Appendix 16.4
Preliminary Hydrogeological Assessment Report

M74 Junction 5, Raith

A Preliminary Hydrogeological Assessment of Options for the Proposed Upgrade of the M74 Junction 5, Raith

Mouchel Fairhurst JV
Ellismuir Way
Tannochside Park
Uddingston
G71 5PW

T 01698 802 850
F 01698 803 542

November 2006

In association with

SiAS
37 Manor Place
Edinburgh
EH3 7EB

Young Associates
75 Trafalgar Lane
Leith
EH6 4DQ

Document Control Sheet

Project Title	M8 Baillieston to Newhouse and Associated Improvements
Document Title	A Preliminary Hydrogeological Assessment of Options for the Proposed Upgrade of the M74 Junction 5, Raith
Report No	M8MFJV/52
Revision	2
Status	FINAL
Control Date	24th November 2006

Record of Issue

Issue	Status	Author	Date	Check	Date	Authorised	Date
1	DRAFT FOR APPROVAL	S Saunders	07-03-05	W Huston	07-03-05	R Ireland	07-03-05
2	FINAL	S Saunders	24-11-06	W Huston	24-11-06	R Ireland	24-11-06

Distribution

Organisation	Contact	Copies
MouchelFairhurst	Mike Hodgson	1
MouchelFairhurst	Laurence Campbell	1

Contents

1 Introduction

1.1 General

As part of their commission to undertake an assessment of the M8 Baillieston to Newhouse scheme, Mouchel Fairhurst JV (MFJV) was instructed to consider consequential and complementary improvements elsewhere in the adjacent trunk road network. The proposed upgrading of M74 Junction 5, Raith has been identified and is being developed as part of these complimentary improvements.

Environmental conditions at M74 Junction 5, Raith are such that it was necessary to construct a preliminary hydrogeological model of the site and to undertake preliminary assessments of the likely impacts of three improvement options (B1, C1 and D) on local, sensitive water bodies. These include Sites of Importance for Nature Conservation (SINC), a Site of Special Scientific Interest (SSSI), and the River Clyde. The scope of the study included consideration of the requirements for further assessment work.

No discussion has taken place with any of the regulatory authorities at this stage.

1.2 Scope of Work

The work has involved a review of pertinent reference material, listed in Appendix A, to define the following:

a) A preliminary hydrogeological model of the site, to include the:
   - (i) relative importance of sources of water which feed the SINCs/SSSI and the River Clyde
   - (ii) water balance of such bodies
   - (iii) importance of these receptors locally as water resources
   - (iv) evaluation of sources, pathways and receptors

(b) The sensitivity of the receiving water bodies to changes in surface water or groundwater levels (receptors)

(c) The likely impact on the hydrogeology of the local area as a result of the proposed development and an initial assessment of the significance of these effects (potential sources and pathways)

(d) Outline methods for their mitigation in the event that potentially significant impacts are confirmed

(e) An outline scope for developing an ongoing programme and reducing gaps in existing data.

1.3 Study Objectives

The primary focus of the study has been a high-level technical review of available reference material to determine whether this information is sufficient to allow the completion of a robust hydrogeological assessment. Information gaps have been identified and proposals put forward to permit this information to be collected. A preliminary assessment has been made of the likely impacts of the different options.

2 Review of Supporting Documentation

2.1 Information Sources

Much of the available information has been in draft format and is listed in Appendix A.

The interpretation of hydrogeological information presented has been derived from a desk study review of approximately 45 boreholes records [4] without recourse to site records or original drilling logs. Other information included the British Geological Survey Sheet for Hamilton 23W (Drift) [12], the Hydrogeological Map of Scotland [15], Geological Memoir of the Airdrie District [16] and British Geological Survey Sheet for Airdrie (solid) [17].

3 Site Description

3.1 Setting

The study area is centred on junction 5 of the M74 covering an area of approximately 170 hectares extending north-west along the M74 and includes the Bothwell Park road bridge (see Figure 1). To the south-east the site is bounded by the River Clyde. The area extends approximately 500m northeast, along the A725, and to the River Clyde on the south-west. M74 Junction 5, Raith is situated on a relatively flat area of flood plain adjacent to the River Clyde, at approximately 25m to 30m AOD. The ground level increases to around 40m AOD to the north and north-east of the study area.

3.2 Proposed Junction Options

At the time of writing, three design options (namely B(i), C(i), and D (ii)) were being considered. A series of site plans showing these options are presented in Figures 2a, 2b and 2c, with a description of the options provided below.

Option B(i) takes A725 north/south traffic over Whistleberry Toll and the M74 (at a third level). The existing Raith roundabout is retained to facilitate turning movements to and from the M74. A loop is provided from the M74 Southbound diverge to the A725 towards East Kilbride to ease merging traffic on the East Kilbride Expressway. This merge is constrained by the proximity of the River Clyde and existing structures carrying the A725 and the B7071 over the river. In order for all these links to connect with the existing Raith roundabout it is necessary to construct a new roundabout to the northeast of Raith, adjacent to the proposed loop from the M74 to the A725. Option B(i) requires structures to cross the realigned link road to the B7071, with significant structures spanning above the M74 motorway. In addition, structures will be necessary to allow the Bothwell services exit to cross beneath the A725 and the merge slip (towards Bellshill) to cross beneath the elevated A725. In addition a structure is required to cross the WCML railway.

Option C(i) provides a similar operational solution to Option B(i). The principal difference is that the alignment of the A725, as it passes over Whistleberry Toll, is under the M74. The alignment has moved northwards targeting the back of the noses on the M74 slip roads to cross beneath the M74 and provide the necessary headroom clearance on the proposed A725. Option C(i) requires structures to cross the realigned link road to the B7071 and construction of an under-bridge below the existing M74. In addition structures will be necessary to allow the Bothwell services exit to cross above the A725 and to allow the merge slip towards Bellshill to cross above the A725. As with Option B (i), a structure is required to cross the WCML

Option D takes the A725 beneath the existing Raith Roundabout and the M74. The proposed dual carriageway link would be constructed below the existing circulatory carriageway of the Raith Junction and continue below the M74 at a significant depth, generally 6 to 8 metres below the existing ground level. The profile between the crossing points on the Raith roundabout has been raised to minimise the drainage difficulties of this scheme, giving a maximum depth of 10 to 11 metres beneath the M74. Option D requires significant structures to cross beneath the Raith roundabout twice and the M74 at significant depth. Retaining walls are also necessary to accommodate the slip roads from and to the proposed A725.

3.3 Geology and Ground Conditions

3.3.1 Superficial Deposits

Investigations and reports completed to date (see Figure 3) indicate made ground to be present adjacent to the route of the A725 road north-east of the M74, and also within the embankments of the M74. It is not certain to what depth made ground underlies the major roads themselves. An illustrative geological section (see Figure 4) has been prepared using selected borehole information. This shows in excess of 8 metres of made ground in the area of the junction. The deposits are typically sandy gravelly clays, coarse sands and gravels or burnt shale (blaes).

The youngest natural soil types are alluvial clays and silts, which in the lower-lying areas of the flood plain of the Clyde, generally achieve a thickness in excess of 5 metres. In the area of the junction, however, (BHs G283, R43, R44, R45 and R45a) in excess of 10 metres have been penetrated. The drift sheet for Hamilton [12] shows a strong linear feature associated with the course of the Clyde but the borehole records do not indicate that these maximum thicknesses are developed along the whole line of this linear feature. The distribution suggests that the river has spread its alluvial deposits whilst incising through an irregular land surface.

A poorly sorted sand and gravel is typically penetrated at depth beneath the alluvial clays and silts, particularly in the lower-lying reaches of the Clyde flood plain. The sands and gravels are typically 3 to 10 metres in thickness, although in one locality

(BH 282) in excess of 25 metres of this deposit have been proven. The north-south section investigated by the MFJV [7] shows that the sands and gravels appear to thicken towards the inter-section but the unit is by no means continuous along the line of the section. The unit is recorded in almost 90% of the borehole logs reviewed.

Around 60% of boreholes through the alluvial materials prove the presence of a glacial till at depth but frequently the overlying sand and gravels can be found lying directly on top of the bedrock deposits. The glacial deposits are typical sandy gravelly clays but significant thicknesses of very poorly sorted sands and gravels with cobbles or boulders are also present locally above the Carboniferous bedrock surface.

Drift deposits are thickest at the northwestern site boundary where in excess of 25m are proven in BHs 43, G054 and G132, G133. It is apparent that not only is there significant lateral variations in the nature of the drift deposits but also in the variation of the vertical thicknesses developed. The deposits decrease in thickness away from the Raith Junction towards the northeast, where in BH G078 less than 10 metres are present, and towards the River Clyde where it is less than 8 metres (BHs 103/103A) of drift deposits are recorded.

3.3.2 Bedrock Deposits

The solid geology comprises strata of the Upper Coal Measures of the Upper Carboniferous period, which are sandstones, siltstones and mudstones with seams of coal. Below the study area the strata dip at approximately 5° to the south. Available information suggests that the bedrock is between 5 to 30 metres below ground level; the shallower depths to the south of the M8/A725 intersection west of the Hamilton Low Park SSSI. In general the pre-glacial land surface is around 10 metres Ordnance Datum (mOD) but the thicker sequence of drift deposits noted to the northwest of the intersection is due to the bedrock surface being at elevations of between -6.2mOD (BH G054) and -3.6mOD (R43) in this area. The deeper bedrock surface tends to lie along the NNW/SSE alignment of the alluvial deposits noted earlier and suggests a line of inherent weakness in bedrock along this axis.

3.4 Hydrology

The MFJV Stage 2 Environmental Impact Assessment [6] allows a summary of the hydrological conditions of the study area. The following watercourses are situated within or near the scheme area:

1. River Clyde
2. Unnamed Burn (the Burn)
3. Several local drainage channels and ponds.

The catchment area of the River Clyde as far downstream as the M74 Junction 5 Raith is approximately 1684km^2 consisting of upland moorland and arable lowland with urban areas located in the lower-lying areas within the catchment.

The unnamed Burn is a minor tributary of the River Clyde with a total catchment area of about 1.04km^2. The natural catchment drainage paths of the Burn have been altered over the years by housing development and construction of the local road network. The burn rises to the west of the existing A725 trunk road and town of Orbiston. It flows in a south-easterly direction and passes under the railway line connecting Uddingston and Motherwell. It then flows through an existing pond west of the A725 and continues to flow parallel to the A725 in southerly direction towards the Raith Junction crossing the M74 motorway to the west of the junction. It continues in a southerly direction before it changes direction and passes beneath the A725 to the south of the junction. The Burn once again changes direction and flows in a southerly direction towards the River Clyde discharging into the existing pond situated in the SSSI area south of the junction. There is no apparent overflow route from the pond into the River Clyde although it is conjectured that the flow spills over the bank of the river when the pond has filled up.

There are several surface water features (ponds) present within the catchment of the burn, which are shown on Figure 5. These features include:

1. A large pond (Pond 1) designated a SSSI which is located south of the junction and to the north of the River Clyde at NGR 714578. The SSSI, Hamilton Low Parks, extends to 107.6 ha and has a specific biological designation referring to the flora and fauna located within the site boundary.

2. A small pond (Pond 2) situated to the south west of the junction (NGR 710585).

3. Two small ponds (Ponds 3 and 4) to the north west of the junction west of the M8 motorway at (NGR 711588) and (NGR 712586).

4. A small pond (pond 5) exits to the north east of the junction west of A725 trunk road (NGR 716589).

5. A small pond (Pond 6) situated to the north of the junction south of Bothwell Park Wood (NGR 714591).

6. The Strathclyde Loch (Pond 7 at NGR 719581) is located to the southeast of the junction covering an area of about 87ha. The loch was constructed during early 1970's. It is built on the floodplain of the River Clyde at the confluence of the South Calder Water.

Data taken from the Flood Study [14] and a review of existing topographic mapping suggests that there are identifiable relationships between the ponds, as described in Table 1.

Table 1: Location and level data for surface water features

Description of Water Feature	Surface Water Level (mAOD)	Comments
Pond 1	18.77	Hamilton SSSI
Pond 2	20.67	Remote from Bothwell Park SINC
Pond 3	20.28	Bothwell Park SINC
Pond 4	20.67	Bothwell Park SINC
Pond 5	22.75	Bothwell Park SINC
Pond 6	No Data	Bothwell Park SINC
Pond 7	No data	Strathclyde Loch SINC
Pond 8	20.35	Small loch west of junction
River Clyde	No data	

NOTES: 1. Surface water levels from flood study of January 2005 [14]
2. The reference does not indicate if surface water levels presented are taken at the same time

The proposed options for Raith junction will affect the route of the Burn and it will be diverted to the north and south-west of the junction depending on the proposed option. Pond 1 appears to be fed by the overflow from Pond 4 and the overflow from the Burn through Pond 3 which is culverted under the A725 flowing south entering the SSSI area. However in mid summer, soil moisture levels are high as the water table probably lies close to ground level [15]. The man-made Pond 7 (Strathclyde Loch SINC) is fed directly by the South Calder Water and the River Clyde during flood conditions.

The small Pond 2 is outwith the Bothwell Park/Laighland Wetlands SINC and its source is not obvious from the information used in the study [8, 9 & 10]. The surface water level for Pond 2 is above that for Pond 3 suggesting a recharge other than that from the Bothwell Park ponds.

Ponds 3 to 6 inclusive are part of the Bothwell Park/Laighland Wetlands Site of Importance for Nature Conservation (SINC), whilst the Strathclyde Loch is also designated a SINC.

A study of the drainage of the area suggests that Ponds 5 and 6 are fed by the Burn and its small tributary to the north of the Raith Junction. Ponds 3 and 4 appear to be interlinked and fed by an overflow from the Burn through Pond 5 which is routed under the M74 motorway.

With the exception of the River Clyde, no water quality data exists for any of the watercourses or ponds in the vicinity of Raith Junction.

3.5 Surface Water Sensitivity

The sensitivity of surface water features in the vicinity of the proposed scheme [6] is influenced by associated sites of ecological importance, with which they are closely connected.

According to SEPA River Classification 1996-2003 the River Clyde at Bothwell Bridge is Class 'B' (fair quality) and is thus considered to be of 'medium' sensitivity.

No classification has been attributed to the water in the Burn. However, the Burn discharges into an area of wetland located in the existing SSSI and is thus considered to be a resource of 'high' sensitivity

Raith Haugh/Hamilton Low Parks SSSI is a biological SSSI. The SSSI is reported to be the least affected by previous road building and mining and, as a consequence, contains the most naturalised habitats.

The Bothwell Park/Laighland Wetlands SINC is situated to the north of the Raith junction and this review [18] has shown that there are two locally uncommon plants in the ponds of the SINC. Mudwort is found in all the ponds and in the SSSI further to the south, whilst Grey Club Rush is only found in Laighland Wetland 3 (see below). This SINC is virtually un-managed and suffers from siltation, nutrient enrichment and scrub invasion which have caused long-term reductions in species and habitat diversity. The Bothwell Park/Laighland Wetlands SINC comprises 3 sub-sites:

1. Laighland Wetland 1 (Pond 5) is a complex area of wetland and wet woodland that forms the largest part of the SINC and is adjacent to the A725. The wetland may owe its existence to land subsidence (following mining under the area) combined with up-welling of groundwater from old mine workings [18]. The overall diversity of this wetland has fallen since the mid 1990s.

2. Laighland Wetland 2 (Pond 6), an elongated area of wetland that runs north from the M74 to the southern edge of Bothwell Park Wood. The pond is small in size compared to pond 5 with the source of its water being a small water course that passes through the railway cutting to the north [18]. The pond appears to have dried out since the 1990s [19] and, in general, the species diversity of the wetland is low [18].

3. Laighland Wetland 3 (Ponds 3 and 4) which is an elongated area of wetland lying along the southern edge of the M74 embankment in the Laighland area. The site is physically isolated from the rest of the SINC by the M74. It is reported [18] that the source of Pond 3 is the culverted drain from the western Bothwell Wetland i.e. Pond 5. These ponds are known to have been formed in the low-lying flood prone base of the M74 embankment. The northern part of the Laighland wetland

comprises about 30% of open water with abundant bulrush [18]. The area is described as "species poor".

The northern edge of the North Lanarkshire SINC 75/1a at Strathclyde Country Park comprises Strathclyde Loch, its shoreline and a man-made island. There is limited available background data available for this SINC.

3.6 Hydrogeology

3.6.1 General

The lithological strata described in Section 3.2 can be simply equated to broad hydrogeological units (Table 2).

Table 2: Lithological and Hydrogeological Strata sequence

Lithological Strata	Hydrogeological Significance	Hydrogeological Unit	Comment
Made Ground	Perched Water	Water table system	Locally may contain lenses of groundwater of poor to moderate quality. Local to road and drainage features
Alluvial Silt and Clays	Aquitard	Minor source of groundwater only	May act to "perch" groundwater within the overlying made ground
Alluvial Sands and Gravels (SAG)	Minor Aquifer	May be "confined" or "unconfined". Primary mode of flow is intergranular.	Widespread across the study area. May rest directly on Coal Measures strata
Glacial Till	Aquiclude	Will not transmit or store groundwater in significant quantities. May store groundwater in lenses of sands and gravel.	Not always present under the SAG.
Coal Measures	Aquifer	Locally important for groundwater supply. Primary or secondary modes of flow.	Covered by younger deposits, noticeably till, and alluvial sands, gravels and clays/silts.

3.6.2 Groundwater Occurrence and Flow

It is likely that significant quantities of groundwater will be found in the made ground, alluvial sands and gravels and within the more permeable strata within the Carboniferous bedrock.

The Carboniferous strata are reported as moderately permeable [15] with the predominant flow mechanism being secondary in fissures and other discontinuities such as bedding planes and faults. Based on geology, topography and base flow data, the estimated infiltration into this aquifer is 100 to 300mm/yr. This aquifer is widespread under large areas of the Central Belt of Scotland. Of the records reviewed only one borehole (G132) showed a significant inflow of groundwater when penetrating the Carboniferous bedrock, however the records reviewed do not, as a whole, present a detailed description of inflows either due to the nature of the investigation (i.e. geotechnical) or to the restrictions inherent in the type of drilling methodology (i.e. rotary) at the depths of bedrock penetrated. There are no piezometers constructed within bedrock deposits within the area of study.

Borehole records suggest that significant inflows of groundwater occur within the alluvial deposits after penetrating the less permeable silts and clays. With rare exceptions, (BH103A, R78 and R80), the sands and gravels are not exposed at ground surface in the study area. It is of interest to note that these boreholes are located to the southwest of the Raith Junction west of the Hamilton Low SSSI.

Records suggest that groundwater within the sands and gravels rises above the level of the overlying confining layer. These rises are typically recorded after 20 minutes standing during drilling and may not therefore be water levels that are representative. There are two piezometers monitoring groundwater levels in this unit (BH G051 located to the west of the junction and BH G133 to the northwest). Here the "rest level" of groundwater within the minor aquifer is within 0.5m of the ground level for BH G051 (21.15mOD), whilst G133 was recorded dry at the last time of monitoring (25/01/05).

Given the lack of field data, it is not possible to predict the groundwater direction in the sands and gravel aquifer. If the alluvial deposits form part of the channel underlying the River Clyde then sensibly the flow in the sands and gravels would be expected to follow that of the river toward the sea (i.e. to the northwest). Information [13] pertinent to boreholes drilled along the alignment of the M74 suggest a southerly component of flow but these observations are made during drilling operations and not from fixed piezometers.

3.6.3 Groundwater Quality

There are no records of groundwater quality available for the study area.

3.6.4 Relationship between Groundwater and Surface Resources

A review of hydrogeological data in relation to the sensitive surface water features has been made to derive an understanding of base line conditions pertinent to each location. The information is presented and discussed below.

Pond 1 (circa NGR 714 578)

BH No	Ground Level (mOD)	Distance to pond (m)	Made Ground (m)	Clay/silt (m)	SAG (m)	Lower Clay/silt (m)	B/R (mBGL)	GWL (mOD)	Pond Level (mOD)	Comment
B130	19.34	70	0.0	7.3	1.6	0.0	8.9	NR	18.17	No records
R76	19.66	50	0.0	5.1	0.0	0.0	5.1	NR		Wet at 1.7m

NOTES:
1. Pond level from Flood Survey of January 2005
2. Groundwater levels approximate, generally from October 2004. GW levels are mBGL
3. ND = No data, NP = Not penetrated, SAG = Sands and Gravels, GWL= Groundwater Level, B/R = bedrock. mBGL= metres below ground
4. Thicknesses of lithological units are in metres

The surface water level of Pond 1 relative to Pond 3 (20.28mAOD) and surrounding ground levels suggests drainage of surface water from north of the junction to the south towards the River Clyde. The boreholes records show substantial thicknesses of alluvial clays and silts with only a thin sequence of more permeable strata present below 7.3m in BH B130. It can be concluded with a fair degree of confidence that rainwater and surface water are likely to be the only sources of water for the SSSI. It is believed that the SSSI and the Clyde are hydraulically linked but no data has been presented to substantiate this conjecture. Given the nature of the flow in the river and the low energy environment of the SSSI, it can be reasonably assumed that the contribution of the SSSI to the River Clyde will be insignificant.

Pond 2 (circa NGR 710 584)

BH No	Ground Level (mOD)	Distance to pond (m)	Made Ground (m)	Clay/silt (m)	SAG (m)	Lower Clay/silt (m)	B/R (mBGL)	GWL (mOD)	Pond Level (mOD)	Comment
G049	20.72	40	0.0	3.1	>2.6	NP	NP	19.92	20.67	GW@0.8 mbgl
G051	21.15	40	0.0	1.6	4.2	>2.0	NP	20.1		GW@1.1 mbgl
G056	21.09	80	0.0	2.9	2.3	4.1	NP	20.0		GW@1.1 mbgl

NOTES:
1. Pond level from Flood Survey of January 2005
2. Groundwater levels approximate, generally from October 2004. GW levels are mBGL
3. ND = No data, NP = Not penetrated, SAG = Sands and Gravels, GWL= Groundwater Level, B/R = bedrock. mBGL= metres below ground
4. Thicknesses of lithological units are in metres

The surface water level of Pond 2 relative to Pond 3 (20.28m AOD) and surrounding ground levels suggests that this pond may feed into Pond 1. As with Pond 3, the surface water level is significantly above that of the underlying groundwater contained within the sands and gravels. There is also a significant thickness of surface clay extending to between 2 to 3mBGL which may be the basal unit of the pond in this area. Both strikes in the more permeable alluvial deposits rise above the base of the overlying clay, which when coupled with the relative difference between surface water and ground water levels, suggests that the surface water body is remote from groundwater. There is a minor groundwater occurrence within near-surface sands above the alluvial clays/silts which may feed groundwater into the pond locally.

Pond 3 (circa NGR 712 586)

BH No	Ground Level (mOD)	Distance to pond (m)	Made Ground (m)	Clay/silt (m)	SAG (m)	Lower Clay/silt (m)	B/R (mBGL)	GWL (mOD)	Pond Level (mOD)	Comment
G053	20.49	20	0.0	1.8	3.5	>4.7	NP	19.9	20.28	GW@0.6 mbgl
G054	21.47	30	0.0	2.5	4.7	8.3	NP	19.5		GW@1.0 mbgl
G061	24.53	50	6.6	0.0	0.9	>2.5	NP	21.3		GW@3.2 mbgl

NOTES:
1. Pond level from Flood Survey of January 2005
2. Groundwater levels approximate, generally from October 2004. GW levels are mBGL
3. ND = No data, NP = Not penetrated, SAG = Sands and Gravels, GWL= Groundwater Level, B/R = bedrock. mBGL= metres below ground
4. Thicknesses of lithological units are in metres

The information from BHs G053/4 shows that the pond water level is significantly above that of the underlying groundwater contained within the sands and gravels. The relative surface water levels suggest that this pond is likely to be linked to Pond 4 further to the north. There is a significant thickness of surface clay extending to between 2 to 2.5mBGL which may be the basal unit of the pond. Both strikes in the more permeable alluvial deposits are seen to rise above the base of the overlying clay, which when couple with the relative difference between surface water and ground water levels, suggests that the surface water body is remote from groundwater.

Pond 4 (circa NGR 711 588)

BH No	Ground Level (mOD)	Distance to pond (m)	Made Ground (m)	Clay/silt (m)	SAG (m)	Lower Clay/silt (m)	B/R (mBGL)	GWL (mOD)	Pond Level (mOD)	Comment
G049	20.72	40	0.0	3.1	>2.6	NP	NP	19.92	20.67	GW@1.2 mbgl
G051	21.15	40	0.0	1.6	4.2	>2.0	NP	20.1		GW@1.05 mbgl
G056	21.09	80	0.0	2.9	2.3	4.1	NP	20.0		GW@1.1 mbgl

NOTES:
1. Pond level from Flood Survey of January 2005
2. Groundwater levels approximate, generally from October 2004. GW levels are mBGL
3. ND = No data, NP = Not penetrated, SAG = Sands and Gravels, GWL= Groundwater Level, B/R = bedrock. mBGL= metres below ground
4. Thicknesses of lithological units are in metres

Records available show surface clay extended to between 2 to 3mBGL. Apart from G056, which is the most remote borehole, groundwater is encountered beneath the alluvial clays and rises to a “rest” level of approximately 20mOD, which is below the pond level. It must be remembered that the levels for the two water resources are not taken at the same time. Borehole G051 is constructed with a piezometer with the sand and gravel aquifer (between 1.6 to 5.6mBGL) and suggests a standing (piezometric) water surface associated with the sands and gravels in the region of 20.7mOD for January 2005, the time of the flood study measurements for the pond. This level is very similar to the pond level at this time but the lithological sequence shown in boreholes G049 and G051 suggests that groundwater is unlikely to be feeding the pond.

Pond 5 (circa NGR 716589)

BH No	Ground Level (mOD)	Distance to pond (m)	Made Ground (m)	Clay/silt (m)	SAG (m)	Lower Clay/silt (m)	B/R (mBGL)	GWL (mOD)	Pond Level (mOD)	Comment
G078	27.60	280	0.4	0.0	4.2	1.9	6.5	24.4	22.75	GW@3.2 mbgl
G080	39.88	180	2.6	7.2	>0.2	NP	NP	NR		ND
G081	37.38	220	1.8	>8.25	NP	NP	NP	NR		

NOTES:
1. Pond level from Flood Survey of January 2005
2. Groundwater levels approximate, generally from October 2004. GW levels are mBGL
3. ND = No data, NP = Not penetrated, SAG = Sands and Gravels, GWL= Groundwater Level, B/R = bedrock. mBGL= metres below ground
4. Thicknesses of lithological units are in metres

Only the records for G078 are considered appropriate due to the remoteness of the other boreholes. The conclusions reached must be the same for Pond 6 since the pond level is less than that of the only groundwater record, the potential for groundwater to be feeding the pond cannot be ruled out.

Pond 6 (circa NGR 714591)

BH No	Ground Level (mOD)	Distance to pond (m)	Made Ground (m)	Clay/silt (m)	SAG (m)	Lower Clay/silt (m)	B/R (mBGL)	GWL (mOD)	Pond Level (mOD)	Comment
G078	27.6	280	0.4	0.0	4.2	1.9	6.5	24.4	ND	GW@3.2 mbgl
G133	29.5	220	10.6	1.2	2.3	>9.7	NP	ND		
40A	43.9	280	0.0	5.2	9.4	0.0	14.7	40.3		GW@3.6 mbgl

NOTES:
1. Pond level from Flood Survey of January 2005
2. Groundwater levels approximate, generally from October 2004. GW levels are mBGL
3. ND = No data, NP = Not penetrated, SAG = Sands and Gravels, GWL= Groundwater Level, B/R = bedrock. mBGL= metres below ground
4. Thicknesses of lithological units are in metres

Given the data available it is difficult to present a coherent assessment of surface and groundwater conditions for this pond. The nearest boreholes are some distance from the feature and ground conditions shown to be highly variable. Information from the nearest borehole at a similar ground level to the pond (G078) suggests that the feature may be formed in more permeable alluvial deposits. Ground levels [14] in the vicinity of the feature appear to be approximately 22mOD which are below the groundwater level (GWL) for BH G078 above, inferring that groundwater may be feeding the pond at this locality.

Pond 7 (circa NGR 719 581)

Strathclyde Loch is man-made and is likely therefore to be lined with an impermeable basal unit. The pond is remote from the other ponds described and is not considered further in this assessment.

The River Clyde

According to SEPA River Classification 1996-2003 the River Clyde at Bothwell Bridge is classified as Class 'B' (fair quality) and is thus considered to be of 'medium' sensitivity [6].

The low flow (Q95) of the River Clyde is reported to be approximately 7.7m3/sec [6]. It is not known what contribution groundwater contributes to the base flow in the river. It is to be anticipated that this contribution will not be significant as the base of the river bed is likely to be "lined" with fine-grained sediments such as silts and clays.

It has been reported [15] that the water level of the River Clyde is several metres below the surface level of the flood plain under normal flow conditions but during heavy floods the SSSI to the north is extensively inundated.

4 Preliminary Hydrogeological Conceptual Model

The preliminary hydrogeological conceptual model suggests the presence of three water bearing formations close to the Raith Junction; namely

(a) an upper (perched) water table system in the made ground of limited vertical and lateral extent
(b) an intermediate semi-confined to confined minor aquifer in the alluvial sands and gravels. This is more widespread since it is associated with the flood plain deposits of the River Clyde
(c) a lower confined groundwater system within the Carboniferous bedrock.

Generally these water bearing units are separated by less permeable horizons of alluvial silts and clays and glacial clays/till. Where the upper water bearing formation (the made ground) is not present, the alluvial silts and clays form an upper "confining" lithology over the alluvial sands and gravels.

The distribution and nature of the three water bearing formations are very diverse. In the made ground, which is likely to be found locally near main roads or areas associated with land use other than agriculture, groundwater is likely to be of variable quality and present as a limited volume near the base of the unit. This lithology is not significant as a water resource and, as such, is not considered to be a receptor.

Within the elongate lenses of alluvial deposits associated with the River Clyde is a complex sequence of sands and gravels that are generally widespread and confined by the overlying alluvial silt/clay. The unit will be characterised by inter-granular (primary) groundwater flow. Water quality is likely to be good to moderate. It is not known whether the unit is used locally for water supply purposes but it should be considered as a receptor in the hydrogeological conceptual model in any case.

Bedrock is a locally important source of groundwater which will be derived from secondary sources such as faults, fissures and joints. Water quality is likely to be moderate in areas where coals are present but the system must also be considered as a receptor in the development of a conceptual model for the area.

The limited piezometric data does not allow a clear definition of the inter-relationships between these three water bearing units. It has been demonstrated that the sands and gravels locally lie directly on older Carboniferous strata and this relationship will allow an exchange of groundwater to occur in these areas between the two units.

There is limited information with which to assess fully the hydrological and hydrogeological regimes associated with the sensitive water bodies. It is clear, however, that these features maintain a diverse fauna and flora although the plants present are not the most sensitive to fluctuations of water level, such as exhibited by mosses and peat bogs. , However most of the ponds in the area have been designated SINCs and therefore must be considered as sensitive receptors. Notwithstanding, it is clear from this review [18,19] that the SINCs to the north of the A725 in particular are poorly managed, species-poor, suffer from siltation and have declined in "quality" since the 1990's. It is suggested also that the SINCs may be fed in part by upwelling from abandoned mine-workings. If this is the case, then the resultant surface water quality is likely to be moderate at best.

The presence of near-surface clay or silt at most locations and the apparent hydraulic connection/gradient or flow between the ponds suggests that the main contributing factors to the water balance of the ponds is rainfall and run-off from surface water features higher up the catchment. The information reviewed does not permit a confident evaluation of the contribution, if any, that groundwater makes to the water bodies. It is considered more likely that the ponds are recharging the minor aquifer through leakage via basal units rather than the sands and gravels contributing significantly to the water balance of the surface water features.

5 Potential Impacts

The road engineering options present some potential threats to the existing surface water bodies. In particular, the blockage or hindrance to flow between the ponds is a potential risk in the cases of Options Bi and Ci, whilst the import and placement of significant volumes of earthworks materials in all options may compress underlying lithological units with a resultant reduction in formation permeability and hence groundwater flow capability. Reference to Figure 15.2 [8] suggests that there are significant impacts associated with Option Bi including the apparent loss of Pond 5 and the redundancy of the southern portion of Pond 3 to the northwest of the junction. Furthermore, a significant length of the "drainage" link between Ponds 3 and 1 requires diversion, with the route passing very close to Pond 2. A further risk is the damage of fauna and flora due to the encroachment of earth embankments and the excavation of new drainage channels/burn diversion features.

Option Ci is similar to Option Bi but the A725 passes under the M74 rather than over it. Pond 5 appears to be truncated to the north by this option and flow into this pond is now diverted to Pond 6. The impact of this increased flow into Pond 6 is uncertain. Further impacts associated with this option include the loss of the north end of Pond 3 and the western extremity of Pond 2. Excavation beneath the M74 may have consequences on the local, near-surface groundwater regime (and hence on the local surface water features) both during construction and post completion, depending on the form of the selected scheme.

Option D involves the construction of an underpass for the A725 beneath the M74. The underpass will be excavated to a depth of 6 to 8 metres below existing ground level and to maximum depths of approximately 16mOD over the area of the Raith

Junction Central Roundabout [7] where road construction embankments have effectively raised the ground level. The construction will require the removal of significant thicknesses of made ground and the excavation of saturated sands and gravels which occur at variable depths (BHs 1962/ 43 and /45A refer). This removal may result in impact on the neighbouring environment, including the possible mobilisation of any soluble contaminants associated with the deposits (e.g. burnt shale (G069/070)). It will also generate wastes which will need to be disposed according to current waste-management legislation. Groundwater inflows could be significant at these depths but details of strikes and occurrence are currently sketchy. Further the feature may be normal to the direction of groundwater flow in the sands and gravels with a resultant change in the flow characteristics of the minor aquifer. With the data available it is not possible to predict with any certainty the possible impact on the flow regime within the alluvial deposits.

A possible requirement for the construction of the underpass is installation of a buried wall from ground level, possibly to bedrock. Buried walls may further impede existing groundwater flow patterns and certain piling techniques have the potential to create preferential migration pathways. It is essential to evaluate more fully the likely impact of any preferred designs, particularly those which incorporate piling into bedrock. Groundwater records from boreholes in bedrock are scant but suggest that the Carboniferous aquifer may be under sub-artesian head with upward flow potentials which would preclude the downward migration of any mobile contaminants associated with past land uses located at shallower depths

The proposed development Option Dii requires the excavation of a burn diversion channel from Pond 5 to Pond 3 but these works appear not to influence either the size or drainage characteristics of any of the sensitive water bodies in the area of study [10].

6 Conclusions and Recommendations

6.1 Conclusions

The following conclusions may be drawn from the review:

1. Little location-specific data is available with which to assess baseline hydrogeological environments relative to the sensitive water bodies in the area.

2. The geological sequence beneath the study area is complex but may be simplified into broad hydrogeological units with differing groundwater properties, quality and flow regimes

3. Groundwater is an important resource within sands and gravels of alluvial origin and the underlying Carboniferous bedrock. These resources are thought not to be used locally for water supply purposes.

4. Groundwater fluxes and the direction of flow are not known in the water bearing systems identified

5. Groundwater quality information is not available for either of the two water-bearing units or the perched water table within the made ground

6. The hydraulic relationship between surface water in the River Clyde and groundwater in the underlying alluvial sands and gravels and Carboniferous bedrock is not confirmed.

7. The nature of potential contamination associated with past site land use is not known with any degree of certainty

8. Sensitive water bodies within the study area are likely to be fed by surface water flow from ponds and/or drainage higher up the catchment, and directly by rainfall. The contribution from groundwater is likely to be insignificant although there is insufficient data to support this theory.

9. The species diversity of the SINCs north of the A725 is generally poor with long term reduction in species numbers due to siltation and encroachment of more common fauna.

10. Two of the Ponds (3 and 4) appear to be of recent origin having been formed in the lower-lying land to the south of the M74 embankment.

11. Hamilton Low Park SSSI is an established area of wetland with the pond fed from surface water from the SINCs to the north and flooding by the River Clyde.

12. Proposed junction options may introduce impacts on local surface water (Options Bi and Ci) and groundwater regimes (Option Dii). For example:

    (a) alteration to the local groundwater conditions as a result of dewatering operations to facilitate construction (Option Dii, and perhaps Option Ci). The longer term impact of Option Dii on both groundwater and surface water resources would need to be considered once baseline conditions have been established. The impact on groundwater locally will depend on the form of construction and the need for temporary or permanent de-watering. The impact on the water balance of sensitive sites can only be resolved once hydraulic parameters have been established for the alluvial deposits and the water balance of the ponds has been determined.

(b) encroachment on the flows within drainage ditches either physically during periods of construction, or chemically by the release of potential contaminants such as petroleum products as a result of inadequate site management practices

(c) the mobilisation of contaminants within the made ground, or underlying alluvial deposits, during construction works.

(d) reduction in the permeabilities of the different lithological units due to compression under earth embankments.

(e) the mobilisation of high silt burdens during dewatering or earthworks which impact either the drainage ditches/burns or the SINC/SSSI directly.

13. Options Bi and Ci could result in the partial loss of one or two of the ponds within the Bothwell Park/Laighland Wetland SINC and the total loss of Pond 5 in Option Bi.

14. There is unlikely to be any impact on the groundwater resources within the bedrock from the options proposed

15. The volume and rates of permanent pumping required for Option Dii are not known.

6.2 Option Selection

At this stage the understanding of the hydrogeological regime is insufficient to allow reasoned scheme selection on hydrogeological grounds. However the apparent choice is between a surface (or near-surface) route to the north of the existing junction and a depressed route directly through the junction. Whereas completed construction of the former is likely to have most direct impact on the surface water bodies, the latter is more likely to affect groundwater flows, although possibly not to any significant degree.

6.3 Recommendations

It is recommended that:

1. A detailed site inspection is undertaken in order to:
   (a) identify locations and access for new boreholes
   (b) determine surface water flow into and out of ponds
   (c) locate drainage features associated with existing road infrastructure.
   (d) allow depth profiling across the ponds at risk
   (e) permit site familiarisation
   (f) confirm existing flow linkages between surface water bodies.
   (g) establish locations for sampling and monitoring points.

2. A ground investigation is undertaken to allow:

(a) sampling of soils for analytical purposes and perhaps for geotechnical parameters.

(b) the construction of 10 to 15 piezometers with 50mm standpipes installed and sealed over water bearing horizons. Selected new boreholes should be sunk closely adjacent to margins of those ponds which are sensitive and the boreholes should be retained in order to collect location-specific information to allow an assessment of pond water balance, in particularly the contribution to groundwater inflow. If the contribution of groundwater from the alluvial deposits to the River Clyde is thought to be significant, then a monitoring borehole in close vicinity to the river is required to assess the hydraulic relationships between groundwater in the alluvial aquifer and the river. If piling or buried walls are preferred for Option Dii then boreholes should be constructed into bedrock to determine the piezometric level, aquifer permeability and groundwater quality of the bedrock aquifer.

(c) monitoring of water level with time to establish the hydraulic relationship between groundwater and surface water bodies. Monitoring of completed boreholes should be accompanied by the measurement of surface water levels in the ponds.

(d) purging of boreholes to determine baseline groundwater chemistry and the presence of contaminants associated with the past land use of the area (such as hydrocarbons and metals)

(e) water sampling and chemical analyses of ponds and other sensitive water features to establish baseline quality prior to commencement of site construction activities
Monitoring and assessment of water quality should be continued throughout and after the period of construction to ensure that impacts to water quality and levels are established.

(f) completion of pumping tests to determine hydraulic parameters and discharge/drawdown relationships of alluvial deposits

(g) establishment of a monitoring network and base line water level and water quality conditions prior to implementation of the accepted option of development

(h) trial pitting, where access is possible, to collect soil samples for analyses of potential contamination types

3. Early discussions should be held with relevant authorities and regulators to acquaint them with these proposals and to establish any particular concerns which they may have. In particular there is a need to establish if groundwater resources locally are used for water supply purposes and whether for potable, agricultural or industrial purposes.

APPENDIX A Documents Reviewed/References

1. Mouchel Fairhurst JV, Geotechnical Desk Study Report – M74 Junction 5, Raith, Report No M8MFJV/05, 19 January 2004. Interim Status
2. Mouchel Fairhurst JV, Addendum to Geotechnical Desk Study Report – M74 Junction 5, Raith, Report No M8MFJV/05, 7 December 2004. Addendum Status
3. Mouchel Fairhurst JV, Raith Junction – Stage 2 Environmental Impact Assessment Geology and Soils, Report No M8MFJV, 5 November 2004. Draft Status
4. Numerous Borehole Records (locations as shown on Drawing No 53213/ of January 2005)
5. Dipped Water Levels for Boreholes G051 and G061 between August 2004 and January 2005.
6. Mouchel Fairhurst JV., M8 Baillieston to Newhouse and Associated Improvements Raith Junction Stage 2 Environmental Impact Assessment, Chapter 15 Hydrology Assessment, Draft 2
7. Mouchel Fairhurst JV, Geological Section. Drawing No 53213, June 2004 Draft Status

8, 9 &10 Mouchel Fairhurst JV, Geotechnical Desk Study Report – M74 Junction 5, Raith, Report No M8MFJV/05, 19 January 2004.Figures 15.2, 15.3 and 15.4

11. Description of Options (extract from unidentified Fairhurst Report)
12. British Geological Survey. Hamilton Sheet 23W (Drift)
13. Summary of Drilling Records for the study Area (WAF internal record)
14. Mouchel Fairhurst JV, Geotechnical Desk Study Report – M74 Junction 5, Raith, Report No M8MFJV/05, Indicative Flood Inundation, January 2005. Figure 15.8
15. British Geology Survey, 1988. Hydrogeological Map of Scotland
16. British Geology Survey, 1996. Geological Memoir of the Airdrie District.
17. British Geological Survey, 1994. Airdrie Sheet 31W (Solid)
18. Mouchel Fairhurst JV., M8 Baillieston to Newhouse and Associated Improvements Stage 2 Environmental Impact Assessment, Volume 2-Appendices, Draft 01, September 2004
19. Watson, K., 1990. Sites of importance for Nature Conservation – Hamilton District, Unpublished survey report commissioned by Clyde Calder's Urban Fringe Management Project.