Cranbrook / Counter Drain Flood Risk Management Strategy

Volume 1

Detailed Strategy Report

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The cover photograph shows the existing Welches Dam Pumping Station from the opposite bank of the Counter Drain with the Ouse Washes in the background.

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GLOSSARY OF TERMS

Term	***Meaning / Definition***
FCDPAG	Flood and Coastal Defence Project Appraisal Guidance
IDB	Internal Drainage Board
MLBB	Middle Level Barrier Bank
PS	Pumping Station
cumecs	Cubic metres per second
km	Kilometres
km^2	Square kilometres
ha	Hectares (10,000 m^2)
Flood Risk	Standard of Protection
PAR	Project Appraisal Report
MLC	Middle Level Commissioners
SEA	Strategic Environmental Assessment
SEO	Strategic Environmental Objectives
SPA	Special Protection Area
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
WRc	Water Research Council
CBA	Cost/benefit analysis
SAM	Scheduled Ancient Monument

0 Executive Summary

Key Findings

- *The Cranbrook Drain/Counter Drain/Old Bedford River is primarily a drainage and flood protection system. As structures within this system are approaching the end of their useful lives a strategic approach is required to safeguard the future of the system.*
- *The current Flood Risk to the system is a 1 in 25 chance of flooding in any given year (including flood embankment freeboard allowance). Defra guidelines classes the catchment area as land use B which has an indicative Flood Risk range of 1 in 25 to1 in 100 chance of flooding in any given year.*
- *The Preferred Strategy comprises*
  1. *Refurbishment of the Welches Dam pumping station*
  2. *Implement water levels/pump hours monitoring equipment to all IDB pump stations*
  3. *Implement leakage control measures on the Cranbrook Drain*
  4. *Implement investigation and analysis of flood embankment stability to Low Bank*
  5. *Phase in flood storage to replace Welches Dam pumping station from year 15 to year 25*
  6. *Continuing operation, maintenance, refurbishment and renewal of the other Environment Agency and IDB structures that feed into the Cranbrook Drain/Counter Drain/Old Bedford River*

PV Costs	*£28.7M*
PV Benefits	*£216.0 M*
Benefit/Cost Ratio	*7.5*
Defra Priority Score	*25*

0.1 Background

The Cranbrook Drain/Counter Drain/Old Bedford River System drains part of the 'Middle Level' fenlands in Cambridgeshire and Norfolk.

The Cranbrook Drain carries water from the relatively high land around Somersham, Colne and Earith and discharges by gravity into the head of the Counter Drain at Black Sluice to the north-east of Earith.

The Counter Drain then flows in a north-easterly direction alongside the Middle Level Barrier Bank [MLBB] receiving pumped flows from the lowland fens at six pumping station sites along the watercourse, which are operated by three IDBs and a private landowner. Fluvial evacuation of the drainage system is through the Old Bedford Sluice when tide levels in the Tidal River Ouse are favourable; but during times of flood evacuation is mainly through Welches Dam Pumping Station [PS]. Welches Dam PS and other associated structures are operated by the Environment Agency. These structures manage floodwater levels and other functions of the Environment Agency such as navigation and water resources.

0.2 The Problem

The Welches Dam PS provides flood protection to the Cranbrook Drain/Counter Drain/Old Bedford River and Internal Drainage Board [IDB] drainage systems that feed into it. The station was commissioned in 1948 and is nearing the end of its useful life. Failure of the pumping station in 1998 and 2003 reinforce the need to do something about the poor reliability of the pumping station. In addition other works are necessary in the system, namely the refurbishment of the Old Bedford Sluice and Lock structure, leakage control measures in the Cranbrook Drain and monitoring of the performance from the IDB pumping stations. However, these works cannot be studied/evaluated in isolation and a strategy study is necessary to identify the approach to deal with this problem.

0.3 Preferred Strategy

The short, medium and long-term strategic measures to safe guard the drainage system are detailed in Table 0-1 below.

Table 0-1: Strategic Measures

Time frame	Year	Activity identified in strategy (excluding normal operation and maintenance works)
Short Term	1 to 5 years	• Flood Risk Management Strategy approval • Flood Storage 'high level' technical and environmental follow on study • Flood Storage option liaison and negotiations (mineral extraction is part of a planning application) • IDB pumping station (water levels and pump hours) monitoring equipment installed, and annual data collection following installation • Cranbrook Drain leakage control measures / Low Bank stability PAR • Welches Dam PS refurbishment, PAR, design and implementation
Medium Term	6 to 25 years	• 5 yearly review of Flood Risk Management Strategy • Flood storage option liaison and negotiations • Cranbrook Drain leakage control measures / Low Bank stability implementation • Old Bedford Sluice and Lock replacement, PAR, design and implementation • Flood storage option feasibility study, PAR, design and implementation • Annual IDB pumping station data collection
Long Term	26 to 100 years	• 5 yearly review of Flood Risk Management Strategy • Annual IDB pumping station data collection • Refurbishment and replacement of IDB and Environment Agency major assets

0.4 Financial Implications

The 'Whole life' cash costs of implementing the preferred strategy are £83.2 million over 100 years. The costs and benefits, evaluated in this study, have been based on July 2007 costs. The economic analysis has produced a benefit/cost ratio of 7.5 (incorporating a 60% optimism bias against costs) and a Defra priority score of 25.

0.5 Environmental Factors

A Strategic Environmental Assessment (SEA) report has been produced following a top-down approach, looking at producing a strategy for the wider geographic area, rather than focusing in on particular projects. This approach aims to ensure that any future plans or programmes in the area will be compatible with each other and with current European Directives and Regulations. At this stage, a 15 to 25 year (medium term) timescale is envisaged for implementation of the preferred option which will then have a life-span of at least 50 years.

0.6 Conclusions & Recommendations

This study demonstrates that the preferred strategy for the Cranbrook Drain/Counter Drain/Old Bedford River drainage system is to maintain all structures in the short to medium term with some refurbishment works to key structures such as Welches Dam PS, Old Bedford Sluice and Lock, leakage control measures to Cranbrook Drain and level/duration monitoring of the IDB pumping stations. However, the medium to long term plan for Welches Dam PS is to phase out the pumping station replacing it with a flood storage facility. It is recommended that the preferred strategy as detailed in Table 0-1 be implemented.

1 Benefits of a Strategic Approach

Principal reasons for taking a strategic approach are set out in Defra's 'Flood and Coastal Defence Project Appraisal Guidance' notes [FCDPAG] and are reproduced as follows: -

- Gives the ability to be proactive rather than reactive and achieves the best long-term value for money and environmental and other benefits through a planned approach to integrated investments in major works, management and maintenance;
- Provides sound decision making and balanced solutions on a wide ranging appraisal which takes account of all the key issues, including all impacts or consequences and opportunities. This includes environmental assessment at the strategic level and identifying opportunities for enhancement;
- Encourages co-operation and partnership between operating authorities and other stakeholders and interested parties. A strategy will be a useful platform for opening a rational debate so that, for example, decisions related to standards of defence versus the cost of public investment can be seen to be taken in a reasonable and open way and opportunities for joint action can be identified;
- Promotes long-term sustainability through strategic thinking and planning. This can often avoid the assumption that works are inevitable;
- Provides the opportunity to undertake assessments of risk and sensitivity at the widest levels, for example assessment of the sensitivity to climate change or changes in planning or investment policy.

It should be noted that once a strategic approach has been undertaken for a given river/drain catchment (or lengths of coast) a periodic review should be carried out to reflect changes in the area, improvements in understanding of the processes involved, the results of monitoring and any other lessons learnt from scheme implementation.

2 The Problem & Study Background

2.1 The Problem

The Welches Dam pumping station provides flood protection to the Cranbrook Drain/Counter Drain/Old Bedford River and Internal Drainage Board [IDB] drainage systems that feed into it. The station was commissioned in 1948 and is nearing the end of its useful life. Failure of the pumping station in 1998 and 2003 reinforce the need to do something about the poor reliability of the pumping station. However, the station cannot be studied/evaluated in isolation and a strategy study is necessary to identify the approach to deal with this problem.

2.2 Study Background

2.2.1 The Study Area

The Cranbrook Drain/Counter Drain/Old Bedford River System drains part of the 'Middle Level' fenlands in Cambridgeshire and Norfolk. Figure 1, Figure 2 and Figure 3 (which can be found in Appendix A at the end of this volume) indicate the location and the extent of the study area along with the designated environmental sites in the area. The Welches Dam pumping station is the main discharge for flood waters from the Cranbrook Drain/Counter Drain/Old Bedford River System and supplements the fluvial drainage into the Tidal River Ouse at Salters Lode. In times of flood or when fluvial discharge is limited water is pumped over the Middle Level Barrier Bank and into the Ouse Washes at Welches Dam. The Ouse Washes are part of the River Great Ouse system and drains into the New Bedford River and then the Tidal River Ouse at Denver. The Tidal River Ouse then flows northwards entering the Wash at Kings Lynn.

The Counter Drain/Old Bedford River, which lies on the northern side of the Middle Level Barrier Bank [MLBB], changes its name for historical reasons at Welches Dam. The Old Bedford River/River Delph, which lies on the other side of the MLBB within the system known as the Ouse Washes also change its name at Welches Dam. The Environment Agency operations department has always referred to the Counter Drain/Old Bedford River watercourse as the 'Counter Drain' and the Old Bedford River/River Delph watercourse referred to as the 'River Delph'. This naming policy has been adopted subsequently throughout this strategy study to remove any confusion.

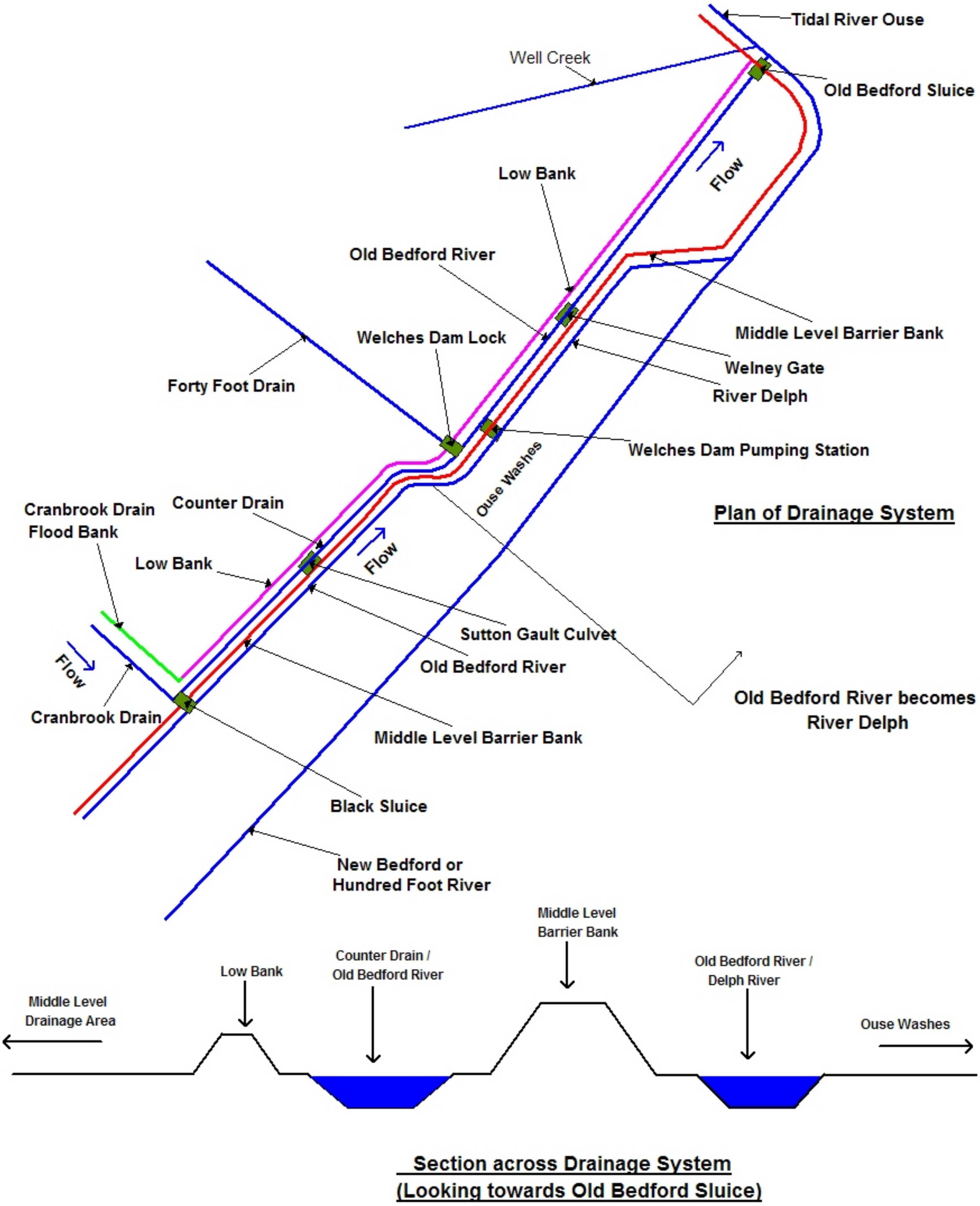
In Figure 4, on the following page, the drainage system has been depicted schematically to show the layout of the watercourses and flood embankments, which lie within or adjacent to the drainage system.

The Cranbrook Drain carries water from the relatively high land around Somersham, Colne and Earith and discharges by gravity into the head of the Counter Drain at Black Sluice to the north-east of Earith.

The Counter Drain then flows in a north-easterly direction between flood embankments known as Low Bank and MLBB. It receives pumped flows from the lowland fens at six pumping station sites along the watercourse, which are operated by three IDBs and a private landowner. Fluvial evacuation of the drainage system is through the Old Bedford Sluice when tide levels in the Tidal River Ouse are favourable; but during times of flood evacuation is mainly through Welches Dam Pumping Station [PS]. Welches Dam PS and other associated structures are operated by the Environment Agency. These structures manage floodwater levels and other functions of the Environment Agency such as navigation and water resources.

Figure 2 in Appendix A shows the catchment boundaries of the Cranbrook Drain/Counter Drain drainage system.

Figure 4: Schematic Diagram of Drainage System



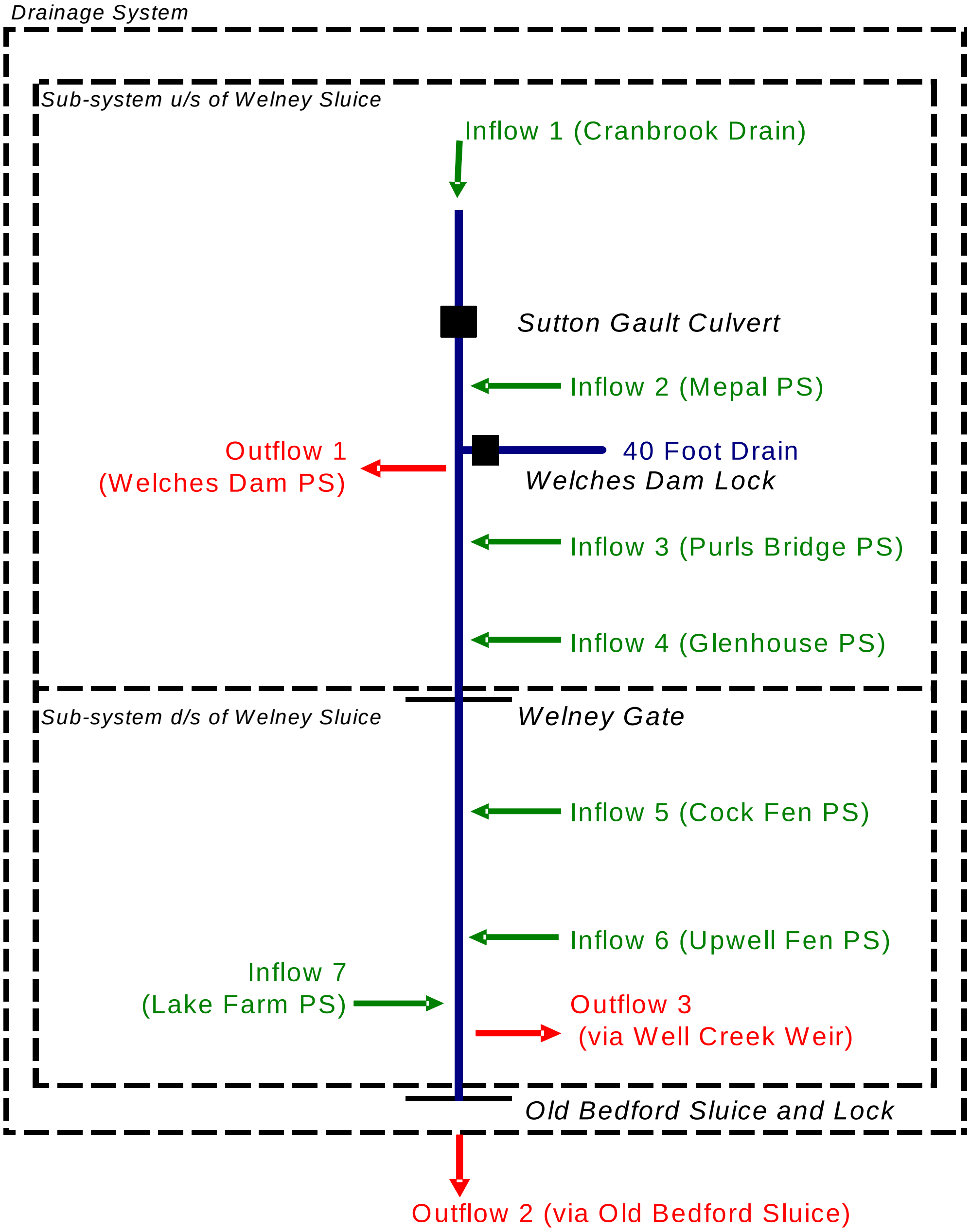
2.2.2 The Drainage System

Figure 5 on the following page gives a schematic representation of the inflows and outflows into the Drainage system.

Figure 3 in Appendix A geographically shows the drainage system to the Cranbrook Drain/Counter Drain and indicates the locations of associated structures within the system. *Appendix B* (which can be found in Volume 2 of this report) sets out the details of this rather complex drainage system.

The drainage system operates under a summer and a winter regime. In the summertime water is taken from the drainage system for irrigation and to support navigation, whilst in the winter the prime function is flood defence.

Figure 5: Inflows/outflows involving the Drainage System



2.2.2.1 *Inflows*

The Cranbrook Drain watercourse is some 5 km long and 26 km^2 in catchment area. It receives runoff from a natural catchment and discharges by gravity into the head of the Counter Drain.

The Counter Drain is some 32 km long and receives pumped flows from the lowland fens at six sites listed in Table 2-1.

Table 2-1: Lowland Pumping Stations

Pumping Station Name	**Maximum Pump Capacity [cumecs]**	**Operated by**	**Catchment Area [km^2]**
Mepal	5.6	Sutton and Mepal IDB	48.6
Purls Bridge	1.1	Manea and Welney IDB	9.3
Glenhouse	4.7	Manea and Welney IDB	21.8
Cock Fen	2.0	Upwell IDB	17.5
Upwell Fen	0.5	Upwell IDB	5.3
Lake Farm	0.3	Private Landowner	1.6

The combined lowland catchment area of these pumping stations is equivalent to 104 km^2.

2.2.2.2 *Outflows*

Under normal winter flow conditions the drainage system discharges by gravity to the Tidal River Ouse through Old Bedford Lock and Sluice (at Salters Lode). When water levels are high in the Counter Drain during flood events the channel is closed by a sluice gate at Welney. Water downstream of this gate gravitates through Old Bedford Sluice (tide permitting) and a secondary means of gravity discharge is over a small weir near Salters Lode. This small weir discharge passes into Well Creek, from where it passes to the Middle Level system. The weir is known as Well Creek Weir.

Floodwater upstream of Welney Gate is pumped through the MLBB by a pumping station at Welches Dam into the River Delph watercourse, which forms part of the Ouse Washes. A secondary means of gravity discharge in the past was through a sluice gate, known as Black Sluice; which discharged into the River Delph. This rarely occurs due to high waters in the Ouse Washes during flood events and this control structure has now become redundant.

2.2.3 Control Structures/Channels/Embankments in the System

Environment Agency associated control structures/channels/embankments in the drainage system are listed as follows in Table 2-2, 2-3 and 2-4. Appe*ndix B* gives further information on these structures.

Table 2-2: Control Structures in the Drainage System

Name	Notes regarding the Structure
Old Bedford Sluice and Lock	Regular flushing and dredging undertaken to clear silt from the channel. Measures are undertaken to ensure gravity discharge from the system and maintain the passage of boats.
Well Creek Weir	Small overspill weir providing a connection to the Middle Level System
Welney Gate	Only operates in times of floods and ensures that drainage system splits into two portions of pumped upstream and gravity downstream of Welney Gate. This is because Upwell IDB and the private landowner at Lake farm do not contribute to the upkeep of Welches Dam PS. Welney Gate ensures that when Welches Dam PS operates only the upstream IDBs and the Environment Agency benefit from its operation.
Welches Dam PS	Existing pumping station which is the sole pumped outlet into the Ouse Washes. Its failure in January 2003 has prompted the strategy study.
Welches Dam Lock	This structure has no flood defence management role in the drainage system and has not been considered for the purpose of this strategy study.
Sutton Gault Culvert	Atkins in their report of April 1998 [*Ref 3*] indicated that an investigation on this structure revealed the need to carry out refurbishment works which have been subsequently undertaken.
Black Sluice	Small sluice which has now operationally redundant

Table 2-3: Channels in the Drainage System

Name	Notes regarding the Channel
Counter Drain	Halcrow in their report of April 2003 [*Ref 5*] stated that regular restricted maintenance in the form of dredging and weed cutting are carried out to maintain navigation with no notable leakage recorded from the channel. All maintenance is subject to English Nature consent.
Cranbrook Drain	Halcrow in their report [*Ref 5*] stated that regular maintenance in the form of dredging and weed cutting are carried out; but with notable leakage from the channel. A project estimate has been previously prepared for leakage control.

Table 2-4: Embankments in the Drainage System

Name	Notes regarding the Embankment
Middle Level Barrier Bank	Major bank strengthening and raising scheme was undertaken in late 1980s/early 1990s amounting to some £12 million. Maintenance on this flood embankment is carried out as part of the maintenance regime for the neighbouring Ouse Washes system.
Low Bank	Halcrow in their report [*Ref 5*] showed that findings where slope stability does not appear to be a problem along most of Low Bank. However, sections of the Low Bank are vulnerable to bank failure by IDB cleaning and deepening adjacent IDB drains and between Delph Junction and Salters Lode. No major works proposed in foreseeable future; but there was a recommendation to carry out an investigation/ analysis into the stability of this flood embankment.
Cranbrook Drain flood bank	The findings in the Halcrow report [Ref 5] showed a risk from channel seepage could cause bank failure. The report included an to resolve the problem of seepage.

Other associated structures within the drainage system are two ‘A’ classified road crossings at Mepal Bridge (culvert) and Welney Bridge. These roads bridges are owned and maintained by the county highway authorities and have been included in the mathematical model to identify if they have any impact on the drainage system itself.

The Ely to Peterborough railway line crosses over the drainage system and the Ouse Washes on a raised embankment/viaduct well above any floodwater levels and does not impact upon the study.

2.2.4 Review of Current Knowledge

Attempts in the past have been made to assess the flood risk Standard of Protection [Flood Risk] afforded by this particular drainage system. A Mott MacDonald Model [*Ref 1*] was produced in 1993 which, due to lack of available data, could only model the system in a simple form. As the system is complex the results of that model require further reworking to achieve the level of certainty required for this strategy study. More sophisticated mathematical river models have been developed in recent years. These developments together with changes to hydrological input data/mapping of flooded areas means that Flood Risk assessment and damage impact assessment can now be more accurately evaluated.

A new river model for the entire drainage system has been built especially for this strategy study. The model enables the system to be assessed for the current Flood Risk and the evaluation of Flood Risk for any strategic proposals considered in the study along with the damage impact assessments for each strategic option.

A full review of the Cranbrook Drain/Counter Drain system, as outlined in Section 2.2.3, has been necessary as input into the river model and to take into account flood risk management aspects of the system. *Appendix B* has been prepared which describes the control structures/channels/ embankments associated with the drainage system.

2.2.5 Links to High Level Plans

Pumped outflow from the Cranbrook Drain/Counter Drain system passes out through Welches Dam PS into the Ouse Washes internationally environmental designated site. The subject of this outflow is discussed throughout various sections of the strategy report.

2.2.6 Previous Policy Options

No previous strategy studies have been undertaken for the Cranbrook Drain/Counter Drain system; but previous options for individual projects have been carried out initially as a pre-feasibility study and then by a project appraisal study basis. The studies are listed in Table 2-5 overleaf.

With regard to Great Ouse Catchment Flood Management Plan [CFMP], the CFMP Report is currently being finalised with completion anticipated in Spring 2008. Details of policy objectives in the draft CFMP are given in the SEA Report (*Volume 3, Appendix G*).

Problems associated with the gravity drainage through the Old Bedford Sluice are being tackled through the Tidal Strategy, which is programmed for completion in 2008.

Table 2-5: Previous Studies/Surveys

Type	Subject	Consultant/ Agency	Report Date
Hydraulic Model Study	Counter Drain	Mott MacDonald	March 1993
Project Appraisal Study	Counter Drain Flood Defences	Binnie and Partners	October 1995
Outline Review	Welches Dam PS and Cranbrook Drain	Environment Agency	March 1997
Structural Survey	Sutton Gault Culvert	W S Atkins	August 1998
Equipment Failure of January 2003	Welches Dam PS	Environment Agency	Undated
Pre-Feasibility Study	Counter/Old Bedford and Cranbrook Drain	Halcrow Group Ltd	April 2003

2.2.7 'Do Nothing' Scenario

All control structures, channels and embankments between the Cranbrook Drain and the Old Bedford Sluice and Lock structure, including Welches Dam Lock on the Forty Foot Drain, would be abandoned. Welches Dam PS would fail within a few days of operation as the diesel fuel would run out. The IDB pumping stations would also cease to pump through lack of maintenance to control gear. Fluvial flooding would commence and the catchment would gradually fill as the only outlet would be the Old Bedford Sluice.

The Old Bedford lock gate, and Welney gate, would both operationally 'fail open' and remain open after a period of between 5 and 10 years. Water would then enter the drainage system via the Tidal River Ouse and flood the catchment. It has been assumed that the tidal doors would fail in the open position as failures generally occur in mid operation. The average tidal flow into the Cranbrook drain is calculated at 15cumec with a peak flow of 46 cumec.

This would result in the whole of the Counter Drain catchment being inundated at an average rate of 15 cumecs. The tidal/fluvial waters would eventually spread into the neighbouring 'Middle Level System (MLS)' which is a drainage system managed by the Middle Level Commissioners (MLC). The flood would spread until it would meet the high ground of Well Creek to the north, the banks of the 16ft drain to the west and the banks of the 40ft drain to the south. The flood flows would then overtop the banks of the 16ft drain (1.4m AOD) and flow into the 16ft drain maintained by the MLC IDB. Once in the 16ft drain the flow would enter into the MLS drainage system ultimately finding its way to the St Germans pumping station. The St Germans pumping station is currently being upgraded with the new facility having a design capacity of 100 cumecs comprising 6 variable speed pumps, each with a maximum capacity of 16.6 cumecs. The new station will be completed in 2010. Consequently the additional 15cumecs from the counterdrain would result in one of the pumps running continuously, averaging 15 cumecs, increasing the annual running cost of the station by between £200k and £300k (depending on the electricity tariff). In addition the maintenance costs of the St Germans pumping station would increase.

The inundation of the Cranbrook catchment would lead to permanent flooding of 308 properties, the A142, A1101 and 8737 ha of agricultural land. In addition 1031 properties would be devalued due to being cut off for long periods.

The new St Germans pumping station is designed to accommodate a one in 66 year fluvial event. In normal circumstances no more than 3 pumps run together in one year. Consequently the additional 15 cumec could be accommodated though this would reduce the MLS SoP. Loss of two pumps in the new station will reduce the SoP to 1 in 14 years (flood risk of 7%). To maintain the MLS to the design SoP would require bank rising at an approximate cost of £8m. The MLS protects some 70,000 ha high grade agricultural land, 24,000 properties and numerous scheduled ancient monuments. Should the MLS flood in the 'Do Nothing' situation the damages would amount to £3.4b. The MLS drainage system would additionally suffer saline infiltration which would influence the use of the drainage system for summer irrigation, the consequences of which would be very damaging to the agriculture.

Should the Old Bedford Sluice fail in the closed position, fluvial flooding would inundate the catchment within 7 years. Should the Old Bedford Sluice continue to be maintained, fluvial flooding would inundate the catchment within 10 to 20 years (depending on the silt levels in the Tidal Ouse).

Finally, the 'Do Nothing' would present a major risk to the integrity of the SAC status of the Counter Drain as it could adversely affect the habitat of the Spined Loach. If this were to prove to be the case, under the Habitats Regulations, this issue would preclude the adoption of 'Do Nothing' if there are feasible alternative options that do not risk adversely impacting the SAC.

3 Strategic Aims & Objectives

3.1 General

The key aims and objectives of the Strategy are:-

- To investigate and assess the flood risk within the Cranbrook/Counter Drain catchment area;
- To review the suitability of the existing part gravity/part pumped drainage system;
- To plan the short, medium and long term strategies for the entire drainage system;
- In determining the long term plans for the drainage system, assess the likely environmental impact upon the drainage system and any effects on adjacent drainage systems;

And subsequent to this:

- identify works in the first 5 years (short term) in sufficient detail to gain Environment Agency Scheme of Delegation (SoD) approval.

3.2 Defined Time Frames

The definitions of time frames used throughout this strategy study are as follows: -

- Short term - from 0 to 5 years;
- Medium term - from 6 to 25 years;
- Long term - from 26 to 100 years

3.3 Opportunities/Constraints

Opportunities, which may arise as part of this strategy study, are noted as:

- Possibility of reducing the pumped outlet into the Ouse Washes through Welches Dam PS;
- Flood risk improvements to the Cranbrook Drain/Counter Drain system; and
- Additional local benefit in relation to tying in flood risk management with other local benefits, identified through examination of local plans and strategies.

Constraints, which may impact on the outcome of this strategy study, are noted as:

- Funding from the IDBs, who part fund, the upkeep of Welches Dam PS;
- Environmental designation of the Cranbrook Drain/Counter Drain system; and
- The performance of the Old Bedford Sluice in relation to its fluvial discharge to the Tidal River Ouse.

4 Flood Risk

This Flood Risk Management Strategy Study has been conducted in line with the new Environment Agency Policy guidelines on the 'Understanding and Communicating Flood Risk'. The Environment Agency defines Flood Risk as a combination of two components:

(a) The chance (or probability) of a particular flood event and;

(b) The impact (or consequence) that the event would cause if it occurred.

Flood Risk has been expressed throughout this report as the probability of flooding in terms of the chance of flooding (e.g. a 1 in 100 chance of flooding at that location in any given year). The consequence has been expressed in flood volume and flood extent as well as the social, environmental and economic impacts.

The indicative Flood Risk for the Cranbrook Drain/Counter Drain has been assessed as land use band B as defined in the Flood and Coastal Defence Project Appraisal Guidance Note 3 [FCDPAG3]. The land use band is based upon the fact that 37 km of 'main river' offers flood protection to 156 km^2 of the catchment, 1339 properties in the lowland catchment together with two major 'A' class road communication links and an entire network of minor roads in the lowland catchment. The classification of land use band B has an indicative Flood Risk range from a 1 in 25 chance up to a 1 in 100 chance of flooding in any given year.

The Flood Risk has been evaluated in *Appendix C* (which can be found in Volume 2 of this report) which covers the mathematic model for the system. From this it can be seen that when determining the Flood Risk, freeboard needs to be taken into account as follows:

- For the determination of the current Flood Risk the point of failure is taken as where water begins to overtop the bank. Freeboard is not included in this determination.
- When considering any future bank works or the vulnerability to bank failure in certain sections of Low bank, freeboard needs to be included in the evaluations. This means the point of failure is where water is within the freeboard of the top of the bank. As detailed in *Appendix C* the freeboard has been calculated at 525mm.

Table 4-1 below sets out the Flood Risk taking into account the above. As the Cranbrook Drain/Counter Drain has been classed as three separate reaches as listed overleaf, the Flood Risk has been determined for each reach.

Table 4-1: Current Flood Risk with Welney Gate closed

Reach	Without freeboard	With freeboard
Cranbrook Drain	> a 1 in 100 chance	> a 1 in 100 chance
Counter Drain (upstream of Welney Gate)	a 1 in 75 chance	a 1 in 25 chance
Counter Drain (downstream of Welney Gate)	> a 1 in 100 chance	< a 1 in 5 chance

From Table 4-1 it can be seen that current Flood Risks (where freeboard is not taken into consideration) for the Cranbrook Drain and both upstream/ downstream of Welney Gate on the Counter Drain are either within or exceed the indicative Flood Risk range.

This current standard of protection is reliant on discharge of normal fluvial flows through the Old Bedford Sluice and Lock structure and the effective operation of the Welches Dam PS. The pumping station was commissioned in 1948 and is nearing the end of its useful life. The pumping station failed in 1998 and 2003 which reinforces the need to do something about the poor reliability of the pumping station. Works are also necessary to refurbish the Old Bedford Sluice and Lock structure as normal fluvial discharge through this structure is becoming less and less efficient.

For future works, Environment Agency best practice guidance dictates freeboard is taken into consideration. From Table 4-1 it can be seen that where freeboard is taken into consideration the Cranbrook Drain and Counter Drain upstream upstream of Welney Gate meets or is above the indicative Flood Risk range. However, the Cranbrook Drain downstream of Welney Gate is below the indicative Flood Risk range. Why this is, is explained in Section 6.1.1. This failure to meet the indicative Flood Risk can be simply rectified if Welney Gate is kept open at all times. The reason for closing Welney Gate (and for Welney Gate being constructed in the first place) is political and related to those that contribute to the upkeep of the Welches Dam PS.

If the removal of Welney Gate is not politically practicable then flood alleviation measures to Low Bank embankment could be considered. Such measures have not been assessed in this study. If they are considered in the future then the cost should be determined and the economic analysis amended accordingly. Now that more information has been gained regarding flood water levels in the Counter Drain, the stability of the Low Bank should also be reassessed.

As explained the existence of Welney Gate is political and its future operation/removal is an unresolved issue which needs to be reviewed by all parties concerned. More details on its performance are given in Section 13 of this report.

5 Alternatives Considered

5.1 Option Development

Four basic conceptual options were developed and they are listed as follows: -

- 'Do Nothing';
- 'Do Minimum' (maintain);
- 'Sustain' (maintain/improve);
- 'Improve' and sustain the drainage system by way of alternative pumping, alternative drainage or flood storage.

A two-staged approach was undertaken for the consideration of strategic options: -

1. A list of options was initially prepared; and
2. Development of a refined shortened list of strategic options, by the strategy team.

A number of strategic options were selected, by means of a workshop conducted by the Environment Agency, Atkins and a representative of the local IDBs in February 2004. The full list of options is detailed in *Appendix G* [*Table 6.2*].

Gravity drainage through the Old Bedford Sluice is important to the catchment and the implementation of the preferred option. The problems associated with the gravity drainage have not been part of the Brief of this Strategy as they are to be tackled by the Tidal Ouse Strategy, which is to be completed in 2008. The Tidal Ouse Strategy work will be used to inform the design for the replacement of the Old Bedford Sluice and Lock and the revision of the Strategy in Year 5.

In brief, the gravity drainage is being compromised by high riverbed levels in the Tidal River Ouse. These high bed levels result in high water levels during the Low Water part of the tidal cycles and thus insufficient hydraulic head at the Old Bedford Sluice. This is aggravated by local siltation at the sluice. In addition, in years to come, climate change leading to an accelerated rise in sea level could result in a general rise in low water levels. In recognition of the poor gravity drainage, provision for a small pumping station has been included in the preferred option in the investment plan in the long term.

It should be noted that, in identifying the initial strategic options, the possibility of raising Low Bank flood embankment was also considered. Low Bank stretches from Black Sluice in the south-west to Old Bedford Sluice and Lock structure in the north-east and is some 31 km long. In order to maintain the current flood risk standard of a 1 in 25 chance, Low Bank would need to be raised by 1.1m to offset pumping out of the Counter Drain. This strategy was discounted as an initial strategic option for the following reasons:

a) A number of sections along Low Bank are considered to be susceptible to failure (see Table 2-4). Raising of Low Bank is likely to have the effect of reducing the stability of this embankment further; both along the sections that are currently known to be susceptible to failure and along sections that are not thought to be at risk of bank failure at present. Failure of Low Bank would result in widespread flooding of the IDB lowland area and would be very similar to the 'Do nothing' scenario as shown in Figure 6 later in this report.

b) In order to maintain the stability of Low Bank and to avoid bank failure when raising the embankment, significant major earthworks would be required by way of:

- Repositioning of existing IDB drains currently situated at the landward toe of Low Bank to allow widening of the embankment base;
- Widening the existing base of the embankment to increase stability of the raised embankment;
- Spreading and mixing of existing bank material (a combination of dredged/imported fill material with poor soil properties) to achieve a homogeneous material over the new embankment base; and
- Building of haul roads for importing new fill material to the site.

c) Similar problems were encountered when the adjacent MLBB was raised by a similar amount in 1990s at a cost of £12 million. This figure is considered to be the minimum cost, if Low Bank were to be raised in the near future.

d) Raising of Low Bank would involve significant earthworks, as outlined above, all along the Counter Drain, which is an internationally designated Special Area of Conservation. Raising of Low Bank along with moving the IDB drains would cause destruction of habitats and would adversely impact on adjacent prime agricultural land through land take. Due to the high potential for environmental degradation of the area, this approach was not considered to satisfy or promote the majority of the Strategic Environmental Objectives and was, therefore, rejected on environmental grounds.

The combination of these economic, technical and environment factors led to an early dismissal of raising Low Bank as a potential initial option and hence it was not carried forward to consultation. However, due to the potential risk posed if Low Bank (in its existing form) was to fail, provisions have been made in the Implementation Plan (Table 14-1) for further analysis and investigation into the need for bank strengthening measures on the existing Low Bank in the future.

The range of options was subsequently refined in July 2004 as a result of comments received in response to the Initial Consultation and an initial technical, economic and environmental evaluation. The remaining options that were taken forward for consideration at the Scoping Stage are presented in Table 5-1 below.

Table 5-1: Summary of Strategic Options at Scoping Stage

Strategic Option			**Description**
No.	**Name**	**Sub-Option**	
1	'Do Nothing'	none	The entire drainage system would cease to be operated and maintained, leading to the failure of Old Bedford Sluice or the immediate cessation of pumped output at Welches Dam PS. This would lead to the tidal/fluvial flooding of the catchment.
2	'Do Minimum' (maintain)	none	Maintain current operation and maintenance regime for as long as practicable (5 to 10 years), eventually leading to the failure of Old Bedford Sluice or the catastrophic failure of the pumps and abandonment of Welches Dam PS. This would lead to the tidal/fluvial flooding of the catchment.
3	'Sustain' (maintain/ improve)	none	Refurbish Welches Dam PS to ensure its ability to provide the current level of flood risk management for the drainage system.

Strategic Option			Description
No.	**Name**	**Sub-Option**	
4(a)	Alternative Pumping	1	Refurbish Welches Dam PS to a reduced capacity, in conjunction with a new pumping station at Black Sluice or Sutton Gault and a possible control sluice at new pumping station.
		2	Refurbish Welches Dam PS to a reduced capacity in conjunction with a new pumping station adjacent to Old Bedford Sluice and Lock.
4(b)	Alternative Drainage	1	Transfer all floodwater from drainage system to the Middle Level drainage system by improving Forty Foot Drain and the abandonment of Welches Dam PS.
	Alternative Drainage	2	As Option 4(b) [Sub-Option 1], but with a reduced amount of floodwater to the Middle Level drainage system and the refurbishment/replacement of a reduced capacity at Welches Dam PS.
4(c)	Flood Storage	none	Provide a flood storage area within or nearby to the Cranbrook Drain/ Counter Drain/Old Bedford River catchment. This would store flows during flood events and would be pumped back into the system with the cessation of the event. This option initially includes refurbishment of the Welches Dam PS.
5	New Pumping Station	none	Abandon Welches Dam PS and build a new pumping station adjacent to Old Bedford Sluice and Lock.

More details regarding the above strategic options are outlined in the following sub-sections of the report

5.1.1 'Do Nothing': Option 1

This option assumes all control structures, channels and embankments between the Cranbrook Drain and the Old Bedford Sluice and Lock structure, including Welches Dam Lock on the Forty Foot Drain, would be abandoned. Welches Dam PS would fail within a few days of operation as the diesel fuel would run out. The IDB pumping stations would also cease to pump as they are automatically controlled and would fail through lack of maintenance to control gear.

Welney Gate would also fail in its open position after a period of 5 to 10 years. Old Bedford lock gate would fail after a period of 10 years, it is assumed the pointing tidal doors would fail in an open state and that water would enter the drainage system via the Tidal River Ouse. The assumptions that all gates and tidal doors would fail in the open position is based upon the fact that failures generally occur in mid operation.

This would result in the whole of the Counter Drain catchment flooding and reverting to its original undrained fen swamp/marshland state. The tidal/fluvial waters would eventually spread further afield into the neighbouring 'Middle Level' drainage system. The failure and flooding mechanism is described in Section 6.1.5 and the flood extent of the 'Do Nothing' scenario is shown in Figure 6.

5.1.2 'Do Minimum' (maintain): Option 2

{Flood Risk deteriorates from a 1 in 25 chance < a 1 in 1 chance over 10 years}

The 'Do Minimum' (maintain) option represents the current situation and assumes that there is no major investment made on any structures in the drainage system apart from attendance to maintain regular items. This non-investment means that the Flood Risk afforded by the current situation will drop over a period of time.

Welches Dam PS would fail through mechanical breakdown. Welney Gate would also fail in its open position after a period of 5 to 10 years. The Old Bedford Sluice would fail after 10 years, and it is assumed the sluice would fail in an open state and that water would enter the drainage system via the Tidal River Ouse.

5.1.3 'Sustain' (maintain/improve): Option 3

{Flood Risk maintained at a 1 in 25 chance}

The 'Sustain' (maintain/improve) option represents the current situation and assumes that there is continuing investment made on all structures in the drainage system and that the level of investment sustains the Flood Risk afforded by the current situation.

The refurbishment of Welches Dam PS pumping plant at its current capacity of 10 cumecs would be undertaken in the short term (within 5 years). Due to the age of Welches Dam PS structure, the complete replacement of this pumping station would need to be undertaken in 20 years time.

All other major control structures in the drainage system would be kept fully operational by refurbishment/replacement and carrying out existing maintenance regime (see Section 5.1.8).

5.1.4 Alternative Pumping: Option 4(a) [Sub-Options 1 and 2]

{Flood Risk maintained at a 1 in 25 chance}

In improving the drainage system, sub-option 1 considers the refurbishment of Welches Dam PS pumping plant in the short term (within 5 years) and the construction of a new additional pumping station at Black Sluice or Sutton Gault. Welches Dam would be refurbished at a reduced rate of 5 cumecs and the new station would also be rated at 5 cumecs. Both pumping stations combined would pump a total of 10 cumecs to match the current pumping capacity of Welches Dam PS. Due to the age of Welches Dam PS structure, the complete replacement of this pumping station would need to be undertaken in the medium term (20 years).

Sub-option 2 considers the refurbishment of Welches Dam PS at 5 cumecs as for sub-option 1 above. However, this sub-option differs in that the additional new 5 cumecs station would be constructed adjacent to the Old Bedford Sluice and Lock and would pump direct to the Tidal River Ouse.

All other major control structures in the drainage system would be kept fully operational by refurbishment/replacement and carrying out existing maintenance regime (see Section 5.1.8).

5.1.5 Alternative Drainage: Option 4(b) [Sub-Options 1 and 2]

{Flood Risk maintained at a 1 in 25 chance}

For this improvement option, sub-option 1 considers the abandonment of Welches Dam PS after 5 years together with improvements of the Forty Foot Drain to accommodate all floodwater to maintain the Flood Risk afforded by the current situation. This effectively passes floodwater from the Cranbrook Drain/Counter Drain system into the Middle Level drainage system. The floodwater would combine with floodwater from the Middle level system and pass by way of the Middle Level Commissioners [MLC] drains and onwards to MLC pumping station at St Germans where it would be returned to Tidal River Ouse.

Alternatively, sub-option 2 considers the refurbishment and reduction of Welches Dam PS to 5 cumecs, after 5 years, using the existing structure. Improvements to Forty Foot Drain would be undertaken to accommodate the remaining 5 cumecs to maintain the Flood Risk afforded by the current situation. The complete replacement of a reduced pumping station at Welches Dam would need to undertaken in 20 years.

All other major control structures in the drainage system would be kept fully operational by refurbishment/replacement and carrying out existing maintenance regime (see Section 5.1.8).

5.1.6 Flood Storage: Option 4(c)

{Flood Risk maintained at a 1 in 25 chance}

There are two ways of providing flood storage capacity within the area; through general land take or as an end-use of worked-out quarries. The latter could be implemented through the use of newly licensed quarries under the Cambridgeshire County Council Earith/Mepal Action Plan, once quarrying has finished. However, as quarrying has only just begun at this location, this is viewed as a medium term solution that could take 20 years to fully implement.

Cambridgeshire County Council Strategic Planning department [Ref 6] are positive about this option and state it “is the most interesting option from a mineral planning perspective”, as it will fit in with and be a part of their Earith/Mepal Action Plan that forms a part of a new Minerals and Waste Development Plan. Further consultation with the Minerals Planning Authority (Cambridgeshire County Council) will be necessary to progress this option.

This improvement option considers the immediate refurbishment of Welches Dam PS pumping plant in the short term (5 years) to extend its life to 20 years. Over the medium term (20 years) the mineral abstractions would take place. The flood storage basin would be created and phased in after 20 years.

Floodwater from the drainage system would then be passed to the exhausted gravel workings, thereby, providing an ample storage basin for floodwater from the entire drainage catchment of the Cranbrook Drain/Counter Drain/Old Bedford River system. A small pumping station would return flows from the storage basin back to the Counter Drain.

Once the storage basin is operational Welches Dam PS would be abandoned. It was recognised that with the rise in tide levels through climatic change that provision of a small pumping station at the site of the Old Bedford Sluice and Lock structure should be included in this option. Normal flows and return flows from the storage basin back to the Counter Drain will still need to be evacuated from the drainage system at Old Bedford Sluice.

All other major control structures in the drainage system would be kept fully operational by refurbishment/replacement and carrying out existing maintenance regime (see Section 5.1.8).

5.1.7 New Pumping Station: Option 5 {Flood Risk < a 1 in 10 chance}

This improvement option considers the abandonment of Welches Dam PS in the short-term (5 years) and the construction of a new pumping station adjacent to Old Bedford Sluice and Lock and this would have the same pumping capacity as the current Welches Dam PS. The removal of Welney Gate and alterations to Sutton Gault Culvert would be necessary.

It should be noted that an increase in pumping capacity at Old Bedford Sluice and Lock will be required to improve the flood risk because of the hydraulic constraint of the Counter Drain in passing flows to the site of a new pumping station.

All other major control structures in the drainage system would be kept fully operational by refurbishment/replacement and carrying out existing maintenance regime (see Section 5.1.8).

5.1.8 Measures Associated with Options 3 to 5

Finally, additional measures need to be undertaken in association with all of the strategic options 3, 4(a), 4(b), 4(c) and 5 which are listed as follows:

- Replacement of Old Bedford Sluice and Lock would take place in the medium term (within 10 years) and would be essential to ensure gravity partial fluvial flow from and maintain navigation rights to the drainage system.
- Refurbishment/renewal of each of the five IDB pumping stations that feed into the Counter Drain.
- Leakage control measures for Cranbrook Drain.
- Instrumentation to be fitted at each of the IDB pumping stations for monitoring pumping hours and water levels at the intake to each station. This requirement has been identified during the study to provide future accurate pump and level data to enable the continuous improvement of the river catchment model.

Also the following maintenance regimes, which are common to each of the strategic options, are listed as follows:

- Continue with current existing maintenance regime to Counter Drain as set out in Table 2-3; and
- Continue with current existing maintenance regime to Cranbrook Drain as set out in Table 2-3.

6 Mathematical Modelling

6.1 Investigation of Option Scenarios

A new MIKE 11 model of the system has been developed which includes the whole of the Cranbrook Drain/Counter Drain. A full model report is included in *Appendix C* (which can be found bound in Volume 2 of this report).

The modelling for this strategy has been carried out with a phased approach as follows:

1. Determine the current exposure within the catchment to Flood Risk and the changes in Flood Risk that would result from any improvements to the drainage system;
2. Determine the flooded areas (and volumes) for each of the options for a range of return periods. This has been done assuming that the total evacuated flow for each option is the same and is set at 10 cumecs, which matches the pumping capacity of the present Welches Dam PS;
3. Determine the flooded areas (and volumes) for a range of pumping capacities at Welches Dam PS once the preferred option had been identified. This has been done for the preferred option only with a range of pumping capacities at Welches Dam PS of 5, 7.5, 10 and 15 cumecs. This has not been repeated with the other options because the selection of the preferred option is not significantly sensitive to optimisation of this type between the main options.

6.1.1 Current Flood Risk

A range of return period simulations were run through the model to determine the current exposure within the drainage system to Flood Risk. The drainage system has been separated into three reaches of Cranbrook Drain, Counter Drain (upstream of Welney Gate) and Counter Drain (downstream of Welney Gate). The Flood Risk associated with these reaches has been previously reported in Table 4-1.

It should be noted that, the Counter Drain downstream of Welney Gate, is currently exposed to a Flood Risk of greater than a 1 in 100 chance of flooding in any given year without freeboard allowance; but reduces to less than a 1 in 5 chance of flooding in any given year with freeboard allowance. The change in Flood Risk does appear large; but can be explained.

Under the current arrangement as water level increases in the Counter Drain it eventually flows out of the system at the Well Creek Weir, before it reaches to the crest level of Low Bank. If freeboard allowance is taken into account then Low Bank crest effectively lies below Well Creek Weir level and floodwater will pass to the lowland catchment over Low Bank rather than through to Well Creek. This means that, when evaluating the Flood Risk, the following is known:

- Without freeboard allowance the Flood Risk evaluation benefits from the significant storage in the lower reach of the Counter Drain;
- With freeboard allowance the Flood Risk evaluation does not benefit from the storage in the lower reach of the Counter Drain. Hence the Flood Risk without freeboard is markedly less than the Flood Risk with freeboard.

6.1.2 Strategic Options Assessment

For the modelling of the options the Cranbrook Drain/Counter Drain was treated as a single system i.e. Welney Gate was simulated open for all the model runs. The results of the model simulations have been processed to determine the area of flooded land, in Table 6-1 below. This information has then been carried forward into the economic assessment, details of which can be found in *Appendix F*.

Table 6-1: Area Flooded [ha] for Strategy Option Assessment

Option	Flood Risk	Flood Risk chance in any given year (1 in x)						
		5	10	25	50	75	100	200
Option 3	1 in 25	0	0	36	290	397	455	581
Option 4(a) [Sub-Option 1]	1 in 25	0	0	18	97	160	208	359
Option 4(a) [Sub-Option 2]	< 1 in 25	0	0	83	366	453	523	668
Option 4(b) [Sub-Option 1]	1 in 25	0	0	36	290	398	456	581
Option 4(b) [Sub-Option 2]	1 in 25	0	0	36	290	398	456	581
Option 4(c)	1 in 25	0	0	36	290	398	456	581
Option 5	< 1 in 10	0	130	351	510	580	638	743

There is a noticeable difference between Option 5 and the other options above. This is because Option 3 and Option 4 involve pumped abstraction close to the point at which overtopping of the Counter Drain occurs. Due to the hydraulic gradient in the Counter Drain this keeps floodwater levels along this reach lower which reduces the volume of water overtopping the Counter Drain. This does not occur for Option 5 as the pumped abstraction, by site of the Old Bedford Sluice and Lock, is some considerable distance from the point on the Counter Drain at which overtopping occurs.

Model runs were also undertaken with the Welney Gate simulated shut and showed that this made very little difference. This is understandable because the vast majority of flows entering the Counter Drain do so upstream of the Welney Gate.

6.1.3 Preferred Option Assessment

The modelling work indicates that Option 4(a) sub option 1 is the best solution as it results in the least area flooded and the highest standard of protection in terms of return period [1 in 25 year event] when compared against the other options. However, the preferred option after due consideration of other factors such as technical, economic, health and safety and environment evaluation (see Section 10 of this report) has been deemed to be Option 4(c). The reasons for this are discussed in more detail in subsequent sections of this report.

The results from the preferred option assessment are given in Table 6-2 below. This information shows the total area flooded by each sub-option modelled and again this information has been carried forward into the economic assessment, details of which can be found in *Appendix F*.

Table 6-2: Area Flooded [ha] for Preferred Option Assessment

Sub-option to Option 4(c) (pumping capacity)	Flood Risk	Flood Risk chance in any given year (1 in x)						
		5	10	25	50	75	100	200
1 (5 cumecs)	< 1 in 5	15	232	431	582	677	751	907
2 (7.5 cumecs)	1 in 15	0	0	295	454	557	604	762
3 (10 cumecs)	1 in 25	0	0	36	290	398	456	581
4 (15 cumecs)	1 in 50	0	0	0	11	46	74	174

6.1.4 Welney Gate

As described above, for all design simulations, Welney Gate has been modelled as fully open. A series of simulations were carried out to test whether the removal of Welney Gate altogether would improve the system performance by reducing the hydraulic gradient in the Counter Drain. This is due to the fact that the gate mechanism in an open position, to a small extent, acts as a physical constraint (i.e. gate width is less than width of the drain). However, the results showed there was no improvement following the removal of this structure.

6.1.5 'Do Nothing' Assessment

6.1.5.1 Counter Drain

The 'Do Nothing' scenario is based upon walking away from the Counter Drain system as a whole. Welches Dam PS would fail within a few days of operation as the diesel fuel would run out. The IDB pumping stations would also cease to pump as they are manually controlled. This would cause the IDB catchments to steadily fill up and coupled with one or other of the following scenarios of breaching of the Counter Drain would cause inundation.

(a) Tidal flooding

Welney Gate would remain in its open position as it is normally open and manually operated. All fluvial flow from the drainage system would discharge through the Old Bedford Sluice. The Old Bedford Sluice would fail in a period of between 5 to 10 years. It is highly probable the gate would fail in a partially to fully open position. This is because mechanical failures occur while movement is taking place and not generally when things are static.

Tidal water would then enter the drainage system via the Tidal River Ouse and because the peak tide levels are above the height of Low Bank on the north-west side of the Counter Drain and this bank would be overtopped or breached. Thus tidal waters would add to the already flooding catchments. In the very unlikely event that the Old Bedford Sluice were to fail shut then the flooding mechanism as detailed in (b) below would take place.

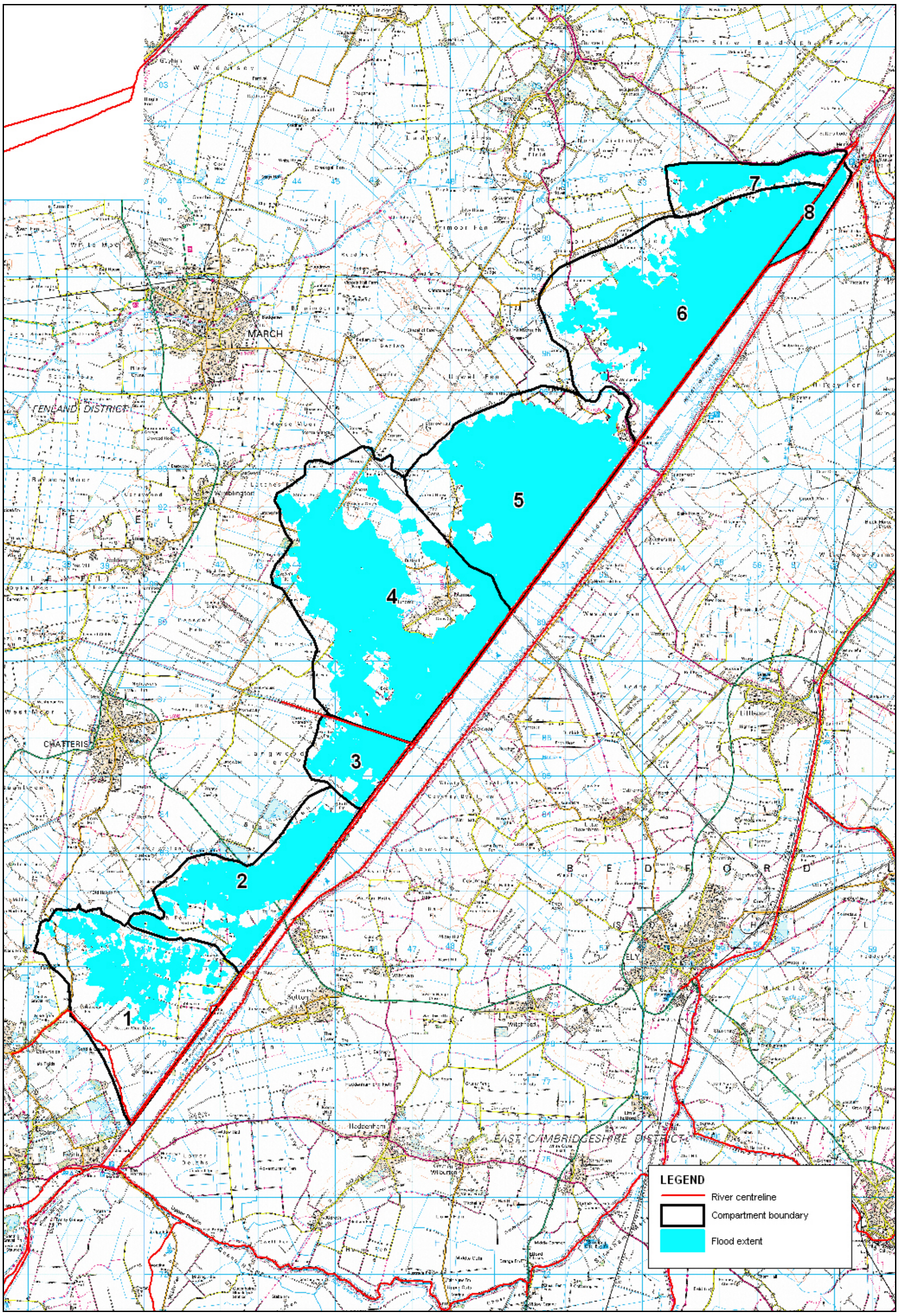
After 5 to 15 years the opening mechanism for Welney Gate would fail allowing the sluice to drop shut or completely collapse. If the sluice were to shut the tidal levels would exceed the top of the Sluice so the situation would not change. After 15 to 25 years the hinges for the Old Bedford Sluice would fail, regardless of whether the gates are open or shut, and the gates would fall down.

(b) Fluvial flooding

With the Welney Gate closed (after 5 to 15 years) the Counter Drain upstream of the Welney Gate would fill with the Cranbrook Drain flows and overtop/breach the Low Bank. As the flows to the Old Bedford Sluice and Lock would be cut off, the Old Bedford Sluice would very quickly become permanently tide locked and would remain shut. As detailed in *Appendix C*, the average pumped flow of the Welches Dam pumping station is 9 million m^3. Based on this it would take 7 years to achieve the same flood levels as detailed in (a) above. Consequently there is no significant difference in timing for the worst case flooding.

The tidal/fluvial waters would not only inundate the drainage IDB areas; but the area would revert back to its original swamp/marshland of the undrained Fens. The tidal/fluvial waters would eventually spread further a field into the neighbouring ‘Middle Level’ drainage system. As can be seen above there is no significant difference in time to cause the same level of inundation with either of the failure mechanisms. Figure 6 shows the flood extent within the system of the ‘Do Nothing’ option within the Counter Drain catchment.

Figure 6: 'Do Nothing' Flood Extent for Counter Drain catchment



6.1.5.2 Cranbrook Drain

A similar 'Do Nothing' scenario for the Cranbrook Drain has been assessed in this strategy study. Flood conditions within the catchment would simply worsen due to the fact that the Counter Drain would either be inundated by tidal water or would not be allowed to freely drain under fluvial conditions.

To represent a 'Do Nothing' scenario the model has been modified to replicate no maintenance being carried out on Cranbrook Drain. Another set of assumptions have been made as follows regarding the Counter Drain:

- All pumps failed (Welches Dam and IDB pumping stations);
- Old Bedford Sluice failed in closed position; and
- Low Bank does not breach.

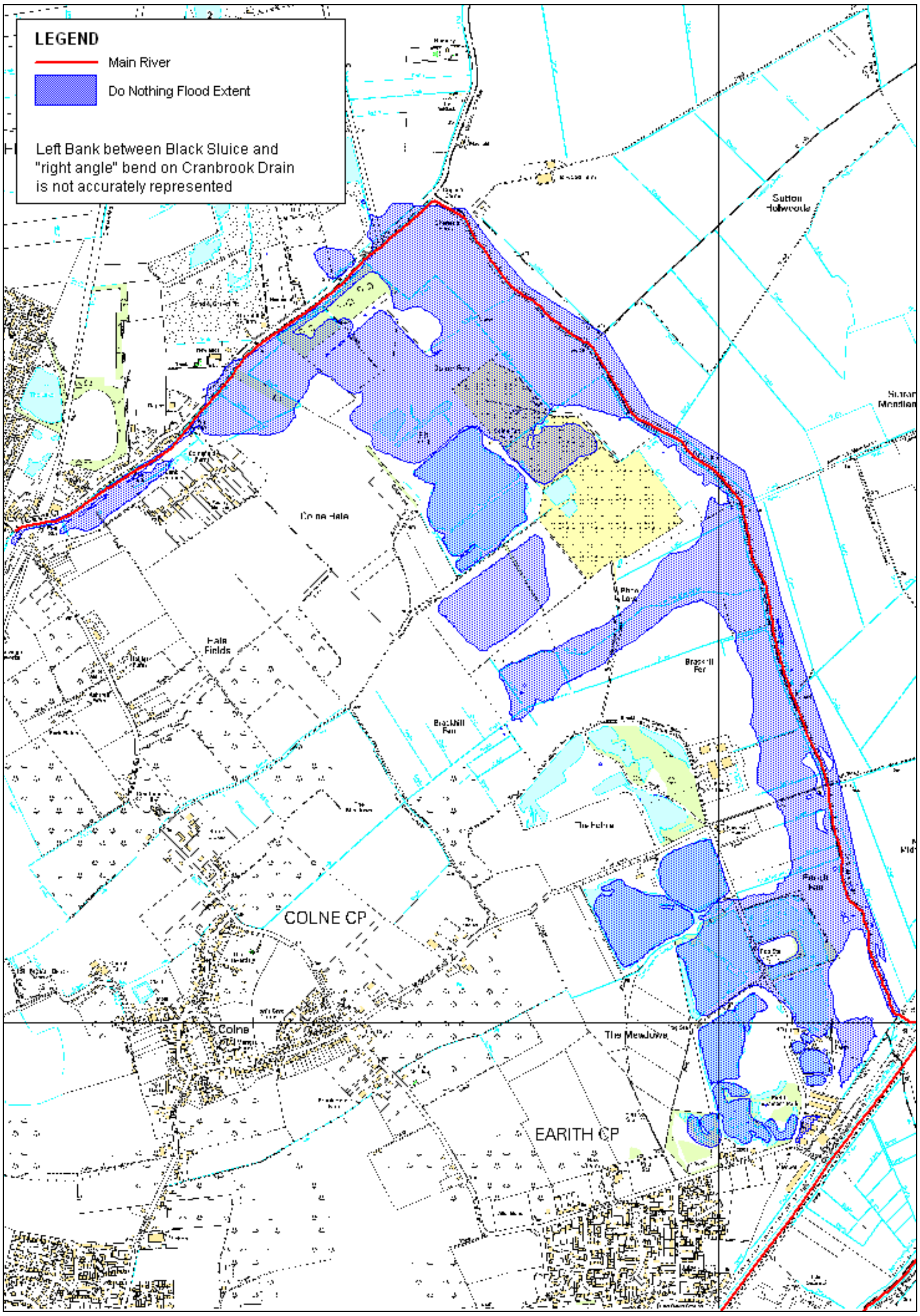
These assumptions have been made to provide the highest probable water level at the downstream end of the Cranbrook Drain, thereby modelling a 'worse case' scenario for the Cranbrook Drain.

The effect of 'Do Nothing' on the Cranbrook Drain is shown in Figure 7 overleaf and indicates that only minor additional flooding in this catchment occurs over and above the current situation. The model demonstrates that water levels are increased by some 500 mm for a Flood Risk of a 1 in 100 chance under the 'Do Nothing' scenario. Examination of the flood extent shows that no properties are at risk from flooding; but it does come very near to properties on Station Approach and Chatteris Road.

A few commercial properties just to the east of Earith are at risk from flooding under this 'Do Nothing' scenario; but damages to these industrial units have been ignored in the economic baseline assessment. The reason is because in the Counter Drain 'Do Nothing' scenario Low Bank will breach and under those conditions the industrial units would not be at a Flood Risk.

It should be noted that flooding to the north eastern side Cranbrook Drain flood bank is not shown in Figure 7; but floodwater would pass over this embankment into compartment 1 of the Sutton and Mepal IDB area. This floodwater would fill up the compartment until it finds its way to the Middle Level drainage system, as does the floodwater from the 'Do Nothing' scenario for the Counter Drain.

Figure 7: 'Do Nothing' Flood Extent for Cranbrook Drain catchment



7 Environmental Summary

7.1 Introduction

The Strategy Study has investigated alternative strategic options, comparing technical, economic, health and safety and environmental aspects of each, with the aim of determining the most suitable long-term drainage strategy for the Cranbrook Drain/ Counter Drain system. As part of the Flood Risk Management Strategy Study, a Strategic Environmental Assessment (SEA) report has been produced in *Appendix G* (which can be found in Volume 3 of this report). The SEA report presents the consideration of environmental aspects in developing a preferred strategy.

The SEA has been carried out following a top-down approach, looking at producing a strategy for the wider geographic area, rather than focusing in on particular projects. This approach aims to ensure that any future plans or programmes in the area will be compatible with each other and with current European Directives and Regulations. At this stage, a 15 year (medium-term) timescale is envisaged for the commencement of the phased implementation of the preferred option which will then have a life-span of at least 50 years.

7.2 The Study Area

The study area has already been described in Section 2.2 of this report and Figure 1 (which can be found in Appendix A indicates the location and the extent of the study area along with the designated environmental sites in the area.

7.3 The SEA Process

This SEA has been undertaken in accordance with, and as a requirement of, EC Directive (2001/42/EC) on the assessment of the effects of certain plans and programmes on the environment. This Directive is commonly known as the 'SEA Directive' and is implemented in England through the '*Environmental Assessment of Plans and Programmes Regulations*' (SI 1633 (2004)). Whilst the Directive does not make use of the term "strategic environmental assessment", or SEA, this term has been adopted to describe the "environmental assessment" required by the Directive, and is used throughout the SEA report.

The objective of the SEA Directive is "to provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development". The Environment Agency regards SEA as a vital tool for putting the environment at the heart of its activities, and ensuring that the implications of its plans and programmes are fully and transparently considered before final decisions are taken. The overall aim of SEA is to help protect the environment and promote sustainability.

The SEA process followed for this study comprises three phases of work that can be broadly summarised as Screening and Scoping/Assessment and Evaluation/ Implementation and Monitoring. The SEA report presents the outputs of the first two phases and makes recommendations for the third (Implementation and Monitoring). Further information regarding the SEA process and methodology is presented in *Section 2* of the SEA Report (*Appendix G*).

7.4 Key Environmental Constraints & Opportunities

The key environmental constraints and opportunities in the study area were identified through a combination of literature review, data request and site visit. These constraints and opportunities are summarised in Table 7-1 below, and are discussed in more detail in *Section 5* of the SEA Report (*Appendix G*). The locations of designated sites situated within the study area are shown in Figure 3 (which can be found in Appendix A at the end of this report).

Table 7-1: Key Environmental Constraints and Opportunities

Receptor	Summary of Key Environmental Issues
Human Beings	♦ Need to balance disturbance caused by construction works against the benefits gained from improved flood risk management. ♦ Recreational opportunities, eg. creation of cycle paths, bridleways, footpaths, navigation inks, water recreation opportunities.
Flora and Fauna	♦ The need to protect the Ouse Washes SPA, SSSI and Ramsar site, and the Ouse Washes SAC as well as other protected species and important conservation sites. ♦ There are also opportunities to enhance protected sites, improve water quality and create new habitats.
Air and Climate	♦ Improved flood risk management can take a sustainable approach to managing the effects of climate change.
Landscape and Visual Amenity	♦ The study area is within an area of fenland characterised by its flat open landscape and rural location. ♦ There is the opportunity to maintain this character and create new wetland areas.
Water	♦ Water resources are carefully managed within the study area and the demands of agriculture and drinking water need to be considered. ♦ There are opportunities for managing the flow and volumes of water in the area more sustainably through use of a flood storage facility to hold floodwater during periods of high flows and control its input into the drainage system (and into the Ouse Washes).
Land Use	♦ Need to balance potential land-take for flood storage area against the benefits of more sustainable and reliable flood protection for the area. ♦ There is the opportunity for a flood storage area to be used as an area for habitat creation.
Cultural Heritage, Archaeology	♦ Need to balance the potential for disturbance of archaeological relics by construction activities with the benefits of improved protection from flooding for Scheduled Ancient Monuments located within the catchment.
Traffic and Transport	♦ Construction traffic may have an impact on the integrity of road infrastructure and disturb local traffic flow during construction works. ♦ There is potential for improved navigable conditions and integration into regional navigation schemes (eg. the proposed Fens Waterways Link).
Soil, Geology and Hydrology	♦ Disturbance of soils during construction works. Opportunity for flood storage option to provide a sustainable end use for local mineral extraction.
Use of Natural Resources	♦ Potential to increase sustainability of the pumping system by reducing use of fossil fuels either by changing to electrically powered pumps or to a reduced or non-pumping drainage solution. This also has the potential to reduce long-term running and maintenance costs and risk of pollution from diesel. ♦ During construction, the opportunity to re-use and recycle materials, and source timber from certified sources.

7.5 Strategic Environmental Objectives

A range of Strategic Environmental Objectives [SEOs] were developed (Table 7-2 below) building on knowledge of the study area and the aspiration and policies of key stakeholders. These SEOs indicate the desired direction for environmental change within the study area. The methodology for developing the SEOs is described in detail in *Section 2.3* of the SEA report (*Appendix G*).

Table 7-2: Strategic Environmental Objectives

Theme	Objective
Flood Management	1. Manage the risk and perception of risk from flooding to people, property, land and the environment. 2. Provide protection from flooding in a manner consistent with plans, policies and objectives.
Climate Change	3. Ensure the strategy is sustainable in terms of climate change over its life time.
Flora, Fauna and Fisheries	4. Protect and enhance biodiversity throughout the study area. 5. Protect and enhance sites of nature conservation importance including designated sites of local, national and international importance particularly the Ouse Washes.
Cultural Heritage and Archaeology	6. Protect and conserve features of archaeological and heritage importance throughout study area.
Landscape	7. Conserve and enhance the landscape character of the area, integrating all works into the local landscape character.
Human Beings	8. Improve sustainability of agricultural and commercial activities reliant on flood protection within the study area.
Recreation and Amenity	9. Protect and enhance recreation and amenity facilities within the study area, including those related to angling, bird watching, navigation, walking, cycling, horse riding and nature conservation.
Traffic, Transport and Navigation	10. Ensure compatibility with transport and navigation infrastructure within the study area.
Land Use	11. Achieve a sustainable approach to land use within the Cranbrook Drain and Counter Drain catchment.
Soils and Geology	12. Protect the quality of soils and underlying geology within the Cranbrook Drain / Counter Drain catchment.
Water	13. Protect and enhance water quality within the Cranbrook Drain / Counter Drain System. 14. Ensure no detrimental impact of changes in water levels and flows within the study area, particularly within the Ouse Washes.
Air Quality	15. Ensure no detrimental impact to local air quality.
Use of Natural Resources	16. Employ the principles of sustainable development as Environment Agency policy dictates.

7.6 Alternative Options Considered

A range of alternative strategic options were considered including various drainage, pumping and water storage options together with the do-nothing and do-minimum benchmarks. Through a process of technical, environmental and economic appraisal coupled with several rounds of consultation with key stakeholders, a long-list of options was reduced firstly to a short-list and finally to the preferred option. The options considered are detailed in Section 5.1 of this report.

Environmental appraisal techniques used included the evaluation and comparison of the alternative strategic options against the SEOs (Table 7-3 overleaf). The options, which accorded most closely with the SEOs, were the alternative pumping option (Option 4a), the alternative discharge option (Option 4b) and the flood storage option (Option 4c). The significance of predicted environmental impacts of each option was also assessed. Selection of the preferred option is discussed in detail in *Section 6* of the SEA report (*Appendix G*).

7.7 The Preferred Strategic Option

The preferred strategic option 4(c) as evaluated in Section 10.1 is to refurbish Welches Dam PS in the short term (ie. within the next 5 years) and maintain for 20 years, whilst developing a longer term flood storage solution as an after use of local minerals extraction.

Environmental issues associated with the preferred strategic option have been identified through data review and a further consultation exercise on the preferred option undertaken in January 2005. The responses to this consultation indicated widespread support for the preferred option from statutory and non-statutory stakeholders.

Key environmental opportunities and constraints of the preferred strategic option, along with some wider implementation issues, are presented in Table 7-4 overleaf. Further details of the preferred option can be found in *Section 6.4* of the SEA report (*Appendix G*).

There a number of internationally designated sites in the vicinity of the Ouse Washes. These include a Special Protection Area [SPA] and Ramsar Site, designated for their bird populations, and a Special Area of Conservation [SAC] designated for its spined loach (Cobitis taenia) population. National designations include the Ouse Washes Site of Special Scientific Interest [SSSI]. The current condition of these sites is deteriorating due to the increase in frequency and duration of spring and summer flooding on the Washes. Flooding is leading to changes in the types of vegetation found on the Washes and this is having an adverse impact on bird populations. The flooding is also causing problems related to the traditional maintenance of the area via grazing.

A current Environment Agency led initiative [Ref 7] is looking to create replacement habitat to compensate for the deterioration of the Ouse Washes SPA. However, it has been agreed between the Environment Agency, English Nature and Defra that the Ouse Washes will still have a conservation value and the on-going requirement for sensitive management to sustain the current conservation interest of the site remain.

An Appropriate Assessment has been carried out, as required by the Habitats Regulations (1994), to assess the potential impacts that implementation of the preferred strategy might have on the integrity of the internationally designated sites. This involved modelling the effect of Welches Dam Pumping Station (both operational and non-operational) on the frequency and duration of flooding of the Ouse Washes by Water Research Council [WRc] in 2005. The results indicated that the average number of days/season that the Ouse Washes are flooded reduces slightly when Welches Dam PS is turned off. The greatest reduction is just under 1 day/season, with most reductions being less than 5%. The effect on average flood durations was also found to be small, with the overall effect of no pumping being a decrease in flood durations.

Table 7-3: Comparison of Alternative Strategic Options with the Strategic Environmental Objectives

Objective Number	Objective	Option Number							
		1	2	3	4(a)[1]	4(a)[2]	4(b)[1]	4(b)[2]	4(c)
1	Manage the risk and perception of risk from flooding to people, property, land and environment.	Negative	Negative	Positive	Positive	Positive	Positive	Positive	Positive
2	Provide protection from flooding in a manner consistent with plans, policies and objectives.	Negative	Negative	Positive	Positive	Positive	Positive	Positive	Positive
3	Ensure the strategy is sustainable in terms of climate change over its lifetime.	Negative	Negative	Negligible	Positive	Positive	Positive	Positive	Positive
4	Protect and enhance biodiversity throughout the study area.	Negative	Negative	Negative	Negative	Positive	Negative	Negative	Positive
5	Protect and enhance sites of nature conservation importance, including designated sites of local, national and international importance, particularly the Ouse Washes.	Negative	Negative	Negative	Negative	Positive	Positive	Positive	Positive
6	Protect and conserve features of archaeological and heritage importance throughout study area.	Negative	Negative	Negligible	Negative	Negative	Negligible	Negligible	Negative
7	Conserve and enhance the landscape character of the area, integrating all works into the local landscape character.	Negative	Negative	Negligible	Negative	Negative	Positive	Positive	Positive
8	Improve sustainability of agricultural and commercial activities reliant on flood protection within the study area.	Negative	Negative	Positive	Positive	Positive	Positive	Positive	Positive
9	Protect and enhance recreation and amenity facilities within the study area.	Negative	Negative	Negligible	Negligible	Negligible	Positive	Positive	Positive
10	Ensure compatibility with transport and navigation infrastructure within the study area.	Negative	Negative	Negligible	Negligible	Negligible	Positive	Positive	Positive
11	Achieve a sustainable approach to land use within the Cranbrook Drain and Counter Drain catchment.	Negative	Negative	Negative	Positive	Positive	Positive	Positive	Positive
12	Protect the quality of soils and underlying geology within the Cranbrook / Counter Drain catchment.	Negligible	Negligible	Negligible	Negative	Negative	Negligible	Negligible	Negative
13	Protect and enhance water quality within the Cranbrook / Counter Drain system.	Negative	Negative	Negative	Positive	Positive	Negligible	Negligible	Positive
14	Ensure no detrimental impact of changes in water levels and flows within the study area, particularly within the Ouse Washes.	Negative	Negative	Negative	Negative	Positive	Positive	Positive	Positive
15	Ensure no detrimental impact to local air quality.	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
16	Employ the principles of sustainable development where practicable.	Negative	Negative	Positive	Negative	Negative	Positive	Positive	Positive

Key to table (significance of impacts):

Negative (adverse) impact — Negligible Impact — Positive

Option 1 'Do Nothing'
Option 2 'Do Minimum' (maintain)
Option 3 'Sustain' (maintain/improve)
Option 4(a)[1] Alternative Pumping [Sub-Option 1]
Option 4(a)[2] Alternative Pumping [Sub-Option 2]
Option 4(b)[1] Alternative Drainage [Sub-Option 1]
Option 4(b)[2] Alternative Drainage [Sub-Option 2]
Option 4(c) Flood Storage

Table 7-4: Issues Associated with the Preferred Strategic Option

Stage of Implementation	Description of Activity	Receptor	Potential Effect on Receptor	Duration of Impact	Significance of Impact	Mitigation / Comments
Refurbish Welches Dam PS	Refurbishment and continued maintenance of pumping station for next 10-15 years.	Human beings	Increased reliability of pumping station (decreased risk of flooding due to failure).	Medium term (ie. 6-25 years), direct impact.	++	NA
			Short timescale for implementation. Standard of protection against flooding quickly brought up to standard and maintained until flood storage available.	Short to medium term (ie. 0-25 years), direct impact.	++	NA
		Human beings, traffic and transport, air quality.	Limited construction works required, therefore less inconvenience due to large vehicles, less noise and dust disturbance.	Short term (temporary), direct impact.	x	Contractor to follow best practice guidelines.
		Natural Resources	Continued use of fossil fuels or electricity to power pumping station.	Short to medium term (ie. for duration of pumping station's life – 0 to 25years), direct impact.	+	NA
		Protected species.	Protected species (otter and watervole) in immediate vicinity of Welches Dam PS may be disturbed during refurbishment works.	Short term (temporary), direct impact.	x	Ecological surveys prior to works commencing.
	Continued pumping of water from Welches Dam PS during high flows.	Fauna and flora on Ouse Washes	Continued pumping of water onto Ouse Washes leading to degradation of internationally designated sites.	Short to medium term (ie. 0-25 years), direct impact.	x	Appropriate Assessment (Section 6.5) has shown that inputs from Welches Dam PS have a minor impact on the Ouse Washes.
			Limited construction works required, therefore less impact likely on flora and fauna.	Short term, secondary impacts during refurbishment works.	++	NA
Flood Storage (General)	Creation of flood storage area.	Human beings	Reduced risk of flooding once operational.	Long-term (ie. 25-100 years), permanent, direct impact.	++	NA
			Loss of prime agricultural land to flood storage facility possibly affecting landowners' livelihoods.	Long-term (ie. 25-100 years), permanent, secondary impact.	x	Planning permission required. Compensation may be paid to landowners.
			Potential for water sport facilities to be integrated into the scheme.	Long-term, secondary impact.	+	Benefit to local community.
		Human beings, traffic and transport, air quality (dust) and noise, natural resources, flora and fauna, soil, geology and hydrogeology, landscape and visual amenity.	Large scale construction works likely.	Short to medium term, permanent, direct impact once construction commences.	xx	Follow best practice guidelines.
	Creation of flood storage area (cont'd)	Flora and fauna	Opportunities for environmental enhancements in flood storage area.	Long term (on completion of flood storage area), secondary impact.	++	NA
		Agricultural land and landscape character.	Loss of prime agricultural land to flood storage.	Long term (permanent), direct impact.	x	Balance between loss of land to flooding versus loss of land to flood storage facility. Will require discussion with landowners.
	Decommissioning of Welches Dam PS.	Natural resources	Pumps no longer required reducing the need for fossil fuels and/or electricity.	Long term (permanent), secondary impact once scheme is operational.	+	Cheaper running costs and more environmentally sustainable system.
		Architectural heritage	Welches Dam PS may fall into disrepair unless maintained as a listed building.	Long term (reversible in short term), secondary impact once PS is abandoned.	x	Liaise with English Heritage and local community groups.
		Flora and fauna, particularly bird populations	No pumping of water onto the Ouse Washes.	Long term (permanent), direct impact.	+	NA

Key to table (significance of impacts):

xxx	Major negative	-/+	Negligible impact	+++	Major positive
xx	Moderate negative			++	Moderate positive
x	Minor negative			+	Minor positive

Table 7-5: Issues Associated with the Preferred Strategic Option (continued)

Stage of Implementation	Description of Activity	Receptor	Potential Effect on Receptor	Duration of Impact	Significance of Impact	Mitigation / Comments
Flood Storage (Disused Quarries)	Use of disused quarries for flood storage.	Human beings	Reduced risk of flooding once operational.	Long-term (ie. 25-100 years), permanent, direct impact.	++	NA
			Land not returned to agricultural use, possibly affecting landowners' livelihoods.	Long-term (ie. 25-100 years), permanent, secondary impact.	x	Planning permission required. Compensation may be paid to landowners. Extraction companies do not need to re-instate land.
			Potential for water sport facilities to be integrated into scheme.	Long-term, reversible, secondary impact.	+	Benefit to local community.
		Land use.	Use of land already damaged / disturbed.	Long term, direct impact.	++	Synergy between EA Strategy and Mineral Planning Authority.
		Water, flora and fauna, land use, human beings.	Storage volume not guaranteed.	Medium to long term (permanent), direct impact.	x	Liaise with Minerals Planning Authority and extraction company.
		Land use and landscape character.	Land not returned to Fenland / agricultural land.	Long-term (permanent), direct impact.	x	Liaise with landowners and extraction company.
		Flora and fauna	Potential for creation of habitat in flood storage area.	Long term (permanent), secondary impact.	++	NA
		Flora and fauna, particularly bird populations	No pumping of water onto the Ouse Washes.	Long term (permanent), direct impact.	+	NA
		Natural resources.	Re-instatement of area after extraction not needed.	Long-term (permanent), direct impact.	+	NA
	Decommissioning of Welches Dam PS	Land use, flora and fauna, natural resources.	Small pumping station required to pump water out of flood storage.	Long- term (permanent), direct impact.	x	Use renewable or "green" energy if possible.
		Architectural heritage	Welches Dam PS may fall into disrepair unless maintained as a listed building.	Long term (reversible in short term), secondary impact.	x	Liaise with English Heritage.

Key to table (significance of impacts):

xxx	Major negative	-/+	Negligible impact	+++	Major positive
xx	Moderate negative			++	Moderate positive
x	Minor negative			+	Minor positive

Modelling was undertaken to determine to what extent the input of Welches Dam PS impacts the ecohydrological regime on the Ouse Washes. The modelling was based upon previous work undertaken by Entec (March 2004), and involved the comparison of the duration and frequency of flood duration on the suitability of the Ouse Washes for the National Vegetation Classification (NVC) MG13 Community.

The NVC MG13 Community is dominated by sprawling grasses with a few, mainly low growing dicotyledonous herbs, and provides the conditions for which the site has been designated under the Wild Birds Directive (79/409/EEC). The conservation value of this plant community lies in the bird populations that use it either to overwinter or to breed. Flooding of the Ouse Washes during the period April to October has led to flooding of nests, change of nesting locations to less suitable habitats and delays in nesting attempts (eg. for black-tailed godwit). With respect to plant communities, flooding is encouraging other types of vegetation to dominate, affecting those bird species which are dependent on particular plant communities for habitat and food. The MG13 Community is considered suitable for determining the appropriate hydrological regime on the Ouse Washes as it is sensitive to prolonged flooding and where this exceeds the preferred threshold, the vegetation will tend towards swamp communities. Further discussion on the selection of the MG13 Community can be found in Annex E of the SEA Report.

Modelled flood durations for scenarios with and without Welches Dam PS were compared to derived preferred inundation period thresholds for the MG13 community. This evaluation showed that there was no difference in the number of field cells in which the preferred inundation threshold for the MG13 community was exceeded between the two scenarios.

Therefore, the Preferred Strategic Option, which involves the decommissioning of Welches Dam PS in the long term, would result in some benefit to the Ouse Washes internationally designated site. However, the benefit of stopping pumping at Welches Dam PS is likely to be small scale and it is unlikely that this would have much effect on the integrity of the Ouse Washes as a whole. The preferred strategy would contribute to the improvement of the Ouse Washes, but is not a solution to the flooding related issues. The results of the modelling work and further discussion are presented in the SEA report.

Another effect of the preferred strategy on the environment is the potential loss of prime agricultural land required for the creation of the flood storage area. Cambridgeshire County Council has, however, identified a site in the vicinity of the Ouse Washes, which is likely to undergo gravel extraction. On completion of the gravel extraction, the disused quarry could potentially be used for flood storage purposes. Part of this flood storage area could be set aside for habitat creation.

7.8 Implementation of the Preferred Strategic Option

The successful implementation of the preferred strategy will depend on a number of key factors:

- Successful refurbishment of Welches Dam PS;
- Identification of a suitable minerals extraction site for after-use as flood storage;
- Successful negotiations with the minerals planning authority and extraction company;
- Securing planning permission and other land use agreements and permissions;
- Maintaining the support of other parties such as the county and local planning authorities, English Nature and the Internal Drainage Boards.

In implementing the preferred strategic option a range of further environmental studies will be needed including the preparation of a Environmental Appraisal Report for the planned refurbishment works at Welches Dam PS. A formal Environmental Impact Assessment to accompany proposals for flood storage after-use at any minerals extraction sites will be necessary. A schedule for the implementation of the works is presented in Table 11-1 and Section 12.0 of this report.

7.9 Additional Measures Associated with the Preferred Strategic Option

Additional measures associated with the preferred strategic option, and other options from 3 to 5, are set out in Section 5.1.8 of this report. These measures generally refer to the refurbishment/renewal of existing Environment Agency and IDB structures on the drainage system and are considered to be minor in relation to the overall strategy for the drainage system. Any such works to these structures would be dealt with in the normal way by going through the Environmental Impact Assessment procedure on an individual basis.

8 Costs & Asset Life

8.1 Estimated Costs

Estimated Capital and Maintenance Costs have been evaluated for all of the strategic options and are detailed in *Appendix E* (which can be found in Volume 2 of this report).

8.2 Asset Life

In order to evaluate 'whole life' costs associated with the strategic options an assessment of 'asset life' has been carried out. The 'residual life' of all existing control structures/channels/ embankments have been assessed along with the 'asset life' of any new possible future control structures/channels/embankments within the drainage system. A similar assessment of the IDB pumping stations within the drainage system has also been undertaken for the strategy study.

8.3 Residual Costs

Some assets have a lifetime beyond that used in the appraisal. These residual costs need to be taken into account to ensure equality of assessment between different options. Residual costs have been assessed for all assets based on the lifespan and year which the works are to be undertaken. This is necessary as costs are incurred at different times during the appraisal period depending on the option.

9 Economic Analysis

9.1 Overview & Staged Approach

The economic assessment for the flood risk management strategy options in the Cranbrook Drain/Counter Drain system has been undertaken in accordance with the Flood and Coastal Defence Project Appraisal Guidance [FCDPAG] reports published by Defra. This assessment is detailed in *Appendix F* (which can found in Volume 2 of this report). The key outputs from this assessment are detailed in the following sections.

The analysis has been undertaken in three stages which are as follows:

9.1.1 Stage 1

This is a 'high level' analysis which is appropriate for comparisons of strategic options. Each of the strategic options has been economically compared using the same flow extraction rate from the Counter Drain. The flow is the rate at which water would either be:

- Pumped out of the Counter Drain; or
- Flow out of the Counter Drain into the Middle Level drainage system through Forty Foot Drain; or
- Flow out of the Counter Drain into storage, in a storm event.

The extraction rate used at this stage was 10 cumecs, which is the nominal capacity of the existing pumping station at Welches Dam. For this stage of the economic analysis the incremental benefit/cost ratio has not been shown as it is not appropriate where differing options with the same extraction rate are being compared.

9.1.2 Stage 2

The economic information from stage 1 has been carried forward to the selection of the Preferred Strategic Option as detailed in Section 10. Here the economic results form one of several fields of comparison for selection of the Preferred Strategic Option. It should be noted that the economic score carries an appropriately high rating in the Section 10 scoring process. Ideally, and as is the case with this strategy, the Preferred Strategic Option should also be the strategic option with the highest benefit/cost ratio. If this were not the case then the strategic options with better benefit/cost ratios would have to be ruled out on justifiable non-economic grounds.

9.1.3 Stage 3

Having established the Preferred Strategic Option further economic analysis has been undertaken to establish a preferred sub-option, i.e. the Preferred Strategic Option was modelled for a range of rates of extraction as follows in Table 9-1 overleaf.

Table 9-1: Preferred Strategic Sub-options

Preferred Sub-option	Pumped Extraction Rate (cumecs)	Flood Risk Chance
1	5	< 1 in 5
2	7.5	1 in 15
3	10	1 in 25
4	15	1 in 50

In this final analysis the incremental ratio was applied. This final stage hones down from the 'high level' strategic analysis to the preferred sub-option within the Preferred Strategic Option in accordance with FCDPAG.

At this stage a test was also undertaken to ensure that it is not probable for another strategic option to give more favourable incremental benefit/cost ratios such that a reduced Flood Risk (i.e. higher standard of protection) could be achieved.

9.2 Benefit/Cost Analysis of Options

Appendix F sets out the benefit/cost analysis of all the strategic options.

9.2.1 Stage 1

The results for Stage 1 are summarised in Table 9-2 overleaf. This shows that the preferred sustainable strategic option with the best benefit/cost ratio is option 4(c), namely refurbish Welches Dam PS within 5 years at 10 cumecs (with a design life of 25 years) and phase in flood storage over the next 15 to 20 years to accommodate the flood flows so that Welches Dam PS would be eventually abandoned and decommissioned.

9.2.2 Stage 2

Stage 2 is detailed in *Section 10* and results show, when considering options/issues/risk and matrix score, that the Preferred Strategic Option is 4(c) in Table 10-1. This options is also the most economic.

9.2.3 Stage 3

9.2.3.1 Refinement of Preferred Strategic Option

The economic assessment for Option 4(c) has been refined for a range of differing pumping capacities and flood risks. The resulting benefit/cost analysis is summarised in Table 9-3 overleaf. Following the FCDPAG3 'Decision Rule', sub-option 3 is the first option falling within the indicative flood risk chance requirement of 1 in 25 where the incremental benefit/cost ratio is greater than 1. Therefore sub-option 3 is the preferred option within the Preferred Strategic Option.

Table 9-2: Benefit/Cost Comparison of the Strategic Options

Variable	'Do Nothing'	'Do Minimum' (Maintain)	'Sustain' (Maintain/ Improve)	Alternative Pumping [1]		Alternative Discharge [1]		Flood Storage [1]	New Pumping Station [1]
	Option 1	Option 2 Extract 10 cumecs from Counter Drain	Option 3 Extract 10 cumecs from Counter Drain	Option 4(a) [sub-option 1] Extract 10 cumecs from Counter Drain	Option 4(a) [sub-option 2] Extract 10 cumecs from Counter Drain	Option 4(b) [sub-option 1] Extract 10 cumecs from Counter Drain	Option 4(b) [sub-option 2] Extract 10 cumecs from Counter Drain	Option 4(c) Extract 10 cumecs from Counter Drain	Option 5 Extract 10 cumecs from Counter Drain
	(£k)	(£k)	(£k)	(£k)	(£k)	(£k)	(£k)	(£k)	(£k)
PVc	-	4,971	29,319	33,630	33,389	35,731	34,198	28,701	30,133
PVd	216,397	174,745	398	217	500	398	398	398	1,098
PVb		41,652	215,999	216,180	215,897	215,999	215,999	215,999	215,299
NPV		36,681	186,681	182,550	182,509	180,268	181,801	187,298	185,167
Average Benefit-Cost Ratio		8.4	7.4	6.4	6.5	6.0	6.3	7.5	7.1

Note:
1. Options 4 and 5 are sustain options
2. The above table does not include a comparison of incremental ratios because it is inappropriate for the economic comparisons of strategic options that all utilise the same extraction rate of flood flows from the Counter Drain. Table 9-3 does include for incremental ratios to optimise the extraction rate for reducing flood risk.

Table 9-3: Benefit/Cost Analysis of the Preferred Option (4c) for a Range of Pumping Capacities and Flood Risks.

Variable	'Do Nothing'	'Do Minimum' (Maintain)	Flood Storage - Option 4(c) [1]			
	Option 1	Option 2 {Flood Risk reduces from a 1 in 25 chance to < a 1 in 1 chance within 10 years}	Sub-option 1 [2] Welches Dam 5 cumec {Flood Risk maintained at < a 1 in 5 chance}	Sub-option 2 [2] Welches Dam 7.5 cumec {Flood Risk maintained at a 1 in 15 chance}	Sub-option 3 [3] Welches Dam 10 cumec {Flood Risk maintained at a 1 in 25 chance}	Sub-option 4 Welches Dam 15 cumec {Flood Risk maintained at a 1 in 50 chance}
	(£k)	(£k)	(£k)	(£k)	(£k)	(£k)
PVc	-	4,971	28,030	28,402	28,701	30,376
PVd	216,397	174,745	1,614	770	398	115
PVb		41,652	214,783	215,627	215,999	216,282
NPV		36,681	186,753	187,225	187,298	185,906
Average Benefit-Cost Ratio		8.4	7.7	7.6	7.5	7.1
Incremental Benefit-Cost Ratio			7.5	2.3	1.2	0.2

Notes:

1. All sub-options to Option 4(c) are sustain options.
2. This process is to determine the economic optimum - including improve options; following the PAG 3 decision rules. Option 4(c) [sub-options 1and 2] fail to meet the minimum indicative Standard of Protection.
3. As Option 4(c) [sub-option 3] has an incremental benefit cost ratio above unity, this becomes the preferred option.

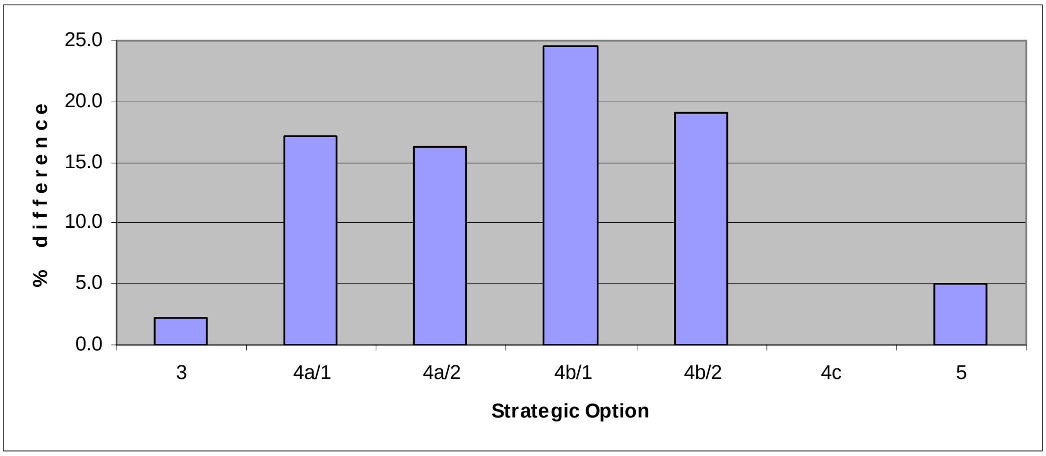
9.2.3.2 Test on Other Strategic Options

A test was carried out to ensure that the Preferred Strategic Option was giving the economic optimum and that another strategic option would not give higher incremental benefit/cost ratio such that a Flood Risk of say 1 in 50 years could be achieved.

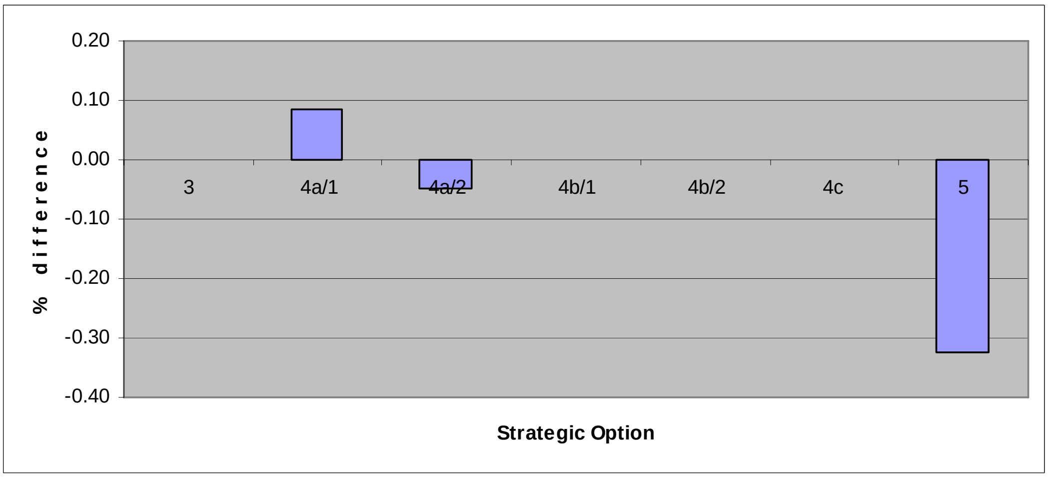
Graphs 9-1 and Graph 9-2 compare the percentage difference for the PVc and PVb for each strategic option with those of the preferred strategic option 4(c). As can be seen the variation in PVc is significant ranging from 2.2% to 24.5%; whereas the variation in PVb is very small ranging from 0% to 0.32%. This means that the lowest cost strategic option will always be the most economic. As the preferred strategic option 4(c) maximises the use of existing structures by refurbishment of the existing station it will always have the lowest cost when compared with the other strategic options for any flow (within a realistic range). This is demonstrated by Graph 9-3.

Based on the above it can be concluded that if a benefit/cost analysis were undertaken for a range of Flood Risks, as has been done for option 4(c), the results would be similar; but with lower benefit/cost ratios.

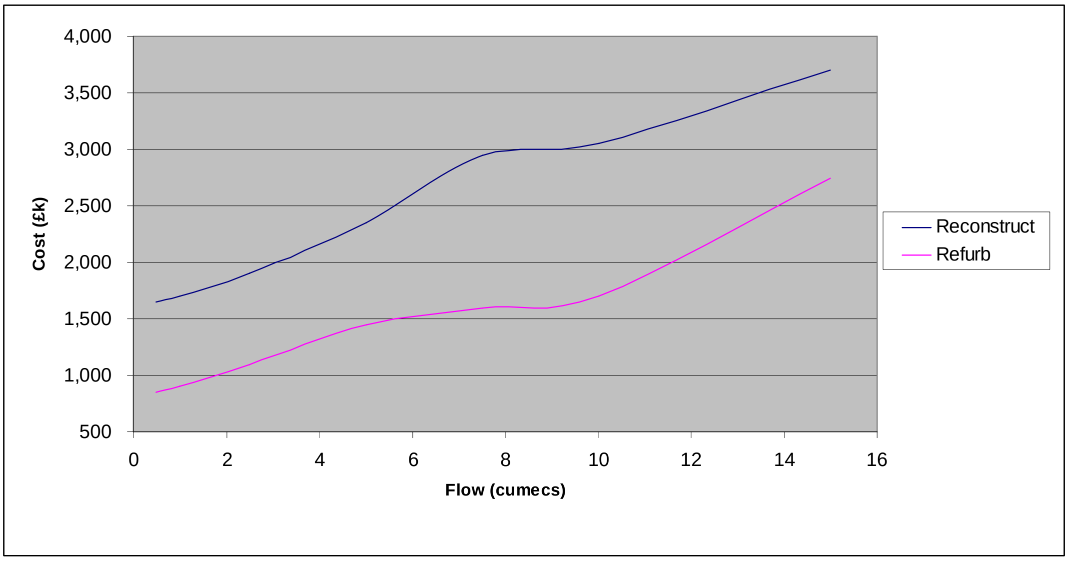
Graph 9-1: % Difference of each option PVc compared to the PVc of Option 4(c)



Graph 9-2: % Difference of each option PVb compared to the PVb of Option 4(c)



Graph 9-3: % Cost curves for new and refurbished Pumping Station costs



By examination of Table 9-3, it can be seen that the incremental benefit/cost ratio from a 1 in 25 chance to a 1 in 50 chance is 0.2. To justify a better standard the incremental benefit/cost ratio would need to be greater than 3.0. This could only be achieved if either the PVc difference reduces by a factor of 30 or the PVb increases by a factor of 30. For any other strategic option the same would be necessary. However, as detailed above, none of the other strategic options have a lower cost curve. Therefore, it is not feasible that another strategic option will give a better incremental benefit/cost ratio justifying a higher Flood Risk standard with a 1 in 50 chance.

10 Choice of Preferred Strategic Solution

10.1 Preferred Strategy Options Evaluation

A workshop held 30th November 2004 with the Environment Agency, English Nature, a representative of the local IDBs and Atkins, considered all technical, economic and environmental issues along with health and safety issues and identified Option 4(c) as the preferred strategy. This is to refurbish Welches Dam with a design life of 25 years and, phase in flood storage over the next 15 to 20 years to accommodate the flood flow so that Welches Dam PS can then be abandoned. This process was informed by comments received during the Initial Consultation. A copy of the minutes of this workshop is provided in *Appendix D* (which can be found in Volume 2 of this report).

Following this workshop the economics have been revisited and the scoring matrix reassessed based on updated economic analysis. This showed that the preferred option remained the same. The updated scoring matrix, agreed by the Strategy Team, is detailed in Table 10-1 overleaf.

The scoring for the preferred option is as follows:

Option score = $2E + T + H + E_s + E_C$

<u>Where</u>
E = score assigned to economic considerations
T = score assigned to technical considerations
H = score assigned to health and safety considerations
E_s = score assigned to environmental considerations of stakeholders
E_c = score assigned to environmental considerations of Consultant Environmental Team

It should be noted that with reference to item 3.1 of the minutes of 30th November, as the economics have changed, the economic score (E) has been adjusted to reflect the increase in benefit/cost ratios as follows:

- Score of 4 = cost benefit ratio > 9
- Score of 3 = cost benefit ratio > 7
- Score of 2 = cost benefit ratio > 5
- Score of 1 = cost benefit ratio > 3

As can be seen from Table 10-1 the preferred strategic is Option 4(c).

In the modelling and economics reports, Option 4(c) has been further refined to economically optimise the capacity of Welches Dam PS. As detailed in *Section 9.2* the economics and modelling were undertaken once more for a range of differing pumping capacities at Welches Dam PS and Flood Risks (and hence flood storage needed in the future). This demonstrated that the pumping capacity of 10 cumecs [Option 4(c) sub-option 3] is the most economic solution.

Table 10-1: Options/Issues/Risk and Score Matrix to Identify the Preferred Strategic Option

Nine options considered in meeting	**Option 1** **'Do Nothing'**	**Option 2** **'Do Minimum' (Maintain One Pumping Station)**	**Option 3** **'Sustain' (Maintain/Improve) (Sustain One pumping Station)**	**Option 4(a)** **Sub-option 1** **Two Pumping Stations**	**Option 4(a)** **Sub-option 2** **Two Pumping Stations**	**Option 4(b)** **Sub-option1** **Ultimately no Pumping Station**	**Option 4(b)** **Sub-option 2** **One Pumping Station**	**Option 4(c)** **Initially one Pumping Station but ultimately no Pumping Station**	**Option 5** **New Pumping Station**
Description of option	Walk away from Welches Dam PS, the Counter Drain and Old Bedford Sluice and Lock	Normal maintenance only until significant breakdown occurs	After 5 years refurbish Welches Dam PS	After 5 years refurbish Welches Dam PS at 5 cumec and new station **upstream**	After 5 years refurbish Welches Dam PS and build new station **downstream**	After 5 years abandon Welches Dam PS and improve the 40 Foot Drain and Middle Level System to accommodate flows	After 5 years reduce Welches Dam and Improve the 40 Foot Drain and Middle Level System to accommodate flows	After 5 years refurbish Welches Dam PS and flood storage area phased in over next 15-20 years to accommodate the flood flows with Welches Dam eventually abandoned	After 5 years abandon Welches Dam PS and build a new pumping station at the Old Bedford Sluice and Lock
Economic consideration. Note following the final consultation issue of the Detailed Strategy Report of March 2006, comments led to changes in Agency maintenance cost estimates. These changes have been applies to all of the options and the assessment rescored. The effect of this has led to changes in the ranking of the non-preferred options as stated in the Final Detailed Strategy Report. The changed values are identified with an asterisk.									
Order of benefit cost ratio with the best at 1 and worst at 8	NA	1	3	6	5	8	7	2	4
Option score. See 3.1 of minutes	NA	4	3	2	2	2	2	3	3
Option final score. See 4.0 of minutes	**NA**	**8**	**6**	**4**	**4**	**4**	**4**	**6**	**6***
Technical/flood management									
Technical comment	Easy option	Risk of breakdown in 5 years and complete failure after 5 years	Risk of breakdown in first 5 years	Risk of breakdown in first 5 years. Then very reliable but 2 pumping stations to maintain instead of one. i.e. greater maintenance	Risk of breakdown in first 5 years. Then very reliable but 2 pumping stations to maintain instead of one. i.e. greater maintenance	Risk of PS failure in first five years then no risk of mechanical failure.	Risk of PS failure in first five years then very reliable.	Risk of PS failure in first five years then very reliable.	Risk of PS failure in first five years then very reliable.
Flood Risk comment	Loss of flood management	Loss of flood management within 6 years	Risk of loss of flood management in first 5 years	Best flood management control	Better flood management control than existing	Good flood management control	Good flood management control	Good flood management control	Worse flood management control. Water pumped to Tidal Ouse
Score in the range:- Poor 1. Best 5.	**NA**	**1**	**2**	**4**	**3**	**5**	**4**	**4**	**2**
Health and Safety									
Score.	**NA**	**3**	**4**	**2**	**2**	**3**	**2**	**2**	**2**
Environmental considerations									
Consultees Comments Score ranked:- Poor 1, Best 5.	**NA**	**1**	**3**	**4**	**4**	**2**	**2**	**5**	**3** (Not in 2nd round of Consultation)
Consultants Comments ranked:- Poor 1, Best 5.	**NA**	**1**	**2**	**2**	**4**	**4**	**3**	**5**	**4**
General Comments	Loss of navigation within 5 years	Loss of navigation within 5 years		Better seepage control				Potential for irrigation storage. Risk that storage does not happen.	Affects navigation due to the drawdown when pumping.
Legal constraints	**Loss of navigation. Rules out option**								
Final score	**NA**	**NA**	**17**	**16**	**17**	**18**	**15**	**22**	**17***
Final ranking	**NA**	**NA**	**3**	**6***	**3**	**2**	**7***	**1**	**3***

***** note: Revised from Detailed Strategy report of March 2006.

10.2 Defra Priority Score

The preferred option has a Defra priority score of 25, as summarised in Table 10-2, indicating the economic viability and importance to the community.

Table 10-2: Preferred Option Priority Score

Criteria	Score
Economic score	14.1
Base people score	*0.8*
Risk factor	*0*
Affluence factor	*0*
People score	0.8
BAP area creation	*0*
SSSI area protection	*3.3*
Other habitat protection	*4.7*
Heritage	*2*
Environmental Score	10.0
Total Priority Score	25

11 Timetable, Milestones & Responsibilities

Timetable, milestones and Responsibilities have been tabulated below for clarity purposes.

Table 11-1: Schedule of Activities for the Preferred Strategy Option

Time frame	Year	Activity identified in strategy (excluding normal operation and maintenance works)	Responsibility
Short Term	1	• Flood Risk Management Strategy approval process • Flood Storage 'high level' technical and environmental pre-feasibility study • Welches Dam PS refurbishment PAR and detailed design commencement	Agency, Strategy Team Agency Agency
	2	• Flood Risk Management Strategy approval **(Milestone)** • Flood Storage option liaison and negotiations • Welches Dam PS refurbishment design completion and tender. • IDB pumping station water levels and pump hours monitoring equipment installed	Agency, Strategy Team Agency Agency IDBs
	3	• Flood Storage option liaison and negotiations • Welches Dam PS refurbishment implementation **(Milestone)** • IDB pumping station data collection	Agency Agency IDBs
	4	• Flood Storage option liaison and negotiations • Cranbrook Drain leakage control measures / Low Bank stability PAR • IDB pumping station data collection	Agency Agency IDBs
	5	• Flood Storage option liaison and negotiations • Cranbrook Drain leakage control measures / Low Bank stability design and tender • IDB pumping station data collection	Agency Agency Agency IDBs
Medium Term	6	• Review Flood Risk Management Strategy **(Milestone)** • Flood Storage option liaison and negotiations • Cranbrook Drain leakage control measures / Low Bank stability implementation **(Milestone)** • IDB pumping station data collection	Agency Agency Agency Agency IDBs
	7	• Flood Storage option liaison and negotiations • Flood Storage option feasibility study • IDB pumping station data collection	Agency Agency IDBs
	8	• Old Bedford Sluice and Lock refurbishment PAR • Flood Storage option liaison and negotiations • IDB pumping station data collection	Agency Agency IDBs
	9	• Old Bedford Sluice and Lock refurbishment design and tender • Flood Storage option liaison and negotiations • IDB pump station data collection	Agency Agency IDBs
	10	• Old Bedford Sluice and Lock refurbishment implementation • Flood Storage option liaison and negotiations • IDB pump station data collection	Agency Agency IDBs

Time frame	Year	Activity identified in strategy (excluding normal operation and maintenance works)	Responsibility
	11 to 15	• Review Flood Risk Management Strategy **(Milestone)** • Flood storage liaison and negotiations continues • Annual IDB pump station data collection	Agency Agency IDBs
	16 to 25	• Review Flood Risk Management Strategy every 5 years **(Milestone)** • Flood storage liaison and negotiations continues • Flood Storage option with PAR, design / tender and implementation **(Milestone)** • Annual IDB pump station data collection	Agency Agency Agency IDBs
Long Term	26 to 100	• Review Flood Risk Management Strategy every 5 years **(Milestone)** • Annual IDB pump station data collection • Refurbishment and replacement of IDB and Environment Agency major assets	Agency IDBs IDBs, Agency

Note: See SEA report (*Appendix G - Table 7*) for related SEA/EIA activities.

12 Risk & Sensitivity Analysis

12.1 High Level Risks of Strategy Study

The 'high level' risk associated with the Strategy Study has been undertaken and Table 12-1 overleaf summarises the analysis.

12.2 Sensitivity of Economic Decision Making

An economic sensitivity analysis has been undertaken (including for climate change and reduction in benefits) as detailed in *Appendix F* (which can be found in Volume 2 of this report). A sensitivity analysis on the benefit-cost ratios determines how robust the appraisal results are to the underlying assumptions within the analysis and, consequently, whether an error in that assumption could affect the decision rule and choice of preferred option.

12.2.1 Deferred Scheme

A sensitivity analysis was run to determine how delaying the scheme costs by 10 year would affect the benefit-cost ratio of the preferred option. Delaying the scheme costs also delays the benefits (i.e. increases the damages) of implementing each of the 'Do Something' options.

12.2.2 Climatic Change

The effect of climate change has been considered for the preferred option. Recent studies on global warming indicate that anthropogenic activity has an impact on climate change, resulting in rising sea levels and precipitation. Defra guidance FCDPAG4 notes that "increases of up to 20% in peak flows for a given return period could be experienced under a changed climate regime within 50 years".

The widely accepted approach to climate change is to assess the impact of progressively increasing flow estimates by 20% over the next 50 years. The effects of climate change have been assessed by increasing the volume of water in Compartment 1 (i.e. only compartment to flood under the preferred option). Each design event was increased by 20% and run through the drainage model. The impact of these design events were then evaluated for preferred option strategy.

Due to the nature of the catchment and the fact that the majority of land and property within the area are considered 'written off' it is fair to assume that there will be no increase in the present value damages for the 'Do Nothing' scenario.

12.2.3 Reduced Benefits

A series of sensitivity tests were undertaken to determine how assumptions made in calculating the 'Do Nothing' damages affect the benefit-cost ratio. One of the main assumptions made was the extent to which properties within the flood risk area depreciated in value. In the initial analysis a 50% depreciation of properties within the flood risk area was assumed.

Table 12-1: 'High Level' Risk Analysis

No	Risk	Mitigation measures. Strategy study stage	Future mitigation measures	Initial Probability Rating	Residual Probability Rating after mitigation
1	Cost estimates	60% optimism bias applied to economic assessment - *Appendix F* Sensitivity analysis in economic assessment - *Appendix F*	Financial risk assessment at PAR/ Detailed Design stage for all works.	High	Low
2	Technical viability of storage option.	Undertake pre-feasibility and feasibility studies. See *Table 11-1*	Review preferred strategy. See *Table 11-1*	Medium	Low
3	Storage reservoir does not get constructed or is delayed	Maintain regular contact with Cambridge County Council. See *Table 11-1*	Review preferred strategy. See *Table 11-1*	Medium	Low
4	Welches Dam PS fails early	Maintain regular maintenance procedures	Ensure Welches Dam PS refurbishment is implemented.	High	Low
5	Environmental changes prevent any pumping to Ouse Washes	Current affect of Welches Dam PS modelled (See SEA report, *Section 6*) and found not to be significant	Review SEA as a part of the preferred strategy review. See *Table 11-1*	Low	Low
6	Changes in regional/national catchment management	Current catchment management plans reviewed as a part of the study (SEA)	Continued liaison with Agency and English Nature as a part of strategy review process. See *Table 11-1*	Low	Low
7	Flood storage becomes designated habitat	Pre-feasibility and feasibility studies to review if area can be set a side for habitat development	Continued liaison with Agency and English Nature as a part of strategy review process. See *Table 11-1*	Medium	Low
8	Design and modelling assumptions	QA procedures	Collect more data and review.	Medium	Low

Sensitivity test were undertaken assuming only a 25% reduction and 10% reduction. A final sensitivity of the damages was undertaken which included no depreciation of properties within the flood risk area. It was deemed unnecessary to test the sensitivity of the present value costs as they were felt to be robust. A 60% Optimism Bias factor has also already been applied to the costs.

12.2.4 Delayed 'Do Nothing'

The underlying assumption to the 'Do Nothing' damages is that Old Bedford Sluice will fail at some point over the next 5 to 10 years. As there is no way of knowing the exact date that the Old Bedford Sluice would fail, a sensitivity analysis has been undertaken to determine the scheme viability should the sluice not fail until between years 15 and 20. The damages would therefore not be realised until year 15 and all time scales associated with the costs remain unchanged.

12.2.5 Sensitivity Results

The results of those various sensitivity tests undertaken for strategy study are given in Table 12-2 below.

Table 12-2: Economic Sensitivity Tests

Sensitivity	'Do Nothing' (PVd)	Benefit/Cost Ratio	Defra Priority Score
Base Case	216,397	7.5	25
Deferred Scheme	216,397	8.5	28
Climatic Change	216,397	7.5	25
Reduced Benefits (25% Depreciation)	182,725	6.4	22
Reduced Benefits (10% Depreciation)	162,521	5.6	21
Reduced Benefits (0% Depreciation)	149,052	1.2	20
Delayed 'Do Nothing'	13,8438	4.8	19

12.3 Health & Safety

Consideration of Health and Safety issues formed an important part of the process for the selection of the preferred strategy as detailed in *Appendix D* [attachment 3] (which can found in Volume 2 of this report).

13 Unresolved Issues

The existence and operation of the Welney Gate is subject to politics ensuring that those that contribute to the upkeep of the Welches Dam PS benefit from its operation and those that do not contribute to its upkeep, do not benefit from its operation. Removing the sluice or keeping it open at all times would not have detrimental effect on the flood protection provided by the Counter Drain and would ensure the downstream section of the Counter Drain would be within the indicative Flood Risk.

To leave the system as it is means that the Flood Risk downstream of Welney Gate is below the indicative Flood Risk and it is understood that there have been occasions in the recent past where the sluice has been opened to prevent downstream flooding i.e. breach of the flood embankment. An alternative solution in leaving the gate open would be to raise that downstream part of the Low Bank. This would be very expensive with an estimated cost in the region of £4 million and has not been included for in the economic assessment of the preferred strategy. The politics of this issue need review with all parties before these additional works to Low Bank are considered.

Gravity drainage through the Old Bedford Sluice is important to the catchment and the implementation of the preferred option. The problems associated with the gravity drainage have not been part of the Brief of this Strategy, but are to be tackled by the Tidal Strategy, which is to be completed in 2008. It is recommended that the Tidal Strategy work be used to inform the design for the replacement of the Old Bedford Sluice and Lock and the revision of the Strategy in Year 5.

In brief, the gravity drainage is being compromised by high riverbed levels in the Tidal River. These high bed levels result in high water levels during the Low Water part of the tidal cycles and thus insufficient hydraulic head at the Old Bedford Sluice. This is aggravated by local siltation at the sluice. In addition, in years to come, climate change leading to an accelerated rise in sea level could result in a general rise in low water levels. In recognition of the poor gravity drainage, provision for a small pumping station has been included in the preferred option in the investment plan in the long term.

14 Conclusions & Recommendations

14.1 Conclusions

This strategic study has shown that in the short to medium term the existing structures should be maintained, refurbished and or replaced to their current specification. Of the measures to be carried out the key works are, subject to individual Project Appraisal:

- Refurbishment of the Welches Dam PS (with a 20-25 year design life);
- The addition of monitoring equipment to the IDB pumping stations;
- Leakage control measures on the Cranbrook Drain/Stability assessment of Low Bank; and
- Refurbishment of the Old Bedford Sluice and Lock.

In the medium to long term, however, the preferred strategy is to develop flood storage reservoirs so that the Welches Dam PS can be abandoned / decommissioned by year 25.

The whole life cash cost of implementing the preferred strategy is £78.14 million [present value cost of £26.4 million]. The costs and benefits, calculated in this study, have been based on December 2006 costs. The economic analysis has produced a benefit/cost ratio of 7.3 (incorporating a 60% optimism bias) with a Defra priority score of 27. The preferred strategy is detailed below in *Table 14-1*

14.2 Recommendations

It is recommended that the preferred strategy as detailed below in Table 14-1 is implemented.

Table 14-1: Implementation Plan

Time frame	Year	Activity identified in strategy (excluding normal operation and maintenance works)
Short Term	1 to 5 years	• Flood Risk Management Strategy approval • Flood Storage 'high level' technical and environmental pre-feasibility study • Flood Storage option liaison and negotiations • IDB pumping station (water levels and pump hours) monitoring equipment installed, and annual data collection following installation • Cranbrook Drain leakage control measures / Low Bank stability PAR and design • Welches Dam PS refurbishment PAR, design and implementation
Medium Term	6 to 25 years	• 5 yearly review of Flood Risk Management Strategy • Flood storage option liaison and negotiations • Cranbrook Drain leakage control measures / Low Bank stability implementation • Old Bedford Sluice and Lock replacement, PAR, design and implementation • Flood storage option feasibility study, PAR, design and implementation • Annual IDB pumping station data collection

Table 14-1: Implementation Plan (continued)

Time frame	Year	Activity identified in strategy (excluding normal operation and maintenance works)
Long Term	26 to 100 years	• 5 yearly review of Flood Risk Management Strategy • Annual IDB pumping station data collection • Refurbishment and replacement of IDB and Environment Agency major assets

14.3 Next Stage

Following approval of the preferred strategy Scheme of Delegation A2 approval for the 5 year work elements will be required. Approval submissions will comprise the following items:

a) Project Appraisal Reports for each individual element of work including:

I. Risk Register in accordance with Risk Assessment and Management for Construction Projects (Version 3); and

II. Quantitative Risk Assessment in order to obtain 95% confidence level of Risk Budget associated with the implementation of the 5 year Strategy Plan.

15 Financial Contributions

Welches Dam PS was built in 1947 and funded by the then Great Ouse River Board for the princely sum of £40,000. The maintenance of Welches Dam PS has been shared between the Environment Agency and the contributing IDBs upon a 24% to 76% basis. The split in contributions being the ratio of upland catchment area controlled by the Environment Agency and lowland catchment area controlled by the IDBs of Sutton/Mepal and Manea/ Welney.

It is therefore proposed future maintenance and operational cost for Welches Dam should continue to be funded upon the same shared contribution basis. For all other assets maintenance and operational costs will be solely funded by the respective Authority.

16 References

No	Document	Consultant/Agency	Date
1	Counter Drain Hydraulic Model Study	Mott MacDonald	March 1993
2	Counter Drain Flood Defences Project Appraisal Study	Binnie and Partners	October 1995
3	Sutton Gault Culvert Structural Survey	WS Atkins	August 1998
4	Welches Dam PS Equipment Failure (January 2003)	Environment Agency	Undated
5	Counter/Old Bedford and Cranbrook Drain	Halcrow Group Ltd	April 2003
6	Response letter to Preferred Option Consultation Document December 2004. (Atkins Ref 5019730/25/CI/157	Cambridge County Council.	22nd February 2005
7	Ouse Washes, Solution to flooding issues.	Environment Agency	September 2004