Project Report

Bedford & Milton Keynes Waterway

Wootton to Green Lane Alignment Option Appraisal

Prepared for

Bedford Borough Council

Date

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B&MK – Bedford and Milton Keynes

SECTION 1

Introduction

1.1 Background and Introduction

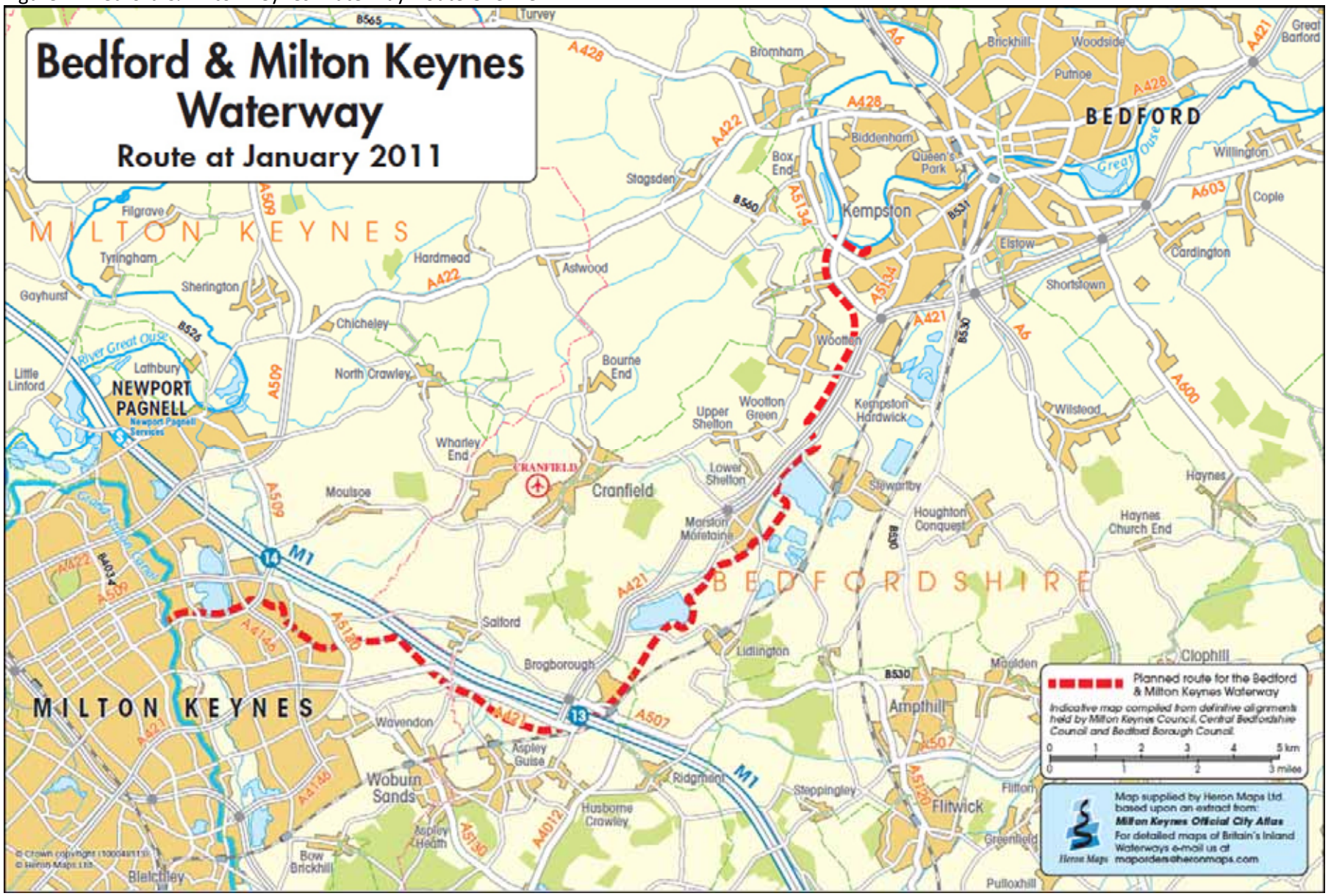
The Bedford & Milton Keynes Waterway (B&MK Waterway) is a proposed new 26 kilometre canal connecting River Great Ouse at Kempston in Bedford Borough with the Grand Union Canal at Newlands in Milton Keynes, located within a series of green corridors. These corridors, or waterway parks are aimed at improving linkage between local communities and providing a more unique and attractive environment in what has been recognised as an important growth corridor in the local development plan. The waterway will also provide a new habitat for wildlife as well as a new channel for drainage and water supply. The route overview of the B&MK Waterway is shown on Figure 1. This overview plan provides a concept design route for future development.

Part of the B&MK Waterway passes through the Bedford Borough Council area. In light of the planned growth and development along the waterway route, Bedford Borough Council wishes to further develop the given concept design of the waterway. To achieve this objective the council has commissioned this study to CH2M HILL to develop designs of the waterway with the aim of defining the route and footprint, developing an understanding of the land take requirements and assessing strategies for staged implementation of the earthworks involved.

This report provides the findings of the study. The study includes the B&MK Waterway route from Green Lane to Wootton within the Wootton and Stewartby area of Bedford Borough Council. The study area stretches along the new dual carriageway (A421) south west of the town of Bedford. The southern end of the study area at Green Lane marks the boundary of the Bedford Borough Council area with Central Bedfordshire.

The report is divided into a number of sections. The sections provide key features and the constraints relevant to the outline designs, drainage considerations, options considered and the preferred option, proposed key waterway structures, land take and earthworks strategy, ecological assessment and construction cost estimates for the proposed waterway.

Figure 1 - Bedford & Milton Keynes Waterway-Route Overview



SECTION 2

Key Design Considerations

This section of the report provide a summary of the key features and constraints relevant to development of the outline designs.

2.1 B&MK Waterway Concept Design

A concept design of the study reach from Green Lane to Homeless Woods which originated from the B&MK Waterway Overview Route has been in use by Bedford Borough Council and other stakeholders. The concept design forms one of the key considerations for this outline design study. The design is shown on Figure 2.

2.2 Topography

The topography of the area is one of the key elements which has influenced the waterway route and design. Along with other constraints, the topography has dictated the general arrangement and sizes of locks in keeping the waterway in an optimal balance of cut and fill and in maintaining the waterway nearer the existing ground.

The study area is generally flat and gradually draining in a north eastern direction. At the southern end near Green Lane, the ground is gently rolling and rises in elevation to 41mAOD. To the north of the new A421, the area is generally flat with elevation gradually reducing from 37mAOD in the south to circa 32.5mAOD in the north. Further north from the A421 into the Marston Vale Forest area towards Bell Farm, the ground gradually starts to rise again.

A detailed topographic survey of the study area (undertaken by Kempston Surveys) has been used in the study. For the area between the new A421 and Green Lane, existing LIDAR data has been used for this outline design.

2.3 Land use and Landownership

The landownership boundaries have been included in the study to enable identification and estimation of land take for the waterway and for consultation with the landowners on the proposed waterway alignment.

From the concept design stage, Bedford Borough Council has divided this route into seven sections. The sections and the landownership are listed below (based on ownership information provided by the council as of April 2013):

2.3.1 Section 7 - Green Lane to Old A421

This section contains land owned by Waste Recycling Group (WRG – part of FCC International Environmental Services), British Agricultural Services Ltd and Belmont.

A good part of the proposed alignment in this section comprises of an excavated ditch or drain which is reported to remain wet throughout the year. The land to the south of this drain (owned by WRG group) forms part of the Stewartby Landfill site and rises steeply to the south. Land to the north of the proposed concept alignment comprises farm/ residential dwellings.

The key features in this section which could influence the waterway alignment are: existing drain, extents of the landfill site and its drainage, existing road level for Green Lane and the road level of the old A421.

2.3.2 Section 6 - Old to New A421

This section contains land owned by the Highways Agency. New trees have been planted as part of the A421 works and it is envisaged that this area will be a woodland area.

An underpass was constructed as part of the new A421. This existing underpass will form a key part of the proposed alignment for B&MK Waterway.

2.3.3 Section 5 – Berry Farm

This section contains land owned by Bedford Borough Council. North of the existing underpass a relatively small area of land is owned by O&H.

The section comprises mostly of woodland area.

2.3.4 Sections 4, 3 and 2 – Marston Vale Innovation Park Phases 2B, 2A and 1

The land in these three sections is owned by Bedford Borough Council and comprises green fields and some woodland. The land is earmarked as a strategic site for employment and business development. An initial master plan has been developed for Marston Vale Innovation Park 1 (MVIP1). The plan includes provision of the waterway through the area.

A number of drains run through these three sections (B42 & B16 as discussed in detail later in the report). These drains are managed by Internal Drainage Board (IDB) and will be one of the key considerations in the vertical and horizontal alignment of the waterway. The boundary of the MVIP1 includes the newly constructed elevated Fields Road and a segment of the old Fields Road (disused).

2.3.5 Section 1 – Persimmon Site

This section is owned by Persimmon Homes. Currently the area comprises open green fields however the land is earmarked for housing development. The IDB drain B16 from MVIP1 continues into this section through a culvert under Fields Road and runs in a north eastern direction roughly parallel to the new A421. Two foul water sewers (one of these being main) owned by Anglian Water also pass through this section.

The drain B16, foul water sewers and the proposed development plan from Persimmon Homes are considered as some of the key considerations governing the waterway route alignment in this section.

2.3.6 Homeless Woods and Bell Farm

Further north north-east from Persimmon Homes site, the area comprises of a combination of woodland (Homeless Woods) and open area (Bell Farm). The wooded area land is owned by O&H and includes an Anglian Water pumping station. This pumping station is not believed to be in current use. The open area after the O&H land is owned by Marston Vale Trust and is earmarked for forest development.

A range of constraints for the waterway alignment through Marston Vale Trust land are relevant for the design development. These include: planted woodland and tree cover, recreational access networks, forest tracks, existing tree planting contracts and agreements and the presence of ridge and furrow area of archaeological value.

The landownership boundaries along with the concept design route of the waterway are shown on Figure 2.

2.4 Other Constraints

2.4.1 Existing Infrastructure

The existing infrastructure of roads, bridges and other structures are also a key consideration for the waterway route alignment. These include:

1. Green Lane
2. Stewartby Landfill Site, its extents and drainage requirements
3. Old A421 Road
4. Recently constructed underpass at new A421 for B&MK Waterway
5. IDB drains
6. Fields Road

The existing Anglian Water pumping station near Homeless Woods is not believed to be in current use and is not considered as a key constraint to the alignment.

2.4.2 Public Rights of Way

At the south end of the study area, a public footpath crosses the old and new A421, and the farm to the west. This primarily follows the proposed alignment of the waterway and is likely to be merged with the towpath of the proposed new waterway.

2.4.3 Drainage

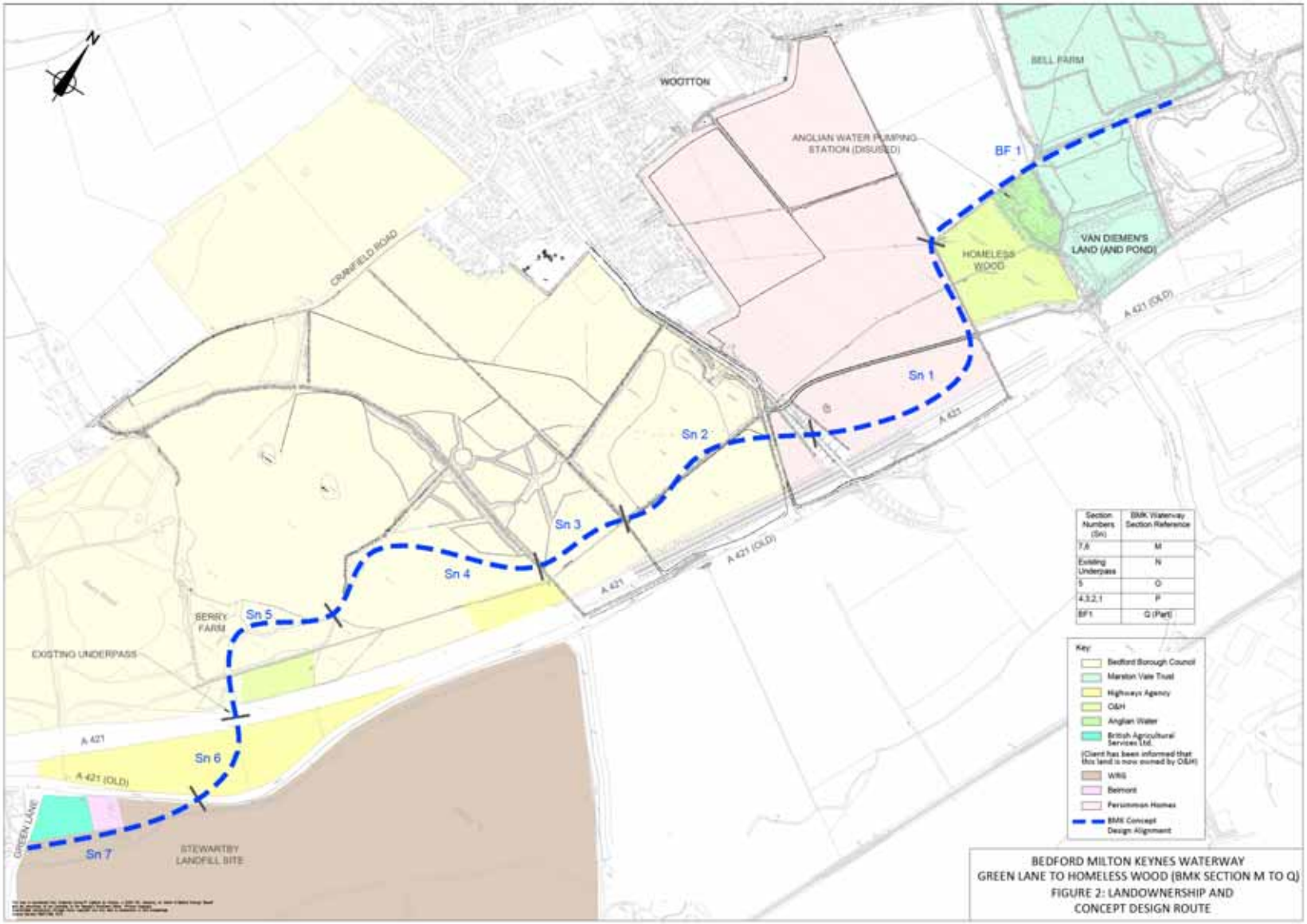
As mentioned above a number of drains pass through the study area. Details on existing and proposed drainage strategy for the study area are one of the main considerations for the waterway design. These are discussed in detail in a separate section on Drainage Considerations later in the report.

2.4.4 Services

The site area contains a number of utility services, both below and above ground. An initial overview services search was conducted through Atkins' Ready to Dig service to determine presence of services along the alignment to guide the design development and to highlight the areas where the services are likely to interact with the waterway alignment. More details on services, their ownership and the need for diversion are given in a separate section on Existing Services.

SECTION 2

Figure 2-B&MK Green Lane to Homeless Woods Landownership and Concept Design



Route

SECTION 3

Drainage Consideration

There are a number of existing drains within the study area as mentioned in the previous section. These drains are being managed by the Internal Drainage Board. As part of this study, information on the existing drains and the future strategy for the drainage area was obtained from Bedford Borough Council and the Internal Drainage Board. This section provides a summary of the information received and sets out the drainage requirements that need to be considered in the waterway design.

Figure 3 shows existing IDB drains in the study area. The drains which are likely to interact with the B&MK Waterway are discussed below.

3.1.1 Green Lane to Old A421 Drain

The existing drain between Green Lane and Old A421 lies almost on the waterway alignment as drawn at the concept design stage. An existing culvert under Green Lane connects it to the drain further south and eventually to Stewartby Lake. The Stewartby Landfill Site area, to the south and south east rises in elevation and the surface drainage from this gravitates towards this drain. Discussions with FCC Environment (landfill operator) suggest that the surface water drainage for landfill on this site is designed to attenuate in the existing drain.

The waterway in this section will therefore be designed to enable the surface runoff to combine with the waterway.

3.1.2 Drain B42

The existing B42 drain (as shown on Figure 3) collects surface water from a large area west of new A421 from Cranfield Road and further west. The drain passes through a culvert under the new and old A421 and eventually joins with the IDB Drain B1.

The surface water drainage strategy for the area suggests that B42 will continue as a main drainage channel after further development in the area (for current drainage strategy see Appendix A). It is envisaged that surface water from a large area of the proposed residential and employment development will continue to drain into the B42 after going through attenuation ponds.

The B&MK Waterway design will therefore need to include a drainage crossing at the intersection point with the drain.

3.1.3 Drain B16

Similar to B42, drain B16 collects surface water from what is currently a large green field area to the south and south east of Wootton as shown on Figure 3. The drain continues in the north north-east direction through the Persimmon Homes land, Homeless Woods and finally connects with the strategic flood attenuation pond in Van Diemen's Land.

The initial master plan for section MVIP1 suggests that drain B16 up to Fields Road is planned to merge with B&MK Waterway in the section. It is planned that surface water will be discharged back into the drain at the upstream end of the culvert under Fields Road. Within the MVIP1 development drain B16 will cease to exist. However after passing through the culvert (Fields Road) the drain will continue through the Persimmon Homes area, carrying surface drainage both from MVIP1 and the Persimmon Homes area. Eventually, it will discharge into the Van Diemen's Pond after going through Homeless Wood as per the existing arrangement.

To accommodate the above development and drainage plans, the B&MK Waterway design through MVIP will need to incorporate inlet arrangements to allow surface water into the waterway. Similarly a suitably designed outlet will be required to discharge the surface water collected through MVIP back to the culvert under Fields Road. At some point within the Persimmon Homes land, drain B16 will intersect with the B&MK Waterway alignment. At this point, a drainage crossing will be required.

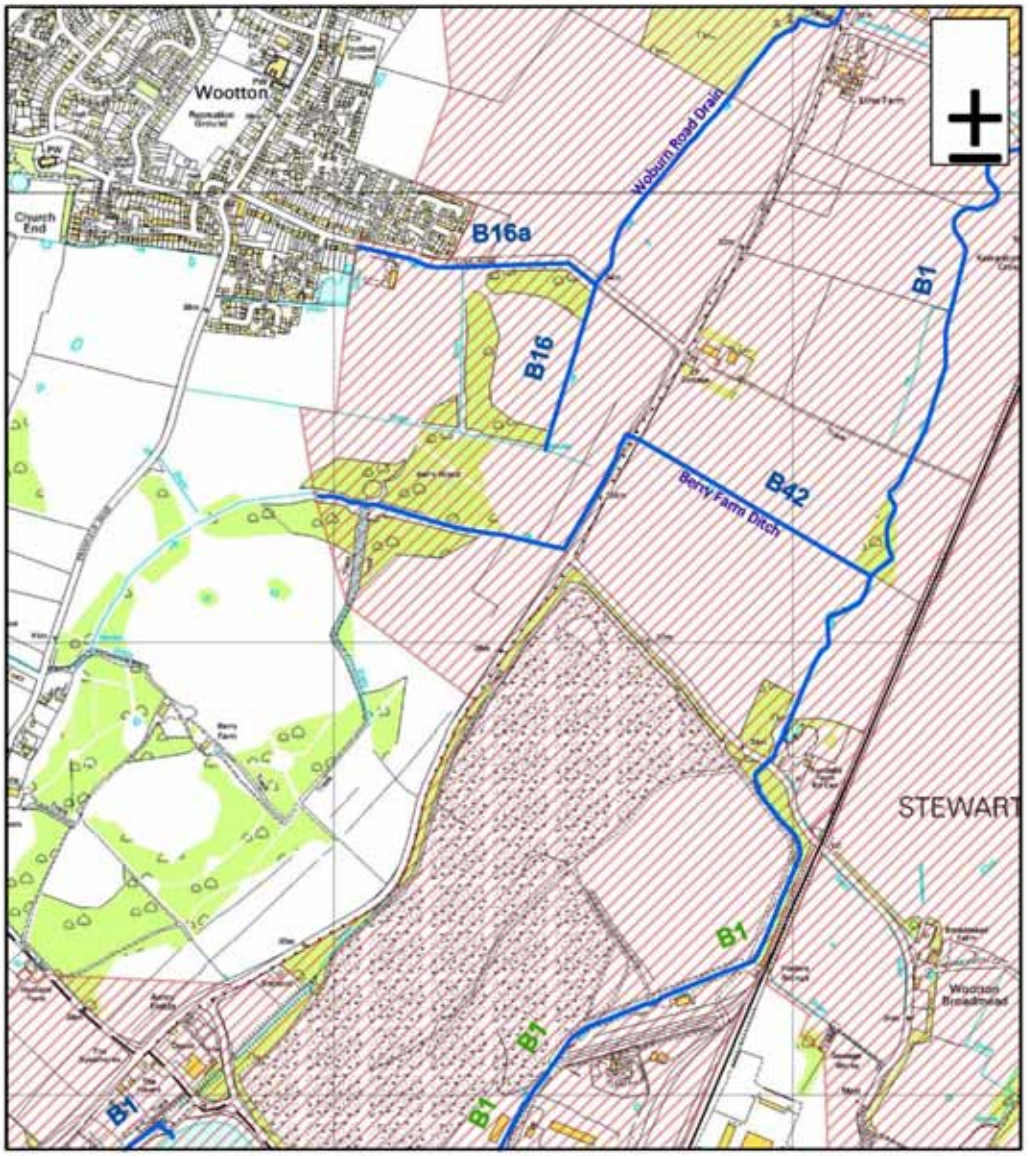
3.1.4 Meeting with IDB

A meeting was held with the Bedfordshire and River Ivel Internal Drainage Board (referred to as the IDB in this report) to discuss the existing drainage system for the B&MK Waterway design. It was noted that:

1. The IDB has principally no objection to the proposal of combining or merging the existing drains with B&MK Waterway where appropriate. Carefully designed inlet and outlet arrangements and other details will need to be agreed with and consented by the board.
2. Due to enhanced risk of blockage and flooding, siphons are considered as the least preferable option for drainage crossings (with waterway or other infrastructure). Instead a gravity flow culvert is preferred.
3. The minimum culvert size on IDB drains is 2.1m wide and 1.8m high (internal dimensions). The drainage culverts, inlets, outlets and siphons constructed on B&MK Waterway would need to be maintained by the waterway operating organisation.

Figure 3- IDB Drains through Study Area (source: Bedfordshire and River Ivel IDB)

Bedford Group of Drainage Boards
Bedfordshire & River Ivel IDB
(Base map obtained from IDB)



Meters
0 130 260 520

Legend

IDB Watercourse
IDB District BOARD

Bedfordshire and River Ivel

BMK Waterway

www.idbs.org.uk

Waterway Outline Design

4.1 General

The study area for B&MK Waterway from Green Lane to Wootton has been divided into a number of sections by Bedford Borough Council to coincide with the strategic development plans for the area as discussed previously.

This section provides a description of the options that have been considered for the waterway for each of the sections and the rationale behind the selection of preferred design arrangements.

The combined length of all the sections is approximately 3½km. Within this, the existing ground levels vary from approximately 39.7mAOD near Green Lane to 32.3mAOD in the Bell Farm area where the current study length ends. In addition to the difference in ground levels, the constraints mentioned in previous sections require a combination of locks and waterway pounds to provide a navigable route from one end to the other.

The standard design requirements for the waterway (waterway width, berms, verges etc.) and the waterway structures (locks, underpasses, bridges etc.) have been taken from the "Brief Guide to Space, Design and Other Technical Issues in Providing for the Bedford Milton Keynes Waterway". The guidance has been produced by B&MK Waterway Consortium to provide guidance on technical design matters for the three planning authorities on the proposed B&MK alignment. Optional dimensions, where relevant (e.g. width of waterway) have been set in consultation with the Bedford Borough Council. The guidance is included in Appendix A. A summary of the design parameters and dimensions adopted for this outline design is summarised in Table 1 below.

Table 1 – B&MK Waterway Standard Design Elements

Features	Design Dimensions
Waterway	9m bed width, 1.5m water depth, 2m total depth
	21m waterway top width at towpath level (for open aspect)
	9m waterway top width at towpath level (for vertical sided waterway)
Bank slopes	1:3 (both for cut and fill sections)
Verges and towpath	2m wide green verges on either side of the waterway
	3m wide towpath on one side, additional 2m verge beyond towpath
Maintenance width	9m from waterway edge (inclusive of verge and towpath) to be provided on towpath side)
Underpasses - One boat width	6m bed/ top width, 1.5m water depth and 2m total depth
	3m towpath (no verges)
	Minimum 3m headroom above water level, minimum 2.5m above towpath
Lock Structures	5m wide, 23m length
Others key dimensions	100m minimum bend radii
	1:16 DDA1 compliant maximum longitudinal gradient for towpath

The design appraisal for each section is discussed separately in the following sections. The proposed waterway plan, longitudinal section and cross sections are included in Appendix B.

2 Disability Discrimination Act

In this report and design plans, the waterway length is referred to in chainage (in meters) starting from Green Lane. The notation of right or left bank has been used considering facing in the ascending chainage direction towards Wootton. Dimensions referred to in regard to the lock structures show net difference in water level across the structure.

4.2 Preferred Option

4.2.1 Section 7 - Green Lane to Old A421

The key considerations for waterway design in this section include: existing roads at Green Lane and Old A421, the extents of the Stewartby Landfill Site and surface water drainage from the landfill site. The waterway in this section can be aligned at existing road levels or alternatively can be set at a lower level to pass under the existing roads.

The option of setting the waterway at or near the existing road levels would involve construction of two road bridges to allow the roads to pass over the waterway (with the required minimum headroom). The approach roads would need to be elevated to pass over the bridge. This option would involve closure/ diversions of roads during construction and diversion of services along the existing roads. In addition to a relatively higher cost, this option would result in a higher level waterway and would have implications for surface water drainage of the section. Beyond this section, towards Stewartby Lake, this option would involve provision of a lock structure to lower the pound level to suit the existing lake (lake level reported to vary from 34.6mAOD to 34.75mAOD).

The alternative option of setting the waterway at a lower level would require provision of two underpasses (one each for Green Lane and for the old A421) and would enable a better arrangement for local surface drainage to combine with the waterway. On the Stewartby Lake side, this arrangement would suit the existing Stewartby Lake level without the need for a lock structure. However, on the newly widened A421, a lock structure would be required to bring the waterway to a higher level to suit the newly constructed underpass. This option would not involve changes to the approach roads.

The option of setting the waterway at a lower level has been selected as the preferred option on the basis of a better arrangement for the existing road network, Stewartby Lake and local drainage requirements. The towpath would be set on the left hand side of the waterway to reduce conflict with the landfill site on the opposite side. The waterway would generally comprise an open aspect cross section.

4.2.1.1 Consideration for Stewartby Landfill Site

The proposed design arrangement for the section of waterway from Green Lane to the Old A421 has also been discussed with the Stewartby Landfill Site operator FCC Environment. A comparison of available data from FCC shows that the footprint for an open aspect waterway (aligned along existing ditch) would interfere with the landfill cell and cap on the landfill side.

At this outline design stage, a number of engineering options have been considered for adjusting the waterway width and discussed with FCC Environment with the aim of keeping the waterway away from landfill cells by reducing the waterway footprint. These options include:

- Steepening the bank cut slopes to 1:1 or 1:2 from standard 1:3 slopes on the landfill side.
- Changing one side bank (landfill side) to a vertical edged arrangement.

A number of cross sections along the length have been prepared, showing the extents of landfill. Both of the above options are feasible. At detailed design stage a preferred option will be developed in line with the above outline options. The design drawings showing the options are included in Appendix C.

The key design parameters for the waterway in this section are summarised in Table 2 below:

Table 2- Section 7 Green Lane to Old A421

Length	Chainage 0 to 420 (420m – excluding underpass at Green Lane)
Waterway	21m wide open aspect, (without adjustments for landfill site) Bed level at 33mAOD (existing road levels at Green Lane and old A421 are approximately 39.5mAOD and 38.7mAOD respectively as noted from: FCC topographic survey)
Footprint Width	49m to 67m (without adjustments of waterway width for landfill site). Waterway in cut.
Structures	Underpass for Old A421 (underpass for Green Lane not included here) Inlet structure for surface water drainage into waterway

4.2.2 Section 6 - Old to New A421

The waterway design in this section will be governed by the design from the previous section and the existing underpass at new A421.

From the proposed designs through Section 7, the waterway bed level will be at a lower level (33mAOD). The bed level of the existing culvert at new A421 is set at approximately 36mAOD. A lock structure will therefore be required to bring the waterway to the required level for the existing underpass.

In addition, due to the location and orientation of underpasses at either end of this section, this section will comprise two curves on the alignment either side of the proposed lock structure. The waterway in this section has been designed to be vertical hard sided waterway to reduce the length of transitions between structures and the waterway and to accommodate smooth curves. The alternative options of open aspect waterway or one side open aspect are also feasible and can be considered at the detailed design stage.

Existing UK Power Network assets (substation-reportedly disused) will fall on the route and will need to be decommissioned and removed. The towpath will continue on the left bank as from the previous section.

The key design features of the waterway in this section are summarised in Table 3.

Table 3- Section 6 Old to New A421

Length	Chainage 420 to 650 (230m net length)
Waterway Design	9m wide vertical hard sided waterway Bed level at 33mAOD and 36mAOD
Footprint width	26.5m to 36.5m. Waterway in cut
Structures	3m Lock, existing underpass at the new A421

4.2.3 Section 5 – Berry Farm

The route alignment for this section will be as per the B&MK Waterway concept design. With the given bed level from the previous section, there are two feasible options for the waterway cross section in this section. The waterway can be designed as open aspect or as a vertical hard sided waterway. To limit the waterway footprint within the land owned by Bedford Borough Council (and to avoid going into O&H land), most of the length in this section has been designed as vertical hard sided waterway. In addition, a curve is required in this length to keep the alignment as per the B&MK concept design. The option of widening the waterway near the summit of the curve (to create a marina, recreational water space etc.) is feasible and can be considered at a later stage.

At the end of the curved length, the waterway has been designed as open aspect waterway. No change in waterway bed level is required within this section and the towpath will continue along left bank as from previous sections.

The key design features of the waterway in this section are summarised in Table 4.

Table 4- Section 5 Berry Farm

Length	Chainage 650 to 1010 (360m net length)
Waterway Design	9m wide vertical hard sided, 200m long 21m wide open aspect, 160m long Bed level 36mAOD
Footprint	Varies from approximately 33.5m to 41m. Waterway in cut.
Structures	None

4.2.4 Section 4 – Marston Vale Innovation Park 2B (MVIP2B)

The key considerations for waterway design in this section are to allow an appropriate crossing for IDB drain B42 and to follow the concept alignment. The route will be set with consideration of the required space between the waterway and the new A421 road for the proposed employment area.

The options considered for drainage crossing include: combine the drain with the waterway (through an inlet/ outlet arrangement – can be a gravity fed or pumped), provide a drainage culvert or a syphon.

The waterway bed level from previous Section 5 is set at a higher level (36mAOD). If this level is maintained, a drainage culvert can be accommodated at the crossing point with drain B42. The alternative options of combining the drainage flow with the waterway would require lowering of the waterway by providing lock structures. Considering the strategic drainage plans, where B42 is one of the key drains for surface water from new developments (Wootton Extension) and further from Cranfield Road, it is preferable to allow an unhindered drainage crossing for B42 instead of combining it with waterway or providing a syphon.

Maintaining the waterway level will also help in the long term operation of the waterway. If the waterway is lowered in this section, the length of summit pound will be shorter than generally recommended (1km). Shorter summit pounds carry the risks of losing water level through locks to lower pounds and could affect the operation of waterway.

In addition, maintaining the waterway bed at a higher level also contributes towards balancing cut and fill material. The material from previous sections (which are wholly in cut) can be utilised for building the waterway embankment and reducing costs and environmental and safety risks related to off-site disposal of surplus excavated material.

The option of continuing the waterway at the same level as the Berry Farm section of the waterway and providing a drainage culvert for B42 has therefore been selected as the preferred arrangement for this section. Similarly the open aspect waterway section has been maintained as from the previous section.

Key features of the proposed waterway in this section are summarised in Table 5.

Table 5- Section 4 Marston Vale Innovation Park 2B

Length	Chainage 1010 to 1450 (440m net length)
Waterway	21m wide, open aspect Bed level 36mAOD
Footprint	Varies from approximately 34m to 54m. Waterway mostly in fill.
Structures	Drainage culvert for IDB drain B42

4.2.5 Section 3 – Marston Vale Innovation Park 2A (MVIP2A)

The waterway design in this section will need to consider the local drainage, existing waterway concept design and the developments planned in the area.

Towards the end of this section, a local area drain from the west feeds into the main B16 drain. In the strategic plans, drain B16 will drain towards Van Diemen's pond (through Woburn Road drain). The future development plans further on show that drain B16 will be merged with the waterway and will cease to exist (up to Fields Road).

Considering the above strategic plans, the waterway in this section has been designed to sit below or near the existing ground level and provide a reasonable length of summit pound. This will enable the surface water to drain into the waterway. A staircase lock will be provided to bring the waterway to the desired level. Towards the end of this section, suitably designed drainage inlet structures will be provided from the left hand bank of the waterway to receive surface water drainage from the existing IDB drain. Continuing the style of the previous section, the waterway will continue to follow an open aspect design.

Key features of the proposed waterway in this section are summarised in Table 6 below.

Table 6- Section 3 Marston Vale Innovation Park 2A

Length	Chainage 1450 to 1710 (260m net length)
Waterway	21m wide, open aspect Bed level 31mAOD
Footprint	Varies from approximately 36m to 39m. Waterway in cut.
Structures	Staircase (double) lock providing total water level difference of 5m.
	Drainage Inlet for IDB drain B16A

4.2.6 Section 2 – Marston Vale Innovation Park 1(MVIP1)

As mentioned previously, the future development plans and strategic drainage plans envisage that the existing drain B16 will be merged with the waterway through the MVIP1. Towards the end of this section, the waterway alignment intersects with the existing Fields Road which has been built at a higher level for the bridge at new A421. The design of the waterway has therefore been developed in consideration of the area plans and road crossing.

The existing ground level in this section varies from 33.5mAOD to 32.8mAOD. The waterway design from the previous section provides a top level of 33mAOD (pound level of 32.5mAOD). This level suits the existing ground and the proposed plans of combining the waterway with the drain and receiving surface water drainage from the surrounding area. Maintaining the waterway level also helps in achieving the required headroom clearance to pass under the existing Fields Road (underpass structure). The waterway bed level from the previous section has therefore been maintained.

Similarly, the open aspect waterway design will be used in line with the previous section. The indicative master plan for the area however includes a combination of vertical and open aspect waterway design, bridge crossings, permanent wet areas for marginal vegetation and areas of extended widths for moorings along the waterway. All of these features will be developed at the detailed design stage and included in the waterway design in consultation with the developer and Bedford Borough Council. At this stage an outline design of an open aspect waterway has been adopted which suits the key requirement of waterway bed level and top level and the alignment is in line with the MVIP1 indicative master plan.

Before the underpass for Fields Road, an overspill structure will be provided on the waterway. This will help in discharging any excess drainage flow (effectively the drainage water collected from the surrounding area within this section and the previous section) back to the existing IDB drain (B16).

Key features of the proposed waterway in this section are summarised in Table 7 below.

Table 7 - Section 2 Marston Vale Innovation Park 1

Length	Chainage 1710 to 2240 (530m net length)
Waterway	21m wide, open aspect Bed level 31mAOD
	(existing Fields Road level at the crossing point 37.7mAOD)
Footprint	Varies from approximately 33m to 35m. Waterway in cut.
Structures	Underpass for Fields Road Outlet structure for excess water discharge back to IDB drain

4.2.7 Section 1 – Persimmon Homes

This section is owned by Persimmon Homes who are developing the area for housing, a school and playing fields. In accordance with Persimmon Homes' master plan the waterway route follows the eastern and northern periphery of the area roughly in line with the concept design. The master plan and the strategic drainage plan shows that the existing drain B16 will be maintained on its existing alignment as the main drainage channel for the area. In addition, two foul water sewers (one of them being main and diverted recently) also pass through the area and will intersect with the waterway route within this section and the next section of the waterway. The design of the waterway has had to take on board these constraints and considerations.

The design of the waterway from MVIP1 includes an underpass for Fields Road. As it enters the Persimmon Homes area, the proposed waterway will be in cut with the verge and towpath being slightly higher than the existing ground. If this level is to be maintained, the drainage crossing for B16 would either be a syphon structure or would need to be combined with the waterway. The syphon structure would have the usual maintenance issues and could cause water level to back-up further upstream in the new development at high flows, reducing the drainage capacity of the system. Similarly, with the defined water level in the waterway (of 32.5mAOD) and the given bed level of the existing drain (approximately 31.4mAOD), provision of a drainage inlet to combine it with the waterway would also result in loss of capacity for the B16 drain within the Persimmon Homes area. For the existing sewage system, if the waterway were to be maintained in cut, it would conflict with the existing foul water sewers (main foul sewer 355 diameter, invert level 30.7mAOD). All these constraints require the waterway to be raised in this section to provide a gravity flow culvert for drain B16 and at the same time avoid conflict with the foul water sewers.

A lock structure has therefore been incorporated in the design to bring the waterway to a higher level before the drainage crossing. To avoid siting it on a curvature, the lock will be provided before the end of the straight stretch prior to the curve that leads to the drainage crossing for B16. Raising of the waterway will however result in a wider footprint for the waterway.

The key features of the proposed waterway in this section are summarised in Table 8 below.

Table 8- Section 1 Persimmon Homes

Length	Chainage 2240 to 2830 (590m net length)
Waterway	21m wide, open aspect Bed level 31mAoD and 34.25mAoD
Footprint	Varies from approximately 33m to 56m. Waterway in cut and fill.
Structures	Lock structure 3.25m Culvert for drain B16

4.2.8 Section BF1– Bell Farm Area 1.

This section covers the area of Homeless Wood and part of the Bell Farm area and contains mature trees, a disused pumping station (owned by Anglian Water), part of the ridge and furrow area within the Bell Farm area and a main IDB drain, B15, towards the end of the section. The foul water sewer mentioned in the previous section also passes through this section diagonally near the boundary with the Persimmon Homes area. The waterway design has taken on board these constraints.

The ground levels in this section vary from 33.25mAoD at the start to 32.2mAoD. With the waterway from the Persimmon Homes area set at 34.25mAoD bed level, continuation of the same level will keep the waterway in fill. Lowering the waterway could result in a number of issues. If the waterway is lowered by providing a lock structure, a very short length of summit pound will be created between this and the previous lock (in the Persimmon Homes area) and the waterway could conflict with the existing main foul water sewer. The waterway would also then need to be elevated for crossing the drainage channel for IDB drain B15 and for the higher ground through the Bell Farm area further north. It has therefore been preferred to continue the waterway at the same level as from Persimmon Homes. This will reduce the need for lock structures, provide a free draining gravity culvert for B15 and a better arrangement for further sections of waterway through the Bell Farm area. The waterway footprint however will be slightly wider.

To reduce the impacts on woodland and the ridge and furrow areas of Bell Farm, the waterway has been aligned along the boundary of the Homeless Wood and ridge and furrow areas.

The key features of the proposed waterway in this section are summarised in Table 9 below.

Table 9- Section BF1 Bell Farm Area

Length	Chainage 2830 to 3360 (530m net length)
Waterway	21m wide, open aspect Bed level at 34.25mAoD
Footprint	Varies from approximately 49m to 56m. Waterway in fill.
Structures	Culvert for drain B15

4.3 Other Discounted Options

The preferred option discussion in the previous section of this report has included discussion on the other options considered for the waterway design arrangement. Following is a summary of these options at an overall study area level.

4.3.1 Option 1- Discounted

In comparison to the preferred option, this option includes:

- Additional lock structure in Berry Farm area to elevate the waterway with the aim of reducing cut material.
- Additional lock structure in MVIP2B to lower the waterway to reduce the amount of fill.
- No lock structure within the Persimmon Homes area with the aim of reducing the footprint.
- Lock structure towards the end of Bell Farm 1 section to elevate the waterway.

This option has been discounted as it results in a short length of summit pound within Berry Farm and MVIP2B. This arrangement of waterway would conflict with the existing drain B16 and the foul water sewers within Persimmon Homes and Bell Farm 1. The option also results in huge quantities of surplus excavated material which will need to be transported off site.

The associated plan and long section for this section are given on drawings 476075-HG-00-00-DR-C-0101 and 476075-HG-00-00-DR-C-0201 included in Appendix D.

4.3.2 Option 2 – Discounted

This option is similar to Option 1 as it contains the same number of locks. The arrangement of locks though, has been modified. The proposed lock from the Bell Farm area has been shifted to the Persimmon Homes area to improve drainage and avoid conflict with the foul water sewer.

This option does help in improving the arrangement through Persimmon Homes (similar to the preferred option) however the option has been discounted as it provides a shorter length of summit pound (same as Option 1) and does not provide an optimal cut-fill balance in comparison to the preferred option. Additionally, as in the case of Option 1, this option involves two additional lock structures. The lock structure, in addition to extra construction cost, will add to the O&M issues and inconvenience for the movement of boats over the waterway length.

The associated plan and long section are given on the drawings 476075-HG-00-00-DR-C-0102 and 476075-HG-00-00-DR-C-0202 respectively in Appendix D.

Proposed Structures

This section provides a brief description of the proposed key structures on the waterway.

5.1.1 Underpasses

Overall, four underpasses are required on the B&MK Waterway length considered in this study. These are for existing roads as below:

- Green Lane
- Old A421
- New A421
- Fields Road

The underpass for Green Lane is not included in this study as this will be (and has been in outline) designed by others and the underpass for the new A421 has already been constructed. The remaining two underpasses have been designed within this outline design. The outline designs for the two underpasses have been included within the set of drawings in Appendix E.

The general arrangement has been adopted from the design guidelines from B&MK Waterway Trust for a one boat width underpass with 6m wide waterway and 3m wide towpath as given in the report section on Waterway Outline Design above. The bed level for the structure and waterway has been set by considering:

- A minimum of 1.5m allowance for road formation including the underpass structure slab. This allowance has been adopted to accommodate most of the existing services without the need for permanent diversion.
- A minimum of 3m headroom clearance from the soffit of the structure to the normal water level, as required by the B&MK Trust design guideline.
- A minimum of 2.5m headroom above towpath level.
- 1.5m water depth (similar to the waterway elsewhere).

The underpasses can be constructed of concrete segments, in-situ construction or of corrugated steel multi-plate construction. The decision on the makeup of the structure will be decided during detailed design stage. A typical drawing of the corrugated steel culvert has also been included within the set of drawings.

5.1.2 Lock Structures

The preferred design arrangement includes three lock structures. These will be as below:

- A 3m lock between the old and new A421.
- A double lock (5m total water level difference) at the start of waterway section through MVIP2A.
- A 3.25m lock within the Persimmon Homes area.

The outline designs for the lock structures have been included within the set of drawings in Appendix E.

The general arrangement has been adopted from the design guidelines from B&MK Waterway Trust for a one boat width lock structures. The proposed locks will be 5m wide and will have 23m clear length of the lock chambers between lock gates. Up to 10m transition wing walls have been incorporated in the outline design to connect the open aspect or wider width waterway with the 5m wide lock structure.

Each lock structure has been designed to include a foot bridge towards the downstream or deeper end of the chamber to allow for a pedestrian crossing facility. The foot bridge will provide a minimum of 3m

clear headroom above the (lower waterway side) water level in the lock chamber to allow a safe access for boats.

The outline designs and cost estimate envisage that the lock structure will be mainly built of reinforced concrete construction. Appropriate type of brick cladding will be provided where required.

The layout of the proposed towpath at the lock structures will be modified. The towpath will be set back from the lock to ensure a maximum gradient of 1 in 16 for change in level at lock structures. The proposed towpath arrangement for the outline designs is shown on the lock structure drawings.

5.1.3 Ancillary structures, other features

The outline designs only include key structures for the waterway. Other ancillary structures and features such as drainage inlets, outlets and culverts for drains, balancing ponds, any pumping arrangement to regulate flow across the lock structures, mooring bollards, mooring areas, rest areas or widening of the waterway at strategic locations, footbridges for public rights of way, any requirements for vehicle road bridges etc. will be designed at the detailed design stage. By then it is envisaged that the development plans for the adjoining areas will allow the design to be developed with appropriate details.

Existing Services

6.1.1 General

This section provides details on the existing utility services and the need for diversion of these services due to the proposed waterway route.

An initial services search was conducted (through Atkins' Ready to Dig service) to determine the known underground services (above-ground services were noted during site visits), utility services within the study area and to highlight the locations where the waterway is likely to interfere with services. Initial contacts were also made with services providers to inform them of the waterway outline designs and to obtain an estimate of the services diversion costs where required. The findings are not exhaustive and are given here for a high level assessment. Further work will be required at the detailed design stage.

The budget estimate provided by the services providers for the diversion of underground services are summarised in Table 10 below. The diversion of the above-ground assets (electricity pylons) requires further consultation with UKPN. When undertaking any detailed design and construction work the service providers should be contacted again to get further details, ascertain any changes to assets and diversion costs.

The plans showing the location of services are included in Appendix F. A brief description of these services is given in the following sections:

6.1.2 UK Power Networks (UKPN)

The services search and the site visits show that:

1. UKPN owns a substation south of Green Lane. An underground power supply from the substation appears to be feeding the overhead power line on pylons running along the northern edge of the existing ditch between Green Lane and the old A421. These UKPN assets are on the proposed waterway alignment and will need to be diverted permanently.
2. Further onward between the old and new A421, a UKPN sub-station (considered as disused) also falls on the waterway alignment and will need to be removed. The services from this substation appear to be connected to the power supply for the newly constructed underpass at new A421.
3. The UKPN overhead power line runs almost parallel to the new A421 within the study area. The waterway alignment crosses the power line alignment at numerous locations. Though there is grade separation between the two alignments, existing pylons would fall on the waterway alignment (especially through Berry Farm and MVIP1 sections). It is understood that this power line is planned to be permanently diverted away from the area. However, if it is not diverted prior to waterway construction, the location of existing pylons will need to be adjusted where required and appropriate safety measures will be required during construction to reduce the risk of cable strike by construction machinery.
4. The UKPN underground power line runs through the Fields Road embankment. These are not likely to involve permanent diversion however temporary diversion may be required during construction of the proposed underpass at this location.

6.1.3 Anglian Water

The services search show:

1. An underground water main runs along Green Lane (where an underpass is proposed for the waterway). Though a permanent diversion is unlikely to be required, temporary diversion work will be required during construction (the underpass and the cost of diversions are not included here).
2. There are three underground water mains near Fields Road. The water mains along the new Fields Road may not require permanent diversion but those along the segment of the old Fields Road alignment within the MVIP1 area will require permanent diversion (if in service).

3. There are two foul water sewers (one of these being main) passing through the Persimmon Homes area and Homeless Wood that fall on the proposed waterway alignment. However, since the waterway will be in fill, these sewers are not likely to be affected. The information on the alignment of these sewers will be useful for the detailed design and construction stage.

6.1.4 British Telecommunications (BT)

The services search shows that BT underground cables are present at three locations (Old A421, old Fields Road route through MVIP1 and through Homeless Wood for the Anglian Water pumping station) on the proposed waterway alignment. The assessment shows that:

1. The cables at the old A421 may not require permanent diversion as the proposed underpass will be set below the cable level. However, temporary diversion/ measures will most likely be required during construction.
2. The BT cables present at the old Fields Road alignment segment within MVIP1 will need permanent diversion as these are in conflict with the waterway (set below ground).
3. The BT cables for Anglian Water pumping station within Homeless Woods are unlikely to be affected as the waterway through this section will be above ground.

6.1.5 Virgin Media

The services search shows that:

1. Virgin Media underground cables run along the new Fields Road and along its old segment through the MVIP1 area. The cables at the old segment will be affected as the waterway is in cut at this location and will need permanent diversion (assuming these remain in service). The cables along the elevated Fields Road embankment may not require permanent diversion however a temporary diversion would be required during the construction of the proposed underpass.

Table 10 provides an overview of the estimated costs for diversion as provided by the services providers. As mentioned above these estimates should be treated as initial estimates (excluding above-ground diversions) to be finalised at the detailed design stage.

Table 10- Services Diversion - Initial Cost Estimates from Service Providers (April 2014)

Service Providers	**Rough Cost Estimate**	**Comments**
BT	£10,000	BT estimated as minimal costs. Allowance included
Anglian Water	£129,000.00	For Permanent Diversion works
Virgin Media	£40,876.87	
UKPN	£900,000.00	Above-ground diversion works not included
GTC	Not Affected	
Total Cost	£1,079,876,87	

Waterway Earthworks and Land Take

7.1.1 Earthworks

The earthworks (excavation and filling) will be one of the major operations for building of the new waterway. To reduce the amount of effort and environmental impacts of the operation, it is aimed that the excavated material from site will be reused to build the waterway embankments, depending on the suitability of the excavated material.

The alignment assessed at the design stage (discussed earlier) have been used with ground level data to estimate the quantity of excavation and fill requirements as per the waterway design. A three dimensional computational model in AutoCad Civil 3D® has been prepared to facilitate the assessment for the three options. At this outline stage, it has been assumed that all material excavated from the site will be suitable to be used as a fill material. This assumption needs to be confirmed through geotechnical investigations at further design development stages. Lock structures have been positioned to optimise the balance between excavation and fill.

Table 11 provides estimated quantities of excavation and fill on the overall level for the three alignment options considered. The quantities show that, in addition to other considerations discussed earlier, the preferred option provides the most favourable excavation and fill balance.

Table 11 - Cut & Fill Estimations for each option

Alignment Option	**Excavation (m^3)**	**Fill (m^3)**	**Net (m^3)**
Option 1	143,385	66,503	76,882 (surplus)
Option 2	126,461	158,194	31,733 (shortfall)
Preferred Option	148,330	147,038	1,292 (surplus)

For the preferred alignment, Table 12 provides more detailed estimates of the excavation and fill.

Table 12 – Preferred Option Earthworks Summary

			Earthworks (m^3)		
Waterway Sections	**Chainage**	**Length (m)**	**Excavation**	**Fill**	**Net**
Green Lane to old A421	0-420	420	65,788	0	65,788 (surplus)
Old to new A421	420-650	230	12,224	3	12,221(surplus)
Berry Farm	650-1010	360	31,566	0	31,566 (surplus)
Marston Vale Innovation Park 2B	1010-1450	440	2,033	31,926	29,893 (shortfall)
Marston Vale Innovation Park 2A	1450-1710	260	11,541	4,907	6634 (surplus)
Marston Vale Innovation Park 1	1710-2240	530	18,826	179	18,647 (surplus)
Persimmon Homes	2240-2830	590	6,352	47,528	41,176 (shortfall)
Bell Farm 1	2830-3360	530	0	62,495	62,495 (shortfall)
Total		**3,360**	**148,330**	**147,038**	**1,292 (surplus)**

7.1.2 Land Take

The following table identifies the total footprint (two-dimensional, plan area) along with individual footprints for each landowner for the preferred option.

Table 13 - Footprint Comparison for each option

Current Ownership	Area (sq.m)
Bedford Borough Council	58,058
Marston Vale Trust	13,661
Anglian Water	5,131
Persimmon Homes	27,999
WRG	15,983
Belmont	1,507
Highways Agency	5,453
British Agricultural Services Ltd	3,039
O&H	9,586
TOTAL	**140,417**

7.1.3 Earthworks and Implementation Strategy

The earthworks strategy has been guided by the aim of reducing environmental and third party risks. The waterway has been designed with the aim of using excavated material from proposed works for building of the proposed waterway embankment. With the preferred design option, if the excavated material is found to be suitable (after geo-environmental and geotechnical investigations), a minimal quantity of surplus material (less than 1% of total excavated material) would be available for use elsewhere. It is envisaged that this surplus material would be used within the site boundary for creating landscape features and for raising any local lower areas.

Three scenarios for waterway implementation have been assessed. The ecological risks and opportunities for these three scenarios have been discussed in detail separately in the following sections. Following is a short description of these scenarios from a general engineering and construction perspective.

The preferred scenario will be selected in consideration of the ecological risks and opportunities in addition to this.

7.1.3.1 Scenario 1 – Do nothing in the interim, construct the waterway in a single phase in future

This scenario considers demarcation of the waterway footprint at this stage (after land agreements with third party land owners) and considers that the construction work will be undertaken in future in a single phase when the funding and other agreements are in place.

This scenario will involve no immediate earthworks or an interim form of the waterway. In future when the waterway is constructed, the excavated material (subject to its suitability) will be used to build waterway embankments along the length without the need for storage of material. Waterway structures and facilities along the length will be built in a single phase and are likely to be of consistent design and operational requirements.

Though this scenario is workable and, from construction point of view, could be a more streamlined scenario, it does not take into account constraints on availability of funding and programmes for the development of areas along the proposed waterway alignment (where waterway development would be an integral component of the area development). In contrast to this scenario, a staged development programme is more feasible and likely to be implemented on the ground.

7.1.3.2 Scenario 2 – Staged construction (dry ditches).

This scenario envisages staged construction of the waterway. It assumes that before a fully connected waterway is achieved, the waterway sections will be excavated as a series of dry ditches as an interim form. This scenario would leave the existing drainage system intact and the excavated material will be stockpiled with due regard to existing drainage systems along the alignment (for fill sections – subject to material suitability) where the material will be used for future waterway embankments.

Under the overall strategy of reusing excavated material on site, this option will require that a number of waterway sections are available to allow stockpiling of the excavated material for future use. Consents for storing material in the floodplain will be required from the IDB / Environment Agency and the excavated ditches and stockpiles will be need to be managed to reduce risks for general public and to the ecology or wildlife.

This scenario provides a more practical approach, allowing a staged strategy for implementation and is recommended as the preferred option.

7.1.3.3 Scenario 3 – Staged construction (wet ditches).

This scenario is similar to the previous scenario however it assumes that before the fully connected canal is completed, the waterway sections will be excavated as a series of wet ponds as an interim form. The excavated sections will be connected to local drainage and interconnected where possible. Similar to Scenario 2, this scenario will require availability of other route sections which are proposed to be in fill or other storage areas to allow stockpiling of the material.

Ecological Assessment

The waterway design study has included an ecological assessment of the proposed waterway route in general and a specific assessment of the three implementation scenarios. The assessment has been based on existing records (through a desk study) and through ecological field surveys.

This section of the report provides a summary of the ecological assessment. The detailed assessment is provided in Appendix G.

8.1 Proposed Alignment General Risk

8.1.1 Desk Study

The desk study has been based on available aerial photos, historical records of presence of protected species and notable wildlife on National Biodiversity Networks (NBN) Gateway, Multi-Agency Geographic Information for the Countryside (Magic) website (www.magic.gov.uk) and previous ecological studies.

The study has shown that there are no Sites for Special Scientific Interest (SSSI) or Local Nature Reserves located within or immediately adjacent to the proposed route. The desk study identified a number of GCN records for ponds within 500m of the proposed waterway. No badger records are shown on the NBN Gateway however the Environmental Statement for the A421 road improvement scheme identified a number of setts, but the exact locations are currently unknown as this detailed information was not available. Similarly there are no bat records for within 2km either side of the proposed route. The records show that there are common lizards from areas of gravel/sand extraction at Stewartby and Kempston Hardwick, whilst grass snakes have also been recorded near to Kempston Hardwick. There are no adder or slow-worm records for within 2km of the proposed waterway route. There are no records of water voles for any ponds or watercourses within 2km of the proposed waterway route. The long linear pond adjacent to the Stewartby landfill site has potential to support this species.

8.1.2 Field Surveys

The route of the proposed B&MK Waterway was walked in April 2014. Existing habitats were mapped and notes were made on dominant species and structure in order to assess their potential to meet criteria as BAP habitats, support protected or notable plant species.

Amphibians

The existing attenuation ponds within and around the site area were assessed for their suitability for supporting Great Crested Newts (GCNs) using the GCN HIS (Habitat Suitability Index) methodology. The survey revealed that a number of ponds near Stewartby Landfill (2 south of landfill site and one along it) support good to excellent habitat suitability for GCN. Similarly the pond in Van Diemen's land and strategic attenuation reservoir support average to excellent GCN habitat.

Badger (Meles meles)

Aerial photos (Bing Maps) show that areas of potential foraging and refuge habitat (e.g. permanent grassland and plantation woodland) exist within or adjacent to the proposed waterway. Disturbance of existing setts (noise, vibration or physical damage) would be an offence under the Protection of Badgers Act 1992. No badger setts were discovered along Chainage 0m to 2800m, but access into the scrub woodland by the sewage works (Chainage 2830m to 3120m) was not possible. Such habitat provides ideal cover for a badger sett especially as it is located immediately adjacent to areas of permanent grassland, which is a favoured foraging habitat for animals hunting earthworms. No obvious well-worn paths were noted around the edge of the woodland.

Bats

A number of bat species such as common pipistrelle (Pipistrellus pipistrellus), Daubenton's (Myotis daubentonii) and soprano pipistrelle (P. pygmaeus) readily forage within riparian habitats including over

rivers. Bats and their roosts receive full protection under The Wildlife and Countryside Act 1981 (as amended) and The Conservation of Habitats and Species Regulations 2010 (as amended).

Chainage 0m – 350m

Along existing linear pond. The banks are very steep and support dense scrub, dominated largely by hawthorn with frequent bramble and dog rose. At the eastern end of the linear pond, there is a rookery with an area of hybrid black poplars and some semi-mature sycamore, hawthorn and field maple. The majority of the trees support no suitable roosting niches but the hybrid black poplars contained some cavities and have the potential to support bats. The scrub habitat provides optimal foraging habitat, especially where it is growing along the banks of the linear pond.

Chainage 650m – 1650m

This section of the canal passes adjacent to or through the area of Berry Wood that was planted between 1991 and 1994. Due to the young age of the trees, very few roosting niches are likely to be present. However, the woodland and grassland rides provide excellent commuting and foraging habitat.

Chainage 2820m – 3200m

This section of the canal as proposed would require the removal of trees and scrub within an area of plantation woodland and adjacent to the sewage works. In addition, an area of woodland and grassland (including some remnant ridge and furrow) that is part of the Bedford Green Gateway will be directly affected by the existing proposed route. The community woodland was planted between 2001 and 2007 and as such, the trees are immature and support no suitable roosting niches. The trees do however provide suitable commuting and foraging habitat.

Otter

Otter and their places of shelter receive full protection under relevant wildlife legislation. No otter holts or resting sites were observed along the proposed route of the canal where access was possible. Due to the steepness of the banks along the long linear pond by the Stewartby landfill site, it was not possible to inspect the banks to confirm absence of field signs and holts. Some pioneer clearance may be required to allow an accurate survey. Given that Stewartby Lake supports a good stock of fish it is likely that otter may periodically visit the lake to feed, whilst animals may visit other fishing lakes, ponds or drains that support fish or amphibians in the locality.

Water vole (Arvicola amphibius)

Water vole and their places of shelter receive full protection. Any temporary disturbance of bank side habitat (e.g. temporary crossings for access etc.) could impact water vole. Conservation licences granted by Natural England are required to use traps to relocate water voles to facilitate development.

A number of ditches were inspected along the route and none of them supported suitable habitat. The long linear pond P14 supports suitable habitat and is close to Stewartby Lake which supports suitable habitat. It was not possible to survey it safely from the bank due to the steep banks and extensive scrub growth. Any future works to widen or re-profile the banks would need to consider the potential for water voles and a boat based survey combined with use of floating platforms would seem the most sensible approach. The new attenuation pond AP2 will provide suitable habitat in time should there be any colonies locally which could colonise them.

Birds

No suitable trees were identified that could support nesting or roosting barn owl, whilst no fallen trees or vertical banks were noted that currently support nesting kingfisher. A large rookery is present with some mature hybrid black poplars at the eastern end of pond P14 (NGR TL0095043282). Given the current proposed alignment of the waterway, these trees would require felling. Should the current waterway alignment remain any future tree felling would need to be undertaken outside of the main bird breeding season (March to August inclusive) if the rookery remains active.

Habitats

An area of ridge and furrow exists within a field from Chainage 3330m which is outside the scope of the existing works for which CH2M HILL have been commissioned to provide design services etc. Ridge and furrow is an important feature both archaeologically and ecologically (can support diverse plant communities) which has been lost from large areas of the country and amending the route by moving it into the area of permanent grassland to the west should be given due consideration.

In addition to the ridge and furrow, the section of the proposed waterway from Chainage 2830m to 3120m will require the removal of woodland and scrub habitat. The adjacent area of grassland to the north looks like it may have been arable farmland in the not too distant past and consideration should be given to moving the route north and retaining the woodland scrub. This would have some added benefits through reduced risk of trees falling into the canal.

Non-native invasive plant species

No Schedule 9 plant species were recorded along the proposed canal route. A further inspection of the working area is recommended prior to works commencing should works not occur for an extended period of time.

8.1.3 Option Appraisal

The following three intermediate scenarios for waterway implementation have been assessed for the ecological implications for a future fully linked waterway:

Scenario 1 Do Nothing

Under this scenario the proposed waterway corridor (c. 60m wide) will be left unaffected until the entire scheme is constructed in one phase i.e. leave the footprint at existing ground level.

This scenario is likely to have no direct ecological impacts (e.g. physical harm) on protected species such as GCNs as there would be no construction works. If the proposed route was left unmanaged, there is the potential for protected species such as GCNs (and common amphibians), badgers and common reptiles (especially grass snake) to colonise. The greatest risks are in areas of arable farmland which are currently of limited value for wildlife due to regular cultivation. Colonisation by GCNs in particular could have significant cost implications should European Protected Species Mitigation (EPSM) licences be required to remove animals from along the route via the use of exclusion fencing and pitfall traps. In addition, badgers could potentially excavate setts.

A negative aspect of not undertaking the piecemeal development of the route in advance of linking the various sections (as opposed to constructing it all in one go) relates to the potential biodiversity benefits that would be lost. A water filled section of channel would have significant biodiversity benefits for amphibians, birds, bats, aquatic invertebrates and plants, otter, grass snake, water voles etc. In addition to loss of biodiversity benefits, there would be recreational benefits should sections close to the Grand Union Canal or Great Ouse.

Scenario 2 Excavate Dry Sections

This scenario would leave the existing drainage system intact and the cut sections of canal left dry. The excavated material will be stockpiled along the alignment (for fill sections) where the material will be used for future waterway embankments.

Construction Phase 1

The construction phase of excavating sections could directly impact upon wildlife inhabiting the areas affected. Species at greatest risk would be GCNs as there are several ponds where they have been recorded that are located within 1km of the proposed route. Other species as identified within baseline surveys undertaken prior to securing planning permission may also be affected. The arable fields supported several nesting skylark during the site walkover.

Post Construction (prior to linking sections)

The excavation of the channel could result in the loss of habitat used by wildlife for refuge (including hibernation) and for breeding (e.g. nesting birds or potentially breeding GCNs). Excavating dry sections of canal (if practically feasible given the channel will be 2m deep) could also affect the movement of wildlife if the sides of the channel were excavated with steep sides. As long as the channels are excavated with gently sloping sides (e.g. 1:3 slope) then trapping of wildlife would probably be low risk such that fencing would not be required. However, issues can arise if the base of excavations become waterlogged such that deer and small mammals can become trapped (C. Whiting pers. obs.).

Dry excavations that are allowed to become vegetated with scrub would be attractive to badgers (e.g. excavation of setts). Stockpiled material could also be used by badgers for excavating setts if it becomes well vegetated and is not subject to regular disturbance.

Depending on timescales for sections being connected and the entire waterway being connected to the Great Ouse and the Grand Union Canal, habitats could develop that are attractive to wildlife, e.g. rough grassland with scrub would support amphibians, reptiles, breeding birds etc.

Newt and reptile fencing could be used to prevent GCNs and common amphibians and reptiles from entering sections of the proposed route, but the effectiveness of this in Milton Keynes for example has been poor (Chris Damant, pers. comm.) for the following reasons:

- Maintenance of the fencing is important and expensive and is seldom done effectively. Sites are often left undeveloped for several years after clearing them of GCNs under licence and without management fencing will deteriorate or be deliberately vandalised so that GCNs recolonise sites;
- EPSM licence are secured by staff that then leave companies and the licence is not taken up by someone else; and
- Fencing can also provide suitable conditions for overwintering GCNs and other newts such that EPSM licences may need to be amended to allow the safe removal of GCNs when the fencing is removed.

Depending on timescales for works commencing, to minimise biodiversity value and hence the cost of mitigation, the proposed route including material stockpiles should be kept bare by repeated herbiciding or cultivation (e.g. ploughing, harrowing etc.). However, this method would have associated cost and potential environmental risks. Spraying if undertaken close to watercourses or ponds could affect aquatic flora and fauna whilst soil runoff could cause turbidity and potentially eutrophication which would impact upon water quality.

A negative aspect of not undertaking piecemeal development of the route relates to the potential biodiversity benefits that would be lost. A dry section of channel would have some biodiversity benefits for invertebrates (e.g. bees, potter wasps etc.) depending on the underlying soils, whilst plant communities would tend to be fairly weedy unless sown with a wildflower seed mix and managed specifically to develop a diverse sward. Areas of rough grassland would provide suitable habitat for common reptiles.

Scenario 3 Excavate Wet Sections

Construction Phase 1

As for Scenario 2 the construction phase of excavating sections could directly impact upon wildlife inhabiting the areas affected including haul routes and compound areas. Species of greatest risk would be GCNs as there are several ponds where they have been recorded that are located within 1km of the proposed route. For sections where GCNs already exist, an EPSM licence would be needed to cover the initial construction period.

Post Construction (prior to linking sections)

The completed sections of waterway could have significant positive impacts for biodiversity which in turn could have negative impacts for project costs and programme.

A major positive impact would be the biodiversity benefits for species associated with the creation of water bodies, e.g. amphibians, birds, bats, aquatic invertebrates and plants, otter, grass snake, water voles etc. As there are numerous ponds that support GCNs, it is possible that some of the excavated sections could become colonised by GCNs which would be considered a major positive impact on the species. However, colonisation by GCNs would have cost implications associated with the need to remove animals under an EPSM licence with significant exclusion fencing costs etc.

The risk of colonisation is time and distance (to existing GCN ponds) dependent. The section of the waterway adjacent to Berry Wood (Chainage 650m – 1650m) is located relatively close to existing GCN ponds and the risk is greater here given the woodland and grassland habitats that have been created.

Should GCNs colonise the completed sections, there would be a legal requirement to secure a further or amend an existing EPSM licence from Natural England to allow the removal of any animals within the proposed working corridor prior to linking completed sections. Should significant GCN breeding populations establish within completed sections there is the potential that Natural England may request the creation of compensatory breeding ponds as the completed waterway will result in the introduction of fish that can predate the various life stages of GCNs. Consultation with Natural England will be required to discuss issues regarding licensing should Scenario 3 be the preferred option.

Newt and reptile fencing could be used to prevent GCNs and common amphibians and reptiles from entering sections of the proposed route, but the effectiveness of this in Milton Keynes for example has been poor (Chris Damant, pers. comm.) for the following reasons:

- Maintenance of the fencing is important and expensive and is seldom done effectively. Sites are often left undeveloped for several years after clearing them of GCNs under licence and without management fencing will deteriorate or be deliberately vandalised so that GCNs recolonise sites;
- EPSM licence are secured by staff that then leave companies and the licence is not taken up by someone else; and
- Fencing can also provide suitable conditions for overwintering GCNs and other newts such that EPSM licences may need to be amended to allow the safe removal of GCNs when the fencing is removed.

A negative impact of excavating sections of the waterway and then connecting them all at a later date (as opposed to constructing it in one go) is that disturbance impacts are greater. A piecemeal approach to the delivery of the waterway has the potential to fragment populations. With different parties potentially delivering sections of the waterway, the risk of fragmentation of populations is increased. A strategic master plan covering ecological mitigation for the entire route is required to maximise biodiversity benefits from the project.

Preferred Scenario

Scenario 1 Do Nothing

This is the cheapest and lowest risk option with respect to protected species but would not show any intent or deliver progress with the project, whilst limited biodiversity benefits would be delivered.

Scenario 2 Excavate Dry Sections

Underlying geology and topography would determine whether the excavations could remain dry without the need for pumping. If the waterway was excavated within sands and gravels there could potentially be issues regarding the waterway holding sufficient water unless clay was used to create a seal. Water filled channels will be more attractive to GCNs than a dry ditch. Mitigation costs for protected species could be high and biodiversity benefits relatively low.

Scenario 3 Excavate Wet Sections

This scenario could deliver high biodiversity benefits whatever the timescale but potentially high/unknown future mitigation costs.

Estimated Construction Costs

A construction cost estimate has been developed for the preferred waterway design option. It is based on unit rates from other similar projects (costs updated in line with inflation to 2014 prices) and researching costs of typical components from suppliers.

Table 14 below gives the estimated construction costs for the key components of the waterway design. Detailed costing and working sheets are included in Appendix H.

The "Miscellaneous" included in the estimate encompasses the costs for services diversion, balancing ponds/pumping arrangements for the system, and any other costs not covered by the other categories.

Table 14- High Level Construction Cost Comparison

Waterway Components	**Unit**	**Quantity**	**Total Cost (£)**
Open aspect waterway	m	2,660	2,205,353
Vertical sided waterway	m	700	2,889,110
Earthworks	Total	-	2,312,569
Locks	Total	-	2,430,025
Underpasses	Total	-	1,276,046
Miscellaneous	Sum	-	3,069,877
		Contingency/optimism bias	4,257,894
		Grand Total	**18,450,873**

Conclusion & Recommendations

10.1 Conclusions

This study concludes that:

1. A number of options have been assessed for the outline design of B&MK Waterway route from Green Lane to Wootton area of Bedford Borough Council. The preferred, deliverable option has been selected in accordance with the key constraints and achieving an optimal arrangement of structures and earthwork excavation and filling.
2. The proposed preferred route alignment has also been surveyed and studied from an ecological risk and opportunities point of view. The findings suggest that the local ecology supports wildlife habitat of protected species. Waterway construction is likely to impact on the habitat of these species. Further surveys and mitigation measures will need to be developed before construction to reduce these risks.
3. The waterway route passes through different ownership boundaries along its length. The waterway will take a total of circa 14ha of land from different landowners along the proposed route.
4. The proposed waterway route will occupy land owned by British Agriculture Services Limited (0.3ha), WRG (1.6ha), Belmont (0.1ha), Highways Agency (0.5ha), Bedford Borough Council (5.8ha), Persimmon Homes (2.8ha), O&H (0.9ha), Anglian Water (0.5ha) and Marston Vale Trust (1.4ha).
5. All landowners have been provided with the proposed waterway plans and longitudinal sections and where appropriate, alternative design options have been developed, for example in consultation with WRG to reduce impact on Stewartby Landfill site. Further development of such alternative options will be discussed at the detailed design stage.
6. The waterway will comprise a predominantly open aspect waterway (2.6km) and some vertical hard sided sections (0.7km) with a total length of circa 3.4km. The waterway will include 2 no. single lock structures, a staircase lock and 2 no. new underpass structures within the designed reach.
7. Services searches have revealed that a number of services will need to be diverted for the waterway. Consultation with the services providers has been undertaken and where applicable, initial estimates for services diversion have been obtained.
8. Three approaches to waterway implementation have also been assessed from engineering and ecological points of view. These will be further discussed within the Bedford Borough Council team to select a preferred scenario.
9. It is estimated that the construction of the preferred option will cost c. £18.5million.

10.2 Recommendations

This report recommends that:

1. Due to the varied topography through the study area, water resource for supplying this section of waterway is a key consideration for further study. With a head difference of up to 7 metres from one end of the study area to the other, and hence a summit pound near the southern end, it is clear that a pumped water supply will be required. A potential option would be to source water from the IDB reservoir (Woburn Road Wetlands), or Stewartby Lake, however these arrangements would need an agreement in place with the IDB. Supply could be based on a closed loop system, with an equivalent amount of water returning to the reservoir, either from the Bell Farm site, or further upstream from the Berry Farm site.
2. Other potential water sources (including using the IDB arterial watercourses which intersect the waterway through the study area) will need to be assessed.
3. A further, more detailed study on water resourcing is required, with a more holistic approach being considered, in association with other reaches of the waterway.

10.3 Others

Further consideration in due course of the following aspects is recommended:

1. Studies of the archaeology of the area, flood risk assessment and mitigation measures.
2. Assessment of the geology, ground water and geo-environmental risks
3. More detailed consultation with all stakeholders (Marston Vale Trust, Environment Agency, Bedford Group of Internal Drainage Boards, other landowners and other owners of utility infrastructure potentially affected)