



Re-opening the
Lagan Navigation
from Belfast Harbour
to Lough Neagh
Preliminary Design Report

April 2012

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Prepared for:
Lagan Canal Trust

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1 EXECUTIVE SUMMARY

1.1 Introduction

Craigavon Borough Council on behalf of the Lagan Canal Trust commissioned URS in December 2011 to undertake preliminary works to review existing documentation, update drawings, carry out topographical surveys and cost planning to assess the potential of restoring the Lagan Navigation from Belfast Harbour to Lough Neagh.

This report will form part of a larger study which includes:

- A Draft Business Case & Funding Strategy for the Reopening of the Lagan Navigation from Belfast Harbour to Ellis's Gut, Lough Neagh
- A Strategic Environmental Assessment from Belfast Harbour to Ellis's Gut, Lough Neagh

1.2 Works Following Closure

Following closure of the canal in the 1950s there were a number of development works and flood alleviation works carried out at various locations along the length of the navigation. Some of these works would significantly impact on a future re-opening of the navigation. Any reopening plan must address these constraints to achieve solutions which are aesthetically attractive and have low Whole Life Costs.

The development works following closure are:-

- Belfast Harbour to Sprucefield
 - Lagan Weir – The completion of the Lagan Weir in 1994 presents an obstruction to river navigation in Belfast at certain states of the tide.
 - Stranmillis – The construction of access roads and car parking facilities, adjacent to the Boat Club has resulted in the infilling of the original canal cut and Lock No.1. These works together with The Cutter's Wharf restaurant development prevent the canal from being re-opened along its original route.
 - Corbie Wood – The original penweir and side overflow weir across the River Lagan at Corbie Wood have been removed for the purposes of flood alleviation.
 - Shaw's Bridge – The original penweir across the River Lagan has been demolished and a new concrete weir and canoe slalom course constructed. In addition a short section of the original cut between Newforge and Shaw's Bridge has been infilled.
 - Drum Bridge – The original penweir across the River Lagan at Drum Bridge has been removed and a short section of canal under the bridge has been infilled to accommodate a pedestrian footpath.
 - M1 Motorway Bridge – The construction of the M1 motorway bridge across the River Lagan adjacent to Lady Dixon Park has led to the infilling of a section of canal cut and the realignment of the river channel.
 - Bridges – Two existing road bridges at Lambeg and Hilden were reconstructed at grade and now form obstructions to the navigation. There are also several accommodation bridges at various locations with insufficient headroom.
 - Hogg's Weir – The original weir has been lowered and the upstream canal cut has been partially infilled
- Union Locks to Moira

- Union Locks to M1 Road Bridge at Moira - Since abandonment of the waterway major infilling has occurred along this section of canal as a result of the construction of the M1 motorway in the 1960s. Furthermore the aqueduct which crossed the River Lagan at Zion Hill was demolished.
- M1 Road Bridge at Moira to Lady's Bridge, Moira - Approx 2 km of original waterway has been infilled, mainly due to the construction of the motorway. Road improvements schemes have resulted in the removal of the Hertford Bridge and Boyles Bridge. The realignment of the Glenavy Road has resulted in an embankment which effectively blocks the route of the waterway.
- Moira to Lough Neagh
 - This is the best preserved section of the navigation with original road bridges and locks remaining intact. The main issues to be addressed are the loss of the towpath for part of its length, and the provision of an adequate water supply for locks and land ownership

1.3 Stakeholder Consultations

Consultations were held with relevant government and non government organisations. In general, reaction to the idea of reopening the Lagan Navigation was very positive and there are no underlying issues which would prevent the reopening of the Lagan Navigation. The main issues to be addressed are:

- Land ownership
- Impact/control of flooding
- Built Heritage
- Environmental Mitigation

1.4 Current Condition (2012 Survey)

During this current study, URS re-inspected the route of the Lagan Navigation to identify any changes or new developments that have occurred along the route since the previous surveys. This inspection followed the original canal route and any alternative sections which were proposed in former reports.

A photographic record was taken of the condition of the navigation.

Generally the condition of the navigation is unchanged from the previous surveys in 1997 and 2000, but it would appear to be more overgrown particularly at the lock structures with significant bushes and trees growing through the stonework. The following are the main changes from the previous surveys:

- Lock No.3 – The existing Lock Keeper's Cottage and Lock No.3 have recently been restored. In addition a new café and visitor centre has been constructed adjacent to the Lock.
- Shaw's Bridge – A new canoe boat house has been constructed upstream of Shaw's Bridge
- Edenderry – The original mill buildings have been demolished and replaced with a new housing development.
- Lock No.4 – The lock gates which were visible in previous surveys have been removed from the lock and placed in the verge adjacent to the lock.
- Horse Bridge – A new footbridge has been constructed which connects the towpath to Union Locks and Blaris Road.

- Union Locks - A Premier Inn Hotel has been developed adjacent to Union Locks.
- The Former Maze Site – The existing buildings within the Former Maze Site are in the process of being demolished.
- Moira – An agricultural building has been constructed between the existing canal and the proposed new route at the Moira roundabout. Although the location of the building would not require the proposed route to be altered, the access road to the buildings must be accommodated within any reopening proposal.
- Broadwater – The Broadwater has remained relatively unchanged. However a large detached dwelling is currently under development, however this new dwelling does not impact directly on the navigation.
- Lock No.18 – There are a number of new housing developments within the village of Aghalee. Upstream of Lock No.18 a gabion retaining wall associated with a housing development now extends into the Navigation.
- Lock No.19 – The towpath now appears to be under private ownership.
- Lock No.20 – The condition of the lock remains unchanged. However the existing towpath appears to be under private ownership.
- Lock No.21, No.22 and No.23 –These locks were unable to be accessed due to the significant amounts of overgrowth.
- Lock No.26 – There are newly constructed foundations for 2 No. dwellings on the north side of the lock

1.5 Proposed Navigation Route

The original line of the summit level of the still water canal between Union Locks at Sprucefield and Lady's Bridge at Moira was significantly demolished during the construction of the M1 Motorway. The cost of reconstruction of the canal along a completely new line either alongside the M1 or parallel to the river would be prohibitively expensive. The most viable means of re-establishing a through navigation is to upgrade the channel of the River Lagan to a navigable condition, together with accommodation works at existing bridges. However a relatively short section of new canal cut and new locks would have to be constructed between Zion Hill and Lady's Bridge.

A survey of the River Lagan from Sprucefield to Zion Hill was previously carried out to determine the feasibility of utilising the river as part of the restored navigation. Two new weirs would be required to provide an adequate navigation depth. The preferred choice would be for new fixed weirs rather than adjustable weirs to minimise operational and maintenance requirements. The weir dimensions and crest levels should allow discharge of flood waters along the watercourse without surcharge above the levels pertaining to the existing system.

1.6 Navigation Study

As part of the structural and engineering assessment of the Lagan Navigation, navigational standards were examined in respect of such issues as depth and width of channel and locks, lock dimensions and navigation headroom at bridges etc.

This section presents the results of previous river craft surveys and makes recommendations regarding suitable navigation standards for the Lagan Navigation that will be consistent with existing and proposed adjacent waterways.

1.7 Water Management

Water availability along the navigation must be sufficient to provide for predicted traffic requirements by supplying lockages, and for losses due to evaporation, leakage and seepage. The amount of water required to supply lockages is a function of traffic on the navigation. Predictions of boat traffic were based on comparisons with other inland waterways in Ireland. Estimates of evaporation loss were made based on meteorological studies. Losses due to leakage and seepage are often specific to a particular navigation system but estimates were made based on experience from other waterways. Estimated water losses for the Lagan Navigation can be broken down as follows:-

A simplified water resource model was developed to provide estimates of the total water requirement to enable the reopening of the Lagan Navigation.

Shortage of water supply during dry spells was always an issue for the Lagan Navigation. Historically, the water supply to the summit level of the Navigation came from the Broadwater Lake, which was enlarged by the provision of a low dam to increase its capacity.

The reinstatement of the Broadwater would not on its own provide a total solution to the Lagan Navigation water requirement. There will be times during periods of high water usage of locks when the draft available in the summit level may be insufficient for navigation.

It is envisaged therefore that during these dry periods the water supply from the Broadwater could be supplemented by backpumping from Lough Neagh or the River Lagan. The main problem with back pumping is the possible transfer of invasive species e.g. zebra mussels between two water catchment areas.

1.8 Hydraulic Study

After the closure of the Navigation a number of the original penweirs were removed to alleviate flooding. If the Navigation is to be re-opened it would be necessary to reconstruct several of these weirs. New weirs would be constructed at Corbie Wood, Shaw's Bridge, Drum Bridge, Becky Hogg's, Young's Bridge and Down Royal.

URS obtained hydrometric data from Rivers Agency Hydrometric Unit for the River Lagan between Belfast Harbour and Zion Hill. This information was used to determine flood and low flow conditions for the River Lagan and to assess the impacts of the proposed works on flooding and land drainage.

Other than the sites described above, levels on the waterway would be controlled by the existing weir system. It is therefore concluded that whilst on some stretches the low-flow water levels would be slightly raised, for all significant flood flows river levels will be either reduced or remain unchanged.

To enable a detailed design to be prepared for the navigation a hydraulic model of the River Lagan and the Navigation would be required to model the flow characteristics of the navigation and identify areas where the Navigation may impact upon properties. This hydraulic model would be required to provide data necessary for obtaining statutory approvals.

1.9 Description of Works

This section summarises the proposed works to be carried out along the route of the Lagan Navigation. To best detail the works and facilitate phasing of the construction of the navigation has been subdivided into seven specific reaches as follows:

- CH-4500 to CH0000 - Belfast Harbour to Stranmillis (Drawing 1001)
- CH0000 to CH7500 - Stranmillis to Edenderry (Drawings 1002 and 1008)

- CH7500 to CH15100 - Edenderry to Lisburn (Drawings 1003 and 1009)
- CH15100 to CH22650 - Lisburn to Maze (Drawings 1004 and 1010)
- CH22650 to CH29450 - Maze to Zion Hill (Drawings 1005 and 1011)
- CH29450 to CH35350 - Zion Hill to Broadwater (Drawings 1006, 1012 and 1013)
- CH35350 to CH42950 - Broadwater to Ellis's Gut (Drawings 1007 and 1014)

The seven reaches have been determined based on a feasible package of works which would maximise the length of navigable channel for each element of construction works. Each reach is then subdivided to provide a breakdown of the element of work.

1.10 Capital costs

A detailed breakdown of the estimated quantities and capital costs for each section was carried out. The capital costs include

- Capital Construction Costs,
- Environmental Impact Assessment
- Site Investigation
- Land Acquisition and Associated Fees
- Professional Fees including Project Management, Resident Engineering Costs and expenses
- Marketing and Public relations

In addition an optimism bias adjustment factor has been calculated to determine risk components of the project. An optimism bias factor of 30% is recommended.

The Table below shows the estimated total costs for reopening the Navigation from Belfast Harbour to Lough Neagh including the provision of an optimism bias.

Table 1.0 – Summary of Costs

Description	Cost
Capital Costs	£53,962,094
Land Acquisition and Additional Costs	£9,150,000
Sub Total	<u>£63,112,094</u>
Optimism Bias (30%)	<u>£18,933,628</u>
Total	£82,045,722

2 INTRODUCTION

The Lagan Navigation as it stands is a valuable asset of immense cultural and historical significance. It forms an important link within extensive navigation network which was constructed in Ireland in the 18th and 19th centuries. On reaching the 21st century, it is still possible to experience directly the canal era by travelling on many parts of this system.

The most important sections in use today in Ireland are the Shannon and the Erne Navigations, including the connecting link called the Shannon-Erne Waterway. Other navigable sections include the Lower Bann Navigation, the Grand Canal, the Barrow Navigation, and part of the Royal Canal. Many lakes are also navigable, most notably Lough Neagh, Lough Erne, and Lough Derg.

2.1 History

Construction and Use

When coal was discovered in Co Tyrone in the 1690's the idea of creating a navigable link with Belfast became very attractive. The construction of the Newry Canal in the 1730's added a new urgency to the situation if Belfast was to develop as a competing port.

Work commenced on the Lagan Navigation in 1756 under the direction of Thomas Omer. In September 1763 amid scenes of great enthusiasm the first boat made the passage from Belfast to Lisburn. Although work progressed to Sprucefield during the following four years, by 1768 all work had ceased due to lack of funding. Severe winter flooding and shortage of water in summer also caused continual difficulties along the completed section of the waterway.

In 1779 a private company was incorporated in which the Marquis of Donegal held the controlling interest. An English Engineer, Richard Owen was employed to oversee the works and the navigation was carried up through four locks (Union Lock) to a summit level which extended for eleven miles to Aghalee. The canal followed a route to the south of the River Lagan and ultimately crossed the river via an aqueduct near Spencer's Bridge. From the summit the canal dropped down approximately 70ft (21m) over a distance of 3.2miles through the locks, each 70ft x 16ft and in December 1793 the canal was driven through to the Lough Neagh shore at Ellis's Gut.

Frequent delays however on the river navigation were common. Regular flooding on the River Lagan sections caused damage to the banks and silting of the channel bed, and there was a constant shortage of water in the summit level during the summer months.

In 1810 control of the company passed from the Donegal family to a number of Belfast businessmen and merchants. Various plans to separate the navigation from the river were proposed but the provision of a water supply conflicted with the vested interests of the Lagan linen manufacturers and the works were never carried out. However a number of improvements were made which included the building of several sections of towpath, cleaning and deepening of sections of river channel and repairing of locks and weirs. As a result of these works traffic increased, particularly between Belfast and Lisburn.

In 1842 legislation was passed creating a new private Lagan Navigation Company and the steady improvement in trade continued allowing it to compete successfully with both the Ulster Railway network and the new roads of the Lagan Valley.

During the latter part of the nineteenth century the Lagan Navigation flourished. Coal, grain, and general merchandise were transported upstream from Belfast whilst sand, native timber, fire clay goods and bricks were the main downstream cargoes.

The tonnage carried on the Lagan Navigation remained fairly constant at about 160,000 tons at the turn of the century and although this figure was reduced during World War 1 the decade following the War proved to be the last really successful period.

By the mid-1930's competition from road and rail brought a decline in tonnage and revenue. Despite Government subsidies the post-war years saw only a negligible traffic. Eventually as a result of the Inland Navigation Act (NI) in 1954 the Lagan Navigation Co was dissolved and the canal between Union Locks and Lough Neagh was officially abandoned, and its responsibility passed to the Ministry of Commerce. In 1958 the Ministry announced its intention to abandon the remaining sections between Stranmillis and the Union Locks at Sprucefield.

Works Following Closure

Following closure of the canal in the 1950s there were a number of development works and flood alleviation works carried out at various locations along the length of the navigation. These works would significantly impact on a future re-opening of the navigation. Any reopening plan must address these constraints to achieve solutions which are aesthetically attractive and have low Whole Life Costs.

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 - Union Locks to M1 Road Bridge at Moira - Since abandonment of the waterway major infilling has occurred along this section of canal as a result of the construction of the M1 motorway in the 1960s. Also the aqueduct which crossed the River Lagan near Spencer's Bridge was demolished.

- M1 Road Bridge at Moira to Lady's Bridge, Moira - Approx 2 km of original waterway has been infilled, mainly due to the construction of the motorway. Road improvements schemes have resulted in the removal of the Hertford Bridge and Boyles Bridge. The realignment of the Glenavy Road has resulted in an embankment which effectively blocks the route of the waterway.
- Moira to Lough Neagh
 - This is the best preserved section of the navigation with original road bridges and locks remaining intact. The main issues to be addressed are the loss of the towpath for part of its length, the provision of water supply for locks and land ownership

2.2 Origins of Brief

Craigavon Borough Council on behalf of the Lagan Canal Trust commissioned URS in December 2011 to undertake preliminary works to review existing documentation, update drawings, carryout topographical surveys and cost planning to assess the potential of restoring the Lagan Navigation from Belfast Harbour to Lough Neagh.

2.3 Objectives of the Study

This technical report will form part of a larger study which includes:

- Draft Business Case & Funding Strategy for the Reopening of the Lagan Navigation from Belfast Harbour to Ellis's Gut, Lough Neagh
- Strategic Environmental Assessment from Belfast Harbour to Ellis's Gut, Lough Neagh

3 CONSULTATIONS

3.1 Policies and Regulations

The Water Environment (Floods Directive) Regulations (Northern Ireland) 2009

The EU Floods Directive came into force in November 2008. It followed major flooding across Europe in recent years. Member States were required to transpose the requirements of the Directive into UK law by November 2009.

The Directive requires member states to develop and update a series of tools for managing all sources of flood risk, in particular:

- preliminary flood risk assessments (PFRAs);
- flood risk and flood hazard maps;
- flood risk management plans;
- co-ordination of flood risk management at a strategic level;
- improved public participation in flood risk management; and
- co-ordination of flood risk management with the Water Framework Directive.

The Northern Ireland legislation to enable the Directive was introduced in 2009 and is called The Water Environment (Floods Directive) Regulations (Northern Ireland) 2009. The Department of Agriculture and Rural Development (DARD), through the Rivers Agency, is the leading authority in Northern Ireland for the delivery of the Floods Directive. The Floods Directive aims to manage the adverse consequences that flooding has on human health, the environment, cultural heritage and economic activity. The Directive focuses on:

- Prevention: of flood damage by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices.
- Protection: taking measures, both structural and non-structural, to reduce the likelihood and impact of floods.
- Preparedness: informing the public about flood risk and what to do in the event of a flood.

The legislation requires the completion of the preliminary flood risk assessment by December 2011, flood risk and flood hazard maps for significant risk areas by December 2013 and flood risk management plans by 2015.

Planning Policy Statement 15 (PPS 15)

The primary aim of PPS 15 is to prevent future development that may be at risk from flooding or that may increase the risk of flooding elsewhere.

The Rivers Agency advises on the extent of riverine and coastal flood plains in Northern Ireland.

Under PPS15 within flood plains Planning Service will not permit development unless it falls within one of the following exceptions or it is demonstrated that the proposal is of overriding regional importance.

- (a) development of previously developed land which is protected by the appropriate minimum standard of flood defence or where such a defence is under construction or where public funding for planned flood defence works has been committed. This does not include

proposals involving essential civil infrastructure or accommodation / facilities for vulnerable groups;

- (b) the replacement of a building in the countryside where this will not materially increase flood risk;
- (c) development where location within a flood plain is essential for operational reasons for example, navigation and water based recreation uses or transport and utilities infrastructure which has to be there;
- (d) the use of land for sport and outdoor recreation use, amenity open space or for nature conservation purposes where this will not materially increase flood risk;
- (e) the extraction of mineral deposits and the ancillary development necessary to facilitate such extraction where this will not materially increase flood risk; or
- (f) the use of land for seasonal occupation by touring caravans and/or camp sites where this will not materially increase flood risk.

To inform the consideration of proposals that fall within the exceptions specified above, such applications will need to be accompanied by an assessment of the flood risk that may affect the development, or result elsewhere because of it. Where appropriate, this assessment shall include details of measures to mitigate any increase in flood risk.

As part of the precautionary approach to dealing with flood risk, measures such as flood compensation storage works or new hard-engineered flood defences will not be acceptable as justification for development in a flood plain.

Environmental

The EU Sustainable Development Strategy was adopted in 2006. It included an objective on "Halting the loss of biodiversity by 2010 – and beyond". The UK is also a Party to the Convention on Biological Diversity (CBD), a principal objective of which is the conservation of biodiversity. Commitment to the CBD led to the preparation of the 1994 UK Biodiversity Action Plan (UK BAP), the overall goal of which is to conserve and enhance biodiversity within the UK and to contribute to efforts to conserve global biodiversity. The UK BAP identifies our most threatened biodiversity assets and includes action plans for the recovery of priority species and habitats.

The Northern Ireland Biodiversity Strategy was signed off by the Environment Minister in 2002 and provides the foundation and basis for biodiversity conservation in Northern Ireland. Part of the strategy committed Government to recognise biodiversity within its policies and establish suitable delivery mechanisms. The Government have since made a commitment to significantly reduce the loss of biodiversity by 2010 and halt the loss entirely by 2016¹ in line with the aims of other European Countries. A number of species and habitat action plans have been produced outlining biodiversity targets and actions to meet them. In addition, six biodiversity delivery groups have been constituted. The remit of these groups includes the co-ordination of arrangements for monitoring and reporting on habitats in the context of the BAPs, co-ordinating activity on the habitats, identifying and supporting research needs, considering cross-border management issues and providing biodiversity advice to government.

Protection for biodiversity is provided under European Directives, national and local legislation. The primary European legislation is the EC Habitats Directive 92/43/EEC and EC Birds Directive 2009/147/EC. The Water Framework Directive (WFD) 2000/60/EC is also highly relevant in this situation. Other national and local legislation includes the Conservation

¹ Programme for Government 2008-2011. Northern Ireland Executive 2008

(Natural Habitats, etc) Regulations (Northern Ireland) 1995 as amended, the Environment (Northern Ireland) Order 2002 as amended, the Nature Conservation and Amenity Lands (Northern Ireland) Order 1995 as amended and the Wildlife (Northern Ireland) Order 1985 as amended. The legislation outlined above has created a network of statutory designated sites which protect a range of habitats and species.

The newly published Wildlife and Natural Environment Act (Northern Ireland) 2011 has also put a legal duty on Government and Public Bodies, including local councils, to further the conservation of biodiversity when undertaking any of their functions. The Department of Environment must provide guidance containing recommendations, advice and information for the assistance of public bodies in complying with the duty.

Planning Policy Statement 2 Planning and Nature Conservation (under review) contains planning policy for statutory designated sites and Sites of Local Nature Conservation Importance (SLNCIs). It ensures that biodiversity and the natural environment must be fully taken into account when considering any sort of development. In addition a range of other policies and legislation detailed in other sections particularly air and climate, water and land management and landscape directly benefit biodiversity.

The Lagan Navigation passes through four council areas, Belfast, Castlereagh, Lisburn and Craigavon. Belfast and Craigavon both have Local Biodiversity Action Plans (LBAPs). Both highlight the importance of species and habitats that are found along the Lagan Navigation system.

3.2 Stakeholder Consultations

URS has consulted with the following stakeholders as part of the Preliminary Design report. These include:

- Rivers Agency
- Department of Culture, Arts and Leisure (DCAL)
- Roads Service
- Councils
- Agri –Food and BioSciences Institute (AFBI)

Rivers Agency

URS met with Rivers Agency in March 2012. The meeting was to discuss any possible issues in relation to reopening the Lagan Navigation. Rivers Agency highlighted the following:

- Frequent out of bank flooding occurs along the River Lagan with properties affected in Lisburn Area, Maze Area and New Bridge Area.
- Reopening the Lagan Navigation should not increase the risk of flooding to properties and landowners.
- Finish floor level of any buildings i.e. toilet blocks, services building must be a minimum 600mm above the 1 in 100 year flood level.
- The raising of water levels within the navigation may impact upon the drainage of low lying farmland.
- A hydraulic model of the Lagan Navigation would be required to assess the impact of flooding.

Agri –Food and BioSciences Institute (AFBI)

URS met with a Robert Rosell from AFBI in April 2012. The meeting was to discuss the impact of reopening the navigation on fish. The following points were highlighted:

- The fish pass in the new weir at the Civic Centre in Lisburn operates satisfactorily. Fishpasses incorporated within the proposed weirs should follow a similar design.
- Between Stranmillis and Sprucefield there are a number of existing weirs along the reaches of the river which are bypassed by the navigation. These weirs are a legacy of the Lagan Mills but are no longer required for mill race supply. Removal of weirs with associated channel enhancement works could significantly improve the quality of these river reaches and could mitigate against the impact of the proposed new navigation weirs.

Roads Service (TBC)

URS met with a representative from Roads Service in April 2012. The meeting was to discuss any issues in relation to bridge replacement and road alignment. Roads Service highlighted the following:

- The proposed new canal bridges at Moira along the main Trunk Roads must comply with the standard outlined within the Design Manual for Roads and Bridges (DMRB). A departure from this standard will not be acceptable.
- A departure from this standard on lower grade roads may be accepted providing the works can be demonstrated to provide an improvement to the existing status quo.
- Roads Service technical approval would be required for all works to roads and bridges
- A structural assessment of the existing bridges would be required and a structural analysis undertaken to identify the effect on the bridge for a watercraft collision.

4 ENGINEERING ASSESSMENT

The Lagan Navigation passes through a variety of landscapes. These include tidal reach, meadowlands, forest, wooded estate, parkland, farmland and urban areas, each having its distinct topography and ground conditions.

This diversity of landscape was reflected in the engineering solutions and route chosen for the waterway, which in turn presents the opportunity of sub-dividing the navigation into seven sections for descriptive purposes. They are as follows:

- Belfast Harbour to Stranmillis (Drawing 1001)
- Stranmillis to Edenderry (Drawings 1002)
- Edenderry to Lisburn (Drawings 1003)
- Lisburn to Maze (Drawing 1004)
- Maze to Zion Hill (Drawing 1005)
- Zion Hill to Broadwater (Drawing 1006)
- Broadwater to Ellis's Gut (Drawing 1007)

4.1 Surveys

Previous Topographical Survey

The project encompasses the restoration of the Lagan Navigation from Belfast Harbour to Ellis's Gut, Lough Neagh, a total length of approximately 49km. The original navigation comprised approximately 15km of river navigation and 12 km of stillwater canal between Belfast Harbour and Sprucefield. The remaining section between Sprucefield and Lough Neagh comprised 22 km of stillwater canal which incorporated the summit level section between Sprucefield and Aghalee and the feeder reservoir at Broadwater. The entire navigation had 27 locks and 20 road bridges and crossed the River Lagan between Lisburn and Moira by aqueduct. The majority of these original structures still remain today. The lock chambers have suffered from natural deterioration and are largely overgrown by tree and plant growth and partly filled with silt, debris and water.

Since closure of the navigation in the 1950s there have been a number of developments and flood alleviation works which affect the reopening of the navigation. The most significant of these was the demolition of the greater part of the summit level section of canal between Sprucefield and Moira during the construction of the M1 Motorway in the early 1960s.

Previous feasibility studies undertaken have identified a preferred alternative route to the lost section which needs to be confirmed based upon engineering, water management, environmental, archaeological, and cost considerations.

During the previous studies topographical surveys were carried out using traditional surveying methods to relate channel bed levels to ordnance datum Belfast and also to confirm levels of existing lock structures, bridges, towpaths etc. Particular attention was paid to the areas where new works would be required. The existing lock structures were generally part-flooded which prevented a detailed survey of the floor and gate sills.

In addition to the ground surveys along the route of the canal, hydrographic surveys were conducted along the route of the navigation to determine navigational depths. The hydrographic surveys covered the length of the River Lagan from Stranmillis to the M1 Road Bridge at Moira. Hydrographic surveys were also carried out on sections of the stillwater canal.

A topographic survey of open farmland was carried out to determine the optimum route to connect the River Lagan in the vicinity of the M1 Road Bridge to the existing canal at Lady's Bridge, Moira.

Current Topographical Survey

This report is essentially based on the topographical survey information used in the 1997 and 2000 reports. An additional topographical survey was undertaken in February 2012 between the former Maze Site and the River Lagan to determine a suitable route to connect the former Maze site with the Lagan Navigation.

Condition Survey (1997 and 2000 Survey)

The canal channel and all structures were visually assessed in 1997 and a further survey undertaken in 2001 to determine their condition.

Previous studies revealed that the original structures, particularly bridges and locks are generic in construction. The remaining arched bridges along the stillwater sections have been constructed with standard canal sizings for arches, spans, towpaths, etc. Locks too have similar widths, lengths etc.

Channel

The navigation channels were mapped to determine the extent to which the original navigation was still intact. The survey confirmed that the majority of the canal channels between Stranmillis and Sprucefield are intact. Except where levels have been lowered by the removal of weirs, both the river and canal generally contain a reasonable depth of water. There appears to have been little deterioration of the banks by either normal erosion or excavations by anglers, although some outside bends of the river sections have been protected by rock armour or timber piles. The Department of Agriculture and Rural Development – Rivers Agency carries out channel maintenance work on a regular basis.

Between Sprucefield and Lady's Bridge at Moira approximately 12.5km of summit level channel was significantly infilled to accommodate the construction of the M1 Motorway in the early 1960s.

The section of canal channel between Lady's Bridge and Ellis's Gut is the best preserved section of the original navigation between Belfast and Lough Neagh. The main fabric has suffered little during the period of abandonment and is capable of full and speedy restoration.

The channel lies mainly within cutting although there are some limited sections of embankment. Since closure of the navigation the channel has continued to collect local land drainage together with flows from the original canal feeders. The original profile of the canal is heavily silted and overgrown along most of its length.

Water levels along the channel are now controlled by mass concrete infill weirs within the lock structures. This work was carried out following abandonment of the navigation in the 1950s. Existing water levels are generally lower than the original navigation levels with a maximum difference of up to 1 metre.

Locks

There were 27 locks along the Lagan Navigation, 17 rising from Stranmillis to the summit level at Sprucefield and 10 locks between the Broadwater and Ellis's Gut at Lough Neagh. Apart from the staircase locks at Sprucefield (set of 4 locks) all the locks exist as single structures (23 No).

Each lock was mapped and inspected to assess the condition of all visible masonry copings, walls, sills, etc. Where locks are demolished or infilled, levels of sills have been determined from records.

Generally locks between Belfast and Sprucefield measure approximately 18.9m x 4.4m and are constructed in sandstone. Most of these are overgrown by tree and plant growth, and are partly filled with debris, water and concrete infill weirs which were installed after abandonment. Inspections were therefore largely confined to the walls. Normally these are built of soft sandstone which has suffered varying degrees of decay, particularly in the approach walls and along the copings and much patching has taken place. There is little evidence of settlement or serious misalignment. It was not possible to inspect the chamber floors and gate sills. However, as a result of the detailed findings during the lock restoration at Locks nos. 3 and 12 it is highly probable that all the floors are timber-planked and that the sills comprise elm clapping sills spiked to oak main sills. The original gates were of simple timber construction with timber balance beams with single boxed rack and pinion, vertically operating paddle gear, with walkways fixed to the gates. The gates have been removed although there are remains of the lower gates at Lock No.4. The gate hanging was of the simple cup and pintle and horseshoe collar type.

The locks between Broadwater and Lough Neagh were constructed in limestone and sandstone and measure approximately 21.3m x 4.9m. Although partly overgrown the locks generally appear in a reasonably sound structural condition. Concrete infill weirs were installed at the majority of locks following abandonment and as a result inspection was largely confined to the walls. Some patching has taken place but generally there is little evidence of movement and deterioration. It was not possible to inspect the chamber floors and gate sills.

Bridges

Between Belfast and Sprucefield there are 22 road bridges and more than 12 main accommodation footbridges along the length of the navigation. Some of these road and footbridges have been reconstructed or built since the abandonment of the navigation. Table 4.0 below summarises the suitability of these bridges for navigational purposes in terms of providing headroom of 3.5m above normal operating level and 5m width.

Table 4.0 – Navigation Clearance to Road Bridge and Accommodation/Footbridges

Road Bridges	Navigational Clearances
Shaw's Bridge (New)	Satisfactory
Shaw's Bridge (Old)	Satisfactory
Drum Bridge	Satisfactory
M1 Motorway Bridge	Satisfactory
Ballyskeagh Bridge	Satisfactory
Lambeg Bridge	Insufficient headroom
Hilden Bridge	Insufficient headroom and width
Lock 12 Canal Bridge	Satisfactory
Union Bridge	Satisfactory
Moore's Bridge	Satisfactory

Young's Bridge	Insufficient headroom
Maze Bridge	Insufficient headroom and width
The New Bridge	Insufficient headroom and width
Spencer's Bridge	Insufficient headroom and width
Lady's Bridge	Satisfactory
Railway Bridge	Satisfactory
Soldierstown Bridge	Satisfactory
Aghalee Bridge	Satisfactory
Aghagallon Bridge	Satisfactory
Goudy Bridge	Satisfactory
Cranagh Bridge	Satisfactory
Annaghdroghal Bridge	Satisfactory

Accommodation/Footbridges	Navigational Clearances
Corbie Wood (2No)	Insufficient headroom and width
Newforge Bridge	Satisfactory
Gilchrist Bridge	Satisfactory
Chimney Bridge	Satisfactory
McVickers Bridge	Satisfactory
Seymour Hill Footbridge	Satisfactory
Lambeg Footbridge	Satisfactory
Hilden Footbridge (Co Down side)	Satisfactory
Horse Bridge	Satisfactory
Wood Lock Bridge	Satisfactory

Weirs

The original navigation levels were controlled by a series of weirs, 7 of which were adjustable timber penweirs and the remainder fixed masonry weirs. All the former penweirs which provided a head of water for both navigation and mill use have been removed. Four of these original structures were replaced with controllable steel penweirs whilst the original timber penweir at Shaw's Bridge has been replaced by a broad-crested concrete weir. Both the steel penweir and the fixed masonry weir at Lisburn have been replaced with a new crescent shaped stepped concrete weir. Where weirs have been removed and not replaced i.e. at Corbie Wood and Drum Bridge, upstream water levels are now lower.

Aqueducts

The original navigation crossed the Lagan in an aqueduct at the location of the existing motorway bridge at Zion Hill approximately 1 km upstream of Spencer's Bridge. The aqueduct was demolished during the construction of the M1 Motorway and no trace of it is visible today.

Dry Dock

In 1837 a dry dock was built in the canal basin just downstream of Union Bridge at Lisburn. The dry dock is no longer visible as it was infilled when Queen's Road was built. However it is understood that the structure of the dry dock is buried under the verge area of the road.

Current Condition (2012 Survey)

During this current study, URS re-inspected the route of the Lagan Navigation to identify any changes or new developments that have occurred along the route since the previous surveys. This inspection followed the original canal route and any alternative sections.

The inspection took the form of a walk-through along the less accessible stretches of the canal and visual assessment from road verges and bridges where the canal is adjacent to the road.

A photographic record was taken of the condition of the canal.

Generally the condition of the navigation is unchanged from the previous surveys in 1997 and 2000, but it would appear to be more overgrown particularly at the lock structures with significant bushes and trees growing through the stonework. The following are the main changes from the previous surveys:

- Lock No.3 – The existing Lock Keeper's Cottage and Lock No.3 have recently been restored. In addition a new café and visitor centre has been constructed adjacent to the Lock.
- Shaw's Bridge – New canoe boat house has been constructed upstream of Shaw's Bridge
- Edenderry – The original mill buildings have been demolished and replaced with a new housing development.
- Lock No.4 – The existing gates which were visible in previous surveys have been removed from the Lock and placed in the verge adjacent to the lock.
- Horse Bridge – A new footbridge has been constructed. The footbridge connects the towpath to Blaris Road.
- Union Locks - The Premier Inn Hotel has been developed adjacent to Union Locks.
- The Former Maze Site – The existing buildings within the Former Maze Site are in the process of being demolished.
- Moira – An agricultural building has been constructed between the existing canal and the proposed new route at the Moira roundabout. Although the location of the building would not require the proposed route to be altered the access road to the buildings must be accommodated within any reopening proposal.
- Broadwater – The Broadwater has remained relatively unchanged. However a large detached dwelling is currently under development. This new dwelling does not impact directly on the navigation.
- Lock No.18 – There are a number of new housing developments within the village of Aghalee. Upstream of Lock No.18 a gabion retaining wall associated with a housing development now extends into the Navigation.

- Lock No.19 – Tow path appears to be under private ownership.
- Lock No.20 – The condition of the lock remains unchanged. However the existing towpath appears to be under private ownership.
- Lock No.21, No.22 and No.23 –These locks were unable to be accessed due to the significant amount of vegetation.
- Lock No.26 – Newly constructed foundations for 2 No. dwellings on the north side of the lock

Photographic Record

The brief required that the canal, significant features and all problem areas be photographed. This was carried out where access and visibility permitted, and the photographic record is to be found in supporting Photographic Survey Condition Reports Part 1 and Part 2 in Appendix D.

4.2 Geology

Solid Geology

For much of its route the Lagan Navigation between Belfast and Moira the Lagan Navigation is underlain by rocks of the Mercia Mudstone and Sherwood Sandstone Groups, both of Triassic Age. Rocks from both groups are generally friable and porous. West of Moira faulted outcrops of the Ulster White Limestone form the boundary between the Mercia Mudstones and more extensive areas of the Tertiary Lower Basalt formations, comprising fine grained igneous rocks.

Drift Geology

The route of the Lagan Navigation closely follows the valley of the River Lagan. The drift geology of the river valley from Belfast to Flatfield to the east of Moira comprises mainly river alluvium extending either side of the river, flanked by glacial sands and gravels. From Flatfield west onwards to Lough Neagh the overburden is predominantly glacial boulder clay, though peat may be encountered in close proximity to the shoreline.

4.3 Navigation Study

Introduction

As part of the structural and engineering assessment of the Lagan Navigation, navigational standards were examined in respect of such issues as depth and width of channel and locks, lock dimensions and navigation headroom at bridges etc.

A 1997 survey of river craft was undertaken to facilitate the development of suitable navigational standards. This survey complements the data gathered for a similar survey which was carried out in 1989 as part of the Shannon-Erne Waterway Project.

This section presents the results of the survey and makes recommendations regarding suitable navigation standards for the Lagan Navigation that will be consistent with proposed adjacent waterways.

Survey

The Lagan Navigation, if reopened along its full extent, will enter Lough Neagh at Ellis's Gut north of Lurgan. The long term aspiration of DCAL and Waterways Ireland is to connect Belfast via Lough Neagh and a reopened Ulster Canal to the Erne-Shannon system and serve the existing cruiser type market. The craft types in use on the Erne Shannon System are likely to be representative of the craft which would use the Lagan Navigation.

The independent hire cruiser companies on Lough Erne are represented on a voluntary basis in the Erne Charter Boat Association.

In the Republic of Ireland the Inland Waterways Association of Ireland is the representative body for private boat owners and the Irish Boat Rental Association represents many of the independent rental companies.

In a previous study in 1997 to ascertain the type of craft which would be likely to use a reopened Lagan Navigation a questionnaire was prepared and sent out with an explanatory cover letter to the organisations listed below. The questionnaire requested details of craft length, beam, draught, height above water level and superstructure width. The associations consulted were:

- Inland Waterways Association of Ireland
- Irish Boat Rental Association
- Erne Charter Boat Association

The results of the survey covered more than 1,000 craft which represented approximately 25% of the overall fleet on the Shannon and Erne Systems.

Analysis of Survey Results

The overall findings of the combined 1989/92 and 1997 surveys are summarised as follows:

- Height
 - 90% of boats have a height above water level less than 3.5m.
- Draft
 - 90% of boats require drafts of 1.2m or less. In general river cruisers produce a squat of 0.15m at 4-5 knots.
- Beam
 - Approximately 90% of the boats have beam dimensions less than 3.8m.
- Length
 - Approximately 90% of the vessels surveyed were less than 12m in length.

Navigational Standards

The recommended standard for the Lagan Navigation which takes these survey results into account is similar to that adopted on the Shannon-Erne Waterway and for the future Ulster Canal restoration. The standards have been selected to allow users of the Lagan Navigation the flexibility to use the adjacent waterways viz. Bann Navigation, and ultimately the Ulster Canal and the Erne-Shannon system.

It is proposed to provide a minimum water depth of 1.55m in the canal which allows a depth of 0.35m for squat, deposit of sediment and weed growth. A beam width of 3.5m has been adopted as representing the majority of boats. Based on this figure and allowing for manoeuvring clearances between boats it is recommended that the canal be designed, where possible, with an 8m base width and a 13m surface water width.

It is recommended that all bridges should provide for a minimum navigation clearance of 3.5m over a 3m width.

The proposed size of any new lock chamber is not less than 20m long by 5m wide.

It is envisaged that the waterway will be re-opened solely as a recreational facility and therefore navigational requirements for heavy commercial craft have not been considered.

Proposed Navigation Route

The original line of the summit level of the still water canal between Union Locks at Sprucefield and Lady's Bridge at Moira was significantly overlain by the M1 Motorway. The cost of reconstruction of the canal along a completely new line would be extremely expensive and prohibitive. The most viable means of re-establishing a through navigation is to upgrade the channel of the River Lagan to a navigable condition, together with accommodation works at existing bridges. A relatively short section of new canal cut would however have to be constructed between Zion Hill and Lady's Bridge.

A survey of the River Lagan from Sprucefield to Zion Hill was previously carried out to determine the feasibility of utilising the river as part of the restored navigation. Two new weirs would be required to provide adequate navigation depth. The preferred choice would be for fixed weirs rather than adjustable weirs to minimise operational and maintenance requirements. The weir dimensions and crest levels should if possible be designed to allow discharge of flood waters along the watercourse without surcharge above the levels pertaining to the existing system.

4.4 Water Management

4.4.1 Hydrological Study

Catchment

The navigation lies within the catchment area of the River Lagan. The total catchment area upstream of the gauging station at Newforge just downstream of Shaw's Bridge comprises approximately 490km² and extends to Slieve Croob at an elevation of 532m.O.D.Belfast. The lower valley consists mainly of medium quality agricultural land and parkland together with the urban developments of south Belfast, Lisburn and Hillsborough. The upper reaches consist mainly of medium to poor quality farmland and moorland but also include the towns of Dromore and Dromara.

Flow Records

The Hydrometric Unit had previously provided flow duration curves for two River Lagan gauging stations located at Newforge and Drumiller. Daily flow records were also available for Newforge. This information was used to assess the potential of using the river for navigation and in particular to consider the extent and frequency of the two main problems which at times restricted the use of the original navigation i.e. flooding and low flows.

It is considered that for safe boating conditions the average velocity of flow in the river should not exceed 1m/s. This corresponds to a maximum operational flow of approximately 25m³/s at Newforge and corresponding flows of 16m³/s and 12m³/s at Becky Hogg's Weir, Lisburn and Moore's Bridge, Lisburn respectively. The hydrometric records for Newforge show that this flow is exceeded on average approximately 25 days per year but mainly during the winter months when navigation for recreational purposes would normally be at its lowest usage level.

4.4.2 Water Supply and Demands

Navigation Demands

An accurate estimate of the potential water demand of the canal is needed to enable quantification of the necessary supplies.

In addition to meeting predicted traffic requirements by supplying lockages, water availability along the canal must be sufficient to provide for losses due to evaporation, leakage and seepage. The amount of water required to supply lockages would be a function of traffic on the navigation. Predictions of boat traffic are based on comparisons with other inland waterways in Ireland. Good estimates of evaporation loss can be made based on meteorological studies. Losses due to leakage and seepage are often specific to a particular navigation system. Seepage is the continuous loss through the pervious bed and banks, reduction of which can only be brought about by lining the canal with impervious material.

Estimated water losses for the Lagan Navigation can be broken down as follows:-

Lockage

Passage of a boat up or down through a lock chamber requires a specified volume of water which is determined by the lock dimensions. The original lock size on the Lagan Navigation was generally 18.9m x 4.4m or 21.3m x 4.9m and lockage throughput volumes range between 200m³ and 300m³, depending on the rise in level at the lock. The proposed lock size is approximately 20.0m x 5.0 and lockage throughput volumes would therefore be similar

As a boat moves up or down through the canal system the largest lock through which it passes defines the lockage requirement during that trip.

Evaporation

Losses from a water surface due to evaporation can be estimated with reasonable accuracy. While the rate would obviously vary with meteorological conditions the yearly loss would be of the order of 500mm. During summer months the evaporation rate would on average be between 2 and 2.5mm/day with peak daily values possibly of the order of 4mm/day. Evaporation is not regarded as a problem for the sections of canal cut below Moira due to the continual 'topping up' effect of the river.

Between Moira and Lough Neagh it is estimated that approximately 600m³/day would be required during the summer months to counteract the evaporation loss.

Leakage

Leakage represents localised losses of water which can be repaired. These include losses due to minor bank failures, losses through lock gates and losses due to vandalism. The provision of watertight locks and regular supervision of the canal system can help keep this figure low. Experience on other navigation systems has shown that significant losses occur due to tampering with lock gates, particularly along urbanised stretches of the system.

There is no recommended figure for losses due to leakage. It is likely that losses would vary substantially during the year. It is assumed, however, that losses due to leakage would be related to the level of traffic using the system. For the purposes of this assessment an allowance for leakage equivalent to between 30% and 50% of lockage volume is assumed.

Seepage

Seepage is the loss through the beds and banks of the canal due to the pervious nature of the material. It is difficult to compare seepage losses between different systems as seepage rates would be specific to a particular navigation and indeed to particular stretches. The loss due to seepage would be greater along embanked reaches. Studies of losses due to seepage on British canals indicate that this can be as high as 20mm per day. This would represent a loss of approximately 6,000 m³/day on the still-water sections of the Lagan Navigation.

The length of the canal sections represent less than 50% of the navigation and as very little of the channel is formed by embankments, seepage should not be significant. However, without the undertaking of water loss tests it is not possible to quantify this leakage. Therefore, for the purposes of this study an allowance for seepage of 10mm per day along the canal length is taken as a conservative estimate equivalent to a loss of 3000 m³/day.

The undertaking of water loss tests would be required to provide a more accurate estimate of losses due to seepage. This would require sections of canal to be stanked off and water drop tests carried out to provide an accurate estimate of losses due to seepage.

Water Resource Model

A simplified water resource model was developed to provide estimates of the total water requirement to enable the reopening of the Lagan Navigation. For the purposes of this water resource model the Navigation was divided into four reaches which are briefly described below.

Belfast Harbour to Stranmillis

This section is approximately approx 4.5 km long and is entirely within the tidal river section of the Lagan. Water supply is therefore not an issue.

Stranmillis Lock 1 to Sprucefield

This reach, which is approximately 17.4 km long, includes 12 locks. Traffic along this reach would be travelling from Belfast Lough towards Sprucefield and vice versa. The significant number of locks along the reach would influence the traffic volumes likely to operate between Lock 1 and Lock 12. An allowance for 10 lockages per day is considered sufficient.

The estimate of the peak demand for this section is 4200 m³/day. The source of supply for this section is the River Lagan and water supply is not considered to be an issue.

Sprucefield to Zion Hill

This section is approximately 12.0 km long and, apart from two proposed new locks and associated navigation cuts, it is essentially river navigation. Traffic along this reach would be travelling from Sprucefield towards Moira and vice versa. An allowance for 10 lockages per day is considered sufficient.

Estimates of the peak demand for this section is 4200 m³/day.

Zion Hill to Ellis's Gut

This section is approximately 13.5 km and includes the summit reach from Zion Hill to Ellis's Gut. The main Navigation supply is the Broadwater at Soldierstown. The Broadwater has a catchment of approx. 8.4km² and a lake surface area of 18 hectares. The yield of the Broadwater has been assessed as approx 2400 m³/day notwithstanding this, pumping from the River Lagan and/or Lough Neagh would be a possible additional source of supply to Broadwater. An allowance of 10 lockages in both directions has been made.

Estimates of the peak demand for this section is 6000 m³/day.

The principal usage of the Lagan Navigation would occur in the months of July and August as on other waterways. The total boating season is assumed to extend from April to October with a typical monthly usage profile as given in Table 4.1 below.

Table 4.1 – Typical Navigation Usage

Month	Percentage of Annual Traffic
March / April	5%
May / June	20%
July / August	65%
September / October	10%

Assumed Traffic Profile on Lagan Navigation

The July/August period would clearly be the period of maximum demand. In addition to peak traffic, losses due to leakage are likely to be at their highest. The peak loss due to evaporation would be during the months May to August. Losses due to seepage are assumed to be constant throughout the season.

Estimated Total Water Demand – Lagan Navigation

The total navigation demand is less than the sum of the four sections as lockages through one section would supply the next. Also as flows in each Navigation section between Belfast Harbour and Zion Hill discharge back into the river there is no flow reduction in the river navigation sections. The maximum abstraction from the river is 4200m³/day. The navigation section between Zion Hill and Lough Neagh has an estimated peak demand of 6000m³/day. These figures are summarised on Table 4.2 below.

Table 4.2 – The Estimated Peak Demand

Total Water Demand (m ³ / day)			
Belfast Harbour to Stranmillis	Stranmillis Lock 1 to Sprucefield	Sprucefield to Zion Hill	Zion Hill to Ellis's Gut
0	4200	4200	6000

Broadwater

Shortage of water supply during dry spells was always an issue for the Lagan Navigation. Historically, the water supply to the summit level of the Navigation came from Broadwater, which was enlarged by the provision of a low dam to increase its capacity.

The reinstatement of the Broadwater would not on its own provide a total solution to the Lagan Navigation water requirement. There will be times during periods of high water usage of locks when the draft available in the summit level may be insufficient for navigation.

Pumping

Pumping from a reliable source and backpumping at locks is the solution often used nowadays to meet navigation demands during critical periods. For example on the Shannon-Erne Waterway two pumps, both of 80l/s capacity, were installed at each lock on the still water section.

Pumping had previously been used on the Lagan Navigation. In the 1880s a small pump was installed at Ellis's Gut to raise water from Lough Neagh into the reach above Lock 27. An American-made Worthington pump at Lock 26 then conveyed the water along the towpath in cast-iron pipes to the summit level. Pumping began in 1885 and continued during the summer months over the next 30 years.

It is envisaged that during dry periods the water supply from the Broadwater could be supplemented by backpumping from Lough Neagh or the River Lagan. Pumping from Lough Neagh would ensure that sufficient supply would always be available. Pumping capacity of 200l/s should also be installed at each of the locks on the east side to enable the summit level to be supplied. The main problem with back pumping is the possible transfer of invasive species e.g. zebra mussels between two water catchment areas.

4.4.3 *Hydraulic Study*

After the closure of the Navigation a number of the original penweirs were removed to alleviate flooding. If the Navigation is to be re-opened it would be necessary to reconstruct several of these weirs. The effects of these works on flooding and land drainage are discussed hereunder.

Corbie Wood Weir

The existing water level between Lock No.2 and Lock No.3 is presently controlled by the penweir at Stranmillis, at a minimum level of approximately 2.0m.O.D.Belfast. On this stretch, the works necessary for re-opening include the construction of a new river weir at Corbie Wood at a level of 2.8m.O.D. Belfast. This weir would control water levels up to Newforge and would affect the Newforge Gauging Station maintained by the Hydrometric Unit.

Shaw's Bridge Weir

The proposals at Shaw's Bridge include for the demolition of the existing weir, which has a crest level of 5.3m.O.D.Belfast, and for its replacement a short distance downstream by a weir with a crest level of 5.5m.O.D.Belfast. This level increase of 0.2m will effectively restore the original navigation depth of 1.5m upstream to Edenderry. An additional side overflow weir is also proposed. Although the normal upstream water level will be increased there will be no increase in the backwater levels with 1-in-1 year flows or higher because of the increased combined lengths of the 2 new weirs and the corresponding reduction in discharge head.

Drum Bridge Weir

As at Corbie Wood the original penweir upstream of Drum Bridge was removed after abandonment. The water level between Lock No.6 and the Motorway Bridge is now controlled by a concrete weir located downstream of Drum Bridge at a crest level of 9.0m.O.D.Belfast.

In order to increase the navigational depth between Lock No.6 and the proposed Lock No.7 it is recommended that a new crescent shaped weir be constructed at Drum Bridge at a crest level of 10.0m.O.D.Belfast. As at Shaw's Bridge the longer weir would result in lower discharge heads for 1-in-1 year flows and higher, and therefore the flood levels for higher return levels would be reduced.

Upstream of Drum Bridge the adjoining fields are lower than the level of the flood banks and towpath. We understand however that the existing land drainage system discharges to a point downstream of the proposed weir and would therefore be unaffected by the works.

Becky Hogg's Weir

The proposals at Becky Hogg's Weir include for the demolition of the existing weir which has a crest level of 26.4m.O.D.Belfast and for its replacement with a new longer weir with a crest level of approximately 26.8m.O.D.Belfast. A previous study has shown that water levels for the 1 in 1 year flood and greater would decrease thereby reducing the risk of flooding.

River Lagan between Sprucefield and M1 Road Bridge at Moira

URS requested hydrometric data from Rivers Agency Hydrometric Unit for the River Lagan between Belfast Harbour and Zion Hill. Rivers Agency provided the mean daily flows for the following gauging stations along the River Lagan:

Table 4.3 – Gauging Stations

Station Name	Station No.	Period of Records
Feney	205209	1994 to 2010
Newforge	205004	1977 to 2010

This information was used to determine flood and low flow conditions for the River Lagan and determine average periods per year where the Navigation could be closed.

Previous studies used the information for a Drumillar Gauging Station upstream of Dromore. However the records from Feney Gauging Station would be more effective as they provide historical records for the River Lagan close to Zion Hill.

Flooding

From historical records and observations made by our survey team it is clear that the River Lagan downstream of the M1 Road Bridge at Zion Hill is susceptible to flooding on a regular basis particularly during the winter months. This section of the river is essentially a floodplain with low velocities and it is not unusual for the flood levels to remain high for three or four days.

Because of low channel gradient, the river velocities are reduced and the high water level which results in bank overtopping and reduced headroom at bridges then becomes the operational restriction. The gauging station information showed that the maximum operational flow of 25m³/s at Newforge is equivalent to a flow of 8m³/s at Feney upstream of Zion Hill. The flow duration curves for Feney would suggest that a flow of 8m³/s would be exceeded on average about 7% of the time i.e. about twenty five days per year. Again most of these high flows would occur during the winter months when the navigation would be closed.

Low Flow Conditions

During the summer months low flows are a greater concern than flooding. The flow records show flows less than 0.25m³/s at Newforge are not uncommon during dry summers.

We have estimated that proposed fish passes at weirs and 10 lock workings per day would require operational flows of 0.2 m³/s and 0.05m³/s respectively. Based on the flow duration curves we estimate that a low flow of 1 m³/s at Newforge equates approximately to a flow of a 0.3 m³/s at the Maze Bridge. It is therefore possible that during prolonged periods of drought, flows less than the normally desirable operational requirements could occur resulting in a reduction in fish pass flow. This should not present a problem since fish movement will not be an issue during low flows in any case.

4.4.4 *Summary*

Other than the sites described above, levels on the waterway would be controlled by the existing weir system. It is therefore concluded that whilst on some stretches the low-flow water levels would be slightly raised, for all significant flood flows the river levels would be either reduced or remain unchanged.

The existing navigation connects into Lough Neagh at Lock 27 at Ellis's Gut. The water level on the downstream side of Lock 27 is determined by the Lough Neagh control levels which are generally maintained between 12.45m O.D.Belfast and 12.60m O.D.Belfast. However in rare drought and flood events, Lough Neagh levels have been as low as 12.2m O.D.Belfast and as high as 13.25m O.D.Belfast respectively.

As part of the detailed design of the Navigation a hydraulic model of the River Lagan and the Navigation would be required to model the effects of the Navigation and identify areas where the Navigation could impact upon properties. The hydraulic model would be required prior to obtaining any necessary statutory approvals for the Navigation. We understand that Rivers Agency are developing a model for the Lagan and it is possible that this could be used to determine the impact of a reopened navigation on the river flows.

4.5 **Lock Operating Systems**

An assessment of the lock operating requirements of the Lagan Navigation has been undertaken. The assessment examines the traditional swing beam method and a fully automatic lock operating system incorporating navigation management features to meet the requirements of the Lagan Navigation.

Traditional Swing Beam Method

The normal arrangement on canals and rivers is a pair of mitre gates at both ends of the lock, those at the head being much shorter than those at the tail and closing against a wooden, stone or concrete cill.

Originally all gates were operated manually, a factor that played a part in determining the depth of the lock. Gates are fitted with long projecting balance beams whose length provides adequate leverage for the gates to be operated by a man walking backwards against the beam. A curved path following the travelling course of the beam and set at intervals with brick or stone projections gives a grip for the feet and prevents this part of the lockside becoming a muddy and slippery hazard. In order to close an open gate an iron or steel handhold is frequently attached to the end of the beam.

The traditional gates are mostly built from wood. Oak greenheart or ekki are the usual woods used, but nowadays steel/timber composite gates are becoming more common. The advantages of composite gates in a non-automated lock are:-

- Long life expectancy.
- Box section creates buoyancy chambers making the gate lighter in the water, and easier for the user to open and close.
- No leaks through planking i.e. no timber shrinkage or swelling.
- Not affected by marine borers.
- Can be easily repaired if damaged.

Fully Automatic Lock Operating System

Based on an assessment of current technologies, an outline fully automatic lock operating system was prepared for the Lagan Navigation. A summary of the system is presented below:

The components of the fully automatic lock system are as follows:

- Lock Automation System
- The system requires that each boat user be provided with a proximity card for operation of locks.
- Proximity card readers located upstream and downstream on each lock serve to enable the lock automation system, while simultaneously determining the boat direction i.e. going upstream or downstream. These card readers could typically be embedded in solid canal-side features resembling mooring posts which would be vandal-proof and not be visually intrusive. Manual push buttons are not required with the exception of an emergency stop button, as this is imperative to satisfy the relevant EU safety directives.
- In the unlikely event of failure of the lock card reader, a message terminal located internally in the control panels can operate the lock gates and sluice gates.
- All cards have a unique identification number, which can be used to track the progress of a boat through the navigation and to view the number of boats travelling in the navigation and their interlock location.

Electro Hydraulic system

This is an outline of the hydraulic system for each navigation lock of which there are understood to be 26 locks. It is assumed that all the locks will be fairly standard with no special requirements (e.g. reverse flows).

The hydraulic system for each lock consists of 8 cylinders, one power unit, 4 valve manifold assemblies, and associated pipe work and sensors.

4.6 River Enhancement Works

Between Stranmillis and Sprucefield there are a number of existing weirs along reaches of the river which are bypassed by the navigation. These weirs are a legacy of the industrial era but are no longer required due to closure of the mills. The weirs are located at Edenderry, New Grove, Seymour Hill, Lambeg, and Hilden

Large weirs on a river normally create long, deep, impounded sections which are unproductive for both invertebrates and fish. Removal of weirs together with associated channel enhancement works can result in restoration of the natural free-flowing channel with a renewed level of productivity. A good example of this is River Boyne where 11 weirs were removed over a 32km reach between Trim and Navan. Ten years after removal of the weirs quantitative electrofishing indicated that the overall section of river was producing in the region of 30,000 smolts a year.

Agri –Food and BioSciences Institute (AFBI) are of the opinion that the removal of some or all of the existing five industrial weirs together with localised channel enhancement works could significantly improve the quality of these river reaches, particularly for fish, and could mitigate against the impact of the proposed new canal weirs. The river enhancement work would include removal of silt deposits, enhancement of river bed through placement of rubble mats, gravels, and boulder deflectors, bank stabilisation and associated planting,

5 DESCRIPTION OF WORKS

This section summarises the works to be carried out along the Lagan Navigation. To best detail the works and facilitate phasing of the construction of the navigation has been subdivided into seven specified reaches as follows:

- CH-4500 to CH0000 - Belfast Harbour to Stranmillis (Drawings 1001)
- CH0000 to CH7500 - Stranmillis to Edenderry (Drawings 1002 and 1008)
- CH7500 to CH15100 - Edenderry to Lisburn (Drawings 1003 and 1009)
- CH15100 to CH22650 - Lisburn to Maze (Drawings 1004 and 1010)
- CH22650 to CH29450 - Maze to Zion Hill (Drawings 1005 and 1011)
- CH29450 to CH35350 - Zion Hill to Broadwater (Drawings 1006, 1012 and 1013)
- CH35350 to CH42950 - Broadwater to Ellis's Gut (Drawings 1007 and 1014)

The above 7 reaches have been determined based on a feasible package of works which would maximise the length of navigable channel for each element of construction works. The reaches have been subdivided further below to provide a breakdown of each element of work within a reach. See Appendix A for drawings.

The typical elements of work to be undertaken together with associated cost rates are described in Appendix B. Typical drawings for an existing lock restoration, a new lock, lock gates, and a new weir are also included in Appendix A.

5.1 CH-4500 to CH0000 - Belfast Harbour to Stranmillis (Drawing 1001)

The navigation along the tidal section of the River Lagan from Belfast Harbour to Stranmillis Weir is 4.5km long. Boat passage at the Lagan Weir is currently possible during high tides when the gates are in the lowered position. To improve navigation at this location a new Lock would be constructed on the east bank of the Lagan Weir to allow navigation through the weir during all states of the tide.

5.2 CH0000 to CH7500 - Stranmillis to Edenderry (Drawings 1002 and 1008)

CH0000 to CH1300 - Stranmillis Gateway Lock No.1 (Drawings 1008, Plan 1)

The existing Stranmillis Weir consists of 3No. adjustable steel penweirs and is the upstream limit of the tidal reach of the River Lagan.

The original navigation cut and Molly Wards Lock (Lock No.1) were infilled and are now under the car park which runs parallel to Lockview Road. Recent developments at Cutters Wharf prevent this section from being re-opened.

However there is sufficient space for a new lock development in parkland on the opposite side of the weir. The land is part of a previous landfill site and is owned by Belfast City Council Parks Department.

The development of this site involves major new works which are as follows:-

- Construct a new stepped concrete weir with fish pass.
- Construct a new lock chamber, using reinforced concrete or steel sheet piles;
- Construct a new section of navigation channel approximately 90m long;

- Dredge the river at the upstream and downstream end of the new channel;
- Construct footbridge downstream of lock, together with pedestrian paths etc;
- Construct new moorings upstream and downstream of the new lock;
- Provide access and service road and parking area;
- Provide ancillary works comprising soft landscaping, signage and service facilities.

CH1300 to CH2900 - Corbie Wood Lock No.2 (Drawings 1008, Plan 2)

The original sluice gates at Corbie Wood have been removed and the lock chamber (No.2) is heavily overgrown and partially infilled with a concrete weir.

The works required to re-open this section of the navigation are as follows:

- Construct a new broad crested weir with fish pass
- Restore the lock and provide upstream and downstream moorings (Type A restoration. See Appendix B).
- Clear navigation channel from overhanging trees and growths and dredge bed to provide adequate depth.
- Dredge River Lagan upstream of new weir to provide adequate depth for navigation.

CH2900 to CH6000 - Shaw's Bridge Lock No.3 (Drawings 1008, Plan 3)

Lock No.3 and surrounding area has undergone recent refurbishment work which included refurbishment of the existing Lock, restoration of the Lock Keeper's Cottage and construction of the Lock Keeper's Café and Visitor centre.

However the original cut from Newforge (Lock No.3) to Shaw's Bridge is partially infilled and is heavily overgrown. A new weir just downstream of Shaw's Bridge now replaces the original weir and fixed side overflow weir which controlled the upstream water level. This weir is set lower than the original weir, and forms the upstream step of a canoe slalom.

In order to re-open the navigation at this location it would be necessary to demolish the existing weir and reconstruct a new weir approximately 50m downstream. The works required at this site are as follows:

- Demolish existing weir and reconstruct new stepped weir with fish pass downstream of the entrance to the navigation cut. The new weir crest level would be raised by 0.2m to 5.5m O.D. Belfast.
- Construct new canoe slalom downstream of new weir.
- Provide moorings upstream and downstream of Lock No.3.
- Clear trees and growths from the navigation channel and dredge it.
- Reconstruct a side overflow weir on the upstream end of channel.
- Dredge river between Shaw's Bridge new weir and Edenderry Village to provide adequate navigation depth.
- Ancillary works, soft landscaping etc.
- In addition Castlereagh Borough Council has commissioned URS to investigate the feasibility of mooring a barge/canal boat at Lock No.3 which would provide meeting /education facilities.

CH6000 to CH7500 - Edenderry Locks No 4 and 5 (Drawing 1008)

This section of Navigation extends from Edenderry village to Lock No.6 at Drum Bridge. Two locks, Nos. 4 and 5 are in close proximity to each other, and both are in poor condition with Lock No.5 heavily overgrown, and partially collapsed at its downstream wing walls.

The works required to open this length of navigation are as follows:

- Restore Locks No.4 and 5. (Type A restoration)
- Clear trees and growth from channel and dredge silt to provide adequate depth.
- Provide moorings upstream and downstream of both locks.
- Dredge river as necessary to provide adequate navigation depth.
- Provide river enhancement measures in the river upstream of Edenderry to improve fish habitat.

5.3 CH7500 to CH15100 - Edenderry to Lisburn (Drawings 1003 and 1009)

CH7500 to CH9500 – Drum Bridge Lock No.6 (Drawing 1009, Plan 4)

This section of Navigation is approximately 2.0 km in length of which 400m is navigation cut, the remainder being navigable river. The original navigational water depth upstream of Drum Bridge was controlled by timber penstock weirs. These have been removed thus reducing the upstream water levels considerably. The major works in this section would include the restoration of a navigation bridge at the existing underpass at Drum Bridge below Upper Malone Road. The works entail the following:

- Construct a new stepped weir and fish pass upstream of Drum Bridge.
- Restore Lock No 6 (Type A restoration).
- Provide moorings upstream and downstream of Lock No.6
- Excavate and restore the navigation channel including the short section under Drum Bridge.
- Restore the original navigation bridge.
- Construct a new pedestrian underpass through Drum Bridge adjacent to the navigation.
- Dredge and carry out realignment works to the river upstream of Lock No. 6.
- Provide a new footbridge and associated walkways.

CH9500 to CH10950 - M1 Motorway New Lock No.7 (Drawing 1009, Plan 5)

The M1 Motorway crosses both the River Lagan and the original navigation cut approximately 1 km south of Upper Dunmurry Lane. A section of the navigation cut was partially infilled during the construction of the motorway embankment and a subway built to accommodate the pedestrian route under the Motorway. The dimensions of this subway however are inadequate to accommodate the reopened navigation. At the same time the river was realigned under the M1 approximately 400m to the north of the subway.

The most cost-effective option at this location is not to follow the original route of the waterway but to utilise the river under the motorway bridge and construct a new short section of navigation cut and lock chamber on the upstream side to connect to the original cut.

The major works are as follows:

- Construct new lock No 7.
- Construct a new section of navigation channel.

- Provide moorings upstream and downstream of lock.
- Dredge navigation channel as necessary.
- Provide new maintenance access road/towpath to lock.

CH10950 to CH12150 - Ballyskeagh Lock No.8 (Drawing 1009)

This section of the navigation is approximately 1.20km in length, of which 550m is navigation cut. The major works in this section entail the restoration of Lock No.8. Other works include channel improvement works.

The significant items of work are as follows:

- Restore Lock No.8 (Type A restoration).
- Provide new moorings upstream and downstream of lock.
- Clear trees and growths from navigation channel and dredge bed to provide adequate depth.
- Provide river enhancement measures in the river upstream of Dunmurray to improve fish habitat.

CH12150 to CH13100 - Lambeg Lock No.9 (Drawing 1009)

This length of the navigation is entirely in navigation cut.

The lock at Lambeg is in poor condition with the downstream extent suffering from collapses. The original arch road bridge has been replaced with a flat deck road bridge with inadequate headroom. The major elements of work at this location are as follows:

- Restore Lock No 9 (Type A restoration).
- Provide new moorings upstream and downstream of the lock.
- Reconstruct new road bridge deck and regrade county road on each approach.
- Clear trees and growths from navigation channel and dredge bed to provide adequate depth
- Provide river enhancement measures in the river upstream of Lambeg to improve fish habitat.

CH13100 to CH15100 - Hilden Lock No 10 and 11 (Drawing 1009)

This length of the Navigation extends from the lock immediately downstream of Hilden Road to the new navigation cut at the Island Civic Centre at Lisburn. There are two locks within this reach, Hilden Lower and Upper (No's 10 and 11). The original arched bridge at Hilden Road has been replaced with a flat decked bridge which requires replacement with a new bridge to provide the requisite headroom and width. The major items of work along this section are as follows:

- Reconstruct Lock Nos 10 and 11 (Type A restoration).
- Provide new moorings at both locks.
- Reconstruct a new road bridge at Hilden Road and regrade the county road on each approach.
- Clear trees and growths from navigation channel and dredge bed to provide adequate depth
- Provide river enhancement measures in the river upstream of Lambeg to improve fish habitat.

5.4 CH15100 to 22650 - Lisburn to Maze (Drawings 1004 and 1010)**CH15100 to CH16420 - Canal Basin (Drawing 1010)**

The canal basin in Lisburn is located immediately upstream of the new crescent weir serving Lock No.12 at the Island Civic Centre and includes the length of river up to Hogg's Weir. The water level in this section was lowered to provide adequate headroom under Union Bridge and consequently some dredging works upstream is required. The proposals for this section include the provision of greater visitor access to the river.

The major work items in this section include the following:

- Provide new moorings and pontoons.
- Dredge the basin and river as required.
- Restore canal basin
- Provide new moorings and pontoons.
- Provide adequate vehicular access and car parking.
- Provide ancillary works and service facilities
- If possible restore infilled dry basin including the provision of new gates
- Remove existing pipeline across river upstream of Union Bridge and replace.

CH16520 to CH17450 - Hogg's Weir Lock No.13 (Drawing 1010, Plan 6)

Lock No 13, known as Becky Hogg's, is at the downstream end of this section, the upstream being the Union Locks near Sprucefield.

The works at this section entail the restoration of Lock No.13 together with the construction of a new weir. In addition environmental improvement works to the area e.g. the provision of picnic areas etc on the island are proposed. The main items of work are as follows:

- Construct a new crescent stepped weir and fish pass.
- Restore Lock 13 (Type A Restoration).
- Provide new moorings upstream and downstream of lock.
- Restore partially infilled navigation channel.
- Dredge the river as necessary and realign the channel adjacent to lock.
- Provide a new footbridge.
- Construct access road and car parking facilities.
- Provide new picnic and landscaped area.

CH17450 - Union Locks Lock No 14 (Drawing 1010, Plan 7)

The Union Locks are a flight of 4 locks which raised the navigation up to the original navigation summit level which extended from Sprucefield to Aghalee.

The summit level between Sprucefield and Moira was infilled during the construction of the M1 motorway and as a consequence the rewatering of the Union Locks would not contribute to a significant extension of the waterway. It is intended therefore that the locks are used as a focal heritage point on the restored navigation and also as a mooring point for those people

wishing to visit the Sprucefield complex. The major items of work at this location are as follows:

- Construct a new boat turning area.
- Construct new moorings.
- Construct access roads and car parking facilities.
- Restore the original stonework of the locks as a visitor attraction.

CH17450 to CH21650 - Union Locks to Young's Bridge (Drawing 1010)

The Lagan Navigation from Union Locks to Moira was infilled during the construction of the M1 Motorway. As a result a new navigation route is proposed utilising the River Lagan. A navigable channel would be provided for a distance of 4.2km between Union Locks and Young's Bridge. The major items of work are as follows:

- Dredging of River Lagan to provide adequate draft
- Construction of 3m wide towpath

CH21650 to CH22650 - Young's Bridge to Former Maze Site (Drawing 1010, Plan 8)

It is proposed to construct a new weir across the River Lagan upstream of Young's Bridge. The weir would be approximately 30m wide with a crest level of 28.0m O.D. Belfast and would control river water level for a distance of 3.2km upstream to Down Royal Race Course. A new navigation cut and lock (Lock No.14A) would be constructed.

- Construct new lock No.14A.
- Construct a new section of navigation channel.
- Provide moorings upstream and downstream of lock.
- Construct 30m stepped weir and fish pass
- Dredge river channel to provide adequate navigational depth.
- Construct 3m wide towpath.

5.5 CH22650 to CH29450 – Former Maze Site Maze to Zion Hill (Drawings 1005 and 1011)

Former Maze Site (Drawing 1011, Plan 9)

A number of options were investigated to link the navigation with the proposals for the former Maze Site. An original study was carried out in 2006 which recommended linking the site using an undesignated watercourse. However the current masterplan for the Maze Site recommends recreational facilities further south of the previous location and the Navigation should link to these facilities.

To provide this link a number of further options were investigated. The first option investigated bringing the navigation directly into the Maze Site. This would require a series of locks to lift the navigation approximately 12m to enter the site. In addition the Navigation would cross under the Bog Road where there is insufficient clearance. This would result in significant road raising and realignment and would impact upon the adjacent properties. There would also be no summit water supply for the new canal link and back pumping from the River Lagan would be necessary as well as the provision of a summit storage reservoir. The estimated cost for this solution would be in excess of £3.5m.

The second solution for the linkage to the former Maze Site is to provide a new marina facility with boat trailer park, slip way and services building. Additional car parking would also be

provided along with a new footpath linking the marina and car park to the site. This would be a more achievable engineering solution. The major items of work at this location are:

- Construct fully serviced marina
- Construct new car park
- Construct new footpath
- Provide additional soft landscaping

CH22650 to CH24850 - Former Maze Site to Down Royal Racecourse (Drawing 1011, Plan 9)

The existing Maze Bridge comprises an old attractive five arch masonry structure. Although there would be sufficient navigational headroom the width of the arches and depth of water restrict the navigation. It is therefore proposed that the existing bridge remain undisturbed and a bypass channel cut around its southern side with a new thin deck bridge to carry Gravel Hill Road. It would be necessary to raise the road levels by approximately 1m locally to accommodate the new bridge.

The main items of work are as follows:-

- Construct new navigation bypass channel
- Construct new navigation bridge
- Construct 3m wide towpath.
- Dredging of River Lagan channel to provide adequate navigational depth.
- Raise and regrade Gravel Hill Road at new navigation bridge.

CH24850 to CH26160 - Down Royal Racecourse to the New Bridge (Drawing 1011, Plan 10)

It is proposed to construct a new weir across the River Lagan upstream of Down Royal Racecourse. The weir would be approximately 30m wide with a crest level of 29.0mO.D.Belfast and would control the river water level up to Zion Hill. A new navigation cut and lock (Lock No.14B) would be constructed. In addition parts of the River Lagan would be realigned to remove a number of meanders in the river in order to provide a more suitable navigable channel. The resulting oxbow lakes would be enhanced as wetland areas.

The main items of work are as follows:-

- Construct 30m crescent weir and fish pass
- Construct new lock No.14B.
- Construct a new section of navigation channel.
- Provide moorings upstream and downstream of lock.
- Dredge river channel to provide adequate navigational depth.
- Realignment of river channel as necessary
- Construct 3m wide towpath.

CH26160 to CH28575 - The New Bridge to Spencer's Bridge (Drawing 1011, Plan 11)

The New Bridge is also a very attractive structure of considerable age. If water levels are raised for navigational purposes there would be insufficient headroom through the bridge. The configuration of the River Lagan is such that the necessary bypass channel could be cut around its southern side and a new bridge constructed to carry Cockhill Road. This would result in the raising of road levels approximately 2m to accommodate the new bridge.

The main items of work are as follows:-

- Construct new navigation bridge
- Construct new navigation bypass channel
- Construct 3m wide tow path
- Dredge river channel to provide adequate navigational depth.
- Raise and regrade Cockhill Road at new navigation bridge

CH28575 to CH29450 - Spencer's Bridge to Zion Hill (Drawing 1011, Plan 12)

At Spencer's Bridge the proposed navigational water levels would result in unacceptable headroom restrictions under Spencer's Bridge which is a three arch masonry structure. A bypass channel around the eastern side of the bridge with a new navigation bridge is therefore proposed. This would result in raising Lany Road levels by approximately 1.2m.

The main items of work are as follows:-

- Construct new navigation bypass channel
- Construct new navigation bridge
- Construct 3m wide tow path
- Dredge river channel to provide adequate navigational depth
- Raise and regrade Lany Road at new navigation bridge

5.6

CH29450 to 35350 - Zion Hill to Broadwater (Drawings 1006, 1012 and 1013)

CH29650 to CH32136 - Zion Hill to Lady's Bridge New Lock Nos. 14C, 14D and 14E (Drawing 1012, Plan 13, Plan 14 and Plan 15)

This section of navigation could not be reopened as a navigable channel without first reinstating the Broadwater as the water supply.

It is proposed to construct a new navigation cut and towpath and construct 3 new locks namely Locks 14C, 14D and 14E.

Near Zion Hill, a new navigation channel would be cut for a distance of 50m up to the first new lock (Lock No. 14C) which would provide a lift of 2.3m. The navigation would then follow the line of the County Drain (Plan 13).

A navigation cut would then follow the contours utilising the line of existing ponds and taking advantage of the screening effect of the original navigation embankments.

A new bridge would be constructed at the Hillsborough Road with minimum internal dimension of 6m wide by 5.5 m high (Plan 14).

A second lock (Lock No.14D) with a lift of 2.0m would be constructed approximately 200m upstream of Hillsborough Road (Plan 14). The proposed navigation cut would then follow the line of the County Drain which could either be diverted or incorporated within the new channel.

At the Lisburn Road embankment a new bridge would be constructed (Plan 15) similar to that proposed at Hillsborough Road. The navigation would then continue across the fields between Lisburn Road and Glenavy Road. A new navigation bridge would be constructed at the Glenavy Road to accommodate the proposed waterway.

The land between Glenavy Road and the original navigation would provide a convenient oblique approach for the third new lock (Lock No.14E) (Plan 15) which would lift the Navigation the remaining 1.9m to the original Broadwater summit level of the Lagan Navigation.

The main items of work are as follows:-

- Construct new Lock No.14C, No.14D and 14E
- Construct new moorings upstream and downstream of each lock
- Construct new navigation bridge at Hillsborough Road
- Construct new navigation bridge at Lisburn Road
- Construct new navigation bridge at Glenavy Road
- Construct new navigation cut
- Construct new 3m wide tow path

5.7 CH32136 to CH35350 - Lady's Bridge to the Lock 17 including Broadwater (Drawing 1013, Plan 16)

The original waterway between Lady's Bridge and Lock 17 remains intact along its full length and restoration works only are required. Refurbishment works would be required at Lock No. 17 and the flood gates at Broadwater. In addition it is proposed to construct a fully serviced marina with slipway, pumpout, fuelling station, boat yard and car park adjacent to Soldierstown Bridge at the south end of the Broadwater.

The main items of work are as follows:-

- New moorings at Lady's Bridge
- Restore Lock 17 (Type B Restoration).
- Restore Flood Gates (Refurbishment Type B)
- Construct new fully serviced 50 berth marina at Soldierstown Bridge

5.8 CH35350 to CH42750 - Broadwater to Ellis's Gut (Drawing 1007 and 1014)

This section of waterway is reliant upon the water supply from Broadwater. It would not be possible to open this section of Navigation as a navigable waterway without first carrying out the reinstatement of the Broadwater for water supply.

CH35350 to CH38850 - Lock No. 17 to Lock No. 24 (Drawing 1007 and 1014)

The original waterway between Lock No. 17 and Lock No. 24 remains intact along its full length and restoration works only are required. The navigation channel although partly overgrown currently acts as a drainage channel for the local catchment and has therefore not been allowed to dry out. It is unlikely therefore that major works to reseal the bed and sides will be necessary and the restoration of the channel would essentially involve minor dredging and removal or cutting back of bank growth. The main issues along this navigation reach relate to land ownership. Land purchase and land agreements will be required to allow the re-opening of this section to proceed.

However since the closure of the Navigation a number of developments have been built adjacent to the Navigation. At Lock No. 18 a gabion retaining wall now extends into the navigation channel. In addition the property at Lock No.19 has been restored. The property owner may also have ownership of the tow path between Lock No.19 and Lock No. 20 (Drawing 1014, Plan 18) which would appear to limit the right of way for the reopening of the original tow path route at this location.

There are no remains of the existing towpath between Lock No. 20 and Lock No. 24. As part of the reopening of the Navigation a new 3m wide towpath along this length would be required. The works required on this section are:

- Restore Lock Nos. 18, 19, 20, 21, 22, 23 and 24 (Refurbishment Type B)
- Construct upstream and downstream moorings at each lock location
- Construct new 3m wide tow path
- Carry out minor repairs to Aghalee Bridge, Aghagallon Bridge and Goudy Bridge
- Service diversions at Aghagallon Bridge

CH38850 to CH42750 - Lock No. 24 to Lock No. 27 (Drawing 1007 and 1014)

The original waterway between Lock No. 24 and Lock No. 27 remains intact along its full length and restoration works only are required. The greater part of the length of the towpath between Annaghdroghal Bridge and Lock No.24 has been reinstated and would not require any significant additional works. There is however a small section of tow path between Lock No. 25 and Lock No.26 which has not been reinstated.

In addition it is proposed to construct a fully serviced marina with slipway, pumpout, fuelling station, boat yard and car park at Ellis's Gut. To facilitate access to Ellis's Gut would a new access road would be required.

- Restore Lock No. 25 (Refurbishment Type B)
- Restore Lock No. 26 (Refurbishment Type B)
- Restore Lock No. 27 (Refurbishment Type B)
- Construct new 3m wide tow path
- Construct new access road to Ellis's Gut
- Carry out minor repairs to Cranagh Bridge and Annaghdroghal Bridge
- Construct new fully serviced 25 berth marina at Ellis's Gut

5.9 Moorings/Marinas/Mooring Basins

Twenty-five metre moorings long should be provided upstream and downstream of each of the locks. In addition mooring basins/marinas have been proposed at the following locations to facilitate overnight stays and visitation to local attractions and villages.

- Stranmillis Gateway – 25 Berth
- Canal Basin – 25 Berth
- Former Maze Site – 25 Berth
- Broadwater – 50 Berth
- Ellis's Gut – 25 Berth
- Aghalee – 5 Berth

- Down Royal Racecourse -5 Berth

Each mooring basin/marina should provide toilet/shower facilities, fresh water, sewage pumpout, and electricity supply. They may also facilitate cruiser hire, carparking, fishing, watersports and boat sales and maintenance.

5.10 Slipways

There will be slipways at the following locations:

- Ravenhill (existing)
- Maysfield (existing)
- Stranmillis
- Corbie Wood
- Lisburn Canal Basin(existing)
- Broadwater(new)
- Ellis's Gut(new)

Fuelling Stations

To facilitate refuelling of boats a number of refuelling stations would be required along the Lagan Navigation. These facilities would be provided as part of the basin developments. Suitable sites would include:-

- Stranmillis
- Lisburn Canal basin
- Former Maze Site
- Broadwater
- Ellis's Gut

6 CAPITAL COSTS

6.1 Construction Cost Estimates

Table 6.0 below shows a summary of the construction costs for each section of navigation based upon the rates outlined in Appendix B. A detailed breakdown of the estimated quantities and capital costs for each section is included in Appendix C.

Table 6.0 - Summary of Construction Cost Estimates

Location	Sub Total inc 15%
CH-4500 to CH0000 - Belfast Harbour to Stranmillis	£2,217,200
CH0000 to CH1300 - Stranmillis Gateway Lock No.1	£2,803,700
CH1300 to 2900 - Corbie Wood Lock No.2	£1,559,400
CH2900 to CH6000 - Shaw's Bridge Lock No.3	£1,915,900
CH6000 to CH7500 - Edenderry Lock No 4 and 5	£2,223,525
CH7500 to CH9500 - Drumbridge Lock No.6	£3,783,213
CH9500 to CH10950 - M1 Motorway New Lock No.7	£1,782,788
CH10950 to CH12150 - Ballyskeagh Lock No.8	£1,133,325
CH12150 to CH13100 - Lambeg Lock No.9	£1,368,500
CH13100 to CH15100 - Hilden Lock No 10 and 11	£2,534,025
CH15100 to CH16420 - Canal Basin	£1,200,600
CH16420 to CH17450 - Hogg's Weir Lock No.13	£2,093,575
CH17450 - Union Locks Lock No 14	£1,725,000
CH17450 to CH21650 - Union Locks to Young's Bridge	£1,117,800
CH21650 to CH22650 - Young's Bridge to Former Maze Site	£2,516,775
CH22650 to CH24850 - Former Maze Site to Down Royal Racecourse	£1,509,375
CH24850 to CH26160 - Down Royal Racecourse to the New Bridge	£1,782,615
CH26160 to CH28575 - The New Bridge to Spencer's Bridge	£644,000
CH28575 to CH29450 - Spencer's Bridge to Zion Hill	£834,613
CH29450 to CH32136 - Zion Hill to Lady's Bridge New Lock Nos. 14C, 14D and 14E	£5,554,454
CH32136 to CH35350 - Lady's Bridge to the Lock 17 including Broadwater	£2,780,700
CH35350 to CH38850 - Lock No. 17 to Lock No. 24	£6,212,300
CH38850 to CH42750 - Lock No. 24 to Lock No. 27	<u>£5,214,100</u>
Total	£54,507,483

6.2 Land Acquisition and Additional Costs

Large parts of the Navigation and tow path between Sprucefield and Ellis's Gut appear to be under private ownership. In order to reopen this section of Navigation this land would require to be purchased from the current land owners. In addition businesses and residences directly affected by the reopening of the Navigation may require to be compensated.

The level of compensation and costs of land acquisition are difficult to estimate accurately. An allowance of £3m has been provided. Other additional costs include professional fees, environmental monitoring, and marketing.

Table 6.1 below includes a schedule of likely non-capital costs associated with the project.

Table 6.1 – Land Acquisition and Additional Costs

Description	Cost
Environmental Impact Assessment	£200,000
Site Investigation	£350,000
Land Acquisition & Associated Fees	£3,000,000
Project Management	£500,000
Professional Fees	£2,000,000
Resident Engineer Costs	£1,500,000
Expenses	£500,000
Environmental Monitoring	£100,000
Marketing and Public Relations	<u>£1,000,000</u>
Total	£9,150,000

Optimism Bias

The Optimism Bias adjustment factor, for the purpose of the appraisal, remains high as there is still a significant amount of survey and investigative work required and potential risk which cannot be ignored at this stage. The main issues outstanding at this point in the project include.

- Detailed ground and service investigation still required
- Land ownership
- Detailed design
- Environmental mitigation
- Availability of funding

These issues have been incorporated into risk components to determine the Optimism Bias adjustment factor. The optimism bias factor of 30% is recommended. The basis of this has been included in Appendix E.

6.3 Summary of Costs

Table 6.2 below shows the summary of costs for reopening the Lagan Navigation from Belfast Harbour to Lough Neagh including the provision of an optimism bias.

Table 6.2 – Summary of Costs

Description	Cost
Capital Costs	£54,507,483
Land Acquisition and Additional Costs	£9,150,000
Sub Total	<u>£63,657,483</u>
Optimism Bias (30%)	<u>£19,097,245</u>
Total	£82,754,728

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CONCLUSIONS

The reopening of the Lagan Navigation between Belfast Harbour and Lough Neagh would constitute a large engineering project. The route is approximately 49km long and although there are a number of constraints the scheme is technically feasible and a practical proposition. In general the construction techniques would be similar to those used on the reopening of the canal channel, restoration of Lock 12, new weir and associated river works at the Civic Centre in Lisburn. Where additional measures would be necessary for example in relation to roadworks and bridge reinstatements, solutions to these issues have been identified and costed.

The major constraint to reopening the waterway is the loss of the original navigation between Sprucefield and Moira. This summit level section between Union Locks and Lady's Bridge was demolished during the construction of the M1 Motorway in the early 1960's. The cost of reconstruction of the canal as a "stillwater section" along a completely new line would be prohibitively expensive. The most viable means of re-establishing a through navigation is to upgrade the channel of the River Lagan to a navigable condition, together with accommodation works at existing bridges. A relatively short section of new canal cut would however have to be constructed between Zion Hill and Lady's Bridge.

The proposed works to reopen the Lagan Navigation have been subdivided into seven specified reaches as follows:

- CH-4500 to CH0000 - Belfast Harbour to Stranmillis (Drawing 1001)
- CH0000 to CH7500 - Stranmillis to Edenderry (Drawings 1002 and 1008)
- CH7500 to CH15100 - Edenderry to Lisburn (Drawings 1003 and 1009)
- CH15100 to CH22650 - Lisburn to Maze (Drawings 1004 and 1010)
- CH22650 to CH29450 - Maze to Zion Hill (Drawings 1005 and 1011)
- CH29450 to CH35350 - Zion Hill to Broadwater (Drawings 1006, 1012 and 1013)
- CH35350 to CH42950 - Broadwater to Ellis's Gut (Drawings 1007 and 1014)

The above seven reaches have been determined based on a feasible package of works which would maximise the length of navigable channel for each element of construction works. The reaches have been subdivided further to provide a breakdown of each element of work within a reach.

A detailed breakdown of the estimated quantities and construction costs for each section was carried out. Non-construction costs which include land costs, legal costs, and professional fees were also considered and estimated. In addition an optimism bias adjustment factor of 30% was calculated to determine risk components of the project.

The Table below shows the estimated total costs for reopening the Navigation from Belfast Harbour to Lough Neagh including the provision of an optimism bias.

Table 7.0 Summary of Costs

Description	Cost
Construction Costs	£54,507,483
Land Acquisition and Additional Costs	£9,150,000
Sub Total	<u>£63,657,483</u>
Optimism Bias (30%)	<u>£18,933,628</u>
Total	£82,754,728