
Coal mining	9	0	1	0	0	0	0	1	0
Lumber and wood products	19	0	9	3	3	12	7	1	6
Wood preserving	14	4	4	1	3	9	9	1	7
Chemicals and allied products	23	6	10	1	2	6	5	7	5
Pesticides and agricultural chemicals	14	3	2	0	13	3	0	0	0
Petroleum and coal products	25	6	8	3	2	22	4	2	10
Primary metals	14	1	8	4	0	2	1	1	2
Electroplating	22	4	20	0	0	1	1	5	0
Landfills	124	34	75	16	32	28	21	25	25
Military operations	10	3	4	2	1	8	1	7	1

[a] SMIS database summary (October 1989).

[b] More than one contaminant class may be present at a given site.

TABLE C-8. RELATIONSHIPS BETWEEN STANDARD INDUSTRIAL CLASSIFICATION CATEGORIES AND AFFECTED ENVIRONMENTAL MEDIA[a]

Standard Industrial Classification Category	Number of Sites	Affected Medium[b]					
		Ground Water	Surface Water	Air	Soil	Sediment	Drinking Water
Metal mining	7	5	6	1	5	3	3
Coal mining	9	2	1	0	0	0	1
Lumber and wood products	19	17	15	2	18	12	7
Wood preserving	14	13	10	1	14	8	5
Chemicals and allied products	23	21	15	3	20	8	10
Pesticides and agricultural chemicals	14	13	6	1	13	6	8
Petroleum and coal products	25	22	14	3	24	8	3
Primary metals	14	12	10	4	12	4	5
Electroplating	22	10	8	1	17	3	4
Landfills	124	103	84	24	99	26	65
Military operations	10	8	5	2	8	2	0

[a] SMIS database summary (October 1989).

[b] More than one medium may be affected at a given site.

TABLE C-9. INVENTORY OF SITE WASTE MANAGEMENT PRACTICES[a]

Waste Management Practice	Number of Sites
Chemical laboratory	2
Drum	36
Impoundment	31
Improper handling	148
Land application	8
Landfill	130
Pesticide application	8
Pesticide disposal	18
Spill	130
Storm drain	7
Tank	82
Unknown	13

Note: More than one waste management practice occurs at some sites.

[a] SMIS database summary (October 1989).

TABLE C-10. INVENTORY OF SITE WASTE MANAGEMENT PRACTICES BY COUNTY[a]

County	Total Number of Sites	Chemical Laboratory	Drum	Impoundment	Improper Handling	Land Application	Landfill	Pesticide Application	Pesticide Disposal	Spill	Storm Drain	Tank
Adams	4	0	0	1	1	0	0	0	0	4	0	2
Asotin	1	0	0	0	0	0	1	0	0	0	0	0
Benton	9	0	0	0	5	0	7	0	3	0	0	0
Chelan	5	0	0	0	1	0	3	0	1	1	0	0
Clallam	4	0	0	0	2	0	0	0	0	0	0	2
Clark	39	1	1	1	12	0	3	0	0	8	1	7
Cowlitz	17	0	1	2	2	0	8	0	1	4	0	1
Douglas	2	0	0	0	0	0	1	0	2	1	0	0
Ferry	1	0	0	1	0	0	0	0	0	0	0	0
Franklin	2	0	0	1	0	0	1	0	1	1	0	1
Grant	4	0	0	0	0	0	2	0	0	1	0	0
Grays Harbor	10	0	1	0	6	0	5	0	0	6	0	0
Island	7	0	0	0	2	0	4	0	0	0	0	0
Jefferson	3	0	0	1	1	0	1	0	0	1	0	0
King	154	0	15	10	40	1	31	0	0	41	5	37
Kitsap	18	0	1	0	5	0	7	0	0	2	0	4
Kittitas	1	0	0	0	0	0	0	0	1	1	0	0
Lewis	10	0	1	1	5	0	2	0	0	7	0	2
Mason	5	0	0	0	1	1	2	0	0	2	0	0
Okanogan	7	0	0	2	2	1	2	0	1	1	0	1
Pacific	4	1	0	0	1	0	1	0	0	1	0	1
Pierce	94	0	10	5	23	1	22	0	0	20	1	13
Skagit	9	0	0	1	2	2	1	1	0	1	0	0
Skamania	1	0	0	0	1	0	1	0	0	0	0	0
Snohomish	22	0	2	1	3	0	8	1	0	2	0	3
Spokane	18	0	0	2	7	1	5	0	0	4	0	3
Stevens	3	0	0	1	1	0	1	0	0	0	0	0
Thurston	20	0	0	0	8	1	1	2	0	9	0	2
Walla Walla	1	0	0	0	1	0	0	0	1	0	0	0
Whatcom	22	0	0	0	6	0	7	3	0	0	0	1
Whitman	2	0	0	0	1	0	1	0	0	1	0	1
Yakima	22	0	4	1	8	0	1	1	7	11	0	1
TOTALS	**521**	**2**	**36**	**31**	**147**	**8**	**129**	**8**	**18**	**130**	**7**	**82**

[a] SMIS database summary (October 1989).

TABLE C-11. RELATIONSHIPS AMONG WASTE MANAGEMENT PRACTICES AND CONTAMINANT CLASSES[a]

Waste Management Practice	Total Number of Sites	Contaminant Class							
		Halogenated Organic Compounds	Priority Pollutant Metals	PCB Mixtures	Pesticides	Petroleum Products	Phenolic Compounds	Nonchlorinated Solvents	PAH Compounds
Chemical laboratory	2	2	2	0	0	0	1	1	0
Drum	36	19	19	10	8	19	10	16	10
Impoundment	31	9	20	4	6	13	9	7	10
Improper handling	148	43	77	39	25	74	25	36	32
Land application	8	3	5	2	2	3	3	2	2
Landfill	130	39	80	20	33	33	24	30	27
Pesticide application	8	0	0	0	8	1	0	0	0
Pesticide disposal	18	4	3	0	17	1	0	0	0
Spill	130	43	55	16	20	88	25	30	31
Storm drain	7	3	4	1	1	5	1	2	1
Tank	82	28	33	13	8	66	17	25	23

Note: More than one waste management practice occurs at some sites, and more than one contaminant class may also be listed at a site.

[a] SMIS database summary (October 1989).

APPENDIX D

CERCLA/SARA Section 121

CHAPTER 9621, CLEANUP STANDARDS
(CERCLA CHAPTER 121)

a. Selection of Remedial Action

The President shall select appropriate remedial actions determined to be necessary to be carried out under section 9604 or secured under section 9606 of this title which are in accordance with this section and, to the extent practicable, the national contingency plan, and which provide for cost-effective response. In evaluating the cost effectiveness of proposed alternative remedial actions, the President shall take into account the total short- and long-term costs of such actions, including the costs of operation and maintenance for the entire period during which such activities will be required.

b. General Rules

1. Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants is a principal element, are to be preferred over remedial actions not involving such treatment. The offsite transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available. The President shall conduct an assessment of permanent solutions and alternative treatment technologies or resource recovery technologies that, in while or in part, will result in a permanent and significant decrease in the toxicity, mobility, or volume of the hazardous substance, pollutant, or contaminant. In making such assessment, the President shall specifically address the long-term effectiveness of various alternatives. In assessing alternative remedial actions, the President shall, at a minimum, take into account:

   A. The long-term uncertainties associated with land disposal;

   B. The goals, objectives, and requirements of the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.];

   C. The persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents;

   D. Short- and long-term potential for adverse health effects from human exposure;

   E. Long-term maintenance costs;

   F. The potential for future remedial action costs if the alternative remedial action in question were to fail; and

   G. The potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

The President shall select a remedial action that is protective of human health and the environment, that is cost effective, and that utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. If the President selects a remedial action not appropriate for a preference under this subsection, the President shall publish an explanation as to why a remedial action involving such reductions was not selected.

2. The President may select an alternative remedial action meeting the objectives of this subsection whether or not such action has been achieved in practice at any other facility or site that has similar characteristics. In making such a selection, the President may take into account the degree of support for such remedial action by parties interested in such site.

c. Review

If the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site, the President shall review such remedial action no less often than each 5 years after the initiation of such remedial action to assure that human health and the environment are being protected by the remedial action being implemented. In addition, if upon such review it is the judgment of the President that action is appropriate at such site in accordance with section 9604 or 9606 of this title, the President shall take or require such action. The President shall report to the Congress a list of facilities for which such review is required, the results of all such reviews, and any actions taken as a result of such reviews.

d. Degree of Cleanup

1. Remedial actions selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment. Such remedial actions shall be relevant and appropriate under the circumstances presented by the release or threatened release of such substance, pollutant, or contaminant.

2. A. With respect to any hazardous substance, pollutant or contaminant that will remain onsite, if—

   i. any standard, requirement, criteria, or limitation under any Federal environmental law, including, but not limited to, the Toxic Substances Control Act [15 U.S.C.A. § 2601 et seq.], the Safe Drinking Water Act [42 U.S.C.A. § 300f et seq.], the Clear Air Act [42 U.S.C.A. § 7401 et seq.], the Clean Water Act [33 U.S.C.A. § 1251 et seq.], the Marine Protection, Research and Sanctuaries Act [33 U.S.C.A. § 1401 et seq.], or the Solid Waste Disposal Act [42 U.S.C.A. § 6901 et seq.]; or

ii. any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation, including each such State standard, requirement, criteria, or limitation contained in a program approved, authorized or delegated by the Administrator under a statute cited in subparagraph (A), and that has been identified to the President by the State in a timely manner,

is legally applicable to the hazardous substance or pollutant or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant, the remedial action selected under section 9604 of this title or secured under section 9606 of this title shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria, or limitation. Such remedial action shall require a level or standard of control which at least attains Maximum Contaminant Level Goals established under the Safe Drinking Water Act [42 U.S.C.A. § 300f et seq.] and water quality criteria established under section 304 or 303 of the Clean Water Act [33 U.S.C.A. § 1314 or 1313], where such goals or criteria are relevant and appropriate under the circumstances of the release or threatened release.

B. i. In determining whether or not any water quality criteria under the Clean Water Act [33 U.S.C.A. § 1251 et seq.] is relevant and appropriate under the circumstances of the release or threatened release, the President shall consider the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which such criteria were developed, and the latest information available.

ii. For the purposes of this section, a process for establishing alternate concentration limits to those otherwise applicable for hazardous constituents in groundwater under subparagraph (A) may not be used to establish applicable standards under this paragraph if the process assumes a point of human exposure beyond the boundary of the facility, as defined at the conclusion of the remedial investigation and feasibility study, except where—

I. there are known and projected points of entry of such groundwater into surface water; and

II. on the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and

III. the remedial action includes enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water,

then the assumed point of human exposure may be at such known and projected points of entry.

C. i. Clause (ii) of this subparagraph shall be applicable only in cases where, due to the President's selection, in compliance with subsection (b)(1) of this section, of a proposed remedial action which does not permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances, pollutants, or contaminants, the proposed disposition of waste generated by or associated with the remedial action selected by the President is land disposal in a State referred to in clause (ii).

ii. Except as provided in clauses (iii) and (iv), a State standard, requirement, criteria, or limitation (including any State siting standard or requirement) which could effectively result in the statewide prohibition of land disposal of hazardous substances, pollutants, or contaminants shall not apply.

iii. Any State standard, requirement, criteria, or limitation referred to in clause (ii) shall apply where each of the following conditions is met:

I. The State standard, requirement, criteria, or limitation is of general applicability and was adopted by formal means.

II. The State standard, requirement, criteria, or limitation was adopted on the basis of hydrologic, geologic, or other relevant considerations and was not adopted for the purpose of precluding onsite remedial actions or other land disposal for reasons unrelated to protection of human health and the environment.

III. The State arranges for, and assures payment of the incremental costs of utilizing, a facility for disposition of the hazardous substances, pollutants, or contaminants concerned.

iv. Where the remedial action selected by the President does not conform to a State standard and the State has initiated a law suit against the Environmental Protection Agency prior to May 1, 1986, to seek to have the remedial action conform to such standard, the President shall conform the remedial action to the State standard. The State shall assure the availability of an offsite facility for such remedial action.

3. In the case of any removal or remedial action involving the transfer of any hazardous substance or pollutant or contaminant offsite, such hazardous substance or pollutant or contaminant shall only be transferred to a facility which is operating in compliance with section 3004 and 3005 of the Solid Waste Disposal Act [42 U.S.C.A. §§ 6924 and 6925] (or, where applicable, in compliance with the Toxic Substances Control Act [15 U.S.C.A. § 2601 et seq.] or other applicable Federal law) and all applicable State requirements. Such substance or pollutant or contaminant may be transferred to a land disposal facility only if the President determines that both of the following requirements are met:

   A. The unit to which the hazardous substance or pollutant or contaminant is transferred is not releasing any hazardous waste, or constituent thereof, into the groundwater or surface water or soil.

   B. All such releases from other units at the facility are being controlled by a corrective action program approved by the Administrator under subtitle C of the Solid Waste Disposal Act [42 U.S.C.A. § 6921 et seq.].

   The President shall notify the owner or operator of such facility of determinations under this paragraph.

4. The President may select a remedial action meeting the requirements of paragraph (1) that does not attain a level or standard of control at least equivalent to a legally applicable or relevant and appropriate standard, requirement, criteria, or limitation as required by paragraph (2) (including subparagraph (B) thereof), if the President finds that—

   A. The remedial action selected is only part of a total remedial action that will attain such level or standard of control when completed;

   B. Compliance with such requirement at that facility will result in greater risk to human health and the environment than alternative options;

   C. Compliance with such requirements is technically impracticable from an engineering perspective;

   D. The remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation, through use of another method or approach;

   E. With respect to a State standard, requirement, criteria, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criteria, or limitation in similar circumstances at other remedial actions within the State; or

   F. In the case of remedial action to be undertaken solely under section 9604 of this title using the Fund, selection of a remedial action that attains such level or standard of control will not provide a balance between the need for protection of public health and welfare and the environment at the facility under consideration, and the availability of amounts from the Fund to respond to other sites which present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats.

The President shall publish such findings, together with an explanation and appropriate documentation.

e. Permits and Enforcement

1. No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely onsite, where such remedial action is selected and carried out in compliance with this section.

2. A State may enforce any Federal or State standard, requirement, criteria, or limitation to which the remedial action is required to conform under this chapter in the United States district court for the district in which the facility is located. Any consent decree shall require the parties to attempt expeditiously to resolve disagreements concerning implementation of the remedial action informally with the appropriate Federal and State agencies. Where the parties agree, the consent decree may provide for administrative enforcement. Each consent decree shall also contain stipulated penalties for violations of the decree in an amount not to exceed $25,000 per day, which may be enforced by either the President or the State. Such stipulated penalties shall not be construed to impair or affect the authority of the court to order compliance with the specific terms of any such decree.

f. State Involvement

1. The President shall promulgate regulations providing for substantial and meaningful involvement by each State in initiation, development, and selection of remedial actions to be undertaken in that State. The regulations, at a minimum, shall included each of the following:

    A. State involvement in decisions whether to perform a preliminary assessment and site inspection

    B. Allocation of responsibility for hazard ranking system scoring

    C. State concurrence in deleting sites from the National Priorities List

    D. State participation in the long-term planning process for all remedial sites within the State

    E. A reasonable opportunity for States to review and comment on each of the following:

        i. The remedial investigation and feasibility study and all data and technical documents leading to its issuance

ii. The planned remedial action identified in the remedial investigation and feasibility study

iii. The engineering design following selection of the final remedial action

iv. Other technical data and reports relating to implementation of the remedy

v. Any proposed finding or decision by the President to exercise the authority of subsection (d)(4) of this section.

F. Notice to the State of negotiations with potentially responsible parties regarding the scope of any response action at a facility in the State and an opportunity to participate in such negotiations and, subject to paragraph (2), be a party to any settlement.

G. Notice to the State and an opportunity to comment on the President's proposed plan for remedial action as well as on alternative plans under consideration. The President's proposed decision regarding the selection of remedial action shall be accompanied by a response to the comments submitted by the State, including an explanation regarding any decision under subsection (d)(4) of this section on compliance with promulgated State standards. A copy of such response shall also be provided to the State.

H. Prompt notice and explanation of each proposed action to the State in which the facility is located.

Prior to the promulgation of such regulations, the President shall provide notice to the State of negotiations with potentially responsible parties regarding the scope of any response action at a facility in the State, and such State may participate in such negotiations and, subject to paragraph (2), any settlements.

2. A. This paragraph shall apply to remedial actions secured under section 9606 of this title. At least 30 days prior to the entering of any consent decree, if the President proposes to select a remedial action that does not attain a legally applicable or relevant and appropriate standard, requirement, criteria, or limitation, under the authority of subsection (d)(4) of this section, the President shall provide an opportunity for the State to concur or not concur in such selection. If the State concurs, the State may become a signatory to the consent decree.

B. If the State does not concur in such selection, and the State desires to have the remedial action conform to such standard, requirement, criteria, or limitation, the State shall intervene in the action under section 9606 of this title before entry of the consent decree, to seek to have the remedial action so conform. Such intervention shall be a matter of right. The remedial action shall conform to such standard, requirement, criteria, or limitation if the State establishes, on the administrative record, that the finding of the

President was not supported by substantial evidence. If the court determines that the remedial action shall conform to such standard, requirement, criteria, or limitation, the remedial action shall be so modified and the State may become a signatory to the decree. If the court determines that the remedial action need not conform to such standard, requirement, criteria, or limitation, and the State pays or assures the payment of the additional costs attributable to meeting such standard, requirement, criteria, or limitation, the remedial action shall be so modified and the State shall become a signatory to the decree.

C. The President may conclude settlement negotiations with potentially responsible parties without State concurrence.

3\. A. This paragraph shall apply to remedial actions at facilities owned or operated by a department, agency, or instrumentality of the United States. At least 30 days prior to the publication of the President's final remedial action plan, if the President proposes to select a remedial action that does not attain a legally applicable or relevant and appropriate standard, requirement, criteria, or limitation, under the authority of subsection (d)(4) of this section, the President shall provide an opportunity for the State to concur or not concur in such selection. If the State concurs, or does not act within 30 days, the remedial action may proceed.

B. If the State does not concur in such selection as provided in subparagraph (A), and desires to have the remedial action conform to such standard, requirement, criteria, or limitation, the State may maintain an action as follows:

i. If the President has notified the State of selection of such a remedial action, the State may bring an action within 30 days of such notification for the sole purpose of determining whether the finding of the President is supported by substantial evidence. Such action shall be brought in the United States district court for the district in which the facility is located.

ii. If the State establishes, on the administrative record, that the President's finding is not supported by substantial evidence, the remedial action shall be modified to conform to such standard, requirement, criteria, or limitation.

iii. If the State fails to establish that the President's finding was not supported by substantial evidence and if the State pays, within 60 days of judgment, the additional costs attributable to meeting such standard, requirement, criteria, or limitation, the remedial action shall be selected to meet such standard, requirement, criteria, or limitation. If the State fails to pay within 60 days, the remedial action selected by the President shall proceed through completion.

C. Nothing in this section precludes, and the court shall not enjoin, the Federal agency from taking any remedial action unrelated to or not inconsistent with such standard, requirement, criteria, or limitation.

(Pub.L. 96-510, Title I, § 121, as added Oct. 17, 1986, Pub.L. 99-499, Title I, § 121(a), Oct. 17, 1986, 100 Stat. 1672.)

EFFECTIVE DATE

Section 121(b) of Pub.L. 99-499, Title I, Oct. 17, 1986, 100 Stat. 1678, provided that: "With respect to section 121 of CERCLA [this section] as added by this section--

"(1) The requirements of section 121 of CERCLA [this section] shall not apply to any remedial action for which the Record of Decision (hereinafter in this section referred to as the 'ROD') was signed, or the consent decree was lodged, before date of enactment [Oct. 17, 1986].

"(2) If the ROD was signed, or the consent decree lodged, within the 30-day period immediately following enactment of the Act [Oct. 17, 1986], the Administrator shall certify in writing that the portion of the remedial action covered by the ROD or consent decree complies to the maximum extent practicable with section 121 of CERCLA [this section].

"Any ROD signed before enactment of this Act [Oct. 17, 1986] and reopened after enactment of this Act [Oct. 17, 1986] to modify or supplement the selection of remedy shall be subject to the requirements of section 121 of CERCLA [this section]".

LIBRARY REFERENCES

Health and Environment 25.5(5.5), 25.7(23).
C.J.S. Health and Environment §§ 91 et seq., 113 et seq.

APPENDIX E

<u>How Clean is Clean</u> Policy

WASHINGTON DEPARTMENT OF ECOLOGY

FINAL CLEANUP POLICY - TECHNICAL
Effective Date July 10, 1984

PURPOSE

The Cleanup Policy provides a framework to determine the cleanup level for releases of materials that threaten public health and/or the environment. The cleanup levels derived from this policy are goals that will be used in the feasibility assessment to evaluate the most appropriate remedial action and may be revised based on the feasibility assessment results.

SUMMARY

The Cleanup Policy identifies three types of cleanup levels: Initial Cleanup Levels, Standard/Background Cleanup Levels, and Protection Cleanup Levels. The three cleanup levels are described in Parts I, II, and III of this policy, and their relationship is shown in Figure F-1. The purpose of the Initial Cleanup (Part I) is to eliminate all **imminent** threats to public health and the environment, and to eliminate situations where the difficulty of cleanup will be increased without a timely response. This may be done by either a Total Cleanup, a Partial Cleanup, Site Stabilization, or a combination of Partial Cleanup and Site Stabilization, depending on the site conditions. The feasibility of these options is determined in the Initial Cleanup Assessment. Standard/Background Cleanup Levels are described in Part II and are assigned to all sites where Total Cleanup is not implemented. The purpose of the Standard/ Background Cleanup is to eliminate any potential threat to public health or the environment over the longer term. The Standard/Background Cleanup Levels are based on appropriate water quality and air quality standards, or, if standards do not exist, background. The technical feasibility of the Standard/Background Cleanup Levels is determined in the Preliminary Technical Assessment. If, based on the Preliminary Technical Assessment, the Standard/ Background Cleanup Levels are judged not to be achievable or appropriate then Protection Cleanup Levels are assigned to the site. Protection Cleanup Levels are described in Part III and are based on the following: (1) multiples of appropriate standards or background (for soil with a threat to surface water or groundwater) or 2) Dangerous Waste Limits (for soil with a threat to air) or 3) site-specific characteristics. Predictive modeling may be used to define Protection Levels if sufficient site-specific information exists. If additional monitoring data is needed to further define the contaminant migration characteristics prior to determining a Protection Cleanup Level, the site may be assigned temporarily to Interim Monitoring status.

PART I: INITIAL CLEANUP LEVELS OF SOIL, SURFACE WATER, GROUNDWATER, AND AIR

Description: An Initial Cleanup Level is implemented at a site when a release of material is an imminent threat to public health or the environment **or** difficulty of cleanup increases significantly without timely remedial action. Examples - spills, sites subject to overland transport or flooding. **All sites** must be evaluated to determine whether Initial Cleanup is needed. The goal of the Initial Cleanup is total cleanup, however, this will not be possible in all cases due to site conditions. A flow diagram for Initial Cleanup decisions is shown in Figure F-2.

A. Remedial Options

1. Total Cleanup - Eliminate all public health and environmental hazards by removing and properly disposing of all known contaminants. Typical site characteristics where Total Cleanup is achievable are listed as follows:

    a. Well-defined contamination boundaries

    b. Concentrated substances

    c. Limited extent of contamination.

2. Partial Cleanup - Eliminate imminent public health and environmental hazards by only removing those portions of the known contamination that represent an immediate hazard, or that significantly increase the difficulty of eventual cleanup.

3. Site Stabilization - Eliminate imminent public health and environmental hazards by removing all contaminant pathways that represent an immediate hazard or that significantly increase the difficulty of eventual cleanup.

4. Combinations of Partial Cleanup and Site Stabilization - Eliminate imminent public health and environmental hazards by removing portions of the contamination and contaminant pathways that represent an immediate hazard or that significantly increase the difficulty of eventual cleanup.

B. Methods to Indicate Contamination Boundaries

1. Discoloration, or

2. Broad indicator chemical tests: pH, Total Organic (TOC), Total Organic Halogen (TOX), Halogenated Hydrocarbons (HH), Polycyclic Aromatic Hydrocarbons (PAH), specific conductance, or

3. Odor/organic vapor detection, or

4. Mass calculations that compare the quantity of contaminants released to the quantity removed

5. Vegetative impacts: withering, yellowing, etc.

C. Followup

1. Total Cleanup - Sampling and monitoring to verify Total Cleanup unless on-site inspection judges Total Cleanup to be complete based on site conditions and effectiveness of the cleanup indicator.

2. Partial Cleanup, Site Stabilization, or Combination - All partial cleanup and site stabilization programs must be followed up with sampling and monitoring to determine the appropriate remedial cleanup levels.

PART II: STANDARD/BACKGROUND CLEANUP LEVELS OF SOIL, SURFACE WATER, GROUNDWATER, AND AIR

Description: Standard/Background Cleanup Levels are assigned to all sites when a release of material represents a threat to public health or the environment over the longer term or Total Cleanup was not implemented during Part I, Initial Cleanup. A flow diagram for Standard/Background Cleanup Level decisions is shown in Figure F-3.

A. Cleanup Levels

1. Soil

   a. 10× the appropriate drinking water or water quality standard, or

   b. If no standard exists, 10× water quality background, or

   c. If water quality background is not detectable, soil background

2. Groundwater or Surface Water

   a. Appropriate drinking water or ambient water quality standard

   b. If no standard exists, background

3. Air

   a. OSHA/WISHA limits for air quality over the site prior to backfilling

   b. Ambient air quality standards at the site boundaries prior to backfilling

   c. If no standards exist, background

B. Followup

1. The technical feasibility of the Standard/Background Cleanup Level is evaluated in the Preliminary Technical Assessment. Site characteristics that should be considered in the Preliminary Assessment are listed as follows:

   - Presence of sole source aquifers
   - Barriers to contaminant migration and degree of natural protection
   - Sorptive properties of soil and/or aquifer
   - Contaminant mobility

- Depth to groundwater
- Groundwater and surface water existing and potential use, quality, and quantity
- Occurrence of volatile contaminants (air)
- Susceptibility to wind erosion or reintrainment (air)
- Availability of alternate water supplies.

If the Standard/Background Level is achievable and appropriate it is used to evaluate the alternative remedial actions in the Feasibility Assessment.

2. If the Standard/Background Level, based on the Preliminary Technical Assessment, is not achievable or appropriate, Protection Levels (site-specific cleanup levels) must be defined for the site in Part III of this policy.

PART III: PROTECTION CLEANUP LEVELS OF SOIL, SURFACE WATER, GROUNDWATER, AND AIR

Description: Protection Levels are site-specific cleanup levels that may be assigned only after the Preliminary Technical Assessment shows that Standard/Background Levels are not achievable or appropriate for the site.

Protection levels are defined using one of the following:

1. Specified multiples of the appropriate water quality standard or background (for contaminated soil with a threat to water), or
2. Dangerous Waste Limits (for contaminated soil with a threat to air), or
3. Site-specific information on contaminant migration characteristics, leaching tests, or biologic tests, etc. Predictive modeling may be used provided sufficient site-specific information exists to calibrate the models.

A flow diagram for Protection Cleanup Level decisions is shown in Figure F-4.

A. Cleanup Levels

1. Soil Protection Level - Threat to Water
    a. 100× the appropriate water quality standard, or
    b. 100× water quality background, or
    c. 10× soil background, or

d. Defined based on site-specific contaminant and soil characteristics, leaching tests, biologic tests, etc. If sufficient data is available predictive models may be used to defined Protection Levels as follows:

1) Define the maximum acceptable level of contamination in the groundwater directly underlying the contaminant source using:

a) The appropriate water quality standard or water quality background,

b) Biologic testing, or

c) The Groundwater Protection Level (defined below).

2) Define the maximum acceptable concentration gradient with verified and calibrated transport models using site-specific contaminant, hydrologic, and soil characteristics. The concentration gradient is used to determine the Soil Protection Level, the maximum acceptable concentration of soil contamination at the source.

2. Soil Protection Level - Threat to Air

a. Dangerous Waste Limit using equivalent concentration for LC_{50} (inhalation) = 0.001 percent, or

b. Dangerous Waste Limit for respiratory carcinogens.

3. Groundwater and Surface Water Protection Levels

a. Defined based on site-specific information such as contaminant migration characteristics, site geology and hydrology, leaching tests, biologic tests, etc. If sufficient data is available predictive models may be used to define Protection Levels as follows:

1) Identify existing and potential receptors, then

2) Define an acceptable concentration for the receptors using the appropriate water quality standards, background, or biologic tests, then

3) Define the maximum acceptable concentration in the groundwater or surface water using site-specific characteristics in verified and calibrated contaminant transport models.

4. Interim Monitoring - Interim Monitoring may be implemented when additional monitoring is required to define site-specific migration characteristics provided that:

a. A delay in cleanup will not increase the risk to public health or the environment, and

b. A delay will not increase significantly the difficulty of cleanup.

B. Followup - The Protection Cleanup Levels are used to evaluate the alternative remedial actions in the Feasibility Assessment. Long-term monitoring must be conducted at all sites where Protection Levels are adopted for cleanup to verify that there is no threat to public health or the environment.

APPENDIX F

The Model Toxics Control Act

Chapter 70.105D RCW

Chapter 70.105D RCW
HAZARDOUS WASTE CLEANUP——MODEL TOXICS CONTROL ACT

Sections

70.105D.010	Declaration of policy.
70.105D.020	Definitions.
70.105D.030	Department's powers and duties.
70.105D.040	Standard of liability.
70.105D.050	Enforcement.
70.105D.060	Timing of review.
70.105D.070	Toxics control accounts.
70.105D.900	Short title——1989 c 2.
70.105D.905	Captions——1989 c 2.
70.105D.910	Construction——1989 c 2.
70.105D.915	Existing agreements——1989 c 2.
70.105D.920	Effective date——1989 c 2.
70.105D.921	Severability——1989 c 2.

RCW 70.105D.010 Declaration of policy. (1) Each person has a fundamental and inalienable right to a healthful environment, and each person has a responsibility to preserve and enhance that right. The beneficial stewardship of the land, air, and waters of the state is a solemn obligation of the present generation for the benefit of future generations.

(2) A healthful environment is now threatened by the irresponsible use and disposal of hazardous substances. There are hundreds of hazardous waste sites in this state, and more will be created if current waste practices continue. Hazardous waste sites threaten the state's water resources, including those used for public drinking water. Many of our municipal landfills are current or potential hazardous waste sites and present serious threats to human health and environment. The costs of eliminating these threats in many cases are beyond the financial means of our local governments and ratepayers. The main purpose of *this act is to raise sufficient funds to clean up all hazardous waste sites and to prevent the creation of future hazards due to improper disposal of toxic wastes into the state's land and waters.

(3) Many farmers and small business owners who have followed the law with respect to their uses of pesticides and other chemicals nonetheless may face devastating economic consequences because their uses have contaminated the environment or the water supplies of their neighbors. With a source of funds, the state may assist these farmers and business owners, as well as those persons who sustain damages, such as the loss of their drinking water supplies, as a result of the contamination.

(4) Because it is often difficult or impossible to allocate responsibility among persons liable for hazardous waste sites and because it is essential that sites be cleaned up well and expeditiously, each responsible person should be liable jointly and severally. [1989 c 2 § 1 (Initiative Measure No. 97, approved November 8, 1988).]

***Reviser's note:** For codification of "this act" [1989 c 2], see Codification Tables, Volume 0.

RCW 70.105D.020 Definitions. (1) "Department" means the department of ecology.

(2) "Director" means the director of ecology or the director's designee.

(3) "Facility" means (a) any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, vessel, or aircraft, or (b) any site or area where a hazardous substance, other than a consumer product in consumer use, has been deposited, stored, disposed of, or placed, or otherwise come to be located.

(4) "Federal cleanup law" means the federal comprehensive environmental response, compensation, and liability act of 1980, 42 U.S.C. Sec. 9601 et seq., as amended by Public Law 99-499.

(5) "Hazardous substance" means:

(a) Any dangerous or extremely hazardous waste as defined in RCW 70.105.010 (5) and (6), or any dangerous or extremely dangerous waste designated by rule pursuant to chapter 70.105 RCW;

(b) Any hazardous substance as defined in RCW 70.105.010(14) or any hazardous substance as defined by rule pursuant to chapter 70.105 RCW;

(c) Any substance that, on March 1, 1989, is a hazardous substance under section 101(14) of the federal cleanup law, 42 U.S.C. Sec. 9601(14);

(d) Petroleum or petroleum products; and

(e) Any substance or category of substances, including solid waste decomposition products, determined by the director by rule to present a threat to human health or the environment if released into the environment.

The term hazardous substance does not include any of the following when contained in an underground storage tank from which there is not a release: Crude oil or any fraction thereof or petroleum, if the tank is in compliance with all applicable federal, state, and local law.

(6) "Owner or operator" means:

(a) Any person with any ownership interest in the facility or who exercises any control over the facility; or

(b) In the case of an abandoned facility, any person who had owned, or operated, or exercised control over the facility any time before its abandonment;

The term does not include:

(i) An agency of the state or unit of local government which acquired ownership or control involuntarily through bankruptcy, tax delinquency, abandonment, or circumstances in which the government involuntarily acquires title. This exclusion does not apply to an agency of the state or unit of local government which has caused or contributed to the release or threatened release of a hazardous substance from the facility; or

(ii) A person who, without participating in the management of a facility, holds indicia of ownership primarily to protect the person's security interest in the facility.

(7) "Person" means an individual, firm, corporation, association, partnership, consortium, joint venture, commercial entity, state government agency, unit of local government, federal government agency, or Indian tribe.

(8) "Potentially liable person" means any person whom the department finds, based on credible evidence, to be liable under RCW 70.105D.040. The department shall give notice to any such person and allow an opportunity for comment before making the finding, unless an emergency requires otherwise.

(9) "Public notice" means, at a minimum, adequate notice mailed to all persons who have made timely request of the department and to persons residing in the potentially affected vicinity of the proposed action; mailed to appropriate news media; published in the newspaper of largest circulation in the city or county of the proposed action; and opportunity for interested persons to comment.

(10) "Release" means any intentional or unintentional entry of any hazardous substance into the environment, including but not limited to the abandonment or disposal of containers of hazardous substances.

(11) "Remedy" or "remedial action" means any action or expenditure consistent with the purposes of this chapter to identify, eliminate, or minimize any threat or potential threat posed by hazardous substances to human health or the environment including any investigative and monitoring activities with respect to any release or threatened release of a hazardous substance and any health assessments or health effects studies conducted in order to determine the risk or potential risk to human health. [1989 c 2 § 2 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.030 Department's powers and duties. (1) The department may exercise the following powers in addition to any other powers granted by law:

(a) Investigate, provide for investigating, or require potentially liable persons to investigate any releases or threatened releases of hazardous substances, including but not limited to inspecting, sampling, or testing to determine the nature or extent of any release or threatened release. If there is a reasonable basis to believe that a release or threatened release of a hazardous substance may exist, the department's authorized employees, agents, or contractors may enter upon any property and conduct investigations. The department shall give reasonable notice before entering property unless an emergency prevents such notice. The department may by subpoena require the attendance or testimony of witnesses and the production of documents or other information that the department deems necessary;

(b) Conduct, provide for conducting, or require potentially liable persons to conduct remedial actions (including investigations under (a) of this subsection) to remedy releases or threatened releases of hazardous substances. In carrying out such powers, the department's authorized employees, agents, or contractors may enter upon property. The department shall give reasonable notice before entering property unless an emergency prevents such notice. In conducting, providing for, or requiring remedial action, the department shall give preference to permanent solutions to the maximum extent practicable and shall provide for or require adequate monitoring to ensure the effectiveness of the remedial action;

(c) Indemnify contractors retained by the department for carrying out investigations and remedial actions, but not for any contractor's reckless or wilful misconduct;

(d) Carry out all state programs authorized under the federal cleanup law and the federal resource, conservation, and recovery act, 42 U.S.C. Sec. 6901 et seq., as amended;

(e) Classify substances as hazardous substances for purposes of RCW 70.105D.020(5) and classify substances and products as hazardous substances for purposes of RCW 82.21.020(1); and

(f) Take any other actions necessary to carry out the provisions of this chapter, including the power to adopt rules under chapter 34.05 RCW.

(2) The department shall immediately implement all provisions of this chapter to the maximum extent practicable, including investigative and remedial actions where appropriate. The department, within nine months after March 1, 1989, shall adopt, and thereafter enforce, rules under chapter 34.05 RCW to:

(a) Provide for public participation, including at least (i) the establishment of regional citizen's advisory committees, (ii) public notice of the development of investigative plans or remedial plans for releases or threatened releases, and (iii) concurrent public notice of all compliance orders, enforcement orders, or notices of violation;

(b) Establish a hazard ranking system for hazardous waste sites;

(c) Establish reasonable deadlines not to exceed ninety days for initiating an investigation of a hazardous waste site after the department receives information that the site may pose a threat to human health or the environment and other reasonable deadlines for remedying releases or threatened releases at the site; and

(d) Publish and periodically update minimum cleanup standards for remedial actions at least as stringent as the cleanup standards under section 121 of the federal cleanup law, 42 U.S.C. Sec. 9621, and at least as stringent as all applicable state and federal laws, including health-based standards under state and federal law.

(3) Before November 1st of each even-numbered year, the department shall develop, with public notice and hearing, and submit to the ways and means and appropriate standing environmental committees of the senate and house of representatives a ranked list of projects and expenditures recommended for appropriation from

both the state and local toxics control accounts. The department shall also provide the legislature and the public each year with an accounting of the department's activities supported by appropriations from the state toxics control account, including a list of known hazardous waste sites and their hazard rankings, actions taken and planned at each site, how the department is meeting its top two management priorities under RCW 70.105.150, and all funds expended under this chapter.

(4) The department shall establish a scientific advisory board to render advice to the department with respect to the hazard ranking system, cleanup standards, remedial actions, deadlines for remedial actions, monitoring, the classification of substances as hazardous substances for purposes of RCW 70.105D.020(5) and the classification of substances or products as hazardous substances for purposes of RCW 82.21.020(1). The board shall consist of five independent members to serve staggered three-year terms. No members may be employees of the department. Members shall be reimbursed for travel expenses as provided in RCW 43.03.050 and 43.03.060.

(5) The department shall establish a program to identify potential hazardous waste sites and to encourage persons to provide information about hazardous waste sites. [1989 c 2 § 3 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.040 Standard of liability. (1) Except as provided in subsection (3) of this section, the following persons are liable with respect to a facility:

(a) The owner or operator of the facility;

(b) Any person who owned or operated the facility at the time of disposal or release of the hazardous substances;

(c) Any person who owned or possessed a hazardous substance and who by contract, agreement, or otherwise arranged for disposal or treatment of the hazardous substance at the facility, or arranged with a transporter for transport for disposal or treatment of the hazardous substances at the facility, or otherwise generated hazardous wastes disposed of or treated at the facility;

(d) Any person (i) who accepts or accepted any hazardous substance for transport to a disposal, treatment, or other facility selected by such person from which there is a release or a threatened release for which remedial action is required, unless such facility, at the time of disposal or treatment, could legally receive such substance; or (ii) who accepts a hazardous substance for transport to such a facility and has reasonable grounds to believe that such facility is not operated in accordance with chapter 70.105 RCW; and

(e) Any person who both sells a hazardous substance and is responsible for written instructions for its use if (i) the substance is used according to the instructions and (ii) the use constitutes a release for which remedial action is required at the facility.

(2) Each person who is liable under this section is strictly liable, jointly and severally, for all remedial action costs and for all natural resource damages resulting from the releases or threatened releases of hazardous substances. The attorney general, at the request of the department, is empowered to recover all costs and damages from persons liable therefor.

(3) The following persons are not liable under this section:

(a) Any person who can establish that the release or threatened release of a hazardous substance for which the person would be otherwise responsible was caused solely by:

(i) An act of God;

(ii) An act of war; or

(iii) An act or omission of a third party (including but not limited to a trespasser) other than (A) an employee or agent of the person asserting the defense, or (B) any person whose act or omission occurs in connection with a contractual relationship existing, directly or indirectly, with the person asserting this defense to liability. This defense only applies where the person asserting the defense has exercised the utmost care with respect to the hazardous substance, the foreseeable acts or omissions of the third party, and the foreseeable consequences of those acts or omissions;

(b) Any person who is an owner, past owner, or purchaser of a facility and who can establish by a preponderance of the evidence that at the time the facility was acquired by the person, the person had no knowledge or reason to know that any hazardous substance, the release or threatened release of which has resulted in or contributed to the need for the remedial action, was released or disposed of on, in, or at the facility. This subsection (b) is limited as follows:

(i) To establish that a person had no reason to know, the person must have undertaken, at the time of acquisition, all appropriate inquiry into the previous ownership and uses of the property, consistent with good commercial or customary practice in an effort to minimize liability. Any court interpreting this subsection (b) shall take into account any specialized knowledge or experience on the part of the person, the relationship of the purchase price to the value of the property if uncontaminated, commonly known or reasonably ascertainable information about the property, the obviousness of the presence or likely presence of contamination at the property, and the ability to detect such contamination by appropriate inspection;

(ii) The defense contained in this subsection (b) is not available to any person who had actual knowledge of the release or threatened release of a hazardous substance when the person owned the real property and who subsequently transferred ownership of the property without first disclosing such knowledge to the transferee;

(iii) The defense contained in this subsection (b) is not available to any person who, by any act or omission, caused or contributed to the release or threatened release of a hazardous substance at the facility;

(c) Any natural person who uses a hazardous substance lawfully and without negligence for any personal or domestic purpose in or near a dwelling or accessory structure when that person is: (i) A resident of the dwelling; (ii) a person who, without compensation, assists the resident in the use of the substance; or (iii) a person who is employed by the resident, but who is not an independent contractor;

(d) Any person who, for the purpose of growing food crops, applies pesticides or fertilizers without negligence and in accordance with all applicable laws and regulations.

(4) There may be no settlement by the state with any person potentially liable under this chapter except in accordance with this subsection.

(a) The attorney general may agree to a settlement with any potentially liable person only if the department finds, after public notice and hearing, that the proposed settlement would lead to a more expeditious cleanup of hazardous substances in compliance with cleanup standards under RCW 70.105D.030(2)(d) and with any remedial orders issued by the department. Whenever practicable and in the public interest, the attorney general may expedite such a settlement with persons whose contribution is insignificant in amount and toxicity.

(b) A settlement agreement under this subsection shall be entered as a consent decree issued by a court of competent jurisdiction.

(c) A settlement agreement may contain a covenant not to sue only of a scope commensurate with the settlement agreement in favor of any person with whom the attorney general has settled under this section. Any covenant not to sue shall contain a reopener clause which requires the court to amend the covenant not to sue if factors not known at the time of entry of the settlement agreement are discovered and present a previously unknown threat to human health or the environment.

(d) A party who has resolved its liability to the state under this subsection shall not be liable for claims for contribution regarding matters addressed in the settlement. The settlement does not discharge any of the other liable parties but it reduces the total potential liability of the others to the state by the amount of the settlement.

(5) Nothing in this chapter affects or modifies in any way any person's right to seek or obtain relief under other statutes or under common law, including but not limited to damages for injury or loss resulting from a release or threatened release of a hazardous substance. No settlement by the department or remedial action ordered by a court or the department affects any person's right to obtain a remedy under common law or other statutes. [1989 c 2 § 4 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.050 Enforcement. (1) With respect to any release, or threatened release, for which the department does not conduct or contract for conducting remedial action and for which the department believes remedial action is in the public interest, the director shall issue orders requiring potentially liable persons to provide the remedial action. Any liable person who refuses, without sufficient cause, to comply with an order of the director is liable in an action brought by the attorney general for:

(a) Up to three times the amount of any costs incurred by the state as a result of the party's refusal to comply; and

(b) A civil penalty of up to twenty-five thousand dollars for each day the party refuses to comply.

The treble damages and civil penalty under this subsection apply to all recovery actions filed on or after March 1, 1989.

(2) Any person who incurs costs complying with an order issued under subsection (1) of this section may petition the department for reimbursement of those costs. If the department refuses to grant reimbursement, the person may within thirty days thereafter file suit and recover costs by proving that he or she was not a liable person under RCW 70.105D.040 and that the costs incurred were reasonable.

(3) The attorney general shall seek, by filing an action if necessary, to recover the amounts spent by the department for investigative and remedial actions and orders, including amounts spent prior to March 1, 1989.

(4) The attorney general may bring an action to secure such relief as is necessary to protect human health and the environment under this chapter.

(5) (a) Any person may commence a civil action to compel the department to perform any nondiscretionary duty under this chapter. At least thirty days before commencing the action, the person must give notice of intent to sue, unless a substantial endangerment exists. The court may award attorneys' fees and other costs to the prevailing party in the action.

(b) Civil actions under this section and RCW 70.105D.060 may be brought in the superior court of Thurston county or of the county in which the release or threatened release exists. [1989 c 2 § 5 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.060 Timing of review. The department's investigative and remedial decisions under RCW 70.105D.030 and 70.105D.050 and its decisions regarding liable persons under RCW 70.105D.020(8) and 70.105D.040 shall be reviewable exclusively in superior court and only at the following times: (1) In a cost recovery suit under RCW 70.105D.050(3); (2) in a suit by the department to enforce an order or seek a civil penalty under this chapter; (3) in a suit for reimbursement under RCW 70.105D.050(2); (4) in a suit by the department to compel investigative or remedial action; and (5) in a citizen's suit under RCW 70.105D.050(5). The court shall uphold the department's actions unless they were arbitrary and capricious. [1989 c 2 § 6 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.070 Toxics control accounts. (1) The state toxics control account and the local toxics control account are hereby created in the state treasury.

(2) The following moneys shall be deposited into the state toxics control account: (a) Those revenues which are raised by the tax imposed under RCW 82.21.030 and which are attributable to that portion of the rate equal to thirty-three one-hundredths of one percent; (b) the costs of remedial actions recovered under this chapter or chapter 70.105A RCW after March 1, 1989; (c) penalties collected or recovered under this chapter; and (d) any other money appropriated or transferred to the

account by the legislature. Moneys in the account may be used only to carry out the purposes of this chapter, including but not limited to the following activities:

(i) The state's responsibility for hazardous waste planning, management, regulation, enforcement, technical assistance, and public education required under chapter 70.105 RCW;

(ii) The state's responsibility for solid waste planning, management, regulation, enforcement, technical assistance, and public education required under chapter 70.95 RCW;

(iii) The hazardous waste cleanup program required under this chapter;

(iv) State matching funds required under the federal cleanup law;

(v) Financial assistance for local programs in accordance with RCW 70.95.130, 70.95.140, 70.95.220, 70.95.230, 70.95.530, 70.105.220, 70.105.225, 70.105.235, and 70.105.260;

(vi) State government programs for the safe reduction, recycling, or disposal of hazardous wastes from households, small businesses, and agriculture;

(vii) Hazardous materials emergency response training;

(viii) Water and environmental health protection and monitoring programs;

(ix) Programs authorized under chapter 70.146 RCW;

(x) A public participation program, including regional citizen advisory committees;

(xi) Public funding to assist potentially liable persons to pay for the costs of remedial action in compliance with cleanup standards under RCW 70.105D.030(2)(d) but only when the amount and terms of such funding are established under a settlement agreement under RCW 70.105D.040(4) and when the director has found that the funding will achieve both (A) a substantially more expeditious or enhanced cleanup than would otherwise occur, and (B) the prevention or mitigation of unfair economic hardship; and

(xii) Development and demonstration of alternative management technologies designed to carry out the top two hazardous waste management priorities of RCW 70.105.150.

(3) The following moneys shall be deposited into the local toxics control account: Those revenues which are raised by the tax imposed under RCW 82.21.030 and which are attributable to that portion of the rate equal to thirty-seven one-hundredths of one percent. Moneys deposited in the local toxics control account shall be used by the department for grants to local governments for the following purposes in descending order of priority: (a) Remedial actions; (b) hazardous waste plans and programs under RCW 70.105.220, 70.105.225, 70.105.235, and 70.105.260; and (c) solid waste plans and programs under RCW 70.95.130, 70.95.140, 70.95.220, and 70.95.230. Funds for plans and programs shall be allocated consistent with the priorities and matching requirements established in chapters 70.105 and 70.95 RCW.

(4) Except for unanticipated receipts under RCW 43.79.260 through 43.79.282, moneys in the state and local toxics control accounts may be spent only after appropriation by statute. All earnings from investment of balances in the accounts, except as provided in RCW 43.84.090, shall be credited to the accounts.

(5) One percent of the moneys deposited into the state and local toxics control accounts shall be allocated only for public participation grants to persons who may be adversely affected by a release or threatened release of a hazardous substance and to not-for-profit public interest organizations. The primary purpose of these grants is to facilitate the participation by persons and organizations in the investigation and remedying of releases or threatened releases of hazardous substances and to implement the state's solid and hazardous waste management priorities. No grant may exceed fifty thousand dollars though it may be renewed annually. Moneys appropriated for public participation from either account which are not expended at the close of any biennium shall revert to the state toxics control account.

(6) No moneys deposited into either the state or local toxics control account may be used for solid waste incinerator feasibility studies, construction, maintenance, or operation.

(7) The department shall adopt rules for grant issuance and performance. [1989 c 2 § 7 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.900 Short title——1989 c 2. This act shall be known as "the model toxics control act." [1989 c 2 § 22 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.905 Captions——1989 c 2. As used in this act, captions constitute no part of the law. [1989 c 2 § 21 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.910 Construction——1989 c 2. The provisions of this act are to be liberally construed to effectuate the policies and purposes of this act. In the event of conflict between the provisions of this act and any other act, the provisions of this act shall govern. [1989 c 2 § 19 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.915 Existing agreements——1989 c 2. The consent orders and decrees in effect on March 1, 1989, shall remain valid and binding. [1989 c 2 § 20 (Initiative Measure No. 97, approved November 8, 1988).]

RCW 70.105D.920 Effective date——1989 c 2. (1) Sections 1 through 24 of this act shall take effect March 1, 1989, except that the director of ecology and the director of revenue may take whatever actions may be necessary to ensure that sections 1 through 24 of this act are implemented on their effective date.

*(2) This section does not apply and shall have no force or effect if (a) this act is passed by the legislature in the 1988 regular session or (b) no bill is enacted by the legislature involving hazardous substance cleanup

(along with any other subject matter) between August 15, 1987, and January 1, 1988. [1989 c 2 § 26 (Initiative Measure No. 97, approved November 8, 1988).]

***Reviser's note:** Neither condition contained in subsection (2) was met.

RCW 70.105D.921 Severability——1989 c 2. If any provision of this act or its application to any person or circumstance is held invalid, the remainder of the act or the application of the provision to other persons or circumstances is not affected. [1989 c 2 § 18 (Initiative Measure No. 97, approved November 8, 1988).]

APPENDIX G

Omitted

APPENDIX H

Site Scenarios

SITE SCENARIOS

The five site scenarios were modeled using the Multimedia Environmental Pollutant Assessment System (MEPAS), a computer model that prioritizes hazardous waste disposal sites according to their potential hazard to public health. MEPAS was used to evaluate the impacts of contaminants remaining at a site after cleanup using site scenarios representative of hazardous waste sites in Washington state.

DESCRIPTION OF THE MEPAS MODEL

MEPAS is an integrated set of computer programs created by Battelle, Pacific Northwest Laboratories for the U.S. Department of Energy that is designed to rank facilities according to the human health effects of environmental problems. MEPAS links a group of software models that evaluate 1) the transport of contaminants through air, soil, ground water, and surface water and 2) the effects of human exposure to the contaminated media or to affected food sources. Results are either expressed as risk (for carcinogens) or as doses relative to the reference dose (reference dose ratios). MEPAS evaluates risk independently for each pathway to a receptor or exposed population.

In addition to detailed modeling of the transport and exposure of contaminants through certain media, MEPAS allows the contaminant source to be characterized in terms of geometry (for example, point, line, or volume), amount of contaminant present, and release rate. The models require detailed data regarding the characteristics of the media (for example, surface roughness and dissociation constants) and contaminants (for example, persistence and toxicity). Default values for much of the required data are stored in MEPAS and can be used if no site-specific data are available.

Calculations of transport and exposure are based on analytical models. Although not as easily tailored to particular site characteristics as numerical models, the analytical approach requires less data and a less complex site characterization. Although mathematically simpler, analytical models are not necessarily any less accurate; the additional interactions between contaminants and transport or exposure pathways that could be specified in a numerical model are likely to be poorly characterized.

Validation and Application of MEPAS

MEPAS incorporates transport and exposure models that are based on previously published mechanisms and mathematics; complete descriptions of the formulas underlying the models and references to previous work are contained in the MEPAS documentation (Battelle 1987). Additional documentation of the function and use of the software is provided by the two-volume Application Guidance document (Droppo et al. 1989a,b). MEPAS has passed an external peer review and has been applied by both the U.S. Department of Energy and the U.S. Environmental Protection Agency (EPA) at a total of 36 sites with 315 transport scenarios. Because the system has not been field tested, it was designed and recommended only for application as a comparative screening tool, rather than as a predictive tool.

Rationale for Use of MEPAS

Final selection of an approach to setting cleanup standards requires consideration of human health effects, effects on natural resources, and maximum steady-state concentrations achieved in soil, water, or air. Although MEPAS is oriented strictly toward producing risk values or reference dose ratios, it is nonetheless applicable for a preliminary assessment of the alternatives. Based on the health effects alone, the relative impact of different alternatives can be determined. Intermediate results such as contaminant concentrations in various media associated with transport and exposure routes can be also be extracted and examined (for example, for comparison with water quality criteria). MEPAS also allows comparison of various site scenarios and the impact of different alternatives across the range of scenarios. Thus, although it does not directly evaluate all of the factors that must be considered during selection of a standard-setting approach, MEPAS can identify candidate alternatives (or combinations of alternatives and sites) that can be eliminated or should be retained on the basis of health effects.

Structure of MEPAS

The models used in MEPAS are built around three types of entities: contaminant sources, media through which contaminants are transported, and the final exposed population. Multistep transport pathways, involving multiple media, may be used. The mechanisms of contaminant transport between the source and environmental media, between each environmental medium in a pathway, and between each medium and the final population are all defined by the model. Specific mechanisms are built into the model for each type of interaction. For example, an inhalation pathway can be used to link airborne contaminants and the exposed population, but this pathway cannot be applied to surface soil exposure. All possible interactions between sources, media, and exposed populations are shown in Table H-1.

Interactions between sources and media also depend on source geometry and volume. In ground water, both the unsaturated and saturated zones are modeled separately; transport between them is accomplished by infiltration. Within a medium, transport is generally governed by advection and dispersion, although the way in which these are modeled vary from one medium to another.

Transport within and between media is modeled so as to retain an overall mass balance for each contaminant. Degradation rates can be applied, however, to reduce the overall mass of a contaminant; the transport and fate of daughter products can also be modeled.

Although MEPAS is designed to handle almost any type of interaction (as listed in Table H-1), it imposes a limit on the number and length of transport pathways that may be used as part of one transport scenario. Allowable transport scenarios are listed in Table H-2.

The models for each component of a transport scenario are executed in sequence and each transport mechanism is modeled separately. For example, water movement and contaminant movement through unsaturated soil are modeled separately. This sequential aspect of the calculations limits the interactions between components. That is, the movement of contaminants in the unsaturated zone may depend on the movement of water, but not vice versa: the movement of contaminants cannot affect the movement of water. In this case, the practical limitation of the model coincides well with actual physical processes. As another example, however, seepage of ground water into surface water and infiltration of surface water into ground

TABLE H-1. INTERACTIONS BETWEEN SOURCES, ENVIRONMENTAL MEDIA, AND POPULATIONS SUPPORTED BY MEPAS

Entity 1	Interaction	Entity 2
Source	Infiltration	Ground water
Source	Plume	Atmosphere
Source	Point	Surface water
Ground water	Seepage	Surface water
Ground water	Deposition	Surface soil
Ground water	Irrigation	Surface soil
Ground water	Root uptake	Terrestrial plants
Ground water	Irrigation	Terrestrial plants
Ground water	Drinking	Population
Ground water	Ingestion/Inhalation	Population
Atmosphere	Deposition	Surface water
Atmosphere	Deposition	Surface soil
Atmosphere	Deposition	Terrestrial plants
Atmosphere	Inhalation	Population
Atmosphere	Absorption	Population
Surface water	Infiltration	Ground water
Surface water	Irrigation	Surface soil
Surface water	Volatilization	Atmosphere
Surface water	Irrigation	Terrestrial plants
Surface water	Bioaccumulation	Aquatic animals
Surface water	Drinking	Terrestrial animals
Surface water	Drinking	Population
Surface water	External exposure[a]	Population
Surface soil	Runoff	Surface water
Surface soil	Root uptake	Terrestrial plants
Surface soil	Infiltration	Ground water
Terrestrial plants	Decomposition	Surface soil
Terrestrial plants	Ingestion	Terrestrial animals
Terrestrial plants	Ingestion	Population
Aquatic animals	Ingestion	Population
Terrestrial animals	Drinking (milk)	Population
Terrestrial animals	Ingestion	Population

[a] Radionuclides only.

TABLE H-2. TRANSPORT SCENARIOS SUPPORTED BY MEPAS

Source	-->	Surface soil						
Source	-->	Air						
Source	-->	Air	-->	Surface soil	-->	Air		
Source	-->	Air	-->	Surface soil	-->	Surface soil		
Source	-->	Air	-->	Surface soil	-->	Ground water		
Source	-->	Air	-->	Surface soil	-->	Ground water	-->	Surface water
Source	-->	Air	-->	Surface soil	-->	Overland	-->	Surface water
Source	-->	Ground water						
Source	-->	Ground water	-->	Surface water				
Source	-->	Surface water						
Surface soil	-->	Air						
Surface soil	-->	Surface soil						
Surface soil	-->	Ground water						
Surface soil	-->	Ground water	-->	Surface water				
Surface soil	-->	Overland	-->	Surface water				
Surface water	-->	Air						
Surface water	-->	Air	-->	Surface soil				

water cannot be simultaneously modeled; MEPAS requires that one mechanism must be fully modeled and the results must be obtained before the other mechanism can be modeled.

Similarly, exposure to contaminated crops and to contaminated water must be modeled separately; MEPAS will not compute a combined exposure level on which to base risk calculations. This limitation allows simpler models to be used and allows the models to be combined in various ways. Tighter coupling of the models, so that all transport and exposure pathways operated simultaneously, would require the entire complex model to be run for each scenario. For scenarios in which there is little interaction among pathways, this aspect of MEPAS presents no limitation. However, when more complex scenarios are modeled, for which additional interactions would be appropriate, the consequences of neglecting the interactions must be considered.

Transport among environmental media and transport from the final environmental medium to an exposed population are modeled separately by MEPAS (that is, exposure pathways are distinguished from transport pathways). This design simplifies the development or modification of interactions between environmental media, as exposure assessments are based only on final concentrations in each medium. Assessment of exposures to media that are contaminated by multiple transport pathways (for example, surface water contaminated by both overland transport and ground water seepage) are based on the concentration in the final medium resulting from the combination of all transport mechanisms. For scenarios that include multiple exposure pathways (for example, ingestion and inhalation), MEPAS calculates the risk or reference dose ratio separately for each exposure pathway, then combines the individual risk estimates to generate a single final risk estimate.

Modeling of ground water and surface water transport is based on maintenance of a water balance, including the effects of rainfall, runoff, ice and snow, evapotranspiration, dispersion, and advection. Waste released into the unsaturated soil zone is modeled as though it moves vertically downward until it reaches the saturated zone. The rate of transport is controlled by the amount of precipitation, the rate of leaching from the waste site, and the rate of soil transmission. After entering the saturated zone, waste moves in a three-dimensional horizontal plume by means of advection and dispersion.

The surface water model used in MEPAS considers only nontidal river transport, with no sediment interaction. Advection and dispersion mechanisms control the distribution of contaminants. Evaporation of volatile contaminants from surface water is also included in the model.

Runoff is modeled as overland transport of water and contaminants. Contaminants may be dissolved in surface water and/or moved along on particulates. These calculations are based on precipitation measurements and soil characteristics. Contaminants carried in runoff can enter surface water, and the infiltration of runoff can contribute to leaching of subsurface contaminants. The overland transport model is linked to the ground water model so that the overall water balance is maintained.

The atmospheric model used in MEPAS calculates the movement of particulate and vapor contaminants through the atmosphere and allows both wet and dry deposition. Climatological effects (wind speed and direction, precipitation, and atmospheric stability) modify the effects of a three-dimensional normal (Gaussian) dispersion. Distance between the source and the receptor (exposed population) is an important aspect of exposure to atmospheric contaminants.

Operation of MEPAS (entry of data and execution of the models) is facilitated by an interactive shell that asks for all of the required data and prepares the formatted files required by the various analytical models. Menus and prompts lead the user through the steps of describing the contaminant source, transport pathways, and exposure pathways. The data needed to describe each source and pathway are entered on a specifically designed worksheet, which is automatically checked for completeness before the models can be run. Worksheets can be printed to provide permanent documentation of the data entered.

Before the models are run, each set of data is transformed from the storage format used by the interface software to the structure needed by the models. These input files can be examined and edited to better represent special conditions that are not included in the choices provided the interactive software. Intermediate files that are produced by one model for use by other models include data such as time of arrival of a contaminant at an interface between media and concentrations in a medium or at a receptor as a function of time. Intermediate files can also be examined and modified if necessary to further customize the analysis.

Output files from the transport models include 70-year average concentrations of each contaminant. These data are the basis for exposure calculations. Exposure calculations yield a risk value or reference dose ratio for each contaminant and each exposure pathway. These risk estimates are used to generate a Hazard Potential Index (HPI) for each exposure pathway from the site. The HPI incorporates the effects of carcinogenic, noncarcinogenic, and radiological toxicity; population exposure; and time of exposure and is used to prioritize sites for remedial action. Because the HPI is most appropriate for use in ranking sites, it is not used for evaluation of the alternatives in this EIS. Instead, the risk calculations for individuals are used.

MODELING OF SITE SCENARIOS

MEPAS requires a variety of data to model a hazardous waste site. Input data used for each of the site scenarios are summarized in Tables H-3 to H-7. The following discussion summarizes parameters and assumptions that were the same for all five site scenarios.

For each scenario, an initial assumption was made that the site had been cleaned up under each of the alternative approaches for setting cleanup standards. In order to model the impacts of these alternative approaches, example concentrations were derived that would be representative of standards under these alternatives for the contaminants used in the site scenarios. This modeling was performed in April 1990; the form of the regulations and each of the alternative approaches has changed, in some cases substantially, since that time. Therefore, these alternative concentrations are not entirely representative of typical concentrations that would be derived under the current alternative approaches. However, certain generalizations and patterns can be found in the results, which are presented in *Discussion of Results*, below. In addition, the risks predicted by MEPAS vary linearly with the initial concentration entered. Therefore, using these results, the risk for any concentration used as a standard for these contaminants can be determined.

Each of the alternative concentrations (background, risk, ARAR, or technology-based) was modeled under each site scenario, unless the concentrations to be modeled were lower than another alternative that had already been shown to carry no appreciable risk. Some variations on the site scenarios were also run using the maximum of the four alternative concentrations. A start date of 1 May 1990 was used to indicate the time that the site achieved the alternative

TABLE H-3. MEPUS INPUT DATA FOR LANDFILL SITE SCENARIO.

LOCATION	PUGET SOUND 1								PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY	MAXIMUM	MAXIMUM	MAXIMUM
CONTAMINATED MEDIA	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
TRANSPORT SCENARIO	GW-T1	GW-T1	GW-T1	GW-T1	GW-T2	GW-T2	GW-T2	GW-T2	GW-T1	GW-T1	GW-T1
EXPOSURE SCENARIO	GW-E1	GW-E1	GW-E1	GW-E1	SW-E8	SW-E8	SW-E8	SW-E8	GW-E1	GW-E1	GW-E1
Distance from Site to Receptor (ft)	3500	3500	3500	3500	4000	4000	4000	4000	3500	3500	3500
Drinking Population Served	200,000	200,000	200,000	200,000	-	-	-	-	200,000	200,000	200,000
Average Water Distribution Time (days)	0.5	0.5	0.5	0.5	-	-	-	-	0.5	0.5	0.5
Population Involved in Recreation	-	-	-	-	2000	2000	2000	2000	-	-	-
Drinking Water Treated?	No	No	No	No	-	-	-	-	No	No	No

GW-T1: Transport of contaminants from landfill to groundwater
GW-T2: Transport of contaminants from landfill to groundwater to surface water
GW-E1: Exposure to contaminated groundwater through ingestion and showering
SW-E8: Exposure to contaminated surface water through recreation

TABLE H-3. MEPUS INPUT DATA FOR MUNICIPAL LANDFILL SITE SCENARIO (CONT.)

LOCATION	PUGET SOUND 1								PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY	MAXIMUM	MAXIMUM	MAXIMUM
CONTAMINANT DATA											
1,1,1-TRICHLOROETHANE											
Total Mass Contaminated Soil (gm)	6.34E+04	1.90E+11	6.80E+08	-	6.34E+04	1.90E+11	6.80E+08	-	1.90E+11	1.90E+11	1.90E+11
Alternative Concentration (mg/kg)	1.00E-02	2.80E+04	1.00E+02	-	1.00E-02	2.80E+04	1.00E+02	-	2.80E+04	2.80E+04	2.80E+04
Surface Absorption Coefficients	4.61E-01	4.61E-01	4.61E-01	-	4.61E-01	4.61E-01	4.61E-01	-	8.80E-01	1.65E+00	4.61E-01
Subsurface Absorption Coefficients	4.61E-01	4.61E-01	4.61E-01	-	4.61E-01	4.61E-01	4.61E-01	-	8.80E-01	8.80E-01	4.61E-01
TETRACHLOROETHENE											
Total Mass Contaminated Soil (gm)	6.34E+04	4.15E+07	6.80E+08	6.80E+06	6.34E+04	4.15E+07	6.80E+08	6.80E+06	6.80E+08	6.80E+08	6.80E+08
Alternative Concentration (mg/kg)	1.00E-02	6.10E+00	1.00E+02	<1.00E+00	1.00E-02	6.10E+00	1.00E+02	<1.00E+00	1.00E+02	1.00E+02	1.00E+02
Surface Absorption Coefficients	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	2.11E+00	3.96E+00	1.10E+00
Subsurface Absorption Coefficients	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	2.11E+00	2.11E+00	1.10E+00
TRICHLOROETHENE											
Total Mass Contaminated Soil (gm)	6.34E+04	1.90E+08	6.80E+08	6.80E+06	6.34E+04	1.90E+08	6.80E+08	6.80E+06	6.80E+08	6.80E+08	6.80E+08
Alternative Concentration (mg/kg)	1.00E-02	2.80E+01	1.00E+02	<1.00E+00	1.00E-02	2.80E+01	1.00E+02	<1.00E+00	1.00E+02	1.00E+02	1.00E+02
Surface Absorption Coefficients	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	7.30E-01	1.37E+00	3.82E-01
Subsurface Absorption Coefficients	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	3.82E-01	7.30E-01	7.30E-01	3.82E-01

TABLE H-3. MEPUS INPUT DATA FOR MUNICIPAL LANDFILL SITE SCENARIO (CONT.)

LOCATION	PUGET SOUND 1								PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY	MAXIMUM	MAXIMUM	MAXIMUM
MEDIA DATA											
SOIL PARAMETERS											
Top Soil Type (SCS Classification)	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY CLAY LOAM	SILTY CLAY	SANDY LOAM
Saturated Zone Soil (SCS Classification)	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY CLAY LOAM	SANDY CLAY LOAM	SANDY LOAM
Bulk Density Top Soil (gm/cm^3)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.36	1.5
Bulk Density Saturated Zone (gm/cm^3)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.5
Total Porosity of Saturated Zone (%)	44.0	44.0	44.0	44.0	44.0	44.0	44.0	44.0	39.8	39.8	44.0
Effective Porosity of Saturated Zone (%)	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	17.0	17.0	21.0
Moisture Content (%)	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	24.0	42.0	17.5
Top Soil Water Capacity (in.)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.9	2.9	0.2
SCS Curve Number	58	58	58	58	58	58	58	58	84	91	58
Pore Water Velocity/Saturated Zone (ft/day)	10	10	10	10	10	10	10	10	8	.001	10
Saturated Hydraulic Conductivity (ft/day)											2.8
Length of Site in Direction of GW Flow (ft)	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
Width of Site Perpendicular to GW Flow (ft)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Thickness of Saturated Zone (ft)	40	40	40	40	40	40	40	40	40	40	40
Thickness of Partially Saturated Zone (ft)	-	-	-	-	-	-	-	-	-	-	10
Elevation of Landfill (ft)	400	400	400	400	400	400	400	400	400	400	2357
GROUNDWATER PARAMETERS											
Thickness of Aquifer (ft)	40	40	40	40	40	40	40	40	40	40	40
Depth of Waste in Saturated Zone (ft)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Leaching to Partially Saturated Zone	No	No	No	No	No	No	No	No	No	No	Yes
Leaching to Saturated Zone Directly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

TABLE H-4. MEPAS INPUT DATA FOR LEAKING UNDERGROUND STORAGE TANKS SITE SCENARIO.

LOCATION	PUGET SOUND 1			PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	MAXIMUM	MAXIMUM	MAXIMUM
CONTAMINATED MEDIA	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
TRANSPORT SCENARIO	SS-T2	SS-T2	SS-T2	SS-T2	SS-T2	SS-T2
EXPOSURE SCENARIO	GW-E1	GW-E1	GW-E1	GW-E1	GW-E1	GW-E1
Distance from Site to Receptor (ft)	3500	3500	3500	3500	3500	3500
Drinking Population Served	200000	200000	200000	200000	200000	200000
Average Water Distribution Time (days)	0.5	0.5	0.5	0.5	0.5	0.5
Drinking Water Treated?	No	No	No	No	No	No

SS-T2: Transport of contaminants from surface soil to groundwater

GW-E1: Exposure to contaminated groundwater through ingestion and showering

CONTAMINANT DATA						
BENZENE						
Total Mass Contaminated Soil (gm)	5.10E+02	4.38E+05	5.10E+06	5.10E+06	5.10E+06	5.10E+06
Alternative Concentration (mg/kg)	1.00E-02	8.60E+00	1.00E+02	1.00E+02	1.00E+02	1.00E+02
Surface Absorption Coefficients	2.52E-01	2.52E-01	2.52E-01	4.81E-01	9.03E-01	2.52E-01
Subsurface Absorption Coefficients	2.52E-01	2.52E-01	2.52E-01	4.81E-01	4.81E-01	2.52E-01
TOLUENE						
Total Mass Contaminated Soil (gm)	5.10E+02	4.70E+09	-	4.70E+09	4.70E+09	4.70E+09
Alternative Concentration (mg/kg)	1.00E-02	9.30E+04	-	9.30E+04	9.30E+04	9.30E+04
Surface Absorption Coefficients	9.10E-01	9.10E-01	-	1.74E+00	3.27E+00	9.10E-01
Subsurface Absorption Coefficients	9.10E-01	9.10E-01	-	1.74E+00	1.74E+00	9.10E-01
XYLENE						
Total Mass Contaminated Soil (gm)	5.10E+02	3.16E+10	-	3.16E+10	3.16E+10	3.16E+10
Alternative Concentration (mg/kg)	1.00E-02	6.20E+05	-	6.20E+05	6.20E+05	6.20E+05
Surface Absorption Coefficients	7.28E-01	7.28E-01	-	1.39E+00	2.61E+00	7.28E-01
Subsurface Absorption Coefficients	7.28E-01	7.28E-01	-	1.39E+00	1.39E+00	7.28E-01

TABLE H-4. MEPAS INPUT DATA FOR LEAKING UNDERGROUND STORAGE TANKS SITE SCENARIO (CONT.)

LOCATION	PUGET SOUND 1			PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	MAXIMUM	MAXIMUM	MAXIMUM
MEDIA DATA						
SOIL PARAMETERS						
Top Soil Type (SCS Classification)	SANDY	SANDY	SANDY	SANDY	SILTY CLAY	SANDY
Partially Saturated Zone (SCS Classification)	LOAM	LOAM	LOAM	CLAY LOAM		LOAM
Saturated Zone Soil (SCS Classification)	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY CLAY LOAM	SANDY CLAY LOAM	SANDY LOAM
Bulk Density Top Soil or Part. Sat. Zone (gm/cm^3)	1.5	1.5	1.5	1.6	1.36	1.5
Bulk Density Saturated Zone (gm/cm^3)	1.5	1.5	1.5	1.6	1.6	1.5
Total Porosity of Partially Saturated Zone (%)	-	-	-	-	-	44.0
Total Porosity of Saturated Zone (%)	44.0	44.0	44.0	39.8	39.8	44.0
Effective Porosity of Saturated Zone (%)	21.0	21.0	21.0	17.1	17.1	21.0
Field Capacity of Partially Saturated Zone (%)						17.5
Moisture Content (%)	17.5	17.5	17.5	24.0	42	17.5
Top Soil Water Capacity (in)	0.2	0.2	0.2	1.9	2.9	0.2
SCS Curve Number	58	58	58	84	91	58
Pore Water Velocity Saturated Zone (ft/day)	10	10	10	.1	.001	10
Saturated Hydraulic Conductivity (ft/day)	-	-	-	-	-	2.8
Length of Site in Direction of GW Flow (ft)	200	200	200	200	200	200
Width of Site Perpendicular to GW Flow (ft)	400	400	400	400	400	400
Depth of Site (ft)	15	15	15	15	15	15
Thickness of Partially Saturated Zone (ft)	-	-	-	-	-	10
Elevation of Site (ft)	400	400	400	400	400	2357
GROUNDWATER PARAMETERS						
Thickness of Saturated Zone (ft)	40	40	40	40	40	40
Depth of Waste in Saturated Zone (ft)	0.1	0.1	0.1	0.1	0.1	0.0
Leaching to Partially Saturated Zone	No	No	No	No	No	Yes
Leaching to Saturated Zone Directly	Yes	Yes	Yes	Yes	Yes	No

TABLE H-5. MEPAS INPUT DATA FOR METAL PLATING FACILITY SITE SCENARIO.

LOCATION	WESTERN WASHINGTON			
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	BACKGROUND	RISK	RISK
CONTAMINATED MEDIA	SOIL	SOIL	SOIL	SOIL
TRANSPORT SCENARIO	SS-T4	SS-T3	SS-T4	SS-T3
EXPOSURE SCENARIO	SW-E2	SW-E2	SW-E2	SW-E2
Distance from Site to Receptor (ft)	100	100	100	100
Finfish Production (kg/yr)	41000	41000	41000	41000
Finfish Consumption Delay (days)	0.5	0.5	0.5	0.5

SS-T3: Transport of contaminants through groundwater to surface water
SS-T4: Transport of contaminants overland to surface water
SW-E2: Exposure through ingestion of fish/shellfish from surface water

CONTAMINANT DATA				
CHROMIUM III				
Total Mass Contaminated Soil (gm)	5.16E+05	5.16E+05	2.29E+08	2.29E+08
Alternative Concentration (mg/kg)	5.40E+01	5.40E+01	2.40E+04	2.40E+04
Surface Absorption Coefficients	168	168	168	168
Subsurface Absorption Coefficients	-	168	-	168
COPPER				
Total Mass Contaminated Soil (gm)	2.49E+05	2.49E+05	1.79E+09	1.79E+09
Alternative Concentration (mg/kg)	2.60E+01	2.60E+01	1.80E+05	1.80E+05
Surface Absorption Coefficients	41.9	41.9	41.9	41.9
Subsurface Absorption Coefficients	-	41.9	-	41.9

TABLE H-5. MEPAS INPUT DATA FOR METAL PLATING FACILITY SITE SCENARIO (CONT.)

LOCATION	WESTERN WASHINGTON			
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	BACKGROUND	RISK	RISK
ZINC COMPOUNDS				
Total Mass Contaminated Soil (gm)	6.31E+05	6.31E+05	9.56E+03	9.56E+03
Alternative Concentration (mg/kg)	6.60E+01	6.60E+01	1.00E+06	1.00E+06
Surface Absorption Coefficients	12.9	12.7	12.9	12.7
Subsurface Absorption Coefficients	-	12.7	-	12.7
MEDIA DATA				
SOIL PARAMETERS				
Soil Type (SCS Classification)	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM
Moisture Content (%)	17.5	17.5	17.5	17.5
pH of Top Soil	5.5	-	5.5	5.5
pH of Pore Water in Partially Saturated Zone	-	5.5	-	5.5
pH of Pore Water in Saturated Zone	-	5.5	-	5.5
Bulk Density Top Soil (gm/cm^3)	1.5	-	1.5	-
Bulk Density Partial Sat. Zone (gm/cm^3)	-	1.5	-	1.5
Bulk Density Saturated Zone (gm/cm^3)	-	1.5	-	1.5
Top Soil Water Capacity (in.)	0.2	0.2	0.2	0.2
SCS Curve Number	69	69	69	69
Thickness of Partially Saturated Zone (ft)	-	12	-	12
Thickness of Saturated Zone (ft)	-	40	-	40
Total Porosity of Partially Sat. Zone (%)	-	44.0	-	44.0
Total Porosity of Saturated Zone (%)	-	44.0	-	44.0
Field Capacity of Partially Sat. Zone (%)	-	17.5	-	17.5
Effective Porosity of Saturated Zone (%)	-	17.5	-	21.0
Longitudianal Dispersivity of Partially Sat. (ft)	-	0.12	-	0.12
Pore Water Velocity of Saturated Zone (ft/day)	-	10	-	10
Saturated Hydraulic Conductivity (ft/day)	-	2.8	-	2.8

TABLE H-5. MEPAS INPUT DATA FOR METAL PLATING FACILITY SITE SCENARIO (CONT.)

LOCATION	WESTERN WASHINGTON			
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	BACKGROUND	RISK	RISK
Length of Site in Direction of GW Flow (ft)	300	300	300	300
Width of Site Perpendicular to GW Flow (ft)	75	75	75	75
Depth of Site (ft)	10	10	10	10
OVERLAND PARAMETERS				
Precipitation Frequency (in)	1.5	-	1.5	-
Overland Slope (%)	4.0	-	4.0	-
Soil Erodibility Factor	0.27	-	0.27	-
Vegetative Cover Factor	1.2	-	1.2	-
Land Management Practice Factor	1.3	-	1.3	-
SURFACE WATER PARAMETERS				
Length of River Adjacent to Facility	500	-	500	-
River Flow Velocity (ft/sec)	2.5	2.5	2.5	2.5
River Depth (ft)	50	8	8	8
River Width (ft)	100	50	50	50
Discharge at Receptor (ft^3/sec)	1000	1000	1000	1000
GROUNDWATER PARAMETERS				
Thickness of Aquifer (ft)	-	40	-	40
Depth of Waste in Saturated Zone (ft)	-	0.0	-	0.0
Travel Distance in Saturated Zone (ft)	-	100	-	100
Leaching to Partially Saturated Zone	No	Yes	No	Yes
Leaching to Saturated Zone	No	No	No	No
Discharge to Surface Water from Overland Runoff	Yes	No	Yes	No

TABLE H-6. MEPAS INPUT DATA FOR WOOD TREATMENT FACILITY SITE SCENARIO.

LOCATION	PUGET SOUND BAY							
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY
CONTAMINATED MEDIA	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
TRANSPORT SCENARIO	SS-T4	SS-T4	SS-T4	SS-T4	SS-T1	SS-T1	SS-T1	SS-T1
EXPOSURE SCENARIO	SW-E2	SW-E2	SW-E2	SW-E2	A-E1	A-E1	A-E1	A-E1
Distance from Site to Receptor (ft)	100	100	100	100	-	-	-	-
Finfish Production (kg/yr)	14300	14300	14300	14300	-	-	-	-
Shellfish Production (kg/yr)	43700	43700	43700	43700	-	-	-	-
Finfish/Shellfish Consumption Delay (days)	0.5	0.5	0.5	0.5	-	-	-	-
Total Exposed Population	-	-	-	-	888552	888552	888552	888552

SS-T4: Transport of contaminants overland to surface water

SS-T1: Transport of vapors/particulate contaminants in surface soil to air/surface soil

SW-E2: Exposure through ingestion of fish/shellfish from surface water

A-E1: Exposure to contaminated air through inhalation and soil ingestion

CONTAMINANT DATA								
2,3,7,8 TCDD								
Total Mass Contaminated Soil (gm)	7.73E+00	1.16E+01	-	3.87E+02	-	-	-	-
Average Soil Concentration (mg/kg)	-	-	-	-	2.00E-05	3.00E-05	-	1.00E-03
Area Gas. Emmissions/Mean Soil Conc. (ug/kg)	-	-	-	-	2.00E-02	3.00E-02	-	1.00E+00
Alternative Concentration (mg/kg)	2.00E-05	3.00E-05	-	1.00E-03	2.00E-05	3.00E-05	-	1.00E-03
Surface Absorption Coefficients	1.00E+04	1.00E+04	-	1.00E+04	-	-	-	-
PENTACHLOROPHENOL								
Total Mass Contaminated Soil (gm)	1.94E+04	-	-	3.87E+05	-	-	-	-
Average Soil Concentration (mg/kg)	-	-	-	-	5.00E-02	-	-	1.00E+00
Area Gas. Emmissions/Mean Soil Conc. (ug/kg)	-	-	-	-	5.00E+01	-	-	1.00E+03
Alternative Concentration (mg/kg)	5.00E-02	-	-	1.00E+00	5.00E-02	-	-	1.00E+00
Surface Absorption Coefficients	1.61E+02	-	-	1.61E+02	-	-	-	-

TABLE H-6. MEPAS INPUT DATA FOR WOOD TREATMENT FACILITY SITE SCENARIO (CONT.)

LOCATION				PUGET SOUND BAY				
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY
PHENANTHRENE								
Total Mass Contaminated Soil (gm)	5.81E+05	3.87E+04	3.87E+09	1.94E+04	-	-	-	-
Average Soil Concentration (mg/kg)	-	-	-	-	1.50E+00	1.00E-01	1.00E+04	5.00E-02
Area Gas. Emmissions/Mean Soil Conc. (ug/kg)	-	-	-	-	1.50E+03	1.00E+02	1.00E+07	5.00E+01
Alternative Concentration (mg/kg)	1.50E+00	1.00E-01	1.00E+04	5.00E-02	1.50E+00	1.00E-01	1.00E+04	5.00E-02
Surface Absorption Coefficients	4.25E+01	4.25E+01	4.25E+01	4.25E+01	-	-	-	-
MEDIA DATA								
TOP SOIL PARAMETERS								
Soil Type (SCS Classification)	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	-	-	-	-
Percent Sand in Top Soil (%)	65	65	65	65	65	65	65	65
Moisture Content (%)	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5
Bulk Density of Top Soil (gm/cm^3)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Depth of Contamination (m)	-	-	-	-	1.5	1.5	1.5	1.5
Depth of Dry Zone (m)	-	-	-	-	0.1	0.1	0.1	0.1
Top Soil Water Capacity (in.)	0.2	0.2	0.2	0.2	-	-	-	-
SCS Curve Number	84	84	84	84	-	-	-	-
Type of Atmospheric Release	-	-	-	-	AREA SOURCE	AREA SOURCE	AREA SOURCE	AREA SOURCE
Contaminated Surface Area (m^2)	-	-	-	-	16900	16900	16900	16900
Ratio of N-S and E-W Area Width	-	-	-	-	1.08	1.08	1.08	1.08
Length of Site in Direction of GW Flow (ft)	1300	1300	1300	1300	-	-	-	-
Width of Site Perpendicular to GW Flow (ft)	1400	1400	1400	1400	-	-	-	-
Depth of Site (ft)	5	5	5	5	-	-	-	-

TABLE H-6. MEPAS INPUT DATA FOR WOOD TREATMENT FACILITY SITE SCENARIO (CONT.)

LOCATION	PUGET SOUND BAY							
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY
OVERLAND PARAMETERS								
Precipitation Frequency (in)	1.5	1.5	1.5	1.5	-	-	-	-
Overland Slope (%)	4.0	4.0	4.0	4.0	-	-	-	-
Soil Erodibility Factor	0.27	0.27	0.27	0.27	-	-	-	-
Vegetative Cover Factor	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0
Land Management Practice Factor	0.9	0.9	0.9	0.9	-	-	-	-
Length of Bay Adjacent to Facility (ft)	400	400	400	400	-	-	-	-
Ocean Bay Flow Velocity (ft/sec)	0.01	0.01	0.01	0.01	-	-	-	-
Ocean Bay Depth (ft)	80	80	80	80	-	-	-	-
Ocean Bay Width (ft)	1000	1000	1000	1000	-	-	-	-
Discharge at Receptor (ft^3/sec)	.3	.3	.3	.3	-	-	-	-

ATMOSPHERIC PARAMETERS

See Attached Worksheets

Table H-7. MEPAS INPUT DATA FOR AGRICULTURAL CHEMICAL SITE SCENARIO.

LOCATION	EASTERN WASHINGTON	
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	TECHNOLOGY
CONTAMINATED MEDIA	SURFACE WATER	SURFACE WATER
TRANSPORT SCENARIO	SW-T2	SW-T2
EXPOSURE SCENARIO	SW-E3 SW-E5	SW-E3 SW-E5

SW-T2: Surface water as a source of contaminants

SW-E3: Exposure to contaminated surface water through ingestion of crops irrigated by surface water

SW-E5: Exposure to contaminated surface water through ingestion of animals fed and watered by surface water

CONTAMINANT DATA

ARSENIC		
Date of Measurement	04/26/90	04/26/90
Alternative Concentration (ug/L)	1.00E+00	5.00E+01
DDT		
Date of Measurement	04/26/90	04/26/90
Alternative Concentration (ug/L)	2.00E-02	1.00E+00
GAMMA-HCCH (LINDANE)		
Date of Measurement	04/26/90	04/26/90
Alternative Concentration (ug/L)	2.00E-01	1.00E+00

Table H-7. MEPAS INPUT DATA FOR AGRICULTURAL CHEMICAL SITE SCENARIO (CONT.)

LOCATION	EASTERN WASHINGTON	
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	TECHNOLOGY
MEDIA DATA		
SURFACE WATER PARAMETERS		
Discharge at Sample Site (ft^3/s)	2500	2500
Water Pump (ft^3/s)	2500	2500
Irrigation Usage Type	Crops and Animals (Feed and Water)	
Leafy Vegetable Production (kg/yr)	1.00E+05	1.00E+05
Other Vegetable Production (kg/yr)	1.54E+07	1.54E+07
Meat Production (kg/yr)	1.73E+05	1.73E+05
Milk Production (kg/yr)	6.60E+06	6.60E+06
Irrigation Rate (L/m^2/month)	1.00E+02	1.00E+02

concentration. The combination alternative was not modeled separately, because the standard under the combination alternative would be equal to one of the other four alternative concentrations.

Partially saturated and saturated soil types were described using soil survey report information from the Soil Conservation Service. The total mass of each contaminant was calculated by multiplying the length, width, and depth of the site by the bulk density of the surface soil and the alternative concentration. The rate at which the contaminants are released to the environment is internally calculated by MEPAS using precipitation data, hydrogeologic data, and surface soil concentrations. The assumption was made that the contaminants are not replenished over time. Contaminants were allowed to degrade at the source and in the environment using highly conservative (slow) degradation rates.

The percent of organic matter, iron, and aluminum in the soil was always assumed to be zero, to allow the most transport through soil. Little or no vegetative cover was assumed to be present at the site, and a soil pH of 7.0 was assumed for all site scenarios except the metal plating facility, for which a soil pH of 5.5 was used.

The following sections discuss input parameters and assumptions that are associated with each of the five site scenarios.

Landfill

The landfill scenario was modeled in four separate locations, varying hydrogeologic and meteorologic parameters: three in the Puget Sound region (labeled Puget Sound 1, 2, and 3) and one in the Spokane area (labeled Spokane). The landfill used in each location had the same volume of contaminated soil and the same volatile organic compounds: 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene.

Puget Sound 1 was expected to have the fastest contaminant transport, because it used a soil with high hydraulic conductivity and because it was located in an area of the state with high rainfall. Therefore, all four alternative concentrations were modeled at that location. At the other three locations, only the maximum of the alternative concentrations was modeled for each contaminant. The risk-based alternative had the highest alternative concentration for 1,1,1-trichloroethane, and the ARAR alternative had the highest alternative concentrations for trichloroethene and tetrachloroethene.

A variety of exposure models were used. At each location, exposure to ground water through drinking water and showering was modeled using a domestic water well located 3,500 feet from the source. At Puget Sound 1, an additional exposure scenario was modeled that addressed contaminants moving through ground water to surface water, and subsequent recreational exposure to the surface water. Ingestion of surface water is considered the primary exposure route associated with recreational exposure.

At all Puget Sound locations, Seattle-Tacoma airport climatological data were used. Spokane climatological data were used for the Spokane location. Puget Sound 1 uses a soil type of sandy loam (SCS classification). The soil type differs between this and the other Puget Sound locations; Puget Sound 2 uses sandy clay loam, while Puget Sound 3 uses silty clay for the top soil and sandy clay loam for the saturated soil. The soil types used at these three locations were intended to bracket the possible soil types for sites in the Puget Sound area by providing high, medium, and low estimates of hydraulic conductivity and other soil properties. The Spokane location uses a soil type of sandy loam.

Leaking Underground Storage Tanks

The leaking underground storage tanks scenario was modeled in the same locations as the landfill scenario; three in the Puget Sound region (labeled Puget Sound 1, 2, and 3) and one in the Spokane area (labeled Spokane). The leaking underground storage tank facility in each location was based on the same volume of contaminated soil and the same volatile organic compounds (benzene, toluene, and xylene). The scenarios vary according to the alternative concentration of contaminants in soil, the climatological setting, and the soil types and corresponding hydrogeologic parameters. Contaminants were assumed to move through ground water to a set of domestic water supply wells located 3,500 feet from the source. Exposure to human health through showering and ingestion of the ground water from the wells was modeled.

The leaking underground storage tank locations, soil types, and meteorologic parameters are the same as those used for the landfill scenario described above. Background, risk, and ARAR alternative concentrations were modeled at Puget Sound 1; the technology-based concentrations were lower than the other alternatives that carried no appreciable risk. At the other three locations, the highest of the four alternative concentrations was modeled for each contaminant. The ARAR alternative concentration was the highest concentration for benzene, and the risk-based alternative concentration was the highest alternative concentration for toluene and xylene.

Metal Plating Facility

The metal plating facility is located in western Washington near a large river that supports a large tribal steelhead fishery and recreational salmon fishing. Seattle-Tacoma airport climatological data were used to model infiltration at the site. A sandy loam soil type, which has high hydraulic conductivity, was used to provide a conservative transport scenario.

The metal plating facility scenario modeled contamination by chromium, copper, and zinc. Background and risk-based alternative concentrations of contaminants in soil were modeled; concentrations for the other alternatives were close to background values. Two separate transport pathways were used: one pathway modeled transport of contaminants on surface soil through overland runoff to a river, while the other pathway modeled transport of contaminants through ground water to the same river. The MEPAS model calculates the combined risk of both pathways to human health from exposure to surface water through ingestion of fish caught in the river.

Wood Treatment Facility

The wood treatment facility is located on an urban bay in Puget Sound. Seattle-Tacoma airport climatological data and a sandy loam soil type were used for this scenario. For the air transport modeling, it was assumed that the site is bare and that the soil is somewhat compacted and rutted from heavy machinery. The four sets of alternative concentrations were modeled for each transport pathway.

The wood treatment facility scenario addressed risks from 2,3,7,8-TCDD, pentachlorophenol, and phenanthrene (a PAH). The four alternative concentrations of contaminants in soil were modeled using two separate transport pathways. One pathway modeled contaminants moving from surface soil through overland runoff to an ocean bay. For this pathway, the MEPAS model calculated exposure to human health by ingestion of fish and shellfish caught in the bay. The second transport pathway modeled transport of vapors and particulate contaminants from surface soil through the atmosphere. Therefore, for this pathway, the MEPAS model calculated human health exposure from inhalation of the air and ingestion of surface soil onto which contaminants had been deposited.

Agricultural Chemical Contamination

The agricultural chemical scenario is located on the east side of the Cascade Mountains in a major agricultural valley. This scenario was based on contamination of a river with arsenic, DDT, and τ-hexachlorocyclohexane (Lindane). The background and technology-based alternative concentrations were modeled for two pathways: use of the river water as drinking water for livestock and use of the river water to irrigate corn and lettuce (the risk-based and ARAR alternative concentrations were not modeled because their concentrations were lower than either of the other alternative concentrations). It was assumed that the river water was used without treatment. The MEPAS model calculated exposure to human health through ingestion of leafy and other vegetables that had been irrigated by contaminated surface water and ingestion of meat and milk from livestock that had been watered with contaminated surface water.

DISCUSSION OF RESULTS

Modeling results are summarized in Tables H-8 through H-12. For each site scenario that included a ground water transport pathway, the maximum concentration at the source in the ground water beneath the site was calculated. The maximum concentration at each receptor (for example, ground water well, surface water, water pump) was also calculated for each site scenario. The length of time for the maximum concentration of the contaminant to reach the receptor was calculated for the scenarios that included ground water pathways (for example, landfill, leaking underground storage tank, metal plating facility).

TABLE H-8. MEPAS OUTPUT DATA FOR LANDFILL SITE SCENARIO.

LOCATION	PUGET SOUND 1								PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY	MAXIMUM	MAXIMUM	MAXIMUM
RECEPTOR	GW (a)	GW	GW	GW	SW (b)	SW	SW	SW	GW	GW	GW
1,1,1-TRICHLOROETHANE											
Max. Concentration at Source (DMAX) (ug/L)	4.47E-02	1.25E+05	4.47E+02	-	4.47E-02	1.25E+05	4.47E+02	-	8.34E+06	4.02E+08	1.98E+08
Max. Concentration at Receptor (ug/L)	3.52E+00	9.85E+06	3.52E+04	-	2.41E-03	6.76E+03	2.41E+01	-	1.81E+07	6.76E+04	2.35E+06
At Time: (years)	16	17.7	17.7	-	16.3	18	18	-	608.5	7001	106
Risk (carcinogenic)											
Drinking Water	1.35E-06	4.05E+00	1.45E-02	-	-	-	-	-	2.98E+01	8.84E-02	3.84E+00
Showering	4.28E-07	1.28E+00	4.59E-03	-	-	-	-	-	9.42E+00	2.80E-02	1.22E+00
Swimming	-	-	-	-	1.52E-12	4.56E-06	1.63E-08	-	-	-	-
TETRACHLOROETHENE											
Max. Concentration at Source (DMAX) (ug/L)	2.12E-02	1.29E+01	2.12E+02	2.12E+00	2.12E-02	1.29E+01	2.12E+02	2.12E+00	1.36E+04	6.60E+05	3.35E+05
Max. Concentration at Receptor (ug/L)	1.66E+00	1.02E+03	1.67E+04	1.67E+02	1.14E-03	6.97E-01	1.14E+01	1.14E-01	2.92E+04	5.72E-24	4.01E+03
At Time: (years)	33.9	37.2	37.2	37.2	34.4	37.8	37.8	37.8	1575	7001	212.7
Risk (carcinogenic)											
Drinking Water	1.20E-06	7.89E-04	1.29E-02	1.29E-04	-	-	-	-	4.28E-02	<1.00E-25 (c)	5.38E-03
Showering	1.27E-08	8.35E-06	1.37E-04	1.37E-06	-	-	-	-	4.53E-04	<1.00E-25 (c)	5.69E-05
Swimming	-	-	-	-	1.36E-12	8.89E-10	1.46E-08	1.46E-10	-	-	-
TRICHLOROETHENE											
Max. Concentration at Source (DMAX) (ug/L)	5.18E-02	1.45E+02	5.18E+02	5.18E+00	5.18E-02	1.45E+02	5.18E+02	5.18E+00	3.49E+04	1.68E+06	8.21E+05
Max. Concentration at Receptor (ug/L)	4.07E+00	1.14E+04	4.08E+04	4.08E+02	2.79E-03	7.82E+00	2.79E+01	2.79E-01	7.64E+04	7.64E+02	9.65E+03
At Time: (years)	14.1	15	15	15	14.3	15.2	15.2	15.2	516.7	7001	91.2
Risk (carcinogenic)											
Drinking Water	2.59E-07	7.77E-04	2.78E-03	2.78E-05	-	-	-	-	2.42E-02	2.34E-04	2.67E-03
Showering	9.75E-08	2.92E-04	1.05E-03	1.05E-05	-	-	-	-	9.08E-03	8.78E-05	1.00E-03
Swimming	-	-	-	-	2.92E-13	8.76E-10	3.13E-09	3.13E-11	-	-	-

TABLE H-9. MEPAS OUTPUT DATA FOR LEAKING UNDERGROUND STORAGE TANK SITE SCENARIO

LOCATION	PUGET SOUND 1			PUGET SOUND 2	PUGET SOUND 3	SPOKANE
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	MAXIMUM	MAXIMUM	MAXIMUM
RECEPTOR	GW (a)	GW	GW	GW	GW	GW
BENZENE						
Max. Concentration at Source (DMAX) (ug/L)	7.01E-02	6.03E+01	7.01E+02	4.84E+04	2.31E+06	1.11E+06
Max. Concentration at Well (ug/L)	7.05E-02	6.06E+01	7.05E+02	7.27E+02	1.90E-03	8.64E+01
At Time: (years)	4.9	4.9	4.9	451.5	7001	51.4
Risk (carcinogenic)						
Drinking Water	3.84E-09	3.30E-06	3.84E-05	6.05E-04	1.46E-09	2.98E-05
Showering	1.22E-09	1.05E-06	1.22E-05	1.92E-04	4.64E-10	9.48E-06
TOLUENE						
Max. Concentration at Source (DMAX) (ug/L)	2.52E-02	2.34E+05	-	1.50E+07	7.30E+08	3.71E+08
Max. Concentration at Well (ug/L)	2.59E-02	2.41E+05	-	2.24E+05	1.09E-15	3.09E+04
At Time: (years)	14.2	14.2	-	1400	7001	145.5
Risk (reference dose ratio)						
Drinking Water	4.41E-13	4.10E-06	-	2.13E-05	<1.00E-25	2.08E-06
Showering	2.80E-14	2.61E-07	-	1.35E-06	<1.00E-25	1.33E-07
XYLENE						
Max. Concentration at Source (DMAX) (ug/L)	3.06E-02	1.93E+06	-	1.25E+08	6.05E+09	3.05E+09
Max. Concentration at Well (ug/L)	3.13E-02	1.97E+06	-	1.82E+06	4.23E-12	2.49E+05
At Time: (years)	11.3	11.3	-	1050	7001	120.6
Risk (reference dose ratio)						
Drinking Water	6.62E-14	4.10E-06	-	2.61E-05	5.06E-23	3.31E-06
Showering	2.10E-14	1.30E-06	-	8.30E-06	1.61E-23	1.05E-06

a. GW - Groundwater

TABLE H-10. MEPAS OUTPUT DATA FOR METAL PLATING FACILITY SITE SCENARIO.

LOCATION	WESTERN WASHINGTON			
ALTERNATIVE CONCENTRATIONS USED PATHWAY/RECEPTOR	BACKGROUND OL/SW (a)	BACKGROUND GW/SW (b)	RISK OL/SW	RISK GW/SW
CHROMIUM III				
Max. Concentration at Source (DMAX) (ug/L)	-	1.19E+03	-	5.29E+05
Max. Concentration in Surface Water (ug/L)	7.32E-06	1.69E-04	3.25E-03	7.49E-02
At Time: (years)	0	6177.7	0	6177.7
Risk (reference dose ratio)				
Ingestion: Finfish	3.13E-16 (c)		1.39E-13 (c)	
COPPER				
Max. Concentration at Source (DMAX) (ug/L)	-	2.29E+03	-	1.59E+07
Max. Concentration in Surface Water (ug/L)	3.52E-06	3.21E-04	2.44E-02	2.30E+00
At Time: (years)	0	1554.7	0	1554.7
Risk (reference dose ratio)				
Ingestion: Finfish	4.01E-14 (c)		2.87E-10 (c)	
ZINC COMPOUNDS				
Max. Concentration at Source (DMAX) (ug/L)	-	1.88E+04	-	2.80E+04
Max. Concentration in Surface Water (ug/L)	8.87E-06	2.65E-03	7.49E-03	2.13E-05
At Time: (years)	0	475.2	0	433.4
Risk (reference dose ratio)				
Ingestion: Finfish	4.43E-13 (c)		3.33E-15 (c)	

a. OL/SW - Overland runoff to surface water
b. GW/SW - Groundwater to surface water
c. Risk value is for both OL/SW and GW/SW

TABLE H-11. MEPAS OUTPUT DATA FOR WOOD TREATMENT FACILITY SITE SCENARIO.

LOCATION				PUGET SOUND BAY				
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	RISK	ARAR	TECHNOLOGY	BACKGROUND	RISK	ARAR	TECHNOLOGY
RECEPTOR	SW (a)	SW	SW	SW	AIR	AIR	AIR	AIR
2,3,7,8 TCDD								
Max. Concentration in Surface Water (ug/L)	5.42E-07	8.14E-07	-	2.71E-05	-	-	-	-
At Time: (years)	0	0	-	0	-	-	-	-
Risk (carcinogenic)								
Ingestion: Finfish	4.74E-04	7.12E-04	-	2.37E-02	-	-	-	-
Ingestion: Shellfish	5.96E-05	8.94E-05	-	2.98E-03	-	-	-	-
Ingestion: Soil	-	-	-	-	2.68E-17	4.11E-17	-	2.32E-15
Inhalation: Air	-	-	-	-	<1.00E-25	<1.00E-25	-	<1.00E-25
PENTACHLOROPHENOL								
Max. Concentration in Surface Water (ug/L)	1.36E-03	-	-	2.71E-02	-	-	-	-
At Time: (years)	0	-	-	0	-	-	-	-
Risk (non-time weighted)								
Ingestion: Finfish	1.25E-11	-	-	2.50E-10	-	-	-	-
Ingestion: Shellfish	1.24E-12	-	-	2.48E-11	-	-	-	-
Ingestion: Soil	-	-	-	-	6.88E-25	-	-	2.29E-23
Inhalation: Air	-	-	-	-	<1.00E-25	-	-	<1.00E-25
PHENANTHRENE								
Max. Concentration in Surface Water (ug/L)	4.06E-02	2.71E-03	2.71E+02	1.35E-03	-	-	-	-
At Time: (years)	0	0	0	0	-	-	-	-
Risk (carcinogenic)								
Ingestion: Finfish	5.01E-05	3.34E-06	3.34E-01	1.67E-06	-	-	-	-
Ingestion: Shellfish	4.62E-06	3.08E-07	3.08E-02	1.54E-07	-	-	-	-
Ingestion: Soil	-	-	-	-	<1.00E-25	<1.00E-25	<1.00E-25	<1.00E-25
Inhalation: Air	-	-	-	-	<1.00E-25	<1.00E-25	<1.00E-25	<1.00E-25

a. Surface water

Table H-12. MEPAS OUTPUT DATA FOR AGRICULTURAL CHEMICAL SITE SCENARIO.

LOCATION	EASTERN WASHINGTON	
ALTERNATIVE CONCENTRATIONS USED	BACKGROUND	TECHNOLOGY
RECEPTOR	SW (a)	SW (a)
ARSENIC		
Max. Concentration at Water Pump (ug/L)	1.00E+00	5.00E+01
At Time: (years)	0.0	0.0
Risk (carcinogenic)		
Leafy Vegetables	1.40E-05	7.00E-04
Other Vegetables	8.91E-06	4.00E-04
Meat	1.48E-06	7.38E-05
Milk	2.09E-05	1.05E-03
DDT		
Max. Concentration at Water Pump (ug/L)	2.00E-02	1.00E+00
At Time: (years)	0.0	0.0
Risk (carcinogenic)		
Leafy Vegetables	6.40E-08	3.20E-06
Other Vegetables	4.06E-08	2.03E-06
Meat	1.27E-07	6.33E-06
Milk	3.40E-07	1.70E-05
GAMMA-HCCH (LINDANE)		
Max. Concentration at Water Pump (ug/L)	2.00E-01	1.00E-06
At Time: (years)	0.0	0.0
Risk (carcinogenic)		
Leafy Vegetables	6.24E-09	3.12E-08
Other Vegetables	3.96E-09	1.98E-08
Meat	7.26E-09	3.63E-08
Milk	7.77E-09	3.89E-08

Results from the ground water, surface water, overland flow, and atmospheric transport pathways were used in the various exposure assessments to calculate risk values for each contaminant. The exposure assessments considered potential exposure of the surrounding population through ingestion of contaminated drinking water, soil, crops, meat, milk, fish, and shellfish; dermal contact with chemicals through showering and swimming; and inhalation of airborne contaminants.

Based on contaminant levels in affected media, MEPAS calculated the average daily human exposure to each contaminant. The risks from chemical carcinogens are expressed as a lifetime probability of getting cancer, based on cancer potency factors derived by EPA (1982). For noncarcinogens, risks are expressed as the ratio of the dose received to the reference dose. Risks were calculated based on an exposure of 70-year increments (approximately one human life span) by averaging the exposures received during the lifetime.

In general, results from the modeling indicated that site variation due to soil type and climate affected the level of risk associated with the contaminant and the amount of time before the contaminant reached the receptor. Soils with lower permeability (high in silts and clays) restricted the horizontal movement of the contaminants; therefore, contaminants reached the receptor after a greater number of years. The concentration at the source was also higher in the soils with low permeability because contaminants infiltrated the ground water faster than they were carried away by the ground water. This caused the contaminants to pool under the site, raising the concentrations at the source and, ultimately, at the receptor.

The effect that differences in climate have on contaminant concentrations and on risks at the receptors was also examined. Climatological regimes for western and eastern Washington were compared for sites with identical soil types (sandy loam) using the landfill and leaking underground storage tank scenarios. In the site scenarios for the drier Spokane climate, results showed lower concentrations at the receptor and longer times for contaminants to reach the receptor. These differences are attributable to both lower rainfall and greater depth to ground water.

The following sections describe the results of modeling each of the five site scenarios.

Landfill

Results from the modeling were examined with respect to differences between the four alternative concentrations (for example, background, risk-based, ARAR, and technology-based), the differences in soil type (Puget Sound 1, 2, and 3), and differences in climate (Puget Sound vs. Spokane). The MEPAS model treats all three contaminants under this scenario as carcinogens. EPA currently considers 1,1,1-trichloroethane a noncarcinogen. Therefore, the model results for 1,1,1-trichloroethane may predict higher risks than would actually be caused by this contaminant.

Maximum Concentration at the Source—To determine whether the alternative concentrations in soil would cause ground water impacts, the maximum concentrations of contaminants in ground water under the source were compared to drinking water MCLs (200 μg/L, 5 μg/L, and 5 μg/L for 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene, respectively). Based on this comparison, all the alternative concentrations resulted in MCLs being exceeded in ground water, except the background and technology-based concentrations for tetrachloroethene. The risk and ARAR alternative concentrations exceeded the MCL for surface water for all three contaminants. Background and technology-based concentrations did not exceed the MCL for surface water.

When these concentrations were developed, protection of other media had not yet been considered in development of the alternatives for setting soil standards. These data show that soil standards for volatile organic contaminants, when set based on risk or ARARs in soil alone, are not protective of ground water uses. The current draft of the regulations takes into account ground water protection by requiring that the soil standard be no higher than 100 times the MCL. These modeling results show that such standards would not exceed the MCL in ground water for these contaminants.

Maximum Concentration at the Receptor—The maximum concentrations at the ground water well were compared to the MCLs for 1,1,1-trichloroethane, tetrachloroethene, and trichloroethene. Based on this comparison, all the alternative concentrations exceeded the MCL in ground water, except for the background alternative concentration. The risk-based concentration exceeded the MCL in surface water for 1,1,1-trichloroethane and trichloroethene. The ARAR alternative concentrations for tetrachloroethene and trichloroethene also exceeded the MCL at the surface water receptor. Both background and technology-based alternative concentrations met the MCLs for surface water. Again, these exceedances of MCLs would be avoided if protection of ground water were taken into account (as they are in the draft regulations) when the soil standards are set.

Time for Maximum Concentration to Reach Receptor—The time it takes for the maximum concentration of the contaminant to reach the receptor increases in the following order: Puget Sound 1, Spokane, Puget Sound 2, and Puget Sound 3. At Puget Sound 1, the time is less than 50 years for all contaminants; at Spokane, the time ranges from 100 to 200 years; and at Puget Sound 2 and 3, the time ranges from 500 to more than 7,000 years (MEPAS does not go beyond 7,000 years). The difference between the time it takes for contaminants to arrive at Puget Sound receptors and at Spokane receptors is attributable to differences in amount of rainfall and the greater depth of the saturated zone near Spokane. The differences observed between Puget Sound 1, 2, and 3 are due to the differences in soil type and hydrogeologic properties; more restrictive soil types result in longer times to maximum concentration.

Human Health Risks—The risks associated with the risk-based, ARAR, and technology-based concentrations for ground water use (drinking and showering) were found to be greater than $1x10^{-6}$ for all of the contaminants at every location. Only the background alternative concentrations had risks of less than $1x10^{-5}$. At Puget Sound 3, the risks appear artificially low because the maximum concentration at the receptor was not reached in 7,000 years.

These human health risks are again related to soil standards that are not designed to be protective of ground water. The draft regulations are expected to reduce, but not entirely eliminate, these risks. These modeling results indicate that soil standards based on drinking water MCLs may not be entirely protective of all human health risks from exposure to contaminated ground water, particularly when volatile contaminants are present that may enter household air. Even at such high concentrations, the risks associated with recreational use of surface water were all estimated at less than $1x10^{-5}$ and all but one were less than $1x10^{-6}$.

Leaking Underground Storage Tanks

Alternative concentrations for benzene, toluene, and xylene were modeled. Benzene, toluene, and xylene are constituents of gasoline and, as a result, are commonly found at sites with leaking underground storage tanks. Benzene is a carcinogen, and xylene and toluene are noncarcinogens. The same four locations and soil types were used for this scenario as were used for the landfill scenario.

Maximum Concentrations—The maximum concentrations at the source and at the receptor exceeded MCLs for the risk-based and ARAR alternative concentrations. Again, these concentrations did not consider protection of ground water. The background and technology-based concentrations did not exceed MCLs in ground water at the source or at the receptor. It is anticipated that the proposed regulations would not exceed MCLs, because they take into account protection of ground water.

Time for Maximum Concentration to Reach Receptor—The maximum concentration of all contaminants at Puget Sound 1 reached the receptor within 15 years. At Spokane, the time to maximum concentration was 50-150 years. At Puget Sound 2 and 3, the time to receptor was between 450 and 7,000 (or more) years. Again, these variations are due to soil type, depth to ground water, and meteorological differences. This scenario, together with the landfill scenario, suggests that only soils with a similar or greater hydraulic conductivity than sandy loam would allow migration of contaminants to occur within a foreseeable time period. In addition, the contaminants included in these two site scenarios are among the most mobile of contaminants. Many other contaminants would be more highly retarded in the soil.

Human Health Risks—Human health risks are based on ground water use for drinking water and showering. Modeling results for this scenario suggest that such risks are negligible for noncarcinogens such as toluene and xylene. Even though drinking water MCLs are exceeded for these contaminants, the MCLs are secondary MCLs based on taste and odor and do not directly relate to human health. Risk-based and ARAR concentrations for benzene, on the other hand, carried risk in the range of $1x10^{-6}$ to $1x10^{-4}$. These soil concentrations were not intended to be protective of ground water. It is expected that the proposed regulations would not have resulted in risks under this scenario.

Metal Plating Facility

The metal plating facility addressed copper, chromium, and zinc moving overland and through ground water to a river. None of these metals is considered carcinogenic when ingested orally.

Maximum Concentrations in Ground Water—Based on the modeling results, all of the alternative concentrations for soil (including background concentrations) resulted in exceedances of the MCLs in ground water under the metal plating facility. These results may be somewhat misleading, as the model assumes that all of the metals are in a more soluble form than naturally occur in soils. Therefore, natural metals in soils at these concentrations would probably not cause MCLs to be exceeded in ground water because the metals would be in a more insoluble form.

Maximum Concentrations in the River—All the concentrations of metals in the river were below both water quality criteria for the protection of aquatic life and below MCLs. Maximum concentrations in the river were not reached until over 400 years had passed.

Human and Ecological Health Risks—Human health risks from eating fish in the river were all below $1x10^{-9}$. These risks are considered negligible. In addition, no drinking water MCLs were violated in the river. If a ground water well were placed directly under the site, some health risk from metals contamination might be expected. All of the metals concentrations are well below water quality criteria, suggesting that no adverse health effects to aquatic life would be predicted.

Wood Treatment Facility

This site scenario addressed risks in air and in marine water from 2,3,7,8-TCDD, pentachlorophenol, and phenanthrene. All of these contaminants are currently considered carcinogens by EPA (the slope factor for pentachlorophenol is under development). However, MEPAS considered pentachlorophenol a noncarcinogen, possibly resulting in an underestimate of risks from this contaminant.

Maximum Concentrations in Surface Water—Concentrations in the marine bay near the site from surface water runoff occasionally exceeded water quality criteria for the protection of marine aquatic life. The technology-based concentration for 2,3,7,8-TCDD exceeded the water quality criterion, as did the ARAR for phenanthrene. Based on these results, the proposed regulations would not have exceeded the water quality criteria under this scenario.

Human and Ecological Health Risks—Human health risks from contamination of air from all alternative concentrations were negligible. Air contamination was assumed to be caused by soil contamination at the site. Much higher human health risks were caused by ingestion of fish and shellfish contaminated with 2,3,7,8-TCDD and phenanthrene. The risk-based and technology-based concentrations came closest to being protective; the ARAR alternative is the least protective. It is anticipated that the proposed regulations would also have resulted in human health risks under this scenario. Because water quality criteria were exceeded by some alternatives, some risk to aquatic life from the ARAR and technology-based alternatives would be expected.

Agricultural Chemical Contamination

The agricultural chemical scenario addressed the risk from contamination of a river by agricultural contaminants such as DDT, Lindane, and arsenic. These contaminants are all considered carcinogens.

Maximum Concentrations in the River—The river was assumed to be uniformly contaminated up to the cleanup standard; therefore, the maximum concentration in the river is equal to the cleanup standard at the beginning of modeling. It was also assumed that the water is not treated before use.

Human Health Risk—Risk from eating vegetables and beef and from drinking milk that were produced in areas using contaminated water for irrigation or livestock watering was addressed. The risks from arsenic were higher than $1\text{x}10^{-6}$, even at background concentrations. This result illustrates the controversy surrounding cleanup standards for arsenic in an area with naturally high background arsenic concentrations. However, background concentrations resulted in risks below $1\text{x}10^{-4}$, while other alternative concentrations exceeded this range. No risks from Lindane at any of the alternative concentrations were predicted. Risks from DDT were borderline for the technology-based alternative and low for other alternatives.

Summary

These modeling results suggest several general conclusions:

- Soil standards based on risk or ARARs for soil alone will not be protective of ground water in many cases
- Soil types and climate have a large impact on risks and on time required for contaminants to reach the receptor
- The differences among the alternative concentrations are generally less important than other factors, although the ARAR and technology-based alternatives may be less protective in certain situations
- On a site-specific basis, risks from ingestion of fish, shellfish, and backyard crops could be important.

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APPENDIX I

Remedial Technologies

REMOVAL OF VOLATILE ORGANIC COMPOUNDS FROM GROUND AND SURFACE WATERS

Volatile organic compounds (VOCs) of interest consist of simple aromatics (benzene, toluene, ethyl benzene and xylene or BTEX) and chlorinated hydrocarbons (1,1,1 trichloroethane, trichloroethene, tetrachloroethene, dichloromethane, and vinyl chloride). While some of these chemicals are susceptible to biodegradation, they are not uniformly so and can inhibit biological activity if present in high concentrations. Under certain circumstances, degradation of these chemicals can lead to the production of toxic by-products. For example, in anaerobic environments, trichloroethylene will degrade first to dichloroethene and then to vinyl chloride.

In general, three modes of treatment are applied to ground or surface waters containing VOCs: 1) Air stripping; 2) Granular activated carbon (GAC); and 3) Ultraviolet catalyzed oxidation with ozone or peroxide (UV-ozone or UV-peroxide). The most commonly applied process is air stripping. Air stripping takes advantage of the relatively high vapor pressure and low solubility of VOCs to remove them from water in the vapor phase. Contaminated water is input in the top of a tower packed with media that provides extensive surface area. Air is pumped into the bottom of the tower. As the air rises through the media, VOCs volatilize and are carried out into the atmosphere. Properly designed air stripping units with a sufficient detention time can remove VOCs down to a concentration of 0.5 ppb in fresh water and 1.0 ppb in saline waters. This level of removal is adequate to meet virtually all of the proposed clean up standards. Most VOCs readily photolyze in sunlight. As a consequence, the vapor emissions can be released without adverse effects. However, in areas with other sources of VOCs or pristine areas, there may be requirements to prevent releases of large quantities of VOCs. Current EPA policy limits emissions of VOCs from site treatment to 15 lbs/day or less. Local air districts may impose even stricter constraints. As a consequence, air stripper exhaust may have to be fitted with controls such as activated carbon adsorption columns or catalytic burners. Emission controls add significantly to the cost of air stripping.

GAC treatment uses the affinity of VOCs for organic surfaces and their low water solubility to extract the chemicals from wastewaters. The GAC media is placed in large, packed columns through which the wastewater is pumped. As the water contacts the carbon, VOCs are adsorbed to active sites. Removal efficiencies are a direct function of the solubility of the VOC and its concentration in the wastewater. More soluble chemicals and more concentrated wastewaters exhaust the capacity of the carbon more rapidly. GAC treatment is often applied in a two column configuration. The lead column removes the bulk of the contaminants while the second column acts as a polishing unit. When breakthrough is detected (i.e., when VOCs are detected in the effluent) the first column is charged with new carbon or regenerated and the second column is put in the lead position. This pattern of use maximizes the amount of VOCs removed per mass of GAC employed. GAC is capable of reducing VOC concentrations to the ppb range. This is adequate to meet any of the proposed clean up standards. It is more costly than simple air stripping, but can be competitive if extensive emission controls are required for the stripper unit.

UV-ozone or UV-peroxide processes degrade organic contaminants including VOCs. A bank of ultraviolet lamps is employed to supply ultraviolet energy to the contaminants. In their energized state, the contaminants have bonds broken which are quickly oxidized by the ozone or peroxides introduced in the liquid stream. The degree of oxidation achieved is a function of how long the wastewater is exposed (detention time) and the intensity of the UV source. Theoretically, any organic can ultimately be converted to CO_2 if treated for a sufficient period of time. Obviously, costs increase with the detention time and energy requirements. UV-ozone/UV-peroxide are generally more expensive than simple air stripping, but can be less expensive when emission controls are required on the air stripper. Effluent concentrations vary with the process design, but are most likely in the ppb range. This level of treatment is adequate to meet any of the proposed standards.

Each of the three approaches offer advantages and each has weaknesses. Air stripping is inexpensive, simple to operate, and reliable, but it transfers contamination from the water to air. If the VOCs are highly concentrated, adverse impacts can be expected unless emission controls are implemented. Air stripping is most effective for VOCs with Henry's Law constants greater than 0.003 (dimensionless constants >0.01). Therefore, the presence of semivolatile contaminants necessitates use of additional treatment processes. Furthermore, the presence of high total dissolved solids can lead to scaling of the stripping media which reduces stripping efficiency and may produce product water of an unacceptable quality.

GAC is more versatile than air stripping in that it is effective for a wide range of both volatile and semivolatile organic chemicals. GAC transfers the water problem to a solid waste issue by putting the contamination in a solid carbon matrix. If thermal regeneration is employed, the contaminants will be destroyed. If the carbon is buried, the chemicals remain toxic. GAC is sensitive to salinity only to the degree that the salts present effect the solubility of the contaminants of interest. If the wastewater contains undissolved solids, filtration may be required in advance of the GAC columns. GAC in generally reliable as long as effluents are properly monitored for breakthrough.

UV-ozone/peroxide is the most versatile of the three processes in that it can treat any organic contaminants. To be effective, however, the wastewater must allow light penetration. Therefore, color agents and turbidity will hamper treatment efficiencies. There is some concern that UV-ozone/peroxide may produce toxic by-products if it is not taken to completion. As the newer of the three processes, it is the least well characterized and is generally not recommended because of uncertainty over effluent quality. UV-ozone/peroxide may be the least reliable of the three processes because of its sophisticated nature, sensitivity to the water's light transmission properties and concerns over producing low levels of toxic by-products.

Given the above considerations, air stripping remains the most likely treatment process to be applied for the removal of VOCs from ground and surface waters. If emission controls are required, carbon adsorption units are likely to be put on the exhaust stream. If nonvolatile, low solubility organic contaminants are also present, GAC will likely be selected. UV-ozone/

peroxide is not a likely choice unless highly soluble organic contaminants like acetone are also present or if the water chemistry is such that GAC is found to have a very low capacity for the target chemicals.

REMOVAL OF PESTICIDES FROM GROUND AND SURFACE WATERS

Pesticides for which standards are to be developed include a large complex chlorinated molecule and its degradation by-products (DDT or DDD and DDE) a chlorinated six carbon ring (hexachlorocyclohexane), and a volatile, brominated ethane (ethylene dibromide). The first two are relatively insoluble organic chemicals with an affinity for organic solvents. The third is volatile, but has a sufficient solubility to make it difficult to remove with air stripping.

Pesticides will most likely be removed from water by application of activated carbon. By design, pesticides interfere with the biochemistry of life forms. As such, they are often resistant to biodegradation. When removal does occur in biological processes, it can often be attributed to adsorption onto the organic solids. Hence, the cell matter is replacing the carbon particles in the activated carbon system. Pesticides may also be removed through ultra violet (UV) catalyzed oxidation with ozone or peroxide and through desalinization technology such as reverse osmosis.

Activated carbon may be applied as granules in a column arrangement (GAC) or as a powder in conjunction with biological treatment (e.g., PACT process). In the former case, removal is achieved strictly through physical-chemical adsorption on the surface of the carbon particle. The less soluble the pesticide, the more efficient its removal by carbon. Typical applications use two columns in series with the first taking the brunt of the load and the second acting as a polishing unit. When detectable levels of contaminate appear in the effluent from the second column, the first is regenerated and returned to service as the polishing unit while the unregenerated column is placed in the lead. Operating in this mode, treatment capabilities are generally limited to the detection threshold for the contaminant, approximately 0.5 to 1.0 ppb. This degree of removal will meet technology based standards and background or ARAR based standards for ground water, but not risk based standards or standards for surface or marine waters.

Powdered carbon systems can be operated as a purely physical-chemical process or in conjunction with a biological process. In the latter arrangement, the powdered carbon is added in slurry form as a reagent. By adsorbing toxic chemicals, it can protect the biological cultures so that they can metabolize the more soluble constituents in the wastewater. To the extent that some pesticides are biodegradable, an added level of removal is achievable above and beyond simple carbon systems. However, it is not clear that removals will be substantially better than those obtained in a two column GAC system for the pesticides of interest to the State of Washington.

Carbon systems, both GAC and powdered, are reliable, stable approaches to wastewater treatment. The presence of other contaminants is not disruptive when the systems are operated in an abiotic mode. Once treatment is effective, the contaminants have been transferred from a liquid waste to a solid waste. With GAC systems, the spent carbon may be disposed (landfill or incineration) or regenerated for reuse. It is technically feasible to reactivate powdered carbon also, but there are few commercial facilities equipped to accomplish regeneration. Therefore, powdered carbon is typically disposed.

UV-ozone or UV-peroxide are feasible alternatives for destroying organic chemicals in water. A bank of lamps is employed to put energy into the wastewater and the chemicals in the form of ultra violet light. This energy excites the molecules and causes bonds to rupture or weaken to attack by the oxidizing agent (ozone or peroxide). Ultimately, the chemical is completely converted to water, carbon dioxide and salts. The degree of treatment achievable is a function of the detention time and the amount of energy introduced through the lamps. UV-ozone/peroxide has been studied for many years but was always expensive. New designs have rendered the technology more cost competitive in recent years. A few installations have been built to treat pentachlorophenol wastes from wood preservation operations. Concerns over the production of toxic by-products (products of partial oxidation) linger. The technology should be stable to upsets since it can oxidize any organics that appear in the wastewater. However, color bodies or turbidity will dramatically decrease light penetration and must be pretreated to prevent declines in product quality. Current designs are likely to achieve effluent levels in the ppb range. This like GAC, will meet technology based standards and ARAR or background-based standards for groundwater only.

Desalination technology, and reverse osmosis in particular, can be very effective for concentrating pesticides into a much smaller volume of waste liquor. The resulting liquids still require treatment or disposal. Depending on the concentrations involved, the concentrated portion may be susceptible to wet oxidation or solvent extraction. Reverse osmosis is relatively stable for inorganic contaminants but may be susceptible to upset with certain organics. For instance, the presence of solvents can degrade the membrane and lead to leakage. Reverse osmosis is quite expensive and will not work well in saline water because of the much greater osmotic pressures involved.

Given all of the aforementioned factors, GAC is most likely to be applied for the removal of pesticides from ground and surface waters. It is the most stable of the candidate processes, it can handle a wide range of organic contaminates, it is a well known, readily available technology. GAC is less expensive than the proven alternatives and is available off-the-shelf. Units can be purchased or leased, and regeneration services can be contracted.

It should be noted that risk based standards for the pesticides of interest are lower than the stated effluent concentrations for GAC. In part, this situation reflects the constraints of analytical detection capabilities. Longer detention times can produce very clean effluents. However, from a practical standpoint, economic configurations will likely produce effluents in the range of 1.0 ppb of pesticides. Therefore, background and ARAR based standards for surface and marine waters, and all risk based standards are not likely to be met with current technology.

REMOVAL OF DIOXIN FROM GROUND AND SURFACE WATER

Dioxin is a chlorinated heterocyclic molecule of extremely low solubility with a strong affinity for organic solvents. When observed in wastewaters, dioxin is invariably associated with any particulate matter present. When released to the environment, dioxin has been found to be persistent, but can photolyze if associated with catalysts such as amines.

The most likely technology for removal of dioxins from water is granular activated carbon (GAC). Activated carbon has an extensive surface area with numerous sites for surface charges to hold chemicals through adsorption processes. The capacity for individual chemicals is determined in part by their solubility in water. The less soluble the chemical, the more strongly it will sorb on the carbon, and hence, the greater the carbon's capacity for removing the chemical from wastewaters. Removal can also be achieved with ultra violet (UV) ozone or peroxide oxidation or reverse osmosis.

Activated carbon can be applied in granular form (GAC) or in a powdered form (e.g., PACT). GAC consists of columns of carbon granules through which the wastewater is pumped. Typically, a treatment process is configured with two columns in series. The lead column removes the bulk of the contaminant, while the second column polishes the effluent. When chemicals are detected in the effluent from the polishing column, the lead column is regenerated or its carbon replaced and the flow directed to the polishing column as the new lead unit. This allows for a maximum loading rate on the carbon while keeping effluent concentrations very low. Carbon in the powdered form is usually applied in conjunction with biological treatment. While this can be an effective combination, facilities for powdered carbon regeneration are not readily available and the technology is not available off-the-shelf.

GAC is a very stable alternative since it can be effective on most organics and is not overly sensitive to the presence of other contaminants. It is capable of producing effluents with dioxin concentrations in the range of 0.5 to 1.0 ppb. This is well above the risk, ARAR and background based standards for dioxin (1 x 10^{-5} to 8 x 10^{-9} ppb). It meets the technology-based standards.

UV-ozone/peroxide utilizes the energy from ultra violet lights to disrupt bonds and oxygenate them with ozone or peroxide. Oxidation in this manner can conceivably take the effluent concentrations to deminimus levels. However, practically speaking, removal is limited to the limits of detection. The lower levels of treatment require longer periods of detention and greater power for the lamps. In a typical configuration that would be competitive with GAC, UV-ozone/peroxide is likely to produce effluent with 1 ppb dioxin. As such, the technology could meet only technology-based standards. UV-ozone/peroxide is not a standard technology at this time. It is sensitive to color bodies and turbidity, and it is suspect for potentially producing toxic by-products.

Reverse osmosis will remove dioxins along with other large molecules which are rejected as they approach the membrane under pressure. Empirical results indicate that effluent quality is likely to be on the order of 0.5 to 1.0 ppb. However, removal efficiency will decline with increases in total dissolved solids levels. As a consequence, treatment will be more costly, and less efficient in marine water. For fresh or marine waters, reverse osmosis will not meet risk, ARAR or background based standards.

GAC is the probable choice for treating ground and surface waters for dioxin removal. GAC is available off-the shelf, cost effective, not easily disrupted by fluctuations in contaminant levels, not likely to produce toxic by-products, and is a "trusted" technology. However, GAC is not capable of meeting risk, ARAR or background based standards in any kind of practical configuration. Theoretically, UV-ozone/peroxide is the technology with the most likelihood of achieving the extremely low risk based concentrations, but the desired levels are so far below normal analytical detection limits that no matter how the treatment plant is operated, it would be difficult to differentiate performance levels.

REMOVAL OF SEMIVOLATILES FROM GROUND AND SURFACE WATERS

Semivolatiles of interest include pentachlorophenol (PCP), polynuclear aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCBs). None of these compounds are highly soluble and all are strongly attracted to organic solvents. PCP is a chlorinated phenol that has been successfully biodegraded in acclimated cultures. PAHs are known to degrade in aerobic environments. PCBs have extremely long half-lives and for all practical purposes, do not degrade well.

For the most part, the semivolatiles share the same properties and amenability to treatment as the pesticides. Therefore, the reader is referred to that discussion with the following additions:

- Pentachlorophenol is one of the few contaminants that has been successfully treated with UV-ozone/peroxide. As such, UV-ozone/peroxide has fewer unanswered questions about the technology and potential toxic byproducts when applied to water contaminated solely with PCP.
- PAHs are biodegradable and can be reduced to levels comparable to GAC in biological treatment systems such as activated sludge, sequencing batch reactors, or rotating biological discs. Combined activated carbon-biological processes such as PACT would also be effective.
- PCBs' extremely low solubility make them similar to dioxins and therefore, particularly susceptible to GAC.

Given these considerations, semivolatiles can be removed from water at levels of 0.5 to 1.0 ppb. This will meet technology, ARAR and background based standards, but not risk based standards. Risk based standards are below typical detection limits and are not likely to be met with available technology short of extensive UV-ozone/peroxide run for long detention times or reverse osmosis run at very low yields. In either case, analytical difficulties would make it extremely hard to confirm attainment of the desired levels of treatment.

REMOVAL OF VOLATILE ORGANIC COMPOUNDS FROM SOIL

Volatile organic chemicals (VOCs) of concern include simple aromatics (benzene, toluene, ethyl benzene, and xylene-BTEX) and chlorinated short chain organic solvents. By definition, these chemicals have high vapor pressures. Most are relatively insoluble and therefore display high Henry's Law constants (>0.003), a fact which suggests that they can be readily stripped from soil water. These chemicals also display low order partition coefficients suggesting that soil concentrations will not be significantly higher than the concentration in associated pore water. It follows that these chemicals will be susceptible to air stripping from soil as they are from water. The VOCs can be biodegraded in aerated soils. BTEX are particularly susceptible with half-lives on the order of 50 to 75 days. The chlorinated species are more resistant to degradation and under anaerobic conditions can be dehalogenated until they form vinyl chloride. Hence, degradation of the chlorinated solvents can lead to a toxic endpoint.

The most likely means of removing VOCs from soil is soil vapor extraction (SVE). Removal can also be achieved through soil aeration and biological treatment. SVE is the most common approach taken because it can be performed in situ and, hence, provides significant cost advantages. A typical SVE design consists of a series of vertical pipes installed on a grid in the target soil column. Each pipe is screened at the depth where the VOCs have been encountered. The separation distance between the pipes will depend in part on the depth at which extraction is required. Since air can be drawn down from the surface, the radius of influence of an extraction pipe is generally limited to the depth from the soil surface to the screened area. The extraction pipes are connected through a header system to a vacuum pump which is used to maintain negative pressure in the system. Extracted vapors can be exhausted to the atmosphere where VOCs will disperse and photolyze, or they can be treated in an activated carbon column or a catalytic burner.

SVE systems are limited in effectiveness to volatile chemicals. As a consequence, the presence of any nonvolatile chemicals of concern will necessitate application of alternate or additional processes. For application to

VOCs, SVE effectiveness approaches low concentrations asymptotically. As a consequence, the process is very efficient during the initial phases, but loses efficiency as concentrations drop. Recent studies suggest that practical limits for SVE systems are in the range of 1 ppm residual VOCs. This is adequate to meet all but background based standards.

If emission controls are not applied, VOCs are released to the atmosphere. If controls are applied, the chemicals may be transferred to solid waste in the form of spent activated carbon or destroyed in a burner and released as hydrochloric acid vapor.

Aeration/biological treatment are usually achieved through a cultivation approach. The soil is excavated and managed like compost or disced and turned over in place to encourage vapor losses and access to oxygen. Nutrients and moisture may be added to maintain an atmosphere conducive to biological growth. Removal results from both the biological degradation and volatilization. This approach has been very common for addressing BTEX contamination from underground tank spills. More recent concerns over uncontrolled releases of vapor to the atmosphere have curtailed use. In some instances, tents are constructed over the soil area to capture vapors and route them to emission control devices. In either event, the approach involves movement and disruption of the soil surfaces.

As with SVE, aeration/biodegradation are limited to volatile, degradable chemicals. The presence of other contaminants necessitates use of alternative or additional processes. Removal levels are comparable to those for SVE if not a little better and therefore, will meet all proposed standards with the possible exception of those based on background.

In theory, solvent extraction or soil washing can be applied to remove VOCs from soil. Since the VOCs are often the solvents of choice, there is not real advantage to solvent extraction and washing agents are not as effective on these chemicals as their own volatile properties.

SVE is the approach of choice because of its proven capabilities, lower costs associated with in situ application, lack of disruption, and ability to control extracted vapors. SVE will meet all proposed standards except those based on background concentrations.

REMOVAL OF SEMIVOLATILES, PESTICIDES AND DIOXIN FROM SOILS

There are seven chemical groups of concern categorized as semivolatiles (pentachlorophenol-PCP, polynuclear aromatic hydrocarbons-PAHs, and polychlorinated biphenyls-PCBs), pesticides (DDT-DDD and DDE, hexachlorocyclohexane, and ethylene dibromide-EDB), and dioxins (tetrachloro-dibenzo-dioxins). All but EDB share common properties of low volatility, low solubility and high affinity for organic matter. EDB is much more volatile and more soluble. The nonvolatile compounds have a tendency to partition in soils at concentrations significantly higher than those in associated soil waters. Hence, contaminated soils show low leachability. Indeed, dissolved dioxin and PCBs are rarely detected in water associated with soil particles unless other chemicals are present to promote cosolvation. PCP and PAHs can biodegrade in soils, but PCBs, dioxins, hexachlorobenzene and EDB are quite resistant to biological attack. DDT metabolizes to DDD and DDE and, hence, remains toxic even after degradation.

Based on the properties of these chemicals, all but EDB are most likely removed from soil through incineration or soil washing. Polyethylene glycol salt dechlorination is also effective for the chlorinated species. EDB can be handled as a volatile. As such, the reader is referred to the discussion of removal of volatile organic compounds (VOCs) from soil. Based on the VOC analysis, soil vapor extraction (SVE) is the probable method of removal for EDB in soil. EDB has a dimensionless Henry's Law constant of 0.028, while SVE is affective for chemicals with a Henry's Law constant (dimensionless) in excess of 0.01. SVE will generally achieve removal down to 1 ppm or less. This is not sufficient to meet any but the technology based standards.

Incineration of soils consists of placing the contaminated soil in a thermal oxidation device to destroy the organic matter present. The incinerator itself may follow any of several designs which can handle soils including atmospheric fluidized bed (AFBC), rotary kiln, and infrared. Newer designs including molten salt beds and plasma arc may also be utilized. In a properly run incinerator capable of accepting soil, removals are on the order of 99.9999%. If starting concentrations are in the thousands of parts per million, this suggests residuals levels of 1 ppb. Lower starting concentrations would result in commensurate reductions in the residuals levels. These levels of removal would meet all of the proposed standards except risk and background based standards for dioxin. When chlorinated species are present, off-gases will contain hydrochloric acid and should be treated prior to release. When PCP and PCBs are burned, dioxin formation at low levels may occur in the exhaust gases.

Incineration is expensive and not efficient for low levels of contamination in that much of the cost is associated with heating and dewatering the inert soil mass. On the other hand, incineration is capable of addressing all organic constituents and, therefore, will be effective even when multiple contaminants are encountered. Incineration is difficult to implement because of public fears about emissions. The latter are most pronounced when volatile metals (e.g., lead and cadmium) or chlorinated aromatics are present. As a consequence, technical considerations may not be sufficient to dictate incineration as the removal option of choice.

Specialized chemical treatment is available for the chlorinated compounds such as PCBs and PCP. Application of polyethylene glycol salts to soil containing these chemicals results in dechlorination of the root compound. The nonchlorinated shell is then much more susceptible to biological degradation and disappears from the soil. Since the dechlorinated compound is generally much less toxic, its presence during the biological degradation phase is not of the same level of concern as it would be if the compound still carried its chlorine. Polyethylene glycol dechlorination is a proven technology that has been demonstrated with soil contamination. It is only effective on chlorinated organics and therefore, is not broadly applicable to situations with mixed contaminants. When applicable, the technology has been shown to remove contaminants to less than 60 ppb dioxin and <1 ppm PCBs. These concentrations are not sufficiently low to assure compliance with proposed standards with the exception of those for PCP.

Soil washing technology can be used to remove organics and subsequently treat or dispose of them in an aqueous form. The typical approach for soil washing involves use of surfactants in water to solubilize the chemicals of interest and physically separate them from the soil just as detergents are used to separate stains or dirt from clothing in the laundering process. The key to successful soil washing is to find a surfactant that will efficiently solubilize the chemicals of interest from the soil matrix. Newer technology has included such sophisticated reagents as supercritical fluids and organic solvents. Costs are higher in the former case, while the latter may leave solvent residuals that are problematic in their own right. In general, soil washing creates a liquid waste which subsequently must be managed. Past experience suggest residuals levels in the range of 10's of ppb. Such residual concentrations would be adequate for PAHs but not the other semivolatiles, pesticides or dioxins.

Biological treatment can be applied for PAHs and PCPs. In this application, nutrients, moisture and air would be introduced to the soil mass to encourage activity of extant biota. The chemicals of concern would be metabolized in the process. Removals are likely to take some time and will result in residues of 10 to 1,000 ppb. These removals meet the standards for PAH and PCP.

Based on the inability for most processes to meet the proposed standards for nonvolatile organics in soil, incineration is the probable remedy of choice for all pesticides, dioxin, and PCBs. Soil vapor extraction is attractive for EDB, but can only meet the technology based standards. Biological treatment would be preferred for PCP and PAHs.

REMOVAL OF METALS FROM GROUND AND SURFACE WATERS

Metals can be found in ground and surface waters as ionic species. In general, of the six metals of interest, four are found as positively charged cations (cadmium-Cd, copper-Cu, lead-Pb, and zinc-Zn), one is found as a negatively charged anion (arsenic-As), and one is amphoteric, i.e., can be present as a positively or negatively charged ion depending on conditions (chromium-Cr). For the most part, cationic species are easier to remove than anionic species. Therefore, it is often advantageous to convert amphoteric materials to their cationic form. Removal is also affected by chemical reactions with other ions or dissolved chemicals that can be complex or sequester metals in forms that resist removal. The latter property makes it very difficult to evaluate metals as a group. As a consequence, removal technologies are discussed here on a metal by metal basis.

Arsenic is generally found in waste waters in one of two valence states: arsenate-ASO_4^{-3} (pentavalent) and arsenite-ASO_2 (trivalent). Of these, the arsenate is more stable and easier to remove. The most common approach for arsenate removal is through coagulation with lime, ferric chloride or mixtures of these reagents. The arsenate does not form an insoluble salt, rather it adsorbs onto the hydrous oxide floc and/or coprecipitates with it. Under properly controlled conditions, arsenic can also be converted to a cation and precipitated as a sulfide. This treatment results in low residual levels. Effluent levels as low as 2 to 62 ppb can be reached depending on the starting concentration. Because of interferences, a probable expected residual level would be 50 ppb. Further polishing with activated carbon or ion exchange could approach 10 ppb effluent concentrations. However, the high salinity levels of marine water would interfere with these processes and raise effluent concentrations for coagulation to a level closer to 500 ppb. As a consequence, the ARAR and technology based ground water standards for arsenic can be achieved with coagulation as can the technology based standards for surface water and marine waters. All other proposed standards can not be achieved with any approach short of deionization through ion exchange. Such an approach would be extremely costly for marine waters because of the dissolved salt content.

Cadmium is generally found in ground and surface waters as the Cd^{+2} cation. The carbonate and hydroxide salts of cadmium have extremely low solubilities and often regulates the concentration of soluble cadmium to be found in water. Similarly, coagulants such as lime and carbon dioxide can be added to water to reduce cadmium levels through formation of these insoluble salts. As the hydroxide or carbonate levels rise, the residual dissolved cadmium is reduced. Hence, coagulation is an effective means of removal for cadmium. Residual cadmium levels of 5 ppb can be achieved. This is sufficiently low to meet all but the background based standards for ground water. It also meets the technology based standards for surface water. Polishing with ion exchange would be needed to go to the lower background based standard in ground water as well as all proposed surface water standards other than the technology based standard. All marine water standards except those based on technology are not readily achievable. The presence of the high levels of dissolved salts will rule out ion exchange polishing of the coagulation effluent.

Chromium can exist in a dissolved state as hexavalent anions (chromates or chromites) or as trivalent cations (Cr^{3+}) or anions ($Cr_2O_4^{-2}$). Solubility is most readily controlled for the trivalent form. Therefore, removal of chromium is often initiated by reducing the soluble chronic to the trivalent form. Reduction is often effected through addition of sodium metabisulfite. The solubility of trivalent chromium is thought to be controlled by the hydroxide salt and coprecipitation on iron oxides. Therefore, removal is achieved with lime, ferric chloride or mixtures of the two. Minimum solubility levels are achieved over a relatively narrow pH range. Under optimum conditions, effluent concentrations will be 10 to 15 ppb after reduction and coagulation of fresh waters. This is adequate to meet all ground and surface water standards except those for surface water based on background. Subsequent polishing with a deionization column could reach the latter standard. Coagulation processes alone may achieve the risk and ARAR based standards for ground water. In marine waters, the high levels of salt present are likely to reduce coagulation efficiency such that product water would have residual chromium levels closer to 100 to 150 ppb. This concentration would meet the technology based standard only. Since deionization would be prohibitive with marine waters, the other proposed standards for marine waters can not be met.

Copper is generally present in water as the divalent cation Cu^{+2}. Solubility is generally controlled by the formation of hydroxides although carbonate complexes can increase copper solubility at high levels of pH (pH >9). Copper is generally removed from water through the use of lime. It can also be scavenged with sulfides through the formation of very low solubility sulfide salts. Sulfide precipitation is less common than the use of lime because of the toxicity of hydrogen sulfide gas and the hazards attributed to sulfide salts. Coagulation of copper will generally result in effluent concentrations of 100 ppb. Further polishing with ion exchange could further reduce the concentration to the range of 10 ppb. The efficiency of coagulation is sufficient to meet technology, ARAR and risk based standards for ground water and technology based standards for surface water. Deionization polishing with ion exchange would be needed to meet background based standards for ground water and background, ARAR and risk based standards for surface waters. In marine waters, the concentrated salts present will interfere with coagulation processes resulting in effluent levels more on the order of 1 ppm. This level is not sufficient to meet any but the technology based standard. Deionization through ion exchange would be cost prohibitive because of the high salt concentrations. As a result, the nontechnology based standards for marine water are not achievable.

Lead is generally found in water as the divalent cation Pb^{+2}. Solubility of lead is controlled by phosphates when present, but more likely hydroxides and carbonates. Minimum solubility is observed in the neutral pH range with carbonate and hydroxide complexes resolubilizing the metal under alkaline conditions. Under properly controlled pH conditions, lime and carbon dioxide as well as ferric chloride can be used to precipitate lead. Sulfide is also very effective as are a number of proprietary reagents including potassium polysilicate. In general, these reagents can be used to reduce effluent concentrations to the range of 10 ppb. Ion exchange polishing may not improve on those levels short of complete deionization. In marine waters, interferences will increase residual lead levels to the 100 ppb range. As a consequence, only the technology based standards for lead can be achieved. All other standards are unattainable for fresh and marine waters.

Zinc is predominately found in water as the divalent cation Zn^{+2}. Hydroxide and carbonate salts appear to be the solubility controlling forms. As a consequence, lime or carbon dioxide can be used to remove zinc from water. Sulfide precipitation is also effective. Like copper, zinc removal with coagulation will leave residuals in the range of 100 ppb. This is sufficiently low to meet all but background based standards for ground and surface waters. The background based standards should be achievable with ion exchange polishing of coagulation effluent. Interference present in marine water are likely to damage treatment efficiency such that effluent levels would be closer to 1 ppm. This is too high to meet any but the technology based standard. Deionization is not economically achievable with marine waters, so other proposed standards for marine waters are not achievable.

To summarize, precipitation-coagulation processes can remove metals to a level that will achieve many of the proposed standards for fresh waters. Some standards could not be achieved without subsequent polishing with ion exchange. A few proposed standards are not achievable. Marine water standards are generally not achievable except for those that are technology based.

REMOVAL OF METALS FROM SOIL

Of the six metals for which standards in soil are being proposed (arsenic, cadmium, chromium, copper, lead and zinc), all but arsenic tend to be tightly held in soils. As a consequence, the five binding metals do not leach as readily and, therefore, pose a lower risk to ground water quality. At the same time, it is more difficult to remove these metals and, hence, more difficult to comply with cleanup standards based on total metals levels rather than leachable metals levels.

Clean-up options for soil containing heavy metals are relatively limited. In general, soils can be: 1) excavated and taken to secure disposal sites; 2) stabilized to prevent leaching and/or resuspension; 3) capped to exclude infiltration; or 4) treated with soil washing to remove the metals. Of these alternatives, only the fourth, soil washing, addresses criteria for total metal content by actually removing metal residuals. The other alternatives may curtail a specific pathway such as leachate generation and infiltration or direct ingestion by eliminating access or otherwise reducing transport. Hence, to the extent that total metal standards are to be employed, soil washing will be the alternative of choice.

Soil washing can be accomplished in situ or on soils that have been excavated. In the former case, site characterization data must be comprehensive to insure that pregnant liquors can be collected and treated. The washing itself may be accomplished with a range of working fluids starting with water and ending with very sophisticated solvents or surfactants. For metal removal, the most efficient washing agents are acids or complexing agents such as EDTA. Efficiencies of removal vary with the metal and the soil type. In general, soil washing contractors believe they can achieve the following residual levels:

Arsenic	50 ppm
Cadmium	10 ppm
Chromium	150 ppm
Copper	50 ppm
Lead	100 ppm
Zinc	50 ppm

Once the washing is complete, the pregnant liquors must be treated for removal. If acids were employed, the solution can be neutralized and the metals precipitated into a concentrated sludge. When complexants are employed, additional treatment may be required to break down the solubilizing agent or concentrate the liquors.

Soil washing is capable of meeting technology, ARAR and risk based standards for all metals except arsenic. Rick based standards for arsenic are too low for technology to meet. Similarly, technology can not achieve any of the background based standards.

SUMMARY

Based on technological and economic considerations, technologies likely to be employed for site clean up have been evaluated for each contaminant. When a technology can achieve the proposed standard, it is assigned to that chemical-standard combination. Summaries of all assignments for ground water, surface water, marine waters, and soil are provided in Tables 1 through 4. In a number of cases, no technology was identified that could routinely provide the level of removal required by a standard. Background and risk based standards are particularly difficult to achieve for pesticides and dioxin in fresh water, metals and semivolatiles in marine waters, and metals in soil. These categories have been designated "not achievable" at this time.

TABLE 1. Probable Technology Applied to Meet Proposed Standards in Ground Water

	Background	Risk	ARAR	Technology
Metals				
Arsenic	NA	NA	P-C	P-C
Cadmium	C-IE	P-C	P-C	P-C
Chromium	R-P-C	P-C	P-C	R-P-C
Copper	C-IE	P-C	P-C	P-C
Lead	C-IE	--	C-IE	P-C
Zinc	C-IE	P-C	P-C	P-C
Volatile Organic Compounds	AS	AS	AS	AS
Semivolatile Organic Compounds				
Pentachlorophenol	GAC	--	GAC	GAC
PAH Compounds	GAC	NA	--	GAC
PCB Mixtures	GAC	NA	GAC	GAC
Pesticides				
DDT, DDD, DDE	NA	NA	NA	GAC
Hexachlorocyclohexane	NA	NA	NA	GAC
Ethylene Dibromide	NA	NA	NA	GAC
Dioxins				
2,3,7,8-TCDD	NA	NA	--	GAC

NA = Not Achievable
P = Precipitation
C = Coagulation
IE = Ion Exchange
R = Reduction
AS = Air Stripping
GAC = Granular Activated Carbon

TABLE 2. Probable Technology Applied to Meet Proposed Standards in Surface Water

	Background	Risk	ARAR	Technology
Metals				
Arsenic	NA	NA	NA	P-C
Cadmium	NA	NA	NA	P-C
Chromium	NA	R-C	R-C	R-P-C
Copper	NA	C-IE	C-IE	P-C
Lead	NA	NA	NA	P-C
Zinc	C-IE	P-C	P-C	P-C
Volatile Organic Compounds	AS	AS	AS	AS
Semivolatile Organic Compounds				
Pentachlorophenol	GAC	GAC	GAC	GAC
PAH Compounds	GAC	NA	NA	GAC
PCB Mixtures	GAC	NA	NA	GAC
Pesticides				
DDT, DDD, DDE	NA	NA	NA	GAC
Hexachlorocyclohexane	NA	NA	NA	GAC
Ethylene Dibromide	NA	NA	NA	GAC
Dioxins				
2,3,7,8-TCDD	NA	NA	--	GAC

NA = Not Achievable
P = Precipitation
C = Coagulation
IE = Ion Exchange
R = Reduction
AS = Air Stripping
GAC = Granular Activated Carbon

TABLE 3. Probable Technology Applied to Meet Proposed Standards in Marine Water

	Background	Risk	ARAR	Technology
Metals				
Arsenic	NA	NA	NA	P-C
Cadmium	NA	NA	NA	P-C
Chromium	NA	NA	NA	R-P-C
Copper	NA	NA	NA	P-C
Lead	NA	NA	NA	P-C
Zinc	NA	NA	NA	P-C
Volatile Organic Compounds	AS	AS	AS	AS
Semivolatile Organic Compounds				
Pentachlorophenol	GAC	GAC	GAC	GAC
PAH Compounds	NA	NA	NA	GAC
PCB Mixtures	--	--	--	--
Pesticides				
DDT, DDD, DDE	NA	NA	NA	GAC
Hexachlorocyclohexane	--	--	--	--
Ethylene Dibromide	NA	--	--	GAC
Dioxins				
2,3,7,8-TCDD	NA	NA	NA	GAC

NA = Not Achievable
P = Precipitation
C = Coagulation
IE = Ion Exchange
R = Reduction
AS = Air Stripping
GAC = Granular Activated Carbon

TABLE 4. Probable Technology Applied to Meet Proposed Standards in Soil

	Background	Risk	ARAR	Technology
Metals				
Arsenic	NA	NA	SW	SW
Cadmium	NA	SW	SW	SW
Chromium	NA	SW	SW	SW
Copper	NA	SW	SW	SW
Lead	NA	SW	SW	SW
Zinc	NA	SW	SW	SW
Volatile Organic Compounds	SVE	SVE	SVE	SVE
Semivolatile Organic Compounds				
Pentachlorophenol	B	B	B	B
PAH Compounds	B	B	B	B
PCB Mixtures	I	I	I	I
Pesticides				
DDT, DDD, DDE	I	I	I	I
Hexachlorocyclohexane	I	I	I	I
Ethylene Dibromide	I	I	I	SVE
Dioxins				
2,3,7,8-TCDD	NA	NA	--	NA

NA = Not Achievable
P = Precipitation
C = Coagulation
IE = Ion Exchange
R = Reduction
SVE = Soil Vapor Extraction
B = Biological Treatment
I = Incineration
SW = Soil Washing

APPENDIX J

Distribution List

Distribution List

Federal Agencies

U.S. Environmental Protection Agency Region 10 - Leigh Woodruff, Judy Schwarz, and Ron Lee
Agency for Toxic Substances and Disease Registry - Joel Mulder

State Agencies

Attorney General's Office - Jay Manning
Department of Community Development
Department of Health - Don Oliver, Don Peterson
Department of Corrections - Marc Horton
Department of Ecology - SEPA Review Section, Central Regional Office, Eastern Regional Office, Northwest Regional Office, and Southwest Regional Office
Department of Fisheries - Allen Clark, and Hal Michael
Department of General Administration - Clint Lougheed
Department of Natural Resources - Phil Clark, and Nancy Sprague, Washington Natural Heritage Program
Department of Transportation - Stephan Dobratz
Department of Wildlife - Tom Owens
Parks and Recreation Commission - Mike Swigert

Tribal Governments

Squaxin Tribe - Jeff Dickison
Muckleshoot Tribe - Morgan Bradley
Puyallup Tribe - Bill Sullivan

Legislature

House of Representatives Energy and Utilities Committee - Harry Reinert
Senate Environment and Natural Resources Committee - Gary Wilburn

Department of Ecology Science Advisory Board

Dr. Dave Eaton
Dr. Henry Landau
Dr. KNona Liddell
Dr. Frieda Taub
Dr. Don Wood
Dr. Tom Sibley

County Planning Departments

Adams County Building and Planning Department - Ed Preuschoff
Asotin County Planning Commission - Don Brogham
Benton County Planning Department - Terry Mardin
Chelan County Planning Department - Edward Loidhamer
Clallam County Department of Community Development - Jim Falk
Clark County Planning and Code Administration - Glen Gross
Columbia County Planning Department - Kim Lyonnais
Cowlitz County Department of Community Development - Sarah Deatherage
Douglas County Planning Commission - Jerry Litt
Ferry County Planning Department - Buck Wilhite
Franklin County Planning Department - Robert Booth
Garfield County Board of County Commissioners
Grant County Planning Department - Billie Sumrall
Grays Harbor County Planning and Building Department - Bob Witzel
Island County Planning Department - Larry Kwarsick
Jefferson County Planning and Building Department - David Goldsmith
King County Planning and Community Development - Joe Nagel
Kitsap County Department of Community Development - Ron Perkerewitz
Kittitas County Planning Department - Thomas Pickerel
Klickitat County Planning Department - Stephen Andersen
Lewis County Planning Department - Michail Zengel
Lincoln County Planning Department - Terry Goodman
Mason County General Services Department - Mike Bryne
Okanogan County Planning Department - Dan Powers
Pacific County Planning Department
Pend Oreille County Planning Department - Paul Wilson
Pierce County Department of Planning and Development - Sally Sharrard
San Juan County Planning Department - Paul Wilson
Skagit County Planning Department - Robert Lee
Snohomish County Department of Planning and Community Development - Greg Williams
Spokane County Planning Development - Wallis Hubbard
Steven County Planning and Emergency Development - Richard Nourse
Thurston County Regional Planning - Neil Aaland
Wahkiakum County
Walla Walla County Planning Department - Bill Trimm
Whitman County Planning Council - Buz Dammarell
Yakima County Planning Commission - Richard Anderwald

Cleanup Standards Work Group Members and Interested Citizens

AEQUUS - Randy Ray
Association of Cities - Dennis Hein, Spokane
Association of Counties - Randy Scott
Association of Washington Business - Roger van Gohren, Dan Syrdal (Heller, Ehrman) and Lynda Brothers (Heller, Ehrman)
Boeing - Kris Hendrickson
CH2M Hill - Steve Trudell
Independent Business Association - Gary Smith
King County Solid Waste Division - Debra Lambert
Landau Associates - Julie Wilson
League of Women Voters - Nancy Pearson
Northwest Pulp and Paper - Chris Holm
Puget Sound Alliance - Vim Wright
Sierra Club - Bruce Wishart
Washington Environmental Council - Elizabeth Tabbutt
Washington Public Ports Association - Eric Johnson
Western States Petroleum Association - Gary Goodman

Libraries - Government Publications Section

State Library
Seattle Public Library
University of Washington Library
King County Library
Everett Public Library
Western Washington University Wilson Library
Tacoma Public Library
Central Washington Library
Eastern Washington Library
Washington State University - Holland Library and Science Library
Gonzaga Main Library
Mount Vernon Library