TECHNICAL REPORT

Oxford Flood Alleviation Scheme: Multi-Criteria Options Appraisal

Prepared for

Environment Agency

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CH2M
Burderop Park
Swindon
SN4 0QD

Contents

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Executive Summary

1.1 Introduction

The report entitled *'Channel Corridor Options Report, November 2015'* identified various options for the potential corridors to form the western bypass flood channel around the western side of Oxford. The *Channel Corridor Options Report* divided the scheme into seven areas as shown on Figure 1 and then proposed three to four options in each area.

This report presents a Two-Phase Options Appraisal process for determining an optimised preferred option for the Western Conveyance Channel that is equally balanced across the five principal objectives used to evaluate the scheme, namely; economic, social, technical, environment, and institutional objectives.

1.2 Overview of Multi-Criteria

The criteria on which to assess the various options was developed by the CH2M technical specialists based on published flood risk guidance and the use of similar approaches on other schemes. It was then tailored to suit the specific requirements and objectives of the Oxford Flood Alleviation Scheme whilst trying to keep the process as simple and transparent as possible.

Consultation within the team then identified the key parameters within the sub-objectives which underpin the review. These parameters are not designed to be a comprehensive list of every topic which could be reviewed but include the key parameters that are representative of each of the sub-objective and likely to create a differentiation between options. Table 1 outlines the principal objectives and the sub-objectives.

1.3 Two-Phase Options Appraisal Process

The adoption of the Two-Phase Options Appraisal process enabled a progressive approach for determining a final Preferred Corridor that was equally balanced across all five Principal Objectives of the scheme. This allowed an initial ranking of options based on socio-environmental criteria, this also ensured the best option was chosen which not only delivers flood risk management benefits but also other benefits required by the various stakeholders.

All objectives were evaluated individually for each area with the exception of the Economic Objectives. The evaluation of the Economic Objectives cannot be appraised exclusively for each individual area as the hydraulic modelling will only show significant flooding benefits if the combined options are included in the hydraulic model.

Therefore the second phase of the assessment process was developed to allow combinations of the options for each of the scheme areas to be assessed as overall scheme options, this links in with the recommendations of the Strategy to investigate different channel sizes.

1.4 Summary of First-Phase Appraisal

The detailed appraisal tables for the seven areas are included in Appendix B. Following the First-Phase appraisal review based on socio-environmental aspects the Preferred Options and Sub-Preferred Options has been identified for each area. These are summarised in the table overleaf.

	Preferred Option	Sub-preferred Option
Area 2	Option 2D - Existing channel retained and second stage on farmland upstream of pylon	Option 2C - Existing channel retained and second stage on farmland downstream of pylon
Area 3	Option 3A - New 2-stage channel	Option 3D - New 2-stage channel with a series of offline ponds/lakes
Area 4	Option 4A - New single 2-stage channel	Option 4B - New two 2-stage channels
Areas 5&6	Option 5B&6C - New 2-stage channel and returning upstream of Sandford Lane	Option 5B&6B - New 2-stage channel and returning downstream of Sandford Lane
Area 7	Option 7C – New constrained channel across Iffley Meadow	Option 7B – New 3 culverts through Donnington Bridge Road

Table E1 - Table of Preferred Corridors at First-Phase Appraisal

1.5 Options development during the Second-Phase

One of the early outcomes from the hydraulic and economic analysis was the decision to omit Areas 5&6 and Area 7 from the scheme. The modelling results showed that a greater amount of flood risk reduction could be achieved by proposing alternative options at other areas upstream of Areas 5&6 and Area 7.

The omission of Areas 5&6 and Area 7 triggered a review of alternatives to try and provide additional flood risk reduction to the New Hinksey and Grandpont areas of Oxford. A review on the introduction of raised defences at various locations was carried out to determine the optimal alignment of the raised defences. A summary of this review is provided in Appendix E.

The design development in Area 1 progressed following the determination of the Preferred Corridor. The objectives of the design were; to maximise the conveyance capacity through Botley Bridge by deepening the channels through the bridge, and to protect the properties to the north of Botley Road by introducing a flood bund to the north of the area.

All of the options in the First-Phase Appraisal proposed channel widening works at the railway bridge on the A423 Southern By-pass to improve the flow conveyance. A buildability review on the widening design concepts raised numerous feasibility and safety concerns associated with working beneath a railway bridge and resulted in abandoning the widening works. Consequently, alternatives were considered and the optimum alternative for increasing the conveyance through A423 was found to be the introduction of jacked box culverts on either side of the rail bridge.

1.6 Summary of Second-Phase Appraisal

The preferred corridor was created by amalgamating the preferred options in each area which were determined from the First-Phase Appraisal process. The preferred corridor was then hydraulically and economically modelled to determine the optimal size of the preferred channel corridor (Optimised Preferred Corridor) with respect to the Economic and Social (flood risk) Objectives.

- Option 1 – Do Nothing
- Option 2 – Do Minimum
- Option 3 – Raised Defences only
- Option 4a - Small channel on its own
- Option 4b - Small channel with raised defences
- Option 5a - Medium channel on its own

- Option 5b - Medium channel with raised defences

Options 1 and 2 are baseline options for comparison and did not feature in the assessment. Option 3 is a fall back option. The assessment undertaken focused on the channel options as Options 4b and 5b include all the raised defence from Option 3 as wider integrated solutions. A large channel was found to be physically impractical to construct primarily due to the constraint on the culvert sizes through Botley Bridge and Old Abingdon Road.

A summary of the Phase 2 assessment is included in Appendix G. The results showed that Option 5b outperformed the other three options on all parameters. The results also indicated that Option 5b is the Optimised Preferred Corridor which would give the most flood risk benefits within the study area whilst providing the opportunity to achieve all the other objectives for the scheme.

Therefore, it is recommended that Option 5b from the Phase 2 assessment is taken forward as the preferred route corridor to outline design and onto the Outline Business Case. An outline of this route appears in the figure below.

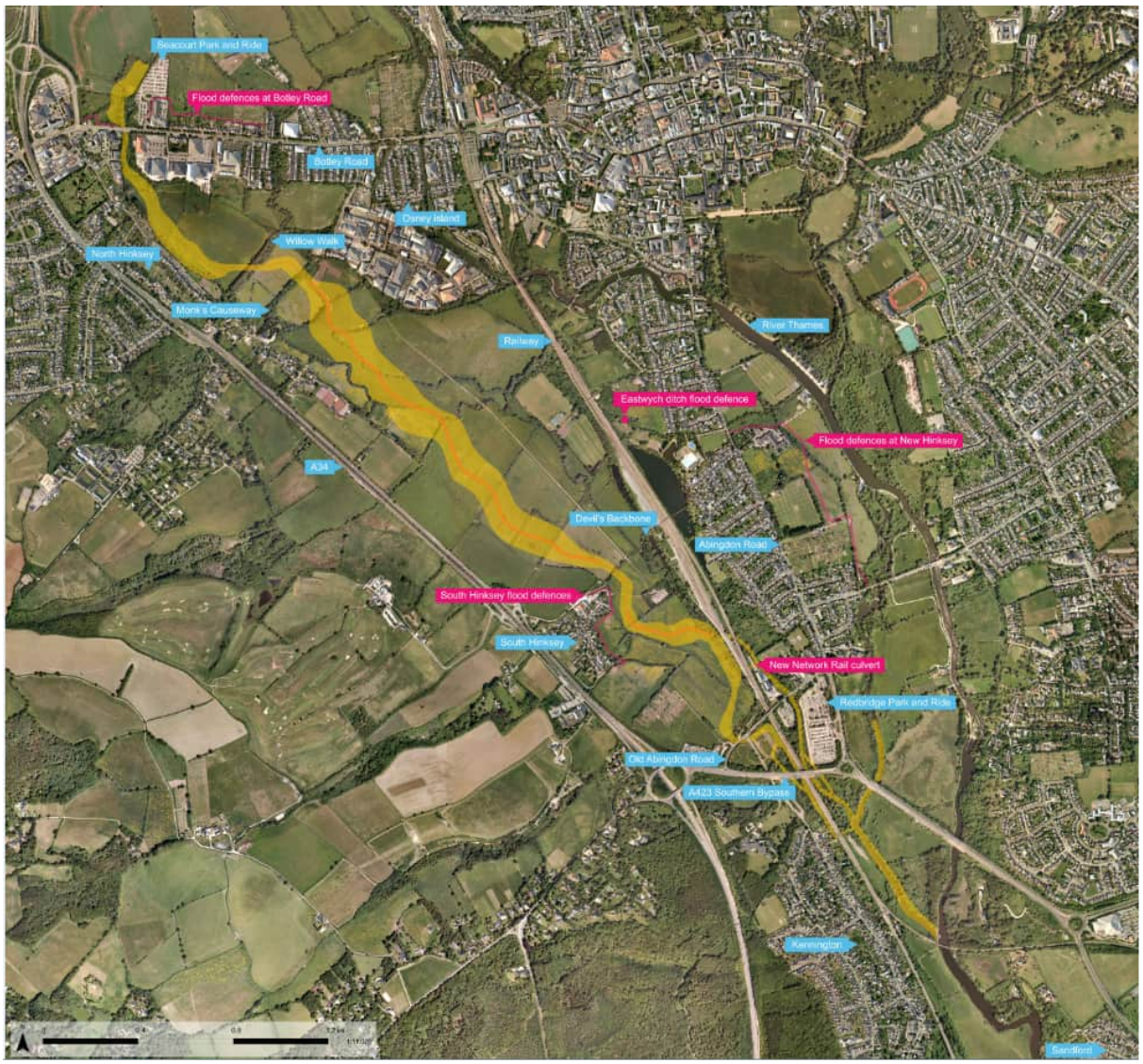


Figure E1 – Recommended Route Corridor

Introduction

2.1 General

The report entitled 'Channel Corridor Options Report, November 2015', hereinafter referred to as the Options Review Report, identified various options for potential corridors to form the western bypass flood channel around the western side of Oxford. The Options Review Report divided the scheme into seven areas as shown on Figure 1 and then proposed three to four options in each area with the exception of Area 1 where there were no separate options proposed, and Areas 5&6 which were merged.

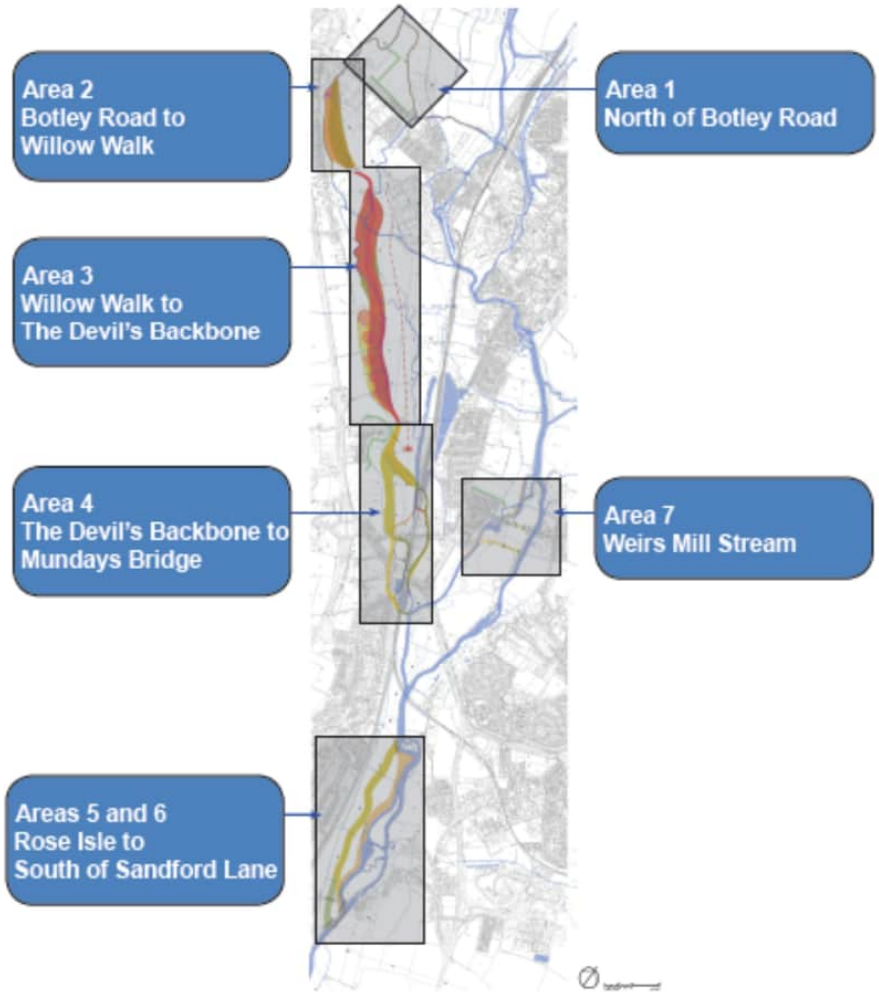


Figure 1 - Seven Study Areas at First-Phase Appraisal

Following on from the Options Review Report, this report presents a Two-Phase Options Appraisal process for developing an optimised preferred option for the Western Conveyance Channel that is equally balanced across the five principal objectives used to evaluate the scheme, namely; economic, social, technical, environment, and institutional objectives.

The Two-Phase process comprises the First-Phase wherein the preferred option is determined based on the social (excluding flood risk), technical, environmental, and institutional objectives. The resulting preferred option is then taken to the Second-Phase wherein it is optimised to meet the economic and social flood risk objectives to identify the preferred option which will be taken forward for design.

2.2 Background

Previous stages of the project undertook a detailed strategic appraisal of a whole range of technical solutions to flood risk management in the Oxford area. This culminated in the publishing of a Strategy in September 2010 which has since been verified by an Initial Assessment study. Subsequently, the Strategic Outline Case (SOC) was published in November 2014.

This stage of the project develops the recommendations of the previous studies which proposed the use of the flood conveyance channel through the western flood plain around Oxford. The current project does not revisit any of the previous decision points but adds more detail to the recommended option to develop the outline design and produce the Outline Business Case.

The SOC document outlined the Investment Objectives and the Critical Success Factors for the scheme. This options appraisal report used the same approach as outlined in the SOC. However the terminologies used herein are slightly different (nevertheless, parallel to the SOC) to enable a more detailed evaluation to be undertaken.

The work since the Strategy and the Initial Assessment stage has focused on gathering more detailed information on the area and reviewing the technical challenges to implementing the new conveyance channel. This resulted in the identification of a number of corridor options for each of the seven areas covered by the scheme. This options appraisal reviews the options via a number of socio-environmental criteria to select the optimum corridor option for each area which can be taken forward as a preferred option to the next stage of the scheme.

Overview of Multi-Criteria

3.1 Selection of the Multi-Criteria

There are a number of guidance documents published by the government for undertaking a multi-criteria analysis for options assessment. The key relevant documents are;

- *Multi-criteria analysis: a manual*. Published by the Department for Communities and Local Government in April 2013.
- *Integrating Cost-Benefit Analysis and Multi-Criteria Analysis of Flood and Coastal Erosion Risk Management Projects - R&D Project Record FD2018/PR2.* Published by the Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme in April 2005.
- *Evaluating a multi-criteria analysis (MCA) methodology for application to flood management and Coastal defence appraisals. Guidance for the MCA-based element of the current approach to appraisal - R&D Technical Report FD2013/TR.* Published by the Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme in November 2004.
- *Flood and Coastal Erosion Risk Management: Economic Valuation of Environmental Effects*
- *HANDBOOK for the Environment Agency for England and Wales.* Published by Eftec and Revised March 2010.

These documents provide a framework of guidance for undertaking multi-criteria analysis within the context of flood risk management projects. Whilst they provide guidance there is also an element flexibility in the processes to account for the diverse variability in the nature of flood risk management schemes.

The multi-criteria approach chosen encompasses the five objectives for the scheme, namely; economic, social, technical, environmental, and institutional. Within each objective, three sub-objectives have been identified to cover the topic areas within the scheme. These sub-objectives have been chosen to be mutually exclusive and to avoid overlaps between categories and the risk of any double counting.

The criteria on which to assess the various options has been developed by the CH2M technical specialists based on published flood risk guidance and the use of similar approaches on other schemes. It was then tailored to suit the specific requirements and objectives of the Oxford Flood Alleviation Scheme whilst trying to keep the process as simple and transparent as possible.

Consultation within the team then identified the key parameters within the sub-objectives which underpin the review. These parameters are not designed to be a comprehensive list of every topic which could be reviewed but include the key parameters that are representative of each of the sub-objective and likely to create a differentiation between options. Table 1 overleaf outlines the principal objectives and the sub-objectives.

	PRINCIPAL OBJECTIVES Sub-Objective
1	**ECONOMIC OBJECTIVES**
1i	Reduce the risk of floods impacting on infrastructure
1ii	Reduce the risk of flooding to commercial properties
1iii	Maximise the Net Present Value
2	**SOCIAL OBJECTIVES**
2i	Reduce the risk of flooding to residential properties
2ii	Improve landscape opportunities
2iii	Improve recreational opportunities
3	**TECHNICAL OBJECTIVES**
3i	Minimise engineering risks
3ii	Minimise infrastructure and services disruption
3iii	Safeguards health and safety in buildability and maintenance
4	**ENVIRONMENTAL OBJECTIVES**
4i	Improve ecological opportunities
4ii	Accords with WFD assessment
4iii	Keep environmental impact to acceptable levels
5	**INSTITUTIONAL OBJECTIVES**
5i	Provides Benefits and Minimises Impact on Interested Parties
5ii	Potential policy / legislative conflicts or conforms with wider planning outcomes
5iii	Provide opportunities for partnering/funding

Table 1– Outline of the Principal Objectives and Sub-Objectives

Two-Phase Options Appraisal Process

4.1 Overview of the Two-Phase Options Appraisal Process

The adoption of the Two-Phase Options Appraisal process enabled a progressive approach for determining a final Preferred Corridor that was equally balanced across all five Principal Objectives of the scheme. This allowed an initial ranking of options based on socio-environmental criteria, this ensured the best option was chosen which not only delivers flood risk management benefits but also other benefits required by the various stakeholders.

All Principal Objectives were evaluated individually for each area with the exception of the Economic Objectives. The evaluation of the Economic Objectives cannot be appraised exclusively for each individual area as the hydraulic modelling will only show significant flooding benefits if the combined options are included in the hydraulic model.

Therefore the second phase of the assessment process was been developed to allow combinations of the options for each of the scheme areas to be assessed as overall scheme options, this links in with the recommendations of the Strategy to investigate different channel sizes.

The approach outlined below summarises the Two-Phase Options Appraisal Process:

First-Phase	Phase 1A	• Appraise all options in each area against Environmental, Social (excluding flood risk), Technical, and Institutional Objectives. • Identify the Preferred Option in each area with respect to Environmental, Social (excluding flood risk), Technical, and Institutional Objectives. • Identify Sub-preferred Option in each area with respect to Environmental, Social (excluding flood risk), Technical, and Institutional Objectives.
	Phase 1B	• Integrate Preferred Options + Sub-preferred Options. • Identify Preferred Corridor based on combining the respective Preferred Options and Sub-preferred Options in each area.
Second-Phase	Phase 2	• Hydraulic and Economic modelling of the Preferred Corridor to analyse channel sizes and standards of protection, confirm the effectiveness in reducing flood risk to properties and infrastructure, and costs + economic attractiveness. Completed options appraisal. • Produce Optimised Preferred Corridor.
	Gateway	• Does the Optimised Preferred Corridor meet the flood risk and economic targets? – If No, check sub-preferred options in further detail – If No, abandon the Western Conveyance Channel concept and develop alternative options – If yes, proceed to outline design and Outline Business Case.

Table 2– Outline of the Two-Phase Options Appraisal Process

4.2 First-Phase Options Appraisal

The objective of the First-Phase Options Appraisal was to discount the unfavourable options within the areas in respect to Environmental, Social (excluding flood risk), Technical and Institutional Objectives; and to reduce the different possible permutations of the overall preferred corridor. The outcome from the First-Phase Options Appraisal was the determination of a preferred corridor consisting of the preferred and sub-preferred options in each area.

4.2.1 Application of the assessment criteria in the First-Phase

The scheme has been split down into seven specific areas (as shown on Figure 1) and there are a number of options in each of these areas. The areas were chosen such that the options within each of the areas are mutually independent from a hydraulic aspect, with the exception of Area 5 and Area 6. Each area was subject to a separate review process and the options were assessed in relation to the best opportunities for that area.

Once the appraisal of each option against the Sub-Objectives had been carried out in Phase 1A, a five-point scoring system was applied against the relative performance of each option. The relative five-point scoring system ranges from 'highly++ positive' to 'highly-- negative' in the following order: **High++ (5)**, **Medium+ (4)**, **Low/Neutral (3)**, **Medium - (2)**, and **High—(1)**.

The appraisal process was undertaken by the relevant technical specialists based on their knowledge and understanding of the scheme and the areas. The use of any specific specialist goal planning software was not utilised as these do not pick up the nuances of individual scheme and can give odd results. The options were chosen to avoid the likelihood of 'sudden death' criteria which would prevent an option from being taken forward.

The scoring process was undertaken by the CH2M team which consists of specialists from various disciplines, such as; landscaping, ecology, geomorphology, environmental, engineers, financial analysts, hydraulic modellers, etc. Additionally, due regard to the consultation process undertaken between January and March 2016 was also taken. The results from this consultation process fed into the appraisal process. This included feedback from landowners, residents, the public, Local Authorities, internal Environmental Agency technical specialists and other interested parties and groups.

In the First-Phase analysis the scores for the two Social Sub-Objectives were weighted to compensate for the modelling dependant Sub-Objectives which was not evaluated in the First-Phase. The weighting ensured the outcomes of the First-Phase Options Appraisal were equally balanced. Table 3 overleaf outlines the Principal Objectives and Sub-Objectives that were evaluated for each option at the First-Phase Options Appraisal.

In Phase 1B the preferred options were collated together to produce the Preferred Corridor to be taken forward to the Second-Phase of the assessment process.

Whilst the options were mutually independent from a hydraulic aspect; different options may have different characteristics, for example, from a landscape aspect. If the assessment criteria had determined that adjacent areas have preferred options which are of differing character then a further scheme wide review would be undertaken by the relevant technical specialists to assess any necessary alignment of options. However this additional review was found to be not necessary.

	PRINCIPAL OBJECTIVES Sub-Objective	Weighting of scores on Sub-Objectives in the First-Phase Options Appraisal
1	**~~ECONOMIC OBJECTIVES~~**	
~~1i~~	~~Reduce the risk of floods impacting on infrastructure~~	Not evaluated in the First-Phase
~~1ii~~	~~Reduce the risk of flooding to commercial properties~~	Not evaluated in the First-Phase
~~1iii~~	~~Maximise the Net Present Value~~	Not evaluated in the First-Phase
2	**SOCIAL OBJECTIVES**	
~~2i~~	~~Reduce the risk of flooding to residential properties~~	Not evaluated in the First-Phase
2ii	Improve landscape opportunities	Weighted by multiplying by 1.5
2iii	Improve recreational opportunities	Weighted by multiplying by 1.5
3	**TECHNICAL OBJECTIVES**	
3i	Minimise engineering risks	Not weighted
3ii	Minimise disruption to infrastructure and services	Not weighted
3iii	Safeguards health and safety in buildability and maintenance	Not weighted
4	**ENVIRONMENTAL OBJECTIVES**	
4i	Improve ecological opportunities	Not weighted
4ii	Accords with WFD assessment	Not weighted
4iii	Keep environmental impact to acceptable levels	Not weighted
5	**INSTITUTIONAL OBJECTIVES**	
5i	Provides Benefits and Minimises Impact on Interested Parties	Not weighted
5ii	Potential policy / legislative conflicts or conforms with wider planning outcomes	Not weighted
5iii	Provide opportunities for partnering/funding	Not weighted

Table 3– Outline of Principal Objectives and Sub-Objectives for First-Phase Appraisal

4.3 Second-Phase Options Appraisal

The objective of the Second-Phase Options Appraisal is to produce a single Optimised Preferred Corridor that will then be taken forward to outline design and Outline Business Case.

In the Second-Phase, hydraulic and economic modelling will be undertaken on the Preferred Corridor that was borne from the First-Phase to optimise the economic and social objectives that are outlined in **Table 4**. Additional options of the Preferred Corridor that are primarily based on channel sizes will be introduced and evaluated with hydraulic and economic modelling to determine the optimised corridor size.

The results of the hydraulic and economic modelling will trigger a gateway to confirm whether the flood risk and economic targets have been achieved. Failure to meet any of these targets may result in the review of non-preferred options or ultimately could result in the abandonment of the Western Conveyance Channel solution.

4.3.1 Application of the assessment criteria in the Second-Phase

This phase off the assessment process took the results of the Phase 1 assessment and created the preferred route corridor. In line with the recommendations of the Strategy this corridor was then assessed for a variety of channel sizes to determine the optimum flood risk management solution.

The results of hydraulic and economic modelling of the a range of channel sizes for the preferred corridor were used to score the performance of each option based on the relative five-point scoring system ranges from 'highly++ positive' to 'highly-- negative' and it is in the following order: **High++**

(5), **Medium+ (4)**, **Low/Neutral (3)**, **Medium - (2)**, and **High—(1)**. The totals were summed following scoring of each sub-objective to determine the preferred size option for the corridor which is then defined as the Optimised Preferred Corridor. Table 4 below shows the criteria used to assess the outputs from the Phase 1 process.

	PRINCIPAL OBJECTIVES Sub-Objective	**Weighting of scores on Sub-Objectives in the Second-Phase Options Appraisal**
1	**ECONOMIC OBJECTIVES**	
1i	Reduce the risk of floods impacting on infrastructure	Not weighted
1ii	Reduce the risk of flooding to commercial properties	Not weighted
1iii	Maximise the Net Present Value	Not weighted
2	**SOCIAL OBJECTIVES**	
2i	Reduce the risk of flooding to residential properties	Not weighted

Table 4 - Outline of Principal Objectives and Sub-Objectives for Second-Phase Appraisal

No weightings were applied to the scores in the Second-Phase Options Appraisal, the chosen number of Sub-objectives provided equal weighting between all the categories. Historically, applying weightings at the final appraisal creates a further layer of subjective assessment, and normally the un-weighted screening exercise sufficiently polarises and emphasises the differences between options. In the first instance, weightings in the Second-Phase Options Appraisal were completely avoided and only if there are two or three close-run options then a review of weightings could have been undertaken as a sensitivity exercise.

Principal Objectives in the First-Phase

This section will summarise the methodologies and parameters used to exclusively evaluate each option against each individual principal objectives.

5.1 Overview of Social Objectives

For Phase 1A Social Objectives in the First-Phase Appraisal were split down into two key Sub-Objectives, these are:

- 2ii Improvement on landscape opportunities
- 2iii Improvement on recreational opportunities

Each of the above Sub-Objectives were then expanded to focus on specific parameters. As noted previously, reduction of flood risk will be included in Phase 2 of the appraisal process and was not included at this stage.

The potential social impacts on residents, landowners and other persons were included in Institutional Objectives. This section focused on the social setting, appearance and use of the area.

5.1.1 2ii – Improvement on Landscape Opportunities

This Sub-Objective looked at the potential impact on views into and out of Oxford considering the 'Oxford View cones' to the west of the study area.

Consideration was given to the potential enhancements and effects on landscape and settings in the immediate context of each area. These were generally based on minimising impacts and improving and enhancing the existing landscape. A number of site walkovers and a detailed desk based studies to identify key constraints were undertaken to inform this process. The resulting Environmental Site Appraisal Plans have been used to help inform this part of the assessment.

5.1.2 2iii – Improvement on Recreational Opportunities

This Sub-Objective reviewed the long term recreational opportunities within each area individually and considered the wider possible connections. Activities included, pedestrian and cycleway route, fishing and other water based activities and horse riding.

The specific parameters used to evaluate the Social Objectives across all areas are outlined below:

	Sub-Objectives	**Parameters**
2ii	**Improve landscape opportunities**	Avoids impact on views of Oxford
		Enhances/adds to areas of classic landscape setting
2iii	**Improve recreational opportunities**	Maximises opportunities on dog walking and horse riding activities
		Maximises fishing and rowing
		Maximises future pedestrian and cycleway routes

Table 5 - Parameters for the Social Objectives

It is understood that the implementation of the scheme will have a number of significant temporary dis-benefits on recreational activities during construction and this will be reviewed as part of the Environmental Impact Assessment process for the project. At this stage it was considered that all

options will have similar temporary impacts which whilst needing investigating and mitigating will not impact on the option selection process.

5.2 Overview of Technical Objectives

Technical Objectives in the First-Phase Appraisal were split down into three key Sub-Objectives, these are:

- 3i Minimise Engineering Risks
- 3ii Minimise Disruptions to Infrastructure and Services
- 3iii Safeguards Health and Safety in Buildability and Maintenance.

Each of the above Sub-Objectives were then expanded to focus on specific parameters.

5.2.1 3i – Minimise Engineering Risks

This Sub-Objective looked at the potential engineering risks that would affect the functionality of the each option. The following major engineering risks were evaluated:

- Impacts on the groundwater regime
- Minimise introduction of engineered elements
- Reduce risk of blockages and frequency of maintenance

Ground investigations indicated the water table is high across the site with it being at its highest at Area 2, Area 3 and Areas 5 and 6. The ground investigation also showed that any potential deep excavations will be situated into a gravel strata below the water table. Working within these conditions could prove challenging. It is likely that any construction activity other than channel excavation such as structure foundations that occurs within the gravels will require temporary pumping and cofferdams.

The introduction of heavily engineered elements would add more risks and costs to the construction and operation stages of the scheme. The concept of the scheme is to reduce the number of structures and make the scheme as passive as possible to reduce ongoing operational requirements.

Reducing the risks of blockages and sedimentation at the design stage will be critical to the overall success of the project. The rural setting of the areas means there could be debris such as trees and branches that could potentially cause blockages and reduce the efficiency of the scheme. The required maintenance for this scheme could be intensive due to the lengths of proposed open channels. Therefore, minimising potential maintenance requirements at the design stage has a benefit in reducing the frequency and cost of interventions over the lifetime of the scheme.

5.2.2 3ii – Minimise Disruptions to Infrastructure and Services

This Sub-Objective looked at the potential disruptions to infrastructure and services, both during construction and after construction. The following parameters were used to evaluate this Sub-Objective:

- Impact on infrastructure, accesses and public highways
- Impact on existing buried and overhead services

The construction stage could physically impact the local infrastructure such as roads, private access points, bridges and the railway. Any proposed works on or nearby existing infrastructure could threaten the integrity of the existing infrastructure and would require careful design and construction. The reduction or avoidance of these impacts was assessed for each of the options.

The review on the services that could be potentially affected was undertaken and is outlined in Appendix D. This is a preliminary review based on returns from service providers, this will require updating at the detailed design stage.

The existing services that are within the footprints of the proposed options will require to either be protected or diverted. The presence of gravity drainage services are more limiting as it may not be possible to divert such services. Considerations were given to the presence of pylons within the vicinity of the proposed options as, based on discussions with National Grid, diverting these assets would be a major task with significant associated costs.

The existing services that are immediately outside the footprint of the proposed options may also require protection to ensure they are not damaged by the construction process.

5.2.3 3iii – Safeguards Health and Safety in Buildability and Maintenance

This Sub-Objective evaluated the overview of health and safety during construction and operation of the proposed options. The following parameters are used to evaluate this Sub-Objective:

- Buildability
- Working at height
- Confined spaces

The construction risks of each option would be very similar for all the different types of proposed channels. However, the high water table would impact on the construction of the deeper channels and measures such as installation of cofferdams and over pumping would be required to enable safe construction of structures.

Similarly temporary works such as scaffolding would be required for construction and maintenance activities that require working at height either on new bridge structures or around deep excavations or channels.

The creation of confined spaces or long lengths of culverts was reviewed in each option assessment to minimise and avoid these as the presence of confined spaces will introduce more risks during construction and maintenance.

The specific parameters used to evaluate the Technical Objectives across all areas are outlined below:

	Sub-Objectives	**Parameters**
3i	**Minimise engineering risk**	Impacts on groundwater regime
		Minimise introduction of engineered elements
		Reduce risk of blockages and frequency of maintenance
3ii	**Minimise disruptions to infrastructure and services**	Impact on infrastructure and public highways
		Impact on existing services
3iii	**Safeguard Health and Safety in buildability and maintenance**	Buildability
		Working at height
		Confined spaces

Table 6 - Parameters for the Technical Objectives

5.3 Overview of Environmental Objectives

Environmental Objectives in the First-Phase Appraisal were split down into three key Sub-Objectives, these are:

- 4i Improve Ecological Opportunities
- 4ii Accords with WFD assessment
- 4iii Keep environmental impact to acceptable levels

Each of the above Sub-Objectives were then expanded to focus on specific Parameters.

5.3.1 4i – Improve Ecological Opportunities

This Sub-Objective reviewed the likely impacts and benefits on the designated sites around the area which could be affected. In particular the impacts on the Sites of Special Scientific Interest (SSSI), notably Port Meadow, Hinksey Meadow Iffley Meadow, were assessed to try and ensure that any changes are neutral or net beneficial.

The options were reviewed to ensure that they maximise the wider environmental habitat created, this is mainly centred on the possibilities to maximise in-channel habitat created with the new channel and minimise impacts on existing channels where ever possible, although wider opportunities were considered. In addition to the biodiversity and ecological benefits fisheries improvements to the area were also assessed. In consideration of these aspect the inputs, comments and views of the relevant Environment Agency Technical Specialists and local conservation groups were sought and fed into the appraisal.

5.3.2 4ii – Accords with WFD assessment

The compliance of any new scheme in a riverine environment with the "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" or, in short, the EU Water Framework Directive (WFD) is one of the key elements to consider. This section undertook a high level review of the likely impact on the following areas covered by the WFD;

- Impact on hydrological regime
- Impact on river continuity
- Impact on morphological conditions

This review was undertaken by a geomorphologist and an environmental scientist familiar with the requirements of the WFD. This was a high level review to screen out the most potentially damaging options, a further detailed WFD assessment of the preferred option will be required at a later stage of the scheme.

5.3.3 4iii – Keep environmental impact to acceptable levels

A scheme of this scale will have a number of potential impacts on a range of receptors. This section focused on the potential impacts on archaeology and ecological aspects of the existing area.

There are known archaeological deposits in the area and a number of Scheduled Monuments (SMs) below Old Abingdon Road. A Desk Based Assessment of the known information related to archaeology in the area was used to assess the potential impacts on buried deposits and SMs and inform the selection of the option which is likely to have the least impact.

Similarly ecological impacts on known habitats and species in the area was reviewed to try and minimise impacts as far as possible. A Phase 1 Habitat Survey along with site walkovers and

discussion with local wildlife groups and environment Agency Technical specialists have been used to assess this section.

The specific parameters used to evaluate the Environmental Objectives across all areas are outlined below:

	Sub-Objectives	Parameters
4i	Improve ecological opportunities	Any impacts on SSSIs to be neutral or net beneficial
		Maximises wider environmental habitat created
		Maximises in-channel habitat created and fisheries improvements
4ii	Accords with WFD assessment	Impact on hydrological regime
		Impact on river continuity
		Impact on morphological conditions
4iii	Keep environmental impact to acceptable levels	Minimises impacts to Scheduled Monuments and archaeology
		Minimises ecological impacts

Table 7 - Parameters for the Environmental Objectives

5.4 Overview of Institutional Objectives

Institutional Objectives in the First-Phase Appraisal were split down into three key Sub-Objectives, these are:

- 5i Provides Benefits and Minimises Impact on Interested parties
- 5ii Potential policy/legislative conflicts and conforms with best planning outcomes
- 5iii Provides opportunities for partnering/funding

Each of the above Sub-Objectives were then expanded to focus on specific parameters.

5.4.1 5i – Provides Benefits and Minimises Impact on Interested Parties

This Sub-Objective evaluated the options in terms of which option would provide benefits and minimise impacts to a range of parties who have a direct interest in the areas of the options. These parties are as follows;

- Residents/Landowners/Tenants
- Local Authorities
- Public
- Other interested local organisations and businesses

Five public drop-in meetings were held in various locations around the Oxford area and in Abingdon in January 2016 to gather opinions from the public and other interested organisations. These were generally well-attended with over 170 people attending each individual drop-in session. At these events, the public were asked to complete a questionnaire to indicate any preferences for the particular options presented. In addition, an online e-consultation process was undertaken in parallel to enable the public or other organisations to directly input to the consultation without the need to attend one of the meetings in person. All these responses have been collated and incorporated into the First-Phase Options Appraisal process.

Prior to the public drop in sessions, individual meetings were held with various landowners, residents and tenants across the areas who would be directly affected by any of the options. Where possible, the initial responses to the proposed options for the areas of direct interest from these parties have been incorporated into the First-Phase Options Appraisal process.

Presentations to the following interested local authorities for the area of interest were given to show the proposed options to the various internal departments within these local authorities;

- Oxford County Council
- Oxford City Council
- Vale of White Horse District Council
- South Oxfordshire District Council

Copies of all the public drop-in meeting display material and the options were also circulated to each of the local authorities. Minutes of these meetings and subsequent written feedback from the local authorities have been incorporated into the First-Phase Options appraisal process.

Other interested parties such as Natural England, Berkshire, Buckinghamshire and Oxfordshire Wildlife Trust, statutory service providers and environmental groups were also invited to separate meetings as well as the general public drop in sessions to understand their concerns and comments on the proposed options.

No direct meetings were held with businesses if they are not landowners or tenants that would be directly impacted by the works. However, they were invited the public drop-in meetings and any responses have been incorporated into the First-Phase Options Appraisal process.

5.4.2 5ii - Potential policy / legislative conflicts or conforms with wider planning outcomes

The potential compliance or contradiction of the aims and objectives of the wider planning outcomes for the area were reviewed;

- Links to River Basin Management Plan
- Impacts on river navigation in the Oxford Area
- Links to existing local planning policy

An overview review of all the Sub-Objectives against the published 'Thames River Basin District River Basin Management Plan: 2009' and its updated 2015 Plan published on the 18th February 2016 was undertaken and any potential conflicts or variations were taken into account in the First-Phase Options Appraisal process. Many of the aims and objectives for the Plan are covered in other sections, in particular, the assessment of environmental aspects. This section undertook an overview of the general option concepts to avoid double counting of specific parameters covered elsewhere.

A review of the proposed options with respect to impacts on river navigation on the River Thames and other smaller watercourses was undertaken to assess any potential impacts of the options both in terms of water level management and additional hazards which may be created.

A number of meetings have been held with the planning departments from the four relevant local authorities and local planning guidance documents from these organisations have been reviewed. Care has been taken to avoid double counting where wider benefits include environmental or recreational outcomes as these are accounted for within other sub-objectives.

5.4.3 5iii - Provides opportunities for partnering / funding

The section looks at the various mechanisms for providing wider benefits from the scheme which may create opportunities to involve other public or private organisations - either directly or in the form of contributions or creation of wider benefits to the area. The following parameters were reviewed as part of the First-Phase Options Appraisal process;

- Meets wider stakeholder requirements and objectives
- Provides opportunities for developments
- Provides opportunities for public and private sector funding

Based on the aims and objectives from stakeholders, a number of wider flood risk benefits associated with keeping Oxford open for business during flood events have been identified. These are predominately associated with a reduction in flood risk to Botley and Abingdon Roads and key infrastructure. The direct benefits from this were included in the Second-Phase Options Appraisal process; however this review assessed the potential social benefits.

The Environment Agency and this scheme seek to maintain and optimise the use of existing floodplain and does not have a remit for removing land from the floodplain for development. However it is likely that some of the proposed options may free up some local brownfield sites surrounding the existing developed areas which are currently at flood risk. These brownfield sites could be suitable for re-development following the scheme which may attract re-generation opportunities for the private sector.

As part of the funding strategy for the scheme, contributions from third parties and key stakeholders are being sought to close the funding gap which exists at the time of the First-Phase Options Appraisal process. These could potentially be various kinds of contributions such as costs waived, direct financial contributions, etc. A number of ongoing discussions are underway with various potential contributors and this sub-objective assesses the potential options which could be attractive to investors based on the discussions held before the date of publishing of this report.

The specific parameters used to evaluate the Institutional Objectives across all areas are outlined below:

	Sub-Objectives	**Parameters**
5i	**Provides Benefits and Minimises Impact on Interested Parties**	Residents / Landowners/ Tenants
		Local Authorities
		Public
		Other interested local organisations and businesses
5ii	**Potential policy / legislative conflicts or conforms with wider planning outcomes**	Links to River Basin Management Plan
		Impacts on river navigation in area
		Links to existing planning policy
5iii	**Provide opportunities for partnering/funding**	Meets stakeholder requirements and objectives
		Provides opportunities for development, both public and private
		Provides opportunities for public and private sector funding

Table 8 - Parameters for the Institutional Objectives

First-Phase Options Appraisal

6.1 First-Phase Options Appraisal at Area 1 – Botley Road

6.1.1 Background information on Area 1

Area 1 covers the location immediately upstream of Botley Road and also includes conveyance past Botley Road. It has been identified by the Oxford Flood Risk Management Strategy, Technical Report that the Botley Bridge near the Seacourt Park and Ride can be improved to have sufficient capacity to convey enough water for the western conveyance channel. The above report also found that the other existing conveyance routes under Botley Road were already operating at capacity without the opportunity to further increase capacity.

The main constraint to improvement works in this area is Botley Road itself. The limited flow openings below the road and traffic density creates a barrier between the upstream and downstream sides. This coupled with the density of services running along each side of the road also makes undertaking major bridge upgrade works or installing new bridges to increase capacity difficult and costly.

Figure 2 - Seacourt Stream at Botley Bridge

There are a number of properties, both residential and commercial along Botley Road which are at risk of flooding in relatively low return period events.

Preventing flooding and the associated traffic disruption to Botley Road is one of the objectives of the scheme. The road currently floods at relatively low return period events in the area to the east of the Seacourt Park and Ride. In previous flood events water has been pumped over the road at this

location however the pumping work still resulted in the road being closed to traffic due to pipe runs. A pipe is being installed below the road so that pumping can take place without closing the road in the short-term. The options will look at the opportunities to create a passive solution to reduce flood risk to the road.

6.1.2 Options Development at Area 1

The options available in this area are limited. The approach to the design development in Area 1 was to develop options that will supplement the preferred corridor by proportioning the flow splits at Botley Road towards the channels that will feed the new preferred channel route. Due to the cost constraints associated with new bridges the opportunities for increasing the capacity of existing structures was reviewed.

The overall scheme lowers flood levels in the area of Botley Road however it has not been possible to lower them sufficiently to reduce flood risk to property and infrastructure significantly, therefore a number of local raised flood defences in the form of earth embankments and walls are required to protect the residential properties located on the northern side of Botley Road. These have been located to minimise land take and impacts on the remaining flood plain.

6.2 First-Phase Options Appraisal at Area 2 – Botley Road to Willow Walk

6.2.1 Background information on Area 2

Area 2 - Botley Road to Willow Walk covers the area immediately downstream of Botley Road to Willow Walk. A distance of approximately 1km.

Figure 3- Existing floodplain between Botley Road and Willow Walk

There are several constraints in this area including existing buildings on the right bank downstream of Botley Road Bridge and the narrow strip access from Botley Road on the left bank of the Seacourt Stream. There is also a line of high voltage overhead power lines and associated pylons crossing the area. One particular pylon at the northern end of the area is a significant constraint on the options.

A line of willow trees is present on the right bank of the Hinksey Stream. The willow trees have not been identified as environmentally significant however local residents have indicated the trees hold aesthetic value. The line of mature trees along Willow Walk also has significant visual and landscape value.

There are also other environmental issues and opportunities with the main concern being the presence of MG4 quality grassland which includes a number of rare species.

6.2.2 Available options at Area 2

There are four options proposed for the corridor at Area 2.

All the proposed options feature a constrained channel immediately downstream of Botley Road due to the presence of buildings close to the right bank of the Seacourt Stream. All options will also cross Willow Walk by replacing the existing culverts with a clear-span bridge through the existing culverts.

The proposed channels in all of the options will require to be constrained at the downstream end to facilitate a crossing through Willow Walk. The velocities at this constrained part of the channel are likely to be high enough to cause erosion and therefore there will be a requirement for erosion protection around the structure.

A brief description of each option is given in this report and separate drawings for each option are also provided in Appendix A.

6.2.2.1 Option 2A – Existing channel retained and shallow scrape to convey larger flows

Refer to Appendix A.01 for the conceptual drawing for Option 2A.

Option 2A will retain the Seacourt Stream as the primary channel during low rainfall events and proposes a natural shallow (approx. 1m deep) scrape channel that will be run in parallel to the Seacourt Stream. The proposed scrape channel will have a wide parabolic shape and it will activate before the water level inside Seacourt Stream reaches to the bank levels. A short length (approx. 100m) of the left bank for Seacourt Stream will be lowered to accommodate a spillway which will connect with the proposed scrape channel. The flows on the spillway could be high enough to cause erosion and therefore reinforced section of channel will be required in this location. The dimensions and construction details for the spillway have not yet been established but it is likely to be a grass-reinforced spillway.

It is not envisaged that any works will be required along the banks of Seacourt Stream, therefore the tree lines along both banks of Seacourt Stream would be retained. However, the trees located on the left bank at the upstream end of the channel, would require to be felled to accommodate the works. The ditch located at the upstream end of the proposed scrape channel, at the back of the industrial buildings, will discharge directly to the proposed channel.

The extents/width of the proposed scrape channel in-between its upstream and downstream ends has not yet been established and its required width will be determined by modelling. The current width as shown on the plans ranges from 60m to 130m.

6.2.2.2 Option 2B – New 2-stage channel across area and existing channel modified to form a backwater

Refer to Appendix A.02 for the conceptual drawing for Option 2B.

Option 2B will turn Seacourt Stream into a backwater and proposes a 2-stage channel that will have a total maximum depth of approximately 2m. The proposed 2-stage channel will have a lower (first) stage which will be of similar size to Seacourt Stream; the first stage will likely be constantly wet and it may receive groundwater flows. The higher (second) stage will be a lot wider and will only be active once the capacity of the first-stage channel has been exceeded.

The upstream end of the proposed 2-stage channel will be connected directly to the Seacourt Stream and both channels will have the same invert level at the point of connection. At the upstream end, a small part of Seacourt Stream will require to be filled-in to divert all flows onto the higher (second) stage of the proposed 2-stage channel, therefore this will turn Seacourt Stream into a backwater channel. However, there is an opportunity to maintain a sweetening flow in Seacourt

Stream by constructing a culvert or a control structure at the point of connection with the proposed 2-stage channel. Another opportunity for maintaining a sweetening flow in Seacourt Stream would be to introduce a small channel to create a link between the two channels. However, some trees would require to be removed to accommodate the link channel.

Similar to Option 2A, it is not envisaged that any works would be required along the banks of Seacourt Stream and therefore the tree lines along both banks of Seacourt Stream would be retained. However, the trees located on the upstream end of the channel, near the footpath, would require to be felled to accommodate the proposed 2-stage channel. The single ditch is located at the upstream end of the proposed scrape channel, at the back of the industrial buildings, will discharge directly to the proposed channel.

The second-stage will be a lot wider than the first stage with its left bank being slightly higher that its right bank to prevent overflows onto Seacourt Steam. The extent/width of the second-stage channel has not yet been established and its required width will be determined by modelling. The current width as shown on the plans ranges from 60m to 130m.

6.2.2.3 Option 2C – Existing channel retained and second stage on farmland downstream of pylon

Refer to Appendix A.03 for the conceptual drawing for Option 2C.

Option 2C will retain Seacourt Stream as the primary channel during low rainfall events and proposes a natural shallow scrape channel that will be approximately 1m deep. The proposed scrape channel will have a wide parabolic shape and it will be activated before the water level inside Seacourt Stream reaches to the bank levels. A significant length (approx. 500m) of the left bank for Seacourt Stream will be lowered to connect with the proposed scrape channel. The spill flows from Seacourt Stream into the proposed scrape channel will be distributed across a long length of the channel and therefore the velocities will be much lower; hence there won't be a need to introduce any heavily engineered spillways.

Option 2C will require lowering the left bank of Seacourt Stream, therefore the tree line along left bank of Seacourt Stream would require to be removed. However, the trees located on the upstream end of the channel, near the footpath, will be retained. More flow will also be required to pass down the existing channel past the pylon which will require additional engineered scour protection to avoid long term erosion problems. This will also need to be replicated along the opposite private gardens on the right bank of the Seacourt Stream.

The extents/width of the proposed scrape has not yet been established and its required width will be determined by modelling. The current width as shown on the plans ranges from 60m to 150m.

6.2.2.4 Option 2D – As Option 2C but with second stage starting upstream of pylon

Refer to Appendix A.04 for the conceptual drawing for Option 2D.

Option 2D is very similar to Option 2C. The principal different between these two options is that the upstream end of Option 2D will have an unconstrained channel which would isolate the pylon on an island.

6.2.2.5 Access for construction

Access to this area can be gained by existing routes from Botley Road to the north or via Willow Walk. The stone bridge at the entrance to Willow Walk is steep and has a weight limit which prohibits construction access.

The access for general construction traffic from Botley Road is prohibitive due to the existing volume of traffic on this route as it is a key route into the city centre. Whilst some access will be required

from Botley Road it is proposed the main access would be from the A34 at South Hinksey and then along the channel corridor route. This will also minimize traffic impacts on North Hinksey village.

Light maintenance vehicles could utilise the existing access points in the longer term to avoid creating new access points off the public highways.

6.2.3 Summary of First-Phase Appraisal at Area 2

6.2.3.1 Summary of Social Objectives at Area 2

Refer to Appendix B.01 for the evaluation of Social Objectives at Area 2. The scoring results following the evaluation showed that Option 2A is the preferred options with respect to the Social Objectives in Area 2. For this objective, Option 2A is the preferred option and Options 2C and 2D were the sub-preferred options.

6.2.3.2 Summary of Technical Objectives at Area 2

Refer to Appendix B.02 for the evaluation of Technical Objectives at Area 2. The scoring results following the evaluation showed that Options 2A and 2D are the preferred options with respect to the Technical Objectives in Area 2.

6.2.3.3 Summary of Environmental Objectives at Area 2

Refer to Appendix B.03 for the evaluation of Environmental Objectives at Area 2. The scoring results following the evaluation showed that Options 2D and 2C are the preferred options with respect to the Environmental Objectives in Area 2.

6.2.3.4 Summary of Institutional Objectives at Area 2

Refer to Appendix B.04 for the evaluation of Institutional Objectives at Area 2. The scoring results following the evaluation showed that all the options are of an equal score and this section made no difference to the option selection process in Area 2.

6.2.4 First-Phase Preferred Options at Area 2

Refer to Appendix C.2 for the First-Phase Scoring Matrix for Area 2. The results showed that overall; **Option 2D is the Preferred Option,** and **Option 2C is the Sub-Preferred Option** following the First-Phase Appraisal Process.

6.3 First-Phase Options Appraisal at Area 3 – Willow Walk to South Hinksey

6.3.1 Background information on Area 3

Area 3, Willow Walk to South Hinksey, extends from the section immediately downstream of Willow Walk to the area immediately downstream of the Devil's Backbone, a distance of approximately 2km.

There are a number of significant constraints in this area which have informed the location of the various options. On the eastern side of the area there are a number of significant buried high voltage power cables.

The 'Electric Road' track which runs north-south through the centre of the area between the railway line to the east and the A34 to the west creates a significant barrier to the possible route alignments. There are high voltage power cables in concrete cable trenches each side of this track. Diversion or crossing these cables is likely to be prohibitively expensive and disruptive to consumers.

Figure 4- 'Electric Road'

There are a number of overhead power cables running across the area, however these are less of a restriction, although the pylon locations do limit the extent of channel meanders which can be created.

To the west there is a Thames Water sewer running from North Hinksey to South Hinksey which has underground storm water tanks running alongside St Peters College sports ground and the Rugby Club which demarcates the western edge of the options corridor.

The landowner of the fields between North Hinksey and South Hinksey has identified the opportunity to undertake gravel extraction in this area in parallel with the scheme. Whilst this opportunity has not been reviewed in detail as part of this report it will be included as part of the materials management options which will be considered separately.

6.3.2 Available options at Area 3

There are four options proposed for the corridor at Area 2. All four options propose a 2-stage channel that will have a total maximum depth of approximately 2m. The extents/width of the proposed 2-stage not yet been established and its required width will be determined by modelling. The current width as shown on the plans ranges from 30m to 180m.

The main differences among the options is on how each option will accommodate a lake. Copies of the plans for the various options are provided in Appendix A.

6.3.2.1 Option 3A – New 2-stage channel

Refer to Appendix A.05 for the conceptual drawing for Option 3A.

Option 3A features a 2-stage channel without any inclusion of a lake. The second-stage of this proposed channel will have shallower banks along all of its length to support the existing watercourses at the point of crossings.

6.3.2.2 Option 3B – New 2-stage channel with an offline lake

Refer to Appendix A.06 for the conceptual drawing for Option 3B.

Option 3B proposes a 2-stage channel with the addition of a large offline lake at the southern half of Area 3. It is most likely that the pond will be constantly fed by groundwater and therefore it will have little capacity to store flood water.

6.3.2.3 Option 3C – New 2-stage channel with an online lake

Refer to Appendix A.07 for the conceptual drawing for Option 3C.

Option 3C proposes a 2-stage channel with the addition of a large online lake at the southern half of Area 3. This option will require a control structure to be constructed at the downstream end of the lake to retain the required water inside the lake and to prevent excessive flows exiting the lake. Given that the lake will likely be fed by groundwater, then the control structure will also prevent the conveyance of groundwater flows during periods of dry weather.

This lake has the most potential for being able to store some floodwater and therefore it could be designed to act as a flood mitigation feature.

6.3.2.4 Option 3D –New 2-stage channel with a series of offline ponds/lakes

Refer to Appendix A.08 for the conceptual drawing for Option 3D.

Option 3B proposes a 2-stage channel with the addition of a series of offline ponds at the southern half of Area 3. Effectively, these ponds would act the same way as the lake in Option 3B.

It is envisaged that the ponds would be used for environmental or ecological purposes and they will have limited recreational benefits.

6.3.2.5 Access for construction

The location of the South Hinksey interchange on the A34 and the direct access from the interchange into the works areas mean that this will be the main road vehicle access point for the entire area from Botley Road to Old Abingdon Road. However it may be necessary to carry out some

upgrade works to the short slip roads at this interchange. This will also have a significant temporary impact on the village of South Hinksey during the construction period.

The possibility of utilising the railway sidings to the east of the site is also being investigated to reduce reliance on road transport for materials management. If this proves to be a viable option then a temporary access across to the sidings will need to be installed, this may include temporarily bridging or creating a causeway across the lagoons in this area.

A main compound area for the works could be located in the fields just off the interchange junction which would facilitate access north and south to cover the whole of the area from Botley Road to Redbridge.

6.3.2.6 Proposed clear-span bridges

All the proposed options feature a constrained channel immediately downstream of Willow Walk. There is another footpath which is in parallel to Willow walk and located approximately 200m to the south. This footpath will also require an additional clear-span bridge to be constructed along with a constrained channel to facilitate a crossing for the proposed channels through this footpath.

It may also be necessary to provide an agricultural crossing in the area depending on the needs of local framing practices. However, the location and the type of agricultural crossing will be determined during the outline design stage.

All propose options will also feature a constrained channel at the downstream end of Area 3 to facilitate a crossing for the proposed channels through this Devil Backbone. An additional proposed clear-span bridge at Devil's Backbone will be required to accommodate this crossing.

The velocities at the constrained channels at the vicinity of all the proposed clear-span bridges are likely to be significantly large to cause erosion. Therefore, there could be a requirement to introduce engineered channels at these locations.

All proposed bridges will need to be raised above the levels of existing footpaths to provide sufficient clearance below the soffits for the flood flows and reduce the risk of debris snagging. This will make them highly visible in the predominantly flat existing landscape and they will need a sympathetic design.

6.3.2.7 Crossings of existing watercourses

All of the proposed channels will cross various existing watercourses including; Bulstake Stream, Seacourt Stream, Hinksey Stream, Hogacre Ditch, and various smaller ditches. The crossing of existing watercourses will introduce a risk of changing the upstream and downstream flow characteristics of these watercourses. The change in characteristics could have significant environmental, ecological, and maintenance impacts for the watercourse.

The invert levels of the proposed channels have not yet been established, therefore it is not possible to predict the potential levels at crossing points with existing watercourses. The design approach for the proposed channels will be to try and situate proposed channels so that they will have same or similar invert level to the existing invert levels of watercourses at points of crossings. Note that there are opportunities available for manging upstream and downstream effects, such as: introducing flow control structures at crossing points, and by creating diversion channels to feed existing watercourses. All of these opportunities will be evaluated at outline design stage.

Potential upstream effects on watercourse

The relative invert levels between a proposed channel and an existing watercourse at their crossing point will govern the amount of potential changes to the upstream characteristics of that watercourse. If the invert level of a proposed channel is situated higher than the existing invert level

of a watercourse then there could be an increased flood risk at the upstream end of that watercourse.

Potential downstream effects on watercourses

Similarly, the amount of potential changes to the downstream characteristics of a watercourse will be governed by the relative invert levels between a proposed channel and an existing watercourse at the crossing point. The main potential downstream risk is the conveyance of additional flow into a watercourse from a proposed channel which could cause flooding at the downstream end of a watercourse. Another downstream risk is the discontinuation of flow into the watercourses during conditions of low flow within a proposed channel.

6.3.2.8 High water table

Based on the recent ground investigation, the first-stage of all proposed channels will be situated in the gravel strata which is below the water table. This has the benefit that the channel will be groundwater fed and avoid the reliance for a base flow from other watercourses. It will also improve the quality of the water in the channel over a fluvial fed option. However, there is a risk that the upstream groundwater regime could be affected and this risk will be evaluated further during detailed design.

The ground investigations also showed that the gravels are relatively unstable when exposed which means that creating steep sides to the primary channel will be difficult. Regardless of the construction profile erosion will take place until the natural angle of repose for the gravels is achieved which will form a dish shaped lower channel rather than a steep sided narrow channel. This could help accommodate a wider range of biodiversity but will impact on the visual appearance of the channel.

The high water table will also impact on the construction processes during the excavation of the channel. Some of the material from the lower sections of the channel will potentially be dug underwater and will need to be dried before re-use or disposal. This will require large temporary land areas to facilitate this processing.

Also, the high water table will means that all proposed lakes are likely to be fed by groundwater and this is advantageous as there will be a constant supply of high quality water into the lake. However, this has the potential of impacting the upstream groundwater conditions and it will be evaluated further during outline design stage.

Where possible the proposed channels will be dug from within the footprint of existing channels to minimise impacts on areas outside of the permanent works footprint.

6.3.2.9 Proposed raised flood defences

The new flood defence around South Hinksey should be constructed using suitable material arising from the excavation of the channel. The height and extent of these raised defences will be dependent on the required level of protection.

A brief description of each option is given in this report and separate drawings for each option is also provided.

6.3.3 Summary of First-Phase Appraisal at Area 3

6.3.3.1 Summary of Social Objectives at Area 3

Refer to Appendix B.01 for the evaluation of Social Objectives at Area 3. The scoring results following the evaluation showed that Options 3B and 3C are the preferred options with respect to the Social Objectives at Area 3. For this objective, Option 3C is the preferred option and Option 3B is the sub-preferred option.

6.3.3.2 Summary of Technical Objectives at Area 3

Refer to Appendix B.02 for the evaluation of Technical Objectives at Area 3. The scoring results following the evaluation showed that Options 3A and 3D are the preferred options with respect to the Technical Objectives at Area 3. For this objective, Option 3A is the preferred option and Option 3D is the sub-preferred option.

6.3.3.3 Summary of Environmental Objectives at Area 3

Refer to Appendix B.03 for the evaluation of Environmental Objectives at Area 3. The scoring results following the evaluation showed that Options 3A and 3D are the preferred options with respect to the Environmental Objectives at Area 3. For this objective, Option 3A is the preferred option and Option 3D is the sub-preferred option.

6.3.3.4 Summary of Institutional Objectives at Area 3

Refer to Appendix B.04 for the evaluation of Institutional Objectives at Area 3. The scoring results following the evaluation showed that Options 3A and 3D are the preferred options with respect to the Institutional Objectives at Area 3. For this objective, Option 3D is the preferred option and Option 3A is the sub-preferred option.

6.3.4 First-Phase Preferred Options at Area 3

Refer to Appendix C.3 for the First-Phase Scoring Matrix for Area 3. The results showed that overall; **Option 3A is the Preferred Option**, and **Option 3D is the Sub-Preferred Option** following the First-Phase Appraisal Process.

6.4 First-Phase Options Appraisal at Area 4 – Redbridge

6.4.1 Background information on Area 4

The Redbridge area extends from the area immediately downstream of the Devil's Backbone to Munday's Bridge. This area has multiple key infrastructure crossings; Old Abingdon Road, the Southern Bypass Road and the railway line.

Figure 5- Old Abingdon Road at Redbridge Crossing

There are numerous existing infrastructure in this area which creates a significant number of constraints. The two lines of electricity pylons between the Devil's Backbone and Old Abingdon Road restrict the opportunities for utilising the whole of this area.

The railway runs north-south and flood flows need to cross this line to return to the River Thames at this location. There are currently three existing crossings on watercourses below the railway, Stroud's and Munday's Bridges are located south of Old Abingdon Road and the existing Hinksey Stream culvert (Cold Harbour Bridge) is to the north of Old Abingdon Road. Network Rail are also installing a fourth culvert upstream of Old Abingdon Road.

Old Abingdon Road creates a significant challenge to the scheme. There are a number of existing culverts below the road but these are of insufficient capacity to accommodate the flood flows and additional capacity will be required. This is complicated by the fact that the existing culverts have Scheduled Monument status. There is a significant risk that any additional crossing at this location could encounter more buried archaeology.

The A423 Oxford Southern Bypass cuts across the route on a wide embankment and flood flows need to pass this embankment. The land between Old Abingdon Road and the A423 consists of historic landfill sites. To the east the Park and Ride car park facility restricts opportunities. Kennington Road corridor carries a large number of critical services which restricts work to this corridor.

At Munday's Bridge, there is an electricity pylon and a residential garden bounded by a sheet piled wall that restricts access into this area.

6.4.2 Available options at Area 4

There are three options proposed for the corridor at Area 4. The general philosophy behind the options chosen in this area is to optimise the capacity of the openings under the railway and under the Oxford Bypass and minimise the scale of engineering works.

Immediately adjacent to the proposed flood defence bund at South Hinksey, all of the options would require the construction of a clear span bridge to take the access track for the electricity substation. This bridge will also take some service (electricity) cable diversions.

All options utilise existing watercourses and these watercourses would require widening and dredging to increase their flow capacities. Any proposed widening works on the existing watercourses that span within close proximity and in parallel with the railway embankment will require a more engineered channel to protect the railway embankment.

Similarly, widening and deepening of existing railway and highway crossings will also be required to increase flow capacity. Copies of the plans for the various options are provided in Appendix A.

6.4.2.1 Option 4A – New single 2-stage channel

Refer to Appendix A.09 for the conceptual drawing for Option 4A.

Option 4A proposes a 2-stage channel that will start from Devil's backbone and end at the first railway crossing at Cold Harbour Bridge. The flow will then go into the first flow-split and a proportion of the flow will cross the railway at Cold Harbour Bridge into Hinksey Stream. The remaining flow from the first flow-split will go into the lagoon. A second flow-split will be located downstream of the lagoon to utilise a new culvert that will be constructed by Network Rail. The remaining flow from the second flow-split will go into a proposed constrained channel that will start from the downstream end of the lagoon and end at Old Abingdon Road. This constrained channel will have to meander away from a pylon before it reaches Old Abingdon Road.

Option 4A proposes two new crossings at Old Abingdon Road; one at the western side of Old Abingdon Road by the junction with Kennington Road. The other crossing will be at the eastern side of Old Abingdon Road and it will be situated to the east of existing Mayweed culverts.
The flow after the proposed eastern crossing of Abingdon Road will follow the existing course of Hinksey Stream which crosses the A423 Southern By-Pass Road and then ultimately discharges into River Thames.

The flows after the proposed western crossing of Abingdon Road will flow directly into the railway crossing at Stroud's Bridge via a proposed constrained channel. Only a proportion of the flow will cross at Stroud's Bridge which will then enter Hinksey Stream. The remaining flows will flow in a proposed constrained channel along the western side of the railway embankment to connect with the railway crossing at Munday's Bridge. This proposed constrained channel will have to meander away from a pylon before reaching Munday's Bridge. The flows through the railway crossing at Munday's Bridge will then discharge to Hinksey Stream.

6.4.2.2 Option 4B – New two 2-stage channels

Refer to Appendix A.10 for the conceptual drawing for Option 4B.

Option 4B is very similar to Option 4A for the proposals at the southern side of Old Abingdon Road. At the northern side of Old Abingdon Road, Option 4B proposes a 2-stage channel at the upstream end but then the 2-stage channel will split into two 2-stage channels. A large flow control structure would be required to at the bifurcation point to manage the proportioning of flows across both channels. One of the 2-stage channels from the split will follow the course of Hinksey Stream and cross the railway via Cold Harbour Bridge and the new Network Rail culvert. The other 2-stage channel from the split will continue in a southerly direction to reach the proposed western crossing at Old Abingdon Road.

6.4.2.3 Option 4C – New two 2-stage channels and new constrained channel

Refer to Appendix A.11 for the conceptual drawing for Option 4C.

Option 4C assumes that the Network Rail culvert will not be constructed and proposes other ways of conveying flows across the railway line. Option 4C is very similar to Option 4B for the proposals at the northern side of Old Abingdon Road. At the southern side of Old Abingdon Road, Option 4C proposes a new constrained channel that will start from the proposed western crossing at Old Abingdon Road and end at the railway crossing at Munday's Bridge. The proposed constrained channel will span in parallel to the western side of Kennington Road and through the historic landfill site. To avoid the possibility of contamination to the watercourse, it is likely that this channel would have to be heavily lined/ engineered to separate the potential leachates from the landfill site and the watercourse. Additionally, this proposed channel will require two new crossings to be constructed to firstly cross the A423 Southern By-Pass Road and then Kennington Road.

Following the proposed crossing at Kennington Road, the extent of the proposed constrained channel will be limited by a pylon on the north side and residential properties on the south side before it reaches Munday's Bridge. As a result of this limitation, the proposed channel will require to encroach on the gardens of some residential houses.

6.4.2.4 Culvert crossings below transport infrastructure

All the proposed options split the flows upstream of Old Abingdon Road to utilise the openings underneath the railway at Cold Harbour Bridge and at the new Network Rail culvert (to be constructed). The remaining flow is then taken under Old Abingdon Road at the western end to utilise Stroud's and Munday's bridges. The flow split between the four structures will be adjusted during outline design stage to optimise capacities and operation of the system.

6.4.2.5 Access for construction

Access to the area to the North of Old Abingdon Road would be gained from the South Hinksey access from the A34.

Access to the south of Old Abingdon Road would be directly from this road. Installing new culverts below Old Abingdon Road would require road closures which will be disruptive to road users.

There may also be a need to close the Kennington Road junction at times depending on the exact alignment of any new culvert which will be very disruptive for the public although there is a relatively straight forward diversion via the A423 and the slip roads connecting to Kennington Road. Access to Redbridge Hollow and the businesses on Old Abingdon Road would need to be maintained at all times.

If Option 4C was taken forward there would be a significant impact on a long length of Kennington Road during construction.

New access points would need to be created to the areas to the south of the A423 to facilitate any upgrading of the existing bridges carrying the A423 over the watercourses.

As with any natural watercourses there will be some level of erosion and deposition of sediments and gravels. Given the long section of new semi-natural watercourse upstream of this area and the complexity of access for maintenance at Redbridge it may be worth considering a sediment trap system immediately upstream of Old Abingdon Road. This could provide easy vehicle access for clearance and reduce risk of blockages and need for periodic clearance of material more difficult to access areas and structures downstream.

6.4.3 Summary of First-Phase Appraisal at Area 4

6.4.3.1 Summary of Social Objectives at Area 4

Refer to Appendix B.01 for the evaluation of Social Objectives at Area 4. The scoring results following the evaluation showed that Options 4A and AC were the preferred options with respect to the Social Objectives in Area 4. For this objective, Option 4A is the preferred option and Option 4C is the sub-preferred option.

6.4.3.2 Summary of Technical Objectives at Area 4

Refer to Appendix B.02 for the evaluation of Technical Objectives at Area 4. The scoring results following the evaluation showed that Options 4A and 4B were the preferred options with respect to the Technical Objectives in Area 4. For this objective, Option 4A is the preferred option and Option 4B is the sub-preferred option.

6.4.3.3 Summary of Environmental Objectives at Area 4

Refer to Appendix B.03 for the evaluation of Environmental Objectives at Area 4. The scoring results following the evaluation showed that Options 4A and 4B were the preferred options with respect to the Environmental Objectives in Area 4. For this objective, Option 4B is the preferred option and Option 4A is the sub-preferred option.

6.4.3.4 Summary of Institutional Objectives at Area 4

Refer to Appendix B.04 for the evaluation of Institutional Objectives at Area 4. The scoring results following the evaluation showed that Options 4B and 4C were the preferred options with respect to the Institutional Objectives in Area 4. For this objective, Option 4B is the preferred option and Option 4C is the sub-preferred option.

6.4.4 First-Phase Preferred Options at Area 4

Refer to Appendix C.4 for the First-Phase Scoring Matrix for Area 2. The results showed that overall; **Option 4A is the Preferred Option**, and **Option 4B is the Sub-Preferred Option** following the First-Phase Appraisal Process.

6.5 First-Phase Options Appraisal at Areas 5&6 – North and South Sandford

6.5.1 Background information on Area 5 and Area 6

The Sandford North area runs from downstream of Munday's Bridge to Sandford Weir. The Sandford South area runs from Sandford Weir to downstream of Sandford Lock. Both areas are similar in nature and for the purpose of this report are considered together.

Figure 6 - Floodplain near Sandford Lock

Both Sandford North and South areas have similar characteristics. They have a rural aspect and north of Sandford Lane there is permitted public access which is regularly used by Kennington residents. A row of electricity pylons carrying high voltage cables runs north-south through the area which places restrictions on the alignment of any new channel through the area.

Sandford Lane presents a constraint as vehicle access needs to be retained along this route in the future for both public using the fisherman's car park and for agricultural access.

The fields to the south of Sandford Lane are crossed by a number of significant electrical services both overhead and underground and there is a major sewer crossing the River Thames at the downstream end of the area currently being considered.

Given the public access to the area there are opportunities to enhance the area for users and to improve the biodiversity in the area.

6.5.2 Available options at Areas 5&6

There are two options proposed for the corridor at both Areas 5&6.

Note that Area 6 is a continuation of Area 5 and therefore the selected option for Area 5 has to also be selected for Area 6.

All the proposed options in this area will intercept existing surface water drainage channels and will need to accommodate these. The bases of the existing pylons will require avoiding with any new channel and the area south of Sandford Lane is crossed with numerous overhead and underground cables, some of these will require diverting if Option 6B is taken forward. Copies of the plans for the various options are provided in Appendix A.

6.5.2.1 Option 5A and 6A - New second-stage channel on right Bank of River Thames

Refer to Appendix A.12 for the conceptual drawing for Option 5A&6A.

Option 5A&6A proposes to widen the River Thames by constructing a new channel that will act as a second stage to the existing channel of the River Thames. The proposed second-stage channel will be constructed by lowering the right bank of the River Thames from Rose Isle to downstream of Sandford Lock, a length of approximately 1.5 km.

The proposed second-stage channel will be approximately 60m wide and 1.0-1.5m deep. This channel would only become active before the water levels inside the River Thames begin to rise to the bank levels.

This option will have major impact on the setting of the River Thames and depending on the level of the second stage it could present a hazard to navigation at certain flows or increase risk of grounding.

6.5.2.2 Option 5B and 6B - New 2-stage channel

Refer to Appendix A.13 for the conceptual drawing for Option 5B&6B.

Option 5B&6B proposes a 2-stage channel to span in parallel to the River Thames from Rose Isle to downstream of Sandford Lock, a length of approximately 1.6 km. The proposed 2-stage channel will be approximately 70m wide and 1.5m deep.

Option 5B&6B will require a new footbridge to carry the Thames Path over the entrance to the new channel. These options could also require a form of control structure and heavy erosion control to manage the split of flows from the River Thames.

Option 5B&6B will also require the construction of a new vehicle bridge to carry Sandford Lane over the new channel. Again this will need to be a raised structure to achieve sufficient freeboard over the flood flows and will form a significant structure.

6.5.2.3 Options 6C - As Option 5B&6B but returning to the Thames upstream of Sandford Lane.

Refer to Appendix A.14 for the conceptual drawing for Option 6C.

Option 6C is practically a shorter version of Option 5B&6B as it will re-join the River Thames at upstream of Sandford Lock. Therefore Option 6C will avoid the need for a new bridge on Sandford Lane. However, it is likely to need some work the main River Thames channel downstream of the lock which may create an ongoing maintenance requirements as this is known location for material build up. A significant amount of clearance work has recently been undertaken by the landowner on the right bank in this area which has exposed a large amount of silt deposition along this section.

This option has the benefit of reducing the impact on services to the south of Sandford Lane compared to Option 5B&6B. It also reduce the impact on Sandford Lane itself including the trees along this stretch. A new footbridge will be required on the footpath alongside the weir channel and it may also be necessary to include an additional vehicle bridge to allow the hydro scheme to be serviced and for agricultural access. The outgoing cable from the hydro scheme will need to be diverted over the new bridge.

6.5.2.4 Access for construction

Access into both these areas is difficult. The site is bounded to the west by the railway line and to the east by the River Thames. Based on the above proposals there will be a significant quantity of material to be removed from the area. Current access is via Sandford Lane which is single track, it has two tight corners and a narrow and low bridge with a 3.73m height clearance carrying the railway over the track. This height restriction could limit the size of muck away vehicles to 6 wheel vehicles which would potentially increase the number of vehicle movements. The surfacing of the track is also poor and if subjected to significant heavy road traffic would need resurfacing upon completion.

Access from Sandford Lane to the A34 is either through Kennington village which is narrow and busy or via Radley. Using Kennington Road and White's Lane to the south of Sandford Lane would pass Radley College but skirt the edge of the residential areas. However the size of roads will cause problems with large numbers of vehicle movements.

An alternative could be to utilise the fields to the south west of the channel route for permanent storage if agricultural benefit can be achieved. The use of barges on the river has been discounted due to the need to double handle material and lack of suitable wharf facilities in the area. The use of a temporary Bailey Bridge or conveyor across the River Thames to take material off site via the left bank and to the south via Henley Road has also been discounted due to the height required to maintain navigation on the river and the limited production rates for a conveyor.

Future access for maintenance will be via Sandford Lane. Options utilising a new channel through this area will need to be carefully designed to minimize the risk of sedimentation and creating an ongoing maintenance requirement from this aspect.

6.5.3 Summary of First-Phase Appraisal at Areas 5&6

6.5.3.1 Summary of Social Objectives at Areas 5&6

Refer to Appendix B.01 for the evaluation of Social Objectives at Areas 5&6. The scoring results following the evaluation showed that Option 5A&6A is the preferred option. The other two options in this area ranked equally with respect to the Social Objectives in Area 4; therefore the other two options are both the sub-preferred option.

6.5.3.2 Summary of Technical Objectives at Areas 5&6

Refer to Appendix B.02 for the evaluation of Technical Objectives at Areas 5&6. The scoring results following the evaluation showed that Options 5B&6B and 5B&6C are the preferred options with respect to the Technical Objectives at Areas 5&6. For this objective, Option 5B&6C is the preferred option and Option 5B&6B is the sub-preferred option.

6.5.3.3 Summary of Environmental Objectives at Areas 5&6

Refer to Appendix B.03 for the evaluation of Environmental Objectives at Areas 5&6. The scoring results following the evaluation showed that Options 5A&6A and 6C are the preferred options with respect to the Environmental Objectives in Areas 5&6. For this objective, Option 5A&6A is the preferred option and Option 6C is the sub-preferred option.

6.5.3.4 Summary of Institutional Objectives at Areas 5&6

Refer to Appendix B.04 for the evaluation of Institutional Objectives at Areas 5&6. The scoring results following the evaluation showed that Option 5B&6B and 6C are the preferred options with respect to the Institutional Objectives in Areas 5&6. For this objective, Option 5B&6B is the preferred option and Option 6C is the sub-preferred option.

6.5.4 First-Phase Preferred Options at Areas 5&6

Refer to Appendix C.5&6 for the First-Phase Scoring Matrix for Areas 5&6. The results showed that overall; **Option 5B&6C is the Preferred Option**, and **Option 5B&6B is the Sub-Preferred Option** following the First-Phase Appraisal Process.

6.6 First-Phase Options Appraisal at Area 7 – Weirs Mill Stream

6.6.1 Background information on Area 7

The Weirs Mill Stream area covers the whole length of the Weirs Mill Stream from the River Thames at Long Bridges to the confluence with the Hinksey Stream.

The strategy study identified the need for widening works, mainly along the upper section of this channel but also around the Weirs Mill pool area. This is required due to the River Thames being the restrictive control during flood flows through the Iffley reach.

Weirs Mill Stream has multiple house boat moorings located around the weir pool, these are mainly located on the left bank downstream of the weir pool. These are long standing permanent residential moorings. Residents and landowners from this area have already voiced concern over the scheme and indicated they are likely to object to a solution which has a detrimental impact to the residential moorings.

Figure 7 - Weirs Mill Stream

Iffley Meadows to the east of Weirs Mill Stream is designated as a SSSI which is home to a number of important species including the rare Snakes Head Fritillary which is present in a number of locations at the site. This presents both a constraint and potential opportunity.

Weirs Lane divides the area on a raised embankment across the floodplain with bridge openings to accommodate Weirs Mill Stream.

6.6.2 Available options at Area 7

There are three proposed options at Area 7. Copies of the plans for the various options are provided in Appendix A.

6.6.2.1 Option 7A – Widening of Weirs Mill Stream

Refer to Appendix A.15 for the conceptual drawing for Option 7A.

Option 7A involves widening and straightening of Weirs Mill Stream to increase the flow capacity through the existing stream. The majority of the proposed widening and straightening works are mainly on the right bank of Weirs Mill Stream. However, there will be a small stretch of widening works on the left bank at the length immediately downstream of Weirs Mill Pond.

Option 7A will have the most impact on the boat moorings; it will also require some dredging work on Weirs Mill Stream especially at the Weirs Mill Pond area.

6.6.2.2 Option 7B – Proposed additional culverts at Donnington Bridge Road

Refer to Appendix A.16 for the conceptual drawing for Option 7B.

Option 7B proposes to use the natural floodplain by encouraging the floodwater to flow through Iffley Meadows. The banks of the River Thames at the area north of Donnington Bridge Road will be lowered to allow floodwater to flow southwards towards Donnington Bridge. Option 7B will then require additional culvert crossings at Donnington Bridge Road to convey the additional floodwater. The size and number of the proposed additional culverts are not yet known, however it is likely there will be three new proposed culverts.

Option 7B will require raised flood defences due to the additional floodwater.

6.6.2.3 Option 7C – Proposed constrained channel

Refer to Appendix A.17 for the conceptual drawing for Option 7C.

Option 7C proposes a constrained channel to link the River Thames with Weirs Mill. The proposed constrained channel will be approximately 20m wide and 1.5m deep. This channel will be active before the water levels inside the River Thames channel reaches the bank levels. Option 7C will require a control structure at its upstream side to ensure the water is retained in the River Thames channel during periods of low flows.

6.6.2.4 Access for construction

Access for construction of any works in this area will be difficult and disruptive as all vehicles will need to access the area from Weirs Lane. It may be possible to bring plant in by barge on the River Thames however the headroom on Long Bridges prevents access to the upper reaches of Weirs Mill Stream for anything higher than a standard narrow boat. Boat access to the reach of Weirs Mill Stream downstream of the control structures is possible although the depth of water in the weir pool would be restrictive.

Road access from the A34 and Oxford Ring Road is relatively short via Abingdon Road and Weirs Lane. However this passes through a heavily developed residential area and the areas suffers from congestion at peak traffic times.

Transport of materials by barge is possible but would present a number of problems. The river and navigation structures restrict the size of barges. It is likely that 20 tonne barges could be utilised but numbers of barges per tug would be restricted by lock sizes. However the speed of operation would also be prohibitive due to the need to load, lock down or up the river and unload at a suitable slipway to transfer into road going vehicles. There are also known gravel shoals in the river in the

local area which, whilst navigable by pleasure craft would need to be removed by dredging to allow fully laden workboats to navigate without difficulty or risk of grounding.

Road transport, whilst not ideal, is likely to be the preferred option in this area to maintain production rates during construction although this could be supplemented by river borne transportation on a limited basis.

Access for any future maintenance works is also difficult in some areas. As noted above access for light vehicles is straight forward from Weirs Lane into the meadow, however there will be restrictions on frequency and type of plant due the SSSI status of the area on the south side of the road.

6.6.3 Summary of First-Phase Appraisal at Area 7

6.6.3.1 Summary of Social Objectives at Area 7

Refer to Appendix B.01 for the evaluation of Social Objectives at Area 7. The scoring results following the evaluation showed that Options 7B and 7C are the preferred options with respect to the Social Objectives in Area 7. For this objective, Option 7C is the preferred option and Option 7B is the sub-preferred option.

6.6.3.2 Summary of Technical Objectives at Area 7

Refer to Appendix B.02 for the evaluation of Technical Objectives at Area 7. The scoring results following the evaluation showed that Options 7A and 7B are the preferred options with respect to the Technical Objectives in Area 7. For this objective, Option 7A is the preferred option and Option 7B is the sub-preferred option.

6.6.3.3 Summary of Environmental Objectives at Area 7

Refer to Appendix B.03 for the evaluation of Environmental Objectives at Area 7. The scoring results following the evaluation showed that Option 7B and 7C are the preferred options with respect to the Environmental Objectives in Area 7. For this objective, Option 7C is the preferred option and Option 7B is the sub-preferred option.

6.6.3.4 Summary of Institutional Objectives at Area 7

Refer to Appendix B.04 for the evaluation of Institutional Objectives at Area 7. The scoring results following the evaluation showed that Options 7A and 7C are the preferred options with respect to the Institutional Objectives in Area 7. For this objective, Option 7C is the preferred option and Option 7A is the sub-preferred option.

6.6.4 First-Phase Preferred Options at Area 7

Refer to Appendix C.7 for the First-Phase Scoring Matrix for Area 7. The results showed that overall; **Option 7C is the Preferred Option**, and **Option 7B is the Sub-Preferred Option** following the First-Phase Appraisal Process.

Results of First-Phase Appraisal

The detailed appraisal tables for the seven areas are included in Appendix B. Following the First-Phase appraisal review based on socio-environmental aspects the Preferred Options and Sub-Preferred Options has been identified for each area. These are summarised in the table below;

	Preferred Corridor	Sub-preferred Corridor
Area 2	Option 2D	Option 2C
Area 3	Option 3A	Option 3D
Area 4	Option 4A	Option 4B
Areas 5&6	Option 5B&6C	Option 5B&6B
Area 7	Option 7C	Option 7B

Table 9 - Table of Preferred Corridors at First-Phase Appraisal

It is noted that there are a number of technical challenges surrounding Option 5A&6A in relation to the Sandford hydro-scheme and fish pass and the additional navigational hazards this option may create if this was to be taken forward in the event of the Preferred Option becoming unviable for any reason.

Options Development during the Second-Phase

8.1 Omission of Areas 5&6 and Area 7

One of the early outcomes from the hydraulic and economic analysis was the decision to omit Areas 5&6 and Area 7 from the scheme. The general design concept for the options at Areas 5&6 and Area 7 was to provide a drawdown effect to the upstream flood levels. However, modelling results showed that a greater amount of flood risk reduction could be achieved by proposing alternative options at other areas upstream of Areas 5&6 and Area 7.

Subsequently, the omission of Areas 5&6 and Area 7 triggered a review of alternatives to try and provide additional flood risk reduction to the New Hinksey and Grandpont areas of Oxford. A review on the introduction of raised defences at various locations was carried out to determine the optimal alignment of the raised defences. A summary of this review is provided in Appendix E.

8.2 Preferred options at Area 1 – Botley Road

The design development at Area 1 progressed following the determination of the Preferred Corridor. The objectives of the design were; to maximise the conveyance capacity through Botley Bridge, and to protect the properties to the north of Botley Road.

8.2.1.1 Maximising conveyance capacity though Botley Bridge

Modelling results showed that increasing the flow rates through Seacourt Stream has a direct effect on reducing the water levels in the River Thames to the east where it is more urbanised. Hence, a number of options for maximising the conveyance capacity through Botley Bridge were considered.

The main options considered were:

- A large single stage channel on the Seacourt Stream with a new bridge: this option was discounted due to the amount of disruption it would cause to the traffic in this area. Additionally, the cost to benefit ratio of this option would have been prohibitively low.
- A new culverts beneath Botley Road – this option was also discounted for the same reasons as above.
- A multi-stage channel on the Seacourt Stream and modifications to Botley Bridge – modelling results showed that the multi-stage channel provided the required conveyance with the least amount of ecological and environmental impacts. The proposals to modify Botley Bridge include lowering the channel bed (~0.5m) beneath the bridge and creating a hard bed at the lowered level. This option is the preferred option for increasing the conveyance through Botley Bridge.

8.2.1.2 Raised defences at Botley Road

The properties to the north of Botley Road are situated across the floodplain and are also located in-between two main rivers. The options review in this area showed there are limited amount of available options in this area and the most viable solution was some form of raised defences to the north of the properties. The majority of the proposed raised defences are in the form of an earth bund in keeping with the landscape. However, floodwalls are proposed at the allotments and at the Park & Ride site to reduce the land take at these locations.

8.3 Jacked box culverts through A423 Southern By-pass

Figure 8 - Underside of the A423 Railway Bridge by Kennington

The flow capacity of the channels at either side of the railway embankment is critical to the conveyance of upstream flood water. The channels narrow at either side of the A423 Rail Bridge which reduces the flow capacity and causing higher upstream flood levels. All of the options in the First-Phase Appraisal included channel widening works at this location to improve the conveyance.

The design concept was to try and widen the existing openings below the bridge by excavating the existing sprayed concrete slope on both sides. Once excavated, a new concrete U-channel section would be constructed to support the slope and provide the flow capacity. A sketch of the design concept is provided in Appendix F. A buildability review of this design concept along with other designs was undertaken with the Early Supplier Engagement contractor (Team Van Oord) and the following construction concerns were raised:

- Risk associated with working either side of live railway – this could be managed through solid fencing and temporary works but would require constant track monitoring during the works.
- Risk associated with working below and around the foundations of a 45 year old bridge structure. Based on discussions with Oxfordshire County Council Highways, it appears some remedial works are planned to this bridge in the near future which may raise questions over its current condition.
- Difficulties with installing temporary support for the existing tied sheet pile wall to retain the existing slope during the first phase of the works.
- Access for a suitable size piling rig, sheet piles are not practical to install in this location, bored piles were considered but the size of rig to install the estimated pile diameter required is too large to fit within the existing channel. Widening the channel without temporary support which will further restrict access is not considered practical.
- There is insufficient headroom on the channel side closest to the bridge abutment to allow access for the pile drilling head above pile top.

- There are a number of other issues such as dealing with flows, access for plant, insufficient space to segregate workers from plant and confined space working which could be managed but would create further problems.

Given the construction concerns outlined above, a review was carried out to determine alternatives options which avoid doing any works to the railway bridge which would involve creating a new opening below the bypass embankment on each side of the existing bridge. The existing channels would remain untouched other than minor remedial works to some local scour as maintaining the flow capacity through the existing channels will help reduce the size of the new openings.

The A423 embankment is over 10m high which excludes the use of traditional open trench culvert construction due to the significant temporary works and large amount of earthworks that would be required to excavate the trenches for the culverts. Subsequently, two options were considered for the new openings through the A423 embankment; thrust boring pipes through the embankment, and jacked box culvert through the embankment.

Thrust boring of relatively small pipes is a well proven technology and is cost effective, however a review of the additional capacity required indicates that up to 7 number of 1.8m diameter pipes would be required on each side. Given the space constraints and maintenance issues, this option was discounted.

Box jacking a new culvert through the road embankment at either side of the railway bridge. The hydraulic modelling results indicated the required internal culvert sizes would be in the region of 8m wide and 3.5m high. This option is feasible and again uses proven technology, although it does have a number of specific safety considerations associated with such operations. However, initial discussions by Team Van Oord with a specialist sub-contractor have been positive. This option has the benefit of working in an isolated controlled environment with better access away from the existing bridge structure and railway. The result of the options review concluded that the jacked box culvert is now the preferred option for increasing capacity in this area.

Principal Objectives in the Second-Phase

The Preferred Corridor obtained from the First-Phase Appraisal was then hydraulically and economically modelled to determine the optimal size of the channel corridor (Optimised Preferred Corridor) with respect to the Economic and Social (flood risk) Objectives.

The hydraulic modelling was carried out using the latest industry standard modelling software, Flood Modeller Pro version 4.1. The model schematisation of the Preferred Corridor is given in the report entitled 'IMSE500177-HGL-00-ZZ-RE-N-000124-Modelling_Report'.

Also, a summary of the methodology and assumptions used to calculate the flood damages are given in the report entitled 'Economic Assessment of Oxford Flood Alleviation Scheme'. The construction cost estimates were provided by the Early Supplier Engagement cost consultant, Arcadis and the maintenance costs were given by the Environment Agency.

9.1 Determining the Optimised Preferred Corridor

9.1.1 Evaluating corridor sizes

The following combined route corridor options using the preferred options from the Phase 1 assessment for each area combined together were taken forward for detailed hydraulic and economic modelling:

- **Option 1 – Do Nothing**

Refer to the document entitled "*IMSE500177-HGL-00-ZZ-RE-N-000078-Modelling_Do_Min_and_Do_Nothing*" for details on the schematisation of the Do Nothing option. In summary, this scenario is consistent with the Do Nothing scenario within the FCRM Appraisal Guidance (2010) wherein it is defined as: "*An option used in appraisal to act as a baseline against which all other options are tested. It assumes that no action whatsoever is taken. In the case of existing works, it assumes for the purposes of appraisal that operating authorities cease all maintenance, repairs and other activities immediately. In the case of new works, it assumes that there is no intervention, and natural and other external processes are allowed to take their course."*

- **Option 2 – Do Minimum**

Refer to the document entitled "*IMSE500177-HGL-00-ZZ-RE-N-000078-Modelling_Do_Min_and_Do_Nothing*" for details on the schematisation of the Do Minimum option. In summary, this scenario is consistent with the Do Minimum scenario within the FCRM Appraisal Guidance (2010) wherein it is defined as: "*An option where an operating authority takes the minimum amount of action necessary to maintain an asset."*

- **Option 3 – Raised Defences only**

This option assumes only the three proposed defences are constructed as a standalone option. Hence it assumes the scheme will only comprise of the proposed raised defences at; Botley Road, South Hinksey, and New Hinksey.

- **Option 4a - Small channel on its own**

The small channel is defined as approximately half the size of the Medium channel (Option 5b).

- **Option 4b - Small channel with raised defences**

This option is a combination of Option 4a and Option 3.

- **Option 5a - Medium channel on its own**

The size of the Medium channel is similar to the 'Medium Channel' as described in the Strategic Outline Case. In summary, this channel size is based on achieving the channel capacity that is slightly more than the combined capacity of the existing plus proposed culvert crossings.

- **Option 5b - Medium channel with raised defences**

This option is a combination of Option 5b and Option 3.

9.1.2 Scope of evaluation

Options 1 and 2 are baseline (hypothetical) options which are used only as a comparator for the other options. Option 3 is a fall back option should the full economic assessment indicate that the channel options are not viable or if funding not be available in the future to implement the channel options. All of these options are evaluated and reported in the document entitled "*IMSE500177-HGL-00-ZZ-RE-N-000161-Economic_Assessment_at_Outline_Business_Case*".

The evaluation within this report focuses on Options 4b and 5b as these two options include all the raised defence from Option 3 as wider integrated solutions.

A large channel was found to be physically impractical to construct primarily due to the constraint on the culvert sizes through Botley Bridge and Old Abingdon Road, therefore the 'Large Channel' option described in the Strategic Outline Business Case has been qualitatively discounted and not investigated further.

9.2 Overview of Economic Objectives

Social Objectives in the Second-Phase Appraisal have been split down into three key sub-objectives, these are:

- Reduce the risk of floods impacting on infrastructure
- Reduce the risk of flooding to commercial properties
- Maximise the Net Present Value

9.2.1 Reduce the risk of floods impacting on infrastructure

Reducing the impact of flooding on the infrastructure is essential in keeping Oxford open for business and accessible by emergency services. Additionally, reducing the flooding impact on the infrastructure also creates more opportunities to attract third party funding.

This sub-objective evaluates each option against the flood extent on key roads and also evaluates which option would take out the most amount of business from the high to very high risk bands, 1 in 20 and 1 in 10 return periods, respectively.

9.2.1.1 Keeps strategic roads open, Abingdon Road and Botley Road

The two roads above are two main road routes into the centre of Oxford and both roads are prone to regular flooding. The method use for evaluating the impact of flooding on these two roads is based on the onset of flooding and the Multi Coloured Manual's approach for quantifying the present value Road Delay Damages.

9.2.2 Reduce the risk of flooding to commercial properties

9.2.2.1 Number of commercial properties taken out of high (1:20) and very high risk (1:10)

There are many business premises that are situated within and around the periphery of the floodplain which flood. The evaluation was based on interrogating the flood depths on the commercial properties for each option against the Do Minimum scenario. The commercial properties that have a flood depth for the Do Minimum Scenario but not in the option run will be counted and defined as *taken out of flood risk*. The threshold levels still remain valid.

9.2.2.2 Number of commercial properties taken out of insurance benchmark (1:75)

Taking properties out of the insurance benchmark will deliver tangible benefits to the businesses and reduce the impact on the local economy. Similarly, the evaluation was based on interrogating flood depths for the 1 in 75 return period.

9.2.3 Maximise Net Present Value

This Sub-Objective determines the option with the highest standalone Net Present Value (NPV) which is one of the criteria on which the Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA) is based upon.

NPV is defined as the difference between total present value of benefits minus the total present value of costs. Details of the assumptions used for the calculations are given in the report entitled 'Economic Assessment of Oxford Flood Alleviation Scheme'.

9.3 Overview of Social Objectives

9.3.1 Reduce the risk of flooding to residential properties

This Sub-Objective determines which option would take out the most amount of residential properties from the high and very high risk flood bands, 1 in 20 and 1 in 10 return periods, respectively. Additionally, this Sub-Objective also determines the option that would take out the most amount of residential properties from the 1 in 75 return period which is the typical benchmark standard of protection that is used by insurers.

9.3.1.1 Number of residential properties taken out of high (1:20) and very high risk (1:10)

Similarly, the evaluation was based on interrogating the flood depths on the residential properties for each option against the Do Minimum scenario. The residential properties that have a flood depth for the Do Minimum Scenario but not in the option were counted and defined as *taken out of flood risk*. The threshold levels still remain valid.

9.3.1.2 Number of residential properties taken out of insurance benchmark (1:75)

Taking properties out of the insurance benchmark will deliver tangible benefits to the residents and could open more land for development. Similarly, the evaluation was based on interrogating flood depths for the 1 in 75 return period.

Summary of Second-Phase Appraisal

Option	Benefits to Road Infrastructure (£M)	Reduction in Flooding to Commercial Property (number of properties taken out of flood envelope)			Net Present Value (£M)	Reduction in Flooding to Residential Property (number of properties taken out of flood envelope)		
		1:10	1:20	1:75		1:10	1:20	1:75
4a	2.31	39	40	80	946	199	331	385
4b	2.31	43	60	105	977	215	462	535
5a	2.67	43	49	101	979	215	469	663
5b	2.69	46	65	123	1001	215	508	885

Table 10 - Results of Second-Phase Appraisal

The results in Table 10 have been translated into an assessment scoring matrix similar to the Phase 1 assessment to determine the preferred route corridor option. This matrix is presented in Appendix G of this report and shows that Option 5b outperformed the other three options on all parameters.

The results also indicated that Option 5b is the Optimised Preferred Corridor which would give the most reduction to the flood risk within the study area whilst meeting all the other objectives for the scheme. Therefore, it is recommended that Option 5b route corridor and channel size is taken forward to outline design and onto the Outline Business Case.

An image of the recommended route corridor and channel size and alignment is shown in Figure 9 overleaf.

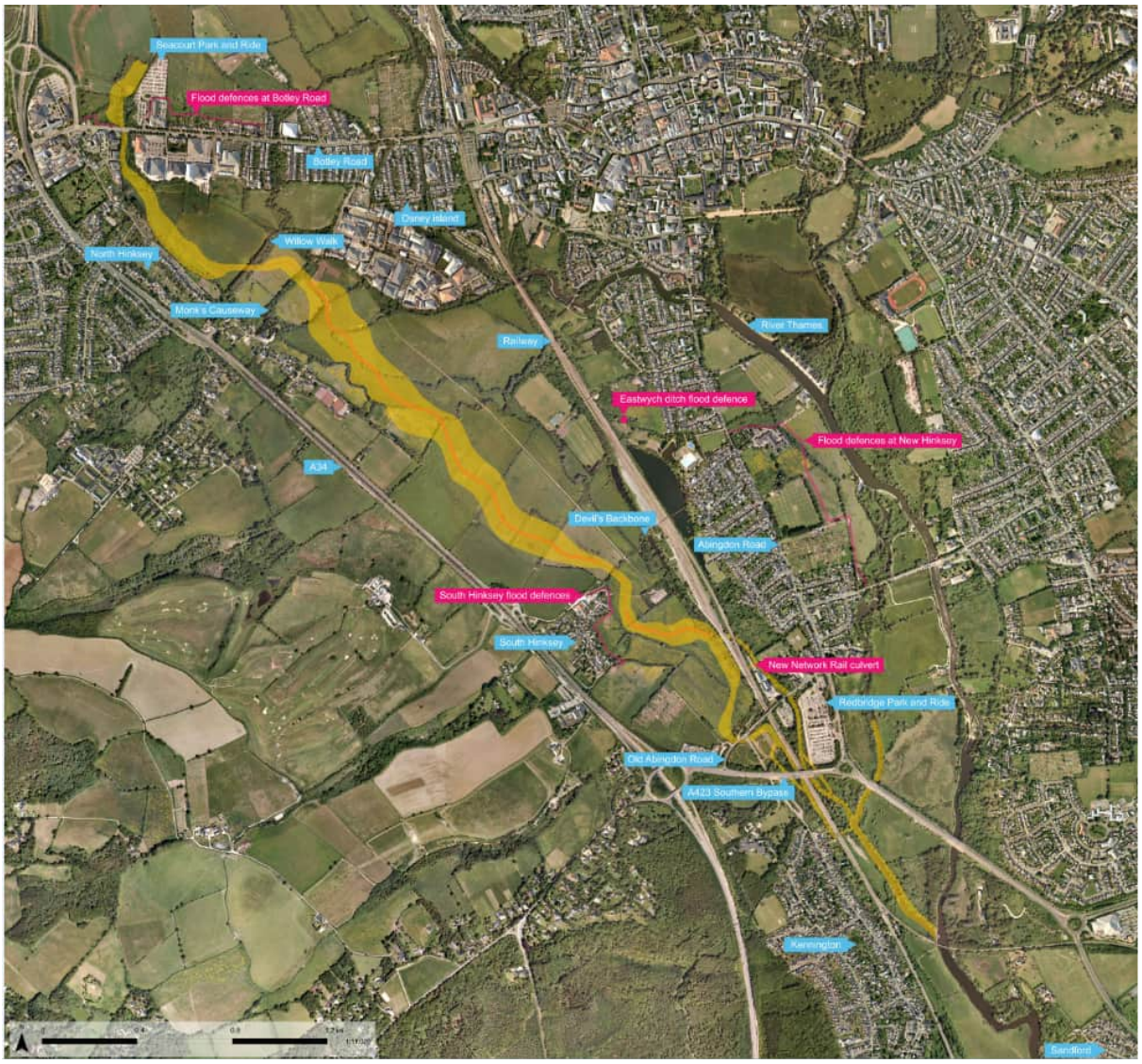
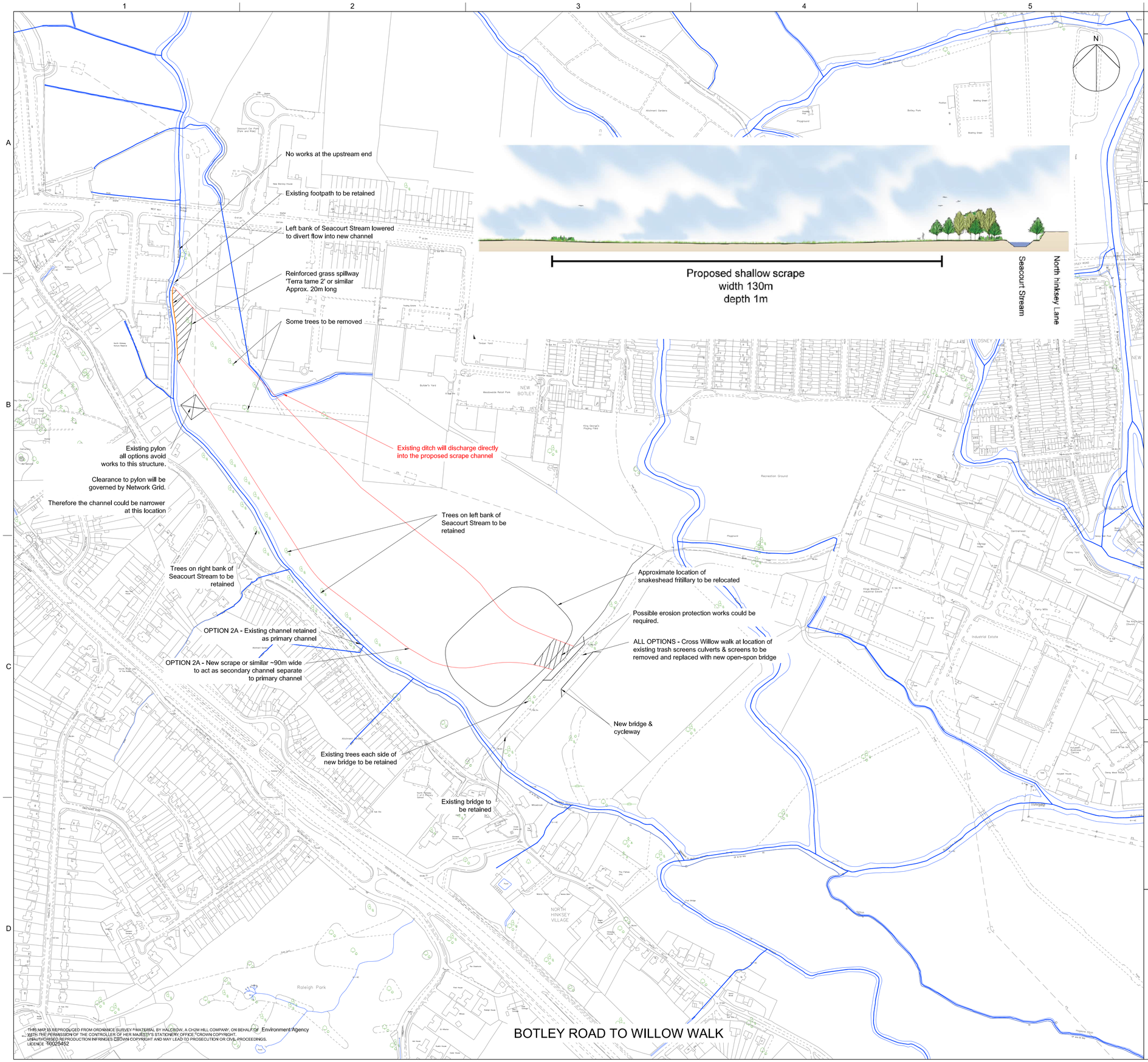


Figure 9 – Recommended Route Corridor

Appendices

Appendix A - Individual Conceptual Drawings for Each Option



GENERAL NOTES

1. ALL DIMENSIONS IN METRES UNLESS STATED OTHERWISE.

NOTES

1. DO NOT SCALE FROM THE DRAWING.

OPTIONS:

2A: EXISTING CHANNEL RETAINED AS PRIMARY CHANNEL. SEPARATE SCRAPE TO ACT AS SECONDARY CHANNEL UNDER FLOOD CONDITIONS.

2B: NEW PRIMARY AND SECONDARY CHANNEL. EXISTING CHANNEL RETAINED AS BACKWATER ONLY.

2C: CONSTRAINED CHANNEL ON LINE OF EXISTING CHANNEL TO PYLON. UNCONSTRAINED CHANNEL DOWNSTREAM OF PYLON.

2D: UNCONSTRAINED WITH EXISTING PYLON WITHIN SECONDARY CHANNEL.

LEGEND

OPTION 2A

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 20 40 60 80 100 200
METERS

BOTLEY ROAD TO WILLOW WALK

REV	STATUS	DATE	DSGN
1	DRAFT	06/11/2015	TP

REVISION: FOR INTERNAL REVIEW

CHK	APVD
EG	PM
DR	APVD
TP	BY
	PM

DRG STATUS: DRAFT

DRG REV: 1

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OXFORD FLOOD ALLEVIATION SCHEME OBC

AREA 2 ROUTE CORRIDOR OPTION 2A

NOT TO SCALE

DATE	06/11/2015
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DWG	0201
SHEET	1 of 1

Proposed two stage channel
width 118m
typical depth 1-1.5m
maximum depth 2m

Seacourt Stream

North hinksey Lane

No works at the upstream end

Existing footpath to be retained

Reinforced grass spillway
'Terra tame 2' or similar
Approx. 20m long

Part of Seacourt Stream will be filled to divert flow into the new 1st stage.

Opportunity to maintain a sweetening flow in Seacourt Stream via a culvert or a control structure

Some trees to be removed

Existing pylon
all options avoid
works to this structure.

Clearance to pylon will be governed by Network Grid.

Therefore the channel could be narrower at this location

Opportunity to connect new channel or scrape to existing channel which is retained as backwater. It could require loss of trees

OPTION 2B - Sinuous low flow channel ~20m wide, alignment to be confirmed

Trees on left bank of Seacourt Stream to be retained

OPTION 2B
New Secondary channel min. 70m wide

Trees on right bank of Seacourt Stream to be retained

Approximate location of snakeshead fritillary to be relocated

Possible erosion protection works could be required.

ALL OPTIONS - Cross Willow walk at location of existing trash screens culverts & screens to be removed and replaced with new open-spon bridge

OPTION 2B - Seacourt Stream retained as backwater

Option 2B will have deepest excavation at the bridge

New bridge & cycleway

Existing trees each side of new bridge to be retained

Existing bridge to be retained

BOTLEY ROAD TO WILLOW WALK

GENERAL NOTES

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2D: UNCONSTRAINED WITH EXISTING PYLON WITHIN SECONDARY CHANNEL.

LEGEND

OPTION 2B

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 20 40 60 80 100 200
METERS

REV	STATUS	DATE	DSGN	CHK	APVD	BY
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OPTION 2B

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NOT TO SCALE

DATE	06/11/2015
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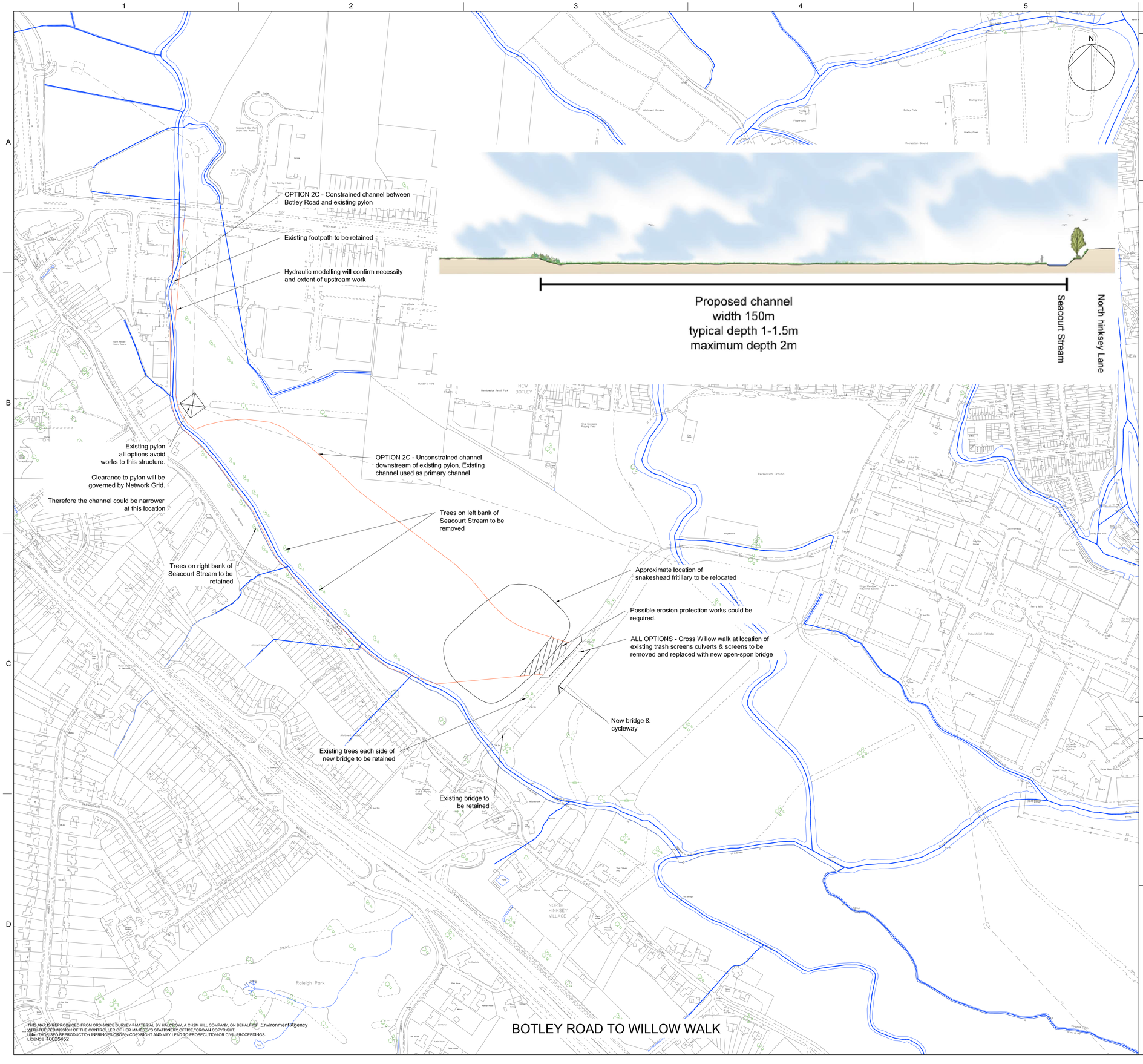
DWG	0201
SHEET	1 of 1



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2D: UNCONSTRAINED WITH EXISTING PYLON WITHIN SECONDARY CHANNEL.

LEGEND

OPTION 2C

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 20 40 60 80 100 200
METERS

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AREA 2 ROUTE CORRIDOR
OPTION 2C

NOT TO SCALE

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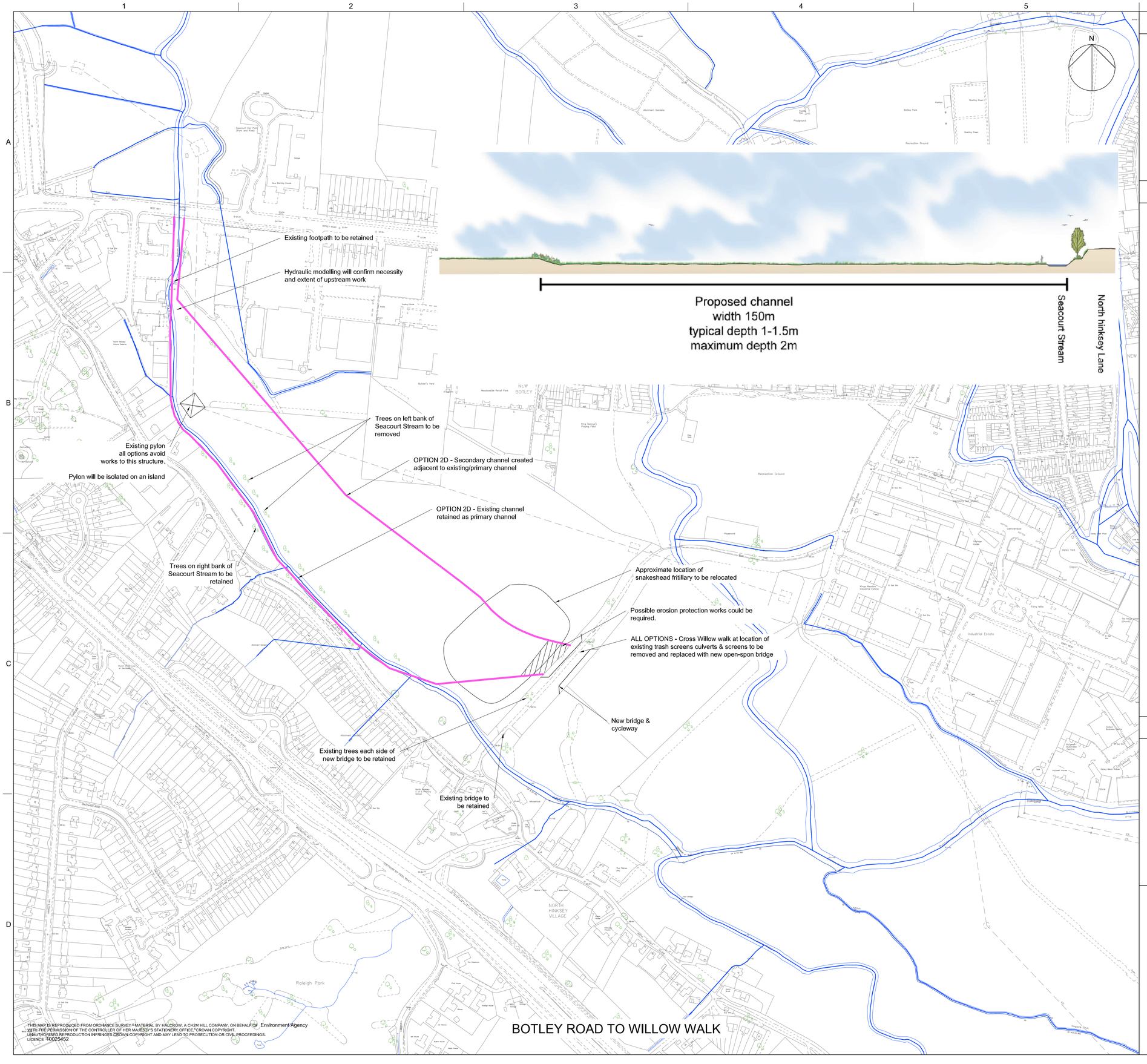
SHEET	1 of 1



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2D: UNCONSTRAINED WITH EXISTING PYLON WITHIN SECONDARY CHANNEL.

LEGEND

OPTION 2D

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 20 40 60 80 100 200
METERS

REV	STATUS	DATE	DR	REVISION	CHK	APVD	BY	APVD	DRG STATUS	DRG REV
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AREA 2 ROUTE CORRIDOR
OPTION 2D

NOT TO SCALE

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SHEET	1 of 1

All options propose a Constrained channel after Willow walk to avoid Creeping Marshwort as far as possible

All options require erosion protection measures

All options propose a clear-span bridge

All options retain the trees in front of village

OPTION 3A - New 2-stage channel with no inclusion of a pond

Electric Road major constraint

All options require gas pipe to be lowered below proposed channels

All options require water pipe to be lowered below proposed channels

All options require erosion protection measures

All options propose a new clear-span bridge at Devils Backbone

All options propose raised flood defences

Hinksey Stream

Electric Road

Proposed two stage channel
width 125m
typical depth 1-1.5m
maximum depth 2m

GENERAL NOTES

1. ALL DIMENSIONS IN METRES UNLESS STATED OTHERWISE.

NOTES

1. DO NOT SCALE FROM THE DRAWING.

NOTES

3A: NEW 2-STAGE CHANNEL.

3B: NEW 2-STAGE CHANNEL WITH AN OFFLINE LAKE.

3C: NEW 2-STAGE CHANNEL WITH AN ONLINE LAKE.

3D: NEW 2-STAGE CHANNEL WITH A SERIES OF SMALL OFFLINE LAKES.

LEGEND

OPTION 3A

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 50 100 150 200 250
METERS

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AREA 3 ROUTE CORRIDOR OPTION 3A

NOT TO SCALE

DATE	06/11/2015
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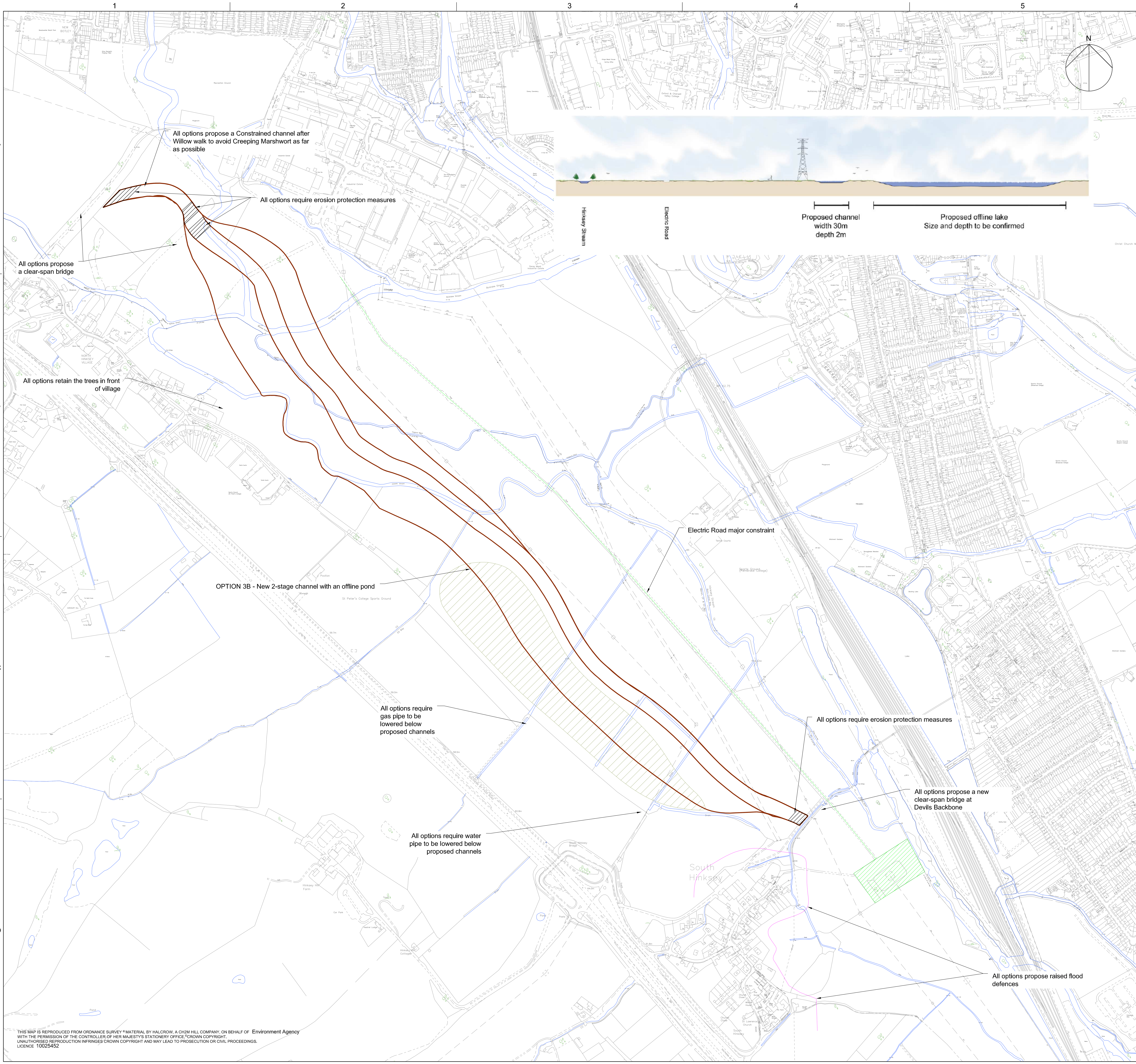
DWG	0301
SHEET	1 of 1



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NOTES

3A: NEW 2-STAGE CHANNEL.

3B: NEW 2-STAGE CHANNEL WITH AN OFFLINE LAKE.

3C: NEW 2-STAGE CHANNEL WITH AN ONLINE LAKE.

3D: NEW 2-STAGE CHANNEL WITH A SERIES OF SMALL OFFLINE PONDS.

LEGEND

OPTION 3B

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 50 100 150 200 250
METERS

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AREA 3 ROUTE CORRIDOR
OPTION 3B

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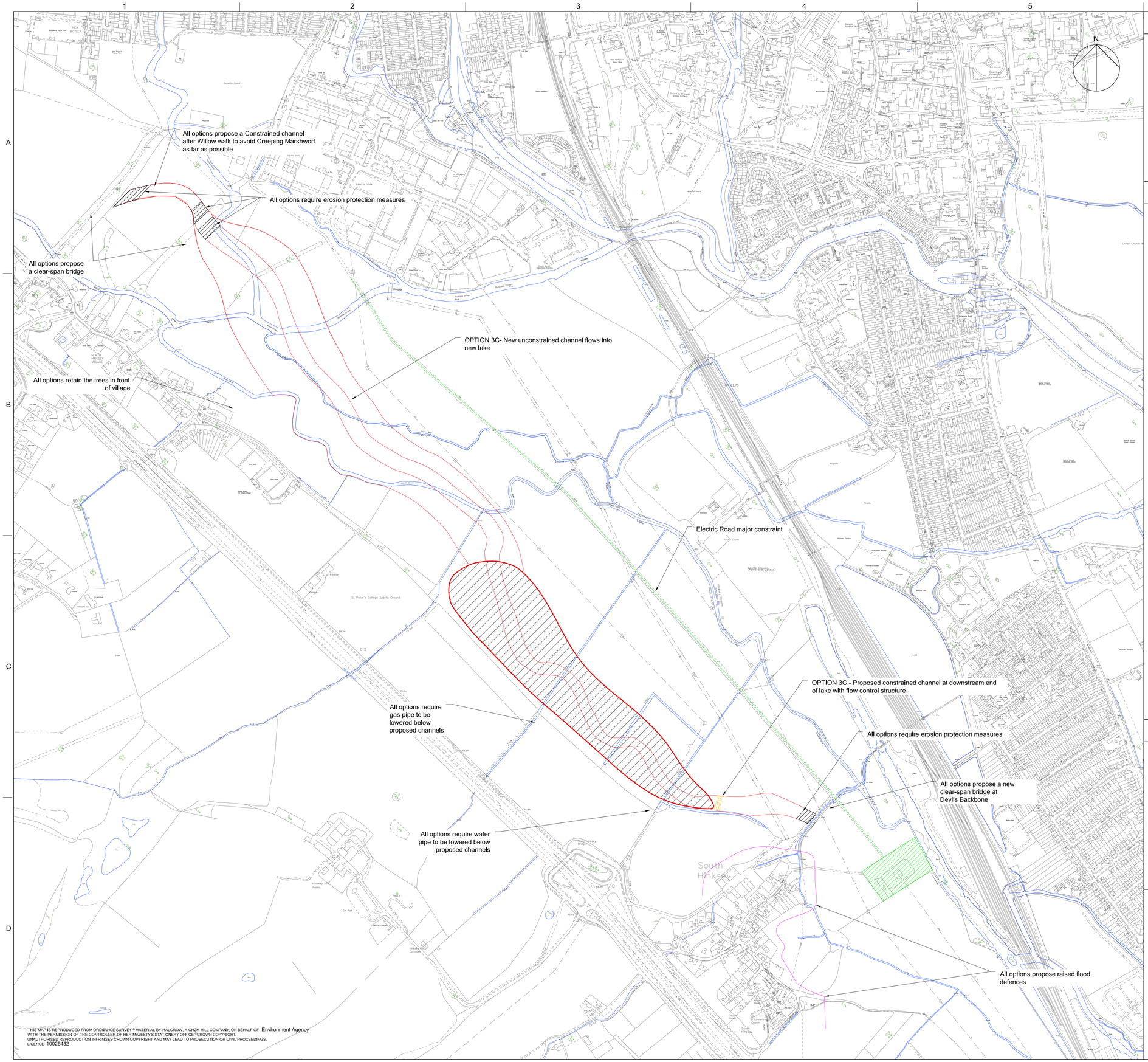

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NOTES

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3B: NEW 2-STAGE CHANNEL WITH AN OFFLINE LAKE.

3C: NEW 2-STAGE CHANNEL WITH AN ONLINE LAKE.

3D: NEW 2-STAGE CHANNEL WITH A SERIES OF SMALL OFFLINE PONDS.

LEGEND

OPTION 3C

EXISTING WATERCOURSES

DRAFT
OFFICIAL:SENSITIVE

0 50 100 150 200 250
METERS

REV	STATUS	DATE	DR	CHK	REVISION	BY	APVD
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