Hereford and Worcester
County Council

DROITWICH CANALS FEASIBILITY STUDY

Draft Report

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HEREFORD AND WORCESTER COUNTY COUNCIL

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DRAFT REPORT, MARCH 1994

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1. INTRODUCTION

1.1 This Report

This Report has been prepared for Hereford and Worcester County Council in fulfilment of a commission awarded to Scott Wilson Kirkpatrick & Partners on 13th December 1993. The commission was for a Feasibility Study for the restoration to cruising standards of the Droitwich Barge and Junction Canals, to address in particular the following principal matters:-

1. Engineering Considerations
2. Water Supply Requirements
3. Cost and Benefit Analysis
4. Environmental Appraisal

A copy of the full Study Brief is included in Appendix A to this Report.

This Report represents all the findings of the field surveys and desk studies, and makes recommendations for the implementation of restoration works. Estimated construction, maintenance and operating costs are given and a development strategy is proposed. Recommendations are also made for the further studies that will be required to bring the project to a successful conclusion.

1.2 Background

1.2.1 Introduction

Droitwich is blessed with two canals: the Barge Canal (1771) connects the Town to the River Severn some 9km to the west, and the Junction Canal (1854) links the Town to the Worcester and Birmingham Canal about 2km to the east. The Barge Canal is one of the earliest canals to be constructed in England. It was engineering by James Brindley and is reputed to have been one of only three canals completed in his lifetime. The Junction Canal on the other hand is one of the last canals to be constructed, and has about the deepest locks of any to be found in England. These canals are therefore historically important in both the socio-economic sense and in engineering terms.

1.2.2 History of Droitwich and the Canals

Droitwich is an ancient town with a fascinating history arising from its location and natural brine springs. The exploitation of the brine springs and the production of salt is well documented[1][2][3] and it is not the intention of this Report to consider these matters in any detail. However the following notes have been prepared from published text[4][5][6] and are included here to explain how the Droitwich Canals came about and to show why they were so important to the Town.

The very existence of Droitwich (and of its two canals) arises from the geology of the area, particularly the fortuitous deposits of rock salt beneath the town. These deposits have been exploited from before the Iron Age, right through to the 20th Century. The canals, however, are relevant only to the last 200 years or so, as may be seen in the Chronology in Table 1.1.

In the case of Droitwich, salt was not mined in the solid but was extracted by the boiling of the naturally occurring brine groundwater. Within and around Droitwich are numerous brine springs which made abstraction relatively easy. The highly concentrated brine in this vicinity is particularly pure so very little additional refining was necessary to make higher value table salt. Thus a substantial local industry of regional and national importance developed through the 17th, 18th and the early part of the 19th Centuries.

This wider importance meant that the local industry was prey to the ups and downs of external economics and national politics, and to fierce competition from other producers. Given that the raw material (brine) was available "free", the principal costs of production arose from the purchase of fuel; and that for marketing from transport. Even the cost of fuel contained a substantial element for the cost of transport, since local sources of wood became exhausted in the 17th Century and this meant the purchase and transport of coal from Coalbrookdale and the Forest of Dean.

It seems likely that in the very early years of salt production in Droitwich the River Salwarpe was navigable to some extent for the whole route between the Town and the River Severn. By the late 16th Century, however, the Salwarpe had ceased to be passable by boats. Several improvement schemes were considered and some lock construction was carried out in the 17th Century but these projects failed, so fuel in and salt out continued to be carried by expensive horse and waggon.

In the early part of the 18th Century the output of brine was dramatically increased when new deeper borings under the Town tapped a more prolific source. This expansion in production lead to decreases in the price of salt and increased sales and competition which together generated pressure to develop more effective and economic transport arrangements. The stage was therefore set to consider again the question of a water based transport system, but this time by means of a completely independent artificial navigation, rather than by improvements to the River Salwarpe.

At this time the Canal Age in England was in its infancy. The Duke of Bridgwater's Canal from Worsley to Manchester had started construction in 1759 with James Brindley in charge of building works. Prior to this the Sankey Canal, near St Helens, had been built (1757) which served, in conjunction with the River Weaver, to carry coal and salt to and from Northwich and Winsford.

Table 1.1 Chronology for Droitwich, Salt and the Canals

C 800BC - AD43	Iron Age - traces of salt production, later well organised, at Bay Meadow north of the River Salwarpe, and Friar Street south of river. Recorded evidence from 200BC.
AD43 - 410	Roman Settlement - Salinae. Well organised and engineered brine extraction and salt production. Use of River Salwarpe for navigation to harbour near Chapel Bridge for Fort Dodderhill?
c 716	Anglo Saxon charters for extensive workings at "Saltwich".
1086	Domesday Book records ten major brine pits, with three main sites of Upwich, Middlewich and Netherwich.
1215	King John Charter - Borough monopoly on salt manufacture.
1378	Richard II grant of rights to Bailiffs of Droitwich, to levy tolls on River Salwarpe.
1600	River Salwarpe considered non-navigable.
1655	Offers to make Salwarpe navigable and claims for construction of 5 flash locks, but now no trace of any works.
1660 - 1693	Various attempts with Bills and construction to restore River Salwarpe for navigation, none successful.
1695	Borough monopoly for salt making ended and start of major expansion in the industry.
1703 and 1747	Further Bills for restoration of River Salwarpe for navigation, but all failed.
1725 - 1727	First deep borings made to expose stronger flows of brine and enable production to increase substantially. Pressure for better transport system in consequence.
1767	Droitwich Corporation appointed James Brindley to provide estimates for an artificial navigation between Hawford and Droitwich.
1768	Act obtained to construct Barge Canal as an independent navigation linking the town of the River Severn.
1771	Official opening of Barge Canal (12th March). "Broad" canal but towpath only suitable for man haulage of small Trows (called Wichs).
1774	Canal company started selling coal wholesale and retail. General salt trade doing well.
1780	Canal company able to sell coal trading business at a profit.

1784	Threat of competition from extension of Stourbridge Canal southwards to Worcester, but scheme failed.
1791	Act for Worcester and Birmingham Canal. Supported by Droitwich Proprietors in return for agreement to underwrite Droitwich shares with 5% dividend, to protect profits.
1806	Droitwich Proprietors constructed proper horse tow path to improve viability and counter competition from road haulage and other canals.
1810	Day-to-day management of canal taken over by Worcester and Birmingham Canal Co.
1815	Opening of Worcester & Birmingham Canal.
1822 and 1825	Partial repeal then the abolition of Salt Duties, with further enhancement of trade and improvement of profitability on Barge Canal.
1828	Discovery of new brine source at Stoke Prior with output routed along Barge Canal. Worc. B'ham Canal
1841	Opening of Birmingham & Gloucester Railway - start of new decline in Barge Canal traffic due to loss of Stoke Prior trade.
1851	Opening of Oxford, Worcester and Wolverhampton Railway, fears of further decline in Barge Canal traffic.
1852	Act obtained to construct Junction Canal as counter measure to declining trade.
1853	Worcester & Birmingham Canal agreed lease of 21 years with Barge Canal company. Carried out improvements including lock lengthening.
1854	Junction Canal opened.
1860s	Trade still declining due to railway competition, and proposals made (unsuccessfully) to convert Worcester & Birmingham and Junction canals to railways.
1868	Worcester & Birmingham in receivership.
1874	Act to transfer ownership of the Barge, Junction and Worcester & Birmingham Canals to the Gloucester & Berkeley Canal Co. (later named the Sharpness New Docks and Gloucester & Birmingham Navigation Co.).
1875 - 1876	Major renovation works including rebuilding Barge Lock (which had decayed due to subsidence of up to 9 feet), but toll income did not cover mortgage interest and shareholder guaranteed dividends.

1890	Stoke Prior output exceeds that for Droitwich, due to more modern works. Droitwich salt workings in decline.
1903	Barge Lock rebuilt again (raised 5 feet). Traffic mainly farm produce or bricks.
1914	End of salt trade on canals.
1918	Last commercial craft on Barge Canal.
1922	Salt production in Droitwich ceased.
1939	Legal closure of Barge and Junction Canals (13th July) with residue of land conveyed to Droitwich Borough Council.
1963	Droitwich Borough Council formed Sub-Committee to review future potential.
1965	Formation of Droitwich Town Development Corporation and production of Town Plan including revival of both canals.
1967	Canal Sub-Committee commissioned restoration survey of both canals. This identified water supply as key issue and authorization given to monitor flows in River Salwarpe.
1969	Worcester & Birmingham Canal Society inaugurated (26th February), with interests extending to Droitwich Canals.
1971	Preliminary restoration work on canals started.
1973	Formal incorporation of The Droitwich Canals Trust Ltd (5th September).

As a response to these mounting pressures the Drotwich Corporation appointed Brindley to engineer a canal (the Barge Canal) from Hawford on the River Severn to the salt workings in what is now the Vines Park area of Droitwich. An act was obtained in 1768 and construction was completed in 1771.

At first trade was quite brisk although the proprietors were kept on their toes to fend off competition and to develop the canal to improve its service. For example the canal had been built as a "broad" waterway to enable it to take sail barges from the River Severn, and did not originally have a proper tow path. This was eventually added so that donkeys could be used to haul the barges.

However, increasing competition, especially from the developing railway network lead to a proposal for linking the Barge Canal to the Worcester and Birmingham Canal so that the trade for the salt works at Stoke Prior could be obtained. The Junction Canal was completed in 1854, and joined the Worcester and Birmingham Canal at Hanbury to the Barge Canal in Droitwich, although the final section within the Town actually made use of the River Salwarpe to avoid the cost of providing a new bridge for Bromsgrove Road.

The Junction Canal was a "narrow" canal to match the Worcester and Birmingham. The locks on the Barge Canal had to be rebuilt to accommodate the narrow barges which were longer than the river barges used on the Barge Canal.

The new canal link failed to halt the gradual decline in the salt trade from Stoke Prior, which of preference use the railways. The end of salt transport came in 1914 although salt production in Droitwich continued until 1922. Both the Barge and the Junction Canals were formally abandoned in 1939 - the common fate of most canals in England, and left to gradually fade away.

1.2.3 Revival of Interest in the Canals

The residue of Canal land was transferred to Droitwich Borough Council on abandonment, and the Barge Canal within the Borough boundary was incorporated into the Town's drainage system. Some small plots of land were also sold, particularly on the Junction Canal, but the vast majority remained in Borough Council ownership. This gave the canal routes a degree of protection against development for other purposes, but could not stop the obstruction of the Barge Canal at Hawford by the remodelled A449 or the construction of the M5 over the Junction Canal just to the east of the Town.

Several attempts to promote schemes for restoration were made in the 1940s and 50s but it was not until the early 1960s that a Councils Sub-Committee of the Borough Council was found with the objective to review the potential of the Canals. The Sub-Committee reported favourably on the prospects for restoration for leisure purposes and their proposals for complete revival were then incorporated into the New Town plans of Droitwich Town Development Corporation.

A Working Party was created to assist with development of the restoration schemes and in 1967 a survey of both canals was commissioned[6]. Further investigations followed as a prelude to the design of restoration works and in 1971 some field teams were organised by the Worcester and Birmingham Canal Society to clear tow paths and to carry out some dredging. The Working Party issued its report in October 1971[7] and the recommendations made were adopted by the Council. Included in the recommendations was the creation of a charitable trust to act as the agent for restoration. The Droitwich Canals Trust Ltd was incorporated on 5th September 1973 and immediately set to work.

Encouraged by a very supportive Borough Council, there followed a remarkable period of sustained activity, mainly by the volunteers of the Trust, which although faltering on occasions (as such organisations inevitably do), has seen the restoration to navigation standards of the Barge Canal between Barge Lock in Vines Park and the top gate of Lock 3 (a distance of approximately 5½km) together with isolated works such as at Linacre Bridge and Lock 3, as reported recently by the Chairman of the Trust[8]. The Trust has an ongoing schedule of restoration work which is only constrained by the pace with which money can be raised and the availability of the volunteer workforce. In some instances the recommendations from this Feasibility Study are awaited to enable the Trust to determine its own restoration strategies.

1.3 Previous Studies

Because of the strong interest in restoration of the canals, particularly since the early 1960s, there is a wealth of information about their condition and on schemes for revival. Much of this is held by Wychaven District Council (as successors to Droitwich Borough Council and the Town Development Corporation), with the Trust holding most of the balance. This information is an important archive and has been extensively consulted during the course of this study. Included in this information are the following documents of separate reference.

As noted in Section 1.2 of this Report there were two studies carried out by the Borough Council/Town Development Corporation in 1967[6] and in 1971[7]. These reports provided the impetus for the restoration carried out to date. The 1967 report concluded that restoration was feasible and suggested how the engineering works and water supplies might be arranged. A management structure for the restoration was proposed, including the setting up of a charitable trust. The 1971 report confirmed the findings of the previous report and recommended restoration of both the Barge and Junction Canals. On the basis of these reports the Town Development Corporation ensured that no further sales of Canal land were made and no developments that would hinder restoration were permitted.

In 1985 a Feasibility Study[9] for restoration of the Junction Canal was carried out for the Trust by ~~Tony Harrison of the Inland Waterways Association (IWA)~~. The Harrison Report is a comprehensive review of the history and then present conditions of the Canals, and includes recommendations for future actions and costs. The emphasis of the Report was on the Junction Canal which at that time had seen little restoration effort but much contemplation over regaining the route from Lock 3 to Barge Lock.

A further detailed review of the top three locks of the Junction Canal was prepared following a walk-over inspection made in October 1991 by Roy Sutton ~~of the IWA~~, on behalf of the Trust. The Sutton Report[10] gives dimensioned data on existing structures, an assessment of their condition, and proposals for repair.

1.4 Restoration Standards

Within the original Study Brief (Appendix A) were the following criteria for the design of channels, structures and water requirements:

Canal Design Criteria

Minimum air draft	2.44 metres
Minimum water depth	1.50 metres
Minimum free board	0.30 metres
Towpath width	2.0 metres
Minimum canal width at structures	4.8 metres - Barge Canal
	2.28(?) metres - Junction Canal
Size of boats using navigation	72' 0" x 14' 6" - Barge Canal
	~~69' 6"~~(?) x 7' 0" - Junction Canal (72)

Dimensions annotated (?) are subject to final confirmation.

New canal cut in open area to be trapezoidal section having a width at operating water level of 12 metres with 1 in 2 side slopes. Operation of the canals should allow for up to a maximum of 24 lockages per day through a 30 week cruising season of April to October.

In general our proposals for restoration comply with these criteria.

In addition we have applied a constraint of 1m/second for velocity of flow for navigation purposes in the River Salwarpe.

1.5 Organisations Contacted

The Study Brief included lists of consultees to be approached for discussions and information for the Study. A full list of all the organisations contacted is given in Appendix C at the end of this Report.

2. ENGINEERING CONSIDERATIONS

2.1 Introduction

In this section of our Report we present our investigations into the Geotechnical, Structural and Hydraulic Engineering of our study. We have also included here a consideration of new works that will be required to allow navigation over the whole length of the Canals from the River Severn to the Worcester and Birmingham Canal.

We have assembled a Schedule of Features of the Canals as a shorthand inventory of all existing principal aspects. This is given in Appendix B to this Report, and might usefully be read in conjunction with this section.

2.2 Geotechnical Considerations

2.2.1 Introduction

A walkover survey of both the Junction and Barge Canal was undertaken between the 10th and 13th January 1994. The object of this survey was to establish the current status of the canal earthworks and identify where repairs or reconstruction would be required prior to re-opening the canal. The survey was based on observations from the towpath or from adjacent lands where access was available.

A summary of the findings of the survey is presented in the Schedule of Features accompanying this report. From this schedule a further Schedule of Defects has been prepared together with an indication of the type of repairs likely to be required. These are in addition to works required in overcoming physical obstructions or involving total reconstruction which are discussed in Section 2.5 of this Report. The Schedule of Defects is presented as Table 2.1 in this Section of the Report.

2.2.2 Geology and Ground Conditions

The 1:50,000 scale geological map of the site area (Droitwich - Sheet 182) shows the solid geology to comprise Mercia Mudstone - this was formerly known as Keuper Marl. Within the valley of the River Salwarpe deposits of alluvium occur with river terrace deposits occurring at the valley sides.

The Mercia Mudstone principally comprises red brown, slightly calcareous, mudstones and siltstones which weather to clays of between firm and very stiff consistency within 5 to 10m of the ground surface. Within the Droitwich area the mudstone originally included two layers or rock salt, each about 5m thick, at some 40m and 90m depth. The salt was eventually dissolved by percolating groundwater and the resulting brine pumped to the surface for commercial salt extraction. Although this practice has ceased natural salt springs still occur within the Vines Park area of central Droitwich and elsewhere in the region.

Solution of the salt has led to surface subsidence which appears a common phenomenon in the Droitwich area. The alluvium typically comprises soft clays and silts with lenses of sand and gravel whilst the terrace deposits are likely to be almost entirely granular.

East of the M5 motorway the Junction Canal appears to run entirely through Mercia Mudstone with little or no superficial cover. West of the M5, as far as the railway line in Droitwich, the Canals traverse alluvial deposits before following almost exactly the junction of the Mercia Mudstone and alluvium as far as Salwarpe. From Salwarpe to Porters Hill bridge the Barge Canal passes entirely through Mercia Mudstone before again continuing to follow the boundary between the Mercia Mudstone and Salwarpe alluvial/terrace deposits. West of the A449 the Canal traverses alluvium and terrace deposits until its junction with the River Severn.

Summaries of site investigations information, for projects associated with and adjacent to the canal, have been provided by the Client for the section of canal between the M5 and Chawson. Information would not appear to be available from here to the River Severn.

At the M5 crossing boreholes indicate the Mercia Mudstone to comprise some 2m of soft-firm clay overlying firm to stiff clays with weak mudstone at 6m depth. Groundwater was first encountered at approximately 3.5m depth (30m AOD).

Between the M5 and Chawson the alluvium varies between 1 and 3m in thickness and comprises soft to firm, grey-black, organic silty clay often with a gravel/cobble layer at its base. The underlying Mercia Mudstone comprises red silty clays and clayey silts which are normally stiff within 1m of their upper surface and very stiff within 3m. As the canal is aligned along the edge of the river valley close to the interface of the Mercia Mudstone and alluvium, cuttings can be assumed to be through the mudstone and embankments to rest upon the alluvium. Groundwater levels appear to be about 1m deep within the river valley and up to 3m deep beneath the slightly higher mudstone deposits at the valley edge.

Although site investigation information is not available beyond Chawson ground conditions are likely to be similar to those described above for the relevant geology.

2.3.3 Earthworks Construction

Site inspection indicates that cutting slopes and the external faces of embankments were originally constructed at between 1:1 and 1:2 (V:H). Exposures within cuttings generally reveal firm to stiff reddish clays which are occasionally shaley (Mercia Mudstone). Similar material was probably used to form the embankments.

It was not possible to check within the timescale of the walkover survey whether the Canals were lined with a clay blanket but we understand that only the embankments were lined with day to a thickness of between 75 and 150mm. Commonly Canals of this age and type commonly included a 450 to 600mm thick clay liner. In view of the relative rarity of seepage through the embankments it is considered that the liner, where present, is in good condition.

2.2.4 Earthworks Condition

Modern design techniques would probably indicate a side slope of between 1:1.5 and 1:2 (V:H) to be appropriate for cuttings and 1:2 for embankments. This is somewhat flatter than the current sideslope and as would be expected indications of instability are present - see Schedule of Features.

However, much of the instability is restricted to shallow surface movements and very few examples of major instability were encountered. This is believed to be due to the following two factors:-

a) Most cutting and embankment slopes have a dense cover of trees/scrub which would bind and dry the slope.

b) Leakage from the canal into the embankments appears in the main to be limited and consequent softening of the fill materials has been avoided.

Where leakage or softening of cutting slopes has occurred or trees are absent instability is often present and it is in these areas that repairs are required. The precise form of the remedial works could only be finalised following detailed stability analyses. However, it is envisaged that they would range from simple reinforced mats or stone mattresses placed about the water line on cutting slopes, to replacement of slipped material on embankment slopes with granular material and/or gabions. In some instances, where property is close to the Canal bank or there is insufficient space to regrade/treat slopes, sheet piling is likely to be required.

The Barge Canal in the Chawson area (chainage 2200 to 2900) is close to the edge of a modern housing estate. The Canal is in cutting of between 1 and 3m depth with side slopes varying from 1:1 to 1:2. For a total 250m length of canal in the vicinity of Oakleigh Road and Little Mill, several properties are within 2 or 3m of the Canal cutting. In these areas the tarmac path immediately behind the crest of the cutting has a cracked/stepped surface and lampposts occasionally lean from the vertical. In one extreme case minor hairline cracking was noted to the brickwork of a property close to the Canal.

The surface of the cutting is clearly unstable but it could not be established within this particular study whether the damage behind the cutting was due to deeper seated instability or some other cause. The latter might include seasonal ground movements due to the generally dense vegetation growing at the crest of the cutting. Further study is recommended.

In some instances streams or rivers flow close to the Canal and instability of the former's banks are jeopardising the Canal. This is particularly true for the stretch of Barge Canal immediately upstream of the A449 crossing. Thus recommendations are also made for remedial works external to the Canals.

2.2.5 Further Studies and Monitoring

The greatest area of uncertainty remaining from the present study concerns the section of Barge Canal in the Chawson area adjacent to domestic properties, see previous section. A further study is necessary to establish the scale of instability in this area. The work would entail:-

a) Desk study to establish the history of the area and foundation details of adjacent properties.

b) Topographic survey to obtain accurate bank profiles.

c) Field inspection to record locations of instability relative to the position and condition of adjacent structures.

d) Limited site investigation comprising two or three 10m deep boreholes.

e) Slope stability analysis and subsequent reporting.

However it is assumed that the responsibility for this further study and consequential remedial works rests with the WDC or house owners, and therefore no cost has been allocated for repairs within the project for restoration of the Canal. Such repairs, it is recommended, should be carried out before an extensive use is made of the restored Canal, to ensure there are no problems caused for example by boat wash.

Heavy rainfall occurred during and immediately prior to the walkover survey which made it difficult to identify any leakage from embankments. It is recommended that a watch be kept in the following areas of embankment where leakage may be occurring:-

a) Chainage 3180, north side.

b) Chainage 3365 to 3465, north side.

c) Chainage 4220 to 4470, north side.

The source of any significant leakage should be established and the adjacent section of canal plugged or sealed.

Evidence of minor instability was noted in a few areas where remedial works do not appear necessary at present. However, ongoing observation should be undertaken in the following areas:-

a) Chainage 3365 to 3465 embankment north side.

b) Chainage 4025 to 4175, cutting north and south sides.

c) Chainage 7020 to 7170, cutting south side.

d) Chainage 8820 to 9220, cutting/natural slope south side. It is particularly important in this area that any storm damage to trees be made good as they probably contribute considerably to the stability of this very high, steep slope.

Ongoing observation should highlight specific locations where further remedial works will be required although it is not anticipated that any would be required within the next 10 or 20 years.

It is believed that the Hampton Road Wharf was formerly the site of a gas works and as such may be heavily contaminated. This may entail significant additional cost for both site investigation and remedial works but this could only be quantified following a detailed desk study based on firm proposals for the actual building works contemplated.

Table 2.1A Schedule of Defects: Junction Canal

LOCATION	DEFECT	PROPOSED REPAIR	LENGTH/ AREA
0-400	Tow path falls towards embankments slope on LHS of canal causing softening	Seal path surface (tarmac) and grade towards canal	400m
200 (Lock No 1)	Shallow rotational failure of embankment	Gabion wall and granular blanket	15m
200-250	Canal bed dry with light vegetation cover	Remove organic matter and re-puddle floor	750m²
300-350	Canal bed dry with light vegetation cover. Also embankment on RHS severely degraded	Remove organic matter and re-puddle floor. Excavate and reconstruct outer face of embankment	750m² 50m
400-550	Undermining/sloughing of canal bank at waterline	Install 3m long trench sheeting to tow path side (LHS)	150m
1775-1825	Unstable left bank behind Texaco garage	Install sheet piling and re-profile slope	50m
2040-2070	Unstable right bank	Reprofile slope and place granular facing	30m
2070-2085	Unstable 2m retaining wall	Remove wall and batter back to 1:2 (V:H)	15m
2030-2080	Undercutting canal bank at water line on LHS	Install 3m long trench sheeting	50m

Table 2.1B Schedule of Defects: Barge Canal

LOCATION	DEFECT	PROPOSED REPAIR	LENGTH/ AREA
90-140	Undercutting of canal bank at water line on LHS	Install 3m long lengths of trench sheeting	50m
600-610	Failure of sheet pile wall	Remove existing piles and install 10m long sheet piles	10m
900-950	Undercutting of tow path at waterline	Install 3m long lengths of trench sheeting	50m
2200-2600	Possibly unstable bank on LHS	OPTION A:- Support face of slope with gabion mattress + mesh OPTION B:- Install sheet pile wall backed with granular fill	100m (in 3 equal lengths) OR 100m (in 3 equal lengths)
2750-2900	Possibly unstable bank on LHS	As above	150m OR 150m
3565-3715	Cutting with surface instability	1/ Provide 1m high gabion support to toe of cutting adjacent to tow path 2/ Plant ground cover/binding vegetation	150m
3715-3745	Unstable cutting on RHS	Provide 2m high gabion retaining wall and granular fill behind	30m
3745-3765	Unstable retaining wall on RHS		20m
4220-4470	Embankment with surface instability	1/ Provide gabion retaining wall with granular backfill behind 2/ Place "anti burrowing" mesh on surface 3/ Provide 1m high gabion support to toe	100m 1,000m^2 150m
4915-5115	Cutting on RHS with instability at waterline exacerbated by grazing annuals	Install Enkamat 'A' about waterline	100m
5675	Martin Brook undermining towpath	Install 4m long trench sheets	10m
6540-6790	Cutting with surface instability	4m wide stone mattress centred on waterline and 2m wide Enkamat 'A' above. Plant binding plants above.	250m
8780	River Salwarpe advancing toward canal	Install 3m lengths of trench sheeting	10m
8820-9220	Partially unstable bank on LHS	Install 4m length of Enkamat 'A' at waterline	400m
8820-9120	River Salwarpe undermining canal embankment	1/ Provide 1.5m high gabion wall 2/ Install 4m long trench sheets	75m 100m

2.3 Structures

2.3.1 Scope of Work

The purpose of this element of the study was to carry out a visual inspection of all existing structures along the route of both the Barge and Junction Canals and to advise on their condition and requirements for remedial and restoration work. A review of existing documents and reports has also been carried out in order to confirm the nature and extent of the necessary remedial and restoration works to structures. In particular the comments given in the Trust Discussions Report[8] and in the Sutton Report[10] have been taken into account.

A brief description of each structure, together with some comments on its condition, is included in the Schedule of Features at Appendix B in this Report. The requirements for remedial and restoration work at particular structures are discussed further in this section of the Report. Proposals for new engineering structures are also discussed in Section 2.5 later.

During the field inspections, obvious deficiencies in structures were noted and recommendations are given in respect of associated maintenance needs. In addition defects which may require further investigation or future monitoring have been identified.

As called for in the Study Brief, the Junction Canal and Barge Canal have been assessed separately.

2.3.2 Review of Existing Documents

A review of existing documents and reports has been carried out with particular reference to the requirements for remedial restoration works to lock structures on the Junction and Barge Canals. A considerable amount of information is contained in references 8, 9 and 10.

It is apparent that detailed inspections have been carried out by the Canals Trust and comprehensive lists of necessary remedial and restoration works drawn up. Our field survey has confirmed the need for these works to be undertaken.

The majority of the restoration works to the lock structures can be carried out by volunteer labour and some of this work is already underway. However, some works, for example the building of new lock gates, may need to be carried out by specialists.

Most of the required restoration work is fairly straightforward and is unlikely to present any insurmountable problems. In terms of the overall scope of the project, that is to restore both Junction and Barge Canals to an operational level, the renovation of existing lock structures is not an aspect which will require a major input in terms of manpower, materials or finance.

2.3.3 **Junction Canal**

An inspection was carried out of the existing structures on the section of the Junction Canal between Hanbury Junction and the County Council Yard. Existing structures on the Body Brook and River Salwarpe west of the M5 Motorway were also inspected. Those structures on the old canal alignment in the Chapel House/Raintree area were not inspected, nor were those in the Old Town Mill area.

Lock Nos 1, 2 and 3

These lock structures comprise brickwork walls topped by sandstone copings. Each lock has an associated side pond. It is proposed elsewhere in this Report that the side ponds be abandoned when the canal is re-opened as an operational waterway.

The general condition of the locks is sound. However, in order to restore the canal to a serviceable condition, work will be required at each of these locks. Lock Nos 1 and 2 have been substantially restored by the Royal Engineers but some work remains to be carried out on both structures. Lock No 3 has had limited restoration work carried out on it to date.

At each lock the required works primarily involve repairs to brickwork and copings, including some demolition and re-building, clearing of vegetation and debris, and the installation of new gates. On this flight of locks the only gate which is in place is the top gate to Lock No 1 which was built and fitted by the Royal Engineers. This gate is in good condition. A new bottom gate is required at Lock No 1 together with new top and bottom gates at Lock Nos 2 and 3.

Corbetts Bridge Culvert

This is a culvert, of brick arch construction, which carries the Body Brook under an embankment carrying an access road to Impney Farm. The culvert is not in good condition but in any case it is too small to permit use with the restored canal. It is therefore proposed that this structure be replaced by a new concrete box culvert, see Section 2.5.

2.3.4 **Barge Canal**

An inspection was carried out of the various structures on the Barge Canal. The structures comprise the following:-

Locks	9 No
Road Bridges	9 No
Railway Bridges	2 No
Agricultural Accesses	2 No
Footbridges	7 No
Culverts	2 No

The nine road bridges are owned by Hereford and Worcester County Council. The two railway bridges are owned by British Rail. The local authority is also responsible for two footbridges over the canal. These organisations are responsible for the maintenance of these bridges. The remaining structures are owned by the Droitwich Canals Trust.

Road Bridges

Each of the nine road bridges carries a trafficked road. The condition of the bridges is unlikely to affect operations on the canal in the foreseeable future. Some maintenance works are required to the bridges, particularly the three older, brick arch structures at Salwarpe, Porters Mill and Mildenham Mill.

Railway Bridges

The two railway bridges both carry operational lines. The condition of these bridges is unlikely to affect operations on the canal in the foreseeable future.

Agricultural Accesses

Linacre Bridge is a brick arch structure which has been restored by the Trust in the recent past. The condition of the structure is sound, but in view of its age regular monitoring of the structure is recommended.

Salwarpe Court Bridge is a swing vehicle bridge, comprising a timber plank decking supported by steel beams. The bridge is presently non-operational and is awaiting repair, having been damaged by vandals. This work has been placed in the hands of a local contractor by the Droitwich Canals Trust. The need to repair this bridge will not affect the operation of the canal.

Footbridges

The two footbridges which are owned by the local authority are both in service at present. Their condition is sound. Of the five footbridges which are owned by the Canals Trust, one is presently awaiting repair. Some repairs are also required to one of the four bridges which are presently in service.

Barge Lock footbridge has just been repaired and is now in good condition.

Ricketts Lane footbridge is presently in service but is in need of repair. The bridge is generally in a sound condition, but a noticeable vibration of the deck occurs when traversed by pedestrians. The counterweighing and/or levelling of the bridge therefore requires attention.

Hill End footbridge is not operational at the present time. The Trust has plans to repair the bridge and to relocate it at Lock No 3.

Culverts

Within the constraints of the field survey it was not possible to carry out an inspection inside the culvert structures. It is recommended that such inspections be carried out during further surveys for remedial works to the appropriate pounds.

Locks

Lock Nos 1 and 2

These locks have been restored by the Trust to an operational level. The Trust has plans[8] for some further improvement works to be carried out, particularly at Lock No 2. The proposed works include re-pointing and making good of brickwork, cleaning and painting of timber and ironwork, fitting handrails and installing mooring bollards. It is intended that these works be carried out by volunteer groups.

Lock No 3

Restoration work is presently in progress on this lock. A schedule of work has been drawn up by the Trust[8] and there are plans for this work to be carried out by volunteer groups. The scope of the work includes repairs to brickwork and copings, cleaning and repainting timber and ironwork, footpath construction, landscaping and the relocation of the footbridge from Hill End. A major item of work will be the building and installation of new bottom gates.

Lock No 4

To date only limited restoration work has been carried out at this lock. Structurally the lock appears to be in a sound condition. Some repairs will be required to the brickwork and copings and new top and bottom gates will need to be built and installed. The extent of the required remedial and restoration works is likely to be similar to that required at the other locks as noted above.

Lock No 5

To date no restoration work has been carried out at this lock. The Trust has provisional plans to carry out the work, using contractors, during 1996[8]. Funding will be required for this work. In general the structure of the lock appears sound. The lock walls are overgrown with vegetation which requires clearing. Some repairs to the brickwork will be necessary. New top and bottom gates will be needed. Bottom gates are presently in place but these are badly deteriorated and will have to be replaced. A detailed inspection of the lock should be carried out and to determine the extent of the necessary restoration works.

Lock No 6

To date no restoration work has been carried out at this lock. The Trust has plans to carry out a detailed inspection of the lock, with restoration work provisionally planned for 1996 or 1997[8]. In general the structure of the lock appears sound. Some repairs to brickwork will be required. The top gates are presently in place. It may be possible to renovate these. New bottom gates will be required. Other repairs will also be required. The nature and extent of these works is likely to be similar to that required at the other locks as noted above.

Lock No 7

The lock structure is presently in a poor state. A detailed inspection of the lock should be carried out. It is apparent that the brickwork is in an unsatisfactory condition. The mortar joints have weathered and many are open. Mature trees are growing through the walls causing severe displacement of the brickwork and copings in numerous areas. Extensive repairs to the brickwork will be required. It may be necessary to substantially rebuild parts of the walls. New top and bottom gates will be required.

Lock No 8

At the time of our visit the water level was approximately 0.5m below the top of the walls. Therefore only a limited part of the lock walls was visible. A detailed inspection of the lock should be carried out. However, it has been reported to us that the condition of the lock is no worse than the other locks on the canal before their repair. Restoration works may therefore be confined to refacing the brickwork and other repairs rather than substantial rebuilding. New top and bottom gates will be required.

2.4 New Junction Canal Route

Particular consideration has been given to the provision of a new route for the Junction Canal, between Lock 3 on Hanbury Road and the branch from the River Salwarpe into the Barge Canal in Vines Park. This problem arises from the sale of the original canal bed over most of this route, as can be seen from the Schedule of Features in Appendix B.

Our proposals for the new route are shown on drawings 10 and 11 at the back of this Report, and are described in the remaining parts of this section.

2.4.1 Barge Lock to Chapel Bridge

The water level in the Salwarpe immediately upstream of Barge Lock is controlled at present by the existing measurement weir (Vines Park Gauging Weir). This is a compound weir with a first stage crest level of 27.45mAOD. An approximate rating curve for this structure is shown as Figure 2.1.

The minimum onward flow in the Salwarpe prescribed by the NRA, before abstraction to the Barge Canal is permitted, is 19.5 Ml/d (0.226 cumecs); this corresponds to a water level of approximately 27.63m which is thus the minimum water level for navigation purposes.

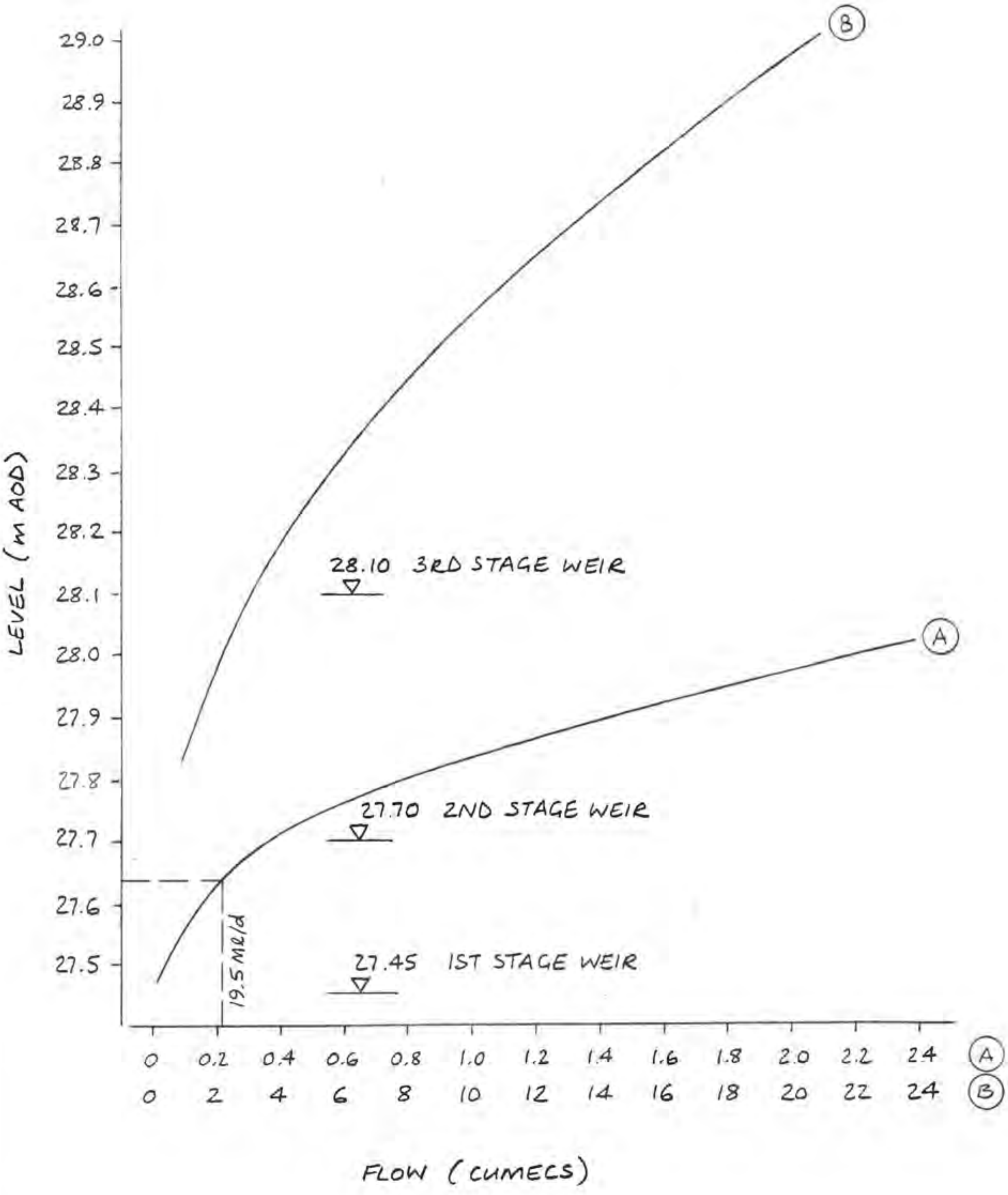
The upper limit for navigation is dictated by the maximum (instantaneous) flow expected during the boating season; as far as reasonably practicable, the canal should be designed to be navigable at flows up to this maximum. Under this maximum flow condition there are two constraints to be considered; firstly the water level, which should not vary significantly at navigable flows (ie tow path flooding should not be permitted, hence water levels should not vary by more than about 300mm from minimum navigable flow condition; headroom availability is encompassed in the same consideration); and secondly, the velocity of flow should not exceed a practicable maximum of about 3 feet per second (0.9 m/s).

Analysis of the mean daily flow records for the Harford Hill gauging station for the years 1962-1983 inclusive (22 years of daily records) reveals the following exceedence probabilities in days per annum for the boating season April to October inclusive.

Table 2.2 Harford Hill Gauging Station
Mean daily flow exceedence probabilities
for April-October (1962-1983)

Mean Daily flow exceeding	No of days per season
5 cumecs	2.50
10 cumecs	0.55
15 cumecs	0.23
20 cumecs	0.05

The maximum mean daily flow from this record was 22.37 cumecs; whilst the maximum instantaneous flow on record is 70 cumecs. Some additional data from the hydrological record gives an indication of the relationship between instantaneous peak discharge and mean daily flow.



VINES PARK GAUGING WEIR ESTIMATED RATING CURVE

FIGURE 2.1

Scale NOT TO SCALE

Drawn GMF	Approved	Revised
Date 9.3.94	Date	Date

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CONSULTING ENGINEERS

Table 2.3 Harford Hill gauging station
Relation between peak and mean daily flow

Date	Instantaneous Peak Flow (cumecs)	Mean Daily Flow (cumecs)	Ratio Peak/Mean
30.12.81	39.0	30.945	1.26
15.07.82	20.0	12.635	1.58
02.05.83	23.8	11.7	2.03

Summer storms are generally more 'peaked' than winter storms and this is supported by this limited data sample. For design purposes it appears reasonable to assume that instantaneous peak flows of twice the daily mean could be expected.

Hydrological analysis has indicated that the flow in the Salwarpe at Vines Park Weir is approximately half that at Harford Hill.

In the reach from Barge Lock to the proposed Rugby Club Lock (Lock 6A), the critical section from the navigation viewpoint is at Chapel Bridge. Here the width of channel reduces to 5.3m; assuming the water depth is restored to 1.5m, the waterway area will be approximately $8m^2$; and hence a limit on velocity of 0.9m/s yields a limiting flow of 7.2 cumecs.

If this is taken as a peak flow, the associated mean daily flow might be estimated at perhaps 3.6 cumecs; from the historic record this would be expected to be exceeded on average on only one or two days per season. This frequency is considered reasonable for design purposes. The situation would be improved only by increasing the waterway at Chapel Bridge; removal of the towpath would increase the waterway to 7.62m width, area $11.4m^2$, limiting flow 10.3 cumecs. The section would then become unnavigable on velocity grounds on one day in perhaps every two seasons. We do not believe this to be a worthwhile trade off for the loss of towpath under Chapel Bridge.

The high flow limit to navigation must also be seen in context to the low flow. The Harford Hill daily record was analysed to assess the average number of days per season on which the flow in the Salwarpe at Vines Park weir would be expected to be less than the prescribed flow (19.5 MLD = 0.226 cumecs) - under which conditions the Barge Canal could not be utilised; and the number of days when flow would be less than prescribed flow + maximum abstraction for navigation (taken as 7MLD = 0.081 cumecs); with the following results:

Table 2.4 Projected limit to navigability in Barge Canal Due to Low Flow Conditions April-October based on Harford Hill GS records 1962-1983

Flow Condition	Frequency	Range
Prescribed flow less than 19.5MLD	25 days/season	0-130
Water available for abstraction less than 7MLD	36 days/season	0-95
Fully Navigable (flow more than 26.5MLD)	153 days/season	52-214

It can be seen that the low flow restriction to navigation is much more severe than the high flow limit.

We conclude that for this feasibility study an upper limit on design flow for navigation of perhaps 8 cumecs should be adopted for the reach incorporating the River Salwarpe. Water levels should be designed to fluctuate no more than 2-300mm over the range of flows 0.225-8 cumecs, being the practical navigability limits.

From the rating curve for Vines Park weir, a flow of 8 cumecs will create an upstream water level of about 28.43m, 0.8m above the estimated minimum of 27.63m at 0.225 cumecs. It is apparent that an additional overflow weir will be required to reduce the fluctuation in water level to the desired range.

The most practicable location for this overflow would be on the north bank adjacent to the existing measurement weir. A long weir could be constructed from sheet piles with a channel formed by a second row of sheet piles to bypass the weir as indicated on Drawing 10. A weir approximately 35m in length, operating in conjunction with the measurement weir, would limit the water level to approximately 27.88m at a flow of 8 cumecs, 250mm above the level at 0.225 cumecs; this is what has been assumed.

In addition to this overflow weir, there is also a requirement for abstraction of water from the Salwarpe into the Barge Canal for navigation downstream. To guarantee the onward prescribed flow, this abstraction needs to be effected by means of a weir set above the measurement weir such that onset of flow over the abstraction weir occurs only when 19.5 MLD passes over the measurement weir, ie at an estimated level of 27.63m. (The exact level will require more detailed calculation or field proving, depending on NRA dictates).

To ensure that, under low flow conditions, as much of the excess flow above 19.5MLD is passed to the Barge Canal is practicable, it is apparent that the abstraction weir should be as long as possible. Although the licensed abstraction quantity has yet to be finalised, for feasibility purposes we have considered an abstraction limit of 7MLD = 0.081 cumecs. A sharp edge weir is probably most appropriate - an adjustable weir plate can be used to ensure that licence condition can be met by practical field trials if necessary and permits future review/adjustment. A 12m long weir set at 27.63m would deliver 0.081 cumecs at a water level of about 27.65m; at which level approx.

0.27 cumecs will pass over the measurement weir, 0.045 cumecs above the prescribed flow; a split of approximately ⅓ to the Salwarpe and ⅔ to the canal. A 24m weir would only offer marginal benefit (30/70 split), whilst a 6m weir yield close to a 50/50 split. A 12m weir has therefore been adopted for the purposes of this study.

To limit abstraction in a failsafe manner (ie such that the licence limit cannot be exceeded on a daily basis) is problematic, but the requirement for the overflow weir for regulating water levels provides the most reasonable practicable solution. By setting this overflow weir at a level corresponding with the maximum abstraction ie about 27.65m; at water levels in excess of 27.65m on the vast majority of the river flow will pass over the measurement weir and overflow weir combination. We believe this should be sufficient to satisfy NRA; other measures could be adopted to limit the abstraction; but to physically guarantee the abstraction limit on a daily basis would require a mechanical system such as a control valve linked to a flow meter which closes off each day when (and if) the daily abstraction is reached.

Because of the small head difference that will generally pertain between the Salwarpe and the Barge canal, the pipe between the collection chamber from the abstraction weir to the discharge point downstream of the lock needs to be of a reasonably large diameter in relation to the flow to limit headloss; a DN450 pipe has been proposed. Abstraction will need to be recorded, we would recommend a non-invasive type of meter (ultrasonic or electromagnetic) for this application, probably DN300.

Water requirement for Barge lock itself would be mostly sensibly taken from the river direct and returned to the river downstream of the measurement weir. Return of water can be guaranteed by not providing sluices in the downstream gate; a side sluice discharging to the river would be the only means of emptying the lock.

The weir arrangement herein described should ensure that a minimum headroom of 2.0m is always available at Chapel Bridge. The invert level of the channel under Chapel Bridge is presently about 26.8-27.0m. However, given that the original depth of the canal was 6 feet and that the towpath level under the bridge is approximately 28.0m; we consider that the original bed level below the bridge was perhaps 26.2 and that this level can be restored by dredging to give a normal 1.5m depth for navigation, some dredging is likely to be needed between the bridge and Barge Lock in addition.

2.4.2 Chapel Bridge to Rugby Club Lock (6A)

The existing river bed level falls fairly steadily from about 28.0m at the Rugby Club bridge to 27.0m at Chapel Bridge as it passes between the recent residential development on the north bank and the older commercial/industrial development on the south bank. If this reach is to be navigable under level control from the weir(s) at Barge Lock, it is apparent that the bed level of the river must be lowered by between 1 and 2m throughout. The channel should also be widened to permit two boats to pass comfortably. Given the depth of excavation required and the proximity of development on both sides, navigability is most sensibly attained by creating a rectangular channel throughout this reach, using sheet piles where practicable. The solution proposed is shown on Drawing 10. Figure 2.2 shows typical sections through two representative parts of this reach.

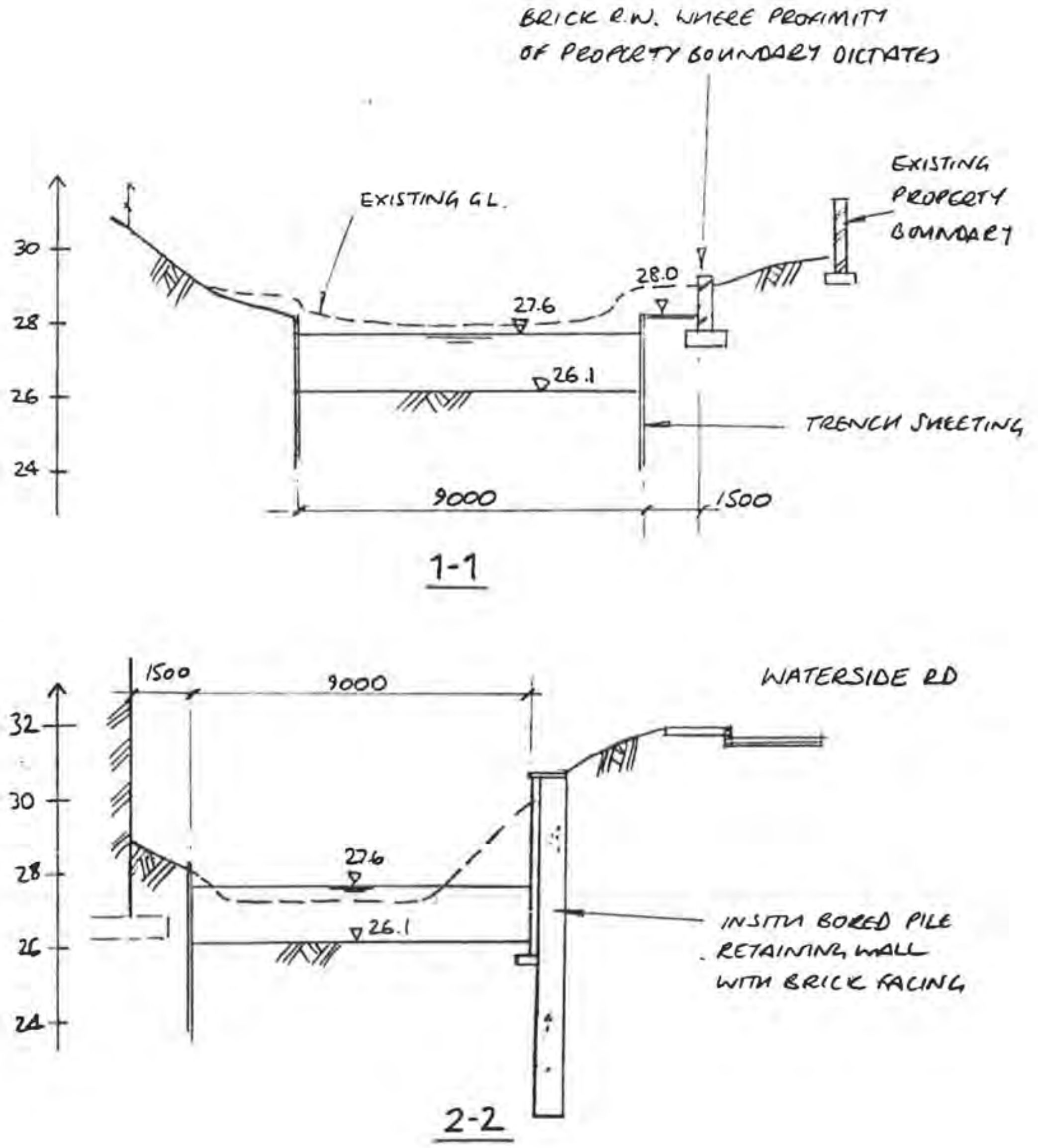
We have taken a minimum width of 9m for the rectangular channel as being sufficient for two boats to pass; it also generates the same waterway area as the proposed trapezoidal channel to be used elsewhere. The 'pinch point' in terms of engineering complexity is where Waterside Road runs close to river on the north bank (see section 2-2). The likelihood of foundations on the south bank suggests that the south bank of the improved channel must be formed at least 1.5m from the face of the buildings; sheet piling would be appropriate for this task. However this constraint then requires up to 4.5m of material to be retained on the north bank. Temporary works requirements to construct a conventional reinforced concrete retaining wall in this area would be excessive, if not impracticable. Steel driven piles of appropriate section might be utilised but are probably aesthetically unacceptable as well as being a future maintenance problem; our preferred solution is insitu bored concrete piles, with subsequent addition of brick facing. Insitu piling of course avoids the need for temporary works for conventional construction. There would not be space for a tow path at canal level (unless single lane operation were adopted), the towpath would be diverted to join the footpath on Waterside Road and thence over Chapel Bridge and to the south bank.

The unavoidable S-bend in this reach will require relatively small radius curves; to compensate and to limit the velocity to ease navigation, this section should be as wide as practicable; 13-14m width is indicated on the drawing.

Further upstream, the proximity of the new housing on the north bank is likely to require a low retaining wall adjacent to the towpath as shown on section 1-1. The retained height should not exceed about 1.5m and brickwork is considered to be the most effective solution.

It is feasible for part of this reach to be constructed as trapezoidal section without the need for sheet piling, and hence at lower cost, but the extra width of construction need would rule out provision of a towpath, and is not therefore preferred.

Clearance under rugby club bridge would be a little less than 2m but could only be improved by reconstruction of this bridge; which may occur as a result of redevelopment in any event.



CROSS SECTIONS
CHAPEL BRIDGE
TO RUGBY CLUB

FIGURE 2.2

Scale 1:200 APPROX		
Drawn EMF	Approved	Revised
Date 9.3.94	Date	Date

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2.4.3 Rugby Club Lock (6A) to M5

This reach encompasses the confluence of the Salwarpe and the Body Brook; the restored canal would follow the alignment of the Body Brook from the existing culvert under the M5. It is this existing culvert which dictates the level requirements for the reach; the culvert is 3.3m high by 3.0m wide with an invert level ranging from 28.45 to 28.50. Hence a water level of about 30.0m is required for navigation purposes based on a 1.5m water depth; this will leave a minimum headroom of 1.8m through the culvert; this is less than desirable but unavoidable.

However to ensure reasonable headroom is available for a new walkway through the culvert, 30.0m should be taken as a maximum; taking an absolute minimum water depth of 1.2m, the minimum operating level should be 29.70m.

To minimise the level fluctuation, given the inflow from the Salwarpe, will clearly require a long weir; furthermore, the generally low lying land between the Body Brook and the Salwarpe will require that levels are largely regulated to ensure flows are in-bank even at peak flows, given that water levels will be raised by perhaps 1m above the present level to permit navigation.

This constraint points to a clear solution made available by virtue of the presence of the original canal adjacent to the river over a distance of some 200m from the Body Brook to the Rugby Club Bridge, which can be utilised to form a two (or more) stage overflow weir. A weir length of about 50m set at 29.70m will regulate water levels in the range 29.70-29.90 at flows up to the 8 cumec design flow described earlier. A second stage weir of 150m length, probably constructed as reinforced grass, would limit the maximum water level to about 30.15 at the maximum historic flood flow of around 35 cumecs (ie half the maximum recorded at Harford Hill).

The overflow channel being the old canal would be used to convey the flow downstream of the proposed Rugby Club Lock as shown on the Drawing. A culvert has been assumed for the present to take the flow beneath the rugby club access road; open channel would be an option, but of course would then require a bridge. A culvert of perhaps 3m x 3m cross section is anticipated.

The lock itself would be best placed just upstream of the Rugby Club Bridge; with perhaps 10m between the bridge and the downstream gates of the lock. Within this space a new drainage ditch would discharge (see drawing). By retaining the narrow lock section through the bridge itself it should be possible to carry out to construction without reconstructing the bridge. Construction of the overflow/bypass culvert as a first stage would enable this to be used to divert the river to permit the lock to be constructed.

Siting of the lock further upstream has been considered but the depth of excavation on the downstream side becomes excessive and the length available for overflow weir reduces; and this is more problematic. Siting the lock upstream of the Salwarpe/Body Brook confluence would eliminate the overflow problem but the excavation and earthworks downstream make this less attractive.

The confluence of the watercourses affords the opportunity to create a canal basin with adjacent mooring potential by removal of the peninsula of land between the two. This material can then usefully be utilised locally to raise ground levels by 0.3-0.9m to a level of 30.3-30.4m, clear of the maximum flood level.

The existing Corbetts Bridge culvert will need to be replaced to permit navigation. Two options have been considered; firstly to replace with a culvert of similar dimension to the M5 culvert, with the navigation between here and the M5 confined to the same width as the culvert itself, and secondly to construct in full width through to the M5 culvert. However, we feel the extra cost of the bridge which would be needed in the latter case not to be justified for the sake of an extra 35m of full width canal. Traffic control for use of the M5 culvert would then be brought to the downstream end of Corbetts Bridge culvert, with the advantage that signals will be clearly visible for a considerable distance.

Throughout this reach the towpath would be situated on the north bank; a new footbridge will be required over the Salwarpe. Adjacent to this bridge on the east bank would be situated the pumping station required for abstraction of water from the Salwarpe to enable navigation upstream as described elsewhere in this report.

2.4.4 M5 to Lock 3

The original canal route in this section is not available for restoration. Negotiations with the landowners between the M5 and Lock 3 have led to the identification of the alignment shown on Drawing 11.

From the M5 the route would initially follow the Body Brook, widening the north bank of the Brook, so as not to encroach on land owned by Mr Hatfield. The alignment would then swing gently to the north through the existing bridge over the Body Brook (which would be reconstructed) on land owned by Mr Pearman before turning south east on the north bank aligned essentially on the tributary of the Body Brook (the north bank of which is land owned by Mr Weston, the south bank by Mr Pearman and Mr Karakashian). The route then passes through the County Council yard before rejoining the original alignment on the approach to Lock 3.

This section originally had two locks; and two locks will still be required. Water conservation requirements dictate that, in essence, volume required for locking from Lock 1 to Lock 5/5A should not increase: hence the lift required for locks 4A and 5A is effectively pre-determined. On grounds of accessibility and topography, the most appropriate locations for the two new locks are at the existing Body Brook bridge (5A) and in the County Council yard (4A).

At Lock 5A, the level required upstream (approximately 33.55m) is too high to enable a water supply from the Body Brook to be utilised for locking, hence the Body Brook will need to be diverted parallel to the new canal to discharge downstream of the new lock.

Between the M5 and Lock 5A, the need to align the canal north of the Body Brook results in some fairly extensive excavation; but mitigation measures to the landowners include provision of a noise bund alongside the M5 on Mr Pearman's land and a landscape bund alongside the canal for Mr Hatfield, will utilise most of the excavated material.

The need for one way traffic through the M5 culvert dictates that a waiting area will be required upstream of the culvert entrance and hence vertical bank protection (sheet piles) have been indicated on the north bank for this purpose. The towpath will need to be on the north bank between M5 and 5A, and will be continued through the M5 culvert, but only as an emergency/maintenance access not as a public footpath.

The towpath between Lock 5A and 4A is problematic since none of the landowners want the towpath on their side. This matter remains to be resolved. The new canal would afford the opportunity to divert the public footpath currently crossing Mr Pearmans and Mr Karakashian's land just north of the original route canal, to the benefit of those landowners. In the event that no public access towpath could be agreed, passage from Lock 4A to 5A would have to be via Hanbury Road.

Just upstream of Lock 5A the new canal would be constructed partially on embankment. This necessity could only be avoided by resiting Lock 5A some 150m upstream, with the attendant access problem; but this is a feasible alternative.

At Lock 4A, a vehicle access bridge would need to be provided for maintenance purposes and to compensate Mr Weston for the loss of his existing field access just east of the council yard across the infilled canal. This will also serve to replace the existing footbridge over the Body Brook tributary. A new outfall for this tributary into the new canal just downstream of Lock 4A would be required (the watercourse is presently culverted from the south side of Hanbury Road).

Between Lock 4A and Lock 3 the towpath would be situated on the south bank which will ensure the works remain entirely on WDC land.

2.4.5 New Structures for Junction Canal

Locks

On the Junction Canal three new locks are required along the proposed line of the canal. These have been identified as locks 4A, 5A and 6A. At locks 4A and 5A a new access bridge is also to be provided across the canal.

The proposed form of construction for all three locks is a reinforced concrete trough similar to that suggested in the 1985 Feasibility Study produced by The Droitwich Canals Trust. The concrete is to be brick faced to match existing structures. See Figure 2.3.

The access bridge adjacent to each of locks 4A and 5A will provide a 3.5 metre wide crossing of the canal. The form of construction for the bridges could be steel, concrete or timber for the spans envisaged.

M5 Culvert

The existing culvert under the M5 provides adequate clearance for boat traffic, but no towpath is provided. The width required for canal traffic, 2.28m minimum as for the locks, will restrict the width available for the walkway to 0.72m. Therefore the walkway will be considered as an emergency/maintenance access only as noted previously. A suggested form of construction is shown on Figure 2.4.

Corbetts Bridge Culvert

A crossing of the canal is required as access to Impney Farm from Hanbury Road.

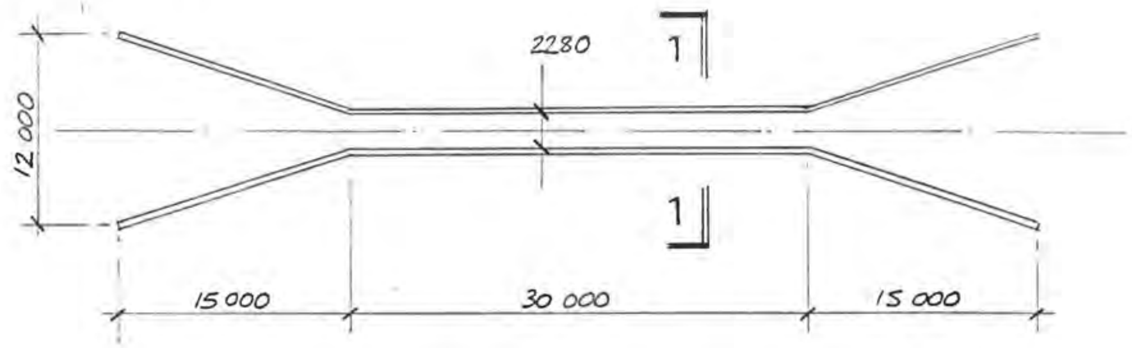
A simple reinforced concrete box culvert would suffice but there is currently a resurgence of interest in the construction of masonry arch bridges. The latter would result in a structure more in keeping with the surroundings and existing structures. There may also be potential for subsidy from research organisations.

2.5 A449 Crossing

2.5.1 Background

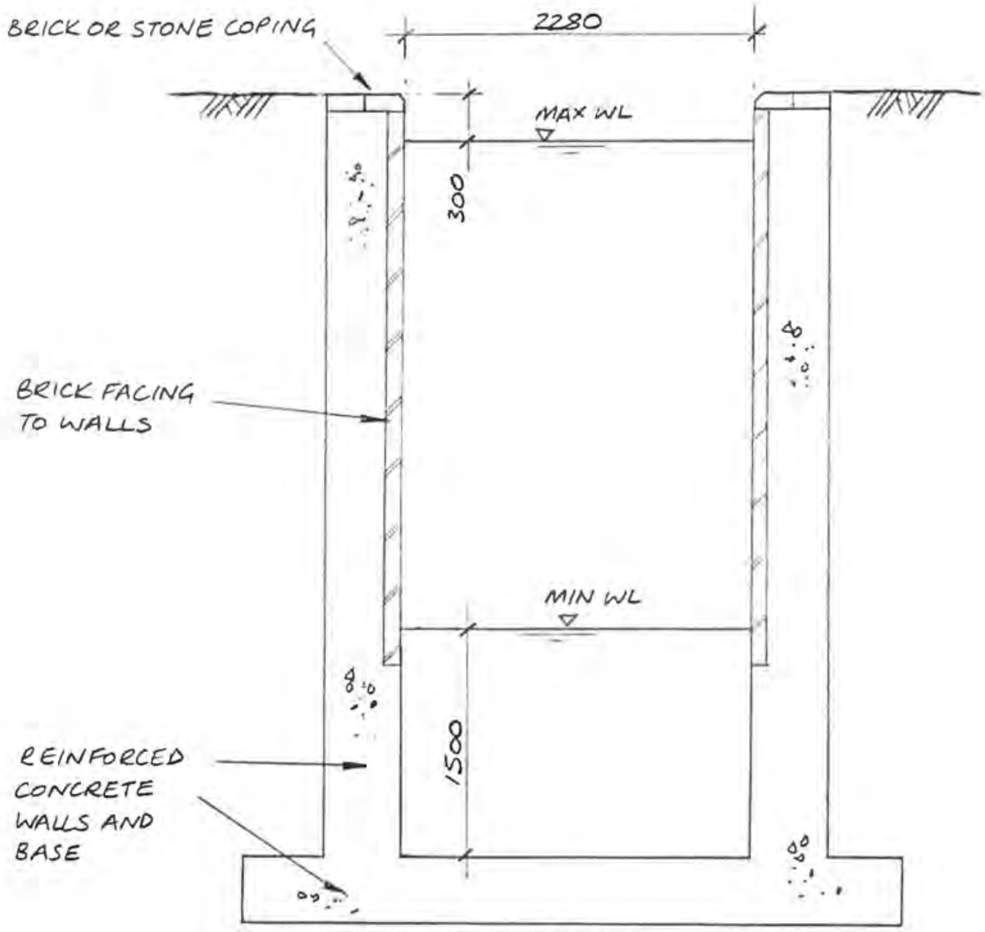
The Barge Canal at Hawford was originally crossed by a brick arch bridge of similar design to others on the canal. During the 1940's the road was upgraded, the crossing was widened and the bridge was partly demolished and replaced with a concrete pipe culvert.

Further changes were made when a new dual carriageway was built over the crossing in the 1960s. The new road was at a slightly different angular alignment to the previous and the culvert underneath was extended to take account of the increased construction width. Because of the road geometry relative to the original canal the culvert has two bends in plane to form an 'S' shape. Record drawings give conflicting sizes for the culvert but it is believed to be 48" diameter.



TYPICAL PLAN GEOMETRY

1:500



TYPICAL SECTION 1-1

1:50

TYPICAL DETAIL FOR NEW LOCKS ON JUNCTION CANAL

FIGURE 2.3

Scale AS SHOWN		
Drawn EMF	Approved	Revised
Date 9.3.94	Date	Date

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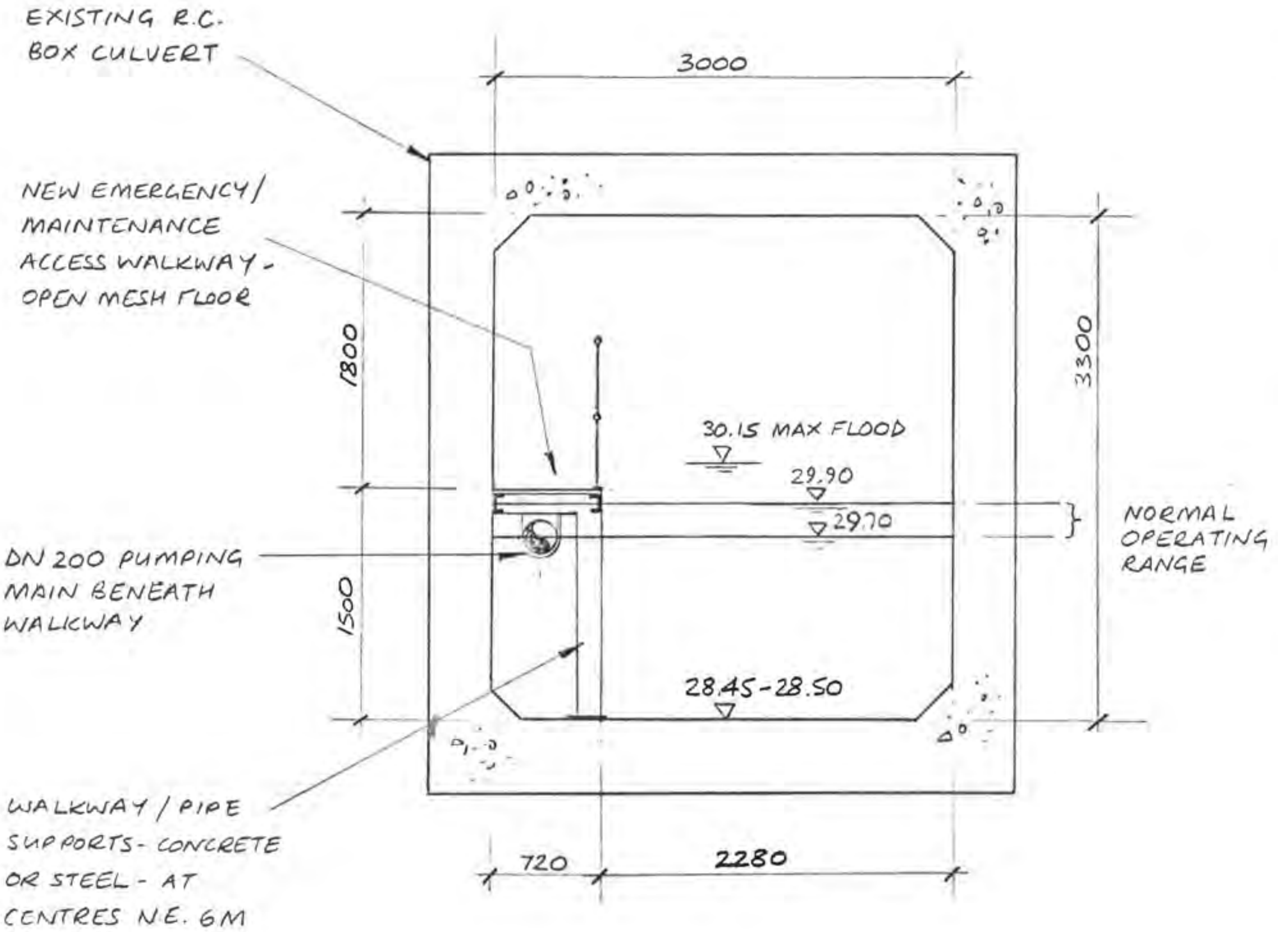


PROPOSED WALKWAY THROUGH M5 CULVERT	FIGURE 2.4			Scott Wilson Kirkpatrick CONSULTING ENGINEERS
	Scale 1:50			
	Drawn EMF	Approved	Revised	
	Date 9.3.94	Date	Date	

2.5.2 **Canals Trust Proposals**

The Chairman's Report contains a description of proposals that had been developed by the Trust over several years based on early evidence about the likely cost of installing a navigation sized culvert under the existing A449. In fact in 1985 the County Council started to prepare a scheme to insert a culvert under this road, but matters were not progressed beyond the initial planning stage.

The Trust's proposals were therefore based on the concept of a new two level lock, constructed to the east of the A449, at a point where the River Salwarpe approaches and runs alongside the Barge Canal (see Drawing 9). A two level lock is required because the Salwarpe at this point is at two levels - the upper level forming a mill pond (for Hawford Mill) and the lower level draining into the River Severn.

As an alternative to the two-level lock two separate locks could be provided, with associated earthworks and additional dredging of the Salwarpe.

The Trust's scheme would require the lower level of the Salwarpe to be straightened out and dredged, to accept full sized narrow boats (72').

The advantage of the Trust's scheme over the culvert under the A449 option was perceived to be financial as the opportunity would be taken to make use of the existing Salwarpe bridge which has ample room for navigation. Indeed it is already used for this purpose as there is a mooring and boat yard at Hawford Mill at present, for the relatively short but wide beamed Severn cruisers.

The Trust's scheme has been fully explored with the NRA, who have raised the following objections:-

a) Straightening of the River Salwarpe would change the river regime and may:-

increase velocities
increase erosion of banks and bed
increase silt loading in the Salwarpe and the Severn
increase flooding

b) Because of changes to the regime there would be environmental changes that may be unacceptable but would certainly need to be addressed in more detail before approval to such a scheme could be given. Typical matters to consider would be:-

loss of floodplain
ecological impact (eg bankside vegetation, aquatic habitats etc)
loss of amenity (eg fishing)

c) There would be an increase in the maintenance requirements of the Salwarpe and possible conflict of interests between the Canal and river needs. NRA would wish to remain the controlling authority in order to fulfil statutory obligations.

d) NRA would be concerned about pressure for ancillary development, eg:-

marinas
sewage disposal (pollution)
water abstraction for boats (resources)

2.5.3 The Culvert Option

Because of these objections by NRA we have considered in detail the option to instal a culvert under the A449, approximately on the line of the original Canal as shown on Drawing No 9.

There would be ample cover available under the road (more than 2m) to instal a full height culvert either by a cut-and-cover method or by thrust boring. Either would be feasible and selection would be based on contractor's tendered prices. In general the cut-and-cover method would be cheaper if traffic interference can be tolerated.

A complication which might militate against the thrust bore approach is the presumed presence of the original bridge in the foundations of the present road.

A reinforced concrete box culvert with internal dimensions 5.8 wide x 4.5m high would be required. This would allow a 1m wide towpath to be installed.

3. WATER RESOURCES STUDY

3.1. Introduction

This section of the Feasibility Report addresses the water resources aspects of the restoration study, both quantitative and qualitative. A considerable amount of data have been collected from previous studies, statutory consultees, other outside organisations and by site investigation in order to quantify the inflows and outflows of the canal system and establish if sufficient resources are available to meet the requirements of the restored canals, without significant environmental impact.

The section is split into five sub-sections. Following the introduction, section 3.2 outlines the work of previous studies and discusses the conclusions that have been reached regarding resource quantity and quality. Section 3.3 describes the site investigation work undertaken for this feasibility study and the methodology employed to quantify the canal system inflows and outflows. In section 3.4, the water balance approach employed to identify the resource deficit is discussed and options for meeting the shortfall are proposed. Section 3.5 details the results of the water quality study and comments on the potential impacts of the restoration proposals in these terms.

3.2. Previous Studies

3.2.1 Water Resources

The Droitwich Canals Trust (DCT) have made considerable efforts in the past to acquire sufficient water resources to supply a fully restored Barge Canal. A detailed investigation undertaken by members of the Trust in the 1970's led to an application for a licence to abstract water from the River Salwarpe. The application was originally drawn-up for pumped abstraction at three locations on the River Salwarpe, one at Navigation Meadow, the other two downstream near Porter's Mill. The intention was that these sites would be used one at a time in the staged restoration of the Barge Canal and would be later replaced by a combined impounding and gravity abstraction licence at Town Lock.

This licence was agreed in principle by Severn Trent Water Authority (STWA) but has not been put in force pending a construction, maintenance and operation agreement being reached with the landowner on whose land the works are to be situated (believed to be the District Council).

The original licence quantities requested by DCT were 62,500 gallons (284.1m^3) per hour, 1.5 million gallons (6,819.1m^3) per day and 225 million gallons (1,022,872m^3) per year. These were agreed to by STWA with the "special condition" that abstraction may be required to be reduced or ceased if the flow in the Salwarpe at the Harford Hill gauging station was 0.37 cumecs or less. In terms of the planned gravity abstraction at Town Lock, this restriction threshold or Minimum Prescribed Flow (MPF) today translates to 19.5 Ml/d at the impounding weir. The weir was actually constructed by the Trust in the late 1980's but has yet to have its plate put in place. The design of the weir satisfied the NRA that the 19.5 Ml/d MPF would be met before the proposed abstraction to the Barge Canal took place. No impounding licence, however, is currently in force for this weir.

DCT re-examined their water requirements for the canal in the late 1970's and concluded that the requirement for the gravity feed at Town Lock could reach 2.5mgd (11.36 m^3/d). Since the existing application was, and still is, to be determined for that point, STWA indicated that a new application for the gravity abstraction should be made at the revised rate.

This is the current stand of the NRA today, who now control the licensing of surface and groundwater abstractions. In 1981, STWA believed that since additional licences had been granted to other applicants since 1977, when the Trust's licence was issued, it would be necessary to restrict the additional 1mgd requested by the Trust to a higher threshold or MPF in the Salwarpe at the impounding weir of 24.5 Ml/d.

Any new application is likely to be subject to fresh consideration by the NRA, taking into account other abstractions from the Salwarpe, discharges to the river, together with fisheries and environmental concerns. However, it is reasonable to assume for the purposes of this feasibility study that an MPF of 19.5 Ml/d at the Vines Park weir will be the approximate threshold for abstraction of 1.5mgd (6.82 Ml/d) from the Salwarpe to feed the canal, rising to around 24.5 Ml/d for any abstraction authorised in excess of 1.5mgd. Before the NRA fully consider a new application from DCT, however, it is impossible to say whether an abstraction quantity in excess of 1.5mgd would be authorised.

With regard to the Junction Canal, it has been recognised for sometime that the water supply for this canal, once restored, would have to come from the Worcester & Birmingham (W&B) Canal. There are no surface inflows to the canal upstream of the Body Brook other than from direct rainfall but there are 3 locks that will be restored and a fourth one will be created in this reach. The W&B is therefore the only available source of water for these locks. However, British Waterways, who own the W&B, have previously stated that any water supplied to the Junction would have to be back-pumped to the W&B, in total. This is also their current stand.

3.2.2 Water Quality

Droitwich is an old salt town and the presence of high salinity in the River Salwarpe as it passes through the town has been well documented (e.g. STWA, 1986). There are currently three areas of significant artesian brine discharge:

(i) to Hen Brook, upstream of Droitwich, which flows into the River Salwarpe

(ii) to Body Brook, at and around Walmer Farm, east of Droitwich

(iii) to the Salwarpe throughout Vines Park, including piped discharge from a well in Vines Lane and by direct seepage through the bed of the river.

Now that the Barge Canal has been restored in Vines Park, artesian discharge to the canal is also occurring, through bed seepage, overflow from the medieval and 19th century brine pits, and from the High Street Brine Pumping Station.

The prospect of the back-pumping of water from the Junction Canal to the Worcester & Birmingham Canal prompted British Waterways (BW) in 1991 to investigate the environmental impacts of this, with particular reference to salinity problems. A detailed conductivity survey of the River Salwarpe, Barge Canal at Vines Park and disused Junction Canal was carried out in September 1991. This revealed a typical conductivity in the River Salwarpe of 3500μS/cm, 6-7 times the conductivity of the Worcester & Birmingham Canal. BW expressed concern that back-pumping the higher salinity water could "form a layer of heavier saltier water sitting on the bed of the canal", which "could be very damaging to wildlife and fishery". However, they also reported that the thorough mixing of the two waters may prevent significant impact, depending on the dilution that could be achieved.

Water Quality problems have also been encountered in the restored Barge Canal at the site of the Hampton Road Wharf and Marina. The DCT headquarters at the Marina now stand on the site of the town's old Gas Works. Pollution has been caused in recent years by overflows of ammoniacal and phenolic gas liquors from two underground tanks, by tar rising to the surface (after one tank was infilled) and by the general release of contaminants as solid wastes are moved within the site.

3.3 Site Investigations and Methodology

3.3.1 Water Resources

The methodology employed in this feasibility study to assess the water resource requirements of the restored Junction and Barge Canals centres on the development of a water balance for the canals. This requires the identification and quantification of all inflows and outflows to the canal system. The balance is discussed in detail in Section 3.4, but the derivation of the inflows and outflows is outlined below.

It was considered that an appropriate design return period for the water balance would be 10 years. This means that the resources aim of the canals restoration would be to ensure sufficient water supply is available to meet the peak demand in, on average, 9 out of every 10 years (i.e. with a 90%

reliability). Since the peak demand occurs in the 30 weeks of "summer" from April to October (the 'cruising season'), the inflows and outflows of the canal system, detailed below, were evaluated as the 1 in 10 year (summer) daily quantities.

All data required to quantify these parameters have been obtained from outside organisations, including the NRA, British Waterways, Droitwich Canals Trust, Hereford and Worcester County Council and Wychavon District Council, from published information and from map inspection. No site investigations such as flow measurement have been undertaken.

The inflows and outflows common to both canals are:

- natural inflow
- direct rainfall
- groundwater inflow
- seepage/leakage
- evaporation
- lockage

Natural Inflow is defined here as the runoff from the natural catchment of the canal. Along most sections of the canal, the contributing catchment is very small and this inflow is particularly low.

Direct rainfall is the quantity of rain falling directly on the surface area of the canal. This parameter and the natural inflow have been estimated from monthly rainfall records for the area received from the NRA.

Groundwater inflow is known to be occurring in the lower sections of the Junction Canal, in the River Salwarpe, and in the upper part of the already restored Barge Canal (see section 3.2.2). However, it is difficult to quantify this artesian discharge and therefore an allowance has been made in the seepage/leakage outflow estimates (see below). For the purposes of the water balance, therefore, groundwater inflow is taken to be zero.

Seepage/leakage is well known as the major outflow or demand on a canal's resources, often exceeding lockage. Seepage and leakage are taken together, as one parameter, although seepage can be defined as a diffuse outflow from the canal bed, which can only be cured by lining, whereas leakage tends to mean localised losses of water which can be repaired, for example, with puddled clay. As with groundwater inflow, it is difficult to quantify without monitoring inflows, outflows and water level change in a section of canal over a period of time.

Observations made in the past in the UK suggest that an average value for seepage/leakage and evaporation on Birmingham Canal Navigation is 20mm/d over the surface area of the canal (Hyde, 1977). Other canals in the midlands have had figures of up to 35mm/d observed. The figure for seepage/leakage on the restored Droitwich Canals could be expected to be somewhat lower because of the known groundwater inflow (which is being accounted for in a net seepage/leakage quantity) and the fact that evaporation is considered separately. However, since leakage has been a known problem in the past, a conservative value of 25mm/d has been adopted for use in the water balance.

Evaporation has been estimated from meteorological data recorded for the area in the Institute of Hydrology's publication Hydrological data UK : The 1984 Drought (IH, 1985). A summer value of 3mm/d has been adopted.

Lockage is required on both canals. The Junction Canal will have 6 locks following restoration, the Barge Canal 8, plus Town Lock. The quantity required for lockage, however, is different. The capacity of the Junction locks (both existing and planned) is approximately $175m^3$. At the peak of 24 lockages per day, the total demand will be some 4.2 Ml/d. The capacity of the Barge locks, on the other hand, is around $235m^3$, thus giving a required lockage of 5.65 Ml/d. Town Lock is an exception. There is little change in depth between the River Salwarpe and Barge Canal, and the estimated capacity of this lock is only about $27m^3$. Peak lockage is therefore estimated at 0.65 Ml/d. Lockage, of course, is both an inflow and an outflow. It is an inflow to a canal pound below one lock and an outflow from that pound at the next lock.

Inflows and Outflows occurring in one or other of the canals include:

- storm sewer inflows
- abstraction
- Body Brook
- Swan Pool catchment
- River Salwarpe
- Linacres Tributary

Storm sewer outflows are located along the Barge Canal through Droitwich and along a short stretch of the River Salwarpe in the vicinity of Chapel Bridge. Discharge quantities have been evaluated from rainfall data, the sewer catchment areas and percentage runoff estimates.

No licensed abstractions exist on either canal or the navigable part of the Salwarpe except for the DCT licence to abstract from the Salwarpe to supply the Barge Canal. This is not yet in force and thus abstraction outflows are zero.

The Body Brook presently flows into the River Salwarpe just upstream of the Rugby Club. Following restoration it will join the Junction Canal near Lock 5a and will contribute its flow to the canal resources. 1 in 10 year (summer) minimum flows have been evaluated from flow gaugings and a flow duration curve produced by the NRA.

The Swan Pool catchment or Hadzor stream feeds into the Body Brook at the M5 culvert. Flows from this catchment have been estimated by proportioning the River Salwarpe flows (see below) on the basis of catchment area.

The River Salwarpe will meet the restored Junction Canal just upstream of the Rugby Club. Flows in the river at this location have been estimated from the flow record for the NRA gauging station at Harford Hill, near Salwarpe village. Mean Daily Flows have been received from the NRA for this station. Spot gaugings of flows at both Harford Hill and Vines Park in the past revealed a flow ratio of 2:1. Therefore, the mean daily flow record from Harford Hill has been processed to derive estimates of the 1 in 10 year (summer) minimum flow for the Salwarpe at the Rugby Club location.

Linacres Tributary is the name given in this study to the small stream that flows into the Barge Canal close to Linacres Cottages, some 700m below Porter's Mill. Flows have been estimated by proportioning the River Salwarpe flows on the basis of catchment area.

3.3.2 Water Quality

To supplement the existing water quality information for the River Salwarpe and canals, briefly discussed in Section 2.2, water quality surveys were conducted in January and February 1994. The first survey involved in-situ measurement of quality parameters at some 27 locations. A hand-held "Water Quality Checker (WQC)" was used to record the pH, conductivity, salinity, dissolved oxygen and temperature at each site. These measurements are shown in Table 3.1.

The second survey comprised sampling at 9 key sites with subsequent laboratory analysis (carried out by H&WCC) for major anions and cations at all sites, metals at 4 of the sites, and Phenols and PAH at one site. The analysis results are presented in Table 3.2. In-situ measurements taken at the same time using the WQC are included in Table 3.1.

The results of the water quality surveys and the implications for the canal restoration are discussed in Section 3.5. All measurement and sample sites are shown on Drawing No 12.

Table 3.1 : SWK Water Quality data for the Droitwich Canals and River Salwarpe – in situ measurements

(Parameters measured on 25/1/94 using the Water Quality Checker (WQC))
(Parameters measured on 14/2/94 using the Water Quality Checker (WQC)) *[sites also sampled – see Table 3.2]*

(Refer to Drawing No. 12 for site locations)

Site No.	Grid Ref.	Site Description	pH	Cond. (uS/cm)	Salinity (%)	DO (mg/l)	Temp. (deg.C)	Comments	WQC No.
1	SO934642	W&B Canal u/s of weir to Body Bk.	8.13	579	0.02	10.08	6.5		d1
2	SO934642	Body Bk. u/s of W&B Canal weir	7.87	3830	0.18	10.87	8.1		d2
3	SO928633	Trib. of Body Bk. near W&B crossing	8.00	660	0.02	10.00	8.0		d3
4	SO922629	Junction/W&B Canals confluence	8.00	619	0.02	8.47	6.8	No cond. change with depth	d4
4	*SO922629*	*Junction/W&B Canals confluence*	*8.11*	*592*	*0.02*	*8.70*	*1.5*	*Turbidity probe worked, = 9 NTU*	
5	SO921630	Junction Canal – above top lock	7.92	612	0.02	5.44	5.9		d5
6	SO919630	Junction Canal – lock 2		637					
7	SO918631	Junction Canal – lock 3	7.24	2390	0.11	0.22	6.8	No cond. change with depth	d7
8	SO917631	Junc. Canal – bet. lock 3 & Council Yard		2880					
8	*SO917631*	*Junc. Canal – bet. lock 3 & Council Yard*	*7.95*	*3340*	*0.15*	*8.81*	*1.0*	*Turbidity probe worked, = 11 NTU*	
9	SO917631	Junc. Canal – just u/s of Council Yard	8.11	3100	0.14	15.60	6.7		d6
9a	*SO912632*	*Body Bk. at footbridge*	*7.74*	*6210*	*0.31*	*11.00*	*2.9*	*Turbidity probe worked, = 13 NTU*	
10	SO909631	Swan Pool	8.27	1210	0.05	10.89	7.8	Receives a lot of M5 drainage	d9
11	SO909633	Body Bk. u/s of Salwarpe confluence	8.03	6030	0.31	11.83	8.9	No cond. change with depth	d12
12	SO908634	Salwarpe u/s of Body Bk. confluence	8.15	1300	0.05	12.39	8.9	No cond. change with depth	d11
13	SO906634	Salwarpe at Rugby Club	8.08	2190	0.10	12.41	8.1	Est. flow = 10 cumecs	d8
13	*SO906634*	*Salwarpe at Rugby Club*	*8.12*	*3070*	*0.12*	*12.32*	*1.8*	*Turbidity probe worked, = 14 NTU*	
14	SO903635	Salwarpe at Chapel Bridge	8.13	2320	0.10	12.49	8.5		d10
15	SO902636	Salwarpe at Vines Pk. u/s of brine outfall	8.20	2600	0.12	12.62	8.6		d13
16	SO901636	Salwarpe at Vines Pk. d/s of brine outfall	8.12	3660	0.18	12.76	8.4		d14
17	SO902635	Barge Canal just d/s of Barge Lock (V.Pk.)	8.41	2640	0.12	11.88	8.4	U/S of 19th century brine pit	d15
18	SO900635	Barge Canal at 2nd swingbridge (V.Pk.)	8.34	3180	0.15	11.71	8.0	Cond. = 3500 at 80cm, >100000 on bed (90cm)!	d16
18a	*SO900635*	*19th century brine pit (at Vines Park)*	*7.17*	*>100000*	*>4.00*	*7.07*	*0.5*		
19	SO896636	Barge Canal by old Gas Works	8.34	4070	0.20	11.27	7.5	Cond. = ~25000 on bed (1.2m)	d17
19	*SO896636*	*Barge Canal by old Gas Works*	*7.84*	*5270*	*0.25*	*10.08*	*1.2*	*Cond. = ~25000 on bed (1.2m); Turbidity = 11*	
20	SO894636	Barge Canal to west of rail bridge (N'wich)	8.28	3660	0.17	10.87	7.2	Cond. = ~25000 on bed (1.7m)	d18
21	SO875621	Barge Canal at Salwarpe Court bridge	8.24	3380	0.16	10.42	6.8	Cond. = ~5000 at depth	d19
21	*SO875621*	*Barge Canal at Salwarpe Court bridge*	*7.86*	*3470*	*0.16*	*10.88*	*1.4*	*Turbidity probe worked, = 4 NTU*	
22	SO873621	Salwarpe at Salwarpe Court	8.45	2960	0.14	13.09	7.8		d20
23	SO868611	Barge Canal at Ladywood	8.02	6070	0.31	10.32	7.1	No cond. change with depth	
23	*SO868611*	*Barge Canal at Ladywood*	*7.75*	*2820*	*0.12*	*10.79*	*2.5*	*Turbidity probe worked, = 44 NTU*	
24	SO864619	Salwarpe at New Mill	8.42	2380	0.11	13.43	7.7	No cond. change with depth	
25	SO862606	Martin Bk. near Porters Mill	8.12	1550	0.06	10.27	7.4		
26	SO846602	Salwarpe at A449 bridge	8.33	2520	0.11	12.70	7.8		
27	SO847599	Barge Canal at A449 culvert	7.90	3030	0.14	7.77	6.7		
27	*SO847599*	*Barge Canal at A449 culvert*	*7.05*	*3040*	*0.14*	*9.02*	*2.2*	*Turbidity probe worked, = 84 NTU*	

Table 3.2 : SWK Water Quality data for the Droitwich Canals and River Salwarpe – sample analysis results

Samples taken on 14/2/94

(Refer to Table 3.1 & Drawing No. 12 for site locations)

Determinand	Units	Site No.								
		4	8	9a	13	18a	19	21	23	27
Sulphate (SO4)	mg/l	50	170	810	330	7100	390	200	120	140
Magnesium (Mg)	mg/l	20	40	105	58	130	55	48	45	45
Sodium (Na)	mg/l	480	530	820	335	144000	825	510	420	460
Potassium (K)	mg/l	7.5	17.2	15.6	20.0	210.0	28.0	20.4	18.4	25.0
Iron (Fe)	ug/l	840	610	390	340	5150	340			1790
Chloride (Cl)	mg/l	120	1050	1820	860	39640	1950	1300	1150	1300
Calcium (Ca)	mg/l	40	80	290	130	860	120	80	60	70
Alkalinity (HCO3)	mg/l	122	439	415	354	49	439	305	354	342
Nitrate (NO3)	mg/l				46	1	41			31
Ammonium (NH4)	mg/l				0.2	2.6	< 0.05			2.6
Aluminium (Al)	ug/l				60	390	110			200
Manganese (Mn)	mg/l				0.02	2.05	0.04			0.03
Copper (Cu)	ug/l				20	600	30			30
Zinc (Zn)	ug/l				40	550	40			70
Phosphorous (P)	ug/l				1143	< 100	1065			1173
Arsenic (As)	ug/l				10	0.9	8.8			3.8
Cadmium(Cd)	mg/l				< 0.02	< 0.02	< 0.02			< 0.02
Chromium (Cr)	mg/l				0.03	0.7	0.02			0.02
Mercury (Hg)	ug/l				< 1	< 1	< 1			< 1
Nickel (Ni)	mg/l				0.02	8.25	0.04			0.05
Lead (Pb)	mg/l				< 0.02	0.38	< 0.02			< 0.02
Total Phenols	ug/l						< 0.05			
Total P.A.H. *	ug/l						0.058			
Benzo 3 4 Pyrene	ng/l						16			

* P.A.H. includes the 6 individuals prescribed by the Water Regulations

3.4 The Water Balance

3.4.1 Introduction

Following the identification of all inflows (supply) to the restored canals and all outflows (demand) from the canals, an initial water balance was prepared to assess any shortfall in resources. This daily balance was constructed in spreadsheet format (using Lotus 1-2-3) so that a conceptual model of the canal system was developed. This had the benefit that changes to any inflow/outflow parameters could be quickly and easily made, and the effect on the rest of the system immediately assessed. The spreadsheet approach also facilitated easy-to-understand graphical representation of the water balance.

The water balance was constructed on a reach-by-reach basis to help identify the location of any shortfall in resources. The Junction and Barge Canals were both divided into four reaches which followed the planned restoration route, rather than the historic course of the canals. The reaches were as follows (refer to Drawing No 12):

Junction Canal	Reach 1 :	Worcester & Birmingham Canal confluence to Lock 4a
	Reach 2 :	Lock 4a to Lock 5a
	Reach 3 :	Lock 5a to Lock 6a
	Reach 4 :	Lock 6a to Town Lock
Barge Canal	Reach 1 :	Town Lock to Lock 2
	Reach 2 :	Lock 2 to Lock 5
	Reach 3 :	Lock 5 to Lock 6
	Reach 4 :	Lock 6 to River Severn

3.4.2 Initial Water Balance (Balance A)

The initial water balance, "Balance A", is shown in Figure 3.1. The peak lockage demand is imposed on the balance, even where there is insufficient water to meet it. It is therefore the lock "Bypass" parameter in the balance which illustrates the surplus or shortfall in the system. The Bypass value is totalled cumulatively as the net inflow/outflow balance passes down the canals from reach to reach.

Balance A illustrates that a shortfall in water resources of some 4.46 Ml/d in the Junction Canal and 7.06 Ml/d in the Barge Canal would exist following the planned restoration, if no new water supply were found. This assumes that no supply is taken from the Worcester and Birmingham Canal and any abstraction from the River Salwarpe at Vines Park to meet the lockage demand of Town Lock is returned to the river.

This is a hypothetical situation but it clearly identifies the magnitude of the resource deficit.

Figure 3.1 : Water Balance for the restored Junction and Barge Canals – Balance A

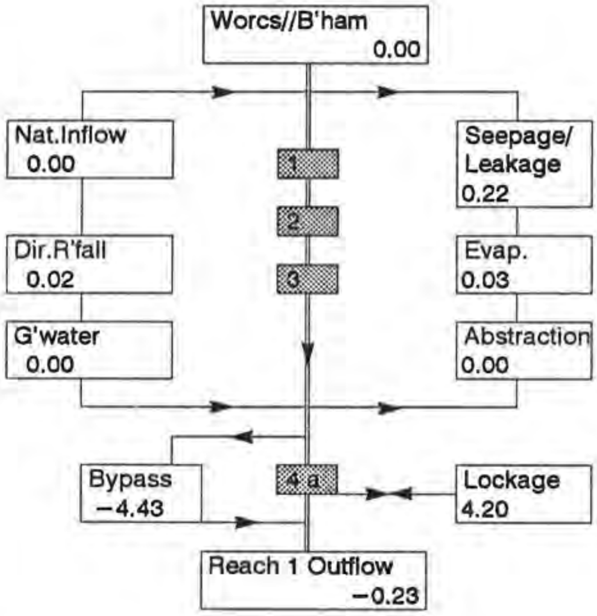
Notes:

1. *Natural Inputs/Outputs are 1 in 10 year minima (to give "reliable yield")*
2. *All values in Ml/d*
3. *Locks represented thus:* 2
4. *Lockage value shown once in a reach applies to ALL locks in that reach*
5. *Groundwater (G'water) inputs are included in Net Seepage/Leakage outputs*

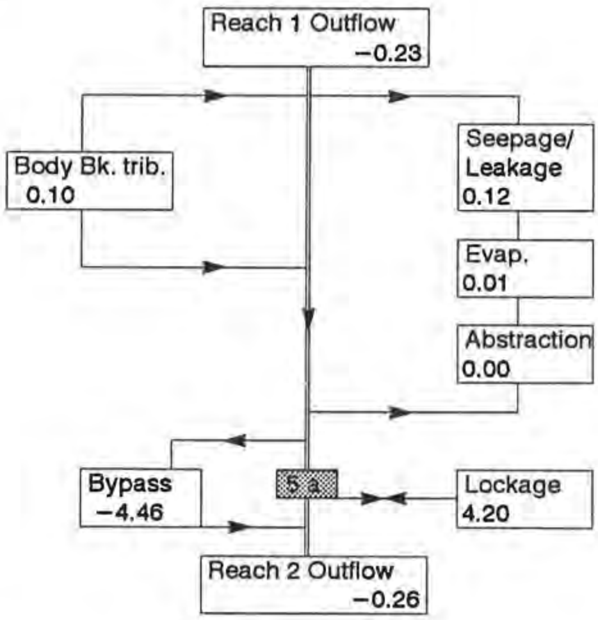
JUNCTION CANAL:

Reach 1: Worcester & Birmingham Canal confluence to Lock 4a
Reach 2: Lock 4a to Lock 5a
Reach 3: Lock 5a to Lock 6a
Reach 4: Lock 6a to Town Lock

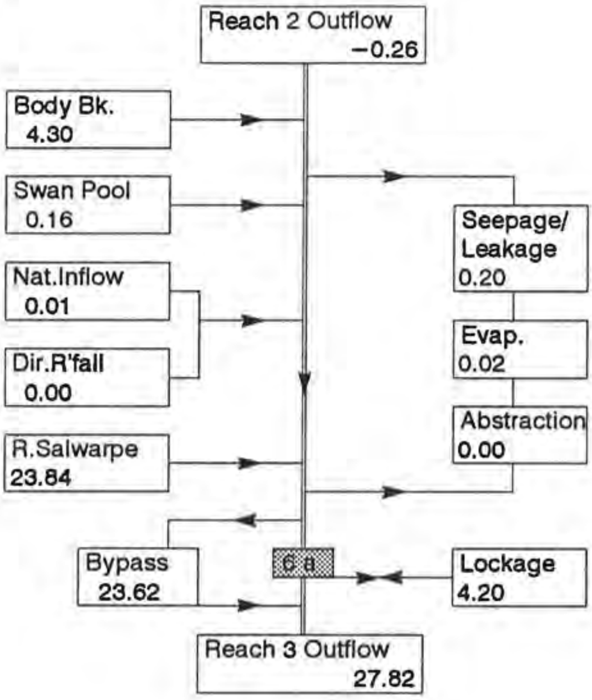
J Reach 1:



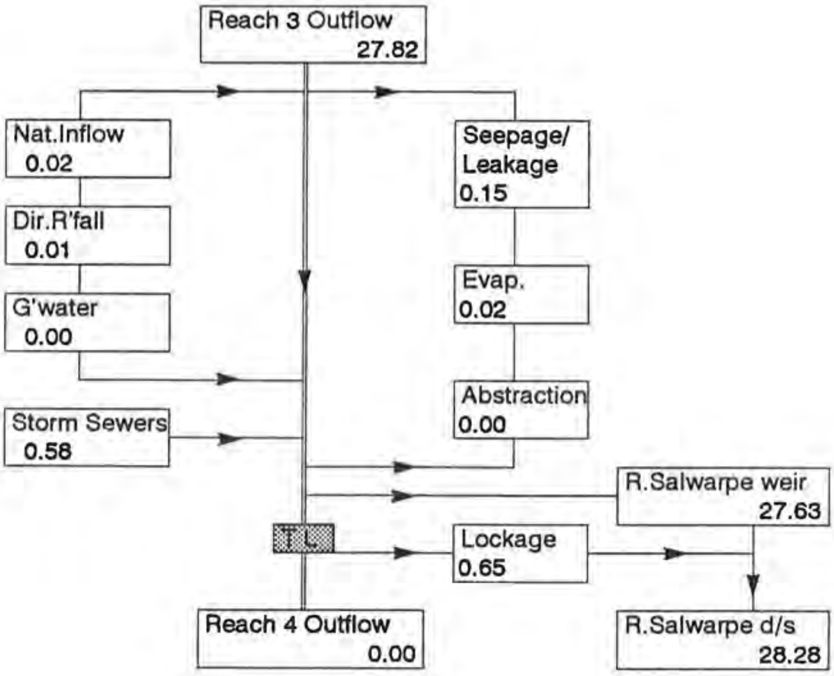
J Reach 2:



J Reach 3:



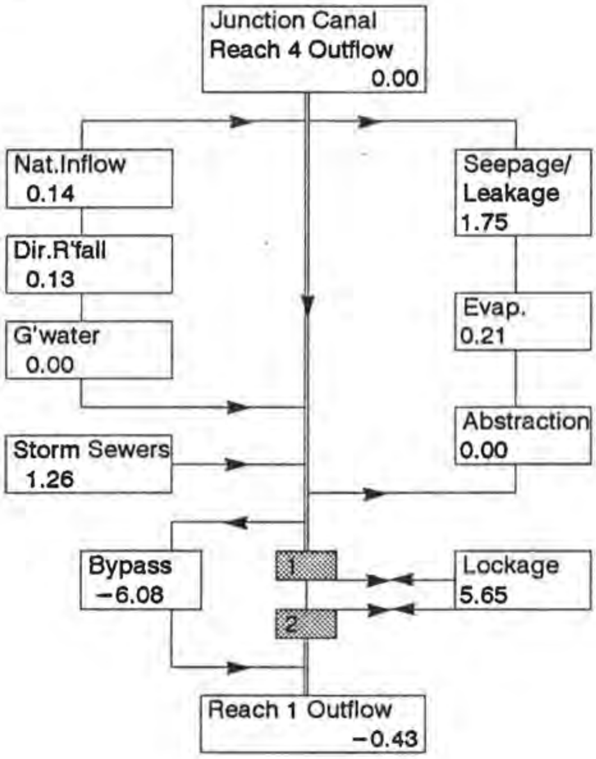
J Reach 4:



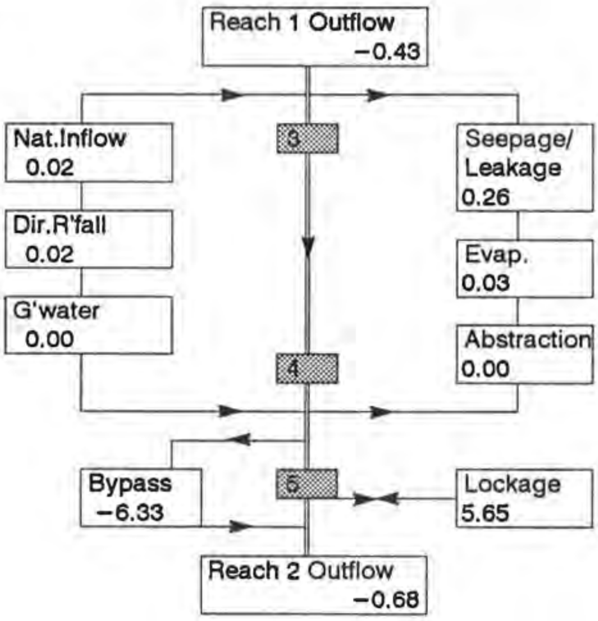
BARGE CANAL:

Reach 1: Town Lock to Lock 2
Reach 2: Lock 2 to Lock 5
Reach 3: Lock 5 to Lock 6
Reach 4: Lock 6 to River Severn

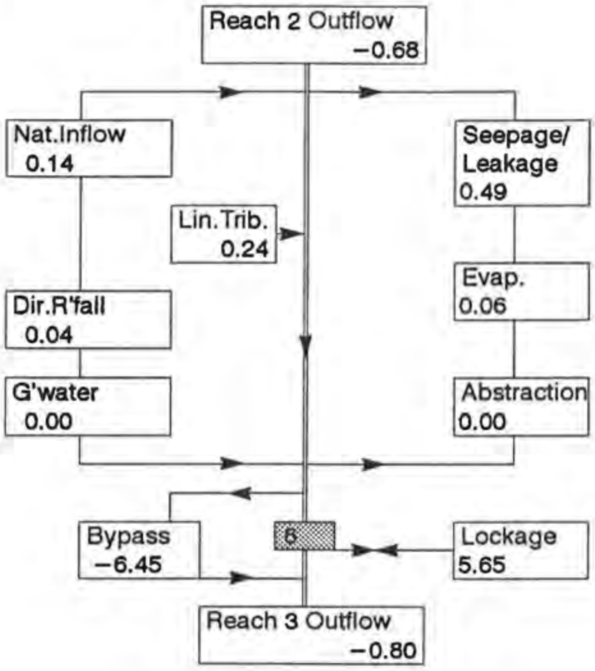
B Reach 1:



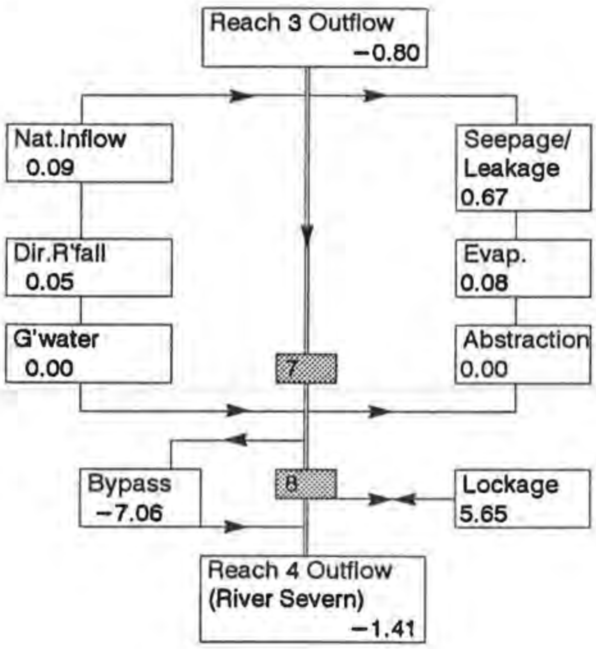
B Reach 2:



B Reach 3:



B Reach 4:



3.4.3 Abstraction from the Worcester & Birmingham Canal and River Salwarpe (Balance B)

British Waterways have stated that a quantity of water may be available for supply to the Junction Canal from the Worcester & Birmingham Canal. However, the quantity abstracted would need to be returned to the Worcester & Birmingham in total. This would be achieved by back-pumping from an appropriate location along the Junction Canal. Balance B (Figure 3.2) illustrates the water balance with the additional inflow from the Worcester & Birmingham Canal that would be necessary to meet the peak lockage and outflow demands on the Junction Canal. This quantity is 4.46 Ml/d and is returned from the River Salwarpe at its confluence with the Junction Canal near the new lock 6a. The back-pumping setup at this location is discussed in detail in Section 2.

From a resource viewpoint, the return of the 4.46 Ml/d could take place earlier, immediately after the confluence of the Body Brook with the canal (just downstream of the new lock 5a). This would help to minimise back-pumping costs. However, as discussed further in Section 3.5.2, back-pumping from the Salwarpe instead would provide a much higher quality water to return to the Worcester & Birmingham and would therefore be more acceptable to British Waterways.

Balance B also incorporates the basics of the proposed engineering solution at Town Lock, where the division of the River Salwarpe and Barge Canal takes place. Due to the upstream inflow of the River Salwarpe, there is a surplus of resources in Reach 4 of the Junction Canal. Abstraction from this navigable part of the Salwarpe, to supply the top of the Barge Canal and help meet its resource deficit, is possible with the formal issue of an abstraction licence by the NRA. An impounding weir has already been constructed on the River Salwarpe immediately downstream of the river/canal division in order to facilitate the proposed abstraction to the canal whilst ensuring at the same time that the Minimum Prescribed Flow (MPF) in the Salwarpe (19.5 Ml/d at this location) is maintained before any abstraction is allowed to take place (see Section 3.2.1).

Balance B thus illustrates the quantity of surplus water available for abstraction from the Salwarpe, under the 1 in 10 year hydrological conditions, with the arrangement that the MPF is satisfied together with any lockage requirement (which is returned to the river downstream of the impounding weir) prior to abstraction. (Note: this surplus available for abstraction is, in fact, estimated as 90% of the total surplus, on the basis that the proposed abstraction weir is designed so that only 10% of the surplus is permitted to continue downstream in the River Salwarpe).

The balance indicates some 10.14 Ml/d would be available for the Barge Canal. This would more than meet the 7.06 Ml/d shortfall discussed above.

Figure 3.2 : Water Balance for the restored Junction and Barge Canals – Balance B

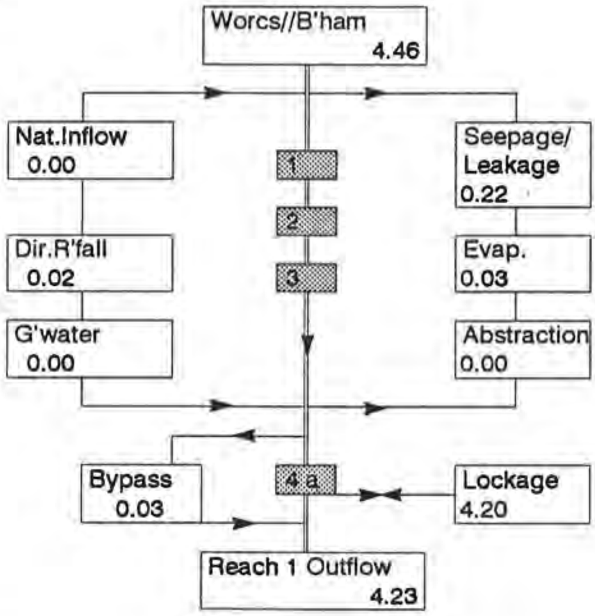
Notes:

1. *Natural Inputs/Outputs are 1 in 10 year minima (to give "reliable yield")*
2. *All values in Ml/d*
3. *Locks represented thus:* 2
4. *Lockage value shown once in a reach applies to ALL locks in that reach*
5. *Groundwater (G'water) inputs are included in Net Seepage/Leakage outputs*

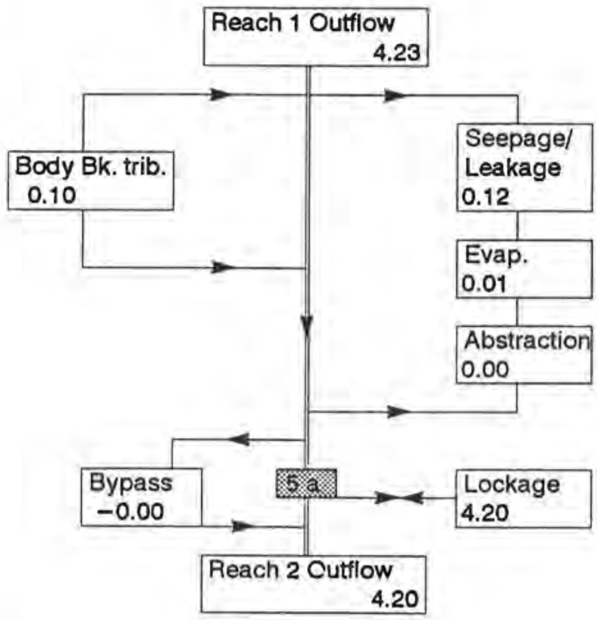
JUNCTION CANAL:

Reach 1: Worcester & Birmingham Canal confluence to Lock 4a
Reach 2: Lock 4a to Lock 5a
Reach 3: Lock 5a to Lock 6a
Reach 4: Lock 6a to Town Lock

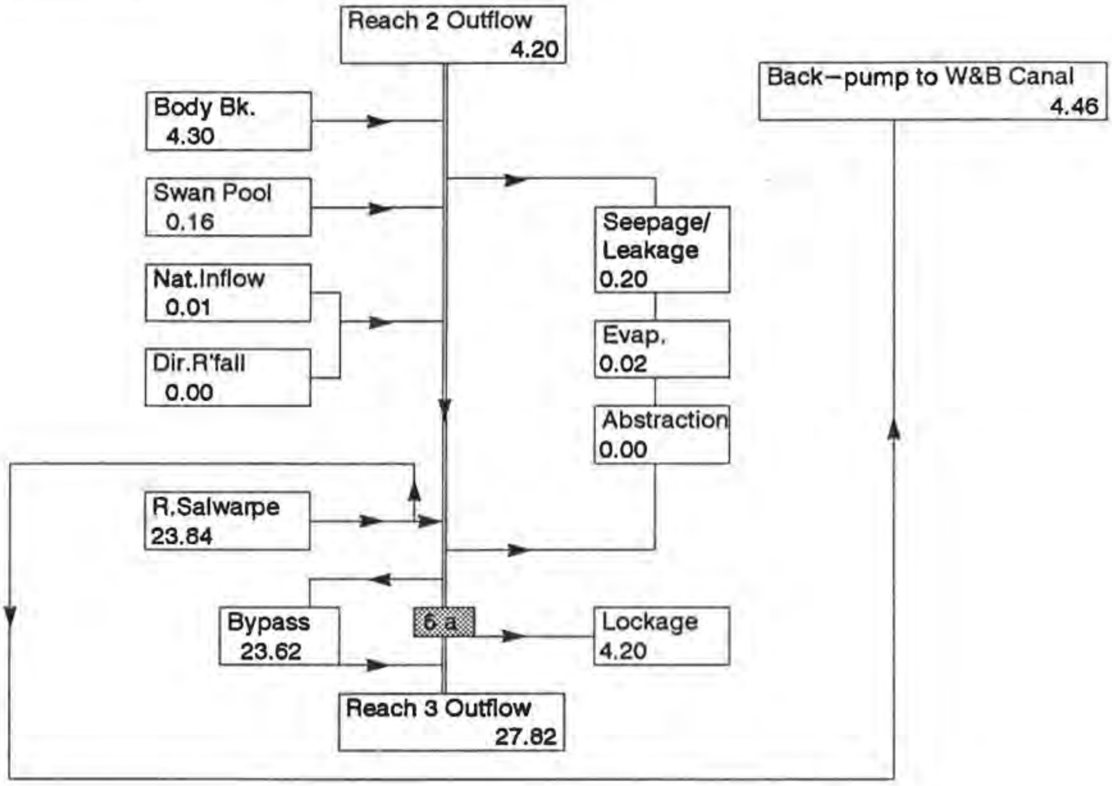
J Reach 1:



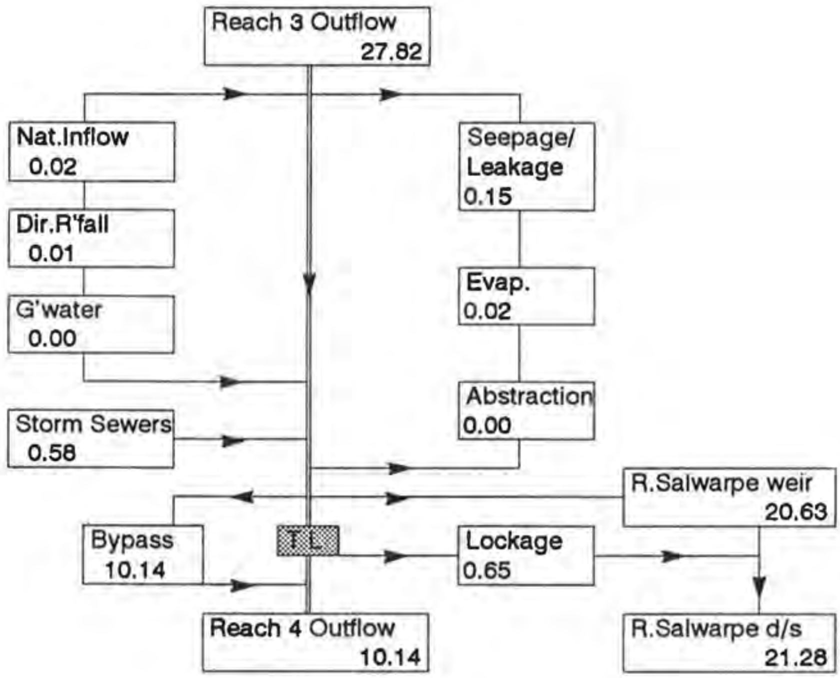
J Reach 2:



J Reach 3:



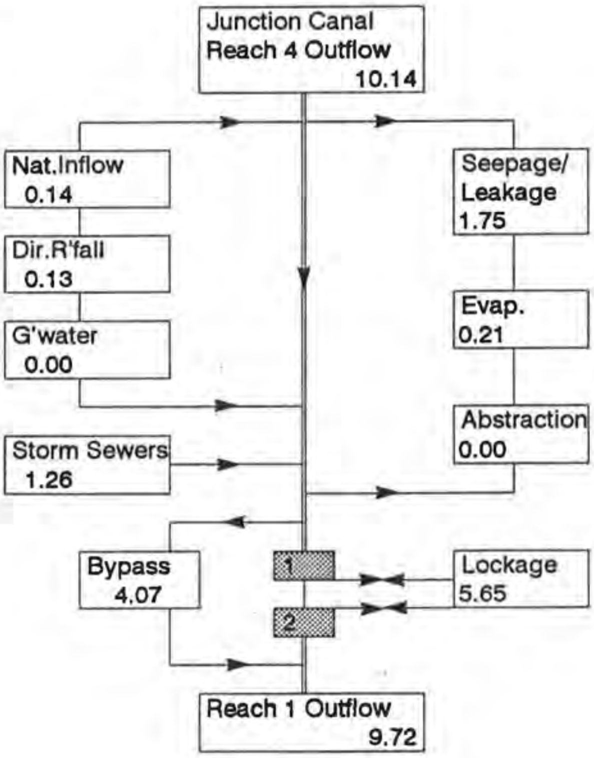
J Reach 4:



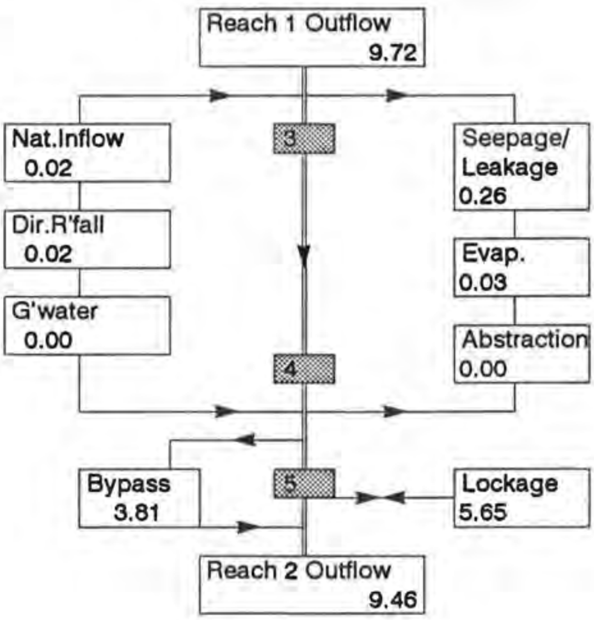
BARGE CANAL:

Reach 1: Town Lock to Lock 2
Reach 2: Lock 2 to Lock 5
Reach 3: Lock 5 to Lock 6
Reach 4: Lock 6 to River Severn

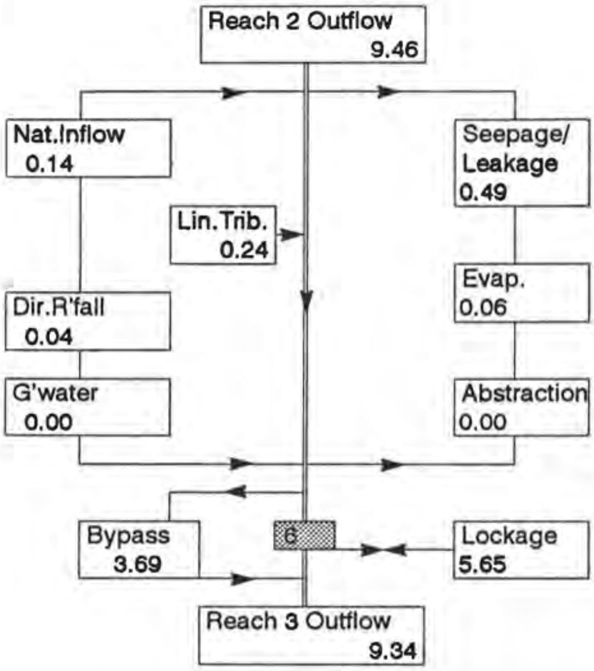
B Reach 1:



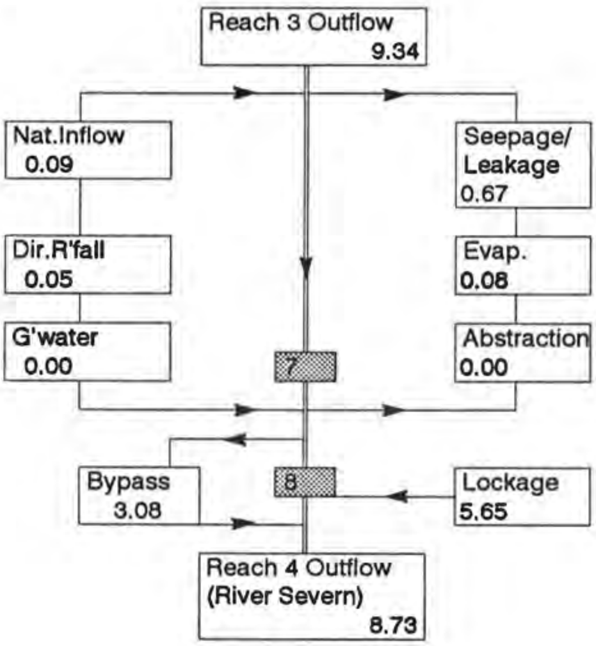
B Reach 2:



B Reach 3:



B Reach 4:



3.4.4 Maximum Permissible Abstraction (Balance C)

Any abstraction licence issued by the NRA will have a maximum allowable quantity. On the licence prepared by the Severn Trent Water Authority for the Droitwich Canals (DCT) back in 1977, but not yet in force, this maximum is 6.82 Ml/d and 1022.7 Ml/a. The length of time in any year when the peak demand in the canal needs to be met has been given as 30 weeks, from April to September. Therefore the annual limit on the present licence would, in fact, only permit the abstraction of 4.87 Ml/d for this period.

Figure 3.3 shows Balance C where 4.87 Ml/d is abstracted from the Salwarpe and becomes the inflow at the top of the Barge Canal. The back-pumping arrangements in the Junction Canal, outlined for Balance B, are maintained in this and all subsequent balances. The result is a shortfall of only 2.19 Ml/d in the system, the bulk of this occurring in Reach 1 of the Barge Canal.

3.4.5 Variations in Seepage/Leakage Estimates (Balance D)

As discussed in Section 3.3.1, determination of the seepage/leakage outflow and groundwater inflow parameters of the balance is, without a more detailed study, very much by estimation. Previous estimates made by DCT of 60,000 gallons/mile for seepage/leakage and evaporation together, work out at just about half those made in this feasibility study. It is possible, therefore, that the seepage/leakage outflows of the balance are actually lower in reality, and the calculated resource shortfall is, in fact, not as high.

This is even more likely when it is considered that artesian groundwater inflow, included in the balance within the net seepage/leakage parameter (as mentioned in Section 3.3.1), is known to be occurring along a long length of Barge Canal Reach 1 and part of Junction Canal Reach 4. This probably takes place through fractures in the impermeable Keuper Marl overlying the salt beds, caused by subsidence following the solution of the rock salt. Furthermore, as a result of the conductivity measurements recorded along the canal and discussed in Section 3.5, it is considered that groundwater inflow is occurring all year round, and is therefore likely to considerably reduce seepage/leakage in these sections, if not completely negate it.

With this in mind, the DCT estimate of seepage/leakage and evaporation has been applied to all reaches of the balance and is shown in Balance D (Figure 3.4), with all other conditions of Balance C applying. The result in the Junction Canal is an increase in the surplus resource available in the Salwarpe, but due to the limit on the abstraction, this extra water cannot be utilised. The inflow to Reach 1 of the Barge Canal therefore remains the same, but due to the lower outflows in this canal, the result is a reduction in the shortfall to only 0.25 Ml/d.

Figure 3.3 : Water Balance for the restored Junction and Barge Canals – Balance C

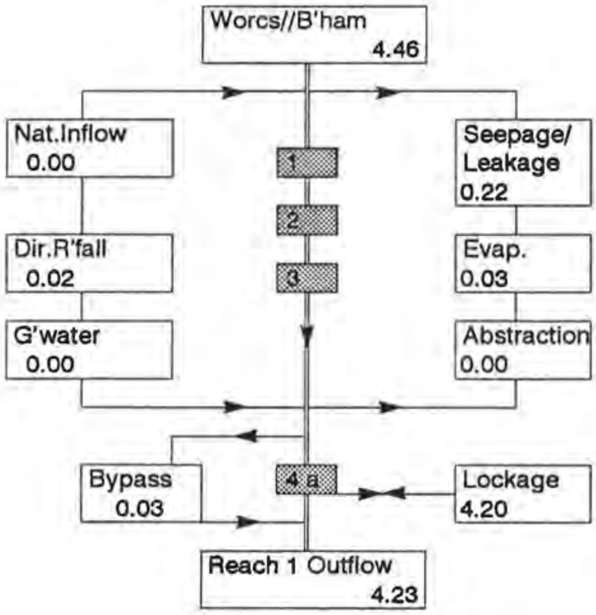
Notes:

1. *Natural Inputs/Outputs are 1 in 10 year minima (to give "reliable yield")*
2. *All values in Ml/d*
3. *Locks represented thus:* 2
4. *Lockage value shown once in a reach applies to ALL locks in that reach*
5. *Groundwater (G'water) inputs are included in Net Seepage/Leakage outputs*

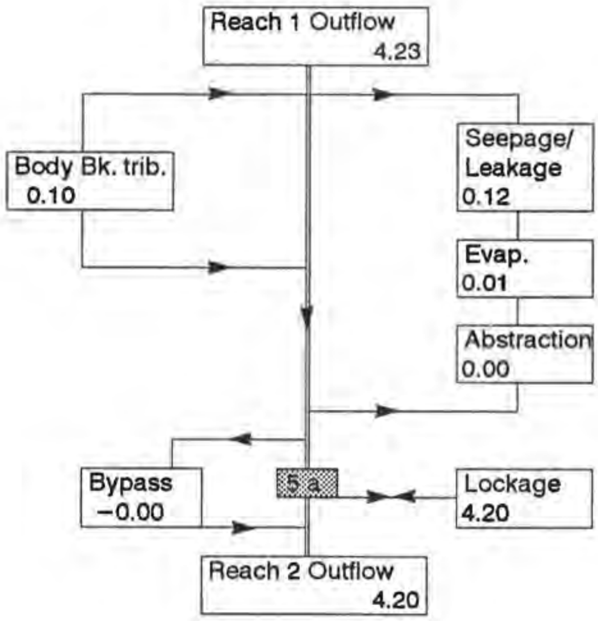
JUNCTION CANAL:

Reach 1: Worcester & Birmingham Canal confluence to Lock 4a
Reach 2: Lock 4a to Lock 5a
Reach 3: Lock 5a to Lock 6a
Reach 4: Lock 6a to Town Lock

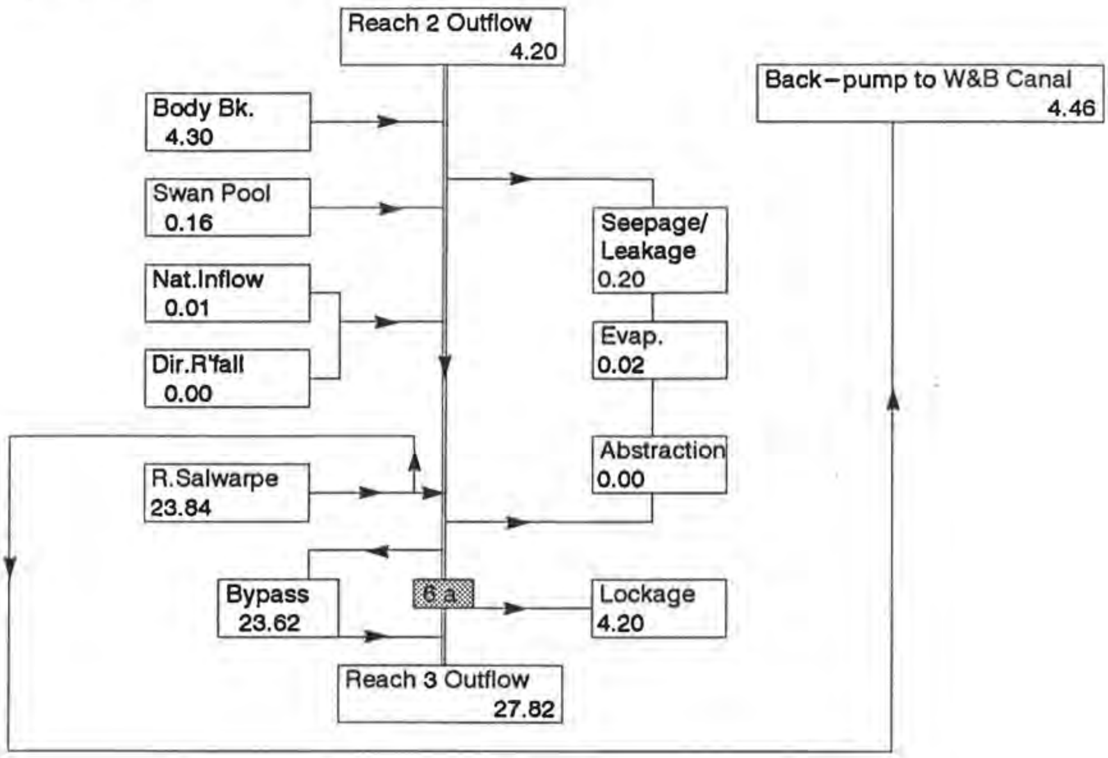
J Reach 1:



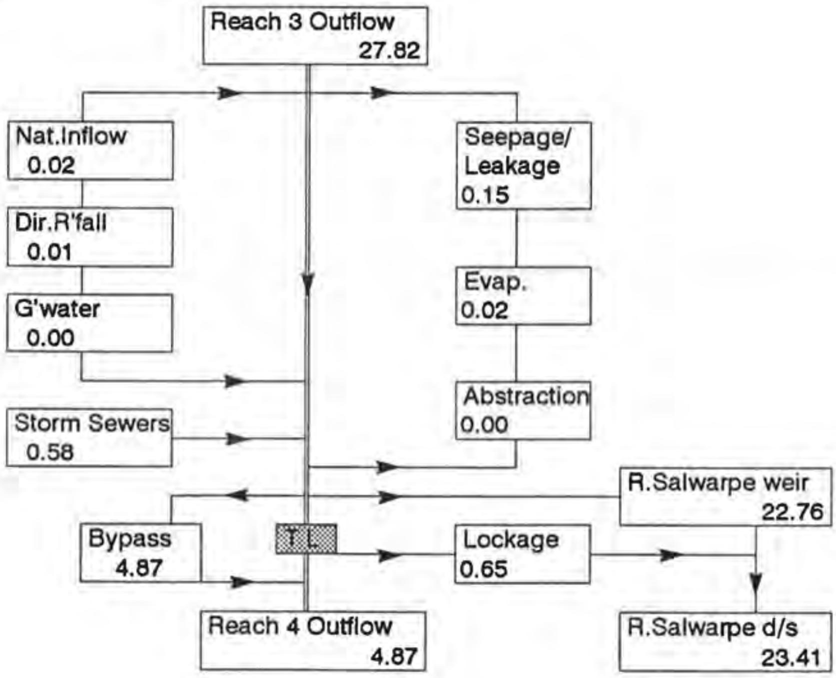
J Reach 2:



J Reach 3:



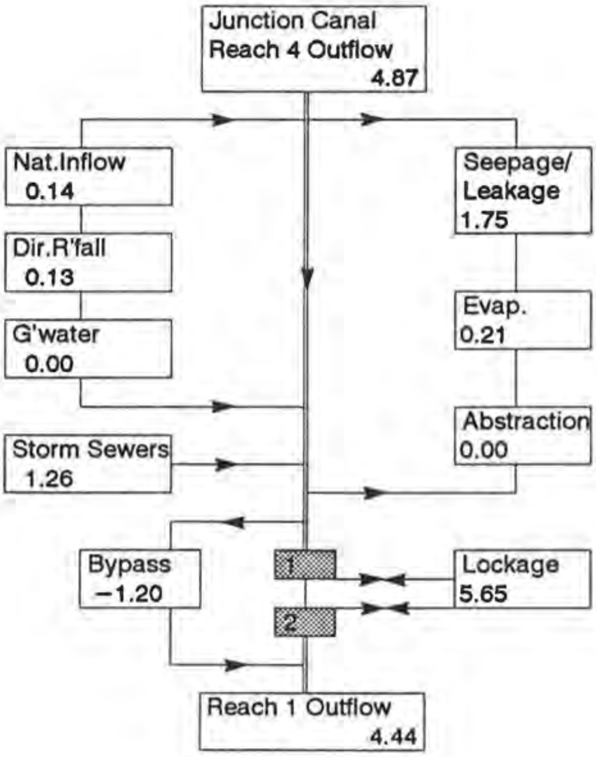
J Reach 4:



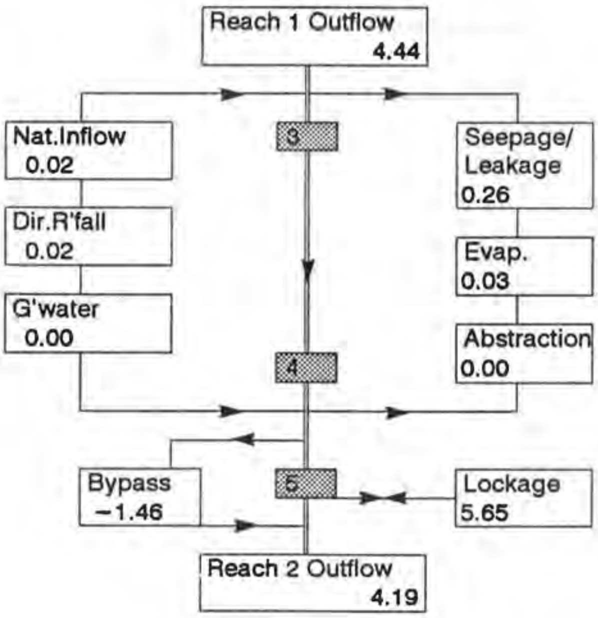
BARGE CANAL:

Reach 1: Town Lock to Lock 2
Reach 2: Lock 2 to Lock 5
Reach 3: Lock 5 to Lock 6
Reach 4: Lock 6 to River Severn

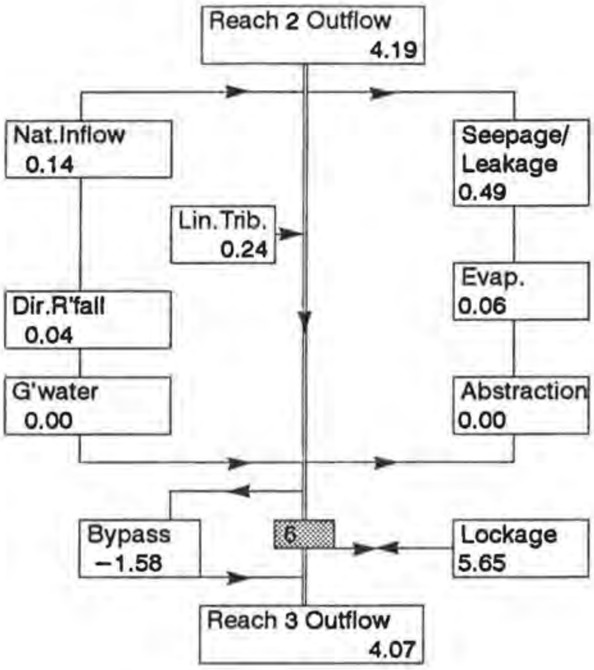
B Reach 1:



B Reach 2:



B Reach 3:



B Reach 4:

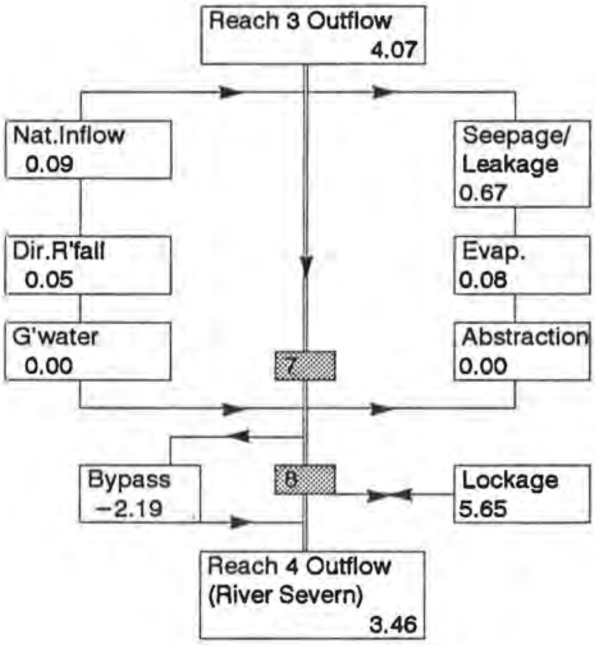


Figure 3.4 : Water Balance for the restored Junction and Barge Canals – Balance D

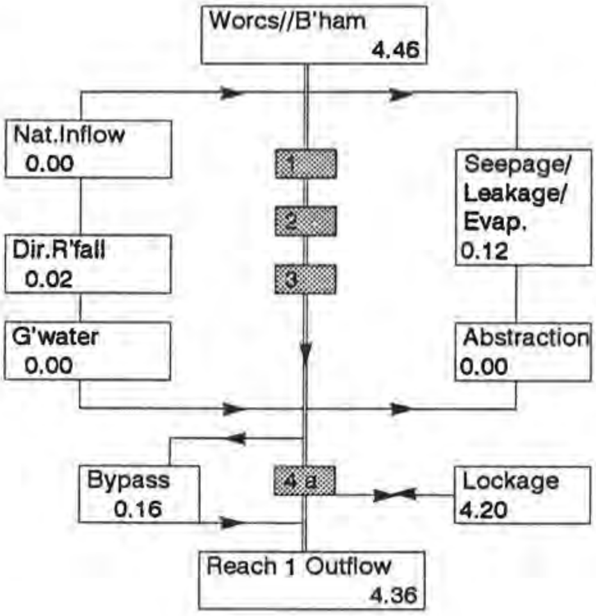
Notes:

1. *Natural Inputs/Outputs are 1 in 10 year minima (to give "reliable yield")*
2. *All values in Ml/d*
3. *Locks represented thus:* 2
4. *Lockage value shown once in a reach applies to ALL locks in that reach*
5. *Groundwater (G'water) inputs are included in Net Seepage/Lockage outputs*

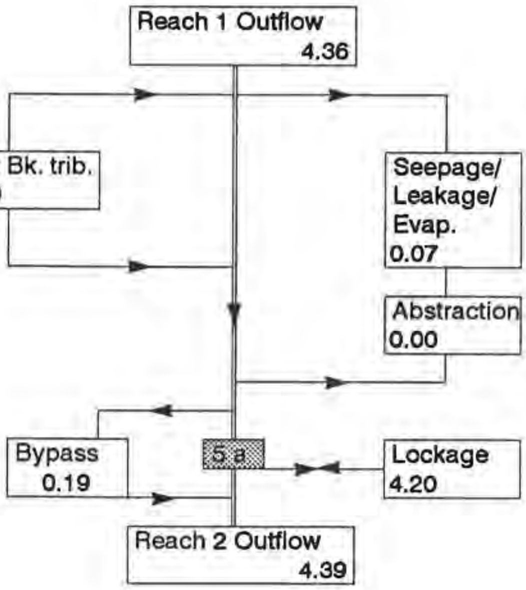
JUNCTION CANAL:

Reach 1: Worcester & Birmingham Canal confluence to Lock 4a
Reach 2: Lock 4a to Lock 5a
Reach 3: Lock 5a to Lock 6a
Reach 4: Lock 6a to Town Lock

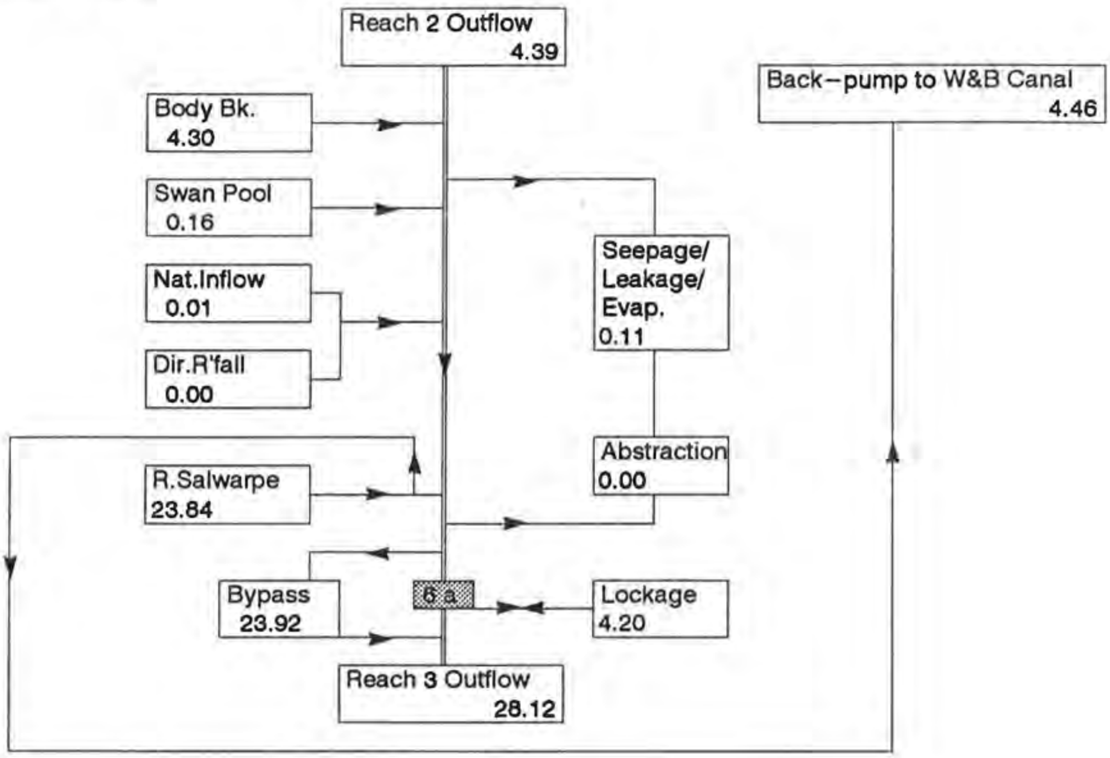
J Reach 1:



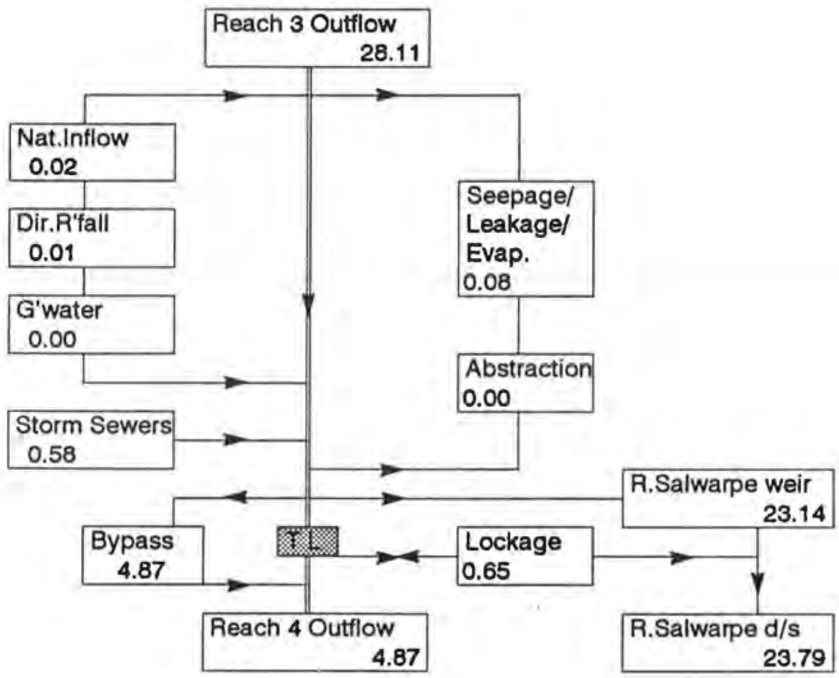
J Reach 2:



J Reach 3:



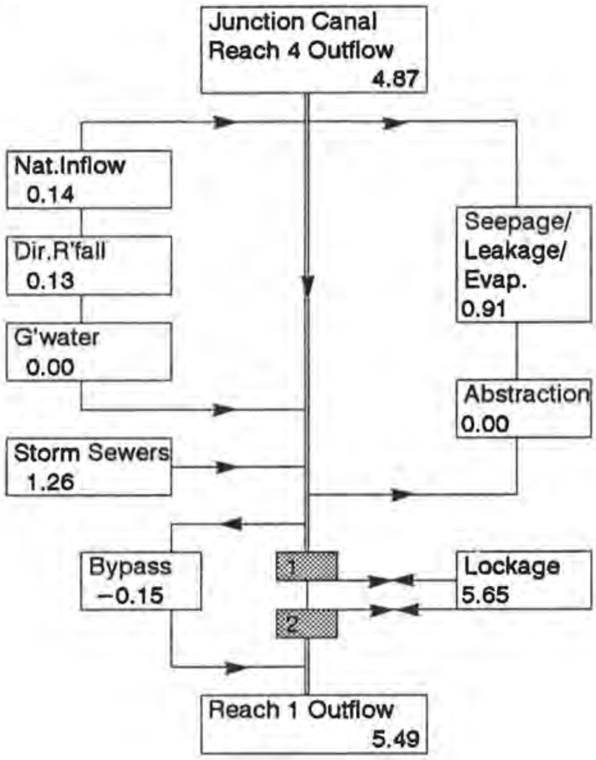
J Reach 4:



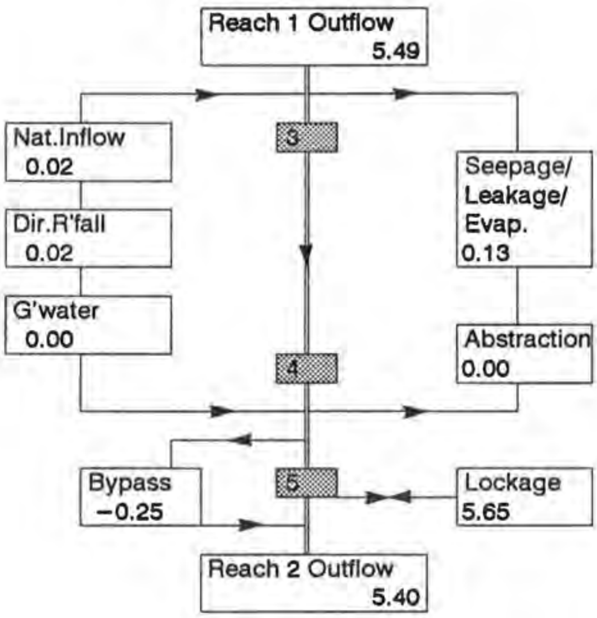
BARGE CANAL:

Reach 1: Town Lock to Lock 2
Reach 2: Lock 2 to Lock 5
Reach 3: Lock 5 to Lock 6
Reach 4: Lock 6 to River Severn

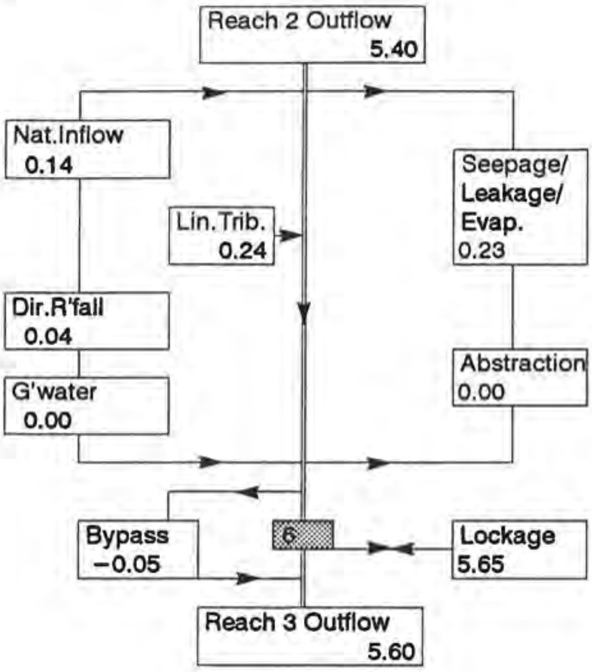
B Reach 1:



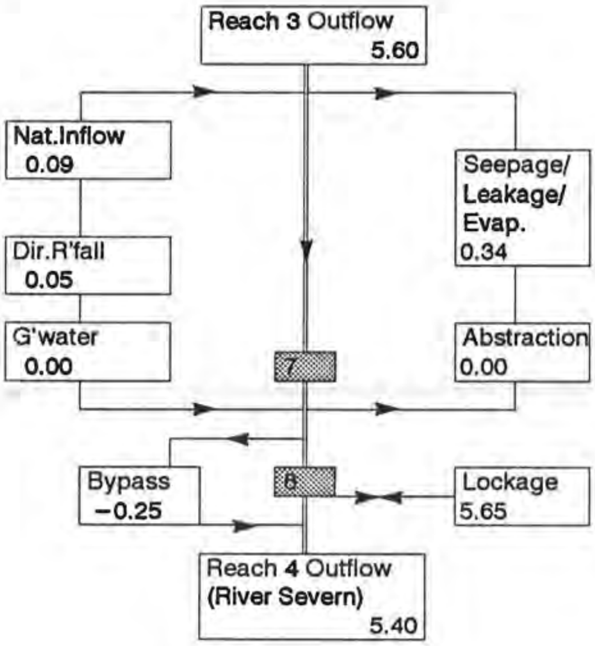
B Reach 2:



B Reach 3:



B Reach 4:



Evaporation maxima with a ten year return period have been calculated in previous balances from reliable meteorological data. It is believed that whilst the SWK (Balance C) estimates of net seepage/leakage may be conservatively high, the DCT gross estimates for these parameters and evaporation combined are probably too low. The results of these Balances C and D are believed to represent either extreme, with the probable seepage/leakage outflows and consequent resource shortfall somewhere in between.

3.4.6 Varying the River Salwarpe Abstraction Licence (Balance E)

Discussions with the NRA have revealed that it may be possible for DCT, when re-applying for an abstraction licence, to increase the annual maximum quantity above 1022.7 Ml. There would certainly be a much greater chance of such an increase being acceptable to the NRA than an increase in the daily maximum. Since the daily maximum is 6.82 Ml/d and abstraction is required for a design period of 30 weeks every year, it would seem appropriate to request an annual maximum value in the region of 1432.2 Ml.

Balance E, in Figure 3.5 shows the effect such an abstraction would have on the whole system, assuming seepage/leakage and evaporation figures are as Balance C. The resource shortfall would be reduced to only 0.24 Ml/d. Due to possible inaccuracies in the estimation of many of the balance parameters, particularly seepage and leakage (as discussed above), 0.24 Ml/d is well within the level of confidence of the results. It is quite possible, therefore, that variation of the permissible annual maximum abstraction would be all that is necessary to provide sufficient resources for the canals with the required 1 in 10 year (90%) reliability.

Furthermore, there may also be a chance that, following negotiation with the NRA and after they have completed their own resource investigations, application to abstract the full shortfall quantity of 7.06 Ml/d (1482.6 Ml/a for the 30 summer weeks) would, in fact, be approved.

3.4.7 Resources from Martin Brook (Balance F)

Martin Brook crosses under the Barge Canal near Collincourt Farm and flows into the River Salwarpe at Porter's Mill. The option of diverting the Brook into the canal to provide additional resources has been considered.

Balance F (Figure 3.6) includes the increased abstraction from the Salwarpe presented in Balance E, and also includes the 1 in 10 year minimum inflow of Martin Brook. This illustrates that the small resource deficit in Balance E is totally removed in Balance F to give a net surplus of 0.5 Ml/d.

However, there are several reasons why such a diversion should remain as an option for the future and not be recommended as an immediate scheme to enhance resources:

Figure 3.5 : Water Balance for the restored Junction and Barge Canals – Balance E

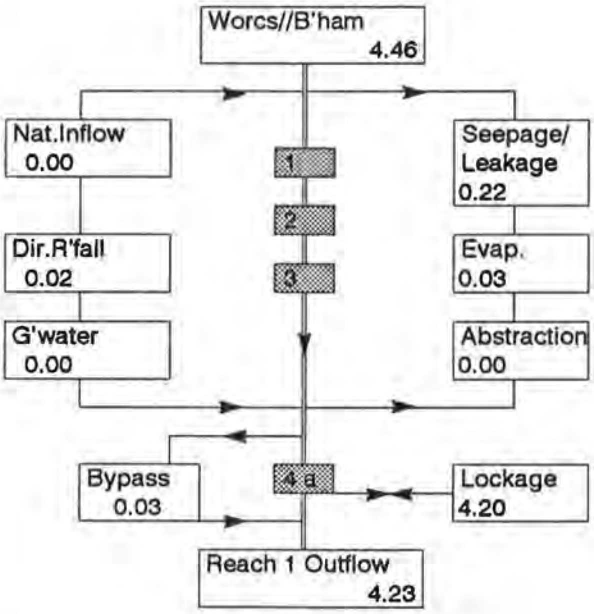
Notes:

1. *Natural Inputs/Outputs are 1 in 10 year minima (to give "reliable yield")*
2. *All values in Ml/d*
3. *Locks represented thus:* 2
4. *Lockage value shown once in a reach applies to ALL locks in that reach*
5. *Groundwater (G'water) inputs are included in Net Seepage/Leakage outputs*

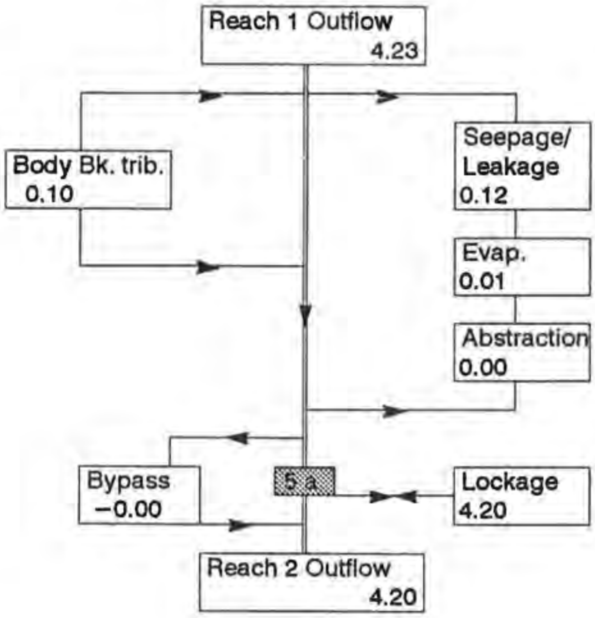
JUNCTION CANAL:

Reach 1: Worcester & Birmingham Canal confluence to Lock 4a
Reach 2: Lock 4a to Lock 5a
Reach 3: Lock 5a to Lock 6a
Reach 4: Lock 6a to Town Lock

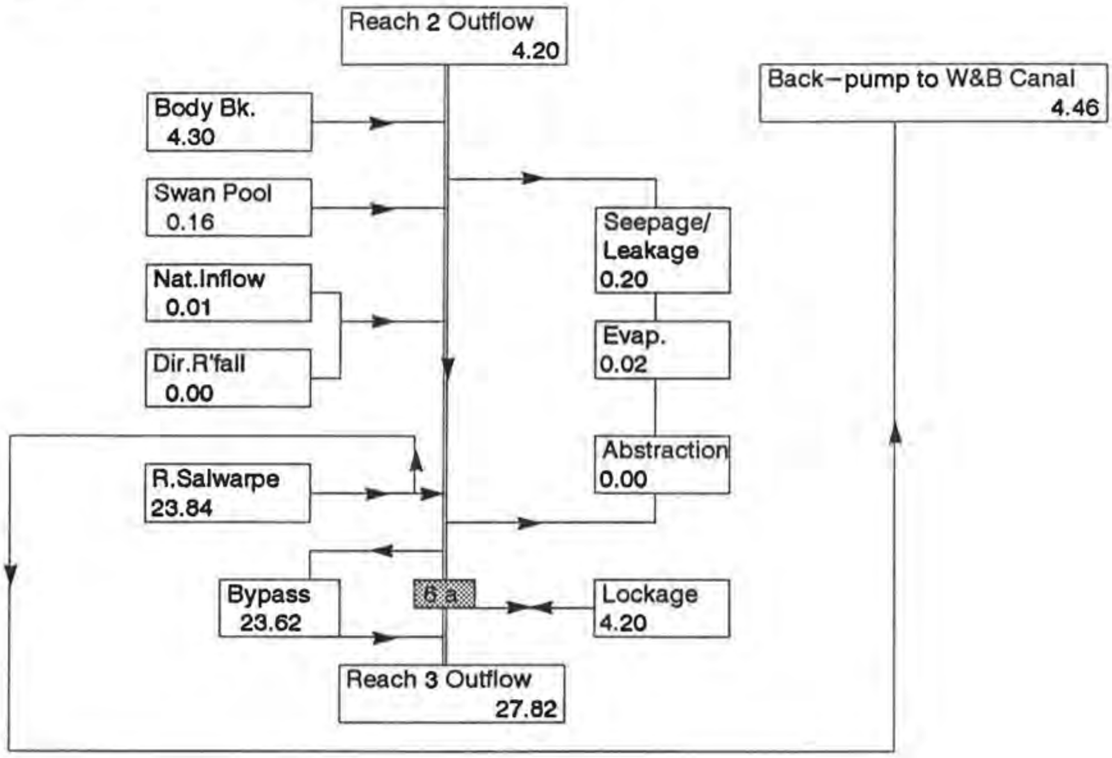
J Reach 1:



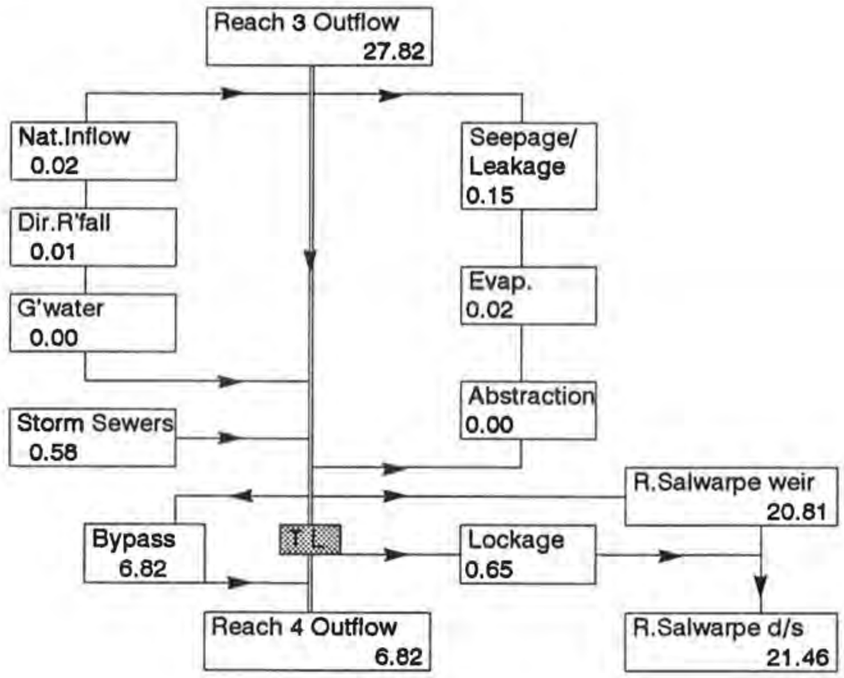
J Reach 2:



J Reach 3:



J Reach 4:

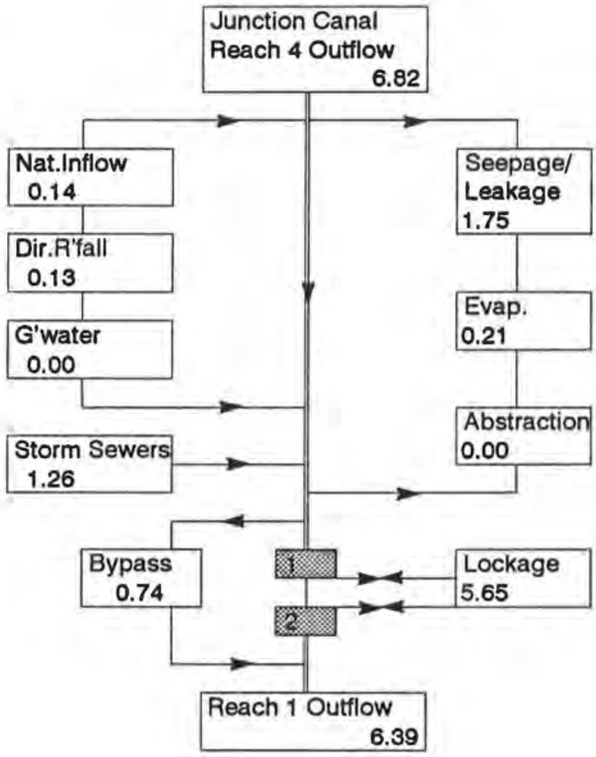


Balance E

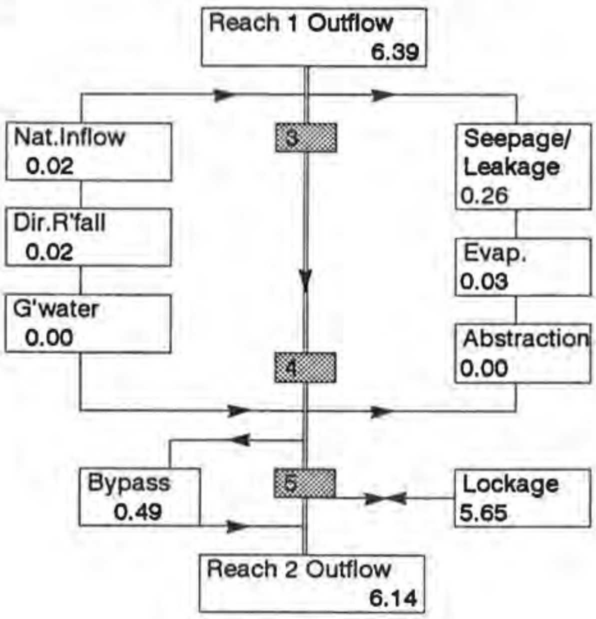
BARGE CANAL:

Reach 1: Town Lock to Lock 2
Reach 2: Lock 2 to Lock 5
Reach 3: Lock 5 to Lock 6
Reach 4: Lock 6 to River Severn

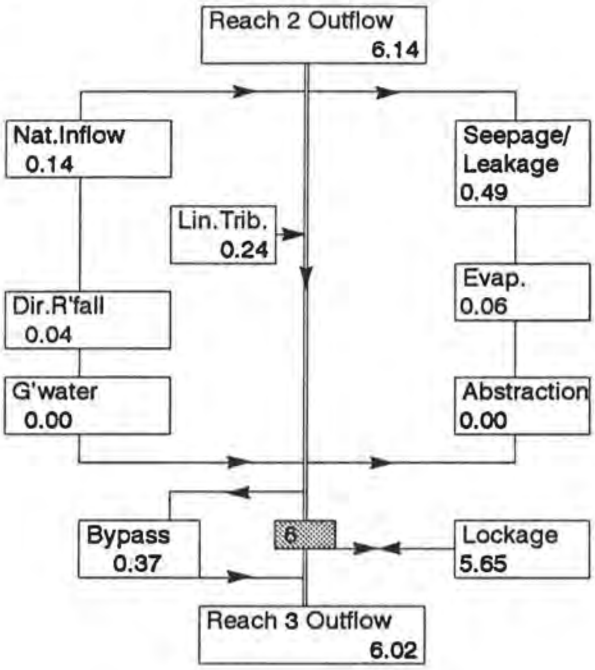
B Reach 1:



B Reach 2:



B Reach 3:



B Reach 4:

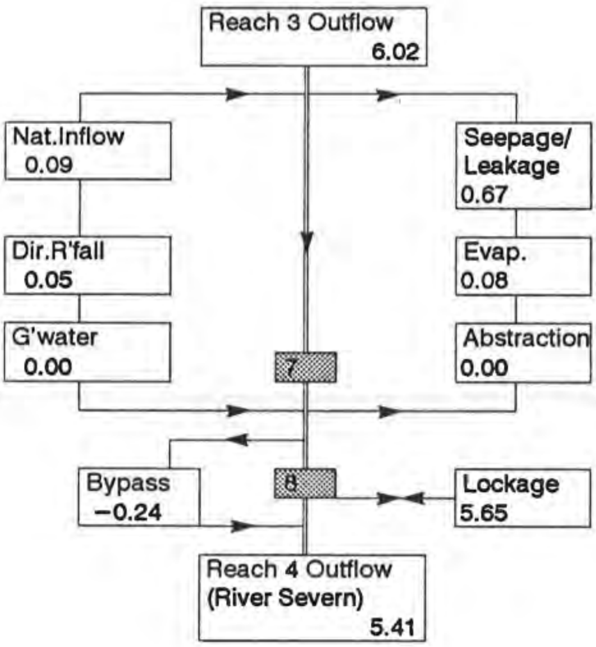


Figure 3.6 : Water Balance for the restored Junction and Barge Canals – Balance F

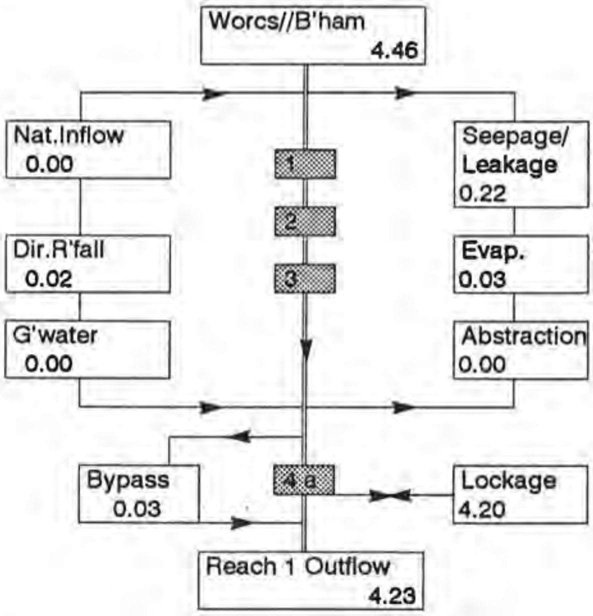
Notes:

1. *Natural Inputs/Outputs are 1 in 10 year minima (to give "reliable yield")*
2. *All values in Ml/d*
3. *Locks represented thus:* 2
4. *Lockage value shown once in a reach applies to ALL locks in that reach*
5. *Groundwater (G'water) inputs are included in Net Seepage/Leakage ouputs*

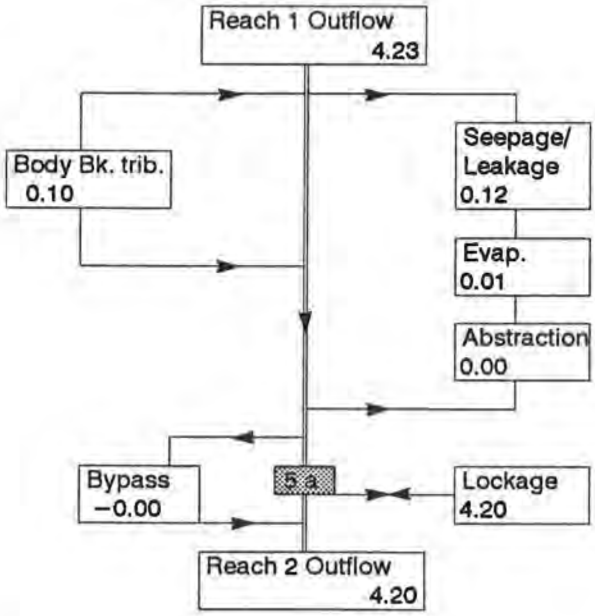
JUNCTION CANAL:

Reach 1: Worcester & Birmingham Canal confluence to Lock 4a
Reach 2: Lock 4a to Lock 5a
Reach 3: Lock 5a to Lock 6a
Reach 4: Lock 6a to Town Lock

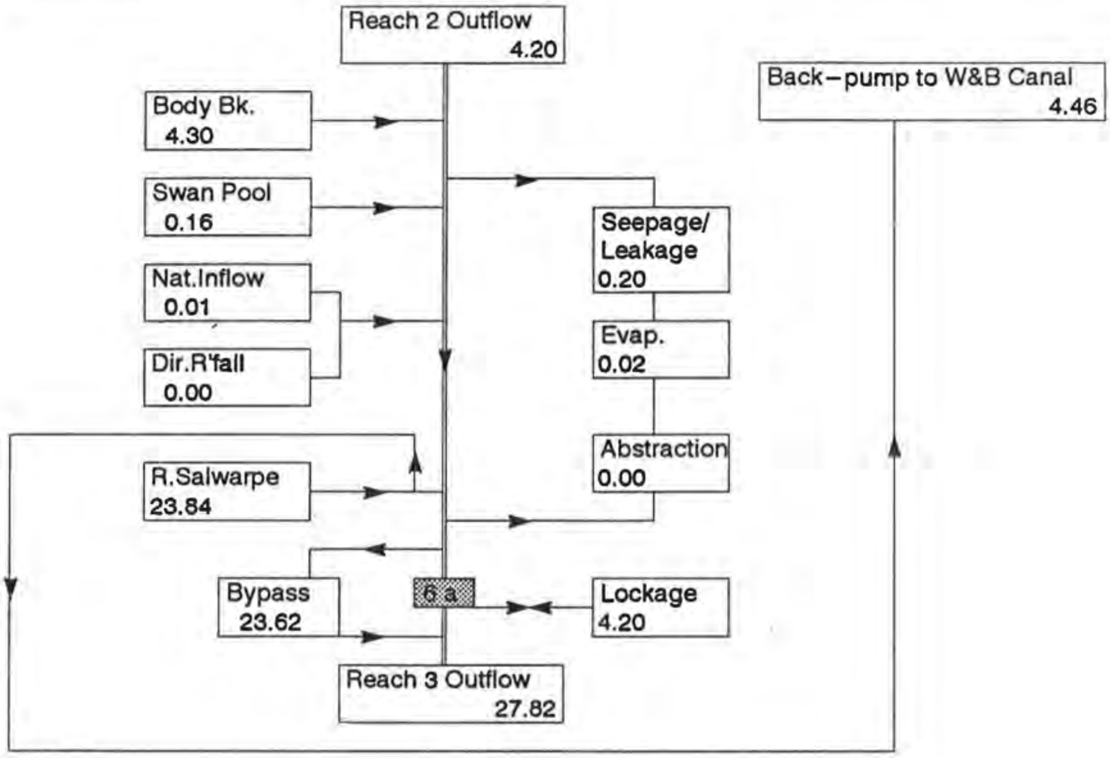
J Reach 1:



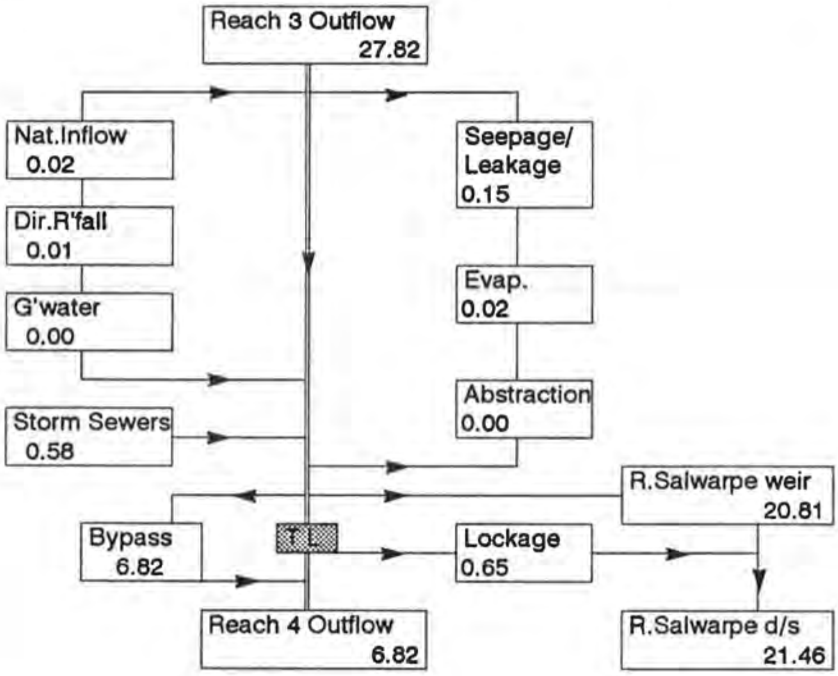
J Reach 2:



J Reach 3:



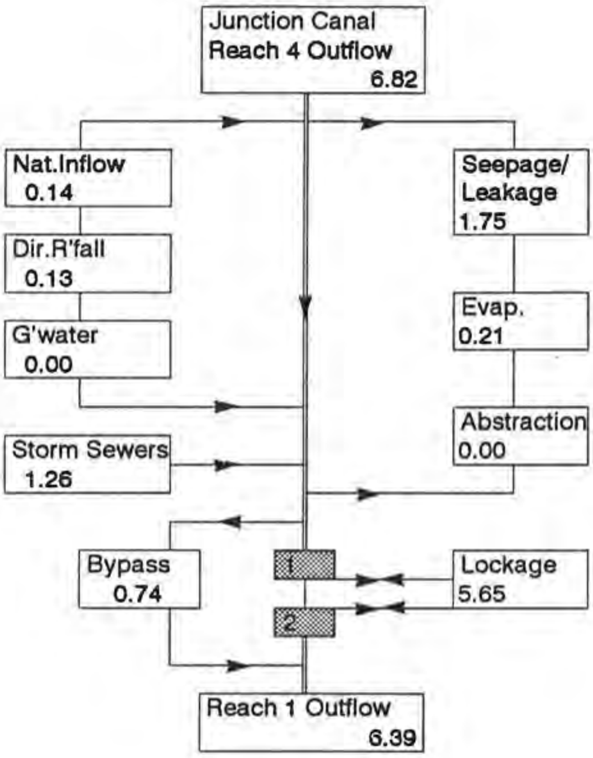
J Reach 4:



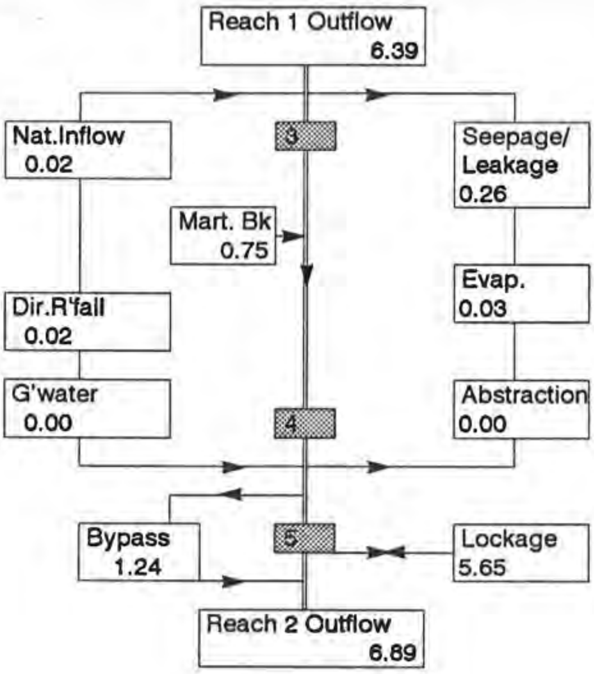
BARGE CANAL:

Reach 1: Town Lock to Lock 2
Reach 2: Lock 2 to Lock 5
Reach 3: Lock 5 to Lock 6
Reach 4: Lock 6 to River Severn

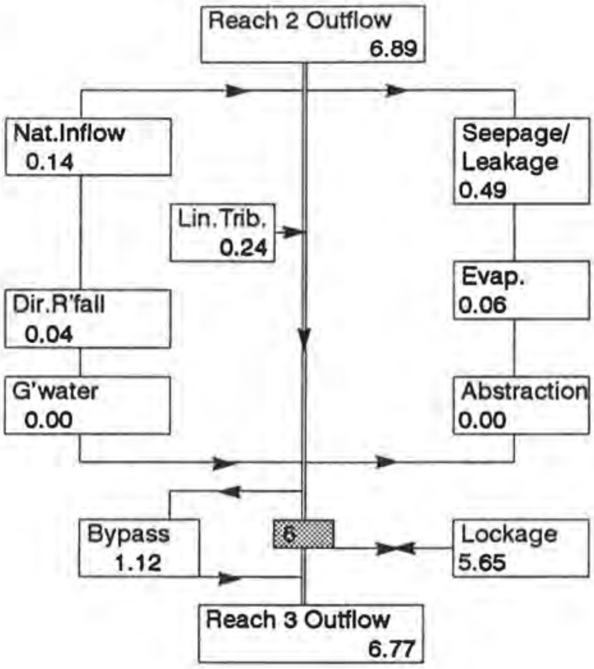
B Reach 1:



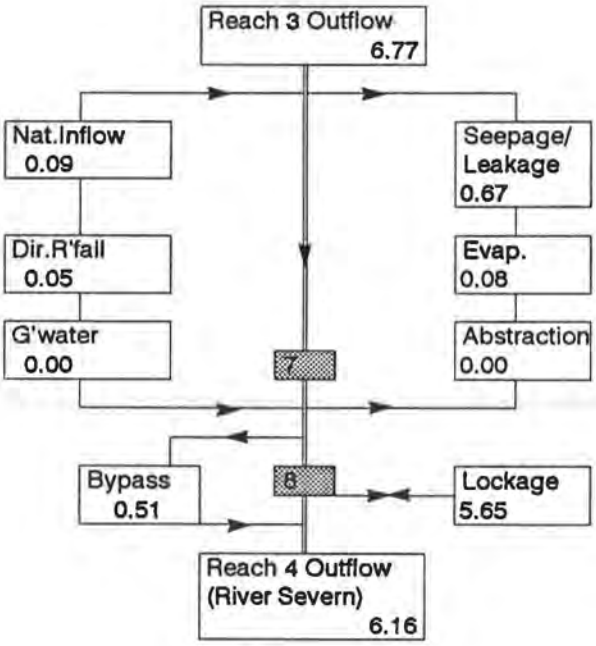
B Reach 2:



B Reach 3:



B Reach 4:



(i) The Martin Brook inflow alone, without the increased abstraction licence from the Salwarpe, is insufficient to meet even half the resource shortfall (0.75 Ml/d out of 2.19 Ml/d).

(ii) With the increased abstraction alone, the shortfall is so small (0.25 Ml/d) that inaccuracies in the estimation of balance parameters may account for some or even all of this, and there may, in fact, be no need for further resources.

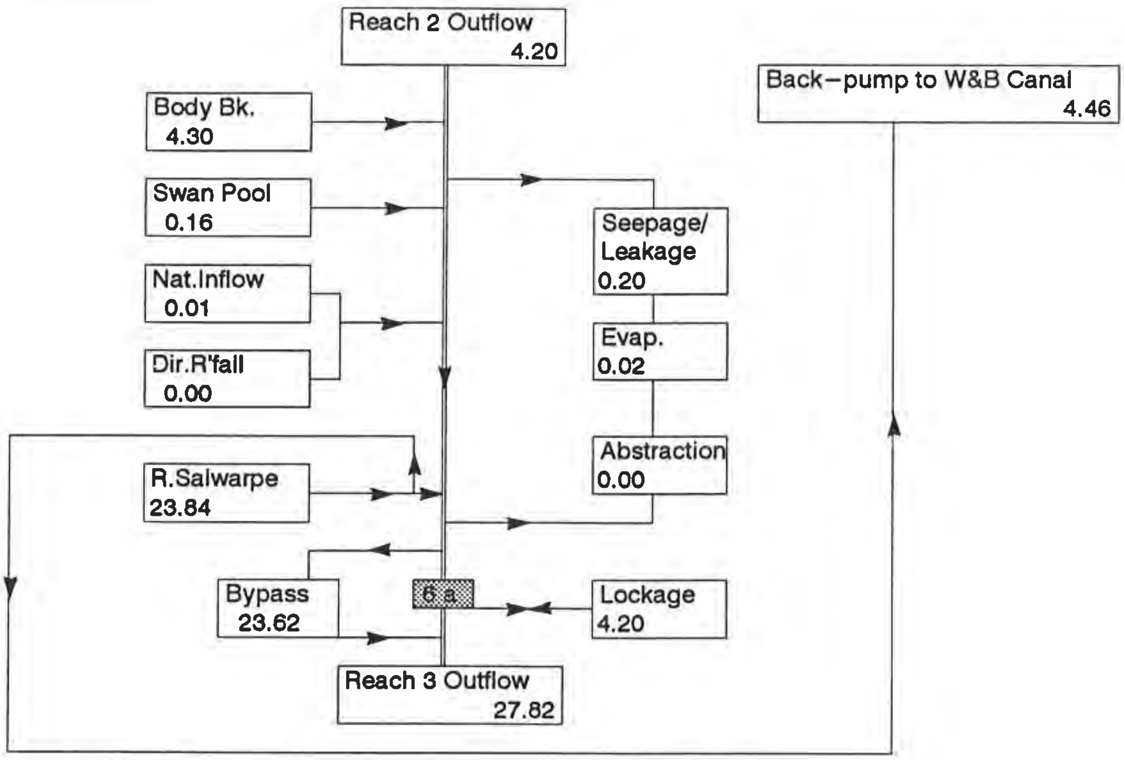
(iii) The diversion of Martin Brook into the canal would constitute an abstraction from the River Salwarpe; this would be permanent and would have to be negotiated with the NRA. The daily maximum of 6.82 Ml/d on the current, but not in force, DCT licence was originally developed for two proposed abstraction points on the Salwarpe very close to the Martin Brook confluence. In view of this, and the associated presence of the Ladywood Sewage Treatment Works effluent discharge only a few hundred metres upstream, it is considered that an increase in the maximum licensed daily abstraction would be unlikely to be granted. In effect, therefore, it is doubtful that permission for this diversion would be given unless the quantity abstracted upstream at Vines Park were reduced by a corresponding amount. This would serve no useful resource purpose and would, in fact, increase restoration costs.

3.4.8 Resources from Boundary Brook

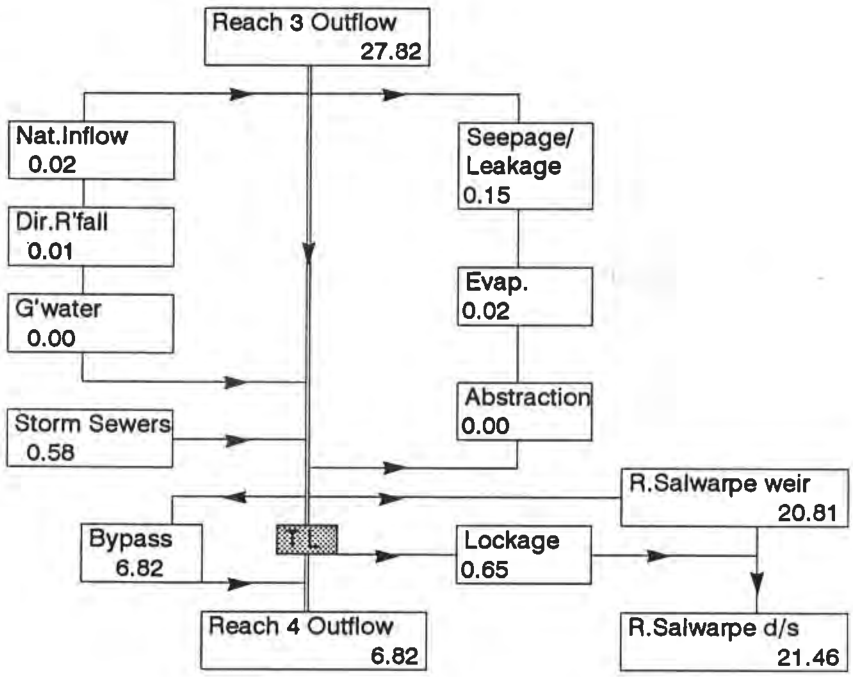
Boundary Brook begins as part of the sewerage system draining the Witton and Chawson districts of Droitwich before passing through a rural catchment to flow into the River Salwarpe at the ring-road crossing near Chawson Farm. The option of diverting the Brook into the Barge Canal to provide additional resources has been briefly considered at the request of Wychavon District Council.

The 1 in 10 year minimum summer flow in the Boundary Brook is 1.94 Ml/d. Although no balance has been produced for this option, it is clear that the Brook could supply nearly 30% of the total Barge Canal shortfall. However, as with Martin Brook, the diversion of Boundary Brook would constitute an abstraction from the Salwarpe which would have to be licensed by the NRA. The same argument exists that the NRA would be unlikely to increase the daily maximum licensed figure issued to DCT above 6.82 Ml/d and therefore, if 1.94 Ml/d were abstracted via the Boundary Brook, the maximum abstraction at Vines Park would need to be reduced by the same amount. There would be no net benefit to the resources of the canal therefore, and the cost of the restoration would be greater than if the diversion did not take place.

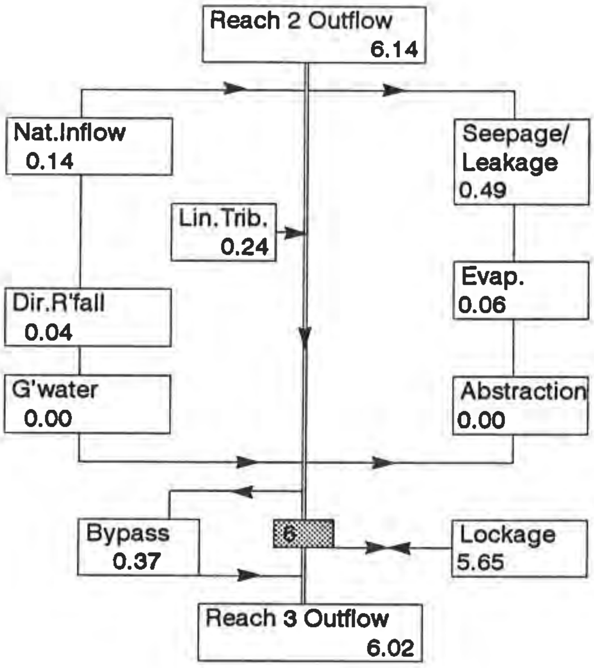
J Reach 3:



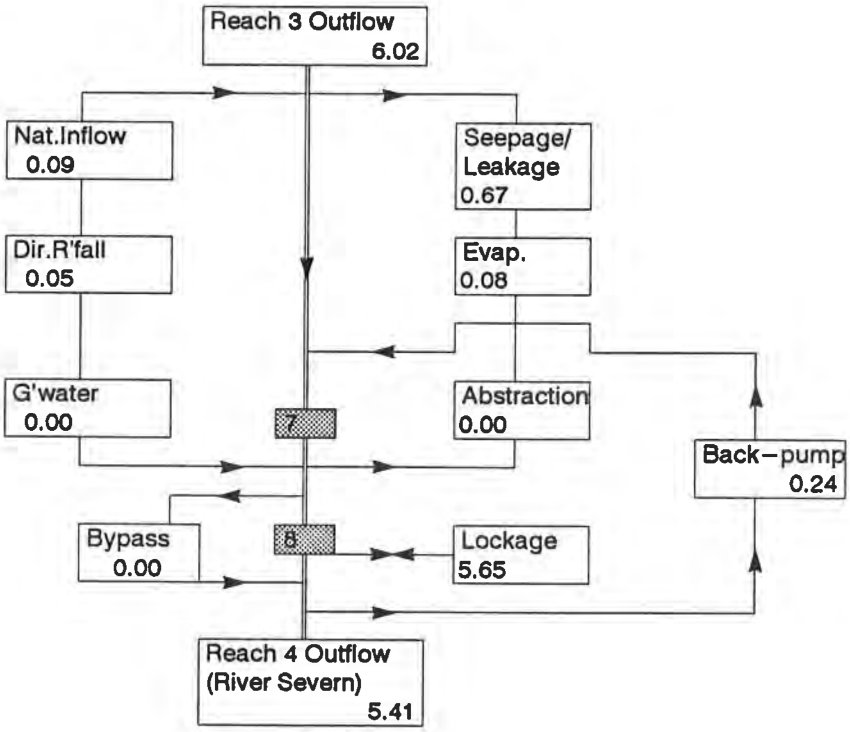
J Reach 4:



B Reach 3:



B Reach 4:



which could be released at an average rate of 0.24 Ml/d. Although this would increase low flows in the Salwarpe, abstraction for the Barge Canal would still be limited by the maximum licensed quantity and so the additional surplus would have no direct benefit to the resources of the canal. The higher low flows, however, would increase the reliability of the abstraction supply, but only by a small amount (from 90% to 91%). The usefulness of the scheme for resource purposes is therefore limited.

3.4.12 Summary

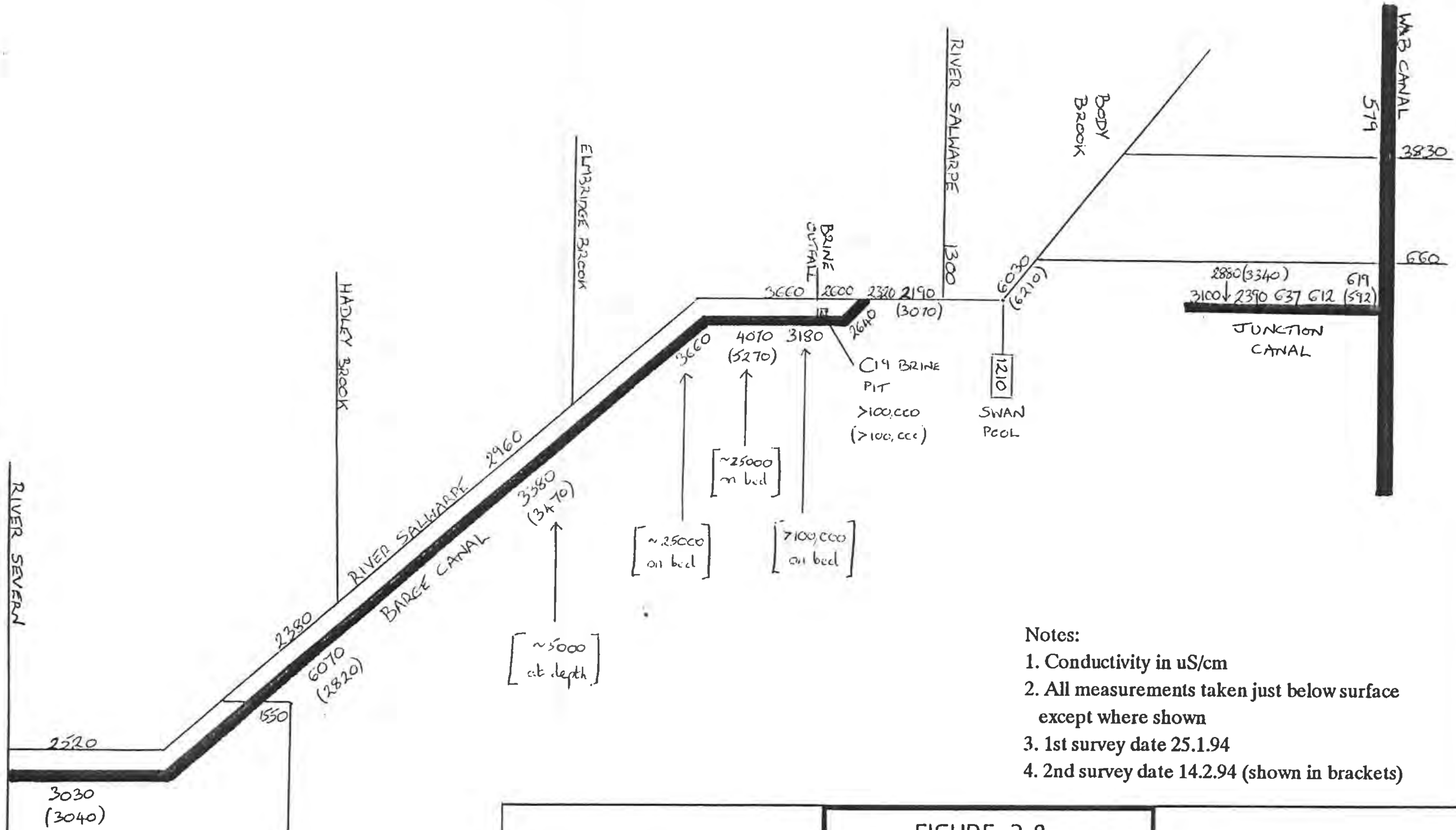
The water balance modelling exercise clearly shows the shortfall in water resources for the restored Junction and Barge Canals operating under the design conditions of 90% reliability (ie 1 in 10 year (summer) minimum inflows and peak demand).

Abstraction from the Worcester & Birmingham Canal with subsequent back-pumping of the same quantity from the River Salwarpe at its confluence with the Junction Canal, will meet the shortfall in the Junction Canal.

In spite of the NRA Minimum Prescribed Flow requirements on the River Salwarpe, sufficient surplus water exists in the river to meet the shortfall in the Barge Canal. However, the authorised annual abstraction quantity on the original licence held by DCT (not yet in force) limits the available supply to the Barge Canal to such a level that a resource shortfall still exists. Increase of this annual maximum to an amount that allows abstraction of the original daily maximum for the entire 30 week 'summer' (ie the design period) would eradicate 90% of this shortfall.

The remainder of the shortfall can be met by a number of options such as the diversion of Martin Brook into the canal or the back-pumping of canal water in the Hawford area. However, it is considered that the calculated shortfall may well be the result of over-estimation of the outflow parameters in the balance (in particular seepage/leakage). Variation of the abstraction licence alone may therefore guarantee sufficient resources to meet the peak demands for an average 9 out of every 10 years.

In any event, it is considered that the new application for an abstraction licence should, in the first instance, request the full 7.06 Ml/d for the 30 weeks (1482.6 Ml/a). Following investigation by the NRA, this may be authorised or may not. If it is not and the quantity remains at 6.82 Ml/d, but with an annual quantity of 1432.2 Ml, then it is still recommended that the Martin Brook or back-pumping option are not implemented unless and until a shortfall in resources is seen to still be occurring following restoration.



Notes:
1. Conductivity in uS/cm
2. All measurements taken just below surface except where shown
3. 1st survey date 25.1.94
4. 2nd survey date 14.2.94 (shown in brackets)

SCHEMATIC TO SHOW RESULTS OF SWK CONDUCTIVITY SURVEY

FIGURE 3.8

Scale NTS		
Drawn NAE	Approved	Revised
Date 9.3.94	Date	Date

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mg/l, also less than twice its present level. It is proposed that mixing is achieved by diffusers on the back-pump outfall or a similar arrangement. If, as is expected, the W&B Canal is used more frequently than the Junction Canal, final conductivities and chloride concentrations in the mixed water can be expected to be even lower than above, with consequently even less impact.

In summary, therefore, it is considered that the final chloride concentrations and salinity levels will be so low, and so close to present levels in the W&B Canal, that there will be no detrimental environmental impacts from the implementation of back-pumping proposals.

3.5.3 The River Salwarpe through Droitwich

The measurement and analysis results for samples 13 and 19, taken from the Salwarpe at the Rugby Club and from the Barge Canal respectively, reveal conductivities, chloride and sodium concentrations lower in the Salwarpe than in the canal. This is due to diluted, flowing, water in the Salwarpe, compared to non-flowing water in the canal receiving significant brine discharge from artesian groundwater. Other facets of the chemistry including metal concentrations are similar and it can be concluded that the abstraction of water from the Salwarpe to feed the Canal will have a positive effect on the quality of the canal, rather than a negative one.

3.5.4 The 19th Century Brine Pit

This brine pit is located near to the medieval Upwich Pit but is obviously more recent. It is known to overflow and discharge to the Barge Canal at certain times, particularly after periods of heavy rainfall. The analysis results from this sample provide an indication of the chemistry of the artesian groundwater in the area and of the contamination that the canal receives at certain times.

All anions and cations tested for are present in high concentrations, but particularly sodium and chloride, as would be expected from the saline nature of the pit. A chloride concentration of nearly 40000 mg/l was recorded. Significantly, most metal concentrations were also much higher than in the canal itself or in the river, although aluminium, chromium, nickel and lead were found to be the only ones exceeding Water Supply (Water Quality) Regulations 1989.

3.5.5 The Barge Canal at the old Gas Works

This sample was analyzed for Total Phenols, Total PAH and the specific carcinogenic PAH Benzo 3,4 Pyrene as well as the standard suite of anions, cations and metals. No contamination from the Gas Works was found in the sample - most determinants were within Water Supply (Water Quality) Regulations 1989 and, as such, constitute a good quality water in chemical terms.

4. COST AND BENEFIT ANALYSIS

4.1 Existing tourism activity in the area

4.1.1 Introduction

Droitwich Spa is located in rural Worcestershire and is the main town to be found on the canal length. Tourism is an important industry to this historic town which is most famous for its Brine Baths.

Within the area there are several tourist attractions. Most of the attractions in Droitwich attract only a relatively small number of tourists except the Brine Baths complex which attracted an estimated 70,000 visitors in 1992 (see Table 4.1).

Table 4.1 Visitor attractions 1992

Attraction	Visitors
Droitwich Spa Brine Bath Complex	70,000
Droitwich Spa Heritage Centre	26,629
Hanbry Holt, near Droitwich	22,750

Source: Survey of Visitor Attractions

Other attractions in Droitwich include the Church of the Sacred Heart, St Peter's Church, Lido Park and Jinnery Ring Craft Centre.

The Droitwich Canals cannot be considered in isolation and it is necessary to gain an appreciation of its place within tourism in the Heart of England and in Hereford and Worcester in general.

Table 4.2 shows that the main activities undertaken by UK tourists on holiday in the Heart of England in 1992 are swimming, hiking/rambling, visiting heritage sites and visiting museums.

The Heart of England Tourist Board (HETB) figures show that in 1992 there were about 8.67 million visits to the area with approximately 85% of these trips made by UK residents. These visitors spent a total of £590 million with a further £298 million being spent by overseas holiday makers as shown in Table 4.3.

The level of expenditure per trip in the Heart of England is approximately £102. In the Hereford and Worcester area there was a total of 1.44 million visits made in 1992. These visitors spent a total of £110 million in that same period. The level of expenditure per trip in Hereford and Worcester is therefore approximately £76.

Table 4.4 below shows the main purpose of visits made to the Heart of England in 1992. "Pure" holiday makers represent the biggest market in both UK and overseas residents.

Table 4.4 Purposes of visit

	UK residents trips (%)	Overseas residents trips (%)
Holiday	51	39
VFR	28	27
Business	16	26
Other	5	7
Total	100	100

Source: Heart of England Regional Tourism Facts

4.1.2 Day trip visits

In addition to the visitor traffic it is also useful to know the scale of the leisure day trip visits within the area. In 1992 there were about 98 million day trips made. These day trip visitors spent about £883 million.

4.1.3 Accommodation

Table 4.5 below shows that the majority of UK residents visit the Heart of England and stay at the home of friends or relations.

Table 4.7 Top 20 attractions in the Heart of England in 1992

	Attraction	Number of visits
1	Alton Towers, Staffordshire	2,501m
2	Drayton Manor Park, Staffordshire	950,000*
3	Warwick Castle, Warwickshire	690,000
4	Shakespeare's Birthplace, Stratford on Avon	577,704
5	Cadbury World, Bournville	416,000
6	Anne Hathaway's Cottage, Stratford on Avon	338,726
7	Walsall Arboretum Illuminations	316,365
8	Ironbridge Gorge Museum, Dudley	311,400
9	Black County Museum, Dudley	264,197
10	Shugborough Estate	243,799
11	Slimbridge Wildfowl Trust	202,978
12	Severn Valley Railway, Shropshire	194,566
13	Sandwell Farm Park	178,000
14	Amerton Working Farm, Staffordshire	165,000
15=	Dudley Zoo and Castle	160,000*
15=	Westonbirt Arboretum, Gloucestershire	160,000*
17	Birmingham Botanic Gardens	154,902
18	Bourton-on-the-Water Model Village	140,000*
19	Weston Park, Shropshire	138,192
20	Hidcote Manor Garden, Gloucestershire	128,051

SHROPSHIRE DUDLEY?

British Waterways estimated typical annual powered boat movements (hire boats, private boating and trip boats) on the Worcester and Birmingham Canal at the junction with the Droitwich Canal at about 4,000-5,000. For the River Severn, at the junction with the Droitwich Canal annual powered boat movements are about 7,000-8,000. This is based on lock-keeper records at Bevere and Holt locks).

4.2.2 Hire boats

One survey undertaken by British Waterways in 1989 estimated that the numbers of adults taking a hire boat holiday on a canal in Britain was 250,000. However, in a separate British Waterways survey the number of people in 1990 was estimated at 174,000.

There are currently a number of hire boat operators on the Worcester and Birmingham Canal, for example:

* Brookline (Dunhampstead)
* Viking Afloat(Worcester)
* Black Prince Holidays (Stoke Prior).

Using the Boat Traffic Model, British Waterways estimate the typical annual hire boat movements on the Worcester and Birmingham Canal at the junction with the Droitwich Canal at about 2,000.

For the River Severn at the junction with the Droitwich Canal this figure is estimated to be about 1,500 (based on lockkeeper records at Bevere and Holt locks).

Table 4.9 Canal visitor numbers

Market sector	Visitors (millions)		
	1984	1986	1989
Holiday hire boating	0.17	0.14	0.25
Private powered boating	----	0.40	0.47
Trip/restaurant boats	----	----	----
Canoeing/other unpowered boats	0.36	0.40	0.22
Fishing	0.77	0.77	0.2
Other informal visits	5.14	4.83	5.82

Source: British Waterways

4.2.7 Informal visitors usage

Informal recreational usage of the Canal system is by far the most important in terms of numbers. Many towpath surveys have been initiated and indicate that many people are our for a pleasant walk, walking the dog, cycling or jogging. In urban areas local use is high whilst in rural areas there are more tourists. (British Waterways estimate that around 130 million visits are made to British Waterway towpaths each year.)

British Waterways estimate that there are about 33,500 visits per km per year on the Worcester and Birmingham Canal at the junction with the Droitwich Canal. For the River Severn at the junction with the Droitwich Canal (on the 6 km stretch of river between Bereve and Holt the figure was estimated at 286,000 in 1989.

4.3 Estimation of boat use

4.3.1 Introduction

The British Waterways' Research Division has constructed a computer model to estimate boat numbers on their canals. We asked them to use the model to generate forecasts for the Droitwich Canals.

The British Waterways' report is included as Appendix D. The following is a brief summary of the results.

Two model runs have been used.
(i) Year 0 ie the first year of opening
(ii) Year 5
The latter can be regarded as a typical year for the purposes of our economic analysis. Under the first scenario the canal is assumed to be used by visiting boats only but by Year 5 there are other boats based (permanently) on it.

The boat number estimates for the two scenarios are summarised in Table 4.10.

4.3.2 Viking Afloat

The company sell narrow boat holidays and are located on the Worcester and Birmingham Canal at Worcester. Viking Afloat believe they would benefit from the restoration of the Droitwich Canals because once completed the canal will create a small ring with the Worcester and Birmingham Canal and the River Severn. This ring would be suitable for a three or four day short break which is very much in demand at the moment. Most other canal rings are much larger in size and not particularly suited to short breaks. Viking Afloat believe that many people look for a ring so that they do not need to retrace their steps.

The company operate six boats for short breaks which are currently not used to their full capacity because Viking Afloat are not able to offer a suitable short break trip. Overall, Viking Afloat believe the restoration of the canal will help increase the number of short breaks they sell which would result in using their short break boats more and possibly also increase the number of boats they operate.

4.3.3 Black Prince Holidays

Black Prince Holidays are also a narrow boat holiday operator who are located at Stoke Prior on the Worcester and Birmingham Canal. The company believe that once completed the Droitwich Canal would provide a ring suitable for short break holidays (with the Worcester and Birmingham Canal and the River Severn). Black Prince stated that they would feature this in their holiday brochure.

However, the company believe that although there is currently a good demand for short breaks the restoration of the canal would not expand the market but instead redistribute it. Black Prince Holidays do not think that they will benefit from increased revenue although they may gain better utilisation of existing boats.

4.3.4 Brook-Line

Brook-Line are based just south of Droitwich on the Worcester and Birmingham Canal and also offer narrow boat holidays. They have approximately 12 boats in their fleet. They also believe that the canal would make a good short break holiday and could result in better utilisation of their existing short break boats (four). This could possibly increase Brook-Line's revenue by about £5,000 per year.

Brook-Line do not believe that a large amount of boats would use the canal when completed. There may be an initial rush of people to try it out but after that they believe that the boat traffic on the canal would ease off.

Saraband also believe that boat facilities at Hawford Mill need to be developed to cater for visiting boats and that the King George playing fields in Droitwich provide an excellent opportunity to hold some kind of annual event based around the canal. Finally, the company stated that if the canal were to be privately owned, people would therefore need to pay a separate licence fee which would have a negative effect on the number of people using the canal.

4.3.7 George Judge Ltd

George Judge Ltd operate a boat yard and chandlers as well as a caravan and camp site. The company is located at Hawford Mill, beside the Droitwich Canal/River Salwarpe. They believe there would be no benefits to any part of the business once the canal has been restored. They also stated that they would strongly object to any kind of further development at Hawford Mill.

4.3.8 Eagle and Sun

The Eagle and Sun pub is located at Hanbury at the junction of the Worcester and Birmingham Canal and the Droitwich Junction Canal. At present the pub does not attract much business from the boats on the Worcester and Birmingham Canal. However, once the canal is restored this would encourage more people to the area and hopefully increase their revenue during the summer months. If a marina is developed nearby, the Eagle and Sun believe this will create a good spin-off for the pub.

4.3.9 The Railway Pub

The Railway Pub is located in the Vines Park area beside the canal and the owner believes it is in an ideal position to benefit from the restoration of the canal. The pub is currently preparing a planning application to develop a roof garden. They strongly believe there is an excellent opportunity in this area for a marina and some kind of housing development.

4.4 Economic benefits

Economic benefits can be assessed in various ways, eg:

* expenditure
* income
* employment.

The study brief requires us to:

* assess the new local tourist expenditures which wold accrue to the region from a commercially orientated exploitation of the restored Canals, consider activities associated directly with the Canals and also the impact of canal restoration upon the level of general tourism in the area.

Similarly, there are assumed to be 23 local hire boats, each operating for an average of 150 days per year. Average passengers per boat have been calculated at 4.1 and average spending per person per day at £9.88, giving total annual expenditure of £544,991, equivalent to £23,695 per boat.

For the local private boats, the key assumptions are 93 boats, 30 days cruising per year per boat, average occupancy of 3.5, average cruising spend £3.20. The total expenditure for this category is £223,757.

Finally, British Waterways estimate that local day boats will generate a further £36,100 per year, giving the grand total of £1,585,634 shown in the table.

A prerequisite of this is obviously that businesses set up in the area to provide the boats and support facilities. British Waterways believe that this will happen over a five year period, based on their experience elsewhere. These businesses could either be new starts at the provision of local facilities by businesses already established elsewhere.

Our research for this study identified interest in such development opportunities although not necessarily on the scale envisaged by British Waterways. These opportunities are discussed below.

4.5 Development opportunities

4.5.1 Introduction

It is widely expected that the reopening of the Canals would boost tourism in the area. The British Waterways figures indicated the level of additional expenditure which might be generated.

That will only happen, however, if the relevant spending opportunities are created in Droitwich and along the canals. This section discusses the main opportunities.

We have walked the length of the canals. From the economic development perspective, we believe that the most likely locations for new economic activity are:

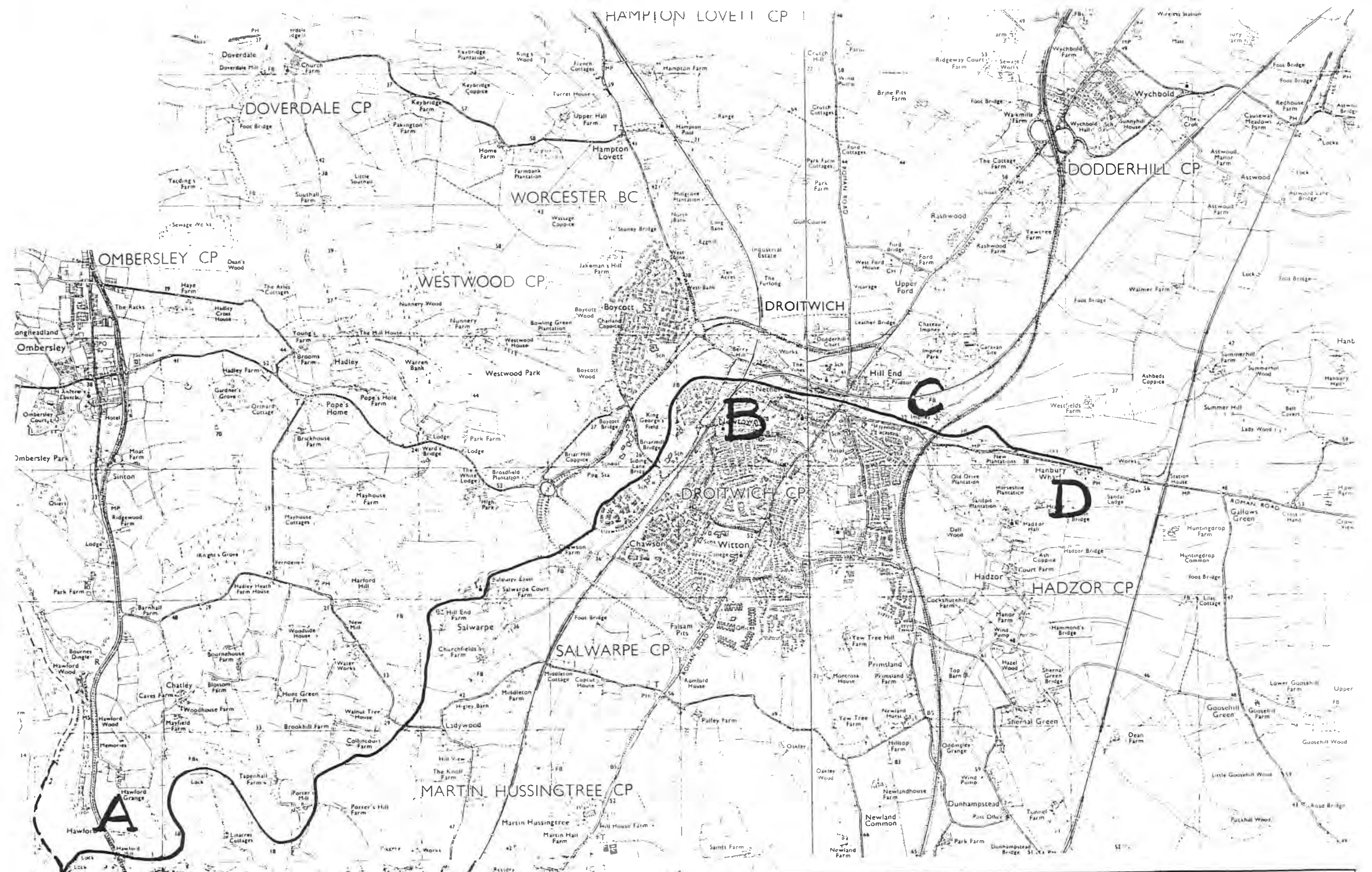
* in Droitwich itself
* and at the junctions with the Worcester-Birmingham Canal and the River Severn.

Within Droitwich the two prime locations are obviously

- Vines Park and
- Impney Farm.

There are existing activities at or near the two junctions, namely

- Hanbury Wharf and
- Hawford Mill.



DEVELOPMENT OPPORTUNITIES

FIGURE 4.1		
Scale		
Drawn	Approved	Revised
Date	Date	Date

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4.5.7 **Development Strategy**

The key objective, in our opinion, should be to maximize the developments as close as possible to the centre of Droitwich. This would encourage visiting boats and other visitors to spend time and money in the town.

It is essential therefore that there are sites available for moorings and related facilities. The obvious locations are in the Vines Park/Netherwich area.

We would also encourage further development at the two junctions with the River Severn and the Worcester - Birmingham Canal.

Private sector investment elsewhere along the Canals should not be discouraged, but there are very few locations at which that is likely to happen on any significant scale. Impney Farm appears to be the likeliest.

The British Waterways traffic forecasts assume that there will be two "trip" boats operating on the Droitwich Canals, plus other local hire boats. These would be operated by either the public sector or the private sector. The latter may need assistance to do so but our survey of local businesses identified real interest.

4.6 Other benefits

4.6.1 Introduction

This section examines other potential benefits arising from the restoration of the canal.

4.6.2 Education

In addition to the benefits previously mentioned the restored canal would provide a number of educational benefits to schools in the area. The canal could be used for classroom projects and possibly even part of the teaching curriculum. Excursions aboard trip boats operating on the canals are now also used by school parties.

4.6.3 Drainage

The canal will also provide an alternative drainage system for the area of Droitwich. We understand that the town of Droitwich used to flood relatively badly and that the incorporation of the Droitwich Canal into the drainage system would help prevent any such incident in the future.

A study carried out in 1988 estimated that if British Waterways could charge for its land drainage services it could receive an annual income of over £20 million. This figure was based on estimates of the costs to land owners, local authorities in the UK etc of providing alternative drainage.

4.6.4 Nature conservation

The capital costs are taken from elsewhere in this report. We have assumed that the total cost of £5,162,810 is incurred in the year before the canals reopen (Year 0 in the table). This assumption can easily be modified.

We have estimated the annual operating costs as £115,000. This is shown as a constraint figure for each year of the analysis.

In accordance with the brief, we have defined the benefits as the expenditure by visitors. This is shown in the fourth column of the table. We have used the British Waterways forecasts of expenditure, as discussed.

British Waterways produced two sets of forecasts for use - for Year 0 and Year 5. The Year 0 figure is actually Year 1 in Table 4.12 and Year 5 - Year 6. We have assumed the same rate of increase in spending over the first five years of the canals' operation, with a constant expenditure figure of £1,585,634 for each year from Year 6 onwards.

The net present value (NPV) calculations are shown in the final, right-hand column of the table. The total figure is

+ £6,953,652

In other words, the reopening of the canals would generate net visitor expenditure (in constant values) of about £7 million over the 25 year lifetime of the project. It is therefore a "worthwhile project" and the investment is justified in terms of the economic benefits which would be created.

As discussed earlier, there are other measures of economic benefit, such as employment creation and income creation. These have not been considered in detail in this report.

The expenditure shown in Table 4.12 is gross expenditure. It does not represent the net benefits to the local economy. If visitors spend money in local shops, the shopkeepers have to purchase the goods involved from elsewhere, plus other expenditure on heat and light, rents etc. A better measure is therefore net expenditure or "value added' in the economists' jargon.

The precise calculation of value added would require detailed survey work, which is outside the scope of this study. The UK average, however, is about 40% of gross domestic product and we have applied that average to the gross expenditure in Table 4.12 This reduces substantially the benefits and the NPV in Table 4.13, is £1,052,731.

However, other benefits need to be taken into account. In particular, there will be multiplier effects - ie indirect and induced benefits - in the local economy. These are also very difficult to calculate precisely but from various other economic impact studies we believe that the value of the local multiplier will probably be around 1.4.

TABLE 4.12 DROITWICH CANALS : NPV ANALYSIS

Year	Capital Costs	Operating Costs	Expenditure by visitors	Total	Discount Factor(8%)	NPV
0	-5162810			-5162810	1.000	-5162810
1		-115000	163553	48553	.926	44960
2		-115000	447969	332969	.857	285354
3		-115000	732385	617385	.794	490204
4		-115000	1016801	901801	.735	662824
5		-115000	1301218	1186218	.681	807814
6		-115000	1585634	1470634	.630	926499
7		-115000	1585634	1470634	.583	857380
8		-115000	1585634	1470634	.540	794142
9		-115000	1585634	1470634	.500	735317
10		-115000	1585634	1470634	.463	680904
11		-115000	1585634	1470634	.429	630902
12		-115000	1585634	1470634	.397	583842
13		-115000	1585634	1470634	.368	541193
14		-115000	1585634	1470634	.340	500016
15		-115000	1585634	1470634	.315	463250
16		-115000	1585634	1470634	.292	429425
17		-115000	1585634	1470634	.270	397071
18		-115000	1585634	1470634	.250	367659
19		-115000	1585634	1470634	.232	341187
20		-115000	1585634	1470634	.215	316186
21		-115000	1585634	1470634	.199	292656
22		-115000	1585634	1470634	.184	270597
23		-115000	1585634	1470634	.170	250008
24		-115000	1585634	1470634	.158	232360
25		-115000	1585634	1470634	.146	214713
		-2875000	35374606	27336796		6953652

TABLE 4.14 DROITWICH CANALS : NPV ANALYSIS

Year	Capital Costs	Operating Costs	Expenditure by visitors	Value Added(40%)	Multiplier 1.4	Total	Discount Factor(8%)	NPV
0	-5162810					-5162810	1.000	-5162810
1		-115000	163553	65421	91590	-23410	.926	-21678
2		-115000	447969	179188	250863	135863	.857	116434
3		-115000	732385	292954	410136	295136	.794	234338
4		-115000	1016801	406720	569409	454409	.735	333990
5		-115000	1301218	520487	728682	613682	.681	417917
6		-115000	1585634	634254	887955	772955	.630	486962
7		-115000	1585634	634254	887955	772955	.583	450633
8		-115000	1585634	634254	887955	772955	.540	417396
9		-115000	1585634	634254	887955	772955	.500	386478
10		-115000	1585634	634254	887955	772955	.463	357878
11		-115000	1585634	634254	887955	772955	.429	331598
12		-115000	1585634	634254	887955	772955	.397	306863
13		-115000	1585634	634254	887955	772955	.368	284447
14		-115000	1585634	634254	887955	772955	.340	262805
15		-115000	1585634	634254	887955	772955	.315	243481
16		-115000	1585634	634254	887955	772955	.292	225703
17		-115000	1585634	634254	887955	772955	.270	208698
18		-115000	1585634	634254	887955	772955	.250	193239
19		-115000	1585634	634254	887955	772955	.232	179326
20		-115000	1585634	634254	887955	772955	.215	166185
21		-115000	1585634	634254	887955	772955	.199	153818
22		-115000	1585634	634254	887955	772955	.184	142224
23		-115000	1585634	634254	887955	772955	.170	131402
24		-115000	1585634	634254	887955	772955	.158	122127
25		-115000	1585634	634254	887955	772955	.146	112851
		-2875000	35374606	14149842	5659937	11771969		1082304

Table 5.1 : Ecological Data Obtained or Requested from Conservation Bodies

ORGANISATION	DATA
English Nature	• Information on the Denotified SSSI at Salwarpe Valley, and the Great Pool SSSI
Worcestershire Nature Conservation Trust	• Special Wildlife Site Designations • 1982 River Survey Data for the River Salwarpe from the Severn to Chateau Impney • Worcestershire Badger Society Sett Information • Brief Survey Results from Body Brook Marsh
Royal Society for the Preservation of Birds	• Telephone Notes Only
British Trust for Ornithology	• Waterways Bird Survey for the Canal from SO 888630 to 860600 for the years 1987 to 1990.
Biological Records Centre	• Invertebrate Site Register Data • Mammal Data • Amphibian and Reptile Data • Botanical and BSBI Data • Ornithological Data if held
National Rivers Authority	• River Vegetation Survey Data for the Salwarpe to Chateau Impney • Invertebrate Data • Fisheries Data
Countryside Commission	• They hold no specific data but are interested in the landscape matters

surveys should be considered to provide targeted information for specific sections.

5.2.2 Existing Conditions

a) Junction Canal

The WNCT have identified only three sites as Special Wildlife Sites (SWS) along the route of the Junction Canal and there are no Sites of Special Scientific Interest (SSSIs). The SWS sites include the Droitwich Canal (Site Ref SO86/22), the River Salwarpe (Site Ref SO86/23) and the Body Brook Marsh (Site Ref SO96/03), with the former two generally including the canal and river along the Barge Canal as of primary interest over that which is along the Junction Canal. The Worcester and Birmingham Canal is also designated as a SWS (Site Ref SO96/19). The SWS sites are illustrated in Figure 5.1.

General Conditions

The general ecological quality of the existing Junction canal and its immediately surrounding habitat is only of Wider Countryside Value, which is not of sufficient quality to merit designation as a SWS or higher classification. Generally along the Junction Canal there are areas with greater potential for habitat enhancement but it consists mainly of areas either managed as town parkland or overgrown but without particular ecological interest. These latter sites could naturally develop some conservation value, particularly as habitat for birds using the canal corridor, but this progression to greater interest could be encouraged by appropriate management options included in the restoration programme. These are discussed below.

Specific Sites

The Droitwich Canal is itself identified by the WNCT as a SWS (Site Ref SO86/22). The WNCT note that the canal is renowned for salt loving plants (see discussion on the Salwarpe Valley below) which live it in and along its banks. The main locations for these species are downstream of the area of Vines Park and therefore are in practice dependent on the brine that flows into the river to maintain these halophytes (see discussion on the water quality issues below). The canal also currently contains large stretches of good reed beds (*Phragmites communis*) which are used by Reed and Sedge Warblers and other birds. The canal is also noted as coordinating well with other countryside features such as hedges and wooded banks and therefore providing a good range of habitats. The WNCT consider that some of the interest is related to the current low level of boat traffic and that when this increases it is likely that the aquatic life will decline. While this is certainly true for much of the canal itself there are adjacent habitats and methods of establishing reed beds and other habitat in the canal that would maintain at least some of the interest.

General Conditions

The general conditions along the Barge Canal are similar to those along the Junction Canal (see above). However the area along the Salwarpe River, particularly in the SWS and below have previously carried a more varied flora and the potential exists for this to be at least partially reestablished with the returning of the brine flow to the canal and the river. The Droitwich Canals, particularly the Barge Canal, have had associated with them important habitats and sites for plants and birds in particular, though badgers are also noted as having setts near the site.

Specific Sites

The Salwarpe Valley SWS (Ref SO86/20) is the same site as a former SSSI, which was notified for its range of halophytes resulting from the salinity in the river. The site has not maintained its interest due to lower brine flows and pressure on the site from use.

The prime area of interest now is this site in the Salwarpe Valley. It is reduced in size to 5 ha, and is the remains of a formerly extensive area of flood plain meadow and associated habitats. The site still supports an unusual wetland flora for an inland site, with salt loving species (halophytes) and invertebrates and bird species associated with these. The plant species formerly and presently recorded indicate the particular salt loving status of the community and therefore the ecosystem. The species are as follows (from Day 1989):

		Still present
Glaux maritima	Sea milkwort	No
Juncus gerardii	Saltmarsh rush	Yes
Spartina x townsendii	Townsend's Cordgrass	No
Spergularia marina	Lesser Sand spurrey	Yes
Atriplex glabriscula	Babington's Orache	No
Puccinellia distans	Reflexed Salt Marsh Grass	Yes
P maritima	Common saltmarsh grass	No
Lepidium latifolium	Dittander	Yes
Scirpus maritimus	Sea clubrush	No
Samolus valerandi	Brookweed	No
Apium graveolens	Wild Celery	Yes
Schoeplectus tabermontani	Glaucous Bulrush	Yes
Carex distans	Distant Sedge	No
Hordeum marinum	Sea Barley	No
Zannichellia palustris	Hborned pondweed	Yes

This site and a surrounding larger area was earlier a Site of Special Scientific Interest (SSSI), notified in 1951 for marsh grasslands, canal reedbeds, the plant species (as above) and birds. There are survey data from 1977, 1978, 1982 and 1983 for this part of the canal. However the SSSI was denotified in 1986 due to the loss of the habitat and the species above, which Day (1989) regarded as not acceptable even if it was not officially a significant impact. The restoration of the canal can and should, however, include provision for the preservation and enhancement of these features and therefore the resulting loss will be less and can be regarded as not significant. The aspects of habitat enhancement and preservation of useful ecological features to include to ensure this are discussed below. However, they would primarily be addressed at the design stage on two levels. These are general guidance briefs on good practice to preserve and enhance these features and specific guidance when detailed information exists to indicate the value of a particular area.

The Body Brook Marsh Special Wildlife Site is, however, of greater interest along the Junction Canal and consideration has been given to mitigate the potential impact of routing the canal through it. The original option was to use the entire area for the canal with the resulting loss of much of the site, and this was considered to be an unacceptable or significant negative impact on the ecology. Therefore an option was considered that will avoid most of the site and will not interfere with the wetland nature of the rest of the site, though some may become a moorings or marina. Therefore rerouting is part of the mitigation proposed and backing water further up the Body Brook is also recommended to be part of habitat creation to offset the loss of part of the existing area. The details of this would need to be decided as part of the detailed design of the embankments of the canal in this area. However, these measures are proposed as suitable mitigation for the only likely significant effect of the canal restoration on the ecology.

It is unlikely with the above mitigation and active enhancement measures in place that there will be a significant loss of habitat or species. Aspects regarding impacts from the use of the canal are discussed below, with habitat enhancement.

b) Barge Canal

The restoration of the Barge Canal is unlikely to have any significant detrimental effects on the ecology. However, the loss of the reed beds that have developed in the canal should be offset in part through the creation of alternative sites and the use of appropriate design guidelines to allow reeds to remain in as much of the canal, along one side, as possible. There are a number of beneficial aspects that should be included in the restoration of this stretch of the canal, including the use of the water with brine to encourage the preservation and or return of some of the halophytes that occur or occurred along this part of the canal. Particular attention will need to be given to the maintenance or restoration of the ecological interests at the junction with the Severn, as the reed beds at that end of the canal are still well established.

The general aspects which may occur along the canal are as those discussed for the Junction Canal above.

The potential impacts on the ecology of the Salwarpe Valley SWS are not considered to be significant if the above general measures are incorporated.

5.3 **Water Quality**

5.3.1 **Water Quality Analysis**

An assessment of existing water quality and the effects of restoration are addressed in section 3.5.

5.3.2 **Ecological Considerations**

The effects of water quality on the ecological interests of the Canal and the River Salwarpe from the restoration relate primarily to the salinity of the water. There are also the general aspects of water quality related to nutrient accumulation and the lower net flows that can exist in the summer, when traffic is highest.

Many of the plants and animals that exist on these waterways can tolerate the variation in salinity that occurs and will occur as they are presently there and the salinity is from a natural source. The decline of the salinity has conversely led to the decline of botanical interest over the last few years. Therefore there is reason to believe that a return to higher salinities in the canal will encourage the return of at least some of these plants. The main concerns relate to the ability of plants to withstand the higher water potential stress that higher salinity will produce. For most crops and many plants protein and DNA synthesis are inhibited at <-0.5 MPa, and a common wilting point is -1.5 MPa (Long, SP and Mason CF 1983, Saltmarsh Ecology, Blackie) (seawater has a water potential of about -2.0MPa (c 10 bars, 32-38ppt). Therefore there are areas downstream of the brine sources that will have too high a water potential for any plants and only with some dilution will the salt tolerant plants thrive in the absence of competition from freshwater plants that could not tolerate the salinity. For non-halophytes the osmotic effects of salinity from an external concentration of only 0.05 MPA (one-tenth seawater) are serious (Ranwell, DS 1972, Ecology of Salt Marshes and Sand Dunes, Chapman Hall. The effects of this stress are:

- depressed growth
- transpiration depressed
- reduced water availability

Most freshwater plants are very susceptible to increasing salinity and so penetrate only a short way into brackish water. The following species have the following limits:

Hippuris vulgaris	5ppt
Butomus umbellatus	4
Elodea candensis	3
Lenna sp	3
Nuphar Iutea	3
Sagittaria sagittifolia	3

Since April 1st 1992, when the Duty of Care provisions of the Environmental Protection Act 1990 Section 34 took effect, each waste producer has been directly responsible for the safe handling and lawful disposal of controlled wastes. As the producer of the excavated material the Client must therefore comply with this legislation. An assessment of the suitability of material for re-use will be required and the local Waste Regulation Authority should be consulted. Material to be re-used for disposed off site must be transported by registered waste carrier. Whatever the end use of the excavated material, the receiver must also be legally authorised to accept the waste.

The problem of mud on roadways should be negated by the requirement of Duty to Care to ensure that loose material loaded in a vehicle or skip should be covered and by appropriate wheel washing facilities.

5.4.2 Vehicle Access

Access to construction sites will be via existing access along the B4090 Hanbury Road. This may cause some disruption to traffic flows on this carriageway, however, this would not be insurmountable and could be resolved by restraining vehicle movements to certain times of day.

5.4.3 Noise Disturbance

Construction activities will cause some disturbance to nearby properties. This will be experienced most significantly by those properties adjacent to the access tracks, ie Kantara, Littlebrook and Raintree. To ensure that construction noise is kept to a practicable minimum, the contractor will be required to conduct activities in accordance with BS5228: 'Code of Practice on the control of noise on construction and demolition sites'. Section 60 of the Control of Pollution Act 1974, Part III gives local authorities the power to serve notice imposing requirements as to the way in which construction works are to be carried out and can therefore establish and enforce suitable noise limits.

5.5 Contaminated Land

In 1987 a ground contamination survey was undertaken on the site of the old gas works situated in Hampton Road. This area of land is owned by Wychavon District Council and leased by the Canal Trust who now wish to develop the site as a marina. The survey results, albeit limited, indicate that the site is extremely contaminated, with certain contaminants above Interdepartmental Committee on Redevelopment of Contaminated Land (ICRCL 59/83) threshold and action trigger levels. The problem of contamination and the potential for pollution of the Canal was highlighted when old below-ground tar pits were exposed during works by the Canals Trust to construct a slipway into Barge Canal. Pollution of the canal resulted and the Canals Trust, as occupier of the land, was charged for the cost of cleanup.

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Appendix A Study Brief

HEREFORD AND WORCESTER COUNTY COUNCIL

DEPARTMENT OF ENGINEERING AND PLANNING

BRIEF FOR A FEASIBILITY STUDY FOR THE RESTORATION TO CRUISING STANDARDS OF THE DROITWICH CANAL AND THE DROITWICH BARGE CANAL

Introduction

The Hereford and Worcester County Council and the Wychavon District Council support the principle of the re-opening of the Droitwich Canals for through navigation. They will resist and object to any further obstruction, in filling or blocking of the Canals which might prevent their eventual restoration for recreational purposes.

To assist in this aim the Droitwich Barge Canal was in its entirety declared a Conservation Area by Wychavon District Council on 11 September 1979 and the Droitwich Junction Canal was similarly so declared on 16 October 1987.

To assist in the restoration of the Canals the two Councils (the County Council acting as agent) intend to commission a study to ascertain how difficulties for restoration can be overcome, to assess the likely costs and benefits and to consider the environmental implications.

Aims of the Study

The aims of the Study fall into four categories of work:

a) Engineering Considerations.
b) Water Supply Requirements.
c) Cost and Benefit Analysis.
d) Environmental Appraisal.

Scope of the Study

The Study will be principally concerned with the Junction Canal and all aspects of the Study listed above will be completed for this Canal. However in order to assess the full potential of costs and benefits it will be necessary to consider the Barge Canal as this full potential can only be realised if through navigation is established to create the cruising ring.

It is expected that due to the already considerable restoration work which has taken place on the Barge Canal and the lesser problems with ownership and water supply that the proportion of work involved with this Canal will be very substantially less although there does remain the considerable engineering problem of crossing under the A449.

The Department of the Environment has offered to consider funding the Study through Derelict Land Grant but this offer may be restricted to the Junction Canal and it will therefore be necessary for the costs of the Study to be apportioned as far as is reasonably practicable to each Canal.

The Study is intended to be a Feasibility Study and at this stage working drawings, bills of quantities and full design calculations are not expected. The Study will, however research and prepare solutions which will be expressed in terms of outline design with the elements of construction sized and presented on suitably scaled sketched drawings the methods of construction to be expressed in statement and supporting sketch format. Where more than one solution is possible a preferred option should be indicated giving

The River Salwarpe passes under the A449 at Hawford and it may be possible to use the river for navigation from Hawford to the River Severn.

Although the Junction Canal was only constructed in the 19th Century, it is not thought that any original construction drawings remain.

The history of the Canals since 1939 is very well documented and is held by the Droitwich Canals Trust and Wychavon District Council in their file 62. Of particular value will be:

- Wychavon District Council survey dated 1967 showing as constructed levels from the Birmingham Worcester Canal to Hawford and levels on the Salwarpe from Hawford to the Severn together with sketches of structures.

- Wychavon District Council 1:10,000 plan dated 1983 detailing engineering obstacles and financial estimates to overcome each.

- Wychavon District Council preliminary proposals plan dated March 1993 showing entire projected course of Junction Canal, line and levels but not ground levels and Wychavon District Council ownership boundaries.

- Droitwich Canals Trust report by David Hutchings on engineering problems, solutions and costs dating from the early 1980's.

- Wychavon District Council 1:2500 plans showing canals and ownerships over the entire length of both canals.

Requirements

Solutions to any of the obstructions to navigation are to be examined to a level of feasibility stage design and where more than one option is possible for any particular obstruction or section of canal, the alternatives must be set out and discussed and a preferred option recommended.

The estimates of cost must be presented to indicate the total costs in terms of feasibility for each stage or part of the canal defined, thus enabling any restorers to restore lengths of canal in stages. Such stages may not be contiguous.

The total cost is to include allowances for land assembly costs and should assume a reasonable commercial price for any land required on a permanent or temporary basis.

It is not intended that the study will include negotiation with landowners for purchase/wayleave costs but should indicate separately an estimate of likely costs in order that the restorers can take such figures into account in drawing up their programme and budget.

A schedule of land ownership of the affected properties should be included.

The estimate of costs of engineering solutions shall be expressed at full present day contract rates but also where appropriate to itemise alternative costs for items of work which would be undertaken by means of volunteers and/or employment training schemes and/or military trainees.

The estimates of cost shall also include allowances for annual maintenance and where appropriate operating costs of a restored canal.

Recommendations should be made concerning any special operating conditions due to any factors peculiar to the Canals which might call for skills or experience unnecessary on other Canals.

feasibility study.

The Study should compare the water supply availability with the navigation requirements stated in this brief and it should:

a) Highlight any likely shortfall in supply with its projected effect upon navigation.

b) Suggest any other possible sources of supply and/or methods to conserve water.

The Consultants should allow for taking water samples from the Barge Canal for checking by the County Analyst to establish the presence or otherwise of pollution or contamination and for brine.

Liaison with British Waterways and National Rivers Authority must establish the extent of water supply potential, the restrictions and requirements of these bodies.

Cost and Benefit Analysis

Consultees

Hereford and Worcester County Council
Wychavon District Council
Worcester City Council (WCC)
Heart of England Tourist Board (HETB)
British Waterways
Inland Waterways Association (IWA)
Droitwich Town Council (DTC)
Droitwich Tourism Association (DTA)
Hereford and Worcester Training and Enterprise Council (HAWTEC)
West Midland Sports Council (SC)
Parish Councils

Background Information

Wychavon District Council as the planning Authority will give advice as to the status of the land adjoining the Canals in planning terms and thus the potential or otherwise for any Canal related development.

The Droitwich Junction Canal Association is actively seeking to develop the land within the proposed loop of the Junction Canal.

Requirements

The Study will detail the technical requirements and costs for restoration, maintenance and operation of the Canals to cruising waterway standard.

Assess the new local tourist expenditures which would accrue to the region from a commercially orientated exploitation of the restored Canals, consider activities associated directly with the Canals and also the impact of canal restoration upon the level of general tourism in the area.

These additional tourist expenditures are to be used to assess the local regional benefits, in terms of retained "household" income and employment, by the application of established economic multipliers.

Requirements

The Study will investigate the effects upon all relevant environmental aspects of the proposed development corridor and present a suitable statement in accordance with the Department of the Environment's guidelines for the content of environmental statements.

The statement must be suitable for adoption by the local Authorities as their approach to the environmental appraisal procedure when and as the development proceeds.

Conditions of Consultancy

General

The County Council will be responsible for arranging access to land along the Canal corridor as required by the Consultants during the Study period.

Any relevant material held by the County Council, Wychavon District Council and the Droitwich Canals Trust will be issued to the Consultants without charge.

In addition to the material mentioned under Engineering Considerations and Background Information there is considerable other relevant material held by the three organisations mentioned above and the Consultants must satisfy themselves as to the extent and value of this material before tendering by contacting the relevant officer of each viz:

County Council - Richard Graves - 0905-766478
Wychavon District Council - Richard Taylor - 0386-565000
Droitwich Canals Trust - John Burman, Chairman - 021-445-1679

The offer of Consultancy must give details of the names, qualifications and relevant experience of the staff who will actually be working on the Study.

The offer of Consultancy must include details of the previous experience of this type of work with suggested references and the Council reserve the right to contact anybody specified to confirm and investigate the claims of the Consultancy.

The Fee

The fee will allow for the provision of 20 no. bound copies of the report.

The fee will include a provisional sum of £2,000.00 (two thousand pounds) for the cost of any unforseen costs or charges which shall be used in whole or in part or not at all on the written instruction of the County Council.

The fee will be the total fee excluding VAT.

The costs will be broken down to apportion the costs between the Barge Canal and the Junction Canal on each of the four elements:

Engineering Considerations
Water Resources
Cost and Benefit Analysis
Environmental Appraisal

Programme

The Consultants will agree a programme for carrying out the Study with the County Council's Countryside Officer within one week of being appointed.

DROITWICH CANALS FEASIBILITY STUDY
SCHEDULE OF FEATURES
JUNCTION CANAL

Sheet No. 1
Date : 9 March 1994

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Junction	Branch from Worcester & Birmingham Canal at Hanbury Wharf			0
		Canal virtually at grade. Some reed growth in entrance to Junction Canal. Towpath on south side.	WDC	47.32	0-30
	Westfields Bridge	Brick arch carrying single lane access to Westfields Farm from Hanbury Road (Bridleway ROW). The structure is generally in a sound condition. The arch shape is good. The arch barrel has no significant defects although some weathering of the brickwork and mortar joints has occured. Water seepage is occurring through the arch. This should be monitored. Some repointing is required to the spandrel walls. Ivy is growing on the spandrels. This should be removed. Vegetation which is growing along the kerblines should be removed.	Mr Weston "Westfields Farm"		30
	Hanbury Wharf	Mooring for residential boats of north side of canal.	WDC		30-160
		Canal virtually at grade on north side but on south side climbs on embankment downstream to reach 4m high adjacent to Lock No. 1. Side slope approximately 1:1.5 and heavily overgrown - only limited surface instability. However, 15m long section close to lock gates at approximately 1:1 - shallow rotational failure has occured.	WDC	47.32	300-200

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
		South side: Embankment up to 3m high with side slope approximately 1:1.5 to 1:2. Well covered by mature trees but surface relatively soft. North side: Canal retained within 2 to 2.5m high embankment with relatively flat outer slope due to placing of dredgings (?) behind. Inner slope steep (approximately 1:1) and disturbed by several animal burrows, quality of fill looks poor.	WDC	40.81	295-400
	Lock No 3	An inspection was carried out in October 1991. This inspection revealed the lock to be generally in a sound condition. However, a number of major work items were identified, primarily involving brickwork repairs and re-construction. New top and bottom gates are needed.	WDC	40.81 36.95	400
		Canal within cutting not exceeding 1m high. Slope is vertical and sloughing/undermining occuring at water line.	WDC	36.95	400-605
	Field Access	Track to field and shooting lodge for Westfields Farm, over infilled Canal.	WDC		600
	County Council Yard	Several temporary buildings within fenced compound - all now disused. Canal infilled.	HWCC		605-730
	Culvert	Just within Yard. Drains area south of Hanbury Road to the north and Body Brook.	HWCC		730

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
		Canal infilled.	Mr Davey "Kantara"		1310-1375
	Corbett's Bridge	Brick arch carrying single lane access to Impney Farm from Hanbury Road (Bridleway ROW). Bridge now used as car garage for Kantara. To the north is a brick arch culvert on Body Brook. The culvert is approximately 20m long under an embankment which carries a single lane access track to Impney Farm from Hanbury Road. The top of embankment is approximately 5m above the culvert. The culvert is approximately 2m wide. At its upstream end the arch barrel has separated from the spandrel. It is likely therefore that some deformation of the arch barrel has occured. Mature trees are growing on the embankment above the culvert.	Mr Tuthill "Impney Farm"		1375

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Bridge	Access to Playing Field / Rugby Club Single span bridge providing vehicular access to Rugby Club from Hanbury Road. The structure comprises 3 No steel girders with a composite concrete deck slab. The girders are supported on rubber bearings. The structure is supported on concrete abutments. The abutment ballast walls are of brickwork construction. A board type filler forms the movement joint between the deck slab and ballast walls. The parapeters are steel pedestrian handrails. The protective paintwork to the steel girders is in a poor condition. The girders require cleaning and repainting. Water leakage is occuring through the movement joints. The water is running across the bearing shelves and down the face of the abutments. It is recommended that proprietary joints be installed to alleviate this problem.	WDC		1675

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	River Salwarpe	The River Salwarpe has been modified between the Rugby Club Bridge and Chapel Bridge, by the removal of the Town Mill weir and partial straightening of its course. Opposite the original location of the mill weir there is a 30m long section of bank on the north side where erosion on outside of meander has generated slope exceeding 1:1. Gabions have been placed at toe but bank continues to fail behind. Immediately downstream is approximately 15m long section of 2m high brick retaining wall showing evidence of movement. For 50m upstream of Chapel Bridge the south bank is virtually at grade but undermining is occuring. The north bank is approximately 1.5m deep cutting.	South Bank WDC	Vines Park Weir set at 27.45	2020-2080
	Outfall No 22	WDC			
	Outfall No 21	WDC			
	Chapel Bridge	Single span road bridge carrying Bromsgrove Road over River Salwarpe. The deck comprises 18 No rivetted steel girders with a steel soffit plate between girders. The abutments are of brickwork construction. A steel ballustrade forms the bridge parapets.	HWCC (bridge)		2080
	River Salwarpe	River Salwarpe about 1.5m below ambient ground level. Vertical walls/sheeting on south side and cutting on north side.			2080-2150
	Outfall No 20	WDC			

DROITWICH CANALS FEASIBILITY STUDY
SCHEDULE OF FEATURES
BARGE CANAL

Sheet No. 1
Date : 9 March 1994

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Junction	River Salwarpe. NRA Impounding Licence No 18/54/7/199 (Not yet in force)	WDC	Vines Park weir set at 27.45	0
		Canal virtually at grade, general local ground level 28.04 (92.00ft)	WDC		0-40
	Barge Lock		WDC		10
	Bridge	Swing footbridge at Barge Lock. Refurbished February 1994.	WDC		20
		Canal virtually at grade through Vines Park. On south side between outfalls 19 and 18 there is an approximate 50m length with evidence of undercutting at toe on water face.	WDC	27.43	40-150
	Outfall No 23	Hereford & Worcester CC			
	Outfall No 19	Hereford & Worcester CC			
	Outfall No 18 sr Canal?	WDC. Original drain discharged to River Salwarpe. Pipe broken during restoration of canal since just above bed level. Now free discharge to river. ?			
	Cross Way Bridge	Swing footbridge comprising 2 No steel beams supporting a timber plank decking. The handrails are of timber. The bridge has been rebuilt in the recent past, the steel beams replacing the original timber sections. The bridge appears to be in a sound condition.	WDC		150

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Netherwich Pit Marina	Canal widened to form Marina on north side. Bank protected with timber piles and whalings - these show some movement and warping. Footpath collapsing behind in some areas.	WDC	27.43	550
	Hampton Road Wharf	Old Gasworks Site on south side of Canal. Immediately upstream of slipway there is a 10m long section of failed sheet piling.	DCT		600
	Outfall No 13	WDC			
	Netherwich Bridge	Single span concrete arch bridge carrying Kidderminster Road. The road over is single carriageway with footways on each side. The spandrels and parapets are of brickwork construction. In general the condition of the structure appears sound. There is a small area of exposed reinforcement in the arch soffit above the south springing. This should be repaired.	HWCC (bridge)		650
	Outfall No 12	Droitwich Boxing Club			
	Railway Bridge	Bridge carries Droitwich-Birmingham railway line. The structure comprises a corrugated steel armco culvert through the railway embankment. At both ends of the culvert there are concrete wingwalls. The towpath passes through the culvert on the right hand bank. A steel pedestrian handrail is located along the towpath edge. The structure appears to be in a sound condition.	BR (bridge)		720
	Outfall No 11	British Rail			

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Salwarpe Road Bridge	Single span bridge carrying Salwarpe Road. The road over is a single carriageway with footways on each side. There is a wide grassed verge on the western half of the bridge deck. The bridge comprises a concrete slab deck supported on concrete abutments with concrete wingwalls. There is some dampness on the deck soffit, particularly on the western half of the bridge beneath the grass verge. Leakage is also occuring through the movement joints at both abutments. The face of the north abutment, but not the south abutment, has been bitumen painted. However, the paint is showing signs of deterioration. There is evidence of previous surface repairs having been carried out to the deck edge face and to the tops of the wingwalls.	HWCC (bridge)		900
		Between Salwarpe Road Bridge and Original Overflow canal is nominal 1m deep cutting. For 50m downstream of Salwarpe Road Bridge undercutting of tow path occurring. Repairs recently carried out on opposite bank using sheet piling.	WDC	27.43	900-1025
	Outfall No 8	Hereford & Worcester CC			
	Overflow	New concrete side weir with 150mm dia outlet. Said to block frequently and to back up at times of high river level.	WDC		910
	Navigation Meadow	Westacre Playing Field	WDC	27.43	920-1010

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Siding Lane Bridge	Arch bridge carrying a single carriageway road with footways. The arch barrel is of concrete construction. On each side of the bridge stone voussoirs form the outer face of the arch. The spandrels, wingwalls and parapets are brick faced. The towpath passes under the bridge on the north bank only. There is evidence of some surface spalling on the arch soffit. Patch repairs to the soffit have been carried out in the past. Water seepage is occuring between the concrete arch and the outer stone voussoirs. There is evidence of water seepage and leached deposits on the south abutment wall. Horizontal cracks are also visible on the south abutment.	HWCC (bridge)		1895
		South side: Canal in approximately 2m deep cutting at about 1:2 slope, grassed and no signs of major instability. However, within 100m of Valley Way footbridge slopes steeper and with signs of instability. Also housing estate close - see downstream of Valley Way Bridge. North side: Canal virtually at grade.	WDC	27.43	1895-2280
	Outfall No 7	WDC			
	Outfall No 6	Hereford & Worcester CC			
	Outfall No 5	WDC			

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Ombersley Way Bridge	Single span bridge carrying a single carriageway road. The bridge comprises a concrete slab deck supported on concrete abutments with concrete wingwalls. Some leakage is occuring through the deck joints. On the north abutment, which is bitumen painted, a number of vertical cracks are visible. Dampness is present adjacent to some of these cracks. It is therefore likely that water is seeping through from behind the wall.	HWCC (bridge)		2600
		South side: Canal in 3m cutting varying between 1:1 and 1:2 with housing estate beyond. Several mature trees but some indications of surface instability. For section 150m upstream of Roman Way Bridge footpath at top of cutting shows cracks/steps and lamp posts lean from vertical. Also several houses within 2 to 3m of top of cutting. North side: Canal virtually at grade.	WDC	27.43	2600-2930
	Outfall No 3	WDC			
	Outfall No 2	WDC			
	Outfall No 1A	Hereford & Worcester CC			
	Roman Way Bridge	Single span bridge carrying A38 Droitwich Bypass. The structure comprises a deck of precast concrete beams supported on concrete abutments with concrete wingwalls. Considerable dampness was present on the deck soffit. The towpath passes under the bridge on the north bank only.	HWCC (bridge)		2930

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Salwarpe Bridge	Single span brick arch bridge carrying a single lane road. A parking area for visitors to Salwarpe Church is also located on the bridge. The following defects were noted: - extensive weathering of brickwork and mortar joints. - numerous displaced or missing bricks. - water seepage, leached deposits and algal growth on arch soffit. - noticeable bulge in wingwall nearest church. Some bricks displaced. - vegetation growth on wingwalls, including ivy and small plants. Some small trees growing through wingwalls. The following work is recommended: - cleaning and repointing of brickwork. - replace missing and badly weathered bricks. - remove vegetation growth from wingwalls. - investigate bulging of wingwall and repair as necessary.	HWCC (bridge)		3715

DROITWICH CANALS FEASIBILITY STUDY
SCHEDULE OF FEATURES
BARGE CANAL

Sheet No. 13
Date : 9 March 1994

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Hill End Bridge	Swing footbridge presently not operational. The bridge is stored beside the towpath on the north bank. The timber plank decking has been removed but the remainder of the bridge frame appears reasonably sound. The Trust has plans to repair the bridge and relocate it at Lock 3 on the Barge Canal.	WDC		4320
		Chainages 4320 to 3650 on south side virtually at grade but north side on 3 to 5m high embankment generally 1:1.5 to 1:2 but locally up to about 1:1. Surface contains many animal burrows and is soft, occasional small patches of wet ground at toe. Much evidence of soil creep and fence at toe pushed from vertical. Two 50m long sections where evidence of deeper instability present. Chainages 4650 to 4925, 4 to 6m high cutting on south side standing at about 1:1. Some evidence of superficial movement especially where sheep have removed plant cover.	WDC	27.43	4320-5085
	Lock No 1	Ladywood Lock. This lock has been restored and is operational. The Trust has plans for some improvement works which will be carried out by volunteer labour during 1994.	WDC	27.43 25.63	5085
	Ladywood Bridge	Single span bridge carrying single carriageway road with a narrow footways on each side. The structure comprises a concrete slab deck supported on brickwork abutments. The metal parapets require cleaning and repainting. The mass concrete infill which forms the footways requires repair in some places.	HWCC (bridge)		5115
		Canal virtually at grade.	WDC	25.63	5115-5345

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
		Canal virtually at grade.	WDC	19.92	5855-6095
	Lock No 5	Porters Mill Lock. To date no restoration work has been carried out at this lock. The Trust has provisional plans to carry out the work, using contractors, during 1996. Funding will be required for this work. In general the structure of the lock appears sound. The lock walls are overgrown with vegetation which requires clearing. Some repairs to the brickwork will be necessary. New top and bottom gates will be needed. Bottom gates are presently in place but these are badly deteriorated and will have to be replaced. A detailed inspection of the lock would have to be carried out to determine the full extent of the necessary restoration works.	Mr & Mrs Smith (Surround) WDC (Structure and Waterway)	19.92 18.11	6095
	Porters Mill Bridge	Brick arch bridge carrying single lane road. A 17 tonne weight limit is presently imposed on the bridge. Previous repairs have been carried out to the structure. In general, the brickwork and mortar joints are extensively weathered. The south east wingwall has cracked. The top section of this wall has previously been re-built. The south parapet is leaning outwards. The condition of the structure should be monitored and repair works carried out as necessary.	HWCC	18.11	6135
		Canal virtually at grade.	WDC	18.11	6135-6410
	Overflow	To River Salwarpe. Brick structure recently rebuilt.	WDC		6410

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
	Mildenham Bridge	Brick arch bridge carrying single lane road. A 7.5 tonne weight limit is presently imposed on the bridge. Previous repairs have been carried out to the structure. The soffit of the arch has been re-pointed in the recent past. At the north west corner of the bridge the parapet wall has cracked and a number of bricks are displaced. Vegetation is growing over the wingwalls and parapets. Mature trees are growing close to the south east and south west wingwalls. In general the brickwork on the spandrels, wingwalls and parapets is badly weathered and in need of repair. The condition of the structure should be monitored and repair works carried out as necessary.	HWCC (bridge)		7485
		Between Mildenham and Linacre Bridges canal in shallow cutting approximately 1m deep.	WDC	16.15	7485-8910
	Pipeline Crossing Under	Severn Trent Water 2 x 600mm dia DI mains, see drg Acc/no 38			7770
	Overflow	Culvert to ditch and River Salwarpe but original weir structure not found. Thought to have been buried by recent earthworks construction.	WDC		7820
	Linacre Bridge	Brick arch bridge providing agricultural access. Restoration work has been carried out on the bridge in the recent past, including repairs to brickwork and placing new coping stones on the parapets. In general the condition of the structure is sound. The structure's condition should be monitored and maintenance works carried out as necessary.	WDC		8910

Ref No.	Name	Description/Remarks	Landowner	Water Level	Chainage
		Downstream of A449 canal is 6m deep. Cutting on south side adjacent to school, shallow. Cutting only on north side. Cut depth quickly reduces downstream to 1.5 to 2m. Slopes steep at 1:1.5 but heavily overgrown and no major instability. For 100m upstream of Lock No 7 canal on 1 to 1.5m embankment with small trees growing on inner face.	WDC	16.16	9220-9415
	Lock No 7	The lock structure is presently in a poor state. A detailed inspection of the lock should be carried out. It is apparent that the brickwork is in an unsatisfactory condition. The bricks appear reasonably sound, but the mortar joints have weathered and many are open. Mature trees are growing through the walls causing severe displacement of the brickwork and copings in numerous areas. Extensive repairs to the brickwork will be required. It may be necessary to substantially rebuild parts of the walls. New top and bottom gates will be required. At present a bridge crosses the lock. The bridge is approximately 2m wide and of "ad-hoc" construction, comprising steel beams with a timber decking.	WDC	16.16 13.68	9415
		Cutting not exceeding 1.5m depth in good order. Shallow bunding on north-west side - flood prevention? Canal in water.	WDC	13.68	9415-9460

Appendix C Consultees

SCOTT WILSON KIRKPATRICK - DOCUMENT REGISTER
LIST OF ORIGINATORS

PROJECT	DROITWICH CANALS	Page	1
JEN	AKXSB100SB	Date	09/03/94

CODE	NAME & ADDRESS	
A01	HEREFORD & WORCESTER COUNTY HALL SPETCHLEY ROAD WORCESTER WR5 2NP	Tel: 0905 763763 Fax: 0905 766899
B01	WYCHAVON DISTRICT COUNCIL CIVIC CENTRE QUEEN ELIZABETH DRIVE PERSHORE WORCS WR10 1PT	Tel: 0386 565000 Fax: 0386 561092
B02	DROITWICH CANAL TRUST LTD 1 HAMPTON ROAD DROITWICH WORCS WR98PN	Tel: 021 445 1679 Fax:
B03	DROITWICH JUNCTION CANAL C/O RAINTREE HANBURY ROAD DROITWICH WORCS WR9 7DU	Tel: Fax:
B04	BRITISH RAIL	Tel: Fax:

SCOTT WILSON KIRKPATRICK - DOCUMENT REGISTER
LIST OF ORIGINATORS

PROJECT	DROITWICH CANALS	Page	3
JEN	AKXSB100SB	Date	09/03/94

CODE	NAME & ADDRESS	
B10	DEPARTMENT OF TRANSPORT WEST MIDLANDS REGION 5 BROADWAY BROAD STREET BIRMINGHAM B15 1BL	Tel: 021 631 8000/8081 Fax:
B11	DROITWICH HERITAGE & ST RICHARD HOUSE VICTORIA SQUARE DROITWICH SPA WORCS. WR9 8DS	Tel: 0905 774312 Fax:
B12	DROITWICH TOWN COUNCIL TOWN CLERK'S OFFICE ST RICHARD'S HOUSE VICTORIA SQUARE DROITWICH WORCS.WR9 8DS.	Tel: 0905 774258 Fax:
B13	ENGLISH NATURE MASEFIELD HOUSE WELLS ROAD MALVERN WORCS WR14 4PA	Tel: 0684 560616 Fax:
B14	THE FORESTRY AUTHORITY WYE & AVON CONSERVANCY BANK HOUSE BANK STREET COLEFORD GLOS. GL16 8BA	Tel: 0594 810983 Fax: 0594 810628

PROJECT	DROITWICH CANALS	Page	5
JEN	AKXSB100SB	Date	09/03/94

CODE	NAME & ADDRESS	
B20	MIDLANDS ELECTRICITY BLACKPOLE ROAD WORCESTER WR4 9BZ	Tel: 0905 613191 Fax:
B21	NATIONAL RIVERS AUTHORITY UPPER SEVERN AREA OFFICE HAFREN HOUSE WELSHPOOL SHELTON SHREWS.SY3 8BB	Tel: 0743 272828 & 3409 Fax:
B22	NATIONAL RIVERS AUTHORITY FOLEY HOUSE 123 STOURPORT TOAD KIDDERMINSTER DY11 7BW	Tel: 0562 60631 Fax: 0562 745531
B23	ROYAL SOCIETY FOR THE 44 FRIAR STREET DROITWICH SPA WORCESTER WR9 8ED	Tel: 0905 770581 Fax: 0905 771713
B24	SEVERN TRENT WATER LTD. WORCESTER DISTRICT OFFICE BROMWICH ROAD LOWER WICK WORCESTER WR2 4BN	Tel: 0905 748484 Fax:

SCOTT WILSON KIRKPATRICK - DOCUMENT REGISTER
LIST OF ORIGINATORS

PROJECT	DROITWICH CANALS	Page	7
JEN	AKXSB100SB	Date	09/03/94

CODE	NAME & ADDRESS	
C03	SWK STRUCTURES SCOTT HOUSE BASINGSTOKE	Tel: Fax:
C04	SWK GEOTECHNICAL WILSON HOUSE BASILDON	Tel: Fax:
C06	MACKAY CONSULTANTS LTD 1 VIEW PLACE INVERNESS IV2 4SA	Tel: 0463 223200 Fax: 0463 230869
C5A	SWK ENVIRONMENTAL SCOTT HOUSE BASINGSTOKE	Tel: Fax:
C5B	ENGINEERING-SCIENCE VENTURE HOUSE ALLENBY BUSINESS VILLAGE CROFTON ROAD LINCOLN LN3 4NL	Tel: 0522 575857 Fax: 0522 575428

Appendix D British Waterways' report

DROITWICH CANAL BOAT MODEL RUN - YEAR 0 ESTIMATE

Distance	Private	Hire	Total	Factor	Private Mod	Hire Mod	Total Mod
0	890	1503.8	2393.8	1.3	1157	1955	3112
1	890.5	1232.2	2122.7	1.3	1158	1602	2760
2	933.1	1167	2100.1	1.3	1213	1517	2730
3	942.6	1178.6	2121.2	1.3	1225	1532	2758
4	953.3	1199.1	2152.4	1.3	1239	1559	2798
5	965	1199.1	2164.1	1.3	1255	1559	2813
6	977.7	1199.1	2176.9	1.3	1255	1559	2813
7	991.6	1199.1	2190.8	1.3	1271	1559	2830
8	1090.8	1246.4	2337.2	1.3	1418	1620	3038
9	1138.1	1246.4	2384.5	1.3	1480	1620	3100
10	1190.4	1246.4	2436.8	1.3	1548	1620	3168
11	1216.2	1242.3	2458.5	1.3	1581	1615	3196

Key

Private, Hire, Total	give the relative figures produced by the model for each of those categories
Factor	is the multiplication factor used to normalise the model's output. Figures for the Droitwich are derived from existing lock counter data for the Worcester & Birmingham
Private Mod, etc	are the model output figures mutltiplied by the factor

DROITWICH CANAL BOAT MODEL RUN - YEAR 5 ESTIMATE

Distance	Private	Hire	Total	Factor	Private Mod	Hire Mod	Total Mod
0	1439.6	2023.6	3463.2	1.3	1871	2631	4502
1	1453.8	1752	3205.8	1.3	1890	2278	4168
2	1597.1	1686.8	3283.9	1.3	2076	2193	4269
3	1612.8	1698.4	3311.2	1.3	2097	2208	4305
4	1628.1	1718.9	3347.1	1.3	2117	2235	4351
5	1642.8	1718.9	3361.8	1.3	2136	2235	4370
6	1656.6	1718.9	3375.6	1.3	2136	2235	4370
7	1669.5	1718.9	3388.4	1.3	2154	2235	4388
8	1732.4	1766.2	3498.6	1.3	2252	2296	4548
9	1756.4	1766.2	3522.6	1.3	2283	2296	4579
10	1782.2	1766.2	3548.4	1.3	2317	2296	4613
11	1795	1762.1	3557.1	1.3	2334	2291	4624

Key

Private, Hire, Total	give the relative figures produced by the model for each of those categories
Factor	is the multiplication factor used to normalise the model's output. Figures for the Droitwich are derived from existing lock counter data for the Worcester & Birmingham
Private Mod, etc	are the model output figures mutltiplied by the factor

Assumptions

Numbers of boats based on the re-opened stretch are assumed to reach the average for surrounding canals.

THE DROITWICH CANAL

YEAR 0 SCENARIO - Canal is assumed to re-opened to visiting boats only

ESTIMATES OF VISITOR SPENDING IN LOCAL COMMUNITIES (ADJUSTED FOR 1992 PRICES)

PRIVATE BOATS
NOTE: All spend figures adjusted to account for time spent off waterway

Boat Traffic	No.days cruised per yr./boat	30	ex.K&A Boating Survey, 1990	
	Cruises per boat per yr.	18	ex.K&A Boating Survey, 1990	
	No.boat licences issued	0	ex.Licence stats, excl.short-term licences	
	Average craft occupancy	3.5	ex.BW 1983 survey	
	Non-cruising visits	33	ex.K&A Boating Survey, 1990	
	Length non-cruising visits (Days)	0.5	assumed	
	Occupancy non-cruising visits	2	assumed	
Trip Spend	Cruising spend/person/day (Inflationary Factor Added)	£9.88	ex.Hire Boat Survey, 1990 (updated to 1992 prices)	
	Non-cruising spend/person/day	£3.20	ex.K&A Informal Visitor Survey, 1990 (updated to 1992 prices	
Travel	All travel to/from boats assumed by car			
	Travel costs for trips < 20 miles assumed spent locally			
	% Trips , 20 miles	65%	ex K&A Boating Survey, 1990	
	Vehicle cost/mile(full car costs)	£0.32	ex.RAC data, 1990 (updated to 1992 prices)	
	Av.distance travelled(<20 miles)	7.5	ex.K&A Boating Survey, 1990	
Boat Spend	Boat running costs assumed to accrue in local area			
	Capital costs assumed to accrue outside local area			
	Annual boat running costs	£1,662.37	ex.'Waterways World' data updated to 1991 prices (50% mix between narrowboats/grp cruisers assumed)	
Total Spend	Boat movement (adjusted by 0.4)	£0		ERR
	Non-cruising visits	£0		ERR
	Travel	£0		ERR
	Boat running costs	£0		ERR
	TOTAL SPEND(£s)	£0		
	Average spend per boat	ERR		

	TOTAL SPEND(£s)	£104,349	

DAY BOATS

Boat traffic	No. of day boats	0	Ex. Licence Stats
	Average days spent on canal	130	Assumed (5 days per week with 26 week season)
	Average craft occupancy	4.1	Ex Hire Boat Survey, 1990
Canalside spend	Cruising spend/person/day	£3.79	K&A Trip Boat Survey, 1991
	Boat hire cost per day	£40.00	Assumed
Travel	Assumed outside local area		
Total Spend	Boat Movement	£0	
	Boat Hire	£0	

TRIP BOATS

Boat traffic	No. of boats	0	Licence stats & estimate
	Passengers carried per boat	70	Assuming 4 trips per week over 26 weeks with a 75% occupanc
	Avg Occupancy rate	60%	Assumed occupancy rate bnased on K&A data
	Avg No. of trips p.a.	1441	Based on existing timetables
Trip Spend	Av. cost per trip	£2.25	Based on Exisitng timetables
	Av. visitor spend per trip	£3.67	ex.Hire Boat Survey, 1990 updated to 1992 prices
	% visitors for whom boat trip was main purpose of visit	66%	
Travel	10% travel to boats on foot, remainder car/ pub transport		
	Travel costs for trips less than 20 miles assumed spent locally		
	% trips less than 20 miles	75%	
	Vehicle cost/ mile (full car cost)	£0.31	
	Av. dist travelled (20 Miles)	9	
	Av. trippers per car/ bus	4.9	
Total Spend (£'s)	Trip spend (Direct)	£0	
	Trip spend (Indirect)	£0	
	Travel	£0	
	TOTAL SPEND(£s)	£0	

THE DROITWICH CANAL

YEAR 5 SCENARIO - Canal has boats based upon it and is re-opened to visiting boats.

ESTIMATES OF VISITOR SPENDING IN LOCAL COMMUNITIES (ADJUSTED FOR 1992 PRICES)

PRIVATE BOATS
NOTE: All spend figures adjusted to account for time spent off waterway

Boat Traffic	No.days cruised per yr./boat	30	ex.K&A Boating Survey, 1990	
	Cruises per boat per yr.	18	ex.K&A Boating Survey, 1990	
	No.boat licences issued	93	Estimates based on surrounding canals average densities	
	Average craft occupancy	3.5	ex.BW 1983 survey	
	Non-cruising visits	33	ex.K&A Boating Survey, 1990	
	Length non-cruising visits (Days)	0.5	assumed	
	Occupancy non-cruising visits	2	assumed	
Trip Spend	Cruising spend/person/day (Inflationary Factor Added)	£9.88	ex.Hire Boat Survey, 1990 (updated to 1992 prices)	
	Non-cruising spend/person/day	£3.20	ex.K&A Informal Visitor Survey, 1990 (updated to 1992 prices	
Travel	All travel to/from boats assumed by car			
	Travel costs for trips < 20 miles assumed spent locally			
	% Trips , 20 miles	65%	ex K&A Boating Survey, 1990	
	Vehicle cost/mile(full car costs)	£0.32	ex.RAC data, 1990 (updated to 1992 prices)	
	Av.distance travelled(<20 miles)	7.5	ex.K&A Boating Survey, 1990	
Boat Spend	Boat running costs assumed to accrue in local area			
	Capital costs assumed to accrue outside local area			
	Annual boat running costs	£1,662.37	ex.'Waterways World' data updated to 1991 prices (50% mix between narrowboats/grp cruisers assumed)	
Total Spend	Boat movement (adjusted by 0.4)	£34,732		16%
	Non-cruising visits	£19,642		9%
	Travel	£14,783		7%
	Boat running costs	£154,600		69%
	TOTAL SPEND(£s)	£223,757		
	Average spend per boat	£2,406		

	TOTAL SPEND(£s)	£104,349	

DAY BOATS

Boat traffic	No. of day boats	5	Estimate
	Average days spent on canal	130	Assumed (5 days per week with 26 week season)
	Average craft occupancy	4.1	Ex Hire Boat Survey, 1990
Canalside spend	Cruising spend/person/day	£3.79	K&A Trip Boat Survey, 1991
	Boat hire cost per day	£40.00	Assumed
Travel	Assumed outside local area		
Total Spend	Boat Movement	£10,100	
	Boat Hire	£26,000	
	Total Spend	£36,100	

TRIP BOATS

Boat traffic	No. of boats	2	Estimate
	Passengers carried per boat	70	
	Avg Occupancy rate	60%	Assumed occupancy rate based on K&A data
	Avg No. of trips p.a.	1441	Based on existing timetables
Trip Spend	Av. cost per trip	£2.25	Based on Exisitng timetables
	Av. visitor spend per trip	£3.67	ex.Hire Boat Survey, 1990 updated to 1992 prices
	% visitors for whom boat trip was main purpose of visit	66%	Ex K&A Trip Boat Survey 1991
Travel	10% travel to boats on foot, remainder car/ pub transport		
	Travel costs for trips less than 20 miles assumed spent locally		
	% trips less than 20 miles	75%	ex K&A Boating Survey, 1990
	Vehicle cost/ mile (full car cost)	£0.31	ex.RAC data, 1990 (updated to 1992 prices)
	Av. dist travelled (20 Miles)	9	ex.K&A Boating Survey, 1990
	Av. trippers per car/ bus	4.9	ex K&A data
Total Spend (£'s)	Trip spend (Direct)	£272,349	
	Trip spend (Indirect)	£293,193	
	Travel	£51,691	

MIDLANDS REGION					No's of Private Craft							Hire(Total)				
					86/7	87/8	88/9	89/90	90/91	91/92		'87	'88	'89	90	91
MD		2502	140	TRENT & MERSEY Trentham - Burton on Trent	0	0	0	110	283	325		0	0	0	21	47
MD	NO	2540	140	TRENT & MERSEY Burton on Trent - Shardlow	207	218	245	242	250	254		12	12	12	10	10
MD	BI	2600	141	COVENTRY CANAL Huddlesford - Fradley	40	25	27	34	60	72		0	0	0	0	0
MD	NR	2700	145	STAFFS & WORCS CANAL Autherley - Gt Haywood	154	171	199	145	11	3		50	49	47	5	0
MD		2701	140	STAFFS & WORCS CANAL Gailey - Gt Haywood	0	0	0	31	80	80		0	0	0	55	55
MD		2702	145	STAFFS & WORCS CANAL Autherley - Gailey	0	0	0	45	148	153		0	0	1	9	14
MD	NR	2821	145	SHROPSHIRE UNION Audlem - Autherley	285	298	284	286	301	316		50	47	48	49	51
MD	BI	4002	145	STAFFS & WORCS CANAL Stourport - Autherley	281	271	295	322	330	348		29	22	31	30	26
MD	BI	4101	143	NORTH STRATFORD CANAL	117	128	158	181	152	158		18	21	21	21	8
MD	BI	4202	144	WORCS & BIRMINGHAM	326	347	390	396	381	347		103	93	97	103	106
MD	BI	4300	142	STOURBRIDGE CANAL Main Line	3	7	21	18	20	28		0	0	0	0	0
MD	BI	4411	142	B.C.N. Birmingham Level Main Line	49	48	47	47	28	30		23	25	32	36	7
MD	BI	4412	142	B.C.N. Dudley Canal	6	11	11	8	9	11		0	0	0	0	0
MD	BI	4420	142	B.C.N. Wolverhampton Level Main Line	1	2	2	1	1	1		2	3	3	3	4
MD	BI	4500	141/142	BIRM. & FAZELEY Huddlesford - Farmers Br Jct	17	19	25	42	5	12		0	0	0	0	0
MD	BI	4600	141	ASHBY CANAL	100	108	113	120	119	120		6	8	9	9	9
MD	BI	4701	141	COVENTRY CANAL Coventry - Fazeley	156	191	223	234	249	246		59	57	43	43	31
MD		4802	141	OXFORD CANAL (NORTH) Hawkesbury - Br.9	0	0	0	17	64	76		0	0	0	0	0
MD		4920	143	GRAND UNION Napton - Camp Hill	0	0	0	110	314	359		0	0	1	17	29
MD	BI	8001	142	STOURBRIDGE CANAL Branch Line	10	11	11	9	6	4		0	0	0	0	1
MD		8111	142	OOZELL ST LOOP								0	0	0	0	15
MD	BI	8113	142	B.C.N. Birmingham Level Branches	1	0	0	0	0	0		0	0	0	0	0
MD	BI	8114	142	B.C.N. Tame Valley Canal	0	0	0	0	0	0		0	0	0	0	0
MD	BI	8115	142	B.C.N. Wolverhampton Level Old Loop	14	17	17	14	12	17		0	0	0	0	0
MD	BI	8117	142	B.C.N. Titford Canal	1	0	0	0	0	0		0	0	0	0	0
MD	BI	8118	142	B.C.N. Dudley tunnel section	16	25	33	32	38	23		0	0	0	0	0
MD	BI	8119	142	B.C.N. Dudley No 2 Section	27	34	39	46	47	63		3	3	3	4	3
MD	BI	8121	142	B.C.N. Bradley Branch	0	0	0	0	2	2		0	0	0	0	0
MD	BI	8122	142	B.C.N. Wyrley and Essington Canal	52	55	41	41	35	39		0	1	0	1	0
MD	BI	8125	142	B.C.N. Walsall Canal	1	1	0	0	2	1		1	1	0	0	0
MD	BI	8126	142	B.C.N. Rushall and Daw End Canal	32	24	25	33	30	27		0	0	0	0	0
MD		8310	143	GRAND UNION Saltersford Arm	0	0	0	5	12	12		0	0	0	0	0
MD	BI	8701	143	SOUTH STRATFORD	0	0	3	32	26	24		0	0	0	0	13
MD	NR	2500	140	TRENT & MERSEY Preston Brk - Burton on Trent	508	541	596	391	11	2		43	45	44	0	0
MD/S	BI	4910	143	GRAND UNION(Birm) Norton Jct - Salford	440	448	475	327	24	7		46	46	49	0	4
				TOTALS	2844	3000	3280	3319	3050	3160		445	433	441	416	433

DISTANCE AND BOAT NUMBERS

Avon River

Feature	Miles	Furlongs	Km	Private Boats	Hire Boats
Jn Stratford upon Avon	0		0		
S'ford Lk		4	0.8		
Weir Brake Lk		5	1.0		
Luddington Lk	3	2	5.3		
Binton Lk	5	1	8.3		
Welford Lk	6	2	10.1		
Grange Lk	8		13.0		
Barton Lk	8	7	14.4		
Bidford			15	150	
Bidford Lk	9	4	15.4		
Marlcliffe Lk	10	6	17.4		
Harvington LK	13	5	22.1		
Billington Lk	14	2	23.1		
Offenham	16		25.9	150	15
Evesham Lk	18	2	29.6		
abbey Manot House			30	150	
Chadbury Lk	20	1	32.6		
Fladbury Lk	23		37.3		
Wyre Lk	27	1	43.9		
Pershore			45	150	
Pershore LK	28	1	45.6		
Nafford Lk	33	5	54.5		
Eckington Lk	35	1	56.9		
Strensham Lk	38	1	61.8		
Bredon	39	1	63.4	120	15
Tewkesbury			67.2	150	
Avon Lk	42	5	69.1		
Jn with Severn	42	7	69.5		

(Note: boat numbers are estimates provided by the Canal Trust)

Gloucester And Severn

Gloucester Lk	0		0.0	
Gloucester Docks		3	0.6	
Llanthony B		5	1.0	87
Sellars B.			6.6	14
Parkend B.			9	15
Saul Jn	7	6	12.6	90
Framptom moorings			13	29
Sharpness Marina			24	147
Tidal Basin	16	2	26.3	

River Severn

Jn Staffs & Worcs	0		0.0		
Stourport Marina			2.3	54	
Lincomb Lk	9	1	5.8		
Holt Lk	14	5	14.7		
Grinley	17	0	18.5	4	
Hawford Jn Droitwich	17	5	19.6		
Bevere Lk	18	1	20.4		
Diglis Jn Worc & Birm	22	0	26.6	12	
Diglis Lk	22	3	27.2		
Teme Jn	23	1	28.5		
Upton	32	0	42.8	77	18
Tewkesbury Avon Jn	38	0	52.6		
Tewkesbury Lk	38	4	53.4		
Mooring			70	2	
Gloucester Lk Jn G&S	51	0	73.6		

Droitwich Canal

Jn Worcs & Birm	0		0.0
Locks (7)	1		1.6
Droitwich	1	6	2.8
Salwarpe B	3	6	6.1
Ladywood Lks (4)	4	4	7.3
Porters Mill Lk	5		8.1
Mildenham Lk	6		9.7
Hawford Lk (2)	7		11.3
Jn Severn	7	2	11.7

HEREFORD AND WORCESTER COUNTY COUNCIL

DROITWICH CANALS FEASIBILITY STUDY

DRAFT REPORT, MARCH 1994

DRAWINGS

1. Location and Route Plan Key Drawing, 1:25,000
2. Overall Route Plan, 1:10,000
3. Route Plan Sheet 1, 1:2500
4. Route Plan Sheet 2, 1:2500
5. Route Plan Sheet 3, 1:2500
6. Route Plan Sheet 4, 1:2500
7. Route Plan Sheet 5, 1:2500
8. Route Plan Sheet 6, 1:2500
9. Works at Hawford
10. Works at Chapel Bridge to M5
11. Works at M5 to Lock 3
12. Water Resources and Water Quality
13. Special Wildlife Sites
14. Regional Canal Network