Steve

June 15, 1992

HDR

RECEIVED JUN 18 1992

Mr. Keith N. Phillips, Chief
Technical Section (6H-CX)
RCRA Enforcement Branch
U.S. EPA, Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Re: Final RFI Report
Sparton Technology, Inc.
Coors Road Facility
Albuquerque, New Mexico

Dear Mr. Phillips:

In response to the telephone request of Mr. Vincent E. Malott on June 2, 1992, we are providing sample calculations of aquifer parameters for inclusion in Attachment 10 of the Final RFI Report. The sample calculations should be inserted immediately after page 12 of Attachment 10.

Page 63 of the Final RFI Report has been revised to include reference to the calculations in Attachment 10. Copies of the revised page 63 are included in this submittal and should be substituted into the Report.

We are also including copies of Figures 81, 82 and 84 with correct page numbers. These figures should be substituted at their appropriate locations.

If you have any questions, or need further information, please call.

Sincerely,

HDR Engineering, Inc.

Pierce L. Chandler, Jr.

Pierce L. Chandler, Jr., P.E.
Senior Project Manager

Enclosure
cc: Mr. Richard Mico
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SAMPLE CALCULATIONS

I. LOWER FLOW ZONES

A. Steady radial flow without vertical movement

1. Using distance-drawdown data given on Figure 23, the Transmissivity, T, may be calculated from:

$$T = \frac{2.30\ Q}{2\pi\ \Delta s/\Delta \log_{10} r}$$

(Lohman, Eq 34, units of $L^2\ T^{-1}$)

with appropriate conversions for T expressed in gallons per day per foot, the equation becomes

$$T = \frac{528\ Q}{\Delta s/\Delta \log_{10} r}$$

where Q = 180 gallons per minute and

$\Delta s/\Delta \log_{10} r$ = 5.2 feet/cycle

T = 18277 gallons per day per foot

The Storage Coefficient, S, may be determined from the calculated T; the radial distance to zero drawdown, r_o = 600 feet extrapolated from the data in Figure 23; and, the nominal time to equilibrium, t_e, of 200 minutes (0.139 days) using:

$$S = 2.25\ T \left(\frac{t}{r^2}\right)_0 \qquad \text{(Lohman, Eq 59, Dimensionless)}$$

with appropriate conversion factors for T in gallons per day per foot

$$S = \frac{0.3\ T\ t_e}{r_0^2} = \frac{0.3\ (18277\ \text{gal/day/ft})\ (0.139\ \text{days})}{(600\ \text{ft})^2}$$

S = 0.0021

note that if $t_e \approx$ 300 minutes

$$\mathbf{S \cong 0.003}$$

2. Using data from MW-12 and MW-13, and assuming <u>confined</u> conditions, Transmissivity was checked using:

$$T = \frac{2.30\ Q\ \log_{10}(r_2/r_1)}{2\pi\ (s_1 - s_2)}$$ (Lohman, Eq 32, L^2T^{-1} units)

in typical units,

$$T = \frac{528\ Q\ \log_{10}(r_{MW\text{-}13}/r_{MW\text{-}12})}{s_{MW\text{-}12} - s_{MW\text{-}13}}$$

For Q = 180 gpm
$r_{MW\text{-}12}$ = 45 feet
$r_{MW\text{-}13}$ = 150 feet
$s_{MW\text{-}12}$ = 5.9 feet
and $s_{MW\text{-}13}$ = 3.1 feet,
the calculation of T is:

$$T = \frac{528\ (180\ \text{gpm})\ \log_{10}(150\ \text{ft}/45\ \text{ft})}{5.9\ \text{ft} - 3.1\ \text{ft}}$$

T = 17,748 gal/day/ft

3. Using the MW-12 and MW-13 data, but assuming <u>unconfined</u> conditions; a saturated thickness, b, equal to 75 feet; and the base of the aquifer at an elevation of 4900 feet, T may be calculated using:

$$K = \frac{2.30\ Q\ \log_{10}(r_2/r_1)}{\pi\ (h^2_2 - h^2_1)}$$ (Lohman, Eq 31, LT^{-1} units)

and T = Kb

with appropriate conversion factors, the combined equation becomes:

$$T = \frac{1055\ b\ Q\ \log_{10}(r_{MW\text{-}13}/r_{MW\text{-}12})}{(h_{MW\text{-}13})^2 - (h_{MW\text{-}12})^2}$$

For
Q = 180 gpm
b = 75 ft
$r_{MW\text{-}12}$ = 45 ft
$r_{MW\text{-}13}$ = 150 ft
$h_{MW\text{-}12}$ = 69.1 ft (75 ft - 5.9 ft)
$h_{MW\text{-}13}$ = 71.9 ft (75 ft - 3.1 ft)

$$T = \frac{1055\ (75\ \text{ft})\ (180\ \text{gpm})\ \log_{10}(150\ \text{ft}/45\ \text{ft})}{(71.9\ \text{ft})^2 - (69.1\ \text{ft})^2}$$

T = 18863 gal/day/ft

II. UPPER FLOW ZONE (from Draft Effectiveness Report)

A. Calculation of In Situ Field Permeability, K

1. Using the pump test drawdown values measured after the pump was shut off, the permeability may be calculated with:

$$K = \frac{d^2 \ln(2\ m\ L/D)}{8\ L\ (t_2 - t_1)} \qquad \ln\ (H_1/H_2)$$

(Hvorslev, 1951)*

* Case G, well point-filter in uniform sand, for variable head tests with the condition m L/D > 4 (see Figure 1).

Where:

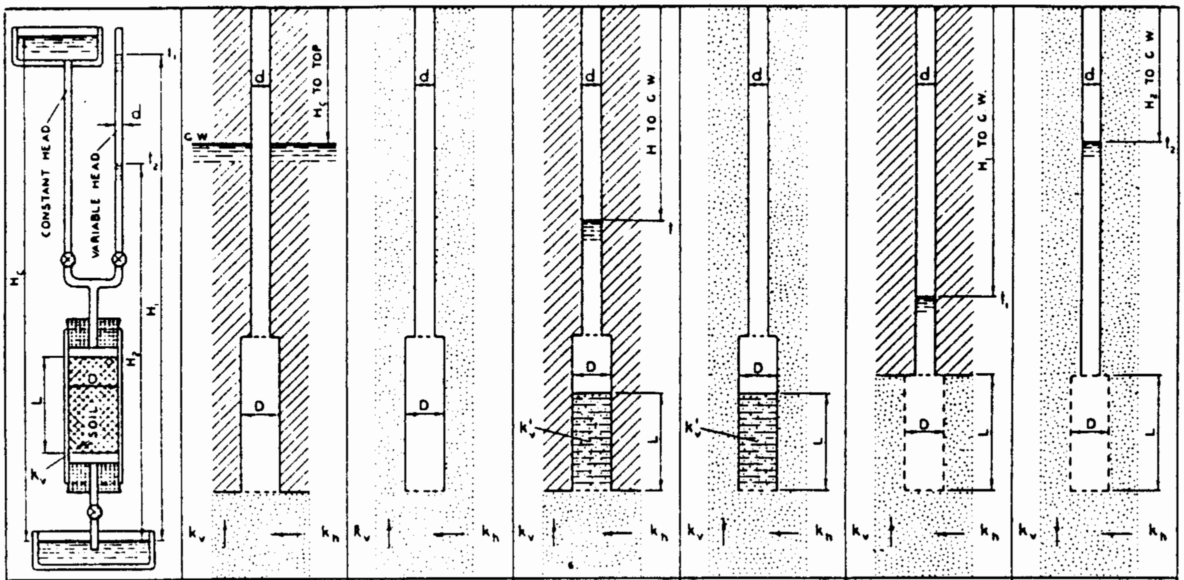
K_h = Horizontal Coefficient of Permeability
K_v = Vertical Coefficient of Permeability
m = Transformation Ratio = $\sqrt{K_h/K_v}$
d = Diameter, standpipe
D = Diameter, intake pipe
L = Length of intake
t = time
H_1 = Drawdown at time t_1
H_2 = Drawdown at time t_2

2. An example of the calculations for Recovery Well PW-1 follows: Using these parameters for Recovery Well PW-1,

m = 3 (approximated)
d = 25.4 cm
D = 25.4 cm
L = 304.8 cm
m L/D = 36 > 4

Hvorslev's equation reduces to

$$K_h = \frac{1.13}{t_2 - t_1} \quad \ln\ (H_1/H_2)$$



LABORATORY PERMEAMETER (CONSOLIDOMETER)	FLUSH BOTTOM AT IMPERVIOUS BOUNDARY	FLUSH BOTTOM IN UNIFORM SOIL	SOIL IN CASING AT IMPERVIOUS BOUNDARY	SOIL IN CASING IN UNIFORM SOIL	WELL POINT-FILTER AT IMPERVIOUS BOUNDARY	WELL POINT-FILTER IN UNIFORM SOIL
A	B	C	D	E	F	G

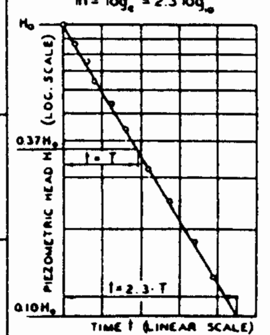
CASE	CONSTANT HEAD	VARIABLE HEAD	BASIC TIME LAG
A	$k_v = \frac{4 \cdot q \cdot L}{\pi \cdot D^2 \cdot H_c}$	$k_v = \frac{d^2 \cdot L}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ FOR $d = D$	$k_v = \frac{d^2 \cdot L}{D^2 \cdot T}$ $k_v = \frac{L}{T}$ FOR $d = D$
B	$k_m = \frac{q}{2 \cdot D \cdot H_c}$	$k_m = \frac{\pi \cdot d^2}{8 \cdot D\,(t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_m = \frac{\pi \cdot D}{8\,(t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $d = D$	$k_m = \frac{\pi d^2}{8 \cdot D \cdot T}$ $k_m = \frac{\pi \cdot D}{8 \cdot T}$ FOR $d = D$
C	$k_m = \frac{q}{2.75 \cdot D \cdot H_c}$	$k_m = \frac{\pi \cdot d^2}{11 \cdot D\,(t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_m = \frac{\pi \cdot D}{11\,(t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $d = D$	$k_m = \frac{\pi \cdot d^2}{11 \cdot D \cdot T}$ $k_m = \frac{\pi \cdot D}{11 \cdot T}$ FOR $d = D$
D	$k'_v = \frac{4 \cdot q \cdot \left[\frac{\pi}{8} \cdot \frac{k'_v}{k_v} \cdot \frac{D}{m} + L\right]}{\pi \cdot D^2 \cdot H_c}$	$k'_v = \frac{d^2 \left[\frac{\pi}{8} \cdot \frac{k'_v}{k_v} \cdot \frac{D}{m} + L\right]}{D^2\,(t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{8} \cdot \frac{D}{m} + L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ FOR $k'_v = k_v$, $d = D$	$k'_v = \frac{d^2 \cdot \left[\frac{\pi}{8} \cdot \frac{k'_v}{k_v} \cdot \frac{D}{m}\right] + L}{D^2 \cdot T}$ $k_v = \frac{\frac{\pi}{8} \cdot \frac{D}{m} + L}{T}$ FOR $k'_v = k_v$, $d = D$
E	$k'_v = \frac{4 \cdot q \cdot \left[\frac{\pi}{11} \cdot \frac{k'_v}{k_v} \cdot \frac{D}{m} + L\right]}{\pi \cdot D^2 \cdot H_c}$	$k'_v = \frac{d^2 \left[\frac{\pi}{11} \cdot \frac{k'_v}{k_v} \cdot \frac{D}{m} + L\right]}{D^2 \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{11} \cdot \frac{D}{m} + L}{t_2 - t_1} \ln \frac{H_1}{H_2}$ FOR $k'_v = k_v$, $d = D$	$k'_v = \frac{d^2 \cdot \left[\frac{\pi}{11} \cdot \frac{k'_v}{k_v} \cdot \frac{D}{m} + L\right]}{D^2 \cdot T}$ $k'_v = \frac{\frac{\pi}{11} \cdot \frac{D}{m} + L}{T}$ FOR $k'_v = k_v$, $d = D$
F	$k_h = \frac{q \cdot \ln\left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{2 \cdot \pi \cdot L \cdot H_c}$	$k_h = \frac{d^2 \ln\left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_h = \frac{d^2 \cdot \ln\left(\frac{4mL}{D}\right)}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $\frac{2mL}{D} > 4$	$k_h = \frac{d^2 \cdot \ln\left[\frac{2mL}{D} + \sqrt{1 + \left(\frac{2mL}{D}\right)^2}\right]}{8 \cdot L \cdot T}$ $k_h = \frac{d^2 \cdot \ln\left(\frac{4mL}{D}\right)}{8 \cdot L \cdot T}$ FOR $\frac{2mL}{D} > 4$
G	$k_h = \frac{q \ln\left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{2\,\pi\,L \cdot H_c}$	$k_h = \frac{d^2 \cdot \ln\left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L\,(t_2 - t_1)} \ln \frac{H_1}{H_2}$ $k_h = \frac{d^2 \cdot \ln\left(\frac{2mL}{D}\right)}{8 \cdot L \cdot (t_2 - t_1)} \ln \frac{H_1}{H_2}$ FOR $\frac{mL}{D} > 4$	$k_h = \frac{d^2 \cdot \ln\left[\frac{mL}{D} + \sqrt{1 + \left(\frac{mL}{D}\right)^2}\right]}{8 \cdot L \cdot T}$ $k_h = \frac{d^2 \cdot \ln\left(\frac{2mL}{D}\right)}{8 \cdot L \cdot T}$ FOR $\frac{mL}{D} > 4$

NOTATION

D = DIAM. INTAKE, SAMPLE, CM
d = DIAMETER, STANDPIPE, CM
L = LENGTH, INTAKE, SAMPLE, CM
H_c = CONSTANT PIEZ. HEAD, CM
H_1 = PIEZ. HEAD FOR $t = t_1$, CM
H_2 = PIEZ. HEAD FOR $t = t_2$, CM
q = FLOW OF WATER, CM^3/SEC.
t = TIME, SEC.
T = BASIC TIME LAG, SEC.
k'_v = VERT. PERM. CASING, CM/SEC.
k_v = VERT. PERM. GROUND, CM/SEC.
k_h = HORZ. PERM. GROUND, CM/SEC.
k_m = MEAN COEFF. PERM., CM/SEC.
m = TRANSFORMATION RATIO

$k_m = \sqrt{k_h \cdot k_v}$ $m = \sqrt{k_h / k_v}$

$\ln = \log_e = 2.3 \log_{10}$



DETERMINATION BASIC TIME LAG T

ASSUMPTIONS

SOIL AT INTAKE, INFINITE DEPTH AND DIRECTIONAL ISOTROPY (k_v AND k_h CONSTANT) - NO DISTURBANCE, SEGREGATION, SWELLING OR CONSOLIDATION OF SOIL - NO SEDIMENTATION OR LEAKAGE - NO AIR OR GAS IN SOIL, WELL POINT, OR PIPE - HYDRAULIC LOSSES IN PIPES, WELL POINT OR FILTER NEGLIGIBLE

Formulas for determination of permeability

Figure 1.

The permeability for various values of H_1, H_2, t_1, t_2 was calculated, then averaged for a reported value as shown in Table 1 below.

Table 1

H_1 (ft)	t_1 (sec)	H_2 (ft)	t_2 (sec)	$\ln(H_1/H_2)$	t_2-t_1(sec)	K_h(cm/sec)
1.98	0	1.90	120	0.041	120	3.86×10^{-4}
1.94	45	1.86	210	0.042	165	2.88×10^{-4}
1.88	150	1.73	360	0.083	210	4.47×10^{-4}
1.80	300	1.66	600	0.081	300	3.05×10^{-4}
1.63	720	1.50	1080	0.083	360	2.61×10^{-4}
1.50	1080	0.93	3000	0.478	1920	2.81×10^{-4}
0.93	3000	0.42	6000	0.795	3000	2.99×10^{-4}

average K_h: 3.24×10^{-4} cm/sec

Table 2 provides a summary of field permeabilities for all eight Recovery Wells and MW-16.

Table 2

Well No.	In situ field permeabilities (cm/sec)
PW-1	3.24×10^{-4}
MW-16	2.39×10^{-4}
MW-18	3.46×10^{-4}
MW-23	2.53×10^{-3}
MW-24	4.36×10^{-4}
MW-25	4.50×10^{-4}
MW-26	3.56×10^{-4}
MW-27	2.90×10^{-3}
MW-28	2.91×10^{-5}

B. Calculation of Radius of Influence, r_o

1. Using the permeabilities calculated with Hvorslev's equation and a well drawdown equal to the upper flow zone saturated thickness, the Radius of Influence (r_o) at each well location may be calculated with the following equation:

$r_o = C (H - h_w) \sqrt{K}$ (Sichardt's method, U.S. Department of the Army, 1971)

Where:

r_o = Radius of Influence, ft
C = Empirical Relation of K vs. r
H = Height of water table (saturated thickness), ft
h_w = Head of water in well, ft
K = Coefficient of Permeability, microns/sec

2. An example of the calculations for Recovery Well PW-1 follows:

C = 3 (for a single well)
K_h = 3.24×10^{-4} cm/sec = 3.24 microns/sec
$H-h_w$ = 10 ft
r_o = 3 (10ft) ($\sqrt{3.24}$)
r_o = 54 ft

Table 3 provides a summary of calculated Radii of Influence for all eight Recovery Wells and MW-16.

Table 3

Well No.	Calculated Radius of Influence (ft)
PW-1	54
MW-16	46
MW-18	56
MW-23	136
MW-24	63
MW-25	93
MW-26	57
MW-27	162
MW-28	35

C. <u>Calculation of Transmissivity, T</u>

1. Using the permeability values calculated with Hvorslev's equation and an upper flow zone saturated thickness of 10 feet, the Transmissivity, T, for each well location may be calculated with the following equation:

$$T = k\,b$$

Where:

T = Transmissivity
k = Permeability
b = saturated thickness

2. An example of the calculations for Recovery Well PW-1 follows:

$k = 3.24 \times 10^{-4}$ cm/sec = 0.28 m/day
$b = 10$ ft = 3.05 m

$T =$ (0.28 m/day) (3.05 m) (80.5 gal/day/ft per m^2/day)
= **68.7 gal/day/ft**

Table 4 provides a summary of Transmissivity values for all eight Recovery Wells and MW-16.

Table 4

Well No.	Transmissivity, T (gal/day/ft)
PW-1	68.7
MW-16	50.7
MW-18	73.7
MW-23	536.4
MW-24	92.5
MW-25	95.5
MW-26	75.5
MW-27	615.0
MW-28	6.2

D. Calculation of Storage Coefficient, S

1. Using the Transmissivity, T, and Radius of Influence, r_o, values previously calculated, as well as the elapsed time from pump test start to finish, the Storage Coefficient, S, for each well location may be calculated with:

$$S = 2.25\,T\left(\frac{t}{r^2}\right)_o \qquad \text{(Lohman, Eq 59, Dimensionless)}$$

Where:

S = Storage Coefficient
T = Transmissivity
t = time
r_o = Radius of Influence

2. An example of the calculation for Recovery Well PW-1 follows:

T = 68.7 gal/day/ft = 0.84 m^2/day
t = 4332 min = 3.0 days
r_o = 54 ft = 16.5 m

$$S = \frac{2.25\ (0.84\ m^2/day)\ (3.0\ days)}{(16.5\ m)^2}$$

S = 0.0205

Table 5 provides a summary of Storage Coefficient values for all eight Recovery Wells and MW-16.

Table 5

Well No.	Storage Coefficient, S
PW-1	0.0205
MW-16	0.0217
MW-18	0.0144
MW-23	0.0261
MW-24	0.0214
MW-25	0.0095
MW-26	0.0207
MW-27	0.0206
MW-28	0.0045

To the west of Irving Boulevard, hydraulic gradients are relatively flat and vary from 1:350 to 1:780 in a generally westward direction. Under the Sparton facility, gradients range from 1:50 to the southwest in the upper flow zone to 1:200 to 1:350 to the northwest in the lower flow zone.

Based on the results of field work and interpretations of pumping tests and water level data, the following aquifer parameters have been calculated for the upper and lower flow zones at the Sparton site:

Upper Flow Zone	Lower Flow Zones
T = 6-615 gpd/ft	T = 12,000-18,000 gpd/ft
K = 2.9×10^{-5}-2.9×10^{-3} cm/sec 0.6-61.5 gpd/ft^2	K = 0.0075-0.011 cm/sec 160-240 gpd/ft^2
S = 0.018	S = 0.002-0.003
N = 0.25-0.40	N = 0.25-0.40

T = Transmissivity
K = Hydraulic Conductivity
S = Storativity (dimensionless)
N = Porosity (dimensionless)

Aquifer parameters are from pumping test analyses and calculations included in Attachment 10. No pumping test data exist for the third flow zone.

Two major sediment types were encountered in borings at the Sparton facility. These sediment types include clays and sandy muds interbedded with gravelly sands. The gravelly sands predominate in the upper and lower flow zones. Both sediment types are found in every boring, however, correlation from boring to boring is not consistent because

FIGURE 81

PREVAILING WINDS AND AVERAGE MONTHLY WIND SPEEDS		
Month	**Average Speed m.p.h.**	**Prevailing Direction**
January	8.0	N
February	8.8	N
March	10.1	SE
April	11.0	S
May	10.5	S
June	10.0	S
July	9.1	SE
August	8.2	SE
September	8.6	SE
October	8.3	SE
November	7.9	N
December	7.7	N

Source: National Oceanic and Atmospheric Administration,
Local Climatological Data, Albuquerque, New Mexico, 1978

FIGURE 82

MAXIMUM CONCENTRATION OF CONSTITUENTS FOR GROUNDWATER PROTECTION	
Constituent	**Maximum Concentration mg/l**
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5- P Silvex	0.01

Source: 40 CFR 264.94

FIGURE 84

NEW MEXICO GROUNDWATER STANDARDS	
Parameter	**Maximum Allowable Concentration**
Arsenic	100 ug/l
Barium	1000 ug/l
Cadmium	10 ug/l
Chromium	50 ug/l
Cyanide	200 ug/l
Fluoride	1600 ug/l
Lead	50 ug/l
Total Mercury	2 ug/l
Nitrate as N	10000 ug/l
Selenium	50 ug/l
Silver	50 ug/l
Uranium	5000 ug/l
Radioactivity: Combined Radium-226 and Radium-228	30.0 pCi/l
Benzene	10 ug/l
Polychlorinated Biphenyls	1 ug/l
Toluene	750 ug/l
Carbon Tetrachloride	10 ug/l
1,2-Dichloroethane	10 ug/l
1,1-Dichloroethylene	5 ug/l
1,1,2,2-Tetrachloroethylene	20 ug/l
1,1,2-Trichloroethylene	100 ug/l
Ethylbenzene	750 ug/l

FIGURE 84 (Continued)

NEW MEXICO GROUNDWATER STANDARDS	
Parameter	**Maximum Allowable Concentration**
Total Xylenes	620 ug/l
Methylene Chloride	100 ug/l
Chloroform	100 ug/l
1,1-Dichloroethane	25 ug/l
Ethylene Dibromide	0.1 ug/l
1,1,1-Trichloroethane	60 ug/l
1,1,2-Trichloroethane	10 ug/l
1,1,2,2-Tetrachloroethane	10 ug/l
Vinyl Chloride	1 ug/l
PAHS: total naphthalene plus monomethylnaphthalenes	30 ug/l
Benzo-a-pyrene	0.7 ug/l
Secondary Standards	
Chloride (Cl)	250 mg/l
Copper (Cu)	1000 ug/l
Iron (Fe)	1000 ug/l
Manganese (Mn)	200 ug/l
Phenols	5 ug/l
Sulfate (SO_4)	600 mg/l
Total Dissolved Solids (TDS)	1000 mg/l
Zinc (Zn)	10 mg/l
pH	between 6 and 9

FIGURE 84 (Continued)

NEW MEXICO GROUNDWATER STANDARDS	
Parameter	**Maximum Allowable Concentration**
Irrigation Standards	
Aluminum (Al)	5000 ug/l
Boron (B)	750 ug/l
Cobalt (Co)	50 ug/l
Molybdenum (Mo)	1000 ug/l
Nickel (Ni)	200 ug/l

Source: New Mexico Water Quality Control Commission Regulations, Part 3-103.