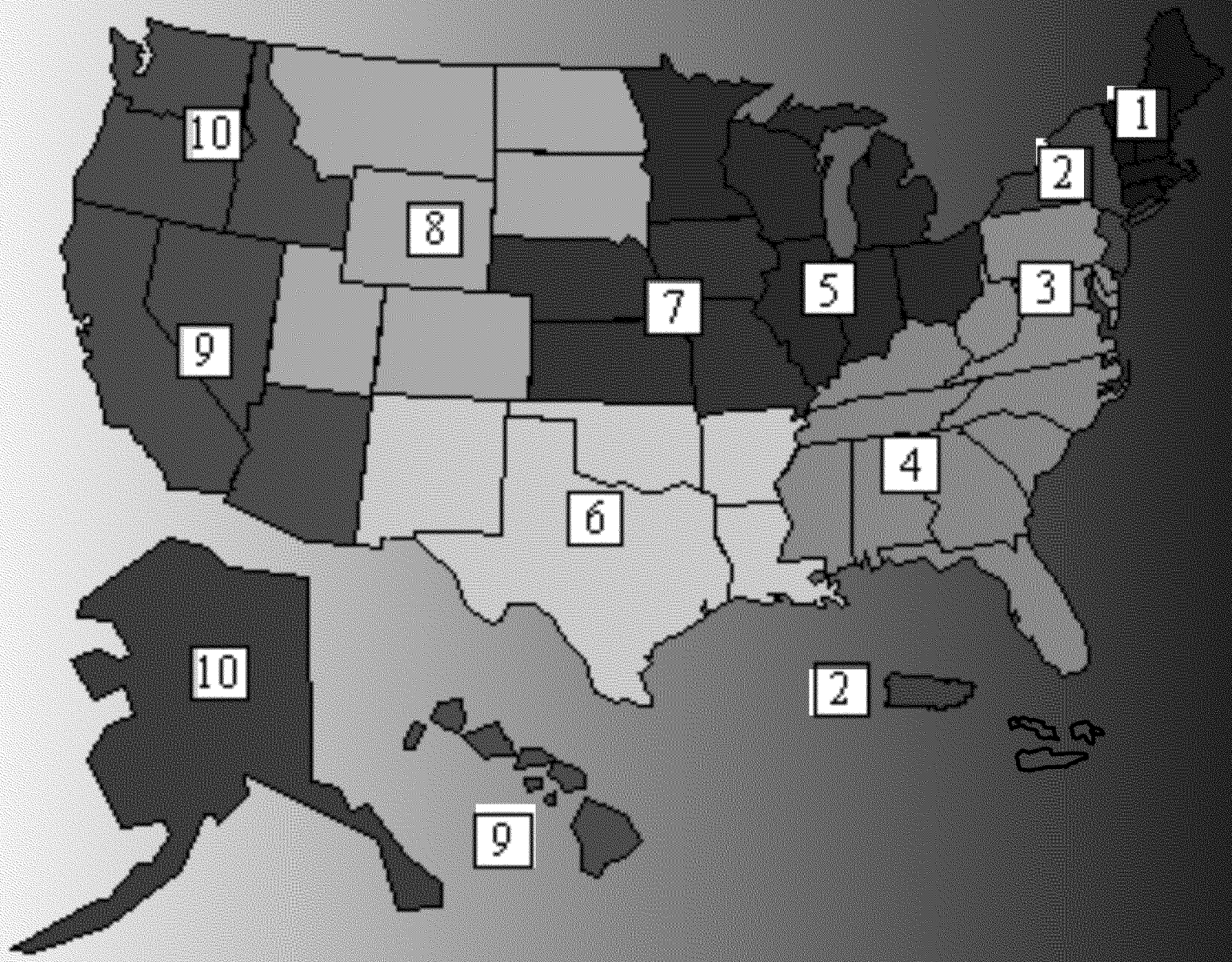
# Niagara Falls Boulevard Removal Site Proposal

Lyndsey Nguyen, Health Physicist
USEPA Environmental Response Team—West

Eric Daly, On-Scene Coordinator
USEPA Region 02

February 29, 2016

# Who we are?



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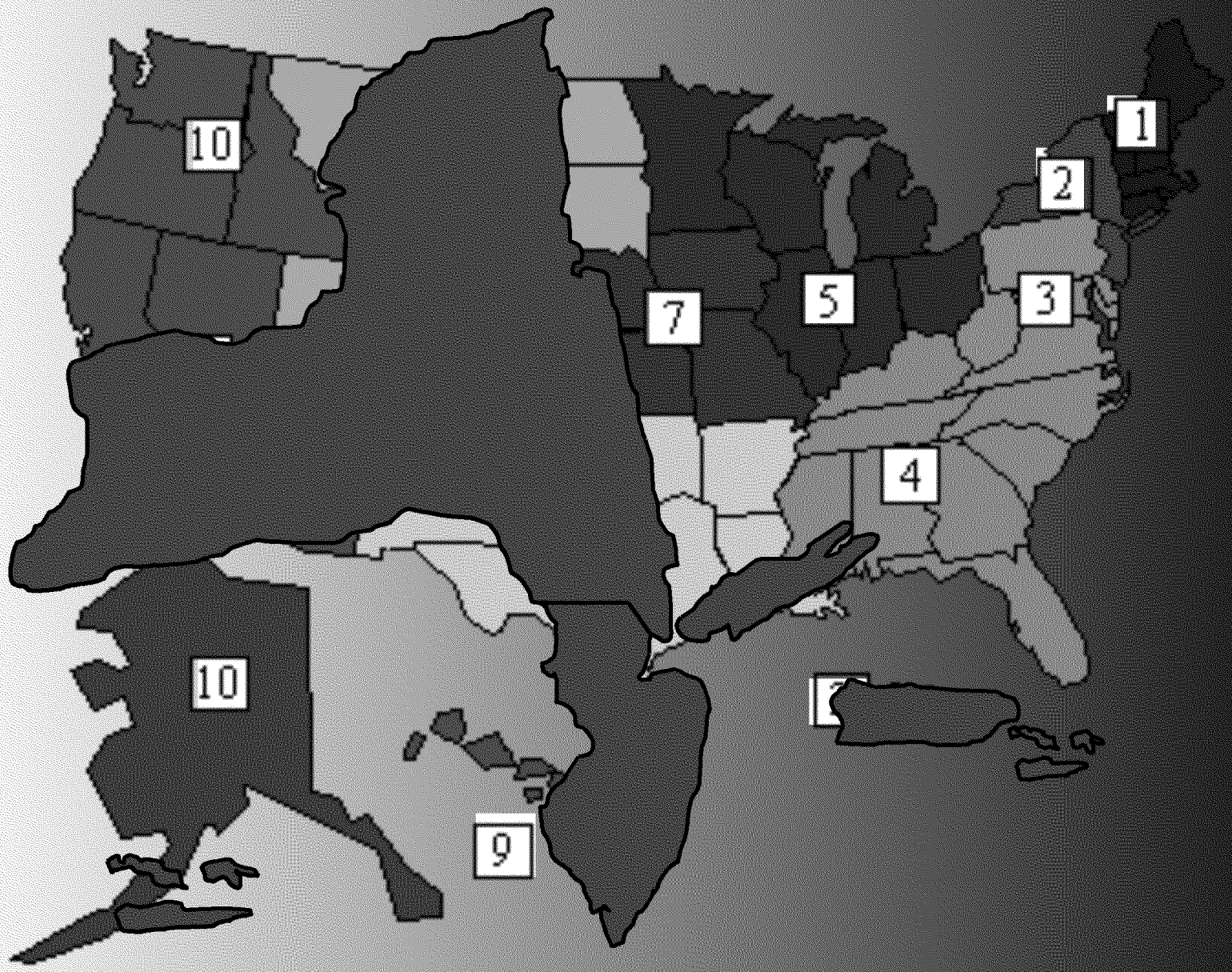
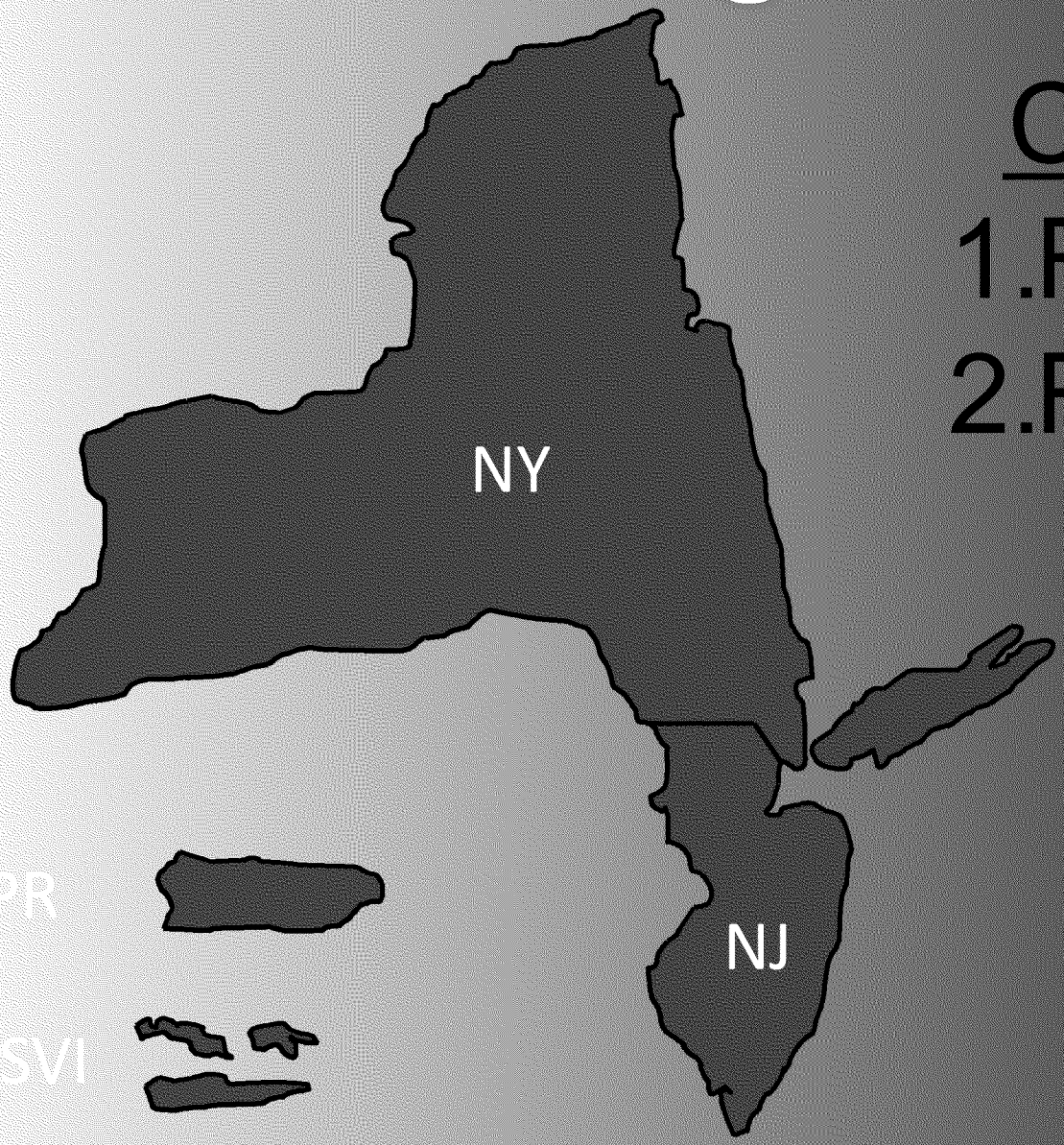


# Region 2




Clean up:

1. Removal – OSC
2. Remedial – RPM

# How does it work?

Immediate Threat?
Emergence aspect?

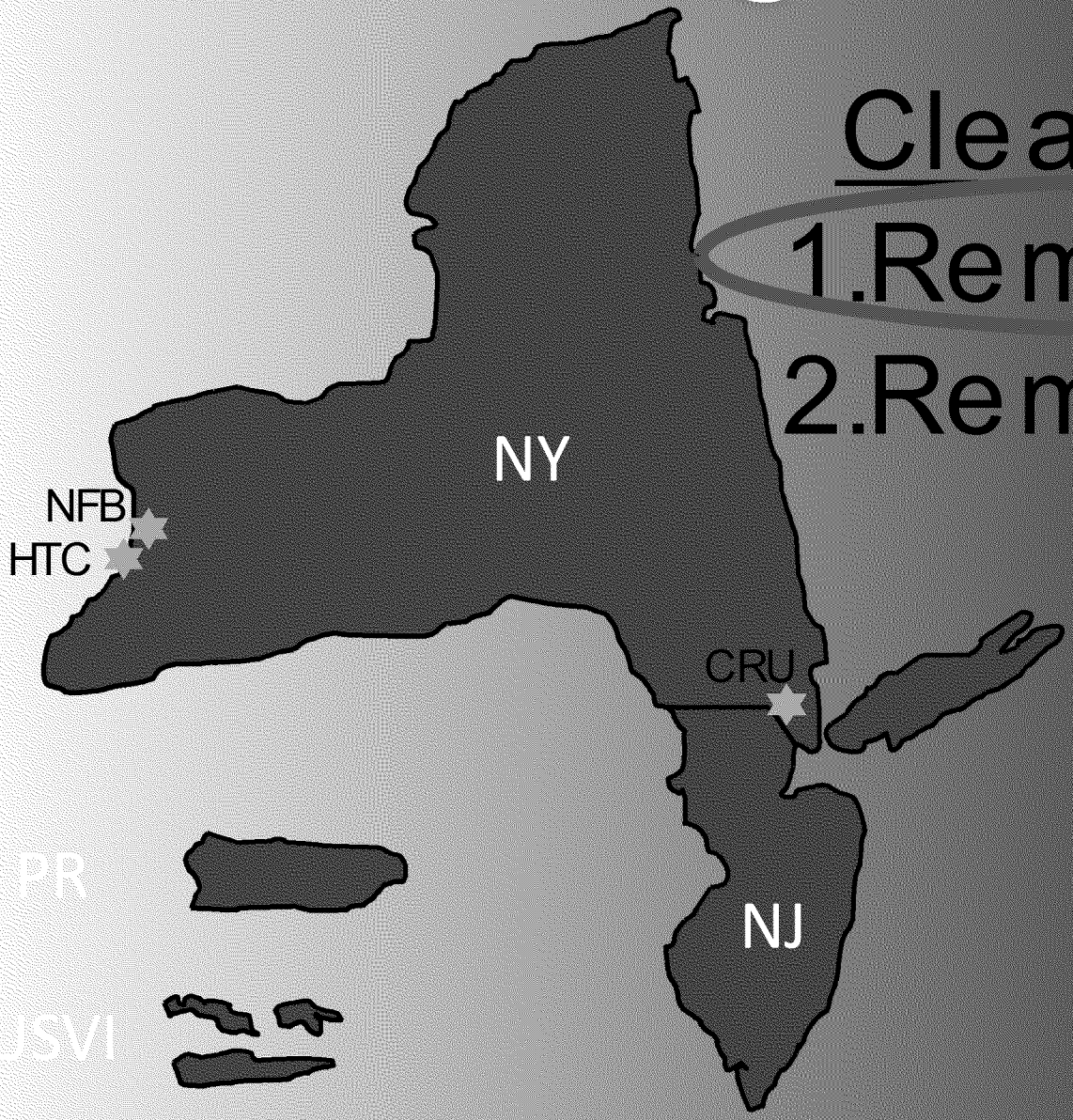
Removal ← → Remedial

Pre-Remedial

Meet the
National Priority List?

Removal ← → Remedial

# Region 2




Clean up:

1. Removal–OSC
2. Remedial–RPM

# Special Teams

- Environmental Response Team (ERT)
- Radiological Emergency Response Team (RERT)
- Consequence Management Advisory Team (CMAT)
- National (NCERT)

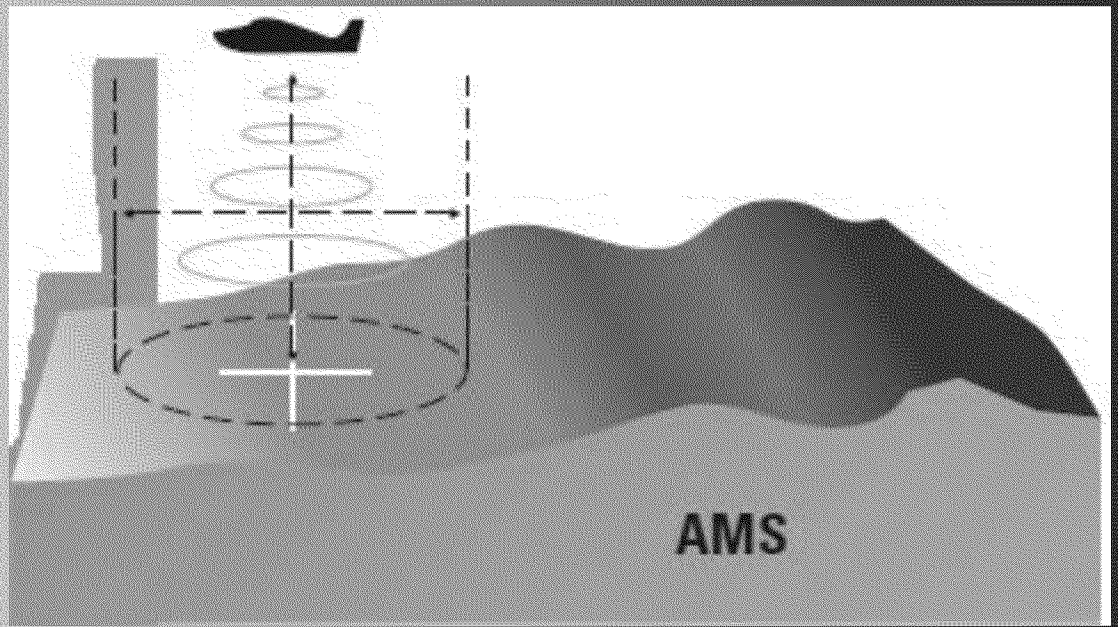
# Property

# History

- 1960s contamination was due to slag from the Union Carbide facility who processed ore containing naturally occurring high levels of uranium and thorium to extract niobium
- Slag was used as fill dirt for roadways and parking lots throughout the Niagara Falls region

# Historical Site Assessment

- 1978—DOE conducted an aerial radiological survey of the Niagara Falls region
- 15 properties were identified having elevated levels of radiation above background



# 1979

- NYDEC and NYDOH—conducted a radiological survey of the interior of the buildings and in the parking lots
- Slag samples were collected
- Highest readings were:
  - 100µR/hr inside the buildings
  - 200-500uR/hr in the parking lot
  - Background 10-20µR/hr
- Slag samples showed:
  - U-238 concentrations of 1,010 pCi/g
  - Th-232 concentrations of 840 pCi/g
  - Ra-226 concentrations of 205 pCi/g
- NYDOH: No risk as long as property owners maintain the surface of the parking lot and notify NYDOH if the property is sold or the parking lot is disturbed.

## ALTERNATIVE ACTIONS

| Alternative | Health Risk Assessment | Engineering and Cost | Comments |
|---|---|---|---|
| 1. Take no action. | a) 0.005 excess fatal cancers per year due to external radiation exposure. This corresponds to 7% of the risk due to natural background radiation.<br><br>b) Risk to 4 workers receiving highest dose is increased by 75% of that due to natural background or 75 mrem/yr.<br><br>c) Risk due to radon emanation and dust from potholes if surface integrity is not maintained.<br><br>d) Potential risk due to collecting loose pieces of slag (for souveniers, e.g.) in area surrounding parking lots. | None. | Concentration of radioactive material exceeds the levels exempted from licensure under Part 16. Measured exposure levels in the parking lot range from 0.2 to 0.5 mr/hr. The maximum calculates to be 4368 mr per year. Part 16 limits the dose to 500 mrem/yr. as the maximum the general public may receive. It is unlikely that an individual will spend sufficient time in the parking lot to receive a dose of 500 mrem in one year (average 19 hours per week). However, there are no restrictions to prevent an individual from doing so.<br><br>The maximum estimated dose received annually by four employees is 75 mrem per person.<br><br>Estimates of dose due to radon in the buildings are to be obtained. |
| 2. Restrict use of parking lot and require proper maintenance of surface via:<br>a) Commissioner's recommendation or<br>b) Commissioner's order. | As in (1) above except:<br>Exposure from airborne activity is reduced as the surface integrity is preserved. | a) Cost of inspecting and maintaining surface.<br>b) Regulatory agency needs to enforce Commissioner's recommendation or order through surveys and enforcement action, if needed. | The Commissioner's recommendation/order needs to take in consideration the long range use of the site which may involve a change in its use. The restriction should be unlimited in time and should stipulate that the land could not be used for a purpose that is likely to lead to a dose to any individual exceeding 170 mrem/year such as parking and living in recreational vans. |

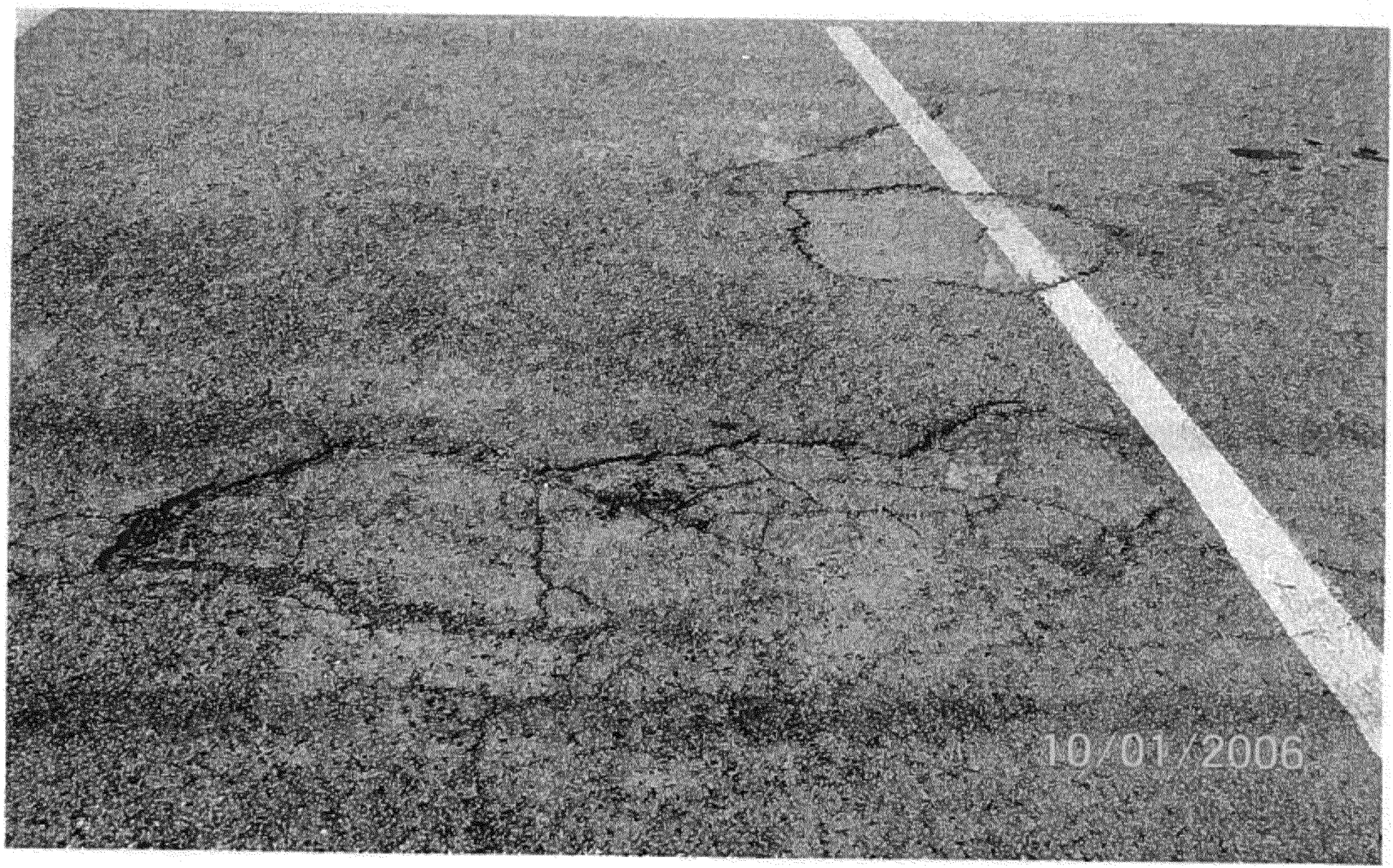
| Alternative | Health Risk Assessment | Engineering and Cost | Comments |
|---|---|---|---|
| 3. Cover parking area to reduce exposure levels and restrict future use of site via Commissioner's order.<br><br>Collect and dispose of loose slag | Can reduce external exposure as well as airborne radioactive material. Risk may be reduced to an acceptable level for unrestricted occupancy. | a) Covering the surface and maintaining the integrity of the cover.<br>b) Regulatory agency monitoring the surface condition.<br>c) Cost of collection and disposal of loose slag | The problem of the long range use of the site will not be solved. The integrity of the covering material needs to be maintained. Thus continued monitoring will be required. The depth of the layer needed will depend upon the material used and the exposure level that is acceptable. The cost of such an action should be considered in the determination of the "acceptable" exposure level. If the total annual dose of 170 mrem cannot be achieved through such an action, additional restrictions on occupancy of the site will be required. |
| 4. Commissioner's order restricting use of parking lot requiring collection and disposal of loose slag and requiring actions to reduce exposure inside the buildings, such as:<br>a) remove slag adjacent to buildings<br>b) cover the floor of the collision shop and car wash area in Baia Pontiac with a concrete layer<br>c) apply sealing material to the floor of the collision shop and wash area in Baia Pontiac in order to reduce radon leakage into these areas (if this is found to be a problem) | Such actions will reduce exposure due to time spent inside the buildings which is about 40 to 50% of the total estimated exposure. It will not affect risks due to exposure in the parking lot. | a) Cost of action taken<br>b) Regulatory agency needs to enforce commissioner's order | The problem of long range use of the site will not be solved. The integrity of the surface in the parking lots needs to be maintained. Such an alternative will be difficult to justify from a risk only point of view as the possibility of exposure approaching, or exceeding Part 16 limits, is associated with the parking lots and not with exposure inside the buildings. In determining the extent of such action, a risk vs cost evaluation needs to be made. |

| Alternative | Health Risk Assessment | Engineering and Cost | Comments |
|---|---|---|---|
| 5. Commissioner's order requiring removal of radioactive material from parking lot and surrounding areas through: | Eliminate risk due to parking and future use of land. | | While the risk due to breathing of dust particles containing the radioactive material is expected to be small, it could be comparable to the risk from external exposure. |
| a) removal to another site. | a) Increased risk to persons involved in the process particularly due to dust particles. | a) Cost of removal, transportation and disposal. Disposal site radiological monitoring. Regulatory agency licensing and control. | Four disposal alternatives might be considered: a) Return to the site where the material originated; |
| b) burial of material on site. | b) Increased risk to persons involved in the process, however, eliminates risks due to transportation. | b) As a) above with reduction of cost of transportation and disposal. | b) Bury on the existing land; |
| | | Perpetual care required by either alternative a) or b). Cost estimate to load on trucks $100,000 to $200,000. | c) Bury at a State controlled land fill; or d) Ship material to a licensed radioactive material commercial disposal site. |
| | | | Relative cost in increasing order are b), a), c), and d). |

# 2006-2007

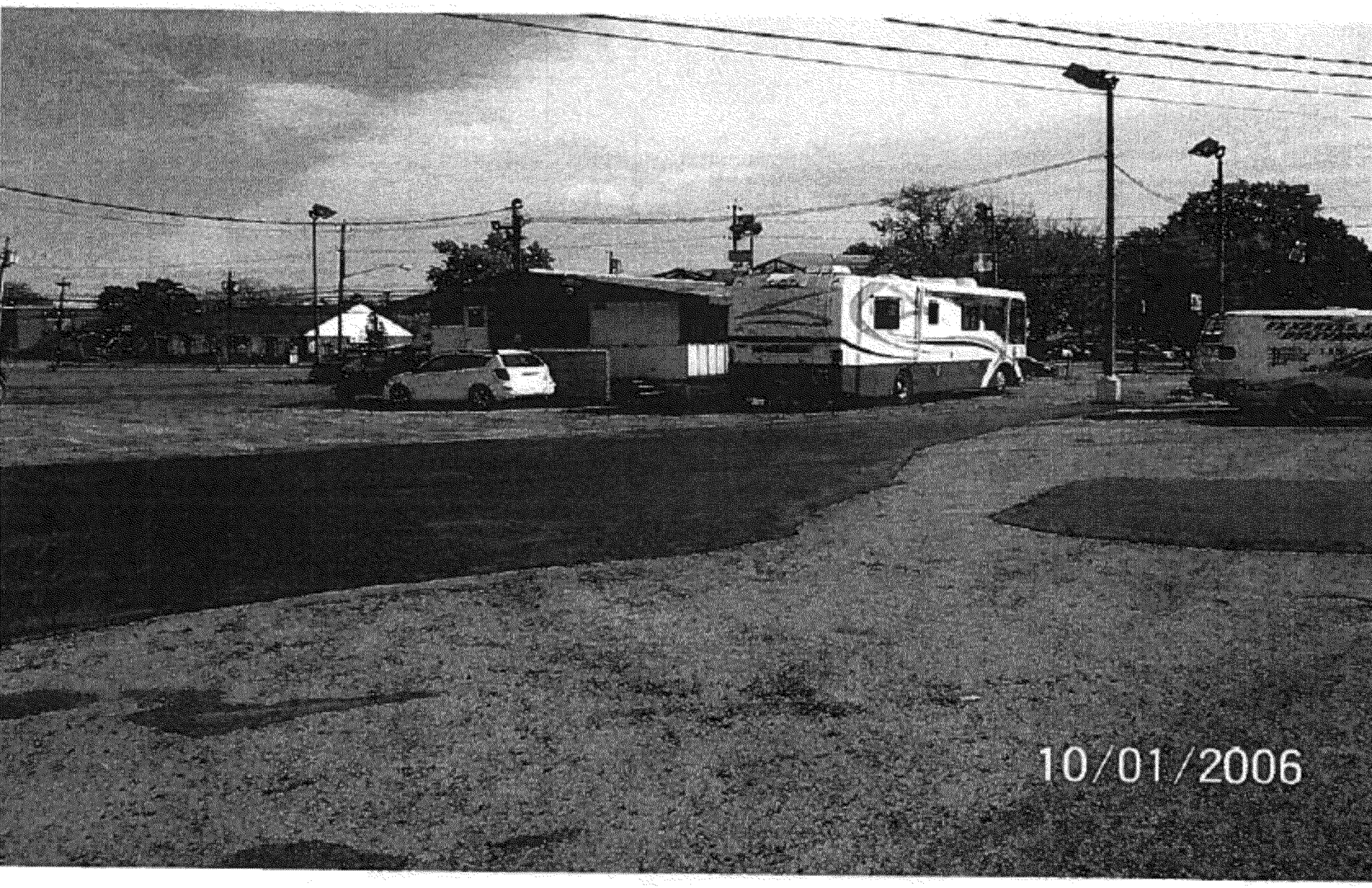
- NYSDEC and NYSDOH—conducted radiological surveys of the interior and exterior of both properties
- New additions to the properties were built on top of the contaminated areas
  - New additions: 115μR/hr
  - Exterior readings max 350 μR/hr at waist and 600 uR/hr contact
  - Background 10-20μR/hr
- Exterior:
  - Loose blacktop: 515,905 cpm (Ludlum)
  - Slag in marshy area: 728,235 cpm (Ludlum)

More debris in the fenced area. This area is blacktopped also and may be the original surface as placed in the early 60's. Note poor condition and the brush growing up through the cracks in the surface.




Area of Rapid Bowl parking lot showing disrepair. Note the underlying layer of asphalt. Typically these areas exhibit higher contact readings than the surrounding top layer of asphalt.

Another area of disrepair in the front parking lot of Rapid Bowl.




Newly paved triangular shaped area between Dunn Tire and the used car dealer lot.

# New Additions

# New Additions

# 2013

- NYDOH and NYDEC –reconnaissance was performed and showed elevated readings around broken asphalt and soil piles containing slag
  - Asphalt: 200uR/hr
  - Slag pile: 500uR/hr (pic)
  - Slag pile: 600,000 cpm
- NYDEC: observed empty beer cans, old tires positioned as seats indicating that area of contamination are readily accessible to the public.

# 2013

- September--EPA Pre-Remedial conducted gamma radiation screening
  - East side of the building: 175,000 cpm
  - Behind the building: 190,000 cpm
  - Broken asphalt: 300,000 cpm
- Source boundary was determined (total area of 168,832 ft2)
- December—EPA collected 16 soil samples and three slag samples including 2 background soil samples located at the First Assembly Church property
- Soil samples were well above 2x background

# Pre-remedial Data: Scan

# Pre-remedial Data: Scan

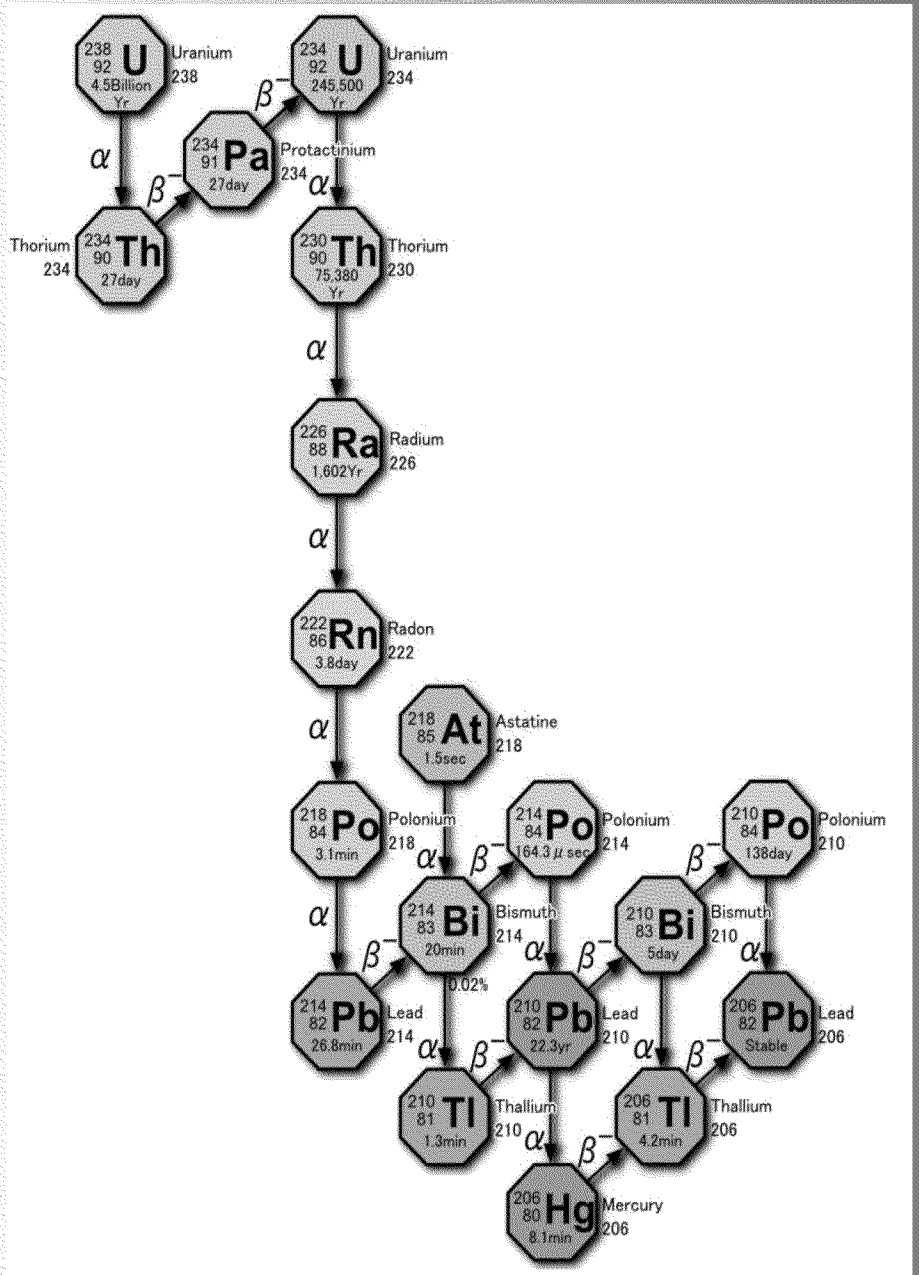
# Pre-Remedial Analysis

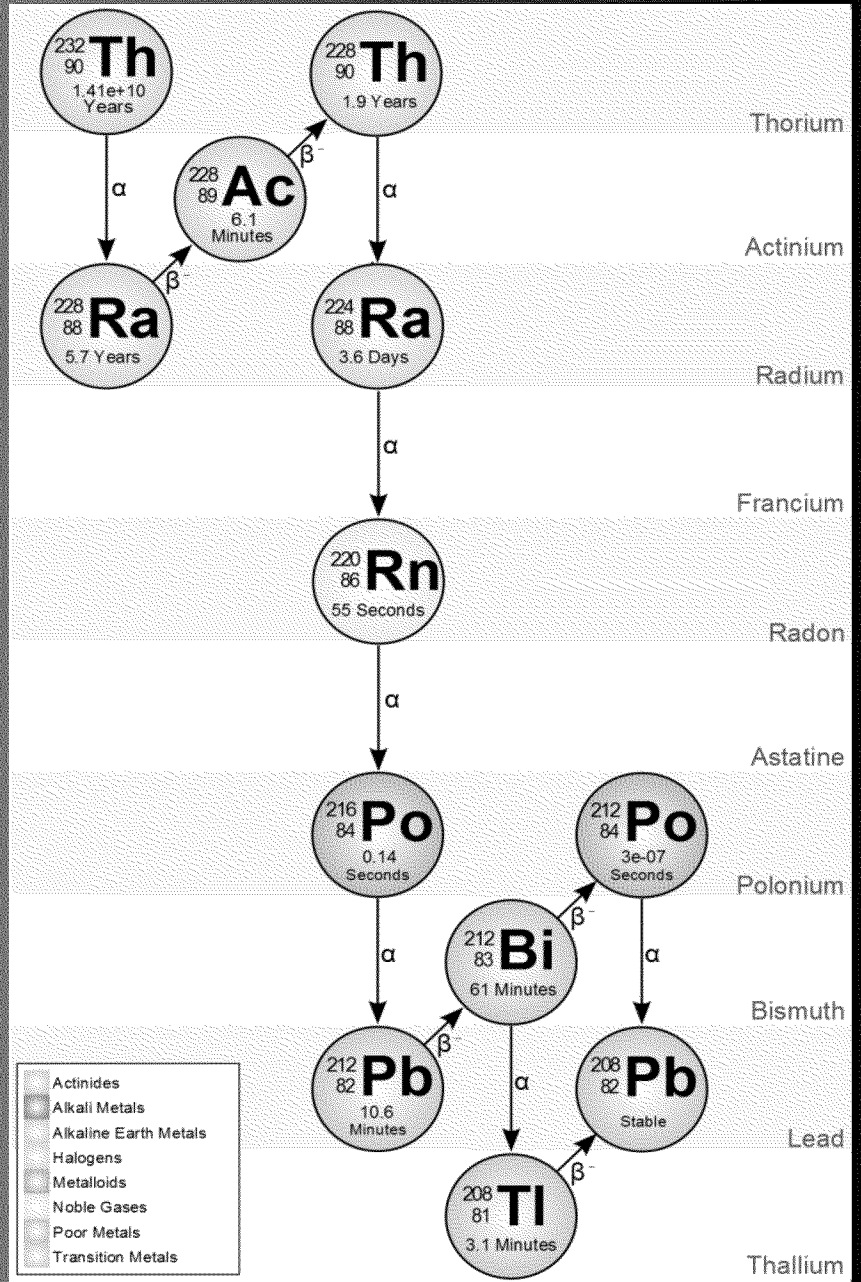
If we compare our samples to background…

| | Background (pCi/g) | Soil (pCi/g) | Slag (pCi/g) |
|---|---|---|---|
| U-238 | 0.911 | 1.37 | 153 |
| U-233/234 | 0.816 | 1.41 | 144 |
| Th-230 | 0.799 | 2.19 | 1.05 |
| Ra-226 | 1.12 | 1.17 | 164 |
| Th-232 | 0.964 | 4.17 | 3.49 |
| Th-228 | 0.712 | 3.92 | 3.35 |
| Ra-228 | 1.42 | 1.48 | 590 |
| U-235/236 | 0.0636 | 0.0623 | 8.17 |

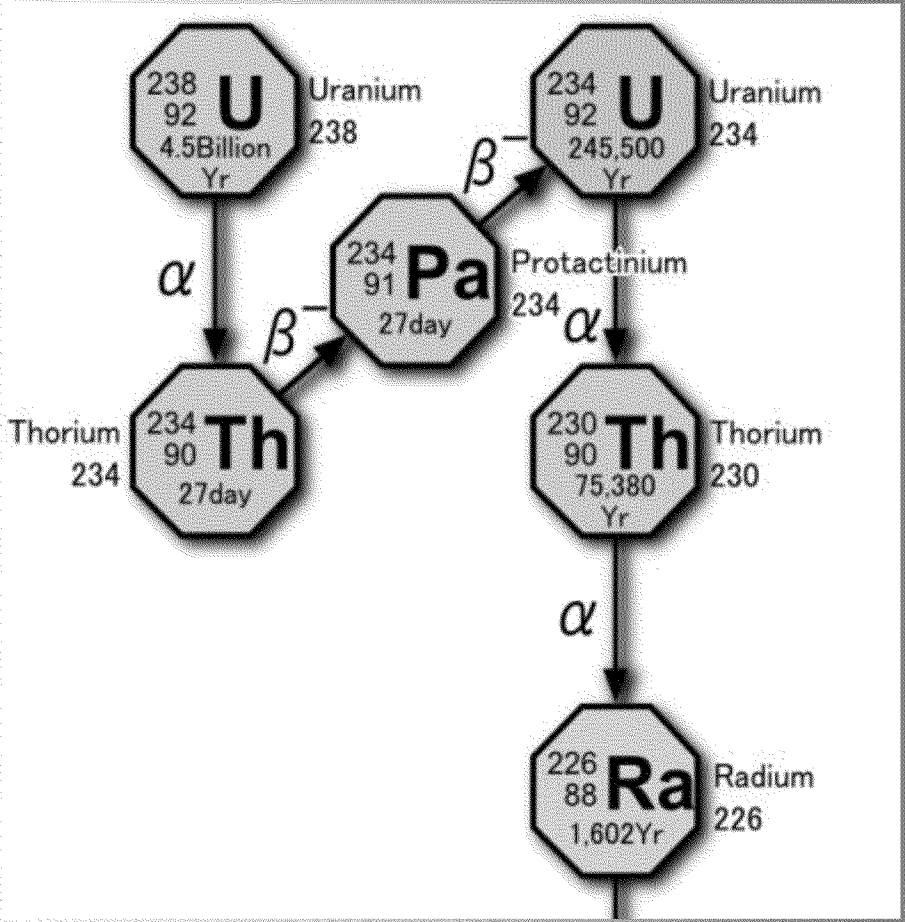
Contamination in all the radionuclides listed!!!

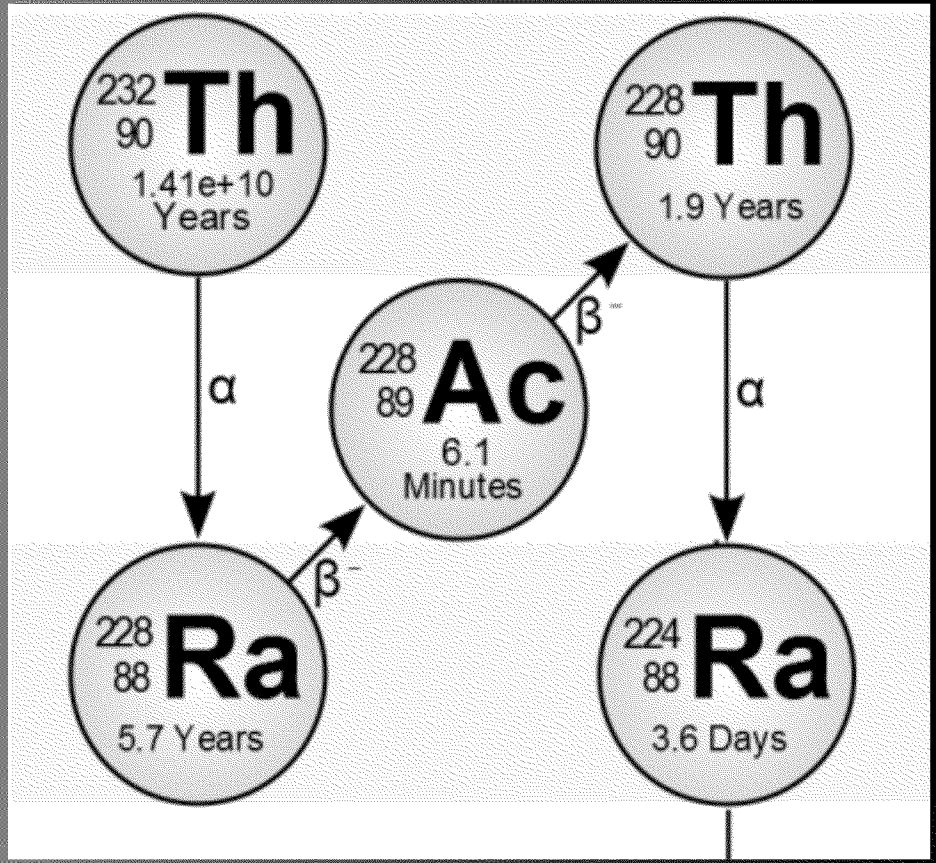
# Secular Equilibrium



# Secular Equilibrium



# Pre-Remedial Analysis

If we compare our samples equilibrium, it makes more sense…

| | | Background (pCi/g) | Soil (pCi/g) | Slag (pCi/g) |
|---|---|---|---|---|
| U-238 decay chain | U-238 | 0.911 | 1.37 | 153 |
| | U-233/234 | 0.816 | 1.41 | 144 |
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Thorium Product?

Depleted Thorium?

# Radon? Thoron

- April 2014--No radon or thoron concentrations that exceeded the site-specific backgrounds

# Removal Assessment Data

- 2015—Removal Site Evaluation (RSE) extent of contamination
- Ground Truthing:
  - How far does it extend past the property
  - Depth of contamination
  - Radon/Thoron measurements
- Analyze for further daughter nuclides—does it tell us anything differently

# Removal vs. Remedial Analysis

| Removal Analysis Radionuclides | Remedial Analysis Radionuclides |
|---|---|
| Th-232 | Th-232 |
| Ra-228 | Ra-228 |
| Ac-228 | |
| Th-228 | Th-228 |
| Pb-212 | |
| Bi-212 | |
| Tl-208 | |
| U-238 | U-238 |
| U-234 | U-234 |
| Th-230 | Th-230 |
| Ra-226 | Ra-226 |
| Pb-214 | |
| Bi-214 | |
| Cs-137 | |
| K-40 | |
| U-235 | U-235 |

# What is our contamination?

**N001-SS006-0012-01** ***(0 - 12)***
AC-228 - 11.5 pCi/g
BI-212 - 13.3 pCi/g
BI-214 - 4.07 pCi/g
CESIUM-137 - 0.277 pCi/g
K-40 - 13.5 pCi/g
PB-212 - 12.4 pCi/g
PB-214 - 4.6 pCi/g
RADIUM-226 - 11.7 pCi/g
RADIUM-228 - 11.5 pCi/g
THORIUM-228 - 10.8 pCi/g
THORIUM-230 - 3.96 pCi/g
THORIUM-232 - 9.56 pCi/g
TL-208 - 4.39 pCi/g
URANIUM-233/234 - 3.35 pCi/g
URANIUM-235/236 - 0.131 pCi/g
URANIUM-238 - 3.92 pCi/g

**N001-SS001-1224-01** ***(12 - 24)***
AC-228 - 1.01 pCi/g
BI-214 - 0.678 pCi/g
CESIUM-137 - 0.215 pCi/g
K-40 - 14.9 pCi/g
PB-212 - 0.986 pCi/g
PB-214 - 0.843 pCi/g
RADIUM-226 - 5.25 pCi/g
RADIUM-228 - 1.01 pCi/g
THORIUM-228 - 0.814 pCi/g
THORIUM-230 - 0.841 pCi/g
THORIUM-232 - 0.714 pCi/g
TL-208 - 0.379 pCi/g
URANIUM-233/234 - 0.791 pCi/g
URANIUM-235/236 - ND
URANIUM-238 - 0.801 pCi/g

**N003-SS002-2436-01** ***(24 - 36)***
AC-228 - 0.839 pCi/g
BI-212 - 1.41 pCi/g
BI-214 - 0.389 pCi/g
CESIUM-137 - ND
K-40 - 14.8 pCi/g
PB-212 - 0.623 pCi/g
PB-214 - 0.734 pCi/g
RADIUM-226 - 3.06 pCi/g
RADIUM-228 - 0.839 pCi/g
THORIUM-228 - 0.635 pCi/g
THORIUM-230 - 0.798 pCi/g
THORIUM-232 - 0.506 pCi/g
TL-208 - 0.261 pCi/g
URANIUM-233/234 - 0.48 pCi/g
URANIUM-235/236 - ND
URANIUM-238 - 0.523 pCi/g

**S13** ***(24-36)***
Uranium-238 - 0.697 pCi/g
Thorium-230 - 0.719 pCi/g
Uranium-233/234 - 1.10 pCi/g
Radium-226 - 1.09 pCi/g
Thorium-232 - 0.731 pCi/g
Radium-228 - 1.32 pCi/g
Thorium-228 - 0.705 pCi/g
Uranium-235/236 - 0.0577 U pCi/g

How hot is hot?

# Is this contamination?

- Three approaches for setting an action limit:
  - Applicable or Relevant and Appropriate Requirements (ARARs)
  - Dose Based Modeling
  - Risk Based Modeling

# Our Risk Approach

- Internal Risk
  - Inhalation—soil (i.e. pCi/g units)
  - Ingestion—soil (i.e. pCi/g units)
  - Absorption
  - Injection
- External Risk
  - Exposure—gamma (i.e. μR/hr)
  - Dose—gamma (i.e. mrem/hr)

# Is this contamination?

- Three approaches for setting an action limit:
  - Applicable or Relevant and Appropriate Requirements (ARARs)
    - UMTRCA ARAR = 5pCi/g for Radium
  - Dose Based Modeling—ResRad (12mrem/yr)
  - Risk Based Modeling—PRG ($10^{-4}$ to $10^{-6}$ risk)

The acceptable risk was set to $10^{-4}$

(Or you could think of it as 1 in 10,000 excess risk of developing cancer)

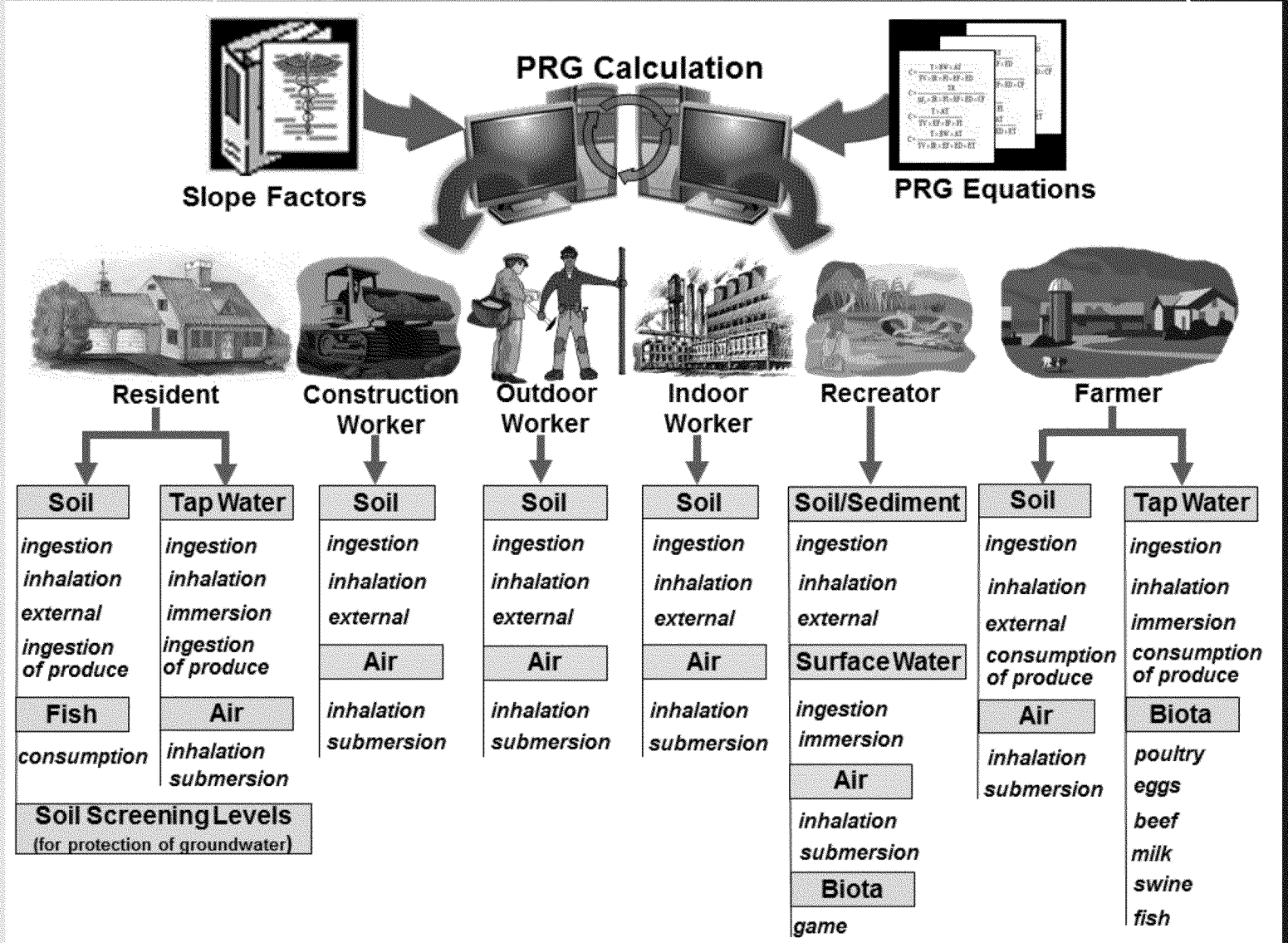
# Our Risk Approach

- Internal Risk
  - Inhalation—soil (i.e. pCi/g units)
  - Ingestion—soil (i.e. pCi/g units)
  - ~~Absorption~~
  - ~~Injection~~
- External Risk
  - Exposure—gamma (i.e. μR/hr)
  - Dose—gamma (i.e. mrem/hr)

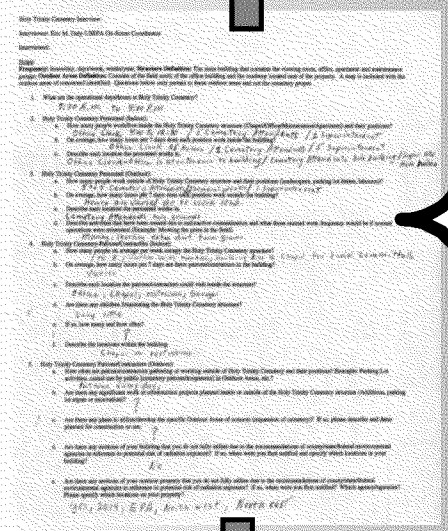
Use quantitative data for determining qualitative risk

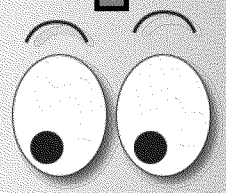
# PRG Overview

## Preliminary Remediation Goals for Radionuclies (PRG)

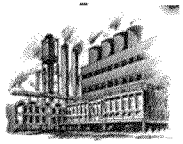


# How to choose?



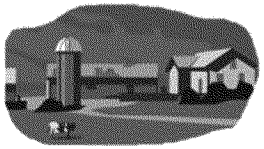


Resident



Indoor Worker

Recreator



Farmer

Outdoor Worker

Construction Worker

1 Minimal

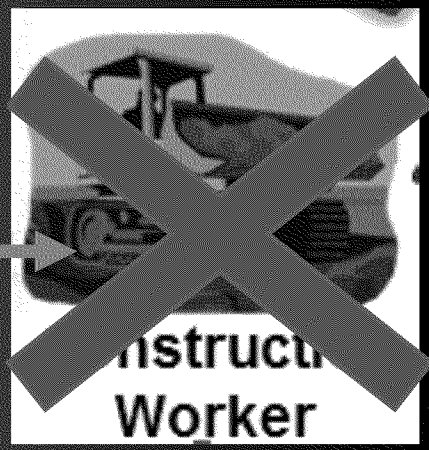
2 Realistic

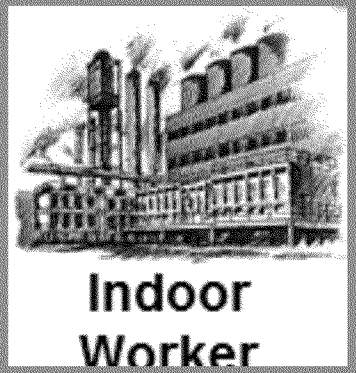
3 Maximum

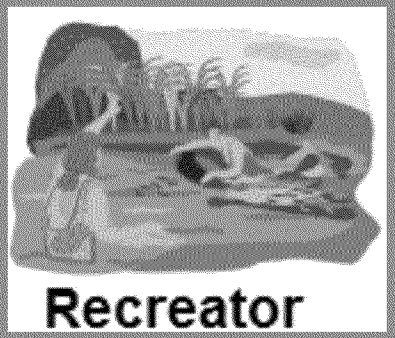
# Test out all receptors!

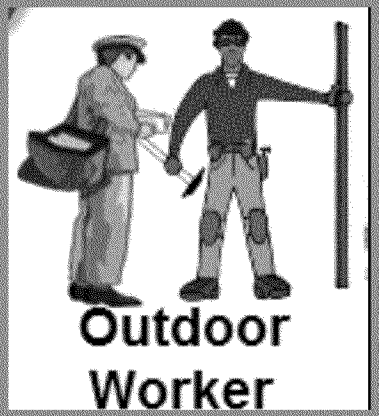
Remember this report is only for one receptor!

Which other receptors are present at your site with the greatest risk?





# Building Supply

| | Scenarios | hrs/d | d/yr |
|---|---|---|---|
| Outdoor Worker | Inventory, loading | 3 | 225 |
| Outdoor Worker | Inventory, loading | 6 | 250 |
| Outdoor Worker | Inventory, loading | 8 | 225 |
| Indoor Worker | Working on top of contaminated soil--4 inch concrete | 8 | 250 |
| Indoor Worker | Working on top of contaminated soil--4 inch concrete | 6 | 250 |
| Composite | Working 6 hours indoors on top of contaminated soil & working 2 hours outside on contaminated soil | 8 | 250 |

# Bowling Alley

| | Scenarios | hrs/d | d/yr |
|---|---|---|---|
| Indoor Worker | Chef--Freezer person | 0.5 | 250 |
| Composite | Chef--freeze, BBQ pit contaminated area, dumpster | 3 | 250 |
| Outdoor Worker | Chef--BBQ pit contaminated area, dumpster | 3 | 225 |
| Recreator | Adult Hangout / Parking lot area: no child | 2 | 200 |
| Recreator | Adult + Child Hangout / Parking lot area | 2 | 200 |
| Recreator | Adult Hangout / Parking lot area: no child | 0.5 | 100 |
| Recreator | Adult + Child Hangout / Parking lot area | 0.5 | 100 |
| Recreator | Adult Hangout / Parking lot area: no child | 2 | 52 |
| Recreator | Adult + Child Hangout / Parking lot area | 2 | 52 |

# NFB Risk Output

**Site-Specific**
**Outdoor Worker Risk for Soil**

| Isotope | ICRP Lung Absorption Type | ICRP Lung Absorption Type | Inhalation Slope Factor (risk/pCi) | External Exposure Slope Factor (risk/yr per pCi/g) | Adult Soil Ingestion Slope Factor (risk/pCi) | Concentration (pCi/g) | Particulate Emission Factor ($m^3$/kg) | Lambda (1/year) | Halflife (years) | 20001 $m^2$ Soil Volume Area Correction Factor | ngestion Risk | Inhalation Risk | External Exposure Risk | Total Risk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ac-228 | S | S | 4.92E-11 | 4.04E-06 | 8.58E-13 | 5.90E+02 | 3.00E+10 | 9.87E+02 | 7.02E-04 | 9.43E-01 | 1.15E-11 | 1.69E-15 | 4.68E-07 | 4.68E-07 |
| Pa-234 | S | S | 1.20E-12 | 6.62E-06 | 9.66E-13 | 1.00E+00 | 3.00E+10 | 9.06E+02 | 7.65E-04 | 9.37E-01 | 2.40E-14 | 7.62E-20 | 1.41E-09 | 1.41E-09 |
| Ra-224+D | S | S | 1.13E-08 | 4.19E-08 | 8.47E-11 | 3.30E+00 | 3.00E+10 | 6.91E+01 | 1.00E-02 | 8.19E-01 | 9.10E-11 | 3.11E-14 | 3.37E-10 | 4.28E-10 |
| Ra-226+D | S | S | 2.82E-08 | 8.37E-06 | 2.95E-10 | 1.64E+02 | 3.00E+10 | 4.33E-04 | 1.60E+03 | 9.38E-01 | 2.71E-05 | 6.63E-09 | 6.58E-03 | 6.60E-03 |
| Ra-228 | S | S | 4.37E-08 | 3.43E-11 | 6.70E-10 | 5.90E+02 | 3.00E+10 | 1.21E-01 | 5.75E+00 | 1.00E+00 | 7.01E-05 | 1.17E-08 | 3.28E-08 | 7.02E-05 |
| Th-228 | S | S | 1.32E-07 | 5.64E-09 | 6.40E-11 | 3.30E+00 | 3.00E+10 | 3.63E-01 | 1.91E+00 | 9.62E-01 | 1.31E-08 | 6.94E-11 | 1.01E-08 | 2.33E-08 |
| Th-230 | F | F | 3.41E-08 | 8.45E-10 | 7.73E-11 | 1.00E+00 | 3.00E+10 | 9.19E-06 | 7.54E+04 | 1.00E+00 | 4.35E-08 | 4.91E-11 | 4.34E-09 | 4.79E-08 |
| Th-232 | S | S | 4.33E-08 | 3.58E-10 | 8.47E-11 | 3.40E+00 | 3.00E+10 | 4.93E-11 | 1.41E+10 | 1.00E+00 | 1.62E-07 | 2.12E-10 | 6.26E-09 | 1.69E-07 |
| Th-234 | S | S | 3.08E-11 | 1.77E-08 | 9.51E-12 | 1.00E+00 | 3.00E+10 | 1.05E+01 | 6.60E-02 | 1.00E+00 | 2.04E-11 | 1.69E-16 | 3.47E-10 | 3.68E-10 |
| U-234 | S | S | 2.78E-08 | 2.53E-10 | 5.11E-11 | 1.44E+02 | 3.00E+10 | 2.82E-06 | 2.46E+05 | 1.00E+00 | 4.14E-06 | 5.77E-09 | 1.87E-07 | 4.33E-06 |
| U-235+D | S | S | 2.50E-08 | 5.76E-07 | 5.00E-11 | 8.10E+00 | 3.00E+10 | 9.84E-10 | 7.04E+08 | 8.52E-01 | 2.28E-07 | 2.92E-10 | 2.04E-05 | 2.06E-05 |
| U-238 | S | S | 2.36E-08 | 1.24E-10 | 4.66E-11 | 1.53E+02 | 3.00E+10 | 1.55E-10 | 4.47E+09 | 1.00E+00 | 4.01E-06 | 5.21E-09 | 9.73E-08 | 4.11E-06 |
| *Total Risk | | | - | - | - | - | - | - | - | - | 1.06E-04 | 2.99E-08 | 6.60E-03 | 6.70E-03 |

# NFB Risk Output

| Isotope | Ingestion Risk | Inhalation Risk | External Exposure Risk | Total Risk |
|---|---|---|---|---|
| Ac-228 | 1.15E-11 | 1.69E-15 | 4.68E-07 | 4.68E-07 |
| Pa-234 | 2.40E-14 | 7.62E-20 | 1.41E-09 | 1.41E-09 |
| Ra-224+D | 9.10E-11 | 3.11E-14 | 3.37E-10 | 4.28E-10 |
| Ra-226+D | 2.71E-05 | 6.63E-09 | 6.58E-03 | 6.60E-03 |
| Ra-228 | 7.01E-05 | 1.17E-08 | 3.28E-08 | 7.02E-05 |
| Th-228 | 1.31E-08 | 6.94E-11 | 1.01E-08 | 2.33E-08 |
| Th-230 | 4.35E-08 | 4.91E-11 | 4.34E-09 | 4.79E-08 |
| Th-232 | 1.62E-07 | 2.12E-10 | 6.26E-09 | 1.69E-07 |
| Th-234 | 2.04E-11 | 1.69E-16 | 3.47E-10 | 3.68E-10 |
| U-234 | 4.14E-06 | 5.77E-09 | 1.87E-07 | 4.33E-06 |
| U-235+D | 2.28E-07 | 2.92E-10 | 2.04E-05 | 2.06E-05 |
| U-238 | 4.01E-06 | 5.21E-09 | 9.73E-08 | 4.11E-06 |
| *Total Risk | 1.06E-04 | 2.99E-08 | 6.60E-03 | 6.70E-03 |

# NFB PRG Output

**Site-Specific**
**Outdoor Worker PRGs for Soil**

| Isotope | ICRP Lung Absorption Type | Inhalation Slope Factor (risk/pCi) | External Exposure Slope Factor (risk/yr per pCi/g) | Adult Soil Ingestion Slope Factor (risk/pCi) | Particulate Emission Factor ($m^3$/kg) | Lambda (1/year) | Halflife (years) | 20001 $m^2$ Soil Volume Area Correction Factor | 0 cm Soil Volume Gamma Shielding Factor | Ingestion PRG (pCi/g) | Inhalation PRG (pCi/g) | External Exposure PRG (pCi/g) | Total PRG (pCi/g) | Total PRG (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ac-228 | S | 4.92E-11 | 4.04E-06 | 8.58E-13 | 3.00E+10 | 9.87E+02 | 7.02E-04 | 9.43E-01 | 1.00E+00 | 5.11E+09 | 3.48E+13 | 1.26E+05 | 1.26E+05 | 5.65E-08 |
| Pa-234 | S | 1.20E-12 | 6.62E-06 | 9.66E-13 | 3.00E+10 | 9.06E+02 | 7.65E-04 | 9.37E-01 | 1.00E+00 | 4.17E+09 | 1.31E+15 | 7.11E+04 | 7.11E+04 | 3.56E-08 |
| Ra-224+D | S | 1.13E-08 | 4.19E-08 | 8.47E-11 | 3.00E+10 | 6.91E+01 | 1.00E-02 | 8.19E-01 | 1.00E+00 | 3.63E+06 | 1.06E+10 | 9.80E+05 | 7.71E+05 | 4.85E-06 |
| Ra-226+D | S | 2.82E-08 | 8.37E-06 | 2.95E-10 | 3.00E+10 | 4.33E-04 | 1.60E+03 | 9.38E-01 | 1.00E+00 | 6.06E+02 | 2.47E+06 | 2.49E+00 | 2.48E+00 | 2.51E-06 |
| Ra-228 | S | 4.37E-08 | 3.43E-11 | 6.70E-10 | 3.00E+10 | 1.21E-01 | 5.75E+00 | 1.00E+00 | 1.00E+00 | 8.41E+02 | 5.04E+06 | 1.80E+06 | 8.41E+02 | 3.09E-06 |
| Th-228 | S | 1.32E-07 | 5.64E-09 | 6.40E-11 | 3.00E+10 | 3.63E-01 | 1.91E+00 | 9.62E-01 | 1.00E+00 | 2.52E+04 | 4.75E+06 | 3.25E+04 | 1.41E+04 | 1.73E-05 |
| Th-230 | F | 3.41E-08 | 8.45E-10 | 7.73E-11 | 3.00E+10 | 9.19E-06 | 7.54E+04 | 1.00E+00 | 1.00E+00 | 2.30E+03 | 2.04E+06 | 2.30E+04 | 2.09E+03 | 1.01E-01 |
| Th-232 | S | 4.33E-08 | 3.58E-10 | 8.47E-11 | 3.00E+10 | 4.93E-11 | 1.41E+10 | 1.00E+00 | 1.00E+00 | 2.10E+03 | 1.60E+06 | 5.43E+04 | 2.02E+03 | 1.84E+04 |
| Th-234 | S | 3.08E-11 | 1.77E-08 | 9.51E-12 | 3.00E+10 | 1.05E+01 | 6.60E-02 | 1.00E+00 | 1.00E+00 | 4.91E+06 | 5.92E+11 | 2.88E+05 | 2.72E+05 | 1.18E-05 |
| U-234 | S | 2.78E-08 | 2.53E-10 | 5.11E-11 | 3.00E+10 | 2.82E-06 | 2.46E+05 | 1.00E+00 | 1.00E+00 | 3.48E+03 | 2.50E+06 | 7.68E+04 | 3.33E+03 | 5.35E-01 |
| U-235+D | S | 2.50E-08 | 5.76E-07 | 5.00E-11 | 3.00E+10 | 9.84E-10 | 7.04E+08 | 8.52E-01 | 1.00E+00 | 3.56E+03 | 2.78E+06 | 3.97E+01 | 3.92E+01 | 1.82E+01 |
| U-238 | S | 2.36E-08 | 1.24E-10 | 4.66E-11 | 3.00E+10 | 1.55E-10 | 4.47E+09 | 1.00E+00 | 1.00E+00 | 3.81E+03 | 2.94E+06 | 1.57E+05 | 3.72E+03 | 1.11E+04 |

# NFB PRG Output

| Isotope | Ingestion PRG (pCi/g) | Inhalation PRG (pCi/g) | External Exposure PRG (pCi/g) | Total PRG (pCi/g) |
|---|---|---|---|---|
| Ac-228 | 5.11E+09 | 3.48E+13 | 1.26E+05 | 1.26E+05 |
| Pa-234 | 4.17E+09 | 1.31E+15 | 7.11E+04 | 7.11E+04 |
| Ra-224+D | 3.63E+06 | 1.06E+10 | 9.80E+05 | 7.71E+05 |
| Ra-226+D | 6.06E+02 | 2.47E+06 | 2.49E+00 | 2.48E+00 |
| Ra-228 | 8.41E+02 | 5.04E+06 | 1.80E+06 | 8.41E+02 |
| Th-228 | 2.52E+04 | 4.75E+06 | 3.25E+04 | 1.41E+04 |
| Th-230 | 2.30E+03 | 2.04E+06 | 2.30E+04 | 2.09E+03 |
| Th-232 | 2.10E+03 | 1.60E+06 | 5.43E+04 | 2.02E+03 |
| Th-234 | 4.91E+06 | 5.92E+11 | 2.88E+05 | 2.72E+05 |
| U-234 | 3.48E+03 | 2.50E+06 | 7.68E+04 | 3.33E+03 |
| U-235+D | 3.56E+03 | 2.78E+06 | 3.97E+01 | 3.92E+01 |
| U-238 | 3.81E+03 | 2.94E+06 | 1.57E+05 | 3.72E+03 |

# Building Supply

| | Scenarios | hrs/d | d/yr | Total Risk Dep. Th |
|---|---|---|---|---|
| Outdoor Worker | Inventory, loading | 3 | 225 | 2.58E-03 |
| Outdoor Worker | Inventory, loading | 6 | 250 | 5.62E-03 |
| Outdoor Worker | Inventory, loading | 8 | 225 | 6.70E-03 Ra-226+D |
| Indoor Worker | Working on top of contaminated soil--4 inch concrete | 8 | 250 | 2.99E-03 |
| Indoor Worker | Working on top of contaminated soil--4 inch concrete | 6 | 250 | 2.26E-03 |
| Composite | Working 6 hours indoors on top of contaminated soil & working 2 hours outside on contaminated soil | 8 | 250 | |

# Bowling Alley

| | Scenarios | hrs/d | d/yr | Total Risk Dep. Th |
|---|---|---|---|---|
| Indoor Worker | Chef--Freezer person | 0.5 | 250 | 2.42E-04 |
| Composite | Chef--freeze, BBQ pit contaminated area, dumpster | 3 | 250 | |
| Outdoor Worker | Chef--BBQ pit contaminated area, dumpster | 3 | 225 | 2.58E-03 |
| Recreator | Adult Hangout / Parking lot area: no child | 2 | 200 | 1.73E-03 |
| Recreator | Adult + Child Hangout / Parking lot area | 2 | 200 | 1.85E-03 |
| Recreator | Adult Hangout / Parking lot area: no child | 0.5 | 100 | 3.14E-04 |
| Recreator | Adult + Child Hangout / Parking lot area | 0.5 | 100 | 3.54E-04 Ra-228 |
| Recreator | Adult Hangout / Parking lot area: no child | 2 | 52 | 4.49E-04 |
| Recreator | Adult + Child Hangout / Parking lot area | 2 | 52 | 4.81E-04 |

# Maximum Concentrations

| Library | Example BKG (pCi/g) | Most Restrictive PRG (pCi/g) | Max Sample Concentration (pCi/g) |
|---|---|---|---|
| Th-232 | 0.92 | 1700 | 541 |
| Ra-228 | 0.949 | 517 | 807 (ing.) |
| Ac-228 | 0.949 | 126000 | 13.6 |
| Th-228 | 0.936 | 12000 | 544 |
| Ra-224+D (inc. Pb-212, Bi-212, Tl-208) | 0.949 | 771000 | 541* |
| U-238 | 1.03 | 2330 | 196 |
| Th-234 | 1.04 | 272000 | 196* |
| Pa-234 | 1.04 | 71100 | 196* |
| U-234 | 1.12 | 2100 | 179 |
| Th-230 | 1.04 | 1880 | 150 |
| Ra-226+D (inc. Pb-214, Bi-214) | 0.962 | 2.48 | 199 (exp) |
| U-235+D | 0.0726 | 39.2 | 10.7 |

# Ok I have contamination… Now what?

- Full Removal
  - Remove areas where your soil samples exceed our action limit. This will reduce the risk to the receptor to $10^{-4}$

# Other options?

- Full shielding
  - PRG can do shielding calculations to determine at what depth of soil will reduce external exposure to a desired risk value
- Partial shielding (Removal + Shielding)

# Which makes more sense for your site based on current operations?

Remove Contamination
No Shielding

Add Shielding to Surface

Or both?

# NFB: Shielding? How much?

| | | Specific Activity pCi/g |
|---|---|---|
| Soil Shielding Depth | Risk | Ra-226 |
| Site's Current State | 6.60E-03 | 199 pCi.g (max) |

# Soil Shielding? How much?

| | | | Specific Activity pCi/g |
|---|---|---|---|
| | Soil Shielding Depth | Risk | Ra-226 |
| | Site's Current State | 6.60E-03 | 199 pCi.g (max) |
| No Shielding | Full Removal | 1E-04 | 2.48 pCi/g |

# Soil Shielding? How much?

| | Soil Shielding Depth | Risk | Specific Activity pCi/g Ra-226 |
|---|---|---|---|
| | Site's Current State | 6.60E-03 | 199 pCi.g (max) |
| No Shielding | Full Removal | 1E-04 | 2.48 pCi/g |
| Shielding needed to obtain $10^{-4}$ | 10 cm | 2.05E-03 | 8.11 pCi/g |
| | 20 cm | 8.41E-04 | 20.1 pCi/g |
| | 30 cm | 3.55E-04 | 50.1 pCi/g |
| | 40 cm | 1.74E-04 | 112 pCi/g |
| | 50 cm | 8.88E-05 | 267 pCi/g |

# Soil Shielding? How much?

| | Soil Shielding Depth | Risk | Exposure Only PRG<br>Ra-226 |
|---|---|---|---|
| | Site's Current State | 6.60E-03 | 199 pCi.g (max) |
| No Shielding | Full Removal | 1E-04 | 2.48 pCi/g |
| Shielding needed to obtain $10^{-4}$ | 10 cm | 2.05E-03 | 8.11 pCi/g |
| | 20 cm | 8.41E-04 | 20.1 pCi/g |
| | 30 cm | 3.55E-04 | 50.1 pCi/g |
| | 40 cm | 1.74E-04 | 112 pCi/g |
| | 50 cm | 8.88E-05 | 267 pCi/g |

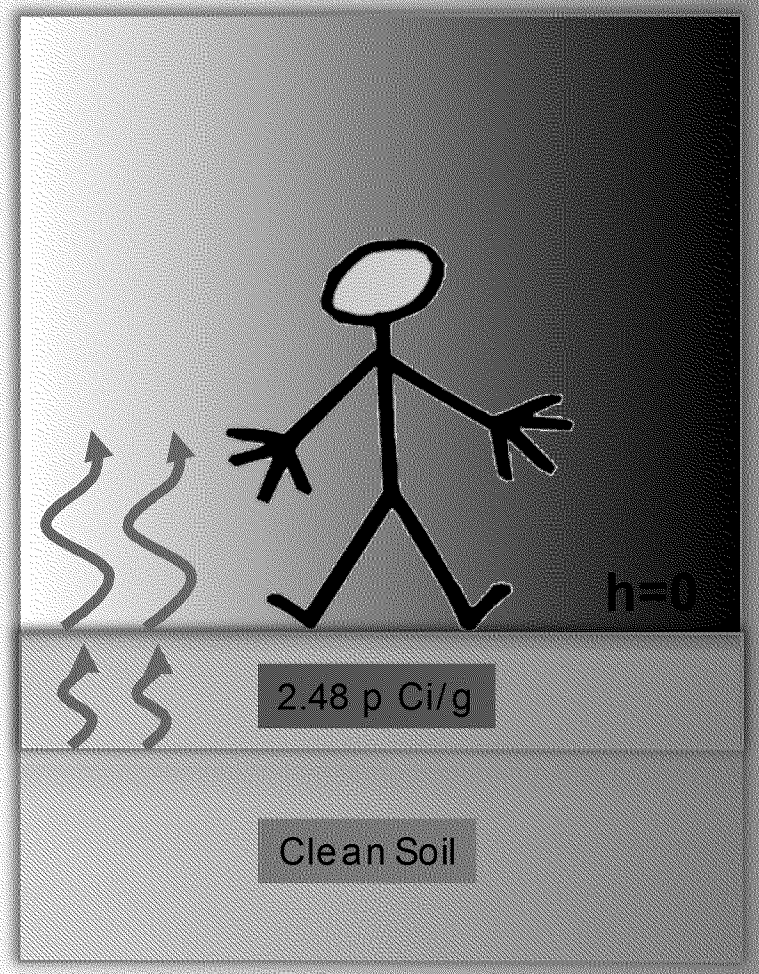
# Other Shielding Options?

| | Lead (inch) | steel (inch) | Concrete | Total depth of shielding in inches |
|---|---|---|---|---|
| | 1/8 inch sheet | 1/2 inch sheet (2 sheets required with lead) | 4 inch depths | |
| Option 13 | 0 | 0 | 4 | 16 |
| Option 12 | 0 | 1 | 3 | 12.5 |
| ~~Option 11~~ | ~~0~~ | ~~2~~ | ~~3~~ | ~~13~~ |
| Option 10 | 0 | 3 | 2 | 9.5 |
| ~~Option 9~~ | ~~0~~ | ~~4~~ | ~~2~~ | ~~10~~ |
| Option 8 | 0 | 5 | 1 | 6.5 |
| ~~Option 7~~ | ~~0~~ | ~~6~~ | ~~1~~ | ~~7~~ |
| Option 6 | 0 | 7 | 0 | 3.5 |
| Option 5 | 1 | 5 | 0 | 2.625 |
| Option 4 | 2 | 4 | 0 | 2.25 |
| Options 3 | 3 | 2 | 0 | 1.375 |
| Option 2 | 4 | 1 | 0 | 1 |
| ~~Option 1~~ | ~~5~~ | ~~0~~ | ~~0~~ | ~~0.625~~ |

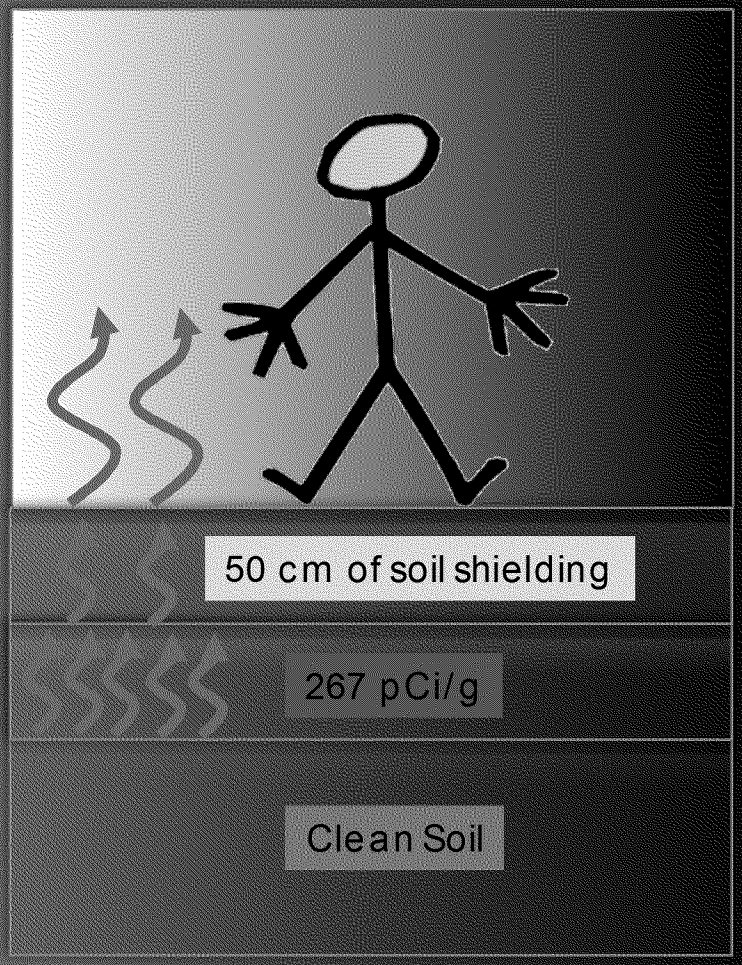
# Removal/Shielding Options

| | Options | Depth Shielding inches | Risk | PRG Ra-226 pCi/g |
|---|---|---|---|---|
| No Shielding | Full removal | ---- | 1E-04 | 2.48 pCi/g |
| Shielding needed to obtain $10^{-4}$ | 16” concrete | 16 | 8.88E-05 | 185 pCi/g |
| | 1/2” steel + 12” concrete | 12.5 | | |
| | 1 1/2” steel + 8” concrete | 9.5 | | |
| | 2 1/2” steel + 4” concrete | 6.5 | | |
| | 3 1/2” steel | 3.5 | | |
| | 1/8” lead + 2 1/2” steel | 2.625 | | |
| | ¼” lead + 2” steel | 2.25 | | |
| | 3/8” lead + 1” steel | 1.375 | | |
| | ½” lead + 1/2” steel | 1 | | |

# Removal vs. Shielding




Having 2.48pCi/g with no soil on top will reduce the external exposure risk to less than $10^{-4}$

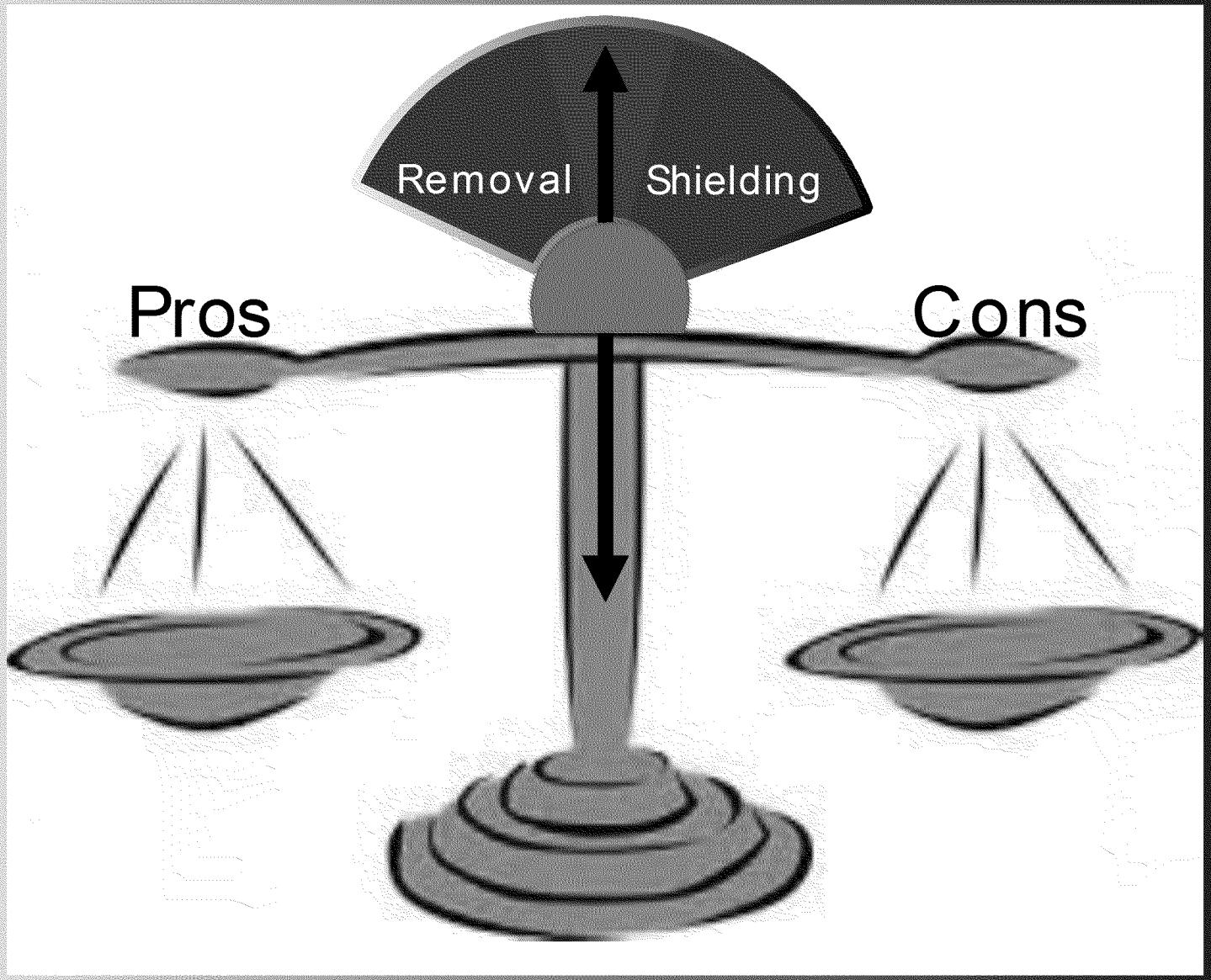



Having 267pCi/g with 50cm of soil on top will reduce the external exposure risk to less than $10^{-4}$

# When should shielding be avoided?

- When you have a risk of inhalation and/or ingestion
- When shielding material does not make sense for the site current operations
- When receptors change (becomes residential)
- When removal of the contaminant is cheaper and feasible

# Let's weight out our options



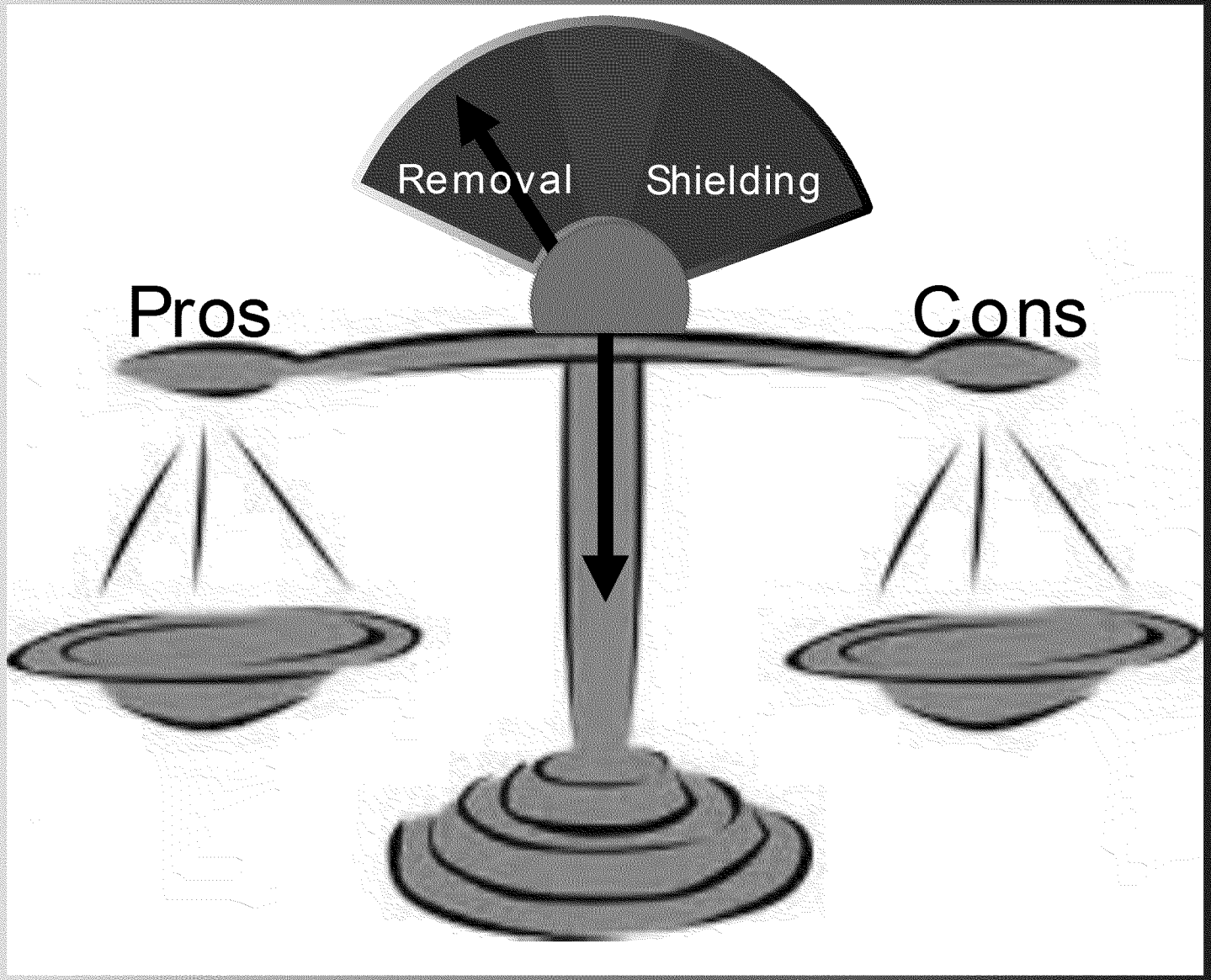
# Full Removal

- Pros:
  - Once the contaminant is removed, the site is CLEAN
  - Positive public reception of EPA
  - Maybe able to do a combined removal especially with HTC
- Cons:
  - Need a better picture of the extent of contamination
  - Cost
  - Time / Interfere with business operations

# Full/Partial Shielding

- Pros:
  - Variety of options
  - Less time / Cost maybe less depending on material
- Cons:
  - It's not "cleaned." May be a waste if determined later site doesn't meet remedial goals of $10^{-6}$
  - Shielding will need to be maintained
  - Will add a height to ground
    - Tripping hazards, installation of ramps or stairs will all need to be considered
    - If you set shielding in ground, contaminated top layer of dirt will need to be removed anyway
  - Deed restrictions will be needed
  - Negative public perception

# Full Removal!!!!



# Write our Action Memo

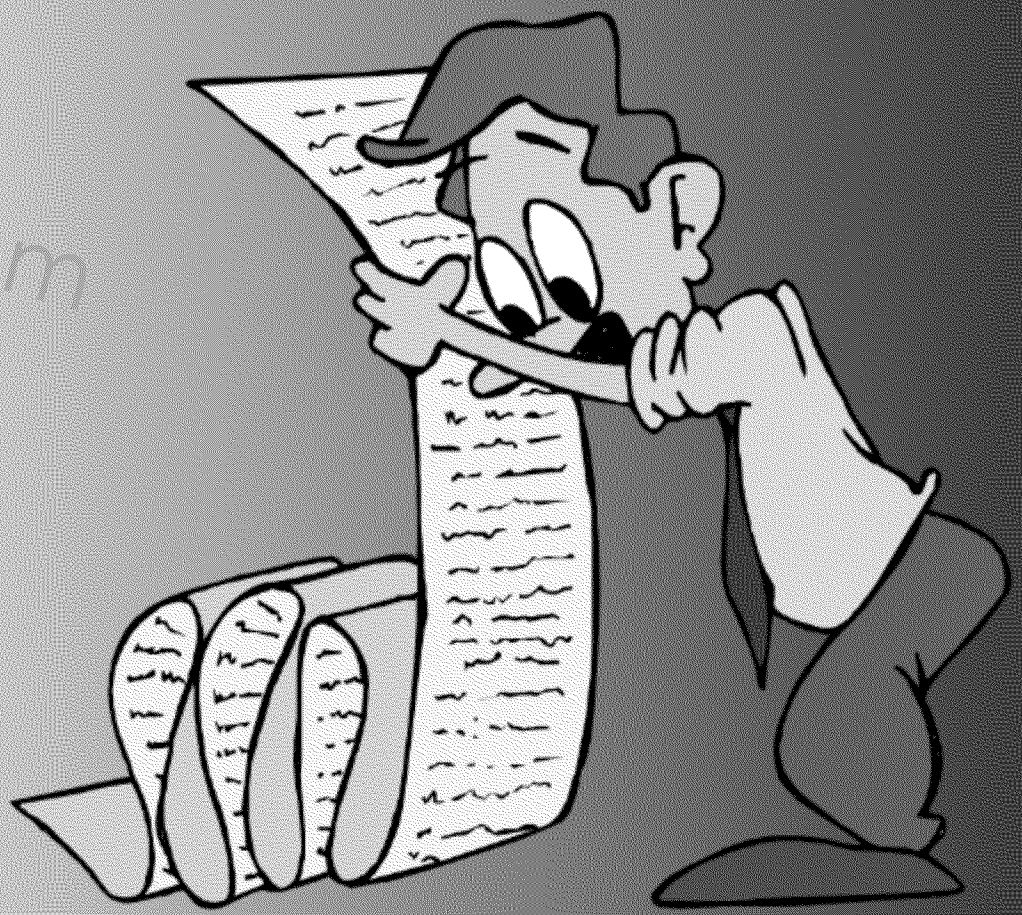
μR/hr

mrem/hr

pCi/g

cpm

pCi/L



# Units: So Confusing!

Soil

- pCi/g--true value of contamination in soil

- cpm--estimating the soil activity from a detector

Gamma

- µR/hr --estimating gammas in air (exposure)
- mrem/hr --estimating gammas to the body (dose)

# Units: So Confusing!

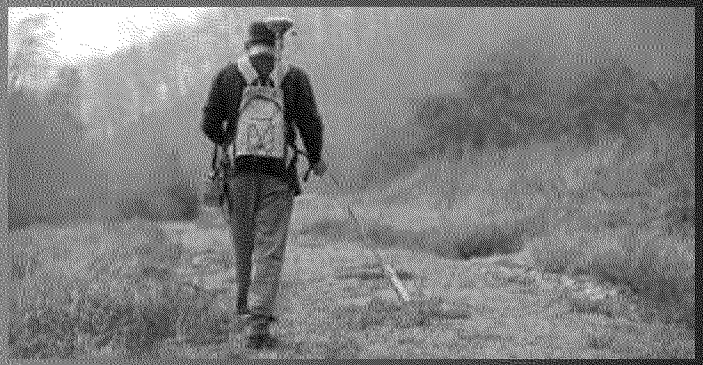
- pCi/g
- cpm

Quantitative Measurements

- µR/hr
- mrem/hr

Qualitative Measurements

Static Measurement
Ex. Scalar Mode



Scan Measurement
Ex. Rate mode

Niagara Falls Boulevard

# Units: So Confusing!

- pCi/g

Quantitative Measurements

- cpm
- µR/hr
- mrem/hr

Qualitative Measurements

Base the Action Memo off of Quantitative Data

# Action Memo Layout

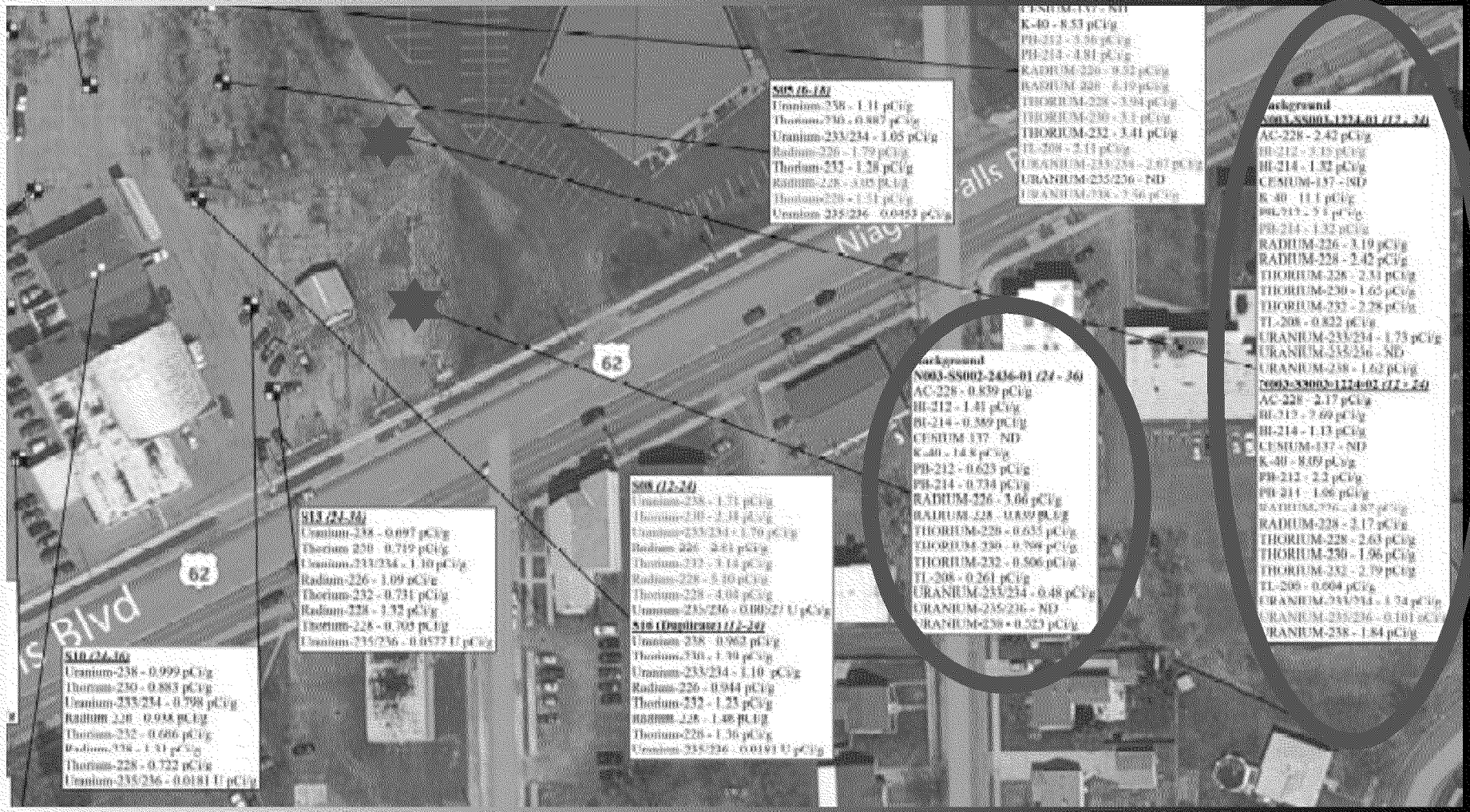
- Basic layout:
  - Background of the site
  - History
  - Terms
  - "Threat to Public Health or Welfare" and "Threat to Environment"
  - Proposed Action
  - Estimated Cost

# NFB:
# Any Additional Assessments Needed?

Suggestion:

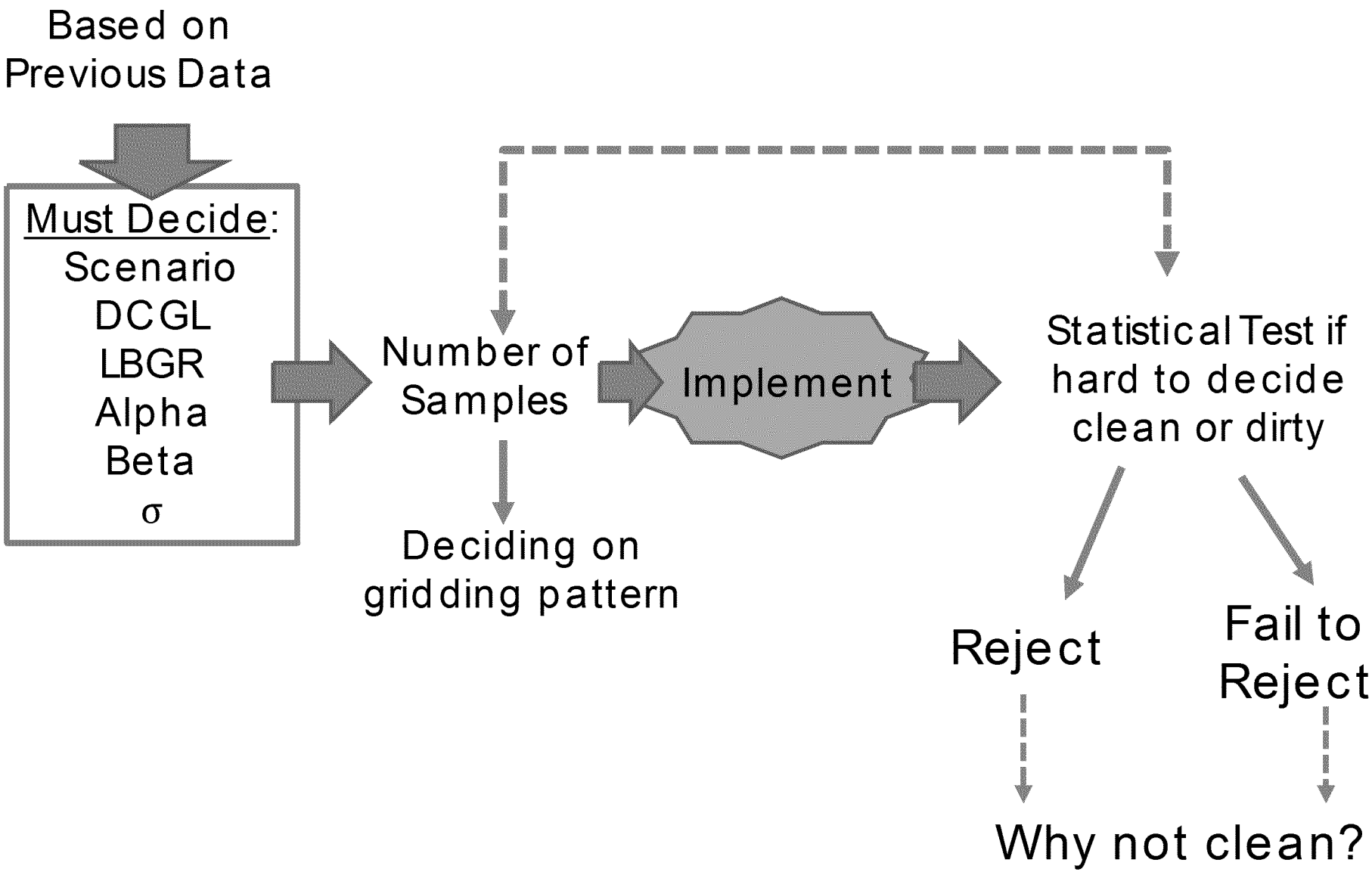
Sampling inside of the building to confirm hotspots and determine if rooms can be occupied

Suggestion:
Further scan north of the property needs to be performed to determine the extent of contamination

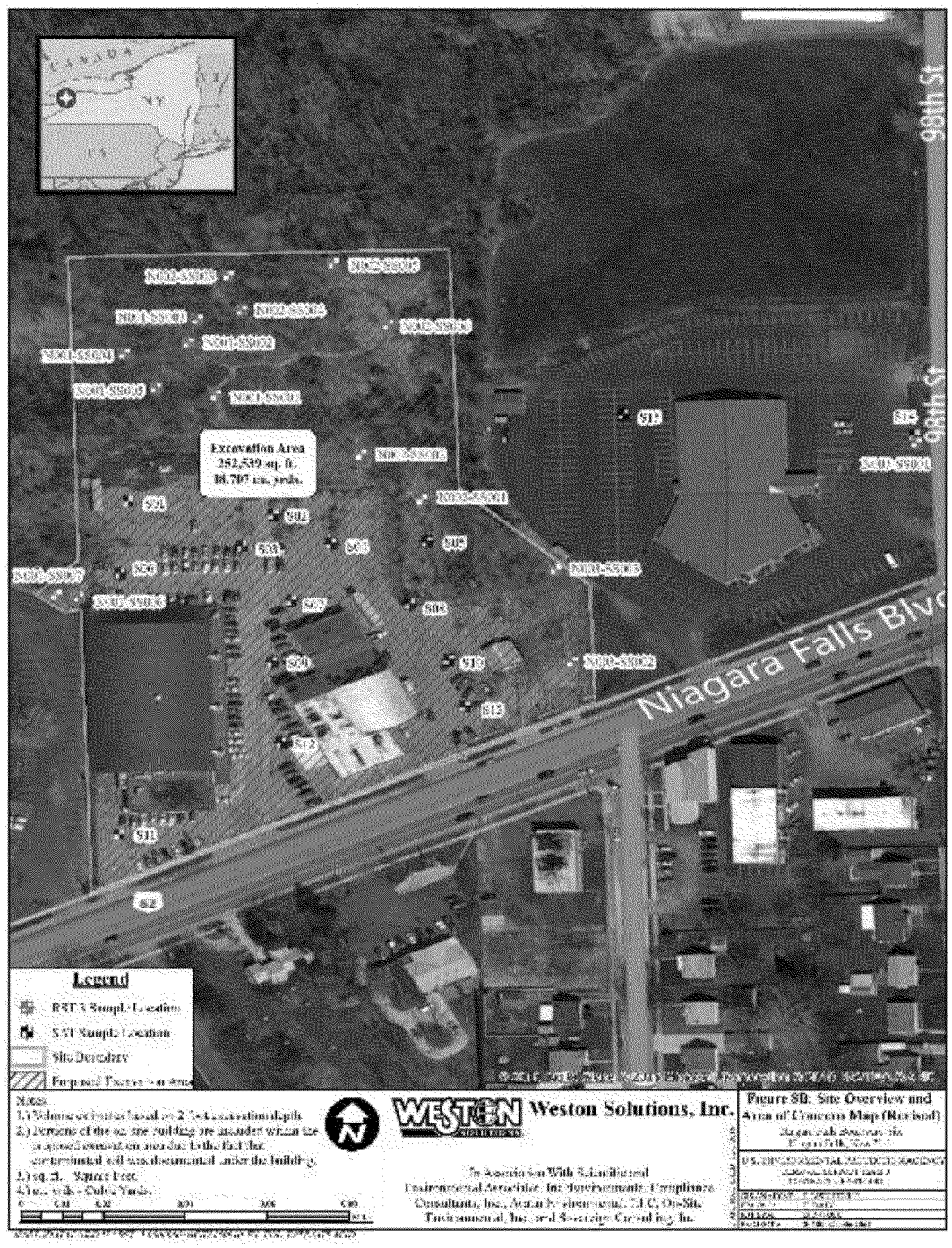


S05 (6-18)
Uranium-238 - 1.11 pCi/g
Thorium-230 - 0.887 pCi/g
Uranium-233/234 - 1.05 pCi/g
Radium-226 - 1.79 pCi/g
Thorium-232 - 1.28 pCi/g
Radium-228 - 3.05 pCi/g
Thorium-228 - 1.51 pCi/g
Uranium-235/236 - 0.0453 pCi/g
K-40 - 8.53 pCi/g
PB-212 - 3.56 pCi/g
PB-214 - 4.81 pCi/g
RADIUM-226 - 9.52 pCi/g
RADIUM-228 - 6.19 pCi/g
THORIUM-228 - 3.94 pCi/g
THORIUM-230 - 3.1 pCi/g
THORIUM-232 - 3.41 pCi/g
TL-208 - 2.11 pCi/g
URANIUM-233/234 - 2.67 pCi/g
URANIUM-235/236 - ND
URANIUM-238 - 2.56 pCi/g
Background
N003-SS003-1224-01 (12 - 24)
AC-228 - 2.42 pCi/g
BI-212 - 3.15 pCi/g
BI-214 - 1.32 pCi/g
CESIUM-137 - ND
K-40 - 11.1 pCi/g
PB-212 - 3.1 pCi/g
PB-214 - 1.32 pCi/g
RADIUM-226 - 3.19 pCi/g
RADIUM-228 - 2.42 pCi/g
THORIUM-228 - 2.31 pCi/g
THORIUM-230 - 1.65 pCi/g
THORIUM-232 - 2.28 pCi/g
TL-208 - 0.822 pCi/g
URANIUM-233/234 - 1.73 pCi/g
URANIUM-235/236 - ND
URANIUM-238 - 1.62 pCi/g
N003-SS002-1224-02 (12 - 24)
AC-228 - 2.17 pCi/g
BI-212 - 2.69 pCi/g
BI-214 - 1.13 pCi/g
CESIUM-137 - ND
K-40 - 8.09 pCi/g
PB-212 - 2.2 pCi/g
PB-214 - 1.06 pCi/g
RADIUM-226 - 4.87 pCi/g
RADIUM-228 - 2.17 pCi/g
THORIUM-228 - 2.63 pCi/g
THORIUM-230 - 1.96 pCi/g
THORIUM-232 - 2.79 pCi/g
TL-208 - 0.604 pCi/g
URANIUM-233/234 - 1.74 pCi/g
URANIUM-235/236 - 0.101 pCi/g
URANIUM-238 - 1.84 pCi/g
Background
N003-SS002-2436-01 (24 - 36)
AC-228 - 0.839 pCi/g
BI-212 - 1.41 pCi/g
BI-214 - 0.389 pCi/g
CESIUM-137 - ND
K-40 - 14.8 pCi/g
PB-212 - 0.623 pCi/g
PB-214 - 0.734 pCi/g
RADIUM-226 - 3.06 pCi/g
RADIUM-228 - 0.839 pCi/g
THORIUM-228 - 0.635 pCi/g
THORIUM-230 - 0.798 pCi/g
THORIUM-232 - 0.506 pCi/g
TL-208 - 0.261 pCi/g
URANIUM-233/234 - 0.48 pCi/g
URANIUM-235/236 - ND
URANIUM-238 - 0.523 pCi/g
S08 (12-24)
Uranium-238 - 1.71 pCi/g
Thorium-230 - 2.38 pCi/g
Uranium-233/234 - 1.70 pCi/g
Radium-226 - 2.61 pCi/g
Thorium-232 - 3.14 pCi/g
Radium-228 - 5.10 pCi/g
Thorium-228 - 4.04 pCi/g
Uranium-235/236 - 0.00527 U pCi/g
S10 (Duplicate) (12-24)
Uranium-238 - 0.962 pCi/g
Thorium-230 - 1.39 pCi/g
Uranium-233/234 - 1.10 pCi/g
Radium-226 - 0.944 pCi/g
Thorium-232 - 1.23 pCi/g
Radium-228 - 1.48 pCi/g
Thorium-228 - 1.36 pCi/g
Uranium-235/236 - 0.0181 U pCi/g
S13 (24-36)
Uranium-238 - 0.697 pCi/g
Thorium-230 - 0.719 pCi/g
Uranium-233/234 - 1.10 pCi/g
Radium-226 - 1.09 pCi/g
Thorium-232 - 0.731 pCi/g
Radium-228 - 1.32 pCi/g
Thorium-228 - 0.705 pCi/g
Uranium-235/236 - 0.0577 U pCi/g
S10 (24-36)
Uranium-238 - 0.999 pCi/g
Thorium-230 - 0.883 pCi/g
Uranium-233/234 - 0.798 pCi/g
Radium-226 - 0.938 pCi/g
Thorium-232 - 0.686 pCi/g
Radium-228 - 1.31 pCi/g
Thorium-228 - 0.722 pCi/g
Uranium-235/236 - 0.0181 U pCi/g
62
62
Niag
alls
Blvd

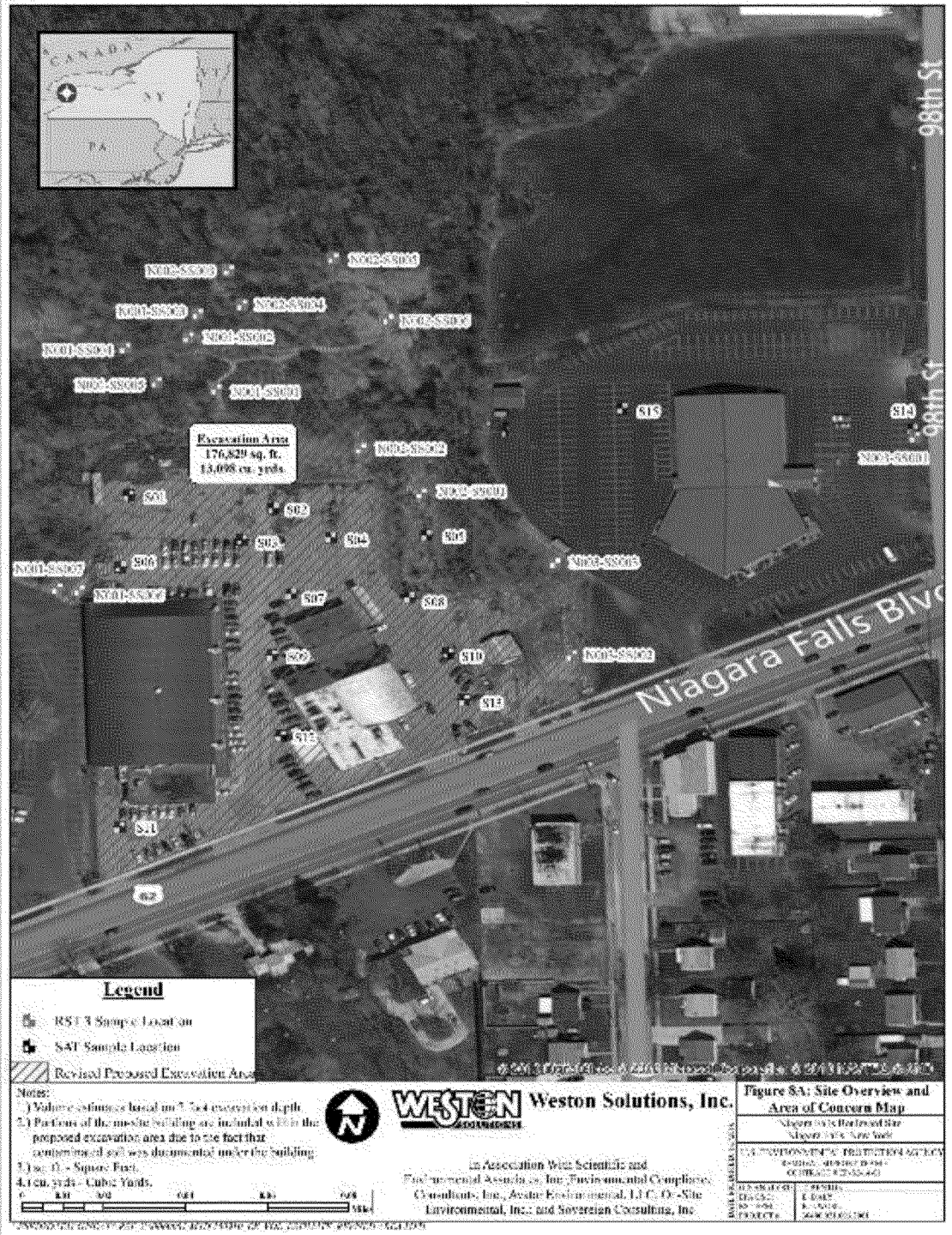
# MARSSIM


Based on Previous Data
Must Decide:
Scenario
DCGL
LBGR
Alpha
Beta
σ
Number of Samples
Implement
Statistical Test if hard to decide clean or dirty
Deciding on gridding pattern
Reject
Fail to Reject
Why not clean?

# NFB:
# Proposed Scope of Work for Removal



98th St
98th St
Niagara Falls Blvd
Excavation Area
252,539 sq. ft.
18,707 cu. yards.
Legend
RSTS Sample Location
SAT Sample Location
Site Boundary
Proposed Excavation Area
Notes:
1.) Volume estimates based on 2 foot excavation depth.
2.) Portions of the on-site building are included within the proposed excavation area due to the fact that contaminated soil was documented under the building.
3.) sq. ft. - Square Feet.
4.) cu. yds. - Cubic Yards.
WESTON
Weston Solutions, Inc.
In Association With Scientific and Environmental Associates, Inc. Environmental Compliance Consultants, Inc., Aquatic Environmental, LLC, On-Site Environmental, Inc. and Sovereign Consulting, Inc.
Figure 5B: Site Overview and Area of Concern Map (Revised)


CANADA
NY
PA
Excavation Area
176,829 sq. ft.
13,098 cu. yrds.
Niagara Falls Blvd
98th St
98th St
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
Legend
RSI 3 Sample Location
SAT Sample Location
Revised Proposed Excavation Area
Notes:
1.) Volume estimates based on 7.5x4 excavation depth
2.) Portions of the modular building are included within the proposed excavation area due to the fact that contaminated soil was documented under the building
3.) sq. ft. - Square Feet.
4.) cu. yrds - Cubic Yards.
Weston Solutions, Inc.
in Association With Scientific and Environmental Associates, Inc.; Environmental Compliance Consultants, Inc., Avatar Environmental, LLC; On-Site Environmental, Inc.; and Sovereign Consulting, Inc.
Figure 8A: Site Overview and Area of Concern Map

Phase Two Excavation Area
Phase One Excavation Area
Niagara Falls Blvd
62
rth

Niagara Falls Blvd
62

# NFB
# Financial Estimates

# NFB Rough Shielding Comparison

**Areas of Concern**

Area for Wolff Sidewalk=1,710 $ft^2$; It took **30 work days** to install this shielding.
Larger Area (Figure 8B) 252,539 $ft^2$ (23461.64 $m^2$) (18,707 cubic yards)
Smaller Area (Figure 8A) 176,829 $ft^2$ (16427.95 $m^2$) (13,098 Cubic Yards)

**Statistics**

Wolff Sidewalk Shielding Total Cost (USEPA, ERRS, RST-Labor, materials, lodging) =**$775,338.00;**
Wolff Shielding Material Cost Only= **$200,687.00**

**Larger Area**-Estimated shielding Material Only at NFB performing straight extrapolation from Wolff Shielding

$$\frac{\$200687}{1710} = \frac{X}{252539} \qquad X = \$29,638,183.00$$

**Smaller Area**-Estimated shielding Material Only at NFB performing straight extrapolation from Wolff Shielding

$$\frac{\$200687}{1710} = \frac{X}{176829} \qquad X = \$20,752,796.00$$

Estimated Total Cost for shielding installation at NFB: **$27,218,000**

Current Estimated Cost for T&D of 18,707 Cubic Yards of waste at NFB is **$4,675,000 (Larger Area).**
Current Estimated Cost for T&D of 13,000 Cubic Yards of waste at NFB is **$3,250,000 (Smaller Area).**

Total estimated cost in NFB Action Memo draft is: **$8,649,000.00 (Larger Area)**
Total estimated cost in NFB Action Memo draft is**: $7,003,000.00 (Smaller Area)**
Total estimated cost in NFB Action Memo draft without disposal **(Phase One-Smaller Area): $2,896,000.00**

# Any Questions?