PFAS Contaminated Site Portfolio Risk Ranking for the Purpose of Funding Prioritization

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Presentation Outline

1 - Objective of the Risk Ranking Development Scheme and Implementation

2 - Existing Risk Ranking Schemes

3 - The Risk Ranking Scoring and Model Components

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Objective of the Risk Ranking Development Scheme and Implementation - Issues to Consider When Developing a Ranking Scheme

The portfolio of potentially contaminated sites is relatively large

A consistent strategy for prioritization of environmental assessment funding was required

Multiple locations with possible PFAS impacts

Many of the target locations had unique site conditions

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Objective of the Risk Ranking Development Scheme and Implementation - Objective

To develop an easy to implement risk scoring method to complete risk ranking of a portfolio of sites

The approach must be adaptable if required and sufficiently detailed to produce a logical ranking

The risk ranking scheme must be broadly simple enough to apply equally to all sites and to possibly new sites should they be identified in the future

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Existing Risk Ranking Schemes – General Types

Three general categories of risk ranking schemes exist

1 - Qualitative

2 - Semi-quantitative

3 - Quantitative

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Existing Risk Ranking Schemes – General Sectors Which Apply Risk Ranking Schemes

Contaminated Sites/Abandoned Mine Sites

Chemical Hazard Management

Chemical Release Event Evaluations or Process Risk

Food Safety

Many, many others…..

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Existing Risk Ranking Schemes
Selected Risk Ranking Approach Examples Which were Considered

Model	Purpose	Type	Reference
Risk Screening System (RSS)	Used to prioritize further assessment	Semi-quantitative, but scoring is not on an ordinal scale	New Zealand Ministry of Environment, 2004
Typical DQRA (USEPA)	Ranking lead contaminated sites to determine funding priority	Quantitative	Olanreaju and Adeniyi, 2017
Hazard Ranking System (HRS)	Evaluation of abandoned contaminated sites for listing on the National Priorities List (NPL)	Semi-Quantitative	US EPA, 1992
Methods for Inventories of Contaminated Sites (MICS)	Used to prioritize further assessment	Qualitative	SERA, 2002
Risk-Ranking Methodology (RRM)	Prioritizing investigation and management efforts at abandonded mine sites in BC	Qualitative	Power et. al., 2009
DOE-ORO risk ranking	Assist in sequencing projects over time	Quantitative	based in part on US DOE, 1999
National Classification System for Contaminated Sites (NCSCS)	Identification and prioritization of sites, typically for funding	Semi-quantitative	CCME, 2008
National Priority Ranking System	Prioritizing sites for assessment and remediation	?	Canadian-Federal. Not publically available

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – NZ MOE, 2004

New Zealand Ministry of Environment Risk Screening System (RSS)

The RSS is based on a risk equation consisting of the following three components

- Hazard component
- Exposure pathway component
- Receptor component

Each of these pathways is treated independently and given an equal importance, with the overall ranking of a site obtained by choosing the worst-case pathway (ie, the pathway with the highest assessed risk)

Scoring within each component uses a point value entered for each subcomponent based on typically three available point value options

The model is considered to not be able to predict subtle differences in risk between sites, therefore final site scoring is based on a three-class system consisting of either low, medium or high ranking

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – Olanreaju and Adeniyi, 2017

Site risk is calculated strictly using a US EPA detailed quantitative risk assessment method

Only human health risk was evaluated

Analysis limited to soil and water ingestion exposure to lead by an adult assuming a residential exposure scenario

Applied at a package of eight sites in Nigeria and used to prioritize funding allocation

Results are ranked hazard indexes

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – US EPA HRS

United States Environmental Protection Agency Hazard Ranking System (HRS)

The model is semi-quantitative, complex and well tested

Intended as a screening tool and does not produce a detailed risk assessment outcome

An HRS score for a site is calculated based on four component (pathway) scores. These components are:

- Ground water migration
- Surface water migration (composed of the three threats — drinking water, human food chain, and environmental)
- Soil exposure (composed of two threats — resident population and nearby population)
- Air migration

The final score can range from 0 to 100 and is calculated from the root mean square of the four component scores. This intentionally biases the final score based on the components with the highest scores

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – SERA, 2002

Swedish Methods for Inventories of Contaminated Sites (MICS)

Can be applied to sites with limited data as the scoring is subjective

Four components are evaluated for a site within the scoring/classification approach consisting of the following:

- Hazard assessment
- Contamination level
- Potential for migration
- Sensitivity and Protection Value

Final scoring (classification) is based on a four-class system consisting of: Very high risk (Class 1), High risk (Class 2), Moderate risk (Class 3) and Low risk (Class, 4)

Sites scored as very high or high risk would be recommended for further assessment

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – Power et. al., 2009

The Risk-Ranking Methodology (RRM) has been used by the B.C. Crown Land Restoration Branch (CLRB) to prioritize assessment and management efforts at abandoned mine sites

The ranking method is qualitative, based on discussion and consensus since the portion of the portfolio of sites requiring ranking each year was considered small

Two components are evaluated to assist in ranking, consisting of human health and ecological health components

Screening quotients are calculated, in some cases employing weighting factors to adjust scores for known versus potential information being used

A final unified score is not provided by the model since a negotiated consensus approach is used to determine a site ranking

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – US DOE, 1999

Risk ranking is conducted quantitatively, using risk assessment results within the Environmental Management Benefit Assessment Matrix

The risks for each site are calculated according to established US EPA methodology obtained from either baseline or screening risk assessment

Sequencing of projects considers more than just contaminant risks posed by each site, but include regulatory milestones, logical progression of cleanup, mortgage reduction (i.e., reduction of life cycle costs), mission impacts, and stakeholder concerns

The overall ranking process was developed specifically for US DOE sites

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Existing Risk Ranking Schemes – Contaminated Site/Mine Site Risk Ranking Approaches – CCME, 2008

National Classification System for Contaminated Sites (NCSCS) is a semi-quantitative risk ranking tool which classifies sites into one of four categories consisting of: Low, Medium and High risk and Not A Priority For Action. There is also an INS classification (insufficient information to classify)

The NCSCS is a screening tool for prioritization of sites for management/assessment funding

Federal sites require NCSCS classification by the TBD and FCSAP. Typically, class 1 (high risk) sites are prioritized for funding

In use since 1992, in either the original or revised versions

The scoring of a site considers contaminant characteristics (exceedance of a guideline, quantity, potential degree of hazard), migration potential for various media and human and ecological exposure conditions. The maximum site score is 100

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Existing Risk Ranking Schemes – General Comparison

The quantitative models discussed employ standard risk assessments frameworks, or aspects of risk assessment, to score sites- although the degree of complexity differs between models

The semi-quantitative models include scoring based on multiple components, typically related to human health, ecological health and off-site migration, in addition to one or more components which capture unique conditions. The criteria to be scored in each component somewhat differ between models, although there are similarities and the weighting systems used differ

Only one purely qualitative model was evaluated

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The Risk Ranking Method and Model Components
Selected Method and General Structure of the Model

Based on a general lack of analytical data for multiple sites, but available information on site conditions and surroundings, a semi-quantitative risk ranking approach was selected to be developed

The model scoring components consist of the following:

- Human health component
- Ecological health Component
- An off-site migration risk component, and
- A component accounting for modifying factors

The model allows for consideration of soil, sediment, surface water and groundwater quality and subsurface and surrounding characteristics at each site

To streamline the structure of the risk ranking scheme, a limited number of simplified exposure scenarios were considered that generally covered all portfolio activities.

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The Risk Ranking Method and Model Components
Selected Method and General Structure of the Model

Risk scoring for each site is on an ordinal scale with up to 437.5 possible points assigned

The ecological health and offsite migration component maximum available scores are set to equal values, while the human health component available maximum score is set to a higher value

Since it is recognized that many sites lack suitable characterization, an uncertainty score is also assigned for each component based on whether input information is known or assumed

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The Risk Ranking Model Components
Human Health Component

Four defined exposure scenarios were considered

Each exposure scenario could result in exposure to up to four media, with consideration for depth ranges of soil exposure

Exposure pathways are automatically assigned based on the exposure scenario selected for each site being ranked, whether a pathway blocking mechanism is present based on user input site information, and whether a media is selected as being inapplicable based on site conditions

The risk ranking includes a hazard quotient calculation for contribution to the risk scoring, if chemical data and an applicable risk-based criterion is available for individual analytes

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The Risk Ranking Model Components
Ecological Health Component

The ecological health risk ranking component scheme is broadly similar to the human health component approach and considers the following:

- Each exposure scenario could result in exposure to up to four media
- Exposure pathways are automatically assigned based on the exposure scenario selected for each site being ranked, whether a pathway blocking mechanism is present based on user input site information, and whether a media is selected as being inapplicable based on site conditions
- The risk ranking again includes a separate hazard quotient calculation for contribution to the risk scoring, if chemical data and an applicable risk-based criterion is available for individual analytes

The ecological risk score is then further adjusted based on a number of considerations, such as:

- If species at risk are known to be or potentially exposed to the site
- Connection of the site to surface water, etc.

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The Risk Ranking Model Components
Off-Site Migration Component

If contaminants defining a site are non-mobile and restricted to the onsite area, they can be reasonably managed by the portfolio manager. If there is the potential for off-site migration, the management requirements and liability can increase significantly, therefore an off-site migration component was considered necessary to include in the model

The off-site migration risk component includes considerations for the following:

- Presence of contaminants exposed at surface
- Whether agricultural activities take place at the site
- Distance to surface water bodies
- Groundwater flow direction relative to location of surface water bodies
- Distance to property boundaries

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The Risk Ranking Model Components
Modifying Factors Component

Adjustments to the final score considered other possible site-specific considerations, such as:

- Size of the contaminated site
- Whether the area of contamination is based on proper delineation or is assumed
- If there is groundwater extraction, whether that well is within a certain arc downgradient of the site, or upgradient
- Whether contaminated surface or groundwater is used for irrigation

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Risk Scoring Example – Well Characterized Site

Table 7: Qualitative Risk Scoring Summary
Site: Well Characterized Example with Known PFAS Contamination
Land Use: Industrial (I2)

Human Health				
Maximum Possible Score	Conservative Score	Pathway Modified Score	Uncertainty Score	Proportion of Score Based on Suspected vs. Known Information
149.5	41.5	41.5	0	0%

Ecological Health				
Maximum Possible Score	Conservative Score	Pathway Modified Score	Uncertainty Score	Proportion of Score Based on Suspected vs. Known Information
125	53	43	0	0%

Offsite Migration		
Maximum Possible Score	Score	Proportion of Score Based on Suspected vs. Known Information
125	83	0%

Modifying Factors			
Maximum Possible Score	Score	Uncertainty Score	Proportion of Score Based on Suspected vs. Known Information*
38	21	0	0%

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Risk Scoring Example – Well Characterized Site (Cont'd)

Media	Groundwater	Surface Water	Soil	Sediment
Human Health Quality Index	56	100	100	100
Ecological Quality Index	99	100	100	100
Maximum Hazard Quotient (Human Health) - Provincial	3.98E-01	4.67E+00	Not Relevent	Not Relevent
Maximum Hazard Quotient (Human Health) - Federal	1.85E+02	4.00E-01	2.01E-02	2.67E-04
Maximum Hazard Quotient (Eco Health) - Federal	3.79E+00	2.18E-02	1.32E-02	4.19E-02

Score Allocation	
Human Health	22%
Ecological Health	23%
Offsite Migration	44%
Modifying Factors	11%

Summary	
Total Score	188.5 out of 437.5 possible points
Total Score	43%
Suspected vs. Known Information	0%

Analytical Data Used in the Ranking	Number of Samples
Groundwater Samples	100
Surface Water Samples	21
Soil Samples	72
Sediment Samples	6

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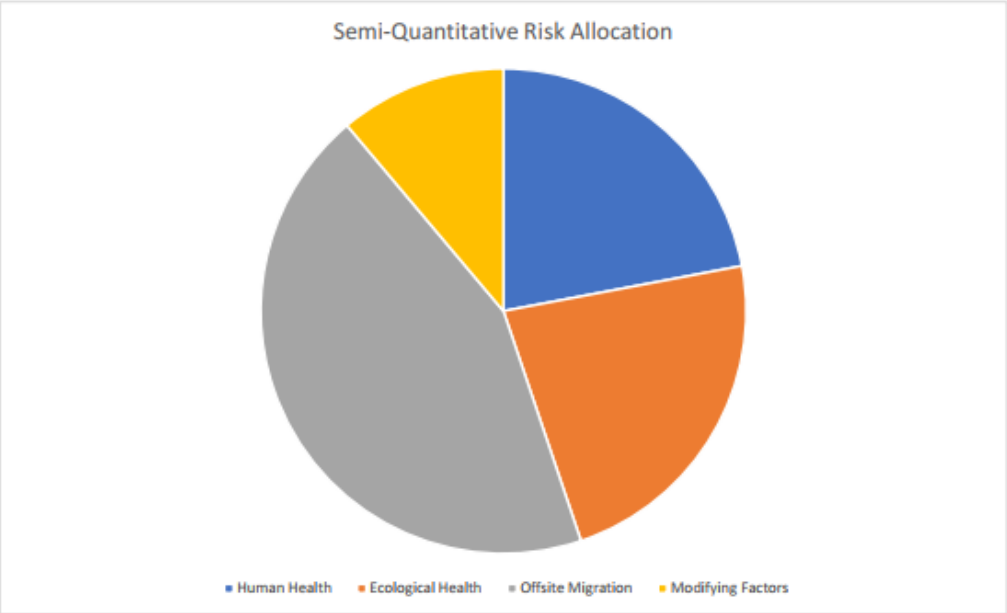
Risk Scoring Example – Well Characterized Site (Cont'd)

Figure 1: Semi-Quantitative Risk Scoring Component Allocation
Site: Well Characterized Example with Known PFAS Contamination
Land Use: Industrial (I2)



Total Score: 188.5 out of 437.5 possible points

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Potential Advantage of the Risk Ranking Scheme Over Other Approaches

The approach selected is a screening approach, rather than a more complex quatitative approach in order to prioritize funding for further assessment. The calculated risk factors for each site do not represent a magnitude of risk that can be compared to a threshold representing an unacceptable risk level

The approach is simple, consistent and easy to implement

Although a full risk assessment approach would produce a more defendable final ranking, risk assessment is time intensive and expensive if the goal is to screen a portfolio for funding prioritization

The output is not a class (i.e. a group of sites considered high risk) therefore the site manager can decide above what rank to prioritize funding

The model is editable, should additional components wish to be added

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Closure

The final risk ranking scheme was successfully applied to the portfolio in year one of the investigation program. The ranking for each site were re-evaluated in year two after year one assessments were completed and rankings were revised to determine year 3 priorities

I would like to thank the Department of National Defence and Public Services and Procurement Canada for funding this project

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Citations

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