APPENDIX A

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DUNDEE CITY COUNCIL

ENVIRONMENTAL & CONSUMER PROTECTION DEPARTMENT

DREAM - DUNDEE RISK EVALUATOR ASSESSMENT MODEL

SEPTEMBER 2001

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DREAM – Dundee Risk Evaluator Assessment Model

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1 INTRODUCTION

The new contaminated land regime requires the Authority to adopt a strategic approach to inspect its area. "The approach should be seen to:

- be rational, ordered and efficient;
- be proportionate to the seriousness of any actual or potential risk;
- seek to ensure that the most pressing and serious problems are located first;
- ensure that resources are concentrated on investigating areas where the authority is most likely to identify contaminated land; and
- ensure that the local authority efficiently identifies requirements for the detailed inspection of particular areas of land."

In order to advance the strategy in line with the above objectives, Dundee City Council have decided that it is necessary to develop a methodology that will enable the prioritisation of sites based on the pollutant linkage principle.

DREAM (Dundee Risk Evaluator Assessment Model) has been developed by the Scientific Officer responsible for contaminated land within the Environmental & Consumer Protection Department (ECPD) of Dundee City Council.

2 RISK ASSESSMENT PROTOCOLS

In order for DREAM to be acknowledged as, fair, impartial and open to examination, it is considered essential that the entire assessment procedure should be transparent.

2.1 DREAM PARAMETERS

In order to carry out the prioritisation of a site using DREAM, it is necessary to identify or determine certain parameters relating to the site. These are as follows:

2.1.1 Sources of contamination

- Historical land uses occurring on the site (S_{Hist})

2.1.2 Sensitive receptors

- Current land use (R_{HH});
- Surface water receptors (R_{SW});
- Groundwater receptors (R_{GW});
- Ecological receptors (R_{Eco}); and
- Property receptors (R_{Prop});

2.1.3 Pathways

- Human health pathways (P_{HH});
- Surface water receptor proximity (P_{SW});
- Aquifer protection of groundwater receptors (P_{GWAP});
- Geological sensitivity of groundwater receptors (P_{GWGS});
- Proximity to designated ecological receptors (P_{Eco}); and
- Harm to designated property receptors (P_{Prop}).

DREAM uses a numerical algorithm developed by the ECPD Pollution Control Section of Dundee City Council. The values associated with the parameters have been selected to emphasise the Authority's current priorities though DREAM retains the flexibility to evolve through time should priorities change.

2.2 PRINCIPLES BEHIND DREAM

The DREAM model is based on the pollutant linkage principle at the centre of the contaminated land regime. DREAM enables scoring of the principal sources of contamination, pathways and receptors to derive individual pollutant linkage scores, which may be combined to give an overall Site Index Score (SIS). In addition, the model also assumes that if receptors or pathways are absent within a linkage, the linkage is considered incomplete and will fail to achieve a linkage score.

2.3 SCIENTIFIC BASIS

The model procedures are based upon professional experience and methodologies derived from a number of published documents including:

- DoE[1] Industry Profiles (47 Vol.);
- DoE Contaminated Land Research Report CLR No. 6 (1995) – Prioritisation and Categorisation Procedure for Sites which may be Contaminated; and
- Desk Reference Guide to Potentially Contaminative Land Uses

2.4 THE DREAM ALGORITHM

DREAM requires a simple algorithm to allow the calculation of the potential risk that may be posed by a particular site. This algorithm has been constructed using empirical means and has been tested to ensure that the SIS accurately reflects the Authorities priorities. The DREAM algorithm is as follows:

$$\mathbf{SIS} = \mathbf{PLS}_{HH} + \mathbf{PLS}_{SW} + \mathbf{PLS}_{GW} + \mathbf{PLS}_{Eco} + \mathbf{PLS}_{Prop}$$

$$\mathbf{SIS} = \mathbf{S}_{Hist} \times (\mathbf{R}_{HH} \times \sum \mathbf{P}_{HH}) + \mathbf{S}_{Hist} \times (\mathbf{R}_{SW} \times \mathbf{P}_{SW}) + \mathbf{S}_{Hist} \times (\mathbf{R}_{GW} \times \{\mathbf{P}_{GWAP} + \mathbf{P}_{GWGS}\}) + \mathbf{S}_{Hist} \times (\mathbf{R}_{Eco} \times \mathbf{P}_{Eco}) + \mathbf{S}_{Hist} \times (\mathbf{R}_{Prop} \times \mathbf{P}_{Prop})$$

2.5 MULTIPLE LAND USE

Should an assessment be carried out on a site with multiple historical land uses, the assessment model will be carried out considering the historical land use with the highest S_{Hist} score.

[1] Industry Profiles - Department of the Environment 1994 - 1995

3 SOURCES

3.1 HISTORICAL LAND USES OCCURRING ON THE SITE (S_{HIST})

The DoE Industry Profiles and the Desk Reference Guide to Potentially Contaminated Land Uses provide detailed insight into the operating procedures in a large number of industrial settings. These documents provide a scientific basis for the categorisation of the contaminative potential of industries and form the basis for our risk ranking.

Historical land uses are scored on a 1 – 4 scale, where 1 has been assigned to land uses which are considered to be the least likely to cause contamination, to a maximum value of 4 which has been assigned to the industries that pose the greatest potential to cause extreme contamination of the land.

S_{Hist} is a professional judgement based on the consequence and confidence of the severity and likelihood of contamination arising from the industrial processes carried out on a site. It should be appreciated that there is the possibility that industrial land uses with a low S_{Hist} may present a greater risk than the DoE industry profiles may indicate due to specific incidents occurring on the site. Should this come to the attention of the Authority, S_{Hist} may be adjusted on a site specific basis as thought appropriate. In such cases, the rationale justifying the alteration of the S_{Hist} will be reported. Conversely, remedial works may have already been carried out on a site that may substantially reduce the potential risks posed by the historical land use. Again, S_{Hist} may be adjusted with rational explaining the adjustment attached.

DREAM's default S_{Hist} values for 51 industries including the 47 reported in the DoE Industry Profiles are as follows:

Historical Land Use	S_{Hist}	Historical Land Use	S_{Hist}
Asbestos manufacturing works	4	Metal manufacturing - refining, finishing, plating	3
Charcoal works	4	Power stations (excluding nuclear)	3
Chemical works - explosives, propellants, pyrotechnics	4	Road vehicle fuelling - transport & haulage centre	3
Chemical works - organic chemicals	4	Sewage works & sewage farms	3
Chemical works - pesticide manufacturing	4	Waste recycling - drum & tank cleaning sites	3
Engineering works - mechanical & ordnance	4	Animal & animal products processing works	2
Gas works, coke works & coal carbonisation plants	4	Chemical works - fertiliser manufacturing	2

Historical Land Use	S_{Hist}	Historical Land Use	S_{Hist}
Oil refineries, oil & petroleum bulk storage	4	Chemical works - rubber processing	2
Pulp & paper manufacturing works	4	Chemical works - mastics, sealants, adhesives	2
Timber treatment works	4	Chemical works - pharmaceuticals	2
Waste recycling - Hazardous waste treatment sites	4	Chemical works - soaps & detergents	2
Waste recycling - Landfills	4	Dockyards & dockland	2
Waster recycling - solvent recovery works	4	Engineering works - aircraft manufacture	2
Chemical works - coatings (paint & printing inks)	3	Engineering works - electrical & electronics	2
Chemical works - cosmetics & toiletries	3	Engineering works - vehicle manufacture	2
Chemical works - disinfectant maufacturing	3	Photographic works	2
Chemical works - fine chemicals manufacturing	3	Printing works	2
Chemical works - inorganic chemicals	3	Railway land	2
Chemical works - lino, vinyl & bitumen flooring	3	Textile works & dye works	2
Engineering works - railway engineering works	3	Timber products manufacturing works	2
Engineering works - Shipbuilding	3	Waste recycling - metal recycling sites	1
Fibreglass & resin works	3	Airports	1
Metal manufacturing - refining, finishing Fe & steel	3	Dry cleaners	1
Metal manufacturing - refining, finishing precious	3	Glass manufacturing	1
Metal manufacturing - refining, finishing, lead	3	Agricultural	1
Metal manufacturing - refining, finishing, non-Fe	3		

In addition to the industrial land uses noted above, the Authority will be able to add additional land uses to the list as they become identified.

4 RECEPTORS

4.1 CURRENT LAND USE (R_{HH})

R_{HH} is the parameter that will allow Dundee City Council to prioritise the sensitivity of human health receptors based on the current use of the land under study. R_{HH} is scored on a 1 – 5 scale, with the least sensitive receptors scoring the lowest values and the most sensitive receptors attaining the highest scores.

The sensitivity of a land use is primarily based on a number assumptions pertaining to the behavioural patterns and physical characteristics associated with the occupants or users ("sensitive receptors") of the parcel of land.

Behavioural characteristics may include:

- time exposed to contaminant;
- rate of dermal exposure;
- inhalation rate; and
- soil ingestion rate, whereas,

Physical characteristics comprise:

- sensitive receptor age and sex; and
- sensitive receptor body weight.

A large volume of research has been carried out to determining how behavioural patterns and physical characteristics of sensitive receptor interact to cause risk. The priorities adopted by Dundee City Council represent the commonly accepted land use sensitivity determination.

Standard current land uses	**R_{HH}**
Allotments	4
Commercial / Industrial	1
Parks / open space / recreational	3
Residential with Gardens	5
Residential without Gardens	3
Non - standard current land uses	**R_{HH}**
Schools	3
Hospitals	2

It is anticipated that further non-standard land uses identified during the implementation of the inspection strategy will be assigned an appropriate R_{HH}.

4.2 SURFACE WATER RECEPTORS (R_{SW})

Surface waters provide amenity to a range of users and the Authority recognise the need to safeguard surface waters for the long term benefit of the council stakeholders. Burns, streams, rivers and reservoirs are open to public access and degradation of either aesthetic quality or water chemistry is likely to be observed and reported to the Authority or SEPA by interested parties.

When considering the significance of a surface water body and assessing its sensitivity to mobile contaminants arising from the land, the end use of the water resource is fundamental in completing the assessment. The Authority consider that the following surface water body uses require protection and in recognition of the different standards sought, the greater the score, the more sensitive the receptor is considered.

Surface water receptor	R_{SW}
Classified as shellfish / salmonid / drinking / bathing water	5
Classified cyprinid / other use	3
Non – classified	2

4.3 GROUNDWATER RECEPTORS (R_{GW})

Groundwater is perhaps the receptor most often overlooked as it is "out of site and out of mind". Dundee's unique geological setting requires that groundwater quality and aquifer protection is addressed.

The Authority recognise that at present, groundwater abstraction is not widespread throughout the City, however increasing water charges may lead to a greater incidence of groundwater abstraction in the future as people switch from potable water supplies to private supplies.

The Authority and SEPA are striving to ensure that the water resources of today are managed in a sustainable manner and maintained for the future by preventing them from becoming contaminated to a state which is unfit for human consumption without costly water treatment processes.

It is recognised that not all groundwater resources have the same priority. The Authority consider that aquifers which provide drinking water or supply significant base flow to rivers be afforded the greatest degree of protection. Potential groundwater resources should be protected, but are given less importance that active supplies. Groundwater which is unlikely to be used is given the lowest priority

Groundwater receptor	R_{GW}
Groundwater used or provides river baseflow in close proximity	5
Potential for groundwater use or provides base flow in less close proximity	3
Groundwater unlikely to be used	1

4.4 ECOLOGICAL RECEPTORS (R_{ECO})

Part IIA provides definitions of a number of specialist ecological receptors which should be considered when evaluating an area of land's potential to cause contamination. Part IIA does not differentiate between ecological receptors and a single score will be applied if an ecological receptor is considered vulnerable.

Ecological receptor classification	R_{Eco}
Ecological receptor defined in Part IIA	5

4.5 PROPERTY RECEPTORS (R_{PROP})

Property receptors are perhaps the most difficult to classify as this branch of receptors cover an extremely diverse group of objects. The values assigned represent the Authority's priorities for dealing with potential threats to property receptors.

Property Types	R_{Prop}
Council owned housing	5
Fishery and game stock	2
Crops	1
Historic and ancient buildings	4
Industrial / commercial	3
Livestock	2
Private Housing	5

5 PATHWAYS

5.1 HUMAN HEALTH PATHWAYS (P_{HH})

Soil contamination may reach the user or occupant of a piece of land via a number of mechanisms. The mechanisms available depend on the current land use and the individual site characteristics. (e.g. vegetable ingestion is an unlikely exposure route within an industrial setting, but much more probable within an allotment environment)

There are five major pathways by which soil contamination may be taken in to a human receptor. These are as follows:

Human Health Pathways (if present, each scores 1 point)	P_{HH}
Ingestion of soil or soil related dust	1
Inhalation of outdoor vapours	1
Inhalation of indoor vapours	1
Dermal contact	1
Ingestion of home grown vegetables	1

As noted above, the pathways likely to be present are closely linked to the current land use, R_{HH} . It is important to consider not only all the pathways that are present at the time of assessment, but also to consider pathways, which may be introduced through site development which does not require planning permission (e.g. a paved or tarmac patio in residential property could be converted to a vegetable plot, etc.)

5.2 SURFACE WATER RECEPTOR PROXIMITY (P_{SW})

The likelihood of a surface water body becoming contaminated from an area of land is closely linked to the proximity of the water course to the land under study and the hydrological situation of the site. It is considered more likely that sites up-hydraulic gradient of watercourses have a greater opportunity to pollute a surface waters than sites down gradient. It is also considered that a site with a direct outfall to a watercourse (e.g. old field drains), or with a watercourse adjacent to the site is more likely to cause a pollution incident than the same site with a watercourse some distance away. To reflect this, we have adopted the following scoring rationale to take into account surface water proximity and hydraulic gradient.

Surface water receptor proximity	P_{SW}
Direct discharge	5
Adjacent to site	4
< 50m from site boundary, down gradient of site	4
<250m from site boundary, down gradient of site	3
< 50m from site boundary, cross / up gradient of site	2
<250m from site boundary, cross / up gradient of site	1
> 250m from site boundary, down gradient of site	1
> 250m from site boundary, cross / up gradient of site	0

5.3 AQUIFER PROTECTION OF GROUNDWATER RECEPTORS (P_{GWAP})

The "Aquifer Protection" (R_{GWAP}) of a groundwater resource is intended to reflect the effectiveness of the underlying strata in preventing downward migration of mobile contaminants from the soils to the aquifer. A substantial thickness of boulder clay can form an effective barrier to many contaminants, protecting the aquifer and is awarded a low R_{GWAP} score. An aquifer overlain by permeable sands and gravels is poorly protected from mobile contaminants and awarded a high R_{GWAP} score.

Protection of groundwater receptors	P_{GWAP}
Permeable strata, clayey sands or discontinuous lenses of boulder clay overlying aquifer	2
Continuous dense plastic boulder clay overlying aquifer	1

5.4 GEOLOGICAL SENSITIVITY OF GROUNDWATER RECEPTORS (P_{GWGS})

Rock strata underlying parcels of land may have varying hydrogeological properties and significance. The major groundwater resources are the most likely to be exploited in the future and, to reflect their importance, it is considered appropriate to place the greatest importance to the protection of these resources.

Sensitivity of groundwater receptors	P_{GWGS}
Lower Devonian sedimentary strata underlying site	3
Lower Devonian volcanic strata underlying site	2
Lower Devonian igneous strata underlying site	1
Quaternary strata underlying site	2

5.5 PROXIMITY TO DESIGNATED ECOLOGICAL RECEPTORS (P_{ECO})

The likelihood of significant harm being caused to an ecological receptor by a parcel of land is related to the proximity of the site to the receptor.

Proximity of designated ecological receptors	P_{Eco}
On or adjacent to the site	5
Less than 50m from site boundary	4
Greater than 50m, but less than 250 from site boundary	3
Greater than 250m, but less than 500m from site boundary	2
Greater than 500m, but less than 1,000m from site boundary	1
Greater than 1,000m from site boundary	0

The ecological receptor pollutant linkage is designed to be indicative of the potential threat posed to a designated ecological receptor and not to be considered as a full determination of the severity of the pollutant linkage. Further investigation into **actual** presence of the linkage will be necessary if it appears that the ecological linkage is significant.

5.6 HARM TO DESIGNATED PROPERTY RECEPTORS (P_{PROP})

Pathways to property receptors are varied and diverse, so difficult to identify individually. At this stage, it is considered sufficient to make an initial determination whether harm, or the or the significant possibility of significant harm, is occurring to property.

Harm occurring to property	P_{Prop}
Actual harm or the significant possibility of significant harm occurring to property	5
No harm	0

As with P_{Eco}, the property receptor pollutant linkage is designed to be indicative of the potential threat posed to property receptors and not to be considered as a full determination of the severity of the pollutant linkage. Further investigation into **actual** presence of the linkage will be necessary if it appears that the property linkage is significant.

5.7 NO PATHWAY OR NO RECEPTORS PRESENT

As DREAM considers the linkage assessments within the context of Part IIA, should a pathway or receptor fail to be identified within a potential pollutant linkage, the linkage is considered to be absent. If no linkages are present, it is not possible to classify the land as contaminated land.

6 DREAM OUTPUT

6.1 POLLUTANT LINKAGE SCORE (PLS) & SITE INDEX SCORE (SIS)

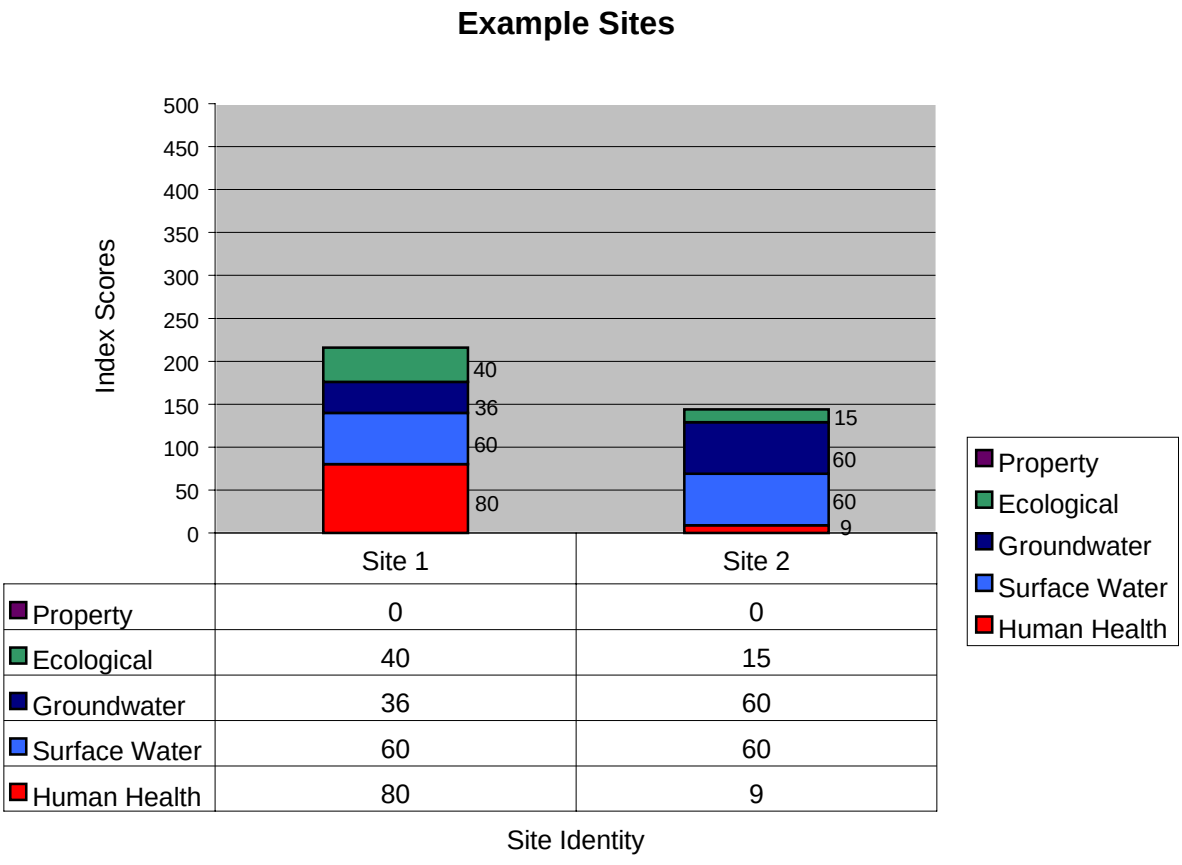
DREAM produces individual "Pollutant Linkage Scores" (PLS) and a combined "Site Index Score" (SIS) for a site, based on the parameters inputted in Chapter 3, 4 and 5 above. The SIS represents the total risk index that a parcel of land poses to the local environment, and the individual components, the PLS reflect the risk to each different environmental setting.

The SIS represents the sum of all five individual pollutant linkages identified above by the formula detailed in Chapter 2.4.

Each pollutant linkage can score up to a maximum of 100, resulting in a maximum SIS of 500. The SIS will be plotted on a chart to illustrate the total SIS and individual PLS.

The ability to break down a SIS into its individual pollutant linkage components enables the Council to quickly determine which linkages are significant on a particular parcel of land and which linkages present little or no threat to receptors.

It is hoped that comparisons between sites can be displayed in a graphical manner such as demonstrated below.



	Site 1	Site 2
Property	0	0
Ecological	40	15
Groundwater	36	60
Surface Water	60	60
Human Health	80	9

6.2 CATEGORISING AND PRIORITISING SITES ON BASIS OF PLS

Pollutant linkages will be reviewed individually and be classified into Priority Categories in accordance with CLR6 to allow the identification of the linkages requiring priority attention. The Priority Category thresholds have been determined empirically to provide appropriate action levels. The Priority Categories comprise:

Priority Category	PLS
Priority Category 1	60 – 100
Priority Category 2	40 – 59
Priority Category 3	20 – 39
Priority Category 4	0 – 19

6.2.1 Priority Category 1

Linkages falling within Priority Category 1 indicate that the land is probably or certainly not suitable for present use and environmental setting. Contaminants are probably or certainly present and likely to have an unacceptable impact on key receptors and urgent action is needed in the short term to resolve these issues.

6.2.2 Priority Category 2

Linkages falling within Priority Category 2 indicate that the site may not be suitable for present use and environmental setting. Contaminants are probably or certainly present and likely to have an unacceptable impact on key receptors and action is needed in the medium term to resolve these issues.

6.2.3 Priority Category 3

Linkages falling within Priority Category 3 indicate that the site is considered suitable for its present use and environmental setting. Contaminants may be present but are unlikely to have an unacceptable impact on key receptors and action is unlikely to be needed if the site remains in its current use or otherwise remains undisturbed.

6.2.4 Priority Category 4

Linkages falling within Priority Category 4 indicate that the site considered suitable for its present use and environmental setting. Contaminants may be present but very unlikely to have an unacceptable impact on key receptors and no action is likely to be needed if the site remains in its current use or otherwise remains undisturbed.

7 REVIEW OF DREAM

DREAM was developed in house in a response to the absence of commercially available software that adequately identified potentially problematic sites within Dundee. DREAM has taken into account the unique set of environmental, geological and historical parameters that define Dundee and has attempted to provide a locally tailored solution to the problem of the identification of potentially contaminated land.

With this in mind, it will be necessary for the DREAM model to evolve with time to accommodate new and unforeseeable scenarios which may be encountered. To allow for this, DREAM will be kept under constant review to ensure that it is performing to the high level expected and new release versions will be published with the annual review of the strategy.

There may be the occasion in the future where it is felt that a commercially produced software package can better serve the purpose of identifying potentially contaminated sited within Dundee. Should this be the case, the Council will undertake a trial of the product to determine its suitability.

8 EXAMPLES

8.1 SCENARIO 1

- Site of old gasworks (S_{Hist});
- Residential development with garden (R_{HH});
- Human health pathways – ingestion of soil, dermal contact, inhalation of outdoor vapour and ingestion of vegetables(P_{HH});
- Salmonid stream 150m down gradient of site ($R_{SW\ and}\ P_{SW}$);
- Potential for groundwater to be used for drinking water in future (R_{GW});
- Aquifer of Lower Devonian igneous strata protected by 10 m of dense boulder clay ($P_{GWGS\ and}\ P_{GWAP}$);
- SSSI 400m away ($R_{Eco\ and}\ P_{Eco}$); and
- No property issues ($R_{Prop\ and}\ P_{Prop}$)

$$\mathbf{SIS} = \mathbf{PLS}_{HH} + \mathbf{PLS}_{SW} + \mathbf{PLS}_{GW} + \mathbf{PLS}_{Eco} + \mathbf{PLS}_{Prop}$$

$$\mathbf{SIS} = S_{Hist} \times (R_{HH} \times \sum P_{HH}) + S_{Hist} \times (R_{SW} \times P_{SW}) + S_{Hist} \times (R_{GW} \times \{P_{GWAP} + P_{GWGS}\}) + S_{Hist} \times (R_{Eco} \times P_{Eco}) + S_{Hist} \times (R_{Prop} \times P_{Prop})$$

$$\mathbf{SIS} = 4 \times (5 \times 4) + 4 \times (5 \times 3) + 4 \times (3 \times \{1 + 2\}) + 4 \times (5 \times 2) + 4 \times (0 \times 0)$$

$$\mathbf{SIS} = \underset{\text{PC 1}}{80} + \underset{\text{PC3}}{60} + \underset{\text{PC2}}{36} + \underset{\text{PC3}}{40} + \underset{\text{PC4}}{0}$$

SIS = 216

Human Health = Primary pollutant linkage of concern

Groundwater = Secondary pollutant linkage of concern

8.2 SCENARIO 2

- Site of chemical works for inks (S_{Hist});
- Commercial / Industrial land use (R_{HH});
- Human health pathways – ingestion of soil, dermal contact and inhalation of outdoor vapour (P_{HH});
- Drinking water stream, less than 50m down gradient of site ($R_{SW\ and}\ P_{SW}$);
- Groundwater used for private drinking water supply (R_{GW});
- Aquifer of Lower Devonian sedimentary strata protected by 10 m of dense boulder clay ($P_{GWGS\ and}\ P_{GWAP}$);
- SSSI 600m away ($R_{Eco\ and}\ P_{Eco}$); and
- No property issues ($R_{Prop\ and}\ P_{Prop}$)

$$\mathbf{SIS} = PLS_{HH} + PLS_{SW} + PLS_{GW} + PLS_{Eco} + PLS_{Prop}$$

$$\mathbf{SIS} = S_{Hist} \times (R_{HH} \times \sum P_{HH}) + S_{Hist} \times (R_{SW} \times P_{SW}) + S_{Hist} \times (R_{GW} \times \{P_{GWAP} + P_{GWGS}\}) + S_{Hist} \times (R_{Eco} \times P_{Eco}) + S_{Hist} \times (R_{Prop} \times P_{Prop})$$

$$\mathbf{SIS} = 3 \times (1 \times 3) + 3 \times (5 \times 4) + 3 \times (5 \times \{1 + 3\}) + 3 \times (5 \times 1) + 3 \times (0 \times 0)$$

$$\mathbf{SIS} = \underset{PC4}{9} + \underset{PC2}{60} + \underset{PC2}{60} + \underset{PC4}{15} + \underset{PC4}{0}$$

SIS = 144

Surface water and groundwater = Joint primary pollutant linkages of concern