

Fre-780

Florida Department of  
**Environmental Protection**

**Memorandum**

TO: District Directors  
Waste Program Administrators

FROM: John M. Ruddell, Director JMR  
Division of Waste Management

DATE: September 29, 1995

SUBJECT: Soil Cleanup Goals for Florida

Attached, please find the soil cleanup goals that should be used when making cleanup decisions. These cleanup goals were developed by Dr. Stephen M. Roberts (UF toxicologist under contract to FDEP). The health-based cleanup goals (residential and industrial) are based on human toxicity using generalized exposure assumptions and are applicable to the upper two feet of soil. If the industrial scenario is warranted, the site should have a deed restriction for the more restrictive land use. If there is ground water contamination above Florida standards and minimum criteria or if there was a recent discharge, the leachability-based cleanup goals should also be considered using the applicable direct contact scenario (residential and industrial). The lowest of the two should be the final cleanup goal for the upper two feet of soil. For soil below two feet, the leachability-based goal should be applied if the parameters of concern are detected above the Florida criteria. In addition, until further notice and where appropriate, the metals should pass TCLP as an indication not only that the soil is not a hazardous waste, but also that the soil will not act as a source of groundwater contamination.

If any of the levels is below site-specific background or the QA acceptable Method Detection Limit (MDL), any of the latter two will suffice.

Site-specific soil characteristics such as porosity, carbon content, moisture content, and dry bulk density are needed to refine acceptable soil concentrations based on site-specific parameters.

If you have any questions, please call Ligia Mora-Applegate at SC 278-3935.

JMR/lm-a

Attachment

cc: Doug Jones  
Bill Hinkley  
Jim Crane  
Satish Kastury

TECHNICAL REVIEW SECTION

Based on Direct Exposure and Migration to Groundwater

September 27, 1995

The appended Table 1 contains acceptable soil concentrations for over 200 chemicals commonly found as contaminants at sites in Florida. Soil cleanup goal concentrations based on direct exposure have been calculated using exposure assumptions consistent with both residential and commercial/industrial land use, and are presented in Table 1. For situations in which there is evidence that soil may be serving as a source of contamination for groundwater, soil cleanup goal concentrations for organic chemicals based on leaching from soil to groundwater are also provided in this table.

For evaluation of direct exposure to contaminants in soils, intake from incidental ingestion, dermal contact, and inhalation is considered. Soil concentrations are calculated using the following equation:

$$C_s = \frac{TR \times BW \times AT}{EF \times ED \times FC \times [A + B + C]}$$

When calculating soil concentrations based on potential carcinogenicity:

- the ingestion component,  $A = (SF_o \times IR_o \times 10^{-6} \text{ kg / mg})$
- the dermal component,  $B = (SF_d \times SA \times AF \times DA \times 10^{-6} \text{ kg / mg})$
- and the inhalation component,  $C = \left( SF_i \times IR_i \times \left( \frac{1}{VF} + \frac{1}{PEF} \right) \right)$

When calculating soil concentrations based on potential non-cancer health effects:

- the ingestion component,  $A = \left( \frac{1}{RfD_o} \times IR_o \times 10^{-6} \text{ kg / mg} \right)$
- the dermal component,  $B = \left( \frac{1}{RfD_d} \times SA \times AF \times DA \times 10^{-6} \text{ kg / mg} \right)$
- and the inhalation component,  $C = \left( \frac{1}{RfD_i} \times IR_i \times \left( \frac{1}{VF} + \frac{1}{PEF} \right) \right)$

The equation variables and assumptions are summarized in Table 2. For most chemicals in Table 1, toxicity criteria (reference doses and slope factors) can be taken from IRIS (Integrated Risk Information System, USEPA). When toxicity criteria are unavailable from IRIS, other sources (e.g. HEAST, ECAO, OPP, and the toxicological literature) were used. Intake from all

routes should be assumed to contribute to toxic endpoints that are systemic in nature. For toxic endpoints that are route-specific (e.g. carcinogenicity from inhalation of hexavalent chromium), only the relevant intake pathway is included in the calculation of the soil cleanup goal. Dermal toxicity criteria were derived using route-to-route extrapolation from available criteria for other routes; for some chemicals, inhalation toxicity criteria can also be derived using this method. For carcinogens, soil cleanup goal concentrations should be calculated for both carcinogenic and non-carcinogenic health effects. Only the lower of the two value is shown in Table 1. These values are intended to be applicable only to soil contamination within 2 feet of land surface.

For leaching of organic contaminants from soil to groundwater, the following equation was used to calculate a soil cleanup goal:

$$C_s = C_w \left[ K_d + \frac{(\theta_w + \theta_a H')}{\rho_b} \right]$$

The variables and assumed values are summarized below:

Variable	Definition	Assumed Value
C <sub>w</sub>	target soil leachate concentration (mg/L)	chemical-specific
K <sub>d</sub>	soil-water partition coefficient (cm <sup>3</sup> /g)	K <sub>oc</sub> x f <sub>oc</sub> (organics)
q <sub>w</sub>	water-filled soil porosity (L <sub>water</sub> /L <sub>soil</sub> )	0.3
q <sub>a</sub>	air-filled soil porosity (L <sub>air</sub> /L <sub>soil</sub> )	0.13
ρ <sub>b</sub>	dry soil bulk density (kg/L)	1.5
K <sub>oc</sub>	organic carbon partition coefficient (cm <sup>3</sup> /g)	chemical-specific
f <sub>oc</sub>	organic carbon content of soil (g/g)	0.002 (0.2%)
H'	dimensionless Henry's Law constant	chemical-specific

Soil concentrations based on partitioning to groundwater are not calculated in the same way for inorganics, and for some organic chemicals the necessary physical-chemical characteristics may be unavailable. Soil cleanup goals for this latter group of chemicals may become available in future updates.

Some risk-based values presented in Table 1 may be less than natural background concentrations for the chemicals in the soils. In such cases, the background concentration would represent a reasonable cleanup goal. Similarly, if the risk based value is less than the Method of Detection Limit (MDL), the MDL would become the operational cleanup goal for practical reasons.

The values in Table 1 were calculated using generic assumptions regarding exposure and soil characteristics and are intended to be broadly applicable to sites in Florida. In some situations it may be desirable to utilize site-specific assumptions in the development of cleanup goals for contaminants in soils. For example, site-specific soil characteristics might be used to refine estimates of acceptable soil concentrations based on both direct contact and leachability. The use of more limited exposure assumptions should be considered in the development of soil cleanup goals only when they can be reasonably assured to reflect both current and plausible future land use.

It is important to recognize that acceptable soil concentrations for individual chemicals will change over time in response to new information regarding the toxicity of the chemical, improvement in exposure modeling, etc. Accordingly, this list will be updated periodically to ensure that the most current information is available.

Table 1. SELECTED SOIL CLEAN-UP GOALS \*Current as of September 27, 1995All values are presented in mg/kg (ppm)

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Acenaphthene	83-32-9	2800	30000	2.0
Acenaphthylene	208-96-8	670	5600	11
Acetone	67-64-1	260	1800	1.4
Acrolein	107-02-8	0.4	2.7	0.3
Acrylonitrile	107-13-1	0.1	0.2	0.02
Alachlor	15972-60-8	14	56	NC
Aldrin	309-00-2	0.06	0.2	0.05
Aluminum	7429-90-5	75000	†	NC
Anthracene	120-12-7	20000	300000	890
Antimony	7440-36-0	26	220	NC
Arsenic	7440-38-2	0.7	3.1	NC
Atrazine	1912-24-9	4.9	20	0.02
Barium	7440-39-3	5200	84000	NC
Benzene	71-43-2	1.4	2.0	0.003
Benzo(a)anthracene	56-55-3	1.4	4.9	29
Benzo(a)pyrene	50-32-8	0.1	0.5	3.7
Benzo(b)fluoranthene	205-99-2	1.4	5.0	71
Benzo(g,h,i)perylene	191-24-2	14	50	320
Benzo(k)fluoranthene	207-08-9	14	48	44
Benzoic acid	65-85-0	130000	†	56
Beryllium	7440-41-7	0.2†	1.0†	NC
Bis(2-chloroethoxy)methane	111-91-1	170	3000	0.03
Bis(2-chloroethyl)ether	111-44-4	0.5	0.9	0.005
Bis(2-ethylhexyl)phthalate (DEHP)	117-81-7	48	110	11
Boron	7440-42-8	7000	180000	NC
Bromodichloromethane	75-27-4	0.7	<del>0.1</del> 1.0	0.002
Bromoform	75-25-2	65	130	0.02
Butanone, 2- (MEK)	78-93-3	2200	15000	8.7
Butyl benzyl phthalate, N-	85-68-7	15000	310000	960
Cadmium	7440-43-9	37	600	NC
Carbaryl	63-25-2	7600	150000	4.6
Carbazole	86-74-8	42	120	0.4

Table 1. SELECTED SOIL CLEAN-UP GOALS \*

Current as of September 27, 1995

All values are presented in mg/kg (ppm)

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Carbofuran	1563-66-2	380	7700	0.1
Carbon disulfide	75-15-0	5.2	34	2.5
Carbon tetrachloride	56-23-5	0.6	0.8	0.02
Chlordane	57-74-9	0.8	3.0	2.1
Chloro-m-cresol, p-	59-50-7	140000	7	42
Chloroaniline, 4-	106-47-8	240	3300	0.08
Chlorobenzene	108-90-7	44	300	0.6
Chloroethylvinylether, 2-	110-75-8	100	690	0.002
Chloroform	67-66-3	0.6	0.8	0.02
Chloromethane	74-87-3	0.2	0.3	0.01
Chloronaphthalene, beta-	91-58-7	560	4000	57
Chlorophenol, 2-	95-57-8	280	3700	0.3
Chlorpyrifos	2921-88-2	190	2900	2.6
Chromium (hexavalent)	18540-29-9	290	430	NC
Chromium (trivalent)	16065-83-1	66000	540000	NC
Chrysene	218-01-9	140	500	31
Cobalt	7440-48-4	4700	110000	NC
Coumaphos	56-72-4	19	410	NC
Cyanide	57-12-5	1600	40000	NC
DDD, 4,4'-	72-54-8	4.5	17	0.2
DDE, 4,4'-	72-55-9	3.0	11	0.2
DDT, 4,4'-	50-29-3	3.1	12	0.5
Dalapon	75-99-0	1900	28000	0.4
Demeton	8065-48-3	3.1	64	NC
Di-n-Butylphthalate	84-74-2	7300	140000	23
Di-n-Octylphthalate	117-84-0	1500	32000	7
Diazinon	333-41-5	66	1300	0.04
Dibenz(a,h)anthracene	53-70-3	0.1	0.5	7.2
Dibenzofuran	132-64-9	240	3500	NC
Dibromochloromethane	124-48-1	1.2	1.7	0.004
Dibromoethane, 1,2- (EDB)	106-93-4	0.01	0.04	0.00006
Dicamba	1918-00-9	1700	23000	0.7

Table 1. SELECTED SOIL CLEAN-UP GOALS \*Current as of September 27, 1995All values are presented in mg/kg (ppm)

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Dichlorobenzene, 1,2-	95-50-1	820	6000	5.8
Dichlorobenzene, 1,3-	541-73-1	1700	13000	0.4
Dichlorobenzene, 1,4-	106-46-7	7.5	11	0.9
Dichloroethane, 1,1-	75-34-3	310	2100	2.3
Dichloroethane, 1,2- (EDC)	107-06-2	0.7	1.0	0.008
Dichloroethene, 1,1-	75-35-4	0.1	0.1	0.03
Dichloroethene, cis-1,2-	156-59-2	26	180	0.2
Dichloroethene, trans-1,2-	156-60-5	62	430	0.3
Dichlorophenol, 2,4-	120-83-2	220	4000	0.02
Dichlorophenoxy acetic acid, 2,4-	94-75-7	110	800	0.2
Dichlorophenoxy) butyric acid, 4-(2,4-	94-82-6	610	13000	NC
Dichloroprop	120-36-5	3.8	15	NC
Dichloropropane, 1,2-	78-87-5	0.8	1.2	0.02
Dichloropropene, 1,3-	542-75-6	0.3	0.4	0.003
Dichlorvos	62-73-7	3.8	15	0.0003
Dicofol (Kelthane)	115-32-2	2.5	10	NC
Dieldrin	60-57-1	0.07	0.3	0.02
Diethylphthalate	84-66-2	56000	970000	20
Dimethylformamide, N,N-	68-12-2	1800	27000	1.5
Dimethylphenol, 2,4-	105-67-9	1200	16000	1.8
Dimethylphthalate	131-11-3	630000	†	200
Dinitrotoluene, 2,4-	121-14-2	130	2000	0.0006
Dinitrotoluene, 2,6-	606-20-2	71	1300	0.0006
Dinoseb	88-85-7	43	470	0.4
Disulfoton	298-04-4	2.8	50	0.01
Diuron	330-54-1	130	2100	0.1
Endosulfan	115-29-7	390	5900	0.7
Endrin	72-20-8	23	470	0.4
Endrin aldehyde	7421-93-4	23	480	0.05
Ethoprop	13194-48-4	1.2	25	NC
Ethyl chloride	75-00-3	8200	56000	0.6
Ethyl dipropylthiocarbamate, S- (EPTC)	759-94-4	1900	38000	NC

Table 1. SELECTED SOIL CLEAN-UP GOALS \*Current as of September 27, 1995All values are presented in mg/kg (ppm) .

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Ethyl p-nitrophenyl phenylphosphorothioate	2104-64-5	0.8	15	0.008
Ethylbenzene	100-41-4	1400	10000	0.2
Fenamiphos	22224-92-6	19	410	0.06
Fensulfothion	115-90-2	19	410	NC
Fenthion	55-38-9	3.8	80	NC
Fluoranthene	206-44-0	2900	48000	280
Fluorene	86-73-7	2400	30000	45
Fluoride	16984-58-8	4700	120000	NC
Guthion (Azinphos-methyl)	86-50-0	120	2500	0.1
Heptachlor	76-44-8	0.2	0.5	0.06
Heptachlor epoxide	1024-57-3	0.1	0.3	0.03
Hexachlorobenzene	118-74-1	0.6	1.6	0.8
Hexachlorobutadiene	87-68-3	3.1	4.9	2.1
Hexachlorocyclohexane, alpha-	319-84-6	0.2	0.6	0.002
Hexachlorocyclohexane, beta-	319-85-7	0.6	2.3	0.005
Hexachlorocyclohexane, delta-	319-86-8	23	470	0.007
Hexachlorocyclohexane, gamma-	58-89-9	0.8	3.0	0.006
Hexachloroethane	67-72-1	27	120	0.4
Hexane, n-	110-54-3	76	510	1.0
Hexazinone	51285-04-2	2500	52000	NC
Indeno(1,2,3-cd)pyrene	193-39-5	1.4	5.0	17
Lead	7439-92-1	500	1000	NC
Linuron	330-55-2	150	3200	NC
Lithium	743-99-32	1600	40000	NC
Malathion	121-75-5	1500	23000	1.1
Manganese	7439-96-5	370	5500	NC
Mercury	7439-97-6	23	480	NC
Merphos	150-50-5	2.3	48	NC
Mesurol (Methiocarb)	2032-65-7	310	4600	NC
Methomyl	16752-77-5	1900	41000	0.5
Methoxychlor	72-43-5	380	7800	62
Methyl parathion	298-00-0	19	350	0.1

Table 1. SELECTED SOIL CLEAN-UP GOALS \*

Current as of September 27, 1995

All values are presented in mg/kg (ppm)

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Methyl tert-butyl ether	1634-04-4	3800	27000	0.1
Methyl-2-pentanone, 4- (MIBK)	108-10-1	520	3700	1.1
Methyl-4-chlorophenoxy acetic acid, 2-	94-74-6	38	800	NC
Methyl-4-chlorophenoxy propionic acid, 2-	93-65-2	77	1600	NC
Methylene chloride	75-09-2	16	23	0.01
Methylnaphthalene, 1-	90-12-0	930	8400	NC
Methylnaphthalene, 2-	91-57-6	960	8800	NC
Methylphenol, 2- (o-cresol)	95-48-7	2600	32000	1.1
Methylphenol, 3- (m-cresol)	108-39-4	3400	55000	4.2
Methylphenol, 4- (p-cresol)	106-44-5	340	5500	0.4
Metribuzin	21087-64-9	1900	42000	NC
Mevinphos	7786-34-7	19	420	NC
Mirex	2385-85-5	0.4	0.8	0.01
Molybdenum	7439-98-7	390	9600	NC
Monuron	150-68-5	9.6	190	NC
Naled	300-76-5	150	3200	NC
Naphthalene	91-20-3	1300	12000	0.1
Nickel	7440-02-0	1500	26000	NC
Nickel subsulfide	12035-72-2	7000	10000	NC
Nitrate	14797-55-8	120000	†	NC
Nitrite	14797-65-0	7800	200000	NC
Nitroaniline, o-	88-74-4	4.0	73	0.02
Nitroaniline, p-	100-01-6	230	4700	NC
Nitrobenzene	98-95-3	22	250	0.04
Nitroso-di-n-propylamine, N-	621-64-7	0.02	0.03	0.009
Nitrosodimethylamine, N-	62-75-9	0.003	0.004	0.02
Nitrosodiphenylamine, N-	86-30-6	73	130	0.06
Oxamyl	23135-22-0	1900	42000	NC
Parathion	56-38-2	450	9000	3.9
Pentachlorophenol	87-86-5	5.4	12	0.01
Phenanthrene	85-01-8	1700	21000	2.8
Phenol	108-95-2	34000	440000	0.02



Table 1. SELECTED SOIL CLEAN-UP GOALS \*Current as of September 27, 1995All values are presented in mg/kg (ppm)

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Phorate	298-02-2	14	240	0.05
Polychlorinated biphenyls (PCBs)	1336-36-3	0.9	3.5	44
Propazine	139-40-2	1500	32000	2.3
Pyrene	129-00-0	2200	41000	290
Pyridine	110-86-1	0.5	3.2	0.02
Ronnel	299-84-3	3700	71000	NC
Selenium	7782-49-2	390	9900	NC
Silver	7440-22-4	390	9000	NC
Sodium diethyldithiocarbamate	148-18-5	4.1	17	NC
Strontium	7440-24-6	47000	7	NC
Styrene	100-42-5	4100	34000	2.0
Tetrachloroethane, 1,1,1,2-	630-20-6	5.9	8.9	0.003
Tetrachloroethane, 1,1,2,2-	79-34-5	0.9	1.4	0.0007
Tetrachloroethene (PCE)	127-18-4	12	28	0.03
Tetrachlorvinphos (Stirophos)	961-11-5	45	180	NC
Tetraethyl dithiopyrophosphate	3689-24-5	34	590	0.06
Tetraethylpyrophosphate (TEPP)	107-49-3	2.5	51	NC
Tin	7440-31-5	44000	670000	NC
Tokuthion	34643-46-4	68	1400	NC
Toluene	108-88-3	520	3500	0.2
Toxaphene	8001-35-2	0.9	3.0	0.04
Trichlorobenzene, 1,2,4-	120-82-1	590	8200	2.3
Trichloroethane, 1,1,1-	71-55-6	610	4300	0.9
Trichloroethane, 1,1,2-	79-00-5	2.0	3.0	0.02
Trichloroethene (TCE)	79-01-6	6.5	9.3	0.01
Trichlorofluoromethane	75-69-4	6.6	44	400
Trichlorophenol, 2,4,5-	95-95-4	7100	130000	0.1
Trichlorophenol, 2,4,6-	88-06-2	87	280	0.08
Trichlorophenoxy acetic acid, 2,4,5-	93-76-5	760	15000	NC
Trichlorophenoxy propionic acid, 2,4,5	93-72-1	610	13000	2.7
Trimethylbenzene, 1,2,3-	526-73-8	6.7	51	0.2
Trimethylbenzene, 1,2,4-	95-63-6	6.2	47	0.2

Table 1. SELECTED SOIL CLEAN-UP GOALS \*

Current as of September 27, 1995

All values are presented in mg/kg (ppm)

<u>Chemical Name</u>	<u>CAS</u>	<u>Residential</u>	<u>Industrial</u>	<u>Leaching **</u>
Trimethylbenzene, 1,3,5-	108-67-8	3.7	27	0.1
Uranium, natural	7440-61-1	120	410	NC
Vanadium	7440-62-2	490	4800	NC
Vinyl acetate	108-05-4	180	1200	0.5
Vinyl chloride	75-01-4	0.005 -	0.007	0.005
Xylene, total	1330-20-7	13000	92000	0.1
Zinc	7440-66-6	23000	560000	NC

\* Soil cleanup goals in these tables are based on human toxicity using generalized exposure assumptions. Some tabulated soil cleanup goals may be less than the minimum detection limit (MDL) for that chemical in soils; in such cases the MDL would be the applicable cleanup goal.

\*\* TCLP for metals applies as appropriate.

NC = No Value Calculated

TCLP = Toxicity Leaching Characteristic Leaching Procedure.

† = Number exceeds 1E+06.

‡ = Based on dermal absorption of 0.0001

**Table 2. Variables and Assumptions for Calculating Soil Cleanup Goals Based on Direct Exposure to Soil**

Variable	Child Resident <sup>1</sup> (age 1-6 years)	Aggregate Resident <sup>2</sup> (age 1 - 30 yrs)	On-Site Worker <sup>3</sup>
BW (body weight)	15 kg	59 kg	70 kg
IRo (ingestion rate, oral)	200 mg/kg·y	120 mg/day	50 mg/day
IRi (inhalation rate)	10 m <sup>3</sup> /day	15 m <sup>3</sup> /day	20 m <sup>3</sup> /day
FC (fraction from contam. source)	1.0 (100%)	1.0 (100%)	1.0 (100%)
EF (exposure frequency)	350 days/yr	350 days/yr	250 days/yr
ED (exposure duration)	6 yrs	30 yrs	25 yrs
SA (surface area of skin exposed)	1,800 cm <sup>2</sup> /day	4,855 cm <sup>2</sup> /day	2,300 cm <sup>2</sup> /day
AF (adherence factor)	0.2 mg/cm <sup>2</sup>	0.2 mg/cm <sup>2</sup>	0.6 mg/cm <sup>2</sup>
AT (averaging time),			
• non-carcinogens	2,190 days	10,950	9,125 days
• carcinogens	25,550 days	25,550 days	25,550 days

<sup>1</sup> used in calculating soil cleanup goals based on non-cancer health effects for a residential scenario

<sup>2</sup> used in calculating soil cleanup goals based on potential carcinogenicity for a residential scenario.

<sup>3</sup> used in calculating soil cleanup goals based on both cancer and non-cancer health effects for commercial/industrial land use.

Variable	
TR (target risk)	1 x 10 <sup>-6</sup> for carcinogens; hazard quotient of 1.0 for non-carcinogens
DA (dermal absorption)	0.01 for organics; 0.001 for inorganics <sup>4</sup>
PEF (particulate emission factor)	1.24 E+09 m <sup>3</sup> /kg
VF (volatilization factor)	compound specific <sup>5</sup>
SF (slope factor)	compound and route specific
RfD (reference dose)	compound and route specific

<sup>4</sup> based upon Region IV guidance

<sup>5</sup> refer to *Technical Background Document for Draft Soil Screening Level Guidance*, EPA 540/R-94/018, July 1994, for the method of calculation.