Appendix 1



# 1 EXECUTIVE SUMMARY

1.1.1 The history of flooding on the Trent is graphically illustrated by the carved level marks on Trent Bridge. The worst recorded event is that of 1795, when flooding through the Trent Valley reached unprecedented levels. The most severe event of the last century was in March 1947, when thousands of properties in Burton upon Trent and Nottingham were flooded. Following this, major flood defences were constructed in the urban areas. These defences limited the extent of flooding during the most recent flood event of November 2000 but villages such as Attenborough and Gunthorpe were affected.

1.1.2 The flood risk has been the subject of a number of discrete studies but there is a need to take a more holistic approach. The principal aim of the Fluvial Trent Strategy is to identify the preferred high level approaches to sustainably manage flood risk along the Trent corridor over the next 50 years. The implementation of any flood protection measures will require more detailed investigations and appraisal.

1.1.3 The Trent has a number of major tributaries, including the rivers Sow, Tame, Dove, Derwent and Soar. Strategic studies are currently being undertaken for these and the tidal reach of the Trent. The relevant findings from this study will be made available to the other teams and a coordinated approach will be taken.

1.1.4 The study considers flood risk solely from the Trent between the head of main river at Stoke-on-Trent, to the tidal limit at Cromwell Weir downstream of Newark, a distance of some 200km. However, in the appraisal of options to reduce the risk of flooding, local and catchment wide solutions are investigated.

1.1.5 The fluvial Trent source is on Biddulph Moor, north of Stoke-on-Trent and the catchment drains an area of approximately 8228km$^2$ to Cromwell Weir. Although the catchment is primarily rural, the Trent flows through the conurbations of Stoke on Trent, Burton upon Trent, Nottingham and Newark.

1.1.6 There are approximately 75km of flood defence in the study area, which are mainly located in Burton upon Trent and Nottingham; these provide a range of standards of protection to over 31,000 properties and businesses. The defences in Nottingham are approaching the end of their design life, which is considered to be 75 years.

1.1.7 To accurately define the extent of the current flooding problem, four separate hydraulic models were constructed. These computer-based mathematical models were calibrated using observed data from recent flood events and were used to produce floodplain maps for a range of return periods between 5 and 200-years.

1.1.8 The models indicate that the Trent floods an area of approximately 160km$^2$ during a 1 in 100-year event; the width of the floodplain generally increases in proportion to the catchment area. There are currently 27 separate flood risk locations and some 15,000 properties in the 100-year floodplain. This takes into account the protection provided by the current defences. The majority of the properties at risk are located in Nottingham, where there are apparent -low spots in the current defences. This is in contrast to Burton upon Trent, where the current defences protect to a 100-year

standard. Outside Nottingham and Burton, other areas with significant numbers of properties at risk include Willington, Barrow upon Trent, Gunthorpe, Farndon and Newark.

1.1.9 There are currently 6 Sites of Special Scientific Interest and a significant number of non-statutory local wildlife sites within the floodplain. These local sites are a significant component of the impoverished bio-diversity resource of the Midlands and many are secondary habitats that have developed on areas of disused mineral workings.

1.1.10 Following extensive consultations during the early stages of the study, 18 generic flood management options were identified and taken forward for consideration. Initially, the generic options were subject to a high level technical and environmental review to assess their suitability. At that stage, a number were discounted and the remaining ones were taken forward for a more detailed appraisal.

1.1.11 The remaining generic options were considered for each of the 27 discrete flood risk locations. The result was that 95 options were identified and a technical and environmental assessment was undertaken for each. This involved a site visit and, where appropriate, the options were incorporated into the hydraulic models to assess their effectiveness. An economic analysis was undertaken for those options which satisfied the technical and environmental criteria.

1.1.12 A computer package was used to estimate the damages associated with flooding. Costs for each option were determined from various sources, including previously completed flood defence schemes and published cost databases. An optimism bias of 60% is included in the cost of all options. This takes into account the difficulty in estimating costs using limited data. The costs were benchmarked against those for recently completed schemes of a similar nature. For each option, the outputs of the economic analysis are: -

- A benefit/cost ratio, which is the reduction in damages divided by the cost of an option. It is an indicator of the cost effectiveness of the works and those options with a ratio less than 1 are not normally promoted.
- A priority score, which takes into account the benefit/cost ratio plus social and environmental factors. This allows the most beneficial schemes to be identified. Schemes must have a priority score of 20 to be considered for construction during the financial year 2004/05. It is likely that, in future years, the qualifying score will reduce as the more beneficial schemes are progressed.

1.1.13 **Table 1.1** highlights the options that have a benefit/cost ratio greater than 2 and a priority score greater than 12. The options are ranked according to their priority score.

1.1.14 A number of the options are located in Burton upon Trent and Nottingham, which presently provide protection to a 100-year standard. Their priority scores are high because of the large number of properties protected. As stated previously, the defences have limited residual lives although failures are not expected for at least another 10 years. The replacement of such defences should be phased, taking into account factors such as their actual condition, priority score and budgetary constraints. The condition

of the defences should continue to be routinely monitored so that any deterioration is identified.

1.1.15 The immediate focus should be on those flood risk areas that are not protected to a 100-year standard. **Table 1.2** ranks these top 10 options on priority score. An important issue which needs to be further considered is the programme for implementation. This is particularly relevant through Nottingham, where raising the defences in an area is likely to have a detrimental effect on flood risk in adjacent areas. For example, works at West Bridgford could impact on Queens Drive, which currently has a 100-year standard of protection. As stated previously, budget constraints will also influence the programme.

1.1.16 The effects of climate change were assessed using the models. Using the current recommendation, this would result in the 100-year water levels in Burton upon Trent and Nottingham increasing by approximately 350mm over the next 50 years.

1.1.17 For illustrative purposes, to maintain this 100-year standard in future years it would be necessary to: -

- Construct the works identified in this study to a higher level. The additional cost of this in Burton and Nottingham would be £10.1m and £2.8m respectively (at 2004 prices).
- Raise those defences which presently meet this standard. It should be noted that the costs of this are not quantified.

1.1.18 In addition, flooding could become more frequent at locations such as Gunthorpe, Caythorpe and Hoveringham. Villages on the periphery of the floodplain could experience flooding in locations previously considered to be at little risk.

1.1.19 A number of options could not be appraised in detail but are considered to be best practice and are recommended. These are: -

- Sustainable Urban Drainage Systems: either retrofitted or on new developments. They would have the greatest impact in the upper reaches of the Trent, particularly in the vicinity of Stoke.
- Development Control: appropriate measures to restrict inappropriate developments.
- Land Management: appropriate land management techniques that could reduce surface runoff.
- Floodplain Obstructions: the removal of such obstructions, where appropriate, to improve local conveyance.

1.1.20 The more detailed appraisal of specific options identified locations where works are not presently economically justifiable. However, the following could provide local environmental benefits and should be considered if alternative sources of funding become available: -

- High Bridge Banks: remove the flood banks upstream of High Bridge to create additional floodplain.

- Flood defences near the sailing club at Holme Pierrepont: remove flood banks on the right bank adjacent to Holme Pierrepont to create additional floodplain.

1.1.21 A further recommendation is to undertake additional investigations, as and when required. In summary, these are: -

- River Models: A more sophisticated hydraulic model is recommended to assess any future works in the floodplain downstream of Nottingham.
- Development Control: for any proposed development in, or on the periphery of, the 100-year floodplain, more detailed local models should be constructed to complement the current models.
- Topographical Surveys:
  1. Determine the levels of those existing defences where the current standard of protection is considered to be less than 100-years.
  2. Determine specifically which properties are at risk. Threshold surveys of those properties within the 100-year floodplain should be undertaken.
- Structural Surveys: the condition codes used in this study are based on visual inspections. Before any defences are replaced, ground investigations and structural analyses should be undertaken.
- Flood Warning:
  1. The Trent hydraulic models should be included in the programme for incorporation into the Agency's new forecasting procedures.
  2. The Agency should review its current Automatic Voice Messaging and flood warning procedures to reflect the 100-year floodplain produced as part of this study.
- Tributary Storage: appropriate results from this study should be passed to those undertaking the strategies for the major tributaries.
- Flood Gates: consideration should be given to the operational suitability of Sawley flood gates (Sheetstones) at the Erewash Canal.
- Flood Proofing: residents should be made aware that flood proofing measures are available. This is particularly important for properties in the floodplain where no protection scheme is likely to be promoted in the near future.

1.1.22 The contributions of the consultees to the strategy and the inputs of staff from the Agency and its Consultants are gratefully acknowledged. It is anticipated that the final version of this report will form the basis for future flood risk management on the River Trent.

## Table 1.1: Preferred Flood Management Options

| Option No. | Location Town | Location F/Cell | Description | Cost (£m) | B/C | PS | EA |
|---|---|---|---|---|---|---|---|
| 3.2 | Burton upon Trent | 3.3 | Defences | £4.0 | 150.4 | 35.0 | ✓✓ |
| 4.1 | Sawley | 4.2 | Defences | £1.9 | 153.4 | 34.0 | ✓✓ |
| 4.7 | Wilford | 4.14 | Defences | £4.3 | 64.7 | 34.0 | ✓✓ |
| 4.11 | West Bridgford | 4.16 | Defences | £3.5 | 26.7 | 34.0 | ✓✓ |
| 4.11 | West Bridgford | 4.21 | Defences | £1.6 | 39.8 | 34.0 | ✓✓ |
| 4.11 | West Bridgford | 4.23 | Defences | £1.6 | 51.9 | 34.0 | ✓✓ |
| 3.2 | Burton upon Trent | 3.4 | Defences | £3.9 | 13.2 | 33.0 | ✓✓ |
| 4.9 | Queens Drive | 4.18 | Defences | £1.3 | 21.6 | 33.0 | ✓✓ |
| 3.2 | Burton upon Trent | 3.1 | Defences | £0.7 | 54.0 | 32.0 | ✓✓ |
| 3.2 | Burton upon Trent | 3.2 | Defences | £0.9 | 76.9 | 32.0 | ✓✓ |
| 4.6 | Rylands | 4.9 | Defences | £2.4 | 43.1 | 32.0 | ✓✓ |
| 4.11 | West Bridgford | 4.24 | Defences | £1.0 | 34.3 | 32.0 | ✓✓ |
| 4.13 | Colwick | 4.29 | Defences | £6.3 | 15.4 | 32.0 | ✓✓ |
| 4.39 | Newark | 4.48 | Defences | £1.1 | 55.8 | 32.0 | ✓ |
| 4.13 | Colwick | 4.25 | Defences | £3.2 | 25.3 | 30.5 | ✓✓ |
| 4.35 | Rolleston (Notts) | 4.43 | Remove banks | £1.0 | 9.3 | 28.8 | ✓✓ |
| 3.2 | Burton upon Trent | 2.19 | Defences | £1.9 | 8.4 | 28.0 | ✓✓ |
| 4.7 | Wilford | 4.12 | Defences | £1.0 | 16.5 | 26.4 | ✓✓ |
| 4.4 | Trent Meadows | 4.4 | Defences | £1.0 | 6.8 | 24.9 | ✓✓ |
| 4.36 | Rolleston (Notts) | 4.43 | Defences | £1.0 | 9.2 | 24.0 | ✓ |
| 4.37 | Farndon | 4.44 | Defences | £1.9 | 4.2 | 20.0 | ✓ |
| 4.8 | Meadows | 4.19 | Defences | £4.1 | 3.6 | 19.6 | ✓✓ |
| 4.5 | Barton in Fabis | 4.6 | Defences | £2.8 | 5.7 | 19.4 | ✓✓ |
| 4.3 | Attenborough | 4.7 | Defences | £3.4 | 3.2 | 19.2 | ✓✓ |
| 3.15 | Shardlow | 3.15 | Defences | £1.6 | 6.0 | 18.7 | ✓✓ |
| 4.9 | Queens Drive | 4.17 | Defences | £1.3 | 2.0 | 16.8 | ✓✓ |
| 4.39 | Newark | 4.50 | Defences | £0.5 | 2.0 | 15.9 | ✓ |
| 4.21 | Gunthorpe | 4.36 | Lower A6097 | £1.3 | 4.4 | 14.5 | ✓ |
| 3.2 | Burton upon Trent | 3.6 | Defences | £2.6 | 4.0 | 14.0 | ✓✓ |
| 3.10 | Swarkestone | 3.12 | Defences | £1.2 | 3.5 | 12.4 | ✓✓ |

B/C: Benefit/Cost ratio

EA: Environmental Assessment; ✓ - Acceptable; ✓✓ - Preferred; X - Unacceptable

PS: Priority Score

100-year standard of protection currently provided

## Table 1.2: Summary of Preferred Options for Immediate Consideration

| Option | | | | Objectives | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Location | | Description | Cost (£m) | Benefit/Cost Ratio | Priority Score | Reduce flood risk | Technically feasible | Increase quality of life | Sustainable | Protect existing uses and future needs for informal water and land based recreation | Conserve features of archaeological and historic interest | Maintain, develop and improve fisheries | Maintain and enhance bio-diversity | Maintain and enhance water quality | Conserve and enhance landscape character | Enhance opportunities for development in accordance with existing planning policy | Maintain and enhance existing transport links in accordance with planning policy | Protect interests of the agricultural community | Minimise use of natural resources |
| | Town | F/Cell | | | | | | | | | | | | | | | | | | | | |
| 4.1 | Sawley | 4.2 | Defences | £1.9 | 153 | 34.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.11 | West Bridgford | 4.16 | Defences | £3.5 | 26.7 | 34.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.11 | West Bridgford | 4.21 | Defences | £1.6 | 39.8 | 34.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.11 | West Bridgford | 4.24 | Defences | £1.0 | 34.3 | 32.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.13 | Colwick | 4.29 | Defences | £6.3 | 15.4 | 32.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.39 | Newark | 4.48 | Defences | £1.1 | 55.8 | 32.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.13 | Colwick | 4.25 | Defences | £3.2 | 25.3 | 30.5 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.35 | Rolleston (Notts) | 4.43 | Remove low banks | £1.0 | 9.3 | 28.8 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4.36 | Rolleston (Notts) | 4.43 | Defences | £1.0 | 9.2 | 24.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| 4.37 | Farndon | 4.44 | Defences | £1.9 | 4.2 | 20.0 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |

✓ Objective is met
X Conflict with objective

Appendix 2



**Flood Risk Location 6: WILLINGTON** **Refer to Figure No. 6.6**

| Option | | | Detail Appraisal Results | | | | | | | Strategy Recommend |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Description | Flood Cell | Technical ✓ Technically acceptable X Technically unacceptable | Passed | Environmental ✓ environmentally acceptable ✓✓ environmentally acceptable & preferred X environmentally unacceptable | Passed | Economic Cost (£M) | B/C | P.S. | |
| 3.3 | Improve pass forward flow at Willington Bridge: lower Willington causeway to improve flood flow across the floodplain. | 3.8 | Model indicates that lowering the right bank causeway by 1m, could improve flood levels at Willington. | ✓ | Environmentally acceptable but not preferred due to potential impacts on archaeology. | ✓ | £7.9 | 0.7 | 4.6 | X |
| 3.4 | Improve pass forward flow at Willington Bridge: construct additional flood relief culverts to improve flow through causeway. | 3.8 | Model indicates that the inclusion of large flood relief culverts (capable of conveying approximately 300 $m^3/s$) would improve flood levels at Willington. | ✓ | Environmentally acceptable but not preferred due to potential impacts on archaeology. | ✓ | £23.6 | 0.2 | 4.2 | X |
| 3.5 | Option number not used | | | | | | | | | |
| 3.6 | Dredge the river between Willington and Weston (15km) | 3.8 | Model indicates that dredging by 300mm would reduce water levels slightly for more frequent flood events (<25year). However, it would have negligible impact on peak flood levels during the 1 in 100year event. | ✓ | Not environmentally acceptable due to potential impacts on biodiversity and riverside structures. | X | £5.3 | 0.1 | 4.8 | X |
| 3.7 | Construct local flood defences to protect property. | 3.8 | Model indicates that embankments would have a negligible detrimental effect on local levels upstream and downstream | ✓ | Environmentally acceptable and preferred subject to EIA. | ✓✓ | £5.8 | 0.9 | 5.5 | X |

**Flood Risk Location 7:** BARROW UPON TRENT & SWARKESTONE **Refer to Figure No.** 6.7

| Option | | | Detail Appraisal Results | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Description | Flood Cell | Technical ✓ Technically acceptable X Technically unacceptable | Passed | Environmental ✓ environmentally acceptable ✓✓ environmentally acceptable & preferred X environmentally unacceptable | Passed | Economic | | | Strategy Recommended |
| | | | | | | | Cost (£M) | B/C | P.S. | |
| 3.8 | Improve pass forward flow at Swarkestone Bridge: lower road or construct additional flood relief culverts | 3.12 | Model indicates that Swarkestone Bridge does have an effect on *100*year levels. Lowering the road or including flood relief culverts would reduce flooding. | ✓ | Environmentally unacceptable due to historic value of bridge. | X | | | | X |
| 3.9 | *Barrow Upon Trent*: construct local flood defences to protect property. | 3.11 | Model indicates that embankments would have a negligible detrimental effect on local levels upstream and downstream | ✓ | Environmentally acceptable and the preferred option. | ✓✓ | £5.0 | 0.5 | 6.9 | X |
| 3.10 | *Swarkestone*: construct local flood defences to protect property. | 3.12 | Model indicates that embankments would have a negligible detrimental effect on local levels upstream and downstream | ✓ | Environmentally acceptable and a preferred option. | ✓✓ | £1.2 | 3.5 | 12.4 | ✓ |
| 3.11 | Assess headloss of Sarsons Railway Bridge to identify whether it affects flood levels at either Swarkestone or Barrow. | 3.12 | Model indicates that there is minimal headloss though this bridge and it has a negligible effect on upstream water levels | X | Environmentally acceptable and a preferred option if bridge not found to have significant historic value. | ✓✓ | | | | X |

**Flood Risk Location 10: WESTON ON TRENT** **Refer to Figure No. 6.10a, b and c**

| Option | | | Detail Appraisal Results | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Description | Flood Cell | Technical<br>✓ Technically acceptable<br>X Technically unacceptable | Passed | Environmental<br>✓ environmentally acceptable<br>✓✓ environmentally acceptable & preferred<br>X environmentally unacceptable | Passed | Economic | | | Strategy Recommend |
| | | | | | | | Cost (£M) | B/C | P.S. | |
| 3.14 | Weston-on-Trent Storage Reservoir: include a dam across the floodplain adjacent to Weston-on-Trent to store flood waters upstream and reduce pass forward flow by 50%. | Entire reach from Willington to Cromwell Weir | Model indicates that the 50% reduction in pass forward flow would reduce the current 100-year levels by approximately 0.4m through Nottingham; which is equivalent to the current 25-year levels. However, there are the following problems:<br><br>- Complete inundation of Barrow and Swarkestone villages upstream (relocation of village required)<br>- Complete protection still not achieved. Villages downstream of Nottingham still liable to flooding in extreme events.<br>- Defences and their maintenance are still required within Nottingham<br>- Storage area is upstream of Derwent and Soar confluence. Therefore a risk still exists from flooding from these major tributaries.<br><br>Figure 6.10 provides a comparison of 100year flood outlines between the existing conditions and with the storage reservoir in place. | ✓ | Not environmentally acceptable due to impacts of increased flooding on communities upstream | X | £177 | 6.6 | 23.5 | X |

**Flood Risk Location 11:** SHARDLOW **Refer to Figure No.** 6.11

| Option | | | Detail Appraisal Results | | | | | | | Strategy Recommend |
|---|---|---|---|---|---|---|---|---|---|---|
| No | Description | Flood Cell | Technical<br>✓ Technically acceptable<br>X Technically unacceptable | Passed | Environmental<br>✓ environmentally acceptable<br>✓✓ environmentally acceptable & preferred<br>X environmentally unacceptable | Passed | Economic | | | |
| | | | | | | | Cost (£M) | B/C | P.S. | |
| 3.15 | *Shardlow*: assess current standard of protection | 3.15 | Currently Shardlow defences provide protection to a 1 in 100+year standard. Replacement is necessary when their 'design life' has expired. | ✓ | Environmentally acceptable and a preferred option due to increased flood protection. | ✓✓ | £1.6 | 6.0 | 18.7 | ✓ |