Scenario: PRG calculation for exposure to benzidine in soil by both the ingestion and dermal exposure pathways, to an individual exposed for 30 years, starting at birth (the standard scenario for an RME resident).

This example uses the USEPA (1991 and 2004) recommended standard default exposure parameters for a RME resident.
(***Note**: Alternate age bins and exposure parameters may be considered to address site-specific exposure scenarios*).

General Equations:

Forward-going Risk Equations

$$TotalRisk_{soil} = Risk_{ingestion} + Risk_{dermal}$$

where:

$$Risk_{ingestion} = C \cdot \sum_{i=a}^{i=d} \frac{IR_i \cdot CF \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot SF \cdot ADAF_i$$

$$Risk_{dermal} = C \cdot \sum_{i=a}^{i=d} \frac{CF \cdot AF_i \cdot ABS_d \cdot EV \cdot SA \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot \frac{SF}{ABS_{GI}} \cdot ADAF_i$$

and:

i = age interval,

a = 0 - <2 years
b = 2 - <6 years
c = 6 - <16 years
d = 16 - <30 years

which simplifies to:

$$Risk_{ingestion} = C \bullet k1$$

$$Risk_{dermal} = C \bullet k2$$

thus:

$$TotalRisk_{soil} = C \cdot (k1 + k2)$$

PRG Equation:

$$PRG\ \ (mg/kg) = C = \frac{T\arg et\ Risk}{(k1 + k2)}$$

where:

$$k1 = \sum_{i=a}^{i=d} \frac{IR_i \cdot CF \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot SF \cdot ADAF_i$$

$$k2 = \sum_{i=a}^{i=d} \frac{CF \cdot AF_i \cdot ABS_d \cdot EV \cdot SA_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot \frac{SF}{ABS_{GI}} \cdot ADAF_i$$

and:

i = age interval,

a = 0 - <2 years

b = 2 - <6 years

c = 6 - <16 years

d = 16 - <30 years

Inputs:

EXPOSURE PARAMTERS (by age interval, i)					
Parameter	Units	0-<2	2-<6	6-<16	16-<30
Target Risk	(unitless)	1.0E-06	1.0E-06	1.0E-06	1.0E-06
IR	(mg/day)	200	200	100	100
CF	(kg/mg)	1.0E-06	1.0E-06	1.0E-06	1.0E-06
BW	(kg)	15	15	70	70
AF [1]	(mg/cm^2-event)	0.2	0.2	0.07	0.07
EV	(event/day)	1	1	1	1
ABS_d	(unitless)	0.1	0.1	0.1	0.1
SA [2]	(cm^2)	2800	2800	5700	5700
EF	(days/year)	350	350	350	350
ED	(years)	2	4	10	14
AT	(days)	25,550	25,550	25,550	25,550
SF_{oral} [3]	(mg/kg-day)-1	2.3E+02	2.3E+02	2.3E+02	2.3E+02
ABS_{GI} [4]	(unitless)	1.0	1.0	1.0	1.0
ADAF	(unitless)	10	3	3	1

Footnotes:

[1] USEPA 2004 recommended default adherence factor (AF) for a child resident (0.2) and adult resident (0.07), see Exhibit 3-3 and pages 3-14 to 3-17.

[2] USEPA 2004 recommended surface area (SA) exposed to contaminated soil for residents.

[3] IRIS 2006. http://www.epa.gov/iris/. Accessed July 2006.

[4] No adjustment of the slope factor recommended by USEPA 2004 (Exhibit 4-1).

References:

USEPA 1991. Standard Default Exposure Factors. OSWER Directive 9285.6-03

USEPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).

PRG Calculations

A. k1:

(0-<2) = [(200 • 1E-06/15) • (350/365) • (2/70) • 2.3E+02 • 10] = 8.4E-04

(2-<6) = [(200 • 1E-06/15) • (350/365) • (4/70) • 2.3E+02 • 3] = 5.0E-04

(6-<16) = [(100 • 1E-06/70) • (350/365) • (10/70) • 2.3E+02 • 3] = 1.4E-04

(16-<30) = [(100 • 1E-06/70) • (350/365) • (14/70) • 2.3E+02 • 1] = 6.3E-05

k1 = 8.4E-04 + 5.0E-04 + 1.4E-04 + 6.3E-05 = 1.5E-03

B. k2:

(0-<2) = [(1E-06 • 0.2 • 0.1 • 1 • 2800/15) • (350/365) • (2/70) • (2.3E+02/1) • 10] = 2.4E-04

(2-<6) = [(1E-06 • 0.2 • 0.1 • 1 • 2800/15) • (350/365) • (4/70) • (2.3E+02/1) • 3] = 1.4E-04

(6-<16) = [(1E-06 • 0.07 • 0.1 • 1 • 5700/70) • (350/365) • (10/70) • (2.3E+02/1) • 3] = 5.4E-05

(16-<30) = [(1E-06 • 0.07 • 0.1 • 1 • 5700/70) • (350/365) • (14/70) • (2.3E+02/1) • 1] = 2.5E-05

k2 = 2.4E-04 + 1.4E-04 + 5.4E-05 + 2.5E-05 = 4.6E-04

C. PRG:

$$PRG(mg/kg) = \frac{1E-06}{(1.5E-03 + 4.2E-03)} = 5.0E-04$$

Scenario: PRG calculation for exposure to benzidine in water by both the ingestion and dermal exposure pathways, to an individual exposed for 30 years, starting at birth (the standard scenario for an RME resident).

This example uses the USEPA (1991 and 2004) recommended standard default exposure parameters for a RME resident.
*(**Note**: Alternate age bins and exposure parameters may be considered to address site-specific exposure scenarios).*

General Equations:

Forward-going Risk Equations

$$TotalRisk_{water} = Risk_{ingestion} + Risk_{dermal}$$

where:

$$Risk_{ingestion} = C \cdot \sum_{i=a}^{i=d} \frac{IR_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot SF \cdot ADAF_i$$

$$Risk_{dermal} = C \cdot \sum_{i=a}^{i=d} \frac{2FA \cdot K_p \cdot CF \cdot \sqrt{(6 \cdot T_{event} \cdot t_{event\ i} / \Pi)} \cdot EV \cdot SA_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot \frac{SF}{ABS_{GI}} \cdot ADAF_i$$

and:

i = age interval,

a = 0 - <2 years
b = 2 - <6 years
c = 6 - <16 years
d = 16 - <30 years

which simplifies to:

$$Risk_{ingestion} = C \bullet k1$$

$$Risk_{dermal} = C \bullet k2$$

thus:

$$TotalRisk_{water} = C \cdot (k1 + k2)$$

PRG Equation:

$$PRG\ \ (ug/L) = C = \frac{T\ \text{arg}\ et\ \ Risk}{(k1 + k2)}$$

where:

$$k1 = \sum_{i=a}^{i=d} \frac{IR_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot SF \cdot ADAF_i$$

$$k2 = \sum_{i=a}^{i=d} \frac{2FA \cdot K_p \cdot CF \cdot \sqrt{(6 \cdot T_{event} \cdot t_{event\,i} / \Pi)} \cdot EV \cdot SA_i \cdot EF_i \cdot ED_i}{BW_i \cdot AT} \cdot \frac{SF}{ABS_{GI}} \cdot ADAF_i$$

and:

i = age interval,

a = 0 - <2 years

b = 2 - <6 years

c = 6 - <16 years

d = 16 - <30 years

Inputs:

EXPOSURE PARAMTERS (by age interval, i)					
Parameter	Units	0-<2	2-<6	6-<16	16-<30
Target Risk	(unitless)	1.0E-06	1.0E-06	1.0E-06	1.0E-06
IR	(L/day)	1	1	2	2
CF	(L/cm^3)	1.0E-03	1.0E-03	1.0E-03	1.0E-03
FA [1]	(unitless)	1.0	1.0	1.0	1.0
K_p [1]	(cm/hr)	1.1E-03	1.1E-03	1.1E-03	1.1E-03
T_{event} [1]	(hr/event)	1.15	1.15	1.15	1.15
EV [2]	(event/day)	1	1	1	1
t_{event} [2]	(hr/event)	1.0	1.0	0.58	0.58
SA [2]	(cm^2)	6,600	6,600	18,000	18,000
BW	(kg)	15	15	70	70
EF	(days/year)	350	350	350	350
ED	(years)	2	4	10	14
AT	(days)	25,550	25,550	25,550	25,550
SF_{oral} [3]	(mg/kg-day)-1	2.3E+02	2.3E+02	2.3E+02	2.3E+02
ABS_{GI} [4]	(unitless)	1.0	1.0	1.0	1.0
ADAF	(unitless)	10	3	3	1

Footnotes:

[1] USdPA 2004 recommended default adherence factor (AF) for a child resident (0.2) and adult resident (0.07), see Exhibit 3-3 and pages 3-14 to 3-17.

[2] USEPA 2004 recommended surface area (SA) exposed to contaminated soil for residents.

[3] IRIS 2006. http://www.epa.gov/iris/. Accessed July 2006.

[4] No adjustment of the slope factor recommended by USEPA 2004 (Exhibit 4-1).

References:

USEPA 1991. Standard Default Exposure Factors. OSWER directive 9285.6-03

USEPA 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment).

PRG Calculations

A. k1:

(0-<2) = [(1/15) * (350/365) * (2/70) * 2.3E+02 * 10] =4.2E+00

(2-<6) = [(1/15) * (350/365) * (4/70) * 2.3E+02 * 3] =2.5E+00

(6-<16) = [(2/70) * (350/365) * (10/70) * 2.3E+02 * 3] =2.7E+00

(16-<30) = [(2/70) * (350/365) * (14/70) * 2.3E+02 * 1] =1.3E+00

k1 = 4.2E+00 + 2.5E+00 + 2.7E+00 + 1.3E+00 = 1.1E+01

B. k2:

(0-<2) = [(2*1) * 1.1E-03 * 1E-03 * √(6*1.15 * 1/π) * 1 * 6,600/15) * (350/365) * (2/70) * (2.3E+02/1) * 10] = 9.0E-02

(2-<6) = [(2*1) * 1.1E-03 * 1E-03 * √(6*1.15 * 1/π) * 1 * 6,600/15) * (350/365) * (4/70) * (2.3E+02/1) * 3] = 5.4E-02

(6-<16) = [(2*1) * 1.1E-03 * 1E-03 * √(6*1.15 * 0.58/π) * 1 * 18,000/70) * (350/365) * (10/70) * (2.3E+02/1) * 3] = 6E-02

(16-<30) = [(2*1) * 1.1E-03 * 1E-03 * √(6*1.15 * 0.58/π) * 1 * 18,000/70) * (350/365) * (14/70) * (2.3E+02/1) * 1] = 2.8E-02

k2 = 9.0E-02 + 5.4E-02 + 6.0E-02 + 2.8E-02 = 2.3E-01

C. PRG:

$$PRG(mg/L) = \frac{1E-06}{(1.1E+01 + 2.3E-01)} = 9.2E-08$$