POOR ORIGINAL

INPUT DATA

FOR RADIOLOGICAL ASSESSMENT OF

THE DAWN MINING COMPANY URANIUM MILL

March, 1981

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I. Principal operating parameter values to be used in radiological assessment of the Dawn Mining Company uranium mill

Parameter	Value(s)
A. General Data	
Average ore grade, % U_3O_8	0.153
Ore concentration, pCi/g U-238 and daughters	432.0
Ore processing rate, MT/d	430.0
Days/yr operational	346
B. Ore Storage Pile(s)	
Actual area, acres	13.6
Annual average dust loss rate, g/m^2-yr	42.0
Dust/ore activity ratio	2.5
Reduction factor for chemical spraying and wetting, %	25%
Release rate for truck dumping and ore pad activities, %	1.8×10^{-5}
Specific Rn-222 flux from ore piles, $\frac{pCi/m^2\text{-sec}}{pCi/gm\ Ra\text{-}226}$	1.0
C. Hoppers and Feeders	
Release rate for ore feeding, %	0.01
Dust/ore activity ratio	2.5
Reduction factor for dust control, %	25%
Fraction of Rn-222 equilibrium ore content released, %	20.0
D. Crushing and Grinding	
Release rate for crushing and grinding, %	0.008
Efficiency of particulate loss control, %	99.5
Dust/ore activity ratio	2.5
Fraction of Rn-222 equilibrium ore content released, %	20.0
E. Fine Ore Storage	
Release rate for fine ore activities, %	0.004
Efficiency of particulate loss control, %	80.0
Dust/ore activity ratio	2.5
Fraction of Rn-222 equilibrium ore content released, %	20.0
F. Yellowcake Drying	
Yellowcake production rate, MT/year	214.0
Release rate of yellowcake product to atmosphere, %	2.26×10^{-5}
Yellowcake fraction of U-238, %	94.0
Yellowcake fraction of Th-230, %	0.5
Yellowcake fraction of Pb-210, %	0.1
Yellowcake fraction of Ra-226, %	0.1
Yellowcake purity, %	79.0

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Parameter	Value(s)
G. Yellowcake Packaging	
Release rate of yellowcake to atmosphere, %	1.62×10^{-5}
Yellowcake fraction of U-238, %	94.0
Yellowcake fraction of Th-230, %	0.5
Yellowcake fraction of Pb-210, %	0.1
Yellowcake fraction of Ra-226, %	0.1
H. Tailings Impoundment System	
General Parameters	
Fraction U to tailings, %	6.0 to 9.2
Fraction Th to tailings, %	95.0
Fraction Ra and Pb to tailings, %	99.8
Annual average dust loss rate, g/m^2-yr	420.0
Dust/tails activity ratio	2.5
Dusting reduction factor for water cover, moisture, and chemical agents, %	80.0
Specific Rn-222 flux from exposed beach, pCi/m^2-sec Rn-222 / pCi/ Ra-226	1.0
Abandoned tailings impoundment	
Total area, acres	59.2
Area exposed to dusting, %	1.0-3.0
Tailings activities, pCi/gm	
U-238	62.1
Th-230	641.2
Ra-226	673.6
Pb-210	673.6
Inactive Tailings Impoundment	
Total area, acres	47.0
Area exposed to dusting, %	0.5 to 10.0
Reduction factor of dust loss by chemical stabilization and wetting, %	50.0
Tailings activities, pCi/gm	
U-238	40.5
Th-230	641.2
Ra-226	673.6
Pb-210	673.6
New tailings impoundment	
Total area, acres	27.2
Reduction factor of dust loss by water cover, chemical stabilization, %	0.2
Tailings activities, pCi/gm	
U-238	26.0
Th-230	410.4
Ra-226	431.2
Pb-210	431.2

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SUMMARY OF SOURCE TERMS

No.	km x	km y	m z	km^2 Area	CI/year U-238	Th-230	Ra-226	P
1	0.18	0.00	-3.00	0.0550	2.89E-03	2.89E-03	2.89E-03	2.
2	0.08	0.07	-3.00	0.0000	1.01E-03	1.01E-03	1.01E-03	1.
3	0.08	0.07	12.00	0.0000	6.43E-05	6.43E-05	6.43E-05	6.
4	0.08	0.06	-2.00	0.0000	1.29E-03	1.29E-03	1.29E-03	1.
5	0.00	0.00	20 00	0.0000	1.08E-03	5.40E-06	1.08E-06	1.
6	-0.01	0.00	11.00	0.0000	7.76E-04	3.88E-06	7.76E-07	7.
7	0.18	0.00	-3.00	0.0550	6.24E-04	6.24E-04	6.24E-04	6.
8	-0.39	-0.52	3.00	0.0072	4.69E-04	4.85E-03	5.09E-03	5.
9	-0.87	-0.40	1.00	0.0950	4.04E-03	6.40E-02	6.72E-02	6.
10	-0.79	-0.62	1.00	0.0950	4.04E-03	6.40E-02	6.72E-02	6.
11	-0.91	-0.81	6.00	0.0410	1.12E-03	1.77E-02	1.86E-02	1.
12	-1.00	-0.86	6.00	0.0690	1.88E-03	2.97E-02	3.12E-02	3.

INPUT TAILS ACTIVITIES, PCI/G

SET	URANIUM	THORIUM	RADIUM	LEAD
1	43.2	43.2	43.2	43.2
2	26.0	410.4	431.2	431.2
3	62.1	641.2	673.6	673.6
4	40.5	641.2	673.6	673.6

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[illegible]	Rn-222	P Size Set	M/sec Exit Vel	Source Name
-03	0.	3	0.	Ore Pad Activities
-03	1.29E+01	2	0.	Hoppers + Feeders
-05	1.28E+01	2	20.	Crushers + Grinders
-03	1.29E+01	2	0.	Fine Ore Storage
-06	0.	1	4.6	Yellowcake Dryer
-07	0.	1	11.	Yellowcake Packaging
-04	7.48E+02	3	0.	Ore Pad Windage
-03	5.09E+03	3	0.	Abandoned Tailings
-02	2.02E+03	3	0.	Inactive Tailings 1
-02	2.02E+03	3	0.	Inactive Tailings 2
-02	3.91E+01	3	0.	Present Tailings 1
-02	6.57E-01	3	0.	Present Tailings 2

PARTICLE SIZES AND FRACTIONAL DISTRIBUTION

1.0	1.0	5.0	35.0	PDEN
1.000	0	0	0	8.900
0	1.000	0	0	2.400
0	0	0.300	0.700	2.400

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Particulate Source Strength Multipliers by Time Step

Source No.	T Step 1 20 yrs	T Step 2 3 yrs	T Step 3 7 yrs	T Step 4 3 yrs
1	1.	1.	1.	0.
2	1.	1.	1.	0.
3	1.	1.	1.	0.
4	1.	1.	1.	0.
5	1.	1.	1.	0.
6	1.	1.	1.	0.
7	0.25	0.25	0.25	0.25
8	1.	1.	0.333	0.333
9	0.05	0.01	0.0025	0.0025
10	0.05	0.01	0.0025	0.0025
11	0.	0.002	0.002	1.
12	0.	0.002	0.002	1.

Radon Source Strength Multipliers by Time Step

Source No.	T Step 1 20 yrs	T Step 2 3 yrs	T Step 3 7 yrs	T Step 4 3 yrs
1	1.	1.	1.	0.
2	1.	1.	1.	0.
3	1.	1.	1.	0.
4	1.	1.	1.	0.
5	1.	1.	1.	0.
6	1.	1.	1.	0.
7	1.	1.	1.	0.
8	1.	1.	1.	1.
9	0.9	1.	1.	1.
10	0.9	1.	1.	1.
11	0.	0.8	0.8	1.
12	0.	0.8	0.8	1.

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II. Source Term Calculations

Refs

Source No. 1 - Ore Pad Activities

- Dust Emission from Truck Dumping

  = .01 kg/MT ore — 1-pg 33

- Dust from Front End Loader Operation — 1-pg 29

  The reference gives .025 kg/MT for loading ore into a truck. But clearly most of the dust must be generated when the load is dropped. In the present case, discharge is not into a truck, but into the hopper of the crusher building, which is described as Source No. 2. Therefore, it is reasonable to assume 20% of the above figure is emitted on the Ore Pad, or .005 kg/MT ore.

- Dust from Bulldozer Operation

  No emission values are reported, so an estimate will be made from the .025 kg/MT value reported above for front end loader operation. The dozer handles only 200 MT/day, compared to 430 MT/day for the loader. Also, the dozer is used only 6 months/yr, compared to 12 for the loader. Finally, we use a reduction factor of 2 because the material is not dropped. Therefore, we estimate:

$$.025\ \frac{kg}{MT} \times \frac{200}{430} \times \frac{6}{12} \times \frac{1}{2} = .003\ kg/MT$$

Total from Machinery on Ore Pad =

$$.01 + .005 + .003 = .018\ kg/MT\ ore$$

Ore Processing Rate, MT/d = 430.0 — 2

Days/yr operational = 346 — 2

Ore Processed, MT/yr = 148,780

Total Dust from Machinery on Ore Pad =

$$.018\ \frac{kg}{MT} \times 148,780\ \frac{MT}{y} = 2678\ kg/y$$

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Refs

Ore activity, pCi/g = 432.0 2

Dust/ore activity ratio = 2.5 2

∴ Source Value, Ci/y =

$$= (432.0)(2.5)(2.678 \times 10^{6})(10^{-12}\ Ci/pCi) = 2.89 \times 10^{-3}\ \frac{Ci}{y}$$

(Ore Pad Windage is not included here. It is presented as Source No. 7. Radon from the ore pad is included with Source No. 7.)

Source No. 2 - Hoppers and Feeders

Front End Loader deposits ore through a grizzly over a hopper which is a part of the dust-controlled crusher building. If the loader were dumping into an open truck, an emission rate of .025 kg/MT ore would be appropriate. Because the material is dumped into a baghouse equipped building, a reduction of 50% is justified; also, because 6 months of the operation takes place under very wet, saturated conditions, another 50% reduction should be applied. Thus, dust emissions are: 1-pg 29

$$.025\ \frac{kg}{MT} \times .5 \times .5 = .0063\ kg/MT\ ore$$

∴ and Source Value = $.0063\ \frac{kg}{MT} \times 148{,}780\ \frac{MT}{y} \times 1080\ \frac{pCi}{g} \times 10^{-12}\ \frac{Ci}{pCi}$

$$\times 10^{3}\ \frac{g}{kg} = 1.01 \times 10^{-3}\ \frac{Ci}{y}$$

Radon in this source:

Estimate 20% of the secular equilibrium content is released: 2

∴ Rn Source Value =

$$148{,}780\ \frac{MT}{y} \times 10^{6}\ \frac{g}{MT} \times 10^{-12}\ \frac{Ci}{pCi} \times .2 \times 432\ \frac{pCi}{g} = 12.9\ \frac{Ci}{y}$$ 2

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Refs

Source No. 3 - Crushing and Grinding

Dust collection efficiency of a properly functioning baghouse exceeds 99.5%. The NRC staff downgraded estimated performance for purposes of this source calculation to 99%, to account for downtime and other routine losses of efficiency. However, Dawn's crusher plant baghouse, rated at 12,500 cfm, was replaced in 1980 by a new Fabri-Pulse collector rated at 18,000 cfm. Furthermore, routine procedure is to shut down the crusher operation when baghouse maintenance is required. Under these circumstances, Dawn believes the 99.5% value is justified. 3, 2, 4-pg 20

Based on Sears, et al, we estimate .008% of the ore crushed becomes dust to the exhaust air ventilation flow. Actually, this is conservative because Dawn ore may be expected to average more than 6% moisture (upon which Sears' value is based). 5-pg 4, Par.1

The release rate to the atmosphere is then:

$$= 148,780 \frac{MT}{y} \times 8 \times 10^{-5} \times \left(\frac{100 - 99.5}{100}\right) = .0595 \frac{MT}{y}$$

.. and the Source Term Value $= .0595 \frac{MT}{y} \times 1080 \frac{pCi}{g} \times 10^{6} \frac{g}{MT} \times 10^{-12} \frac{Ci}{pCi}$

$$= 6.43 \times 10^{-5} \text{ Ci/y}$$

Grinding is done wet, and makes no significant contribution to this source term.

.. Radon from Source No. 3 is taken as the same value as from Source No. 2, for the same reasons, with the minor difference that the computed value in that case, 12.85, was rounded to 12.9; in order to prevent accumulation of rounding error, it is now taken as $12.8 \frac{Ci}{y}$.

. Stack exit velocity

Ventilation exhaust rate = 18,000 cfm.

- Stack cross section = $3.69\ ft^2$

Nominal exit velocity, m/sec =

$$= 18,000 \frac{ft^3}{min} \times \frac{min}{60\ sec} \times \frac{m}{3.2808\ ft} \times \frac{1}{3.69\ ft^2}$$

$$= 24.8\ m/sec$$

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Refs

Measured exit velocity = 19.8 - 20.7 m/sec 6

∴ Value selected for MILDOS calculation = 20 m/sec

Source No. 4 - Fine Ore Storage

For totally enclosed conveyor transfer points, uncontrolled emission factor employed by Colorado Air Pollution Control Division, Dept. of Health, is .02 lb/ton (.01 kg/MT) for each transfer point.

Dawn uses 2 transfer points in and 2 out, of dry crushed ore.

Therefore, emission factor should be $4 \times .01 = .04 \frac{\text{kg dust}}{\text{MT ore}}$

Efficiency of control of these emissions is estimated to be 80%, probably a conservative value, since all of the transfer points are inside the mill building, in a partitioned-off section of it.

$$\text{Quantity of Dust Emitted} = .04 \frac{kg}{MT} \times 148{,}780 \frac{MT}{y} \times .2$$

$$= 1190 \text{ kg/y}$$

$$\therefore \text{Source value, Ci/y} = 1080 \frac{pCi}{g} \times 1.190 \times 10^{6} \frac{g}{y} \times 10^{-12} \frac{Ci}{pCi}$$

$$= 1.29 \times 10^{-3}$$

∴ Again, the radon source term is estimated to be 12.9 Ci/y for reasons given for above unit operations.

Source No. 5 = Yellowcake Drying

(Yellowcake Packaging is treated separately, as Source No. 6)

Recovery rate of U_3O_8 = 94.0% 7

Y.C. Production Rate =

$$148{,}780 \frac{MT}{y} \times .153\% \times 94.0\% = 214.0 \frac{MT}{y}$$ 2

where 0.153% is the average ore grade.

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Refs

Operating Time = $298 \frac{days}{yr} \times 24 \frac{h}{day} = 7152 \frac{h}{yr}$ 8

Hourly Production Rate =

$= \frac{214.0\ MT/y}{7152\ h/y} = .030\ MT/h$

Particulate emission rate, measured = 6.79×10^{-4} kg/h 9

Dryer release fraction =

$= \frac{6.79 \times 10^{-4}\ kg/h}{.030 \times 10^{3}\ kg/h} = 2.26 \times 10^{-5}$

Y.C. annual release from dryer =

$= 214.0 \frac{MT}{y} \times 2.26 \times 10^{-5} = 4.84 \times 10^{-3} \frac{MT}{y}$

U-238 particulate source term =

$= 4.84 \times 10^{-3} \frac{MT}{y} \times 10^{6} \frac{g}{MT} \times 3.33 \times 10^{-7} \frac{Ci}{g\ U\text{-}238} \times .85 \times .79$

$\therefore = 1.08 \times 10^{-3}$ Ci/y

where .85 is the fractional U content of U_3O_8
and .79 is the reported Y.C. purity.

$\therefore$ Th-230 source term = 0.5% of U-238 source term 5
$= 1.08 \times 10^{-3} \times .005 = 5.40 \times 10^{-6}$ Ci/y

$\therefore$ Ra-226 source term = 0.1% of U-238 source term 5
$= 1.08 \times 10^{-3} \times .001 = 1.08 \times 10^{-6}$ Ci/y

$\therefore$ Pb-210 source term = Same as Ra-226 = 1.08×10^{-6} Ci/y 5

Stack Height = 20 meters 8

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Refs

·· Stack Exit Velocity = 15 fps = 4.6 m/sec 9

·· Radon source term = 0

Source No. 6 - Yellowcake Packaging

Hourly Y.C. Production Rate = .030 MT/h 2

Particulate emission rate, measured =

$= 4.85 \times 10^{-4}$ kg/h 9

Packaging release fraction =

$$= \frac{4.85 \times 10^{-4} \text{ kg/h}}{.030 \times 10^{3} \text{ kg/h}} = 1.62 \times 10^{-5}$$

Y.C. Annual release from packaging stack =

$$= 214.0 \frac{MT}{y} \times 1.62 \times 10^{-5} = 3.47 \times 10^{-3} \frac{MT}{y}$$

·· U-238 particulate source term =

$$= 3.47 \times 10^{-3} \frac{MT}{y} \times 10^{6} \frac{g}{MT} \times 3.33 \times 10^{-7} \frac{Ci}{g\ U\text{-}238} \times .85 \times .79$$

$= 7.76 \times 10^{-4}$ Ci/y

where .85 is the fractional U content of U_3O_8

and .79 is the reported Y.C. purity,

·· Th-230 source term = 0.5% of U-238 value 5

$= 7.76 \times 10^{-4} \times .005 = 3.88 \times 10^{-6}$ Ci/y

·· Ra-226 source term = 0.1% of U-238 value, 5

$= 7.76 \times 10^{-4} \times .001 = 7.76 \times 10^{-7}$ Ci/y

·· Pb-210 source term = same as Ra-226 = 7.76×10^{-7} Ci/y 5

Stack Height = 11 meters 8

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Refs

∴ Stack Exit Velocity = 36.3 fps = 11 meters/sec 9

∴ Radon source term = 0

Source No. 7 - Ore Pad Windage

Dust emission rate, uncontrolled = 42.0 g/m²/yr 2

Pad Area = 55,000 m² (10% of tailings dust loss rate)

Ore Activity = 432.0 pCi/g

Dust/Ore activity ratio = 2.5

Control factor due to snow cover and precipitation, 6 months, is 100%

Control factor due to wetting down the pad, during the other 6 months, is 50%

Average annual control = 75%, or

∴ Average annual control factor (Particulate Source Strength Multiplier, all Timesteps) = 0.25

∴ Source value (without control) =

$$42.0 \frac{g}{m^2\text{-}y} \times 55{,}000\ m^2 \times 432 \frac{pCi}{g} \times 10^{-12} \frac{Ci}{pCi} \times 2.5$$

$$= 2.49 \times 10^{-3}\ Ci/yr$$

Radon release from ore stored on pad:

$$\text{Release rate} = 1.0 \frac{pCi/m^2\text{-sec Rn-222}}{pCi/gm\ \text{Ra-226}}$$

∴ Radon source term =

$$1.0 \times 432 \frac{pCi}{g} \times 3.156 \times 10^7 \frac{sec}{yr} \times 10^{-12} \frac{Ci}{pCi} \times 55{,}000\ m^2 =$$

$$= 748\ Ci/yr$$

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Refs

Source No. 8 - Abandoned Tailings Area

MILDOS limits tailings areas, for calculation purposes, to 0.1 km^2. The actual size of the abandoned tailings area at Dawn is 59.2 acres = 0.24 km^2. However, this area is presently covered by a layer of woodchips nominally 2 ft thick. A conservative estimate of the effectiveness of this cover, at present, is 97%, so that 2

Area exposed to dusting = 3% of .24 km^2 = .0072 km^2

Since this is less than 0.1 km^2, there is no need to subdivide it into multiple sources.

When, in 1985, the permanent thick cover is in place, a very conservative estimate of its effectiveness is taken to be 99%, so that only 1% is exposed. We will retain the .0072 km^2 area in the calculation, and account for the threefold future decrease in area exposed to dusting by means of the particulate source strength multiplier, which varies with timestep.

We will assign the timesteps as follows:

Timestep 1	Past Twenty Years	
Timestep 2	1981 - 1984	Three Years (To Final Cover on Source No. 8)
Timestep 3	1985 - 1991	Seven Years (To End of Operation)
Timestep 4	1992 - 1994	Three Years (Drying Time for Sources Nos. 11, 12)

For Source No. 8, the values of particulate source strength multipliers are:

Timestep 1	1.000
2	1.000
3	3.333×10^{-1}
4	3.333×10^{-1}

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Refs

Tailings activities, pCi/g 2

U -238	62.1
Th-230	641.2
Ra-226	673.6
Pb-210	673.6

Fraction U to tailings = 9.2% 2

Fraction Th to tailings = 95.0% 2

Fraction Ra and Pb to tailings = 99.8% 2

Annual average dust loss rate (from uncontrolled tailings)

$= 420.0\ g/m^2/yr$ 2

Dusting reduction factor for water cover, moisture, chemical agents = 80.0% 2

Dust/Tails activity ratio = 2 2

Source Terms (particulates), based on present area exposed to dust erosion, before dust control factors are applied:

$$\therefore \quad U\text{-}238 = \left(420\ \frac{g}{m^2\text{-}y}\right)\left(62.1\ \frac{pCi}{g}\right)(2.5)(.0072\ km^2)(10^{-6}) = 4.69 \times 10^{-4}\ \frac{Ci}{yr}$$

where 2.5 is the Dust/Ore Activity Ratio
and 10^{-6} is a conversion factor $= \frac{Ci}{pCi} \times \frac{m^2}{km^2}$

$$\therefore \quad Th\text{-}230 = (420)(641.2)(2.5)(.0072)(10^{-6}) = 4.85 \times 10^{-3}\ Ci/y$$

$$\therefore \quad Ra\text{-}226 = (420)(673.6)(2.5)(.0072)(10^{-6}) = 5.09 \times 10^{-3}\ Ci/y$$

$$\therefore \quad Pb\text{-}210 = 5.09 \times 10^{-3}\ Ci/y \quad \text{(Same as Ra-226)}$$

Coordinates x, y, z of Source No. 8 were determined by dividing it into three sub-areas of simple geometric shape (rectangles, triangles), locating the center (centroid) of each, and calculating the coordinates by

$$\bar{x} = \frac{\Sigma\, x_i\, A_i}{\Sigma\, A_i} \qquad \bar{y} = \frac{\Sigma\, y_i\, A_i}{\Sigma\, A_i} \qquad \bar{z} = \frac{\Sigma\, z_i\, A_i}{\Sigma\, A_i}$$

Refs

Coordinate values are:

$$x = -0.39 \text{ km}$$

$$y = -0.52 \text{ km}$$

$$z = +3.3 \text{ km}$$

$$\text{Specific Radon flux} = 1.0 \frac{\text{pCi/m}^2\text{-sec Rn-222}}{\text{pCi/g Ra-226}}$$

Area for Rn calculation = 59.2 acres = $2.396 \times 10^5 \text{ m}^2$

∴ Radon Source Term =

$$= (1.0)(673.6 \frac{\text{pCi}}{\text{g}})(2.396 \times 10^5 \text{ m}^2)(3.156 \times 10^7 \frac{\text{sec}}{\text{y}})(10^{-12} \text{ Ci/pCi})$$

$$= 5.09 \times 10^3 \frac{\text{Ci}}{\text{y}}$$

Source No. 9 - Inactive Tailings I

Preparation of a new subgrade tailings disposal area is now underway, and it is contemplated that within a few months, it will be in use. The disposal area previously in use (designated as "Present Pile Area" in the August 1980 Radiological Assessment performed in the course of obtaining a license amendment authorizing the new disposal area) will be allowed to dry, and as it does, the exposed surfaces will be covered initially with a one-foot layer of earth, or by a chemical stabilization technique, with the objective of controlling dust emission. The permanent cover will be designed in accordance with the NRC Mill Licensing Requirements (FR October 3, 1980, 65521-65538), Appendix A, and its counterpart in the regulations of the State of Washington, or whatever revisions thereto may be in effect.

Since the disposal area used recently may no longer be in use at the time the Dawn license renewal application is reviewed, we have changed its name, in the interest of clarity, from Present Tailings Area to Inactive Tailings Area. Similarly, we have changed the designation of what, in the August 1980 assessment was called Future Pit Area to New Tailings Area.

Since the Inactive Tailings Area exceeds 0.1 km^2, we have arbitrarily subdivided it for MILDOS calculation purposes into two parts, locating a center and representative elevation for each. As with Source No. 8, the calculation of coordinates is based on ratios of $\Sigma x_i A_i / \Sigma A_i$, where the x_i (or y_i or z_i) are taken from simple geometric shapes into which the overall area has been divided.

For Source No. 9 (Inactive Tailings I)

$$\text{Area} = 0.095 \text{ km}^2$$
$$x = -0.87 \text{ km}^2$$
$$y = -0.40 \text{ km}^2$$
$$z = +1.0 \text{ m}$$

Efficiency of Dust Control:

During the transition, when this site ceases to receive tailings, is allowed to dry, and a chemical stabilizer or a one-foot cover layer of earth is applied, we assume there will be a small zone which is no longer wet enough to prevent dusting, and to which the cover has not yet been applied. This zone is estimated to be 10% of the area.

During the interim period 1982-1984, when the transition to use of the new tailings area has been made, and the stabilizer or one-foot earth cover is in place, we estimate only 2% of the area will be exposed to dusting. When, about 1985, the final thick cover is in place, we assume 0.5% as a maximum, very conservative estimate of the area exposed to dusting.

Summarizing:

Timestep 1	1981 (Transition	= 10% exposed
Timestep 2	1982-1984 (Interim)	= 2% exposed
Timestep 3	1985-1991	= 0.5% exposed
Timestep 4	1992-1994	= 0.5% exposed

Following the practice of NRC in the August 1980 Radiological Assessment, we retain the full area of .095 km^2 for calculation of the source term table, and apply the above control values by means of particulate source strength multipliers. These are:

For Timestep 1	.100
Timestep 2	.020
Timestep 3	.005
Timestep 4	.005

Refs

These particulate source strength multipliers take into account only the reductions due to areas no longer exposed. In addition, it is appropriate to state the degree of reduction due to wetting. Conservatively, this is taken as 50%, since snow cover and saturation due to precipitation are expected 6 months of the year. The overall control values (particulate source strength multipliers) are then

Timestep 1	.050
Timestep 2	.010
Timestep 3	.0025
Timestep 4	.0025

The fraction of U to tailings has decreased, compared to the Abandoned Tailings areas, because of increased U recovery. Based on 1980 production data, it is:

Fraction U to tailings = 6.0%

Thus U-238 activity = 62.1 x 6.0/9.2 = 40.5 $\frac{pCi}{g}$

Other parameters remain unchanged:

Fraction Th to tailings = 95.0% 2

Fraction Ra and Pb to tailings = 99.8% 2

Annual average dust loss rate (from uncontrolled tailings) = 420.0 g/m^2-yr 2

Source Terms (Particulates), before dust control factors are applied:

·· U-238 $=(420 \frac{g}{M^2-y})(40.5 \frac{pCi}{g})(2.5)(.095 \times 10^6 m^2)(10^{-12} \frac{Ci}{pCi}) = 4.04 \times 10^{-3} \frac{Ci}{y}$

·· Th-230 $= (420)(641.2)(2.5)(.095 \times 10^6)(10^{-12}) = 6.40 \times 10^{-2}$ Ci/y

·· Ra-226 $= (420)(673.6)(2.5)(.095 \times 10^6)(10^{-12}) = 6.72 \times 10^{-2}$ Ci/y

·· Pb-210 $= 6.72 \times 10^{-2}$ Ci/y (Same as Ra-226)

Specific Radon flux = 1.0 $\frac{pCi/m^2\text{-sec Rn-222}}{pCi/g \text{ Ra-226}}$

Refs

∴ Radon Source Term =

$$= (1.0)(673.6)(.095 \times 10^6\ m^2)(3.156 \times 10^7\ \frac{sec}{y})(10^{-12}\ \frac{Ci}{pCi})$$

$$= 2.02 \times 10^3\ Ci/y$$

Source No. 10 - Inactive Tailings II

This has identical parameters to Source No. 9, except for the coordinates, which are:

x = -0.79 km

y = -0.62 km

z = [illegible]1.0 m

Source No. 11 - New Tailings I

The New Tailings area exceeds the MILDOS limit of 0.1 km^2, and is therefore subdivided for calculation purpose into two parts, Sources No. 11 and No. 12. For No. 11:

Area = 0.041 km^2

x = -0.91 km

y = -0.81 km

z ≈ 6 m (1739' Average elevation of area) 10-pg.5

Efficiency of Dust Control:

From the start of use, in 1981, and through its operational period, the new tailings facility provides for complete cover of tailings by water, i.e., the pool will extend over the entire area. The capacity of the facility at the present milling rate is sufficient to accommodate approximately thirteen years' 4-pg.81

Refs

production of tailings, which is in excess of the indicated available ore. Therefore, no exposed tailings beach will exist during the life of the mill. Making some provision for occasional spills, we assume 1% of the area is exposed to dusting, but since spills will be cleaned up, this should be reduced by 80%, providing:

Net overall control factor (particulate source strength multiplier) = .01 x .20

= 2×10^{-3}

This applies to Timesteps 2 and 3. (During Timestep 1, prior to use of the New Tailings Area, the multiplier is of course zero.)

Furing the Drying Period, Timestep 4, the area will be fully exposed, so that the multiplier = 1.00

Tailings are projected to have the following activities, lower than those of tailings deposited earlier, because of declining ore grade:

U-238	26.0 pCi/gm	2
Th-230	410.4	
Ra-226	431.2	
Pb-210	431.2	

The U-238 value above reflects a decrease in the fraction of uranium reporting to the tailings pond, based on 1980 production data, from a former value of 9.2% to the current value of 6.0%. Thus:

Fraction U to tailings = 6.0%

Fraction Th to tailings = 95.0%

Fraction Ra and Pb to tailings = 99.8%

Source terms (particulates) based on full area, before source strength multipliers for % exposed area and % dust control are applied:

$$\text{U-238} = (420\ \frac{g}{m^2\text{-}y})(26.0\ \frac{pCi}{g})(2.5)(.041\ km^2)(10^{-6}) = 1.12 \times 10^{-3}\ Ci/y$$

$$\text{Th-230} = (420\ \frac{g}{m^2\text{-}y})(410.4\ \frac{pCi}{g})(2.5)(.041\ km^2)(10^{-6}) = 1.77 \times 10^{-2}\ Ci/y$$

Refs

∴ $Ra\text{-}226 = (420 \frac{g}{m^2\text{-}y})(431.2 \frac{pCi}{g})(2.5)(.041\ km^2)(10^{-6}) = 1.86 \times 10^{-2}$ Ci/y

∴ $Pb\text{-}210 = 1.86 \times 10^{-2}$ Ci/y (Same as Ra-226)

Radon Source Term:

Since there will be no exposed beach, it is inappropriate to use the specific Rn-222 flux of $1.0 \ \frac{pCi/m^2\text{-sec Rn-222}}{pCi/g \ \text{Ra-226}}$,

used earlier for the tailings areas not convered by water. Tanner used 2.2×10^{-6} as the value of D/P for mud with 85% moisture, which leads to the specific radon flux calculation: 5-pg.G-13

$$J_\infty = [Ra]\ \varepsilon\ \rho\ (\lambda\ D/P)^{1/2} \times 10^4$$ 5-pg.G-12 Equa.(16)

$$= [Ra](0.2)(1.6)[(2.1 \times 10^{-6})(2.2 \times 10^{-6})]^{1/2} \times 10^4$$

$$= [Ra](6.88 \times 10^{-3})$$

We will round this to $7 \times 10^{-3} \ \frac{pCi/m^2\text{-sec Rn-222}}{pCi/g \ \text{Ra-226}}$,

from which:

∴ Radon Source Term = $(7 \times 10^{-3})(431.2)(4.1 \times 10^5\ m^2)(3.156 \times 10^7 \frac{sec}{yr})$

$$(10^{-12} \frac{Ci}{pCi}) = 3.91 \times 10^1 \text{ Ci/y}$$

Refs

Source No. 12 - New Tailings 2

Discussion of the remainder of the new tailings area, designated here New Tailings 2, is identical to New Tailings 1 (Source No. 11), except that:

Area = .069 km^2

x = -1.00 km

y = -0.86 km

z = 6 m

Since the area differs, the particulate and radon source terms are recomputed to reflect this change, giving:

Particulate Source Terms:

U-238 = 1.88×10^{-3} Ci/y

Th-230 = 2.97×10^{-2} Ci/y

Ra-226 = 3.12×10^{-2} Ci/y

Pb-210 = 3.12×10^{-2} Ci/y

Radon Source Term = 6.57×10^{1} Ci/y

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1. Jutze, G., Axetell, K., and Amick, R., "Evaluation of Fugitive Dust Emissions from Mining," (PEDCO Inc.) for EPA-IERL, June, 1976.

2. Dawn Environmental Impact Statement (EIS), August, 1980.

3. Vandegrift, A. E., Shannon, L. J., and Gorman, P. G., "Controlling Fine Particles," Chemical Engineering, June 18, 1973, Table 1.

4. Dawn License Renewal Application WN-1043-1, July 31, 1979.

5. Final Generic Environmental Impact Statement, NUREG 0706, September, 1980.

6. Greenwald, N. and Serrano, L., "Radionuclide Release Rates, Dawn Mining Company, Aug. 4-8, 1980," Magma Copper Company Department of Environmental Affairs.

7. 1980 Dawn production data.

8. Dawn Mining Company, "Principal Parameters for Radiological Assessment," May, 1980.

9. Alsid, Snowden, and Associates, Bellevue, Washington, "Atmospheric Emission Evaluation, Dawn Mining Radionuclide Data, January 30, 1980."

10. Dawn Mining Company, "Response to NRC Questions," July, 1980.

11. NRC Staff Input Values for August 1980, Radiological Assessment of Dawn Mill.

III. Receptor Coordinates

A. Nearest Receptors in the 16 Compass Directions

The 16 compass directions are listed below in order of frequency with which the wind blows toward (not from) that direction. Average wind speed is also listed, and where several sectors have the same wind direction frequency, they are listed in order of decreasing wind speed.

Next, the nearest receptor in the stated direction is identified, followed by his coordinates. Where the nearest receptor in a given direction is located outside the immediate mill vicinity (described under Table B), coordinates are omitted, but the approximate distance of the receptor from the mill is given.

	Direction	Frequency %	Speed mph	Nearest Receptor	x km	y km	z km	Distance km
1	NE	17	11.7	R-17	.52	.69	-2.	.86
2	NNE	15	11.5	R-129				2.2
3	SW	14	5.9	R-154				2.9
4	WSW	8	6.3	R-161				3.1
5	N	7	8.3	R-28	-.11	.68	12.	.69
6	ENE	6	10.4	R-16	.82	.48	-2.	.95
7	NNW	6	7.8	R-27	-.14	.64	12.	.66
8	NW	6	7.1	R-19	-.70	.56	-5.	.90
9	SSW	4	5.8	R-107				4.1
10	WNW	3	5.7	R-31	1.36	.32	-31.	1.40
11	W	3	5.5	R-165				2.50
12	E	2	7.7	R-5	.89	-.07	5.	.89
13	ESE	2	7.5	R-3	.64	.31	2.	.71
14	S	2	5.5	R-109				2.3
15	SSE	1	6.1	R-1	.42	-.62	3.	.75
16	SE	1	5.9	R-2	.44	-.45	2.	.62

B. All Residences in Immediate Mill Vicinity

The immediate vicinity is that shown on a Dawn Mining Company large-scale map (1" = 300'), which extends to 1.25 km north of the mill, 2.1 km to the east, 2.4 km to the south, and 2.4 km to the west of the yellowcake dryer stack.

Residence No.	Direction	Distance (km)	x (km)	y (km)	z (m)
R-1	SSE	.75	.42	-.62	3.
R-2	SE	.62	.44	-.45	2.
R-3	ESE	.71	.64	.31	2.
R-4	ESE	.88	.86	-.19	5.
R-5	E	.89	.89	-.07	5.
R-6	E	.97	.96	.14	1.
R-7	E	1.08	1.06	.18	5.
R-8	E	1.59	1.58	.17	9.
R-9	E	1.70	1.66	.35	8.
R-10	ENE	1.74	1.69	.41	7.
R-11	ENE	2.14	2.00	.75	6.
R-12	E	1.33	1.31	.24	2.
R-13	ENE	1.32	1.25	.43	3.
R-14	E	1.18	1.16	.24	2.
R-15	ENE	1.04	.97	.38	1.
R-16	ENE	.95	.82	.48	-2.
R-17	NE	.86	.52	.69	-2.
R-18	NNW	.85	-.43	.73	-2.
R-19	NW	.90	-.70	.56	-5.
R-20	NNW	1.05	-.58	.88	-2.
R-21	NNW	.98	-.44	.88	-2.
R-22	NNW	.99	-.31	.94	-3.
R-23	NNW	.82	-.32	.75	-4.
R-24	N	1.17	.01	1.17	-1.
R-25	N	1.17	.10	1.17	1.
R-26	NNW	1.27	-.34	1.22	11.
R-27	NNW	.66	-.14	.64	12.
R-28	N	.69	-.11	.68	12.
R-29	NNW	.68	-.14	.67	12.
R-30	NW	1.39	-1.02	.94	-6.

Residence No.	Direction	Distance (km)	x (km)	y (km)	z (m)
R-31	WNW	1.40	1.36	.32	-31.
R-32	NW	1.13	-.93	.65	-12.
R-33	ENE	1.74	1.56	.77	4.
R-34	NW	1.47	-.86	1.19	11.
R-35	ENE	1.75	1.55	.81	4.
R-36	E	1.73	1.70	.34	9.

C. Commercial Receptors and Other Stations of Interest in Immediate Mill Vicinity

C-1 Store	ESE	.78	.75	-.22	4.
C-2 Store	E	1.68	1.65	.33	8.
C-3 Store	E	1.33	1.31	.25	2.
C-4 Store	ENE	1.01	.88	.49	1.
C-5 (Fence Post Factory)	NW	1.27	-.85	.95	-4.
Air Samplg.Stat. 1	SW	1.58	-1.20	-1.03	-6.
Air Samplg.Stat. 2	NE	0.86	Same as R-17		
Stat.2,Direction, Nearer	NE	0.36	.22	.29	-2.
Stat.2,Direction, Farther	NE	1.36	.82	1.09	-2.
Grazing Area 1	W	2.03	-2.03	-.11	-37.
Grazing Area 2	NNW	1.26	-.45	1.1[illegible]	11.
Grazing Area 3	N	.80	.16	.78	-10.
Grazing Area,due S	S	2.00	0.0	-2.00	-36.

D. Specific Towns and Cities

Spokane	SE	41.88	33.3	-25.39	140.
Springdale	NNE	16.46	4.36	15.87	145.
Deer Park	E	27.72	26.98	6.35	0.
Hunters	NW	36.07	-27.78	23.01	0.
Wellpinit	W	11.99	-11.80	-2.10	0.
Davenport	SW	36.79	-24.10	-27.80	0.
Rearden	S	26.98	-0.3	-26.98	0.

E. Mill and Tailings Pond Property Boundaries

	x (km)	y (km)	z (m)
Mill, N Boundary	0.	.39	-24.
Mill, NE Boundary	.36	.41	-18.
Mill, E Boundary	.40	0.	1.
Mill, SE Boundary	.40	-.37	0.
Mill, S Boundary	0.	-1.04	6.
Mill, W Boundary	-1.22	0.	-6.
Tailings, N Boundary	-.64	-.25	-2.
Tailings, NW Boundary	-1.22	-.25	-6.
Tailings, W Boundary	-1.22	-.59	-8.
Tailings, S Boundary	-.82	-1.00	-4.
Tailings, SE Boundary	-.32	-.91	0.

IV. Population Distribution by Directional Sector and Radial Increment, to a Distance of Eight Kilometers from the Mill

	0-1 km	1-2 km	2-3 km	3-4 km	4-5 km	5-6 km	6-7 km	7-8 km
N	2	3	7	2	0	0	0	0
NNE	0	2	12	0	3	15	16	18
NE	5	4	7	6	6	6	14	11
ENE	3	17	2	0	0	0	0	0
E	6	13	0	4	11	0	0	0
ESE	6	0	0	2	8	0	0	0
SE	5	0	0	5	14	11	5	16
SSE	3	0	0	0	13	9	0	21
S	0	0	5	0	0	0	9	29
SSW	0	0	0	0	12	0	8	11
SW	0	0	1	0	3	0	0	9
WSW	0	0	0	14	3	0	0	0
W	0	0	15	15	3	0	18	42
WNW	0	6	13	5	0	0	0	0
NW	4	9	6	0	0	0	0	0
NNW	20	16	13	3	0	6	3	0

V. Characteristics of All Individuals Residing Within One Kilometer of the Mill

No.	Age	Sex	% of Time at Residence	% Annual Consumption of Locally Grown: Meat	Milk	Veg.	% Locally Grown Feed for Fowl	Pork	Beef	Other	% of Local Feed Which is Pasture Grass
R-1-1	26	F	60								
-2	3	F	60	0	0	0	Not Applicable				n.a.
-3	2	M	60								
R-2-1	28	M	60								
-2	25	F	95								
-3	8		80	0	0	0	n.a.				n.a.
-4	3		95								
-5	2		95								
R-3-1	51	M	65								
-2	50	F	100	100	100	100	-	100	20		20
-3	24	M	85								
-4	12	M	80								
R-4-1	61	M	75	50	0	0	-	50	-		
-2	16	M	75								
R-5-1	77	F	100	0	0	75	n.a.				n.a.
R-6-1	35	M	40								
-2	35	F	95								
-3	14	M	80	10	100	25	50	-	-		n.a.
-4	11	M	80								
-5	6	F	80								
R-16-1	47	M	85								
-2	22	M	95	25	0	50	not known				n.k.
-3	17	F	70								
R-17-1	30	M	60								
-2	27	F	75								
-3	9	M	80	15	0	5	-	0	-		0
-4	5	F	75								
-5	2	F	75								
R-18-1	31	M	60								
-2	28	M	60	0	0	0	n.a.				n.a.
-3	22	M	60								
-4	18	F	95								
R-19-1	50	M	75								
-2	43	F	90	0	0	10	n.a.				n.a.
-3	19		75								
-4	17		75								
R-21-1	20	M	30	0	0	0	n.a.				n.a.
R-22-1	23	M	60								
-2	19	F	60	0	0	0	n.a.				n.a.
-3	1	M	90								
R-23-1	32		50								
-2	25		50								
-3	7		80	90	0	50	-	-	50		50
-4	5		90								
-5	2		50								
R-27-1	29	M	90								
-2	27	F	90	0	0	10	n.a.				n.a.
-3	5	F	90								
-4	3	M	90								
R-28-1	50	M	90	10	0	25	-	-	-	10	5
-2	49	F	75								
R-29-1	48	F	60								
-2	40	M	90	0	0	25	n.a.				n.a.
-3	12	M	80								

Notes: R-2 is the nearest residence, at 0.62 km SE.
R-17 is the nearest residence in the prevailing win direction, at 0.86 km NE.