



Comhairle Chontae Fhine Gall  
FINGAL COUNTY COUNCIL



Comhairle Chontae na Mhí  
MEATH COUNTY COUNCIL

# RIVER TOLKA FLOODING STUDY



## TECHNICAL REPORT VOLUME 2: RIVER MODELLING REPORT

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# 1 INTRODUCTION

## 1.1 APPOINTMENT OF RPS-MCOS

In 2001 Dublin City Council, acting on behalf of the Local Authorities in the Greater Dublin area, commissioned a major study of foul and storm drainage needs in the area having regard to current needs and for development horizons to 2011 and 2031. The work was undertaken by a Consultancy Consortium known as the Dublin Drainage Consultancy. This work will culminate in 2003 in the publication of the Greater Dublin Strategic Drainage Study (GSDS).

As an extension of this study, the River Tolka Flooding Study was commissioned by Dublin City Council, in association with Fingal County Council, Meath County Council and the Office of Public Works in 2002. The study arose from concerns regarding increased flooding risk to properties along the River Tolka arising from a significant flood in November 2000, when many properties were inundated particularly in parts of Meath and in the Dublin City Council area. The River Tolka Study has been carried out by M.C. O'Sullivan & Co. Ltd. (RPS-MCOS), on behalf of the Dublin Drainage Consultancy.

## 1.2 PROJECT APPRECIATION

### 1.2.1 Background/Flooding History

The Tolka has a long flat, mainly rural catchment with minimal reaction to short duration heavy rainfall storms. However, the Tolka does have a significant history of flooding after long steady rainfalls, with lands adjacent to the river inundated a number of times during the last century. The extent of the flooding during the 6/11/00 flood, estimated as a one in twenty year event, is shown in Figure 1.1. The long flooding history is reflected in the Tolka's Gaelic name 'An Tulca' which means The Flood.

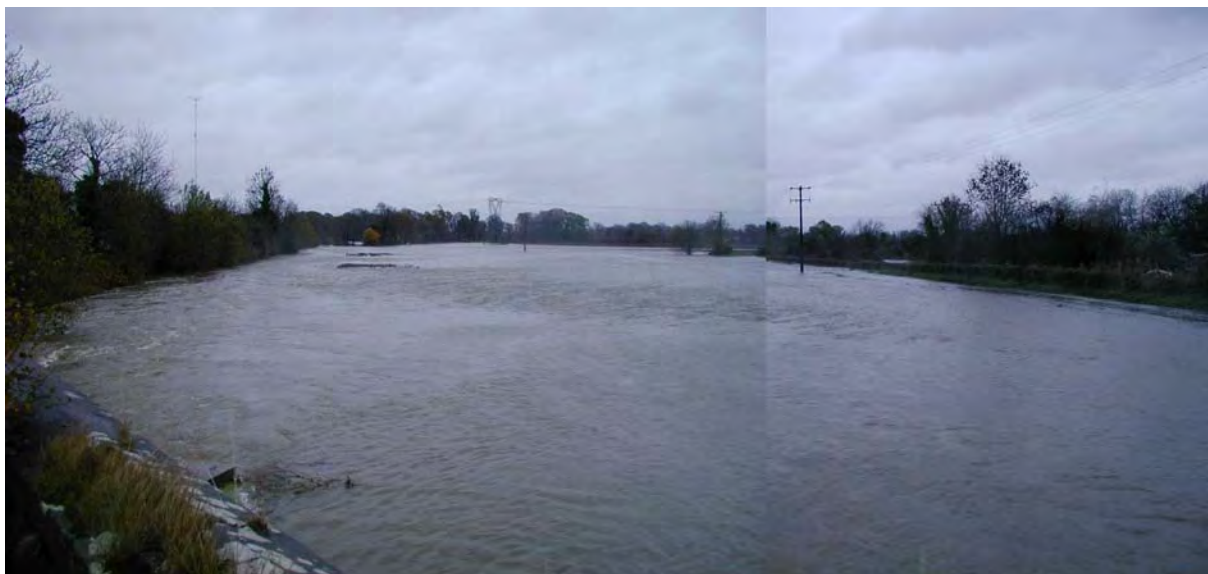


Figure 1.1 - Extent of Flooding on 6/11/00 looking downstream from Loughsallagh Bridge



**Figure 1.2 - Comparative photograph, looking downstream from Loughsallagh Bridge**

The November, 2000 flood revised public awareness of the acute flood risk from the River Tolka to properties along the river, including relatively recent developments. As a result, this study was commissioned to analyse the problem and examine solutions.

From the available data Table 1.1 lists recorded floods occurring since 1880. A full hydrological assessment and results of historical flood analysis are included in Chapter 5

**Table 1.1: Available Historical Flood Data**

Ranking	Date	Estimated Flow at the outlet of the Tolka	Ranking	Date	Estimated Flow at the outlet of the Tolka
1	14/15 <sup>th</sup> November 2002	97m <sup>3</sup> /s	10	20 <sup>th</sup> September 1946 <sup>1</sup>	48 m <sup>3</sup> /s
2	8 <sup>th</sup> December 1954 <sup>1</sup>	85 m <sup>3</sup> /s	11	23rd November 1898 <sup>1</sup>	45 m <sup>3</sup> /s
3	6 <sup>th</sup> November 2000 <sup>2</sup>	76 m <sup>3</sup> /s	12	12 <sup>th</sup> November 1915 <sup>1</sup>	42 m <sup>3</sup> /s
4	28th October 1880	71 m <sup>3</sup> /s	13	3 <sup>rd</sup> April 1909	37 m <sup>3</sup> /s
5	1965 <sup>2</sup>	59 m <sup>3</sup> /s	14	5 <sup>th</sup> February 1946	Minor Flood
6	26 <sup>th</sup> August 1986 <sup>3</sup>	57 m <sup>3</sup> /s	15	3 <sup>rd</sup> January 1948	Minor Flood
7	12th November 1901 <sup>1</sup>	57 m <sup>3</sup> /s	16	19 <sup>th</sup> December 1932	Minor Flood
8	1 <sup>st</sup> September 1931 <sup>1</sup>	54 m <sup>3</sup> /s	17	17 <sup>th</sup> November 1916	Minor Flood
9	1968 <sup>2</sup>	49 m <sup>3</sup> /s			

This table shows that the major flooding has generally been confined to the period between late August and early December. Due to the flatness of the catchment and its retentive vegetation, spring and summer storms have seldom produced flows of any major significance.

Recent flood history (2000 flood in particular) indicated that the catchment could be classified in terms of flood risk generally in accordance with the following:

<sup>1</sup> From 1955 Dublin Corporation Report on the 1954 Flood estimated using debris line at weir upstream of Finglas Bridge.

<sup>2</sup> Recorded at Botanic Gardens station. The rating curve has been developed for flows up to 87m<sup>3</sup>/s, flows in excess of this should be treated with caution.

<sup>3</sup> Recorded at Drumcondra Station.

- Flooding had occurred in the town of Dunboyne on the Castle Stream branch of the River Tolka which required that this branch be modelled in detail. Door to door surveys indicated that a number of properties not flooded during the November 2000 event were close to being flooded and could be considered at risk to flooding during an event of larger magnitude. In addition to this, following the event, a number of recent developments had been constructed in low lying areas, which could be at risk.
- The sensitivity to flooding in the Clonee area needed to be examined together with lands zoned for development in Clonee and Dunboyne areas. Areas upstream of Clonee Bridge have a history of flooding; areas downstream of the bridge were flooded from a secondary flow path due to exceedance of the river capacity in this area.
- Through Mulhuddart and Blanchardstown, much of the flood plain of the River Tolka has been maintained free from development (with the exception of Gleeson's pub at Mulhuddart Bridge) Therefore flooding associated with river levels did not appear to be a significant risk to existing developed areas.
- In the DCC area, a significant developed area of low lying lands below the Botanic Gardens had a propensity for flooding. Careful model construction and analysis was required through Glasnevin and Drumcondra including consideration of numerous bridges, weir structures and other potential controls in the channel in this area to assess flood risk in what is a complex system. Between Drumcondra Bridge and East Point Business Park, the Tolka needed to be considered in terms of inter-tidal conditions with historical references to flooding in the Clonliffe / Ballybough area.

### 1.2.2 Study Context

The recently experienced strong economic growth in the Irish economy, the continuing development of the national road network, availability of public transport services and zoning of land for industrial and commercial development to provide sustainable employment for new populations, has been fuelling the continuing expansion of the Dublin area and is resulting in major development pressure in the greater Dublin area and surrounding counties. Currently land use within the upper catchment is a combination of lightly forested and agricultural land. In the middle catchment residential and commercial development competes with agricultural use but an increasing amount of land is being developed for residential and commercial use. In the lower catchment, the land use is almost entirely residential, public parks and commercial. As the lower and middle catchments in particular, and certain concentrated areas within the upper catchment, are witnessing significant increases in land use change, the risk of flood damage to property and infrastructure is likely to have increased.

Prior to this study, the lower river reaches had been the subject of a number of investigations the most significant of which were those carried out in 1955 and 1986. In both cases the study reports identified and recommended specific remedial measures to be taken that would alleviate or reduce the incidence of flooding. While some of the 1955 proposals were implemented, post 1955 recommendations were not implemented as the downstream effects could not be quantified. In November 2000, the river discharge again reached flood levels and a significant amount of damage was sustained by developments in the upper and middle catchments and by certain areas in the lower catchment that have a propensity for flood damage. There had never been a fully inclusive analysis of the river's behaviour under a full range of potential floods and certainly there has been no investigation of the catchment's response to severe rainfall as it is currently developed and as planned to be developed. In recognition of these pressures, Dublin City Council, in association with Fingal County Council, Meath County Council and the Office of Public Works commissioned this comprehensive study.

## 1.3 OBJECTIVES OF THE REPORT

The objective of the Report is to describe the comprehensive flood analysis of the River Tolka, Castle Stream and Twin Pinkeen Streams and how it developed, from a modelling perspective. The analysis included the development of a robust hydraulic and hydrological mathematical model representing the characteristics of the River Tolka catchment. The model has the facility to map flood risk for design

rainfall events. Using model output and taking account of climate change and of current and future land developments.

From this analysis a flood relief scheme has been developed to protect existing property. Recognising the downstream effects of improvement works, the impacts of local flood alleviation measures have been assessed in the context of the entire river system and measures recommended for mitigating these impacts. Additionally catchment wide schemes such as attenuation and diversions have been assessed. The scheme is considered to offer a sensible level of protection for all areas currently developed. This has involved assessment for the November 15<sup>th</sup>, 2002 flood and the traditional once in 100 year flood (1% risk of occurrence in any year), to cater for development to 2031 and a reasonable degree of climate change, with a reasonable margin of freeboard.

A detailed technical description of the model construction process is outlined. The accuracy of the flow and level calibration and sensitivity to model parameters is assessed and the results are portrayed in the report.

## 2 CATCHMENT DESCRIPTION

### 2.1 OVERVIEW

The Tolka River is the second largest river to enter Dublin City in terms of its length and catchment area, after the Liffey. As depicted in Figure A1.1, Appendix A, the river rises west of the city in County Meath near the Culmullin Cross Roads on the R125 roadway and is fed by a network of small tributaries as it flows through Batterstown, Rathbeggan, Quarryland, Piercetown, Blackbull, Dunboyne, Clonee, Mulhuddart, Blanchardstown, Finglas Bridge, Glasnevin, Drumcondra, North Strand and East Wall to enter the sea east of the DART depot at Fairview Park.

It has a catchment area of 14,150 hectares, and drops 140m in 33.3 kilometres. This makes it a relatively flat river, with modest gradient from source to sea. The upper-catchment can be described as predominantly rural. The river in this area is little more than a stream with small meanders and low banks with a relatively flat bed gradient of about 0.4%. It is roughly 2.5 m wide near Batterstown and 5 m wide just upstream of Clonee Bridge. Despite this, the upper catchment is subject to occasional flooding with the flood plain extending up to 400 meters wide in places.

### 2.2 RIVER NETWORK

The profile of the river changes noticeably as it drops from an open, rural catchment upstream of Clonee into the developing urban environments of Mulhuddart, Blanchardstown and Ashtown. Through the formalised Tolka Valley Park, Botanic Gardens and Griffith Park, it becomes somewhat wider and straighter, with generally higher and more defined grass banks. In its latter reaches through Glasnevin, Drumcondra and Marino, the river becomes increasingly canalised, which is characteristic of many inner city rivers where development extends almost to bank top. In this section, the riverbank varies from natural riverbank to an ad-hoc arrangement of walls of varying height and robustness. Below Drumcondra the river is also subject to tidal influence and the channel is wider with more formal riverside walls in the lower section.

### 2.3 INTERACTION WITH OTHER STUDIES

In parallel with the river study, the GSDS study includes modelling of the stormwater drainage networks connecting to the River Tolka. These studies will include consideration of the interaction between the local drainage networks and river flood conditions in order that secondary flooding risk through backpounding of the pipe networks is dealt with. The ultimate integrated flood relief scheme for the River Tolka must comprise of the recommended river engineering works, pipe network upgrading works as well as the overall catchment management measures proposed.

### 3 DATA COLLECTION

A significant amount of data has been procured and investigated; this data is detailed in the following sections.

#### 3.1 REPORTS

A number of relevant reports have been procured in relation to the study. These reports are detailed in appendix B -1, along with a brief synopsis.

#### 3.2 RAINFALL DATA

Rainfall data shown in Figure B – 2.1, Appendix B.2 is available from a number of meteorological stations located in and around the catchment area. Most historic stations record only daily rainfall with the exception of Dublin Airport and Casement Aerodrome. In addition to this, DCC have detailed station data dating back 5 years for four locations, and an additional 4 stations have been installed in the last 2 years. Rainfall data relevant to the study is included in Appendix B - 2

#### 3.3 FLOODS RECORDS/LEVELS

A number of sources for flood levels and records have been investigated. These include:

- 14<sup>th</sup>/15<sup>th</sup> November 2002 Recorded levels during the flood, debris levels, surveyed levels provided by DCC, MCC and FCC, OPW and FCC video footage and photographs.
- 31<sup>st</sup> November 2002 Recorded flow levels – In channel flood
- 6th November 2000 M3 study recorded levels during the flood, photographs and MCC, photo's and Levels
- 6th November 2000 Dunboyne aerial photography and levels
- 6th November 2000 DCC video and photo's
- 1986 Slides – Drumcondra and Distillery Weir (c.f Figure 3.1)
- Anecdotal evidence from reports and visits to affected residents
- Dublin Corporation – Reported levels from 1955 flooding report. The 1954 album of photos is missing

Anecdotal evidence and flood level data is critically important in building a profile of a flood event and can greatly assist in understanding of flood mechanisms. A degree of caution is needed with regard to accuracy of data and interpretation due to:

- Changes in flood levels/flows during a flood
- Influence of local factors
- Wave effects due to vehicle influence
- Interactions with the piped sewerage systems and blockages of screens, pipe inlets, etc, due to debris

Large flood events have a major impact on those affected and very good information can be derived from local people including information on historical frequency, severity, timing, recorded level information and local changes to the drainage and river system over the years.

This information can be particularly useful in assessing variations in levels that can be achieved in secondary flow paths and as a result of obstructions such as local blockages and boundary walls between properties.

Flood debris levels also should be treated with caution as level variations may be recorded due to pile up of debris providing overestimation of flood levels and floating debris which settles at a lower level providing an underestimation. However an experienced hydraulic engineer can usually make a good estimate when viewing flood debris and taking account of the location, type of debris and local conditions. It is therefore particularly important to collect level information directly following a flood when the amount and quality of information is best. The available flood records are included in Appendix B3.

**Figure 3.1- 1986 Flood - Botanic Avenue**



### 3.4 FLOW INFORMATION

A number of gauges have been installed on the river to monitor flows and levels. These include:

- Botanical Gardens Station 09037 - EPA provided records from Sept 1999. A near continuous record is available. Prior to the 15<sup>th</sup> of November, 2002 flows recorded in excess of 30.5m<sup>3</sup>/s were based on an extrapolated rating curve. However on 15<sup>th</sup> November calibration was carried out by EPA staff and the rating curve is now developed for flows up to 87 m<sup>3</sup>/s. This should be noted when reviewing historical reports.
- Drumcondra Bridge, Station 09019 - Records were received. The records are very intermittent and on review it was shown that all records with levels above mean flows have been removed. The report received, *Summary of Hydrometric records: July 1977. An Foras Forbartha*, indicates that due to silting and vegetation growth, the continuous records were not satisfactory for determining mean and minimum flows, although rare flood flows could be established. Records of use received include an estimate of the flood hydrograph for the 1954 flood at this station, and the flood hydrograph for the 1986 flood.
- The K C O'Donnell report on the 1986 flooding has a rough sheet appended indicating annual peak flows on the Tolka River at Drumcondra. The peak flows are included for the years 1954-1969, 1976-1986, though records from 1970 to 1975 are not available.

- Batterstown Staff gauge 09018 - EPA provided records from March 1985 to Sept 1990. These are spot checks at low flows and are not useful to this study.
- Griffith Park – some flow calibration was done using staff gauge, although this was at very low flows and is not useful for this study
- Cardiff's Bridge has some old records. Again these are at low flows only and are not useful for this study
- MCOS water quality assessment recorded low flows only. (River Tolka draft Water Quality Management Plan)

In summary there is very little high quality flow information available to enable calibration to flow hydrographs within the catchment. There is however some good quality, high flow hydrograph records available in the lower catchment and these were used in calibration of the entire model. There are also a number of level records throughout the catchment. It is often found in modelling rivers that level calibration is of most importance. This is due to factors such as aerial floodplain increase and flood stage velocity increase, whereby large increases in flow can translate into moderate increases in level. Therefore, level information is the issue of most importance as flooding / no flooding are a function of level.

### 3.5 PROPOSED RIVER GAUGES

A report on the suitability of providing two gauges located on the river in addition to the existing gauge at the Botanic Gardens and the existing tide station at Dublin Port was issued to Dublin City Council. It is proposed that these gauges would be linked to the Council's telemetry system. In addition to this it is proposed that the flow monitoring stations be utilised for long term monitoring in conjunction with environmental parameters. The river was investigated taking into account the following general site criteria.

- **Site Security**

The river gauges should be located on private or local authority land with no public access or areas where access is restricted due to geographical location. If the gauging station is located on private land consideration has to be given to the negotiation of rights of access for installation and commissioning of the gauging stations and for regular maintenance.

- **Positioning of River Gauges**

The River Gauges should be positioned in areas where river debris will not dislodge the equipment or unduly affect water levels. If existing low flow weirs are used the infrastructure is already in place to ensure good river bank and river bed conditions as well as ensuring that the river gauges aren't placed above the dry weather flow. The gauges should not be placed in locations that are subject to downstream influences causing the gauges to drown out during flooding events.

- **Upstream / Downstream Riverbank condition**

The upstream and downstream condition of the river bank should be smooth to reduce the possibility of drag and to assist the free movement of water along the river profile.

- **River Bed Conditions**

The river bed should be smooth with a gradual incline to assist in obtaining a smooth flow and should not be prone to scouring or depositing of excessive river material.

Due to the relatively low gradient of the river and the extensive flood plains, only 2 general areas meeting the above requirements were identified as suitable for providing additional flow information relative to the study and include:

- 1) Cardiff's Bridge, Ashtown (Dublin City Council, Fingal County Council boundaries). This location is the current catchment boundary between the semi-rural and urban developed areas. The recommended site in this location is Finglas (Factory) weir, 100m u/s of the road bridge on the N2 (Finglas Road). This site has a weir with a head difference of approx. 2.5m between upstream and downstream. While this site may seem a comparatively long distance downstream from Cardiff's Bridge, the increase in catchment area is small, it is upstream of the confluence of the

Finglas River and will not be influenced by it, as the Finglas river joins the Tolka River downstream of the weir.

- 2) N3 Clonee (Fingal County Council, Meath County Council boundaries). This area is the first suitable site offering smooth flow conditions below the confluence of the upper catchment tributaries. The recommended site is downstream of the Clonee by-pass alongside the Kepak premises. A Non Standard Control structure would be required at this location if monitoring of low flows is also required. This location is well upstream of the next culvert, and is less likely to be effected by backwater than other locations in this area.

These proposed sites could be utilised in conjunction with the existing monitoring sites located at:

a) Dublin Port, which provides tidal records for the hydraulic study and upon investigation by the project team was found to be satisfactory for the project needs, (this station was connected to Dublin City Council's telemetry system in 2003) and;

b) Botanic Gardens, which is currently maintained by the EPA and was also found to be satisfactory for the project needs (following satisfactory extension of the rating curve to  $87\text{m}^3/\text{s}$ ).

## 3.6 TOPOGRAPHICAL DATA / ORTHO-PHOTOGRAPHY

### 3.6.1 Orthophotography

Latest Ordnance Survey V1000 and V2500 mapping have been assessed and details of unmapped recent developments have been included, where available, from the relevant local Authority Building Control sections. The N3 Tolka study topographical Digital Terrain Model (DTM) and Ortho-photography was utilised for the Meath Area along with the N3 Tolka study - cross-sections and Bridge sections of Tolka and Castle Stream (Dunboyne). A LIDAR DTM and Digital Surface Model (DSM) was produced for the remaining length of the Tolka and the tributaries modelled. Ortho-photography is available for almost the entire study area.

### 3.6.2 Topographical Survey

A topographical survey for the remaining length of the river and the Scribblestown and Twin Pinkeen streams was carried out by BKS and subcontracted by them to Longdin and Browning. This survey included river cross-sections, bridge details, outfall pipe locations and house levels for areas initially identified as at risk to flooding. Photographs of cross sections and flow control structures were also provided.

Cross sections were taken approximately every 50m, from left bank to right bank position looking downstream, and extending to the floodplain where necessary. Drawings and data files were provided. The data file was in ASCII Format so a direct import into InfoWorks RS was possible. An example of a cross section taken in ASCII format is shown in Appendix B – 4, Table B.4.1. The writing in *italics* is for information purposes only.

Flow control structures were surveyed immediately upstream and downstream, extending to the floodplain, defining its profile and showing additional points where any significant change in level occurs.

## 3.7 PIPE NETWORKS

Storm water pipe network requirements are generally being dealt with in the GSDSDS storm model catchments, in addition to this: Dublin City Council provided updated digital Network details. These included a detail sheet of Distillery Weir. Hard copy storm water maps were provided by Fingal County Council dated 1990. Network details are not available for Dunboyne and Clonee. Outfalls were initially identified from the draft River Tolka Water Quality Management Plan report (MCOS) and river surveys have included invert levels and diameters for these and other outfalls identified. Wad River Diversion Plans (Ballymun Development) circa 1968 were received from Dublin City Council. The parallel drainage network studies in the GSDSDS will enable the interaction of the network and the river system to be examined. Management of this interaction is a critical element of a secure River Tolka flood defence system in the future.

### 3.7.1 Drainage Networks

There are 6 main drainage networks entering the Tolka River. These are catchments 30-35, see Figure C1.2, Appendix C.1.

Catchment 31 (Green) is the smallest region within the Tolka NDDS catchment at 235 ha bounded by the Finglas River to the north and east, the Scribblestown Stream to the west and the Tolka River to the south. It drains across the steep sided Tolka Valley Park via the Finglaswood Stream, the Scribblestown Stream and numerous smaller piped systems in the lower reaches. The largest outflow from this catchment is the Finglaswood Stream and outfalls via a box culvert in Tolka Valley Park. 4 smaller catchments outfall in this area via 300-600mm Ø pipes.

Catchment 32 (Red) is 373 ha, lies to the south of the Tolka River. It is bounded approximately by Botanic Rd to the east, the Royal Canal / Carnlough Rd / Navan Rd to the south and Ashtown Rd to the west. The Cemetery Drain that services Glasnevin (Prospect) Cemetery in Drumcondra is the only named watercourse in this region. The outfalls consist of a 600m Ø pipe outfalling at Glasnevin Bridge, a 450mm Ø pipe outfalling between Botanic Road and Mobhi Road, a 750mm Ø pipe outfalling at Finglas Road, several 450-600mm Ø pipes between Ratoath Road and Ashtown, and a 450mm Ø pipe at Tolka Valley Park.

Catchment 33 (Orange) is 241 ha and lies between the Wad River Diversion to the east and the Finglas River to the west. This drains to the Tolka from a maximum high point of about 68 m MHD at Finglas East predominantly via the culverted Claremont Stream. It enters the Tolka through a 1370 x 1670 mm box culvert, 19m downstream of Glasnevin Bridge. Three other subcatchments of Catchment 33 enter the Tolka via 300-450mm Ø pipes. This region comprises of well-established urban areas mixed with a good proportion of institutional lands and sports fields in the middle to lower reaches. It is crossed by the regional and main roads of Finglas Rd Old, Griffith Avenue, Glasnevin Av, Ballygall Rd East / Beneavin Dr / Willow Park Cr / Sycamore Rd and Glasanon Rd.

Catchment 34 (Blue) is 536 ha and the eastern most region bounded by the Wad River Diversion to the west, the Wad River catchment proper to the north and east, the Tolka River to the south and the river estuary to the south-east. This region drains from a maximum high point of about 48 m MHD near Dublin City University at the Collins Avenue watershed in the north to the Tolka River and estuary via several watercourses that have now all been culverted and often diverted from their original course. The most significant watercourses are the Marino Stream, 1050mm Ø pipe discharging at Fairview Park, Grace Park Stream, a 1350mm Ø pipe discharging south of Richmond Rd, Drumcondra Rd Upper / Swords Rd drain, 375mm Ø pipe discharging at Drumcondra Bridge and the Hamsstead Stream: 600mm Ø pipe, discharging downstream of Mobhi Rd.

Catchment 35(Finglas River) is 1080 ha runs from north of the M50 to the River Tolka at the Finglas Road. The section of the catchment north of the M50 is rural, whereas the majority of the catchment south of the M50 is urbanised. The Finglas area is served by a partly separate sewerage system, the surface water system is composed of several branches draining to the Finglas River. There are 7 CSO's within the foul/combined system, which discharge to the surface water sewers or directly to the Finglas River.

Catchment 23 and 23A (Blanchardstown/Mulhuddart) is 843 ha in size and incorporates the drainage network from Blanchardstown and Mulhuddart. The majority of the catchment is urbanised. The main outfalls from this network are two 900mm Ø pipes in Tolka Valley Park, one upstream and one downstream of the Northern Cross Route, a 1050mm Ø and 450mm Ø pipe, discharging at Mill Road and James Connolly Memorial Hospital respectively, a 1000mm Ø pipe discharging behind Main Street, Blanchardstown, a 525mm Ø pipe discharging upstream of Snugborough Rd culverts, a 1050mm Ø pipe discharging upstream of Blanchardstown Road North and a 1200mm Ø pipe incorporating Mulhuddart, discharging upstream of Mulhuddart bridge. There are smaller outfalls from this catchment including 4 outfalls ranging from 225mm to 450mm Ø pipes.

In addition to these formal culverted and piped drainage networks, rural and semi rural catchments have been identified and included in the model. These catchments are identified in Figure C1.1, Appendix C1.

### 3.8 FLOOD PROTECTION WORKS / RIVER ALTERATIONS

A number of river alterations have occurred since the 1954 major flooding event. These alterations have been included in the various models where necessary to ensure accurate representation of past existing and future events.

#### 3.8.1 Historical Works

- The Glasnevin Bridge was rebuilt and completed in April 1968.
- River works were undertaken from the Estuary to Ballybough and completed 1966.
- Sections of East Wall have been reclaimed for the business park.
- The residents of Tolka cottages were relocated and the cottages were removed. The area was subsequently built up and a park provided.
- A section of the river that ran where Botanic Avenue now exists was realigned through Griffith park.
- Various minor bed cleaning works have been undertaken.
- Various culverts have been installed with the construction of the N3 motorway.
- Channel works were undertaken at the property surrounding Flat House Bridge.
- A number of developments have occurred in and around the wider flood plain.
- The Wad river diversion was undertaken circa 1968 as part of the Ballymun developments.

#### 3.8.2 Recent / Proposed Works

- A section of the river in Dunboyne was excavated in 2001, following the November 2000 flood event. New cross sections in this area were surveyed for insertion in the model for analysis of future flood risk.
- Irish Rail has upgraded the bridge over the Tolka at East Wall Road in 2002 altering the hydraulic details in this area.
- Works are underway on a proposed new bridge at the Dublin Port Tunnel site.
- A new pedestrian bridge was constructed downstream of Mulhuddart bridge during the study period (no information was available for this bridge and it is not included in the model).
- A small bridge is proposed at Clonee for access to a new development.
- A bridge to James Connolly Memorial Hospital is proposed as part of the M50 upgrade to the N3 interchange.
- Diversions and Culverts are proposed as part of the N3 Clonee to Dunshaughlin Road Scheme.

#### 3.8.3 Study Interim Works

A number of interim works, maintenance cleaning and damage repair works have been undertaken or are proposed and these are dealt with separately within the report.

### 3.9 TIDAL INFORMATION

Alexandra Quay tidal gauge records have been received from Dublin Port Authority for the period 1923 to date. Additional records were requested for the period 1844 – 1922 but Dublin Port Authority advised that these records were unreliable. The 1923 to 2002 records have been digitised and converted from L.A.T datum to Malin Head Datum. A sea level of some 2.95m (MH) was recorded on 1<sup>st</sup> Feb 2002 at 14.30 hours, the highest reading on record. This unprecedented event resulted in East Wall Road/North Strand (a section of the study area) being flooded as a result of the tidal section of the Royal Canal escaping from its channel. No flooding was reported in the tidal reaches of the River Tolka.

Thus, in 2002, two separate independent flood events took place of unprecedented magnitude in the Tolka catchment, a major fluvial flood event and a major tidal event.

A comprehensive analysis of all available tidal data outside the scope of this study is being undertaken for the Dublin Coastal Flood Risk Assessment Study (DCFRAS).

## 4 LAND USE AND PLANNING

### 4.1 EXISTING LAND USE

A comprehensive population and land use study has been undertaken as part of the Greater Dublin Strategic Drainage Study. One element of this land use study involved the assessment of the current development situation (2002) in the Greater Dublin Area through the construction of a database which identifies sites that have been developed since the production of the most recent 1:1000 OS mapping. The database also categorises the type of development at each site into residential, industrial, commercial, mixed use or science and technology. For the construction of the river model, this database, used in conjunction with the County Development Plans and the OS mapping provides a comprehensive knowledge of land use in the catchment. This information is illustrated in Figure B4.1, Appendix B4.

Future Land Use scenarios (2011, 2031) are discussed in Section 4.3 of the report.

The Corrine Land Use mapping in Figure B - 4.2, Appendix B4 also gives an overview of land use in the area.

### 4.2 CONSTRAINTS MAPPING

Various data sets outlined below have been displayed in GIS map format to be used later in the study for identification of possible constraints to solution options and include;

#### 4.2.1 Sites & Monuments; Special Areas of Conservation; Special Protection Areas and Natural Heritage Areas:

Figure B – 4.3, Appendix B4 displays the most up to date information available from the Dúchas website on the various protected and sensitive areas in the catchment. This was downloaded from the website in ArcInfo format and then converted in house to MapInfo format.

#### 4.2.2 Catchment Landuse / Corine Data:

This data shown in Figure B – 4.2, Appendix B4 is developed from an interpretation of Satellite Images from 1989-90 and gives a broad picture of land use during this period. Imagery Software has been used to define the land use depending on the pixels colours. Areas less than 0.25Ha are interpreted only. This data is relatively old and broad, however is included for information purposes. Land use patterns developed in the GDSDS have been used for model input data.

#### 4.2.3 GSI Bedrock / Groundwater and Aquifers:

Details of the geology, groundwater and aquifers in the catchment from the Geological Survey Ireland are shown in Appendix B4 - Figure B4.4 and Figure B4.5.

### 4.3 FUTURE DEVELOPMENT WITHIN THE CATCHMENT

The GDSDS called for population and land use analysis for the three design scenarios of 2002 (existing), 2011 and 2031. A current development database was created for the 2002 scenario. The 2031 planning horizon is well beyond the periods considered by Local Authority Development Plans (2004/2005); The Strategic Planning Guidelines (SPG) (2011); the Dublin Transport Office's Platform for change (2016). It was therefore required to carry out sensitivity analysis on the population projections which were supplied in the Strategic Planning Guidelines and the National Spatial Strategy to estimate the 2011 and 2031 populations for each county. The county development plans, industrial land use surveys, county housing strategies and biannual housing surveys were then used to identify land requirements to accommodate these increases in population. Indicative land area requirements

can be assessed. These same design scenarios are used in the Tolka Flood Study. The resulting development scenarios are illustrated in Appendix B4 - Figure B4.6.

It can be seen that the majority of the future development planned for the River Tolka catchment is proposed in Fingal County with significant development of Greenfield lands in this section of the catchment. Other areas of future development include infill and re-development to higher densities (esp. along future transport routes), in the Dublin City Council areas of the catchment as well as Rail and Road projects. Also envisaged is further development of Clonee and Dunboyne in County Meath along with the proposed N3 National Primary Route and associated interceptor roads. With the exception of the developments in Meath outlined above and possible future development in Batterstown, information to date indicates that the upper catchment will remain relatively unchanged and rural in nature. However, further sensitivity analysis was undertaken during the assessment of hydraulic model forecasts for the future scenarios. This was undertaken to ensure the affects of varying land use on future river levels could be accommodated in the scheme proposed. For further comprehensive details of Land use and planning the reader is referred to the GSDSDS Final Report on Population and Land Use<sup>4</sup> and The National Spatial Strategy<sup>5</sup>.

Table 4.1 gives a brief summary of percentage of catchment developed and estimated to be developed for the various key dates utilised in this study.

**Table 4.1 Catchment Development**

Year	Catchment Area (km <sup>2</sup> )	Area Developed (km <sup>2</sup> )	Percentage Developed (%)
1800's	141.1	0	0
1900	141.1	2.0	1.4
1955	141.1	11.5	8.2
2002	141.1	27.7	19.6
2011	141.1	41.9	29.6
2031	141.1	49.0	34.6

These figures have been used in the development of the hydrological assessment of the catchment, and are refined during the modelling study to include detailed urban percentages for the sub-catchments. (c.f. Appendix C – Figure C1.1 for a detailed map indicating sub catchments and model parameters)

The rate of development between 2002 and 2011 is significantly greater than that between 2011 and 2031. These estimates are partly due to a greater percentage of the catchment in Fingal County being recognised as fully developed by 2011 and therefore further development will be restricted (Blanchardstown/Mulhuddart). In addition the SPG includes policies which limit development outside of the Dublin Metropolitan area to Primary and Secondary development centres. Since Meath is outside of the Metropolitan area and there are no development centres within the Tolka Catchment, future development here “*will be limited to meeting local needs.*” Notwithstanding this objective, sensitivity analysis was carried out using the modelling for alternative development scenarios.

<sup>4</sup> Greater Dublin Strategic Drainage – Population and Land Use, Final Report January 2003, Dublin Drainage Consultancy, GSDSDS/NE02057/094v1.

<sup>5</sup> The National Spatial Strategy, Final Report, October 2001, Jonathan Blackwell and Associates in association with Roger Tym & Partners.

## 5 HISTORICAL EVENT ANALYSIS

### 5.1 ANALYSIS OF FLOOD EVENT OF 14<sup>TH</sup> – 15<sup>TH</sup> NOVEMBER 2002

#### 5.1.1 Rainfall Records

The flood of 15<sup>th</sup> November, 2002, followed 2 days of very heavy rainfall. A previous rainfall event on 8<sup>th</sup>-10<sup>th</sup> November had resulted in a very wet catchment which, combined with Winter vegetation conditions, meant that a very high level of run-off took place on the 15<sup>th</sup> November, with little, if any infiltration/soakage into the ground.

Rainfall data for Dublin Airport and Casement weather stations showed that rainfall commenced in the afternoon/evening of 13<sup>th</sup> November and reached peaks of 8.7mm/hr at Dublin Airport in the afternoon of 14<sup>th</sup> November and 8.3mm/hr at Casement Aerodrome at 1.00am on 15<sup>th</sup> November. The total rainfall depth measured at Dublin Airport over 53 hours was 87mm. 72 mm of rainfall was recorded over a period of 35 hours at Casement. Met Eireann estimate that a rainfall of this duration has a return period of approximately 50 years. However, subsequent investigation of Dublin Airport radar information combined with sub-catchment calibration indicates that some areas within the catchment sustained even heavier rainfall, with over 100mm of rain indicated as falling in the Dunboyne area during this period. Met Eireann estimate that rainfall of this quantity based on Dunshaughlin data to be in excess of 100 year return period.

In summary, the November 2002 flood flows in the River Tolka were the result of a major rainfall event in circumstances which characteristically give rise to serious flooding in the River Tolka, namely, a rainfall duration of 1.5 – 2 days of appropriate intensity and with preceding wet catchment conditions. The modelling studies showed that recorded rainfalls (Dublin Airport and Casement) had to have been significantly exceeded to produce the flood flows at Dunboyne and this was confirmed by reference to radar data.

#### 5.1.2 Affected areas

The extents of flooding on the 15th – 16th November 2002 is illustrated on 26 aerial maps provided in Appendix B of the Final Report, beginning at Batterstown, ending at the ocean outfall at East Wall and are based upon site observations, surveyed debris levels and modelling results. The February 2002 tidal flooding is also depicted on these maps while the 1954 flood is illustrated on 4 additional maps and are provided for reference in Appendix C of the Final Report.

It should be noted that large areas of secondary flooding occurred outside of the analysed and represented flood plain in low lying areas. Where this affected property and information is available these are generally noted within the report.

**The Historical Flood Maps must only be used in conjunction with the Notes and Disclaimers provided in the Final Report and must not be used in isolation to avoid incorrect interpretation of the data provided.**

#### Dublin City Council Administrative Area

The flood mechanism in this area was almost identical to that experienced in 1954. However, in 1954 the low-lying areas of Ballybough, North Strand, East Wall and Fairview were more severely impacted due in part to the lower level of flood defence walls in these areas at that time (the raising of these walls was subsequently undertaken from the Estuary to Ballybough and completed in 1966). Flood levels in 1954 are also thought to have been influenced by the partial collapse of the CIE Bridge, which anecdotal evidence suggests became blocked with debris.

Additionally the rebuilding of Glasnevin Bridge completed in 1968 has reduced the risk of the overflow path to floodwaters in this area and no overflows occurred via this route in November 2002.

The following is an overview of the flood experience in 2002 between Finglas Road and Fairview:

- **Finglas Factory Weir Area:** Flooding of basement car park occurred at Tolka Vale due to the outlet of the storm water pumping system being inundated preventing discharge against the high flood level (refer to Frame 24, Appendix B, Final Report).
- **Finglas Bridge to Glasnevin Bridge:** No property damage occurred in this relatively steep valley section of the river (refer to Frame 24 & 25, Appendix B, Final Report). However erosion of river banks took place due to high water velocities, and additionally significant alluvial material was deposited downstream of Finglas bridge during the flood recession. Some damage was sustained in the Botanical gardens with a number of mature trees being undermined, erosion to banks and walls and general damage to planted areas.
- **Glasnevin Bridge to Deans Swift Bridge:** This short reach of the Tolka extends from Glasnevin Road Bridge located on Glasnevin Hill Road to Deans Swift Bridge located on Mobhi Road (refer to Frame 25, Appendix B, Final Report). No substantial property flooding occurred immediately upstream of Glasnevin Bridge. However immediately downstream of the bridge, the river overtopped its right bank. The resulting overbank spill caused localised flooding at the school and properties immediately adjacent. Flood water from this channel breach continued down Botanic Avenue towards Drumcondra Road Lower where it added to the flooding within that area.
- **Deans Swift Bridge to Griffith Park:** From the Deans Swift Bridge to Griffith Park, flood flows were conveyed within the banks of the River Tolka (refer to Frame 25, Appendix B, Final Report). The residential properties located adjacent to the river over this reach are protected by flood walls and are generally above flood level. Any partial floodwaters in this area arise from overflows upstream described above.

The river kept within its walls and floodplain of Griffith Park within the upper portion of this reach and prevented overbank flows from the Tolka reaching Botanic Avenue. The River began to break its banks and flow onto Botanic Avenue just downstream of the residential properties (85 – 155 Botanic Avenue) within the southern side of Griffith Park, near the Intersection of Botanic Avenue and Mannix Road. Downstream of this location, the area was completely inundated by overbank flows. From anecdotal evidence, including debris left at the entrance to the park, flood waters spilled through the entrance and over the low (300 – 400 mm high) roadside concrete wall. Flood waters from Griffith Park flowing into Botanic Avenue inundated the roadway and residential properties within this area.

The Woodville Road Footbridge at the downstream extent of this reach formed a constriction to main channel discharge capacity by trapping debris in its railings. The river narrows in this area with residential property boundaries located either side further confining the flood flows. At the footbridge, overbank flood flows can discharge to both North and South of the river. Flows spilling north of the footbridge exited to Millmount Road causing inundation of properties on this road. As the area filled up, flood water continued further downstream crossing the Drumcondra Road Lower and Millmount intersection into Clonturk Park and continuing down Richmond Road. Floodwaters overflowing South of Woodville Road Footbridge added to flooding in the Lower Botanic Avenue Area.

- **Woodville Road Footbridge to Drumcondra Road Bridge:** Extensive flooding occurred within the reach upstream of Drumcondra Road Bridge inundating residential properties in the vicinity of Botanic Road and Millmount Road (refer to Frame 26, Appendix B, Final Report).

In addition to the floodwaters described above, the River overtopped its banks within the old Tolka Park Cottages area inundating these grounds and Botanic Avenue. Flow entered onto Botanic Avenue by overtopping the outer perimeter wall and also flowed freely through the entrance to the gardens. As flood waters receded, flows from Botanic Avenue flowed back to the River Tolka via the lower area at Drumcondra Road.

While wall levels on the south bank were high enough to prevent inundation of flood waters within this reach, the inundation of properties behind the wall occurred from the unprotected area leading to the Woodville Road Footbridge and from Botanic Road due to flood waters escaping from Griffith Park. Wall levels immediately downstream of the footbridge on the north bank were below flood level and thus direct inundation occurred to properties behind this wall from the river. Furthermore, surcharging of local drainage pipe systems backpounded manholes and road gullies, this added to flooding of low-lying areas.

- **Drumcondra Road Bridge to Richmond Road Industrial area:** Extensive flooding also occurred within this reach from the Drumcondra Road to the Industrial Area located just downstream of Tolka Park (refer to Frame 26, Appendix B, Final Report). Flood waters also extended back to the low-lying residential areas surrounding Clonturk Park. The River Tolka is bounded by residential property immediately downstream of Drumcondra Road. On the south bank, both walls and natural land levels form limits to flooding in this region. On the north bank floodwaters reached the top of the embankment level behind Nos. 4-52 Richmond Road. However, no significant overtopping occurred.

Flooding of properties over this section occurred from the overtopping of the walls at 60 to 68 Richmond Road, including the entrance to Tolka Park, and was further exacerbated by flows bypassing Drumcondra Bridge which had overflowed upstream from the Tolka at Griffith Park and bypassed the river downstream via Millmount Road.

- **Richmond road industrial area to Distillery Road Bridge:** Distillery Road Bridge is located midway between the Luke Kelly Road Bridge (Ballybough Road) and Drumcondra Bridge (Drumcondra Road Lower) (refer to Frame 26, Appendix B, Final Report).

Sections of the North Bank of this reach are below flood level with intermittent low walls allowing waters to enter the industrial area. On the south bank floodwaters are able to flow onto the river floodplain within the Holy Cross College sports grounds. Distillery Road Bridge was also overtopped allowing floodwaters to escape into areas on both sides of the bridge. Levels in this area were increased due to debris becoming entrapped in the bridge structure.

Extensive flooding occurred on both sides of the river in the lower portion of this reach with the adjacent industrial and residential areas being completely inundated. Flooding occurred within the new apartment complex from floodwater entering across its western boundary and overtopping the flood wall upstream of Distillery weir. In addition to the out of channel flood flows described above, the industrial and residential areas located on either side of Distillery Road Bridge were flooded as a result of the unprotected area leading to the Distillery Road Bridge and via gaps and low points on the industrial side river wall.

- **Tolka Road:** No significant flooding occurred within Tolka Road (refer to Frame 27, Appendix B, Final Report) due to sand bagging on the road preventing flood water entering from Distillery Road and the river remaining within its banks. However flood flows from Distillery road continued downstream to the low-lying areas of Ballybough, where basement flooding occurred. Significant scouring of the riverbank occurred resulting in undermining and failure of the river wall and loss of a backyard shed. The scouring occurred due to increased velocities caused by in-stream blockages from trees growing in the river.

- **Fairview Strand:** Low lying areas in Fairview were inundated (refer to Frame 27, Appendix B, Final Report). This is likely to be due to inundation of storm water outlets servicing this area (backpounding of the drainage system).

- **Distillery Road Bridge to Outlet:** No Flooding problem occurred in this area from the Tolka River. However Luke Kelly Bridge became surcharged due to debris build up partially blocking its waterway. This resulted in vibrations to the Bridge which caused some traffic concerns. No restrictions in flow were evident from recent works to the river in this area.

Overall, there was extensive property flooding because the flows exceeded the “in-bank” capacity of the Tolka through the DCC area, with some local factors (channel obstructions) contributing and with areas of secondary flooding due to backpounding of the piped drainage system in low-lying areas.

### **Fingal County Council Administrative Area**

For much of its length in the Fingal County Council area, the Tolka is contained within an undeveloped linear park with development set well back from the river. This contrasts with the older developed areas in Dublin City Council where developments extend to riverbank. As a result, the extent of development at risk in the floodplain in the Fingal County area is relatively limited. Much of the floodplain surveyed after the 2002 flood provides safe storage of floodwaters, away from developed areas. This provides attenuation of river flows through the reach and is effective in reducing flood flows to the downstream reaches within Dublin City Council administrative area. Nevertheless, some river flooding of properties did occur in the Fingal section as summarised below:

- **Littlepace:** Littlepace is located approximately 600m east of Clonee along the Navan R156 Road and was flooded in conjunction with the flooding of Clonee (refer to Frame 13 & 15, Appendix B, Final Report). Substantial residential property flooding occurred within Littlepace along with flooding of the N3 road in this area. Flooding here was largely caused by Tolka overbank flows occurring upstream at Clonee along with backpounding from a tributary stream.
- **Damastown:** This reach of the River Tolka is centred between the N3 and Damastown Culverts (refer to Frame 13 & 15, Appendix B, Final Report). No habitable property was inundated although two commercial properties were considered at risk (i.e. marginal floor level clearance over flood levels).
- **Damastown North:** This reach centred on the Pinkeen tributary exhibited no direct property flooding. Commercial properties were at risk in this area during the flood (refer to Frame 15, Appendix B, Final Report).
- **Westpoint Business Park – Parslickstown:** This reach of the River Tolka is centred between the Damastown Culverts and Westpoint Business Park (refer to Frame 15, Appendix B, Final Report). A number of the business park properties and a section of the N3 road were inundated within this area.
- **Mulhuddart:** This reach extends from Westpoint Business Park culverts to Mulhuddart Bridge Road located on Church Road (refer to Frame 17, Appendix B, Final Report). Commercial properties and residential properties currently under construction were inundated near Church Road.
- **N3 – Blanchardstown:** This reach extends from the Blanchardstown Road crossing to Snugborough Road Bridge (refer to Frame 18 & 19, Appendix B). Significant flooding occurred on the N3 National Primary Road, effectively closing the road.
- **Herbert Road – Blanchardstown:** This reach extends from Snugborough Road Bridge to the Mill Road Bridge (refer to Frame 19, Appendix B, Final Report). Minor flooding occurred to several residential properties located on the north side of Herbert Road.

The flood mapping of the November 2002 flood, based on the anecdotal evidence collected, shows the extent of the floodplain in the Fingal area and the properties at risk. In summary, the floodwaters largely inundated the undeveloped floodplain over this section with local flooding of properties at a number of sites and extensive flooding of the N3 National Primary Road at Blanchardstown.

#### **Meath County Council Administrative Area**

In County Meath, the areas affected include Clonee on the borders with Fingal and the wide floodplain upstream on the River Tolka and its major Castle stream tributary which flows through Dunboyne. The impact of the 2002 flood in the Meath Administrative area is summarised below:

- **Rural Catchment:** Significant flooding occurred in the flat low lying areas of the rural catchment, affecting agriculture, local roads and land flooding. Some local property flooding occurred in the Bennetstown area as a result of local drainage systems (refer to Frame 13 & 15, Appendix B, Final Report).
- **Bracetown (River Tolka):** Relating to the reach from the intersection of the N3 and Navan Road (R157) to downstream of Navan Bridge crossing of the Tolka (refer to Frame 6 & 7, Appendix B, Final Report). Several rural properties and access roads were flooded in this area.
- **Gunnocks House (River Tolka):** Relating to a reach of approximately 1.2km of the River Tolka from approximately 500m downstream of the R157/Navan Bridge to 300m upstream of Loughsallagh Bridge (refer to Frame 8, Appendix B, Final Report). Minor flooding of the N3 occurred, with significant inundation of the rural floodplain in this area. Secondary flooding of Gunnocks House occurred due to local drainage systems.
- **Dunboyne (Castle Stream):** Relating to the reach of the Castle Stream through Dunboyne between a point downstream of the disused railway bridge to upstream of the Newtown Bridge (refer to Frame 9 & 10, Appendix B, Final Report). Significant land flooding occurred within this reach affecting low-lying areas of Dunboyne, flooding a large number of residential properties and impacting on the village itself.

- **Loughsallagh (River Tolka):** Covering a 1.1km reach from Loughsallagh Bridge to Clonee Bridge. Flooding of local properties occurred adjacent the R156 and in the floodplain in this low-lying flat area (refer to Frame 10 & 11, Appendix B, Final Report).
- **Clonee (River Tolka):** extending from a point upstream of Clonee Bridge to the overpass bridge to Damastown industrial area, downstream of Kepak (refer to Frame 11 & 13, Appendix B, Final Report). Extensive Property flooding occurred within Clonee, from overflowing of the Tolka upstream of the N3 culvert.

The floodplain mapping for the 2002 flood in the Meath County Council area is based on substantial flood level records and anecdotal evidence of areas inundated. It shows significant inundation of residential areas in both Dunboyne and Clonee. The flood mapping demonstrates that this event, corresponding with record (i.e. greater than 100 year 48 hour) levels of rainfall in the catchment area, resulted in concentrated flood storage at the confluence of the Tolka and Castle tributary, with downstream flows crossing the N3 limited by the capacity of the N3 culvert. The flooding mechanisms were inundation of the properties in the floodplain at Dunboyne, including marginal flooding of the commercial village area directly from the Castle stream, with the combined Tolka flows inundating Clonee village and flowing onwards to Littlepace.

### 5.1.3 Impact on River Tolka Flood Study

The impact of this flood event on the River Tolka Study was to provide an extreme event baseline condition against which the mathematical model could be reliably validated. The study team directed considerable effort and resources to obtaining accurate information on flooding mechanisms and flood water levels. The model was then set up, tested and calibrated in an iterative process to replicate the rainfall/run-off and flooding response in the river system to match the recorded flood conditions. This has a number of benefits including:

- It facilitates a more complete understanding of the flooding in each area including the performance of the river structures along the route;
- It facilitates consideration of flood levels and conditions for a range of forecast flood events of different severity; different combinations of rainfall, tide levels and antecedent catchment conditions;
- It facilitates consideration of the impact on flood levels of development in the catchment generally or in the floodplain of the river including changes in storage;
- It facilitates consideration of improvements which might be carried out by way of channel enlargement, enlargement of culverts and bridges, bypass or storage attenuation options or other measures to reduce flooding risk. The model can simulate such improvements and critically, allows assessment of their impact on flood levels and flood conditions upstream and downstream.

The November 2002 flood event in the River Tolka was unprecedented in terms of its scale having regard to all known flooding records in the catchment. It produced flood flows and corresponding flood levels in the Dublin City Council area which were approximately 10% greater in scale than the highest previously recorded flood conditions associated with the 1954 flood.

At the same time, the scale and extent of flooding upstream in the catchment, particularly in the Dunboyne/Clonee area at the confluence of the Tolka and Castle Stream has been demonstrated to correspond to rainfall and run-off conditions well in excess of previous design standards. As a result, the previous design norms for river bridges and culverts in this area require to be re-evaluated in the light of the November 2002 experience. This experience will also influence the management of future development in the catchment having regard to the spatial extent and storage volume of floodwaters in the area.

## 5.2 ANALYSIS OF FLOOD EVENT OF 1954

### 5.2.1 Rainfall Records

The second largest flood ever recorded on the Tolka occurred on 8<sup>th</sup> December 1954. The week preceding was not remarkable as regards rainfall at Dublin, but there was a relatively high rainfall at Dunshaughlin for this period. 69.3mm of rainfall fell in 17 hours on the upper catchment (Dunshaughlin) with 57.8mm of rain falling on the lower part of the catchment (Dublin Airport). The flow estimated at the Finglas Weir for the 1954 event is 85m<sup>3</sup>/s.

### 5.2.2 Affected areas

The 1954 storm caused severe flooding with properties in excess of 1,000 damaged. The worst affected areas were those in the Drumcondra and Ballybough areas. Floodwaters broke out just upstream of Deanswift Bridge causing a flow path down Botanic Avenue and inundating houses in this area with floodwaters. Griffith Park is also shown to be a weak section of the river, with flood waters entering Botanic Avenue, Millmount Avenue and Richmond Road through the park. The collapse of the DART Road Bridge added greatly to the flooding in the East Wall and Fairview areas. The improvement scheme set out in *Dublin Corporation 1954 Flooding Report* involved the improvement of the river from Glasnevin Bridge to the estuary at East Wall Road, as the flooding that occurred upstream of Glasnevin Bridge traversed open land at that time and therefore did not impair serious damage to properties. Works in this report were not specifically carried out; however available records indicate works as described in section 3.8 have been undertaken in the intervening years. Additionally improvements to levels of protection have been made to properties which have been redeveloped in the period since the flood (boundary walls raised).

For a detailed analysis of the 1954 flooding see *Dublin Corporation 1954 Flooding Report*.

## 5.3 ANALYSIS OF FLOOD EVENT OF NOVEMBER 2000

### 5.3.1 Rainfall Records

The flood of 6<sup>th</sup> November 2000 is the 3<sup>rd</sup> largest flood ever recorded on the Tolka. A flow of 76m<sup>3</sup>/s was recorded at the Botanic Gardens station. Hourly rainfall is available for Dublin Airport and Casemont Aerodrome for this period and total rainfall for the entire event is available for Leixlip and Dunshaughlin. 78.3mm of rainfall was recorded at Dublin Airport for a period of 40 hours beginning at 8am on 5<sup>th</sup> November. 95.3mm of rainfall was measured at Casemont Aerodrome, Baldonnel for the same period. 90.8mm and 76.3mm of rainfall was measured at Cellbridge and Dunshaughlin respectively.

### 5.3.2 Affected areas

The worst affected areas from the November 2000 flood were parts of the upper catchment, in particular Clonee and Dunboyne. Many new houses in Beechdale Estate, Dunboyne and Main Street, Clonee flooded in November 2000 and again in November 2002. 62 properties in total were flooded from this event.

## 5.4 FLOOD FREQUENCY ANALYSIS

### 5.4.1 Introduction

Flood estimates are required for the design and economic appraisal of flood mitigation measures and engineering protection works for the River Tolka. In advance of modelling, it is therefore important to attain an understanding of likely floods which will be exceeded at any given site on a given frequency (for example on average once in 100 years or 1% risk on average in any year).

Two main approaches have been used in this study; 1) the statistical analysis of historical flood series and 2) investigation of rainfall data sets and resulting runoff related to catchment characteristics. By using both methods an understanding of the historical reaction of the catchment to rainfall events can be developed to ensure that specific parameters within the model and their influence are understood.

In general these parameters are catchment area, basin slope, soils, catchment wetness, climate, rainfall intensity and duration and time scale of flood events.

Flood hydrographs incorporating flood volume and time to concentration are also required in order to assess storage affects, constraints, the coincidence of tides, and the duration and depths of flooding at given areas. Existing event data analysis therefore forms the basis for the modelling strategy, whereby more comprehensive catchment rainfall runoff models are utilised and calibration and validation undertaken.

#### 5.4.2 Hydrological data series

The data available is limited to the lower catchment area in Dublin City Council. This data can generally be described in three distinct subsets:

1. Data from 1880 to 1955 consisting of eleven (11) estimated peak flows for flooding events from analysis undertaken in 1955. This data set represents only events which provided a large flow in the Tolka and therefore could be considered as a 'Peak over threshold' series. The accuracy of this data could be considered low, however the analysis of the 1954 event was comprehensive and this flow estimate of  $85\text{m}^3/\text{s}$  could be considered to have fair accuracy.
2. Thirty one (31) annual peak flow records from Drumcondra Bridge, station 09019 for the period 1955 to 1986. The accuracy of these records could be considered fair.
3. Three (3) annual peak flow records from Botanic gardens Station 09037 for 2000, 2001 and 2002. (Data revaluated with updated rating curve following November 2002 event). The accuracy of the data could be considered excellent.

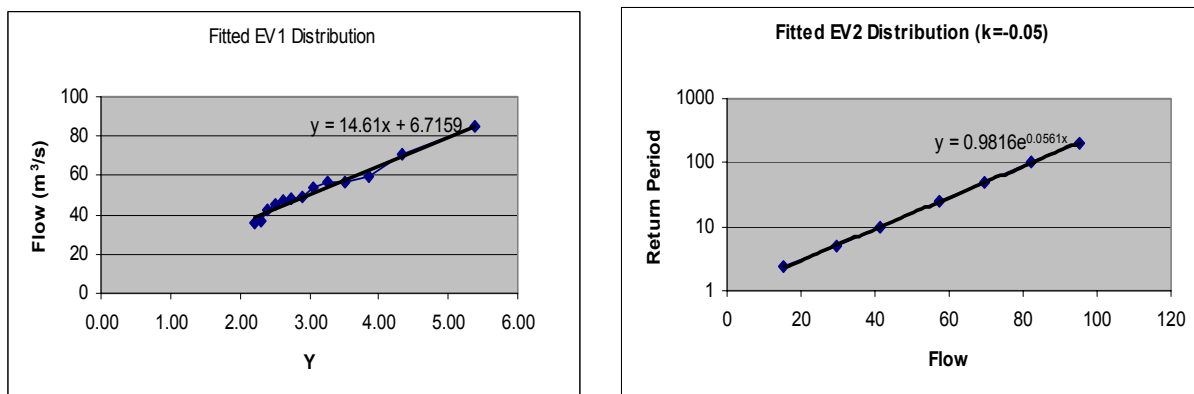
Therefore intermittent records of varying reliability exist, containing 41 peak annual flows spanning a period of 122 years. This data provides a fair representation of the scale and frequency of floods in the Tolka dating back to 1880. It is unlikely that floods of greater severity have occurred during this period without note.

#### 5.4.3 Fitted Distribution based on Peak Over Threshold Series

It was determined that a threshold flow of approximately  $35\text{ m}^3/\text{s}$  has historically resulted in floods that have been of severity enough to warrant record in newspapers. This gives a series from 1880 to 2002 equal to 122 years. Using the assumption that the above flows are the maximum in this period, and then the maximum values in the 122 year series are ordered including the top 14 post 1880 peaks

This series enables the development of a fitted distribution and determination of the  $a$  and  $u$  parameters from the records where  $x=u+ay$ , which then allows for fitting of the extreme value type 1 (Gumbel) distribution.

Chart 5.1 (a&b) Fitted Distributions



From the results of the EV1 distribution the EV2 distribution can be determined whereby  $x = u + aW$  and  $W = (1 - e^{-ky})/k$ . Here  $k$  is the regional shape parameter = -0.05 for Ireland. (The estimate for  $k$  based on the short record was found to be -0.047).

The results of this method provide a fitted curve to historical recorded floods that are assumed to exceed all intermediate unrecorded ones and hence could be considered overly conservative. Generally, this data, based on a curve fitting for only 14 peak records could be considered skewed.

#### 5.4.4 Annual Maxima Series

An annual maximum series was developed for the full available record of 34 years. The Extreme Value Type 2 analysis of this series provided a good fit with catchment characteristics estimate of mean annual flood, and what could be considered a conservative estimate for higher return period events.

#### 5.4.5 Expansion of Annual Maxima Series

A number of methods are available for the extension of short records. The flood studies report generally recommends extension of very short records based on rainfall correlation with adjacent gauged catchments. Unfortunately work undertaken by [redacted] in 1955 indicates that a very poor correlation between rainfall and flooding exists in the Tolka catchment, it is noted that high rainfall (100mm) during summer months does not cause flooding however as little as 50mm during winter months can cause flooding. Additionally surrounding catchments generally have a more rapid response. Therefore it is not considered that an adequate model could be developed to improve the reliability of existing data. For similar reasons the method of extension of the record based on a regional estimate was not considered appropriate.

The above series was expanded using a number of random samples to fill the missing annual maximum records, on the assumption that unrecorded years would have a reasonably even distribution of flood peaks for a period of 120 years ranging in severity up to the threshold developed above. This was undertaken to perform a final check on the skew resulting from sampling choice and distribution errors.

#### 5.4.6 Catchment Characteristics Analysis

A number of possible hydrological model strategies are available for determining model input hydrographs. The most widely accepted in Ireland are those based on FSR techniques which uses Catchment characteristics (CC) methods. To provide initial comparative data CC analysis was undertaken including sensitivity to various parameters and design flows. For this catchment, CC method appears to under predict flows when compared to historical data. This method uses Irish regional multipliers, for the determination of various return period floods, based on the derived mean annual flood. It is interesting to note that the catchment specific growth curve for the Tolka catchment is similar to the UK growth curve 6/7. There are now 9 regional curves for the UK (FSSR 14<sup>6</sup>) and it is instructive that they are all steeper than Ireland and the eastern ones are steeper than the western regions. On comparison of the Tolka curve against the three eastern UK curves (values are provided in Table 5.1), it could be inferred that Dublin reflects the east – west differences seen in UK. This is an important result as from 1975 following FSR many bridges in the catchment are likely to have been generally designed in accordance with this parameter.

**Table 5.1 Adjustment factor comparisons**

Return Period	Adjustment Factor					
	5	10	25	50	100	200
Ireland	1.20	1.37	1.60	1.77	1.96	2.14
UK (standard)	1.22	1.48	1.88	2.22	2.61	3.06
UK Curve 6/7	1.3	1.6	2.13	2.75	3.13	3.75
UK Curve 5	1.32	1.65	2.21	3	3.5	4.2
Tolka Design	1.4	1.8	2.3	2.8	3.3	3.6

<sup>6</sup> Natural Environment Research Council, UK, - Flood Studies Supplementary Reports (1977-1988) No. 14:

When choosing a design curve for the analysis of flooding in the River Tolka the following points require consideration;

- A degree of conservatism is required to ensure that adequate levels of protection are provided by any proposed scheme
- Additional conservatism is inbuilt to the analysis by the use of the design rainfall event which uses a normal distribution and therefore generally provides conservative water levels particularly upstream of flow constraints. This is due to high volumes centred on the peak of the event. (Twin peaked events may however provide higher levels in certain specific circumstances)
- The design uses conservative rainfall parameters including a critical duration event and a 95% rainfall aerial reduction factor for the entire catchment.
- If the design curve is too conservative it may not represent actual conditions and the financial benefits for any scheme may be affected. This could result in a lower level of protection becoming financially viable.
- The positive benefits of implementation of sustainable drainage systems are currently difficult to model and therefore these benefits are not regarded when assessing future development, this provides an additional degree of conservatism, however if the design curve is too conservative, future implementation of SuDS may provide a lesser degree of attenuation due to the increased outflow allowed to mimic existing conditions.
- The design curve must also take account of the errors associated with such an analysis and the limited reliability of the data.

The design curve must therefore be based on a multi criteria assessment of the data using a degree of engineering judgement.

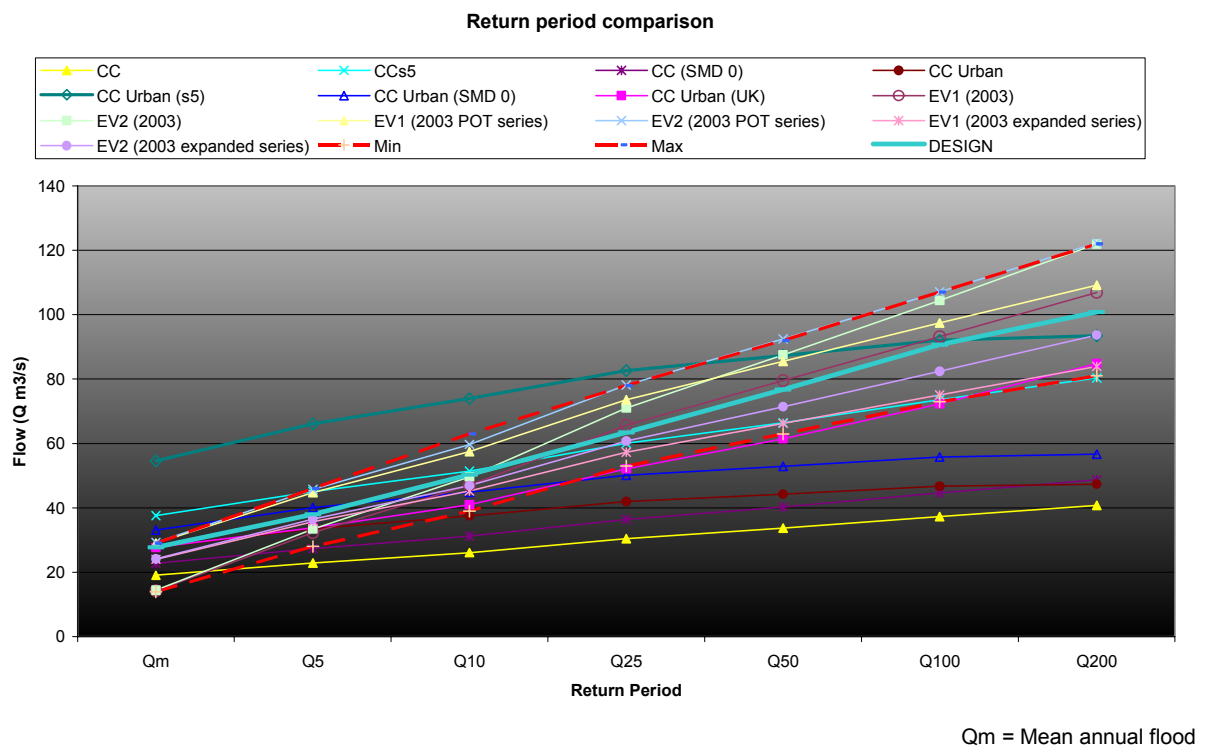
**Table 5.2 Summary of Catchment Flow Analysis**

Analysis	Annotation	Return Period						
		Qm	Q5	Q10	Q25	Q50	Q100	Q200
Catchment Characteristics -standard parameters associated with Tolka catchment	CC	19	23	26	30	34	37	41
Catchment Characteristics Assuming Soil Class 5	CCs5	38	45	51	60	66	74	80
Catchment Characteristics Assuming Soil moisture deficit = 0	CC (SMD 0)	23	27	31	36	40	45	49
Catchment Characteristics, including urbanisation adjustments	CC Urban	28	34	38	42	44	47	47
Catchment Characteristics, including urbanisation adjustments and assuming soil class 5	CC Urban (s5)	55	66	74	83	87	92	93
Catchment Characteristics, including urbanisation adjustments and assuming Soil moisture deficit = 0	CC Urban (SMD 0)	33	40	45	50	53	56	57
Gumbel Analysis without Nov 2002	EV1 (2001)	26	38	48	60	69	79	88
Gumbel Analysis with November 2002 included	EV1 (2003)	14	32	47	66	80	93	107
Extreme Value Analysis type 2 with November 2002 included	EV2 (2003)	14	33	50	71	87	104	122
Gumbel Analysis including only series above 35m <sup>3</sup> /s	EV1 (2003 POT series)	29	45	57	74	86	97	109
Extreme Value Analysis type 2 including only series above 35m <sup>3</sup> /s	EV2 (2003 POT series)	29	46	60	78	92	107	122
Gumbel Analysis expanding to 122 years	EV1 (2003 expanded series)	24	36	45	57	66	75	84
Extreme Value Analysis type 2 expanding series to 122 years	EV2 (2003 expanded series)	24	36	47	61	71	82	94
Error band	Min	14	28	39	53	63	73	81
Error band	Max	29	46	63	78	92	107	122
<b>DESIGN</b>	<b>DESIGN</b>	<b>28</b>	<b>38</b>	<b>50</b>	<b>63</b>	<b>77</b>	<b>91</b>	<b>101</b>

### 5.4.7 Summary

The results of the analyses described above are tabulated and included in Table 5.2. This provides a summary of the analysis of historical catchment flows. While no one method can be considered definitive, the EV1 (Gumbel) and EV2 distributions are considered a good statistical method for arriving at flood estimates based on a sample of real world data. Three such analyses have been investigated to assess the skew resulting from sampling choice and distribution errors. Additionally, Catchment Characteristics method is widely used in Ireland for flooding studies and a number of parameters were checked to establish their sensitivity in the River Tolka. The results indicate that while the Catchment Characteristics method provides good agreement with predicted mean annual floods, the average Irish regional multipliers appear too low for higher return period events for the Tolka specifically. The Design curve chosen takes into account a number of factors including the errors associated with such an analysis and the limited reliability of the data. Of particular note is that a flow of 85m<sup>3</sup>/s being the largest flow within over 120 years record prior to the November 2002 flood would traditionally have been considered to have a return period in excess of 100 years. This flow is now considered to have a return period of approximately 90 years. The November 2002 flow of 97m<sup>3</sup>/s is now considered to have a return period in excess of 100 years and this is supported by analysis of rainfall runoff relationships in the model.

**Chart 5.2 Comparison of growth curves**



The most appropriate method of modelling catchment flows, for use as inputs to the InfoWorks RS model is described further in Chapter 9

Therefore, analysis of historical flow data indicates that the catchment provides a significantly higher response to flooding than that which would generally be calculated by catchment characteristics methodologies, widely used in the design of culverts and bridge structures and indeed in assessing flood levels.

## 5.5 SEA LEVEL / FLOOD INTERACTION

The tidal waterway is that subject to diurnal variation in water levels. The Tolka catchment discharges directly to the sea at East Wall / Clontarf. Analysis of information provided by Dublin Port Authority is provided in this section.

### 5.5.1 Tidal Frequency Analysis

#### Statistical Analysis

A statistical analysis of tidal recurrence was undertaken for annual maximum sea levels at Dublin Port for the period 1923 to Feb 2002, with the results listed below in Table 5.3:

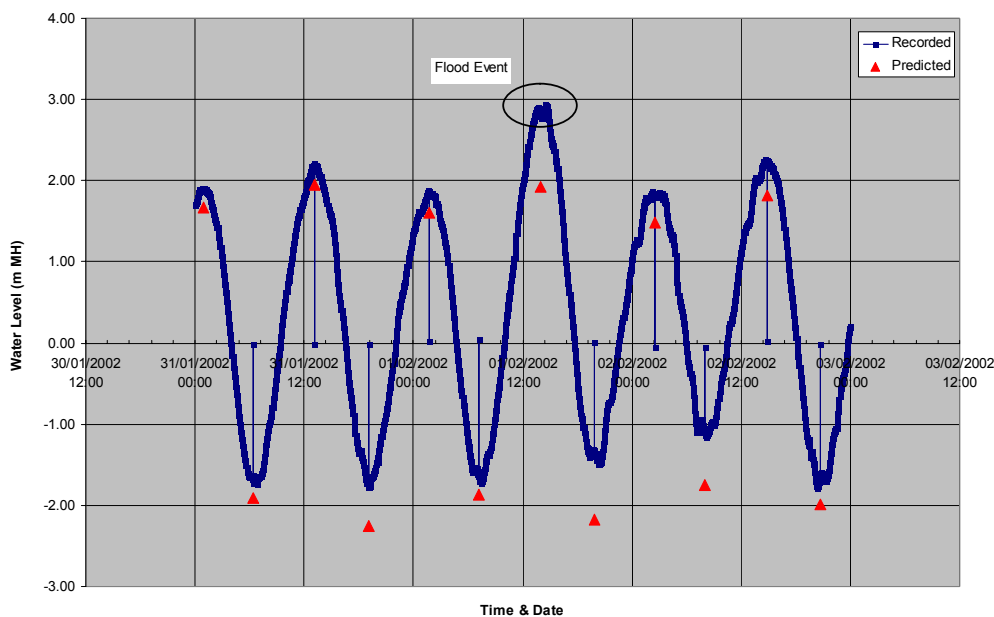
**Table 5.3 Results of Analysis**

% Annual probability of occurrence	Return Period	Level m OD (Malin Head)	
		EV1	EV2
42.9%	2.33	2.30	2.31
20.0%	5	2.40	2.41
10.0%	10	2.48	2.50
4.0%	25	2.58	2.61
2.0%	50	2.66	2.70
1.0%	100	2.73	2.79
0.5%	200	2.81	2.89
0.2%	500	2.91	3.01
0.1%	1000	2.98	3.11

#### Water Levels on 1<sup>st</sup> February 2002

Figure 5.1 below sets out the predicted tide levels from Tide Tables and actual water levels between 31 January and 2 February 2002. The graph reveals that recorded water levels were consistently above those predicted, due to storm surge and wave effects. This illustrates the influence of weather factors on actual tide levels, i.e. extra tide level rise due to low barometric pressure, onshore winds and wave heights.

**Figure 5.1 February 2002 Tide Levels**



The above analysis indicates that the Highest Recorded Sea Level of 2.95m OD (Malin Head) has the following theoretical return periods:

EV1	758 years (average)
EV2	330 years (average)

Again this analysis is theoretical and accounts for incidence of storm surge in the recorded data. Results for return periods greater than 100 years should be treated with caution.

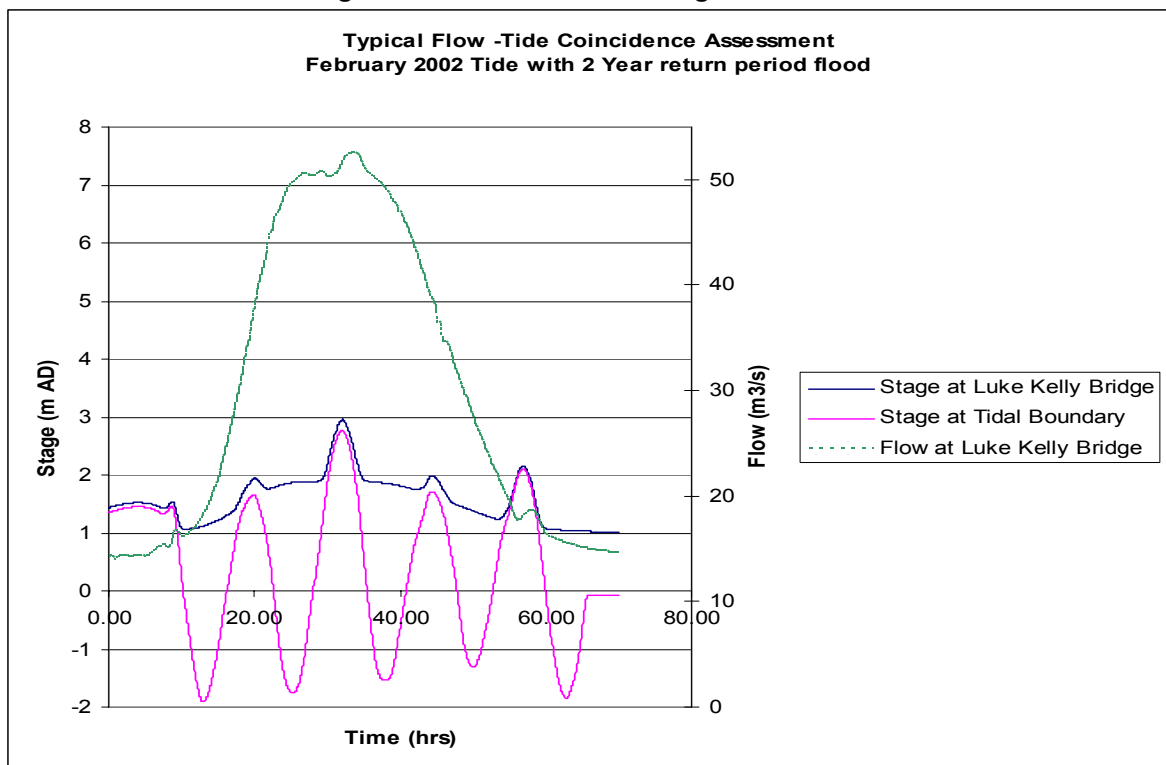
This sea level has been assessed in the model; additionally an increase of 400mm (3.35m OD) to account for possible affects of climate change has been assessed. Climate change effects could reduce return period of extreme tide levels considerably.

**Tidal Coincidence**

Assessment of hourly sea level records surrounding peak flooding events was undertaken to establish coincidence. In general there is not enough data to establish a joint probability for these events. It has been established that due to the long narrow and flat nature of the Tolka river basin, flood hydrographs, where available for the Tolka River, can range up to 48 hours duration with flat peaks of up to 12 hours duration. Therefore, unlike some more flashy rivers, the likelihood of tidal coincidence is increased (1-2 high tides will coincide with a flood typically). The worst scenario for which records exist is 1954. In that case an estimated 90 year return period flood partially coincided with a 1.5 year return period tide. In that instance the flood was rising on the receding tide, and flooding was also influenced by the collapse of the CIE Bridge.

Figure 5.1 indicates that due to the wide channel in the lower tidal reaches the increase in level associated with flow is marginal and the tidal level is the major governing factor relating to flood stage (level) in this area.

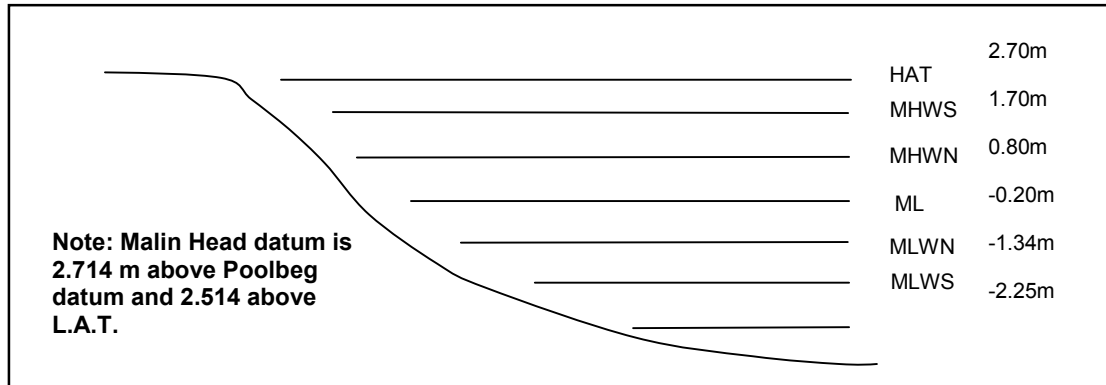
**Figure 5.2 Tides / Flooding Coincidence**



## 5.5.2 Sea levels

Sea levels are recorded by the Dublin Port Authority and have been provided in metres to Malin Head Datum. The usual tidal range is provided by Figure 5.3 below:

**Figure 5.3 Tide Levels for Dublin Bay (Malin Head)<sup>7</sup>**



### Tidal Reach

For a river or watercourse discharging to the sea, the influence of tides decreases as a tide moves up the watercourse. This is due to friction losses in the watercourse channel and results in a gradual decrease in the tidal range when compared to the ocean tidal range. For the Tolka River the maximum tidal range is confined to the reach below Distillery Weir.

### Sea Level Rise

A separate study has been undertaken regarding climate change impact on future tides, and results are utilised in this study. Linear interpolations of the current results are included in Table 5.4 below; however the 400mm rise in sea level is applied for assessment purposes.

**Table 5.4 Sea Level Rise for Dublin Bay**

	2011	2031	2051	2070-2100
<b>Sea Level Rise</b>	33mm	66mm	153mm	300mm
<b>Land Movement</b>	- 3mm	- 7mm	- 15mm	- 30mm
<b>Total</b>	<b>36mm</b>	<b>73mm</b>	<b>168mm</b>	<b>330mm</b>

### Design Tail-water Levels

Due to the lack of detail concerning the joint probability of tide and design flood flows, a simplified approach to inter-tidal flood conditions based on recommendations in the GSDSDS Climate Change Document was undertaken to ensure that practical design scenarios are assessed, these include the following combinations of floods and tides:

1. 50 year river flood flows taken with 1.5 year tides (2.20m OD) (Approximate 1954 event)
2. 2 year river flood flow with 100 year tides (2.79m OD)
3. 0.5 year river flood flow with 200 year tides (2.89m OD)
4. Base flow with highest recorded tide plus 400mm (3.35m OD) (climate change scenario)

<sup>7</sup> HAT Highest Astronomical Tide  
MHWS Mean High Water Springs  
MHWN Mean High Water Neap

ML Mean Level  
MLWN Mean Low Water Neap  
MLWS Mean Low Water Springs

It is likely that the joint probability of these combinations all exceed a 200 year return period criterion.

All additional analysis was undertaken with the following tail-water scenarios:

5. Calibration flows with recorded tide for event
6. Design flows with 1.24m OD tide (average tide)

The tide data was applied as a dynamic level hydrograph using a tide curve and applied to the model at a time to ensure the worst case is established. This was found to be the tide rising on the rising flood. Scenario 1 is an approximation of the 1954 event, and scenario 4 is an approximation of the February 2002 event with the added impact of possible future sea level rise.

## 8 MODEL CALIBRATION / VERIFICATION

The model was calibrated using two flood events; 14<sup>th</sup> / 15<sup>th</sup> November 2002 and 5<sup>th</sup> / 6<sup>th</sup> November 2000 and subsequently verified by the event on 26<sup>th</sup> August 1986. The event of 22<sup>nd</sup> October 2002 was initially used as a verification event but is considered to be of insufficient size for an extreme flow hydraulic model.

Model calibration runs were undertaken to provide a best fit between the 2 events in terms of hydrograph peak and volume in comparison with the recorded hydrographs at Botanic Gardens. Model calibration was particularly focused on the November 2002 flooding event due to the scale of the event and due to the quantity, quality and reliability of the event data including rainfall flow and level information and the fact that the channel characteristics have not changed significantly since this event.

Verification of the model was addressed in terms of historical rainfall, flows, hydrographs and flood levels from previous reports, photographs, Hydrometric station information and anecdotal evidence.

### 8.1 HYDROLOGIC CALIBRATION

A very good fit was achieved without the need to adjust the timing or shape of the derived unit hydrographs. It is noted that an area of flow exists in all of the predicted hydrographs at the start of the event. Infoworks RS has the facility to incorporate a variable percentage runoff throughout the event, based on the FEH decreasing proportional loss model. This allows for an increasing Catchment Wetness Index (CWI) throughout the storm, and hence a greater runoff as the soil becomes more saturated.

Unfortunately, however IWRS does not as yet have the facility to calibrate the increasing CWI during an event. Therefore CWI has been set at a slightly higher than average level to ensure that peak flows are met. It is likely that a higher variance of CWI during the event, (i.e. lower initial value and higher end value) would move this initial flow towards the centre of the hydrograph.

The hydrologic and hydraulic calibration was to some extent an iterative procedure. The hydrologic calibration was achieved to a reasonable level of satisfaction and the hydraulic calibration was then assessed. The hydraulic calibration required adjustments which in turn altered the hydrological calibration.

#### 8.1.1 November 2002

The flow calibration based on an extreme value event such as the November 2002 is considered excellent for flood study purposes. It should however be noted that the model is calibrated to winter storms with wet antecedent conditions, to the slight detriment of summer storm analysis, as this is considered to be a more conservative approach. This also results in a conservative analysis of flood storage effects when using design rainfall events. Results are shown in Graph 1, Appendix D.1

The event was preceded by 2 days of very heavy rainfall. A previous rainfall event on 8<sup>th</sup> -10<sup>th</sup> November resulted in a very wet catchment, which when combined with winter vegetation conditions, resulted in near impervious catchment conditions.

Rainfall commenced in the afternoon/evening of 13<sup>th</sup> November and reached peaks of 8.7mm/hr at Dublin Airport in the afternoon of 14<sup>th</sup> November. The highest total rainfall for the event was 93.45mm recorded at a temporary GSDS gauge in the South East of the catchment, followed by 85.8mm at the Dublin Airport Gauge. A further reading at Casemont Aerodrome, Baldonnel of 72.1mm indicated that the greatest rainfall for the event was received at the eastern extent of the catchment. Rainfall figures of 57mm, 52.5mm, 48.7mm and 55.4mm were measured at Ratoath, Dunshaughlin, Warrenstown and Celbridge respectively to the west of the catchment. Graph 4, Appendix D1 shows a comparison of rainfall recorded at Dublin Airport to flow measured at the Botanic Gauge.

Total measured rainfall amounts were interpolated for every subcatchment and then compared to the total volume of flows measured at the Botanical Garden Gauge. This indicated that 88% of the rainfall contributed to flows above the baseflow.

Six hourly radar precipitation accumulations of the event are shown in Appendix B2, Figure B2.2 - Fig B2.5. Met Eireann have emphasised that the radar plots only have an accuracy of 40% to 70%, and should not be used for determining rainfall amounts in the catchment. Radar images are however a useful tool in observing spatial distribution trends across the catchment. The radar plots indicate a comparative region of high rainfall intensity in the upper western catchments, where raingauge data was unavailable.

The higher rainfall experienced around Dunboyne was further confirmed when the flows required to obtain a match with measured water levels on Castle Stream were found to be higher than the flows derived from measured rainfall in Dublin and Dunshaughlin. It is important to note that the rain gauge, which was decommissioned in Dunboyne would have been invaluable for calibration purposes as there is no rainfall data available within the upper catchment.

Raingauge 1 located in Ashtown as part of the GDSDS was used as the temporal pattern for the rural part of the catchment. This raingauge recorded the highest depth of rainfall of all the available raingauges. It is also the closest available gauge to the upper parts of the catchment. The profile had a sharper peak than any of the other gauges, which resembled the recorded hydrograph at the Botanic gauge. The total depth of rainfall for each individual catchment was scaled up or down, depending on the spatial distribution. The isohyetal distribution derived for this event can be found in Appendix C3, Figure C3.3.

Table 8.1 describes the rainfall used for the urban subcatchments. The data was input directly from the GDSDS Raingauges.

**Table 8.1 Rainfall Data Input for Urban Catchments**

Catchment No	Raingauge No	Location
29	3	Cappagh Orthopaedic Hospital
30	1	St Vincents, Ashtown
31	2	Patrician College, Finglas
32	5	Kartoncraft, Cabra
33	6	Clarehall Community Unit, Glasnevin
34	12	St. Vincent de Paul, Marino
35	4	Finglas Bring Centre

The Antecedent Precipitation Index, which uses preceeding rainfall to the event was used to calculate an initial Catchment Wetness Index. This was used as an initial estimate but both the CWI and SPR were adjusted in parallel to achieve an accurate calibration plot. A CWI of 185 and a Standard Percentage Run Off of 70 was used for the November 2002 event.

### 8.1.2 November 2000

The flood of 6<sup>th</sup> November 2000 is the 3<sup>rd</sup> largest flood ever recorded on the Tolka. A flow of 76m<sup>3</sup>/s was recorded at the Botanic Gardens station. Hourly rainfall is available for Dublin Airport and Casemont Aerodrome for this period and total rainfall for the entire event is available for Leixlip and Dunshaughlin. The hydrologic calibration graph for this storm gave quite a good fit initially and only involved slight refinement of the catchment parameters to achieve the final calibration plot, shown in Graph 2, Appendix D1. Graph 5, Appendix D1 shows a comparison of rainfall recorded at Dublin Airport to flow measured at the gauge in Botanic Gardens.

The temporal pattern based on rainfall recorded at Dublin Airport was used for the November 2000 event as the GDSDS raingauges were not in place at that time. The rainfall was then scaled for each catchment according to the spatial distribution as shown in Figure C3.2, Appendix C3.

A Standard Percentage Runoff of 70 and a Catchment Wetness Index of 165 was used. The measured and modelled peak flows coincide and similar characteristics appear on this graph as in

November 2002. The initial modelled flow is higher than the measured flow as previously due to the limitations in adjusting the CWI throughout the event.

### 8.1.3 August 1986

The model was verified using the August 1986 event, Hurricane Charlie. Hourly rainfall is available for Dublin Airport and Casemont Aerodrome, Baldonnel with daily rainfall available for Leixlip and Dunsanny. Graph 6, Appendix D1 shows a comparison of rainfall recorded at Dublin Airport to flow measured at the gauge in Botanic Gardens. Recorded rainfall at Dublin Airport was used as the temporal pattern, due to the lack of temporal data available. Isohyets were plotted to scale the distribution, as shown in Figure C3.1, Appendix C3.

A Catchment Wetness Index of 50 and a Standard Percentage Run off of 70 was used for this event. The calibration plot is shown in Graph 3, Appendix D1, there appears to be a higher volume of modelled flow compared to measured flow. This inconsistency may be due to the fact that the model was calibrated to a much higher peak flow, for winter conditions and also the extent of calibration data available was not as broad.

It is possible that the increased volume modelled is due to the spatial distribution of rainfall being much more scattered than represented in the model, or that the summer conditions resulted in greater retention and infiltration. However, as outlined previously the model is primarily required to represent winter flooding conditions.

## 8.2 HYDRAULIC CALIBRATION

The hydraulic phase of calibration involved ensuring that the structural model was accurately representing recorded calibration levels. This involved a review of all floodplain storage, secondary flow paths, loss coefficients, and spill structures within the model and sharp bends along the river. Final adjustments included review of roughness values and adjustments to afflux parameters.

There are a number of weirs located along the River Tolka, which are very good calibration points. These include the weir at the Botanic Gardens gauge, Finglas Factory Weir and River Road Weir, Blanchardstown. Hydraulic calibration plots of observed levels against modelled levels for November 2002 and November 2000 are shown in Graph 1-4, Appendix D2.

### 8.2.1 November 2002

The majority of levels taken for the November 2002 storm were at flow control structures, mainly upstream and downstream of bridges or at weirs. There is a wide extent of data available for this event, including levels, flood extents and knowledge of flow paths.

The initial hydraulic calibration before any adjustments were made was quite accurate (approximately 600mm). Then the areas of higher inaccuracies were examined carefully, with respect to the method of flooding and the accuracy of the calibration data itself. Adjustments were made accordingly e.g.

- Spill structures were altered (widened, shortened or lowered) to represent more accurately what occurred during the storm;
- Energy losses associated with bends were modelled as a general headloss and the headloss coefficient adjusted until the observed levels were achieved;
- Flow control structures were modelled in a different manner to produce better calibration results, i.e. a number of arch bridges were modelled as Bernoulli losses and gave a more accurate calibration.

Further calibration then involved adjusting mannings roughness along certain reaches of the river and if necessary altering the calibration coefficients of individual structures. Details of these changes or similar calibration adjustments can be found in Appendix C2 – Flow Control Structures. Table 8.2 shows a comparison of the calibration levels to the modelled levels recorded for the November 2002 event.

**Table 8.2 Calibration Comparison for 14<sup>th</sup> & 15<sup>th</sup> November 2002**

Cross Section	Location	Observed Level (mAD)	Modelled Level (mAD)	Difference (m)
T-003	East Point Business Park.	1.52	1.741	0.221
T-008	John Mc Cormack Bridge	1.66	1.824	0.164
T-015	Footbridge u/s Dart Bridge	2.38	2.277	-0.103
T-027	Luke Kelly Bridge	2.6	2.753	0.153
T-033	Distillery Rd Bridge	4.19	4.164	-0.026
T-036	Upstream of Distillery Weir	4.8	4.738	-0.062
T-039	Downstream of Tolka Park	5	5.131	0.131
T-044	Drumcondra Rd Bridge	6.39	6.194	-0.196
T-049D	Millmount Villas	7.3	7.241	-0.059
T-052U	Drumcondra Footbridge	7.8	7.774	-0.026
T-060	Weir in Griffith Park	8	7.927	-0.073
T-068	Dean Swift Bridge	10.33	10.437	0.107
T-B1U	Glasnevin Rd Bridge	11	10.96	-0.04
B15a	Gauge in Botanic Gardens	13.74	13.745	0.005
T-109	Finglas Road Bridge	17.75	17.781	0.031
T-113AD	Weir beside Tolka Vale	19.63	19.603	-0.027
T-119BU	Finglas Wood Park Bridge	21.5	21.563	0.063
T-120B	Ratoath Rd Bridge	24.44	24.433	-0.007
T-124U	Cardiff's Bridge	26.2	26.162	-0.038
T-136D	Scribblestown Rd Bridge	30.9	30.669	-0.231
T-137U	Scribblestown Rd Bridge	32	31.848	-0.152
T-157	Northern Cross Route	37.7	37.666	-0.034
T-181U	Blanchardstown Bypass	46.3	46.424	0.124
T-182a	Herbert Rd, Blanchardstown	46.5	46.703	0.203
Int183c	Herbert Rd, Blanchardstown	46.8	46.743	-0.057
T-189	Upstream of Blanchardstown Bypass	48.1	48.081	-0.019
T-191D	Corduff Bridge	48.2	48.276	0.076
T-192U	Corduff Bridge	49	49.228	0.228
T-195	Snugborough Rd	51.3	51.348	0.048
T-222bU	Mulhuddart Bridge	54.5	54.677	0.177
T-231	Parslickstown Rd	56.5	56.504	0.004
T-233aD	Parslickstown	57	57.165	0.165
T-243	Huntstown Culverts	59.7	59.599	-0.101
XS108A	Damastown Culverts	60.4	60.343	-0.057
XS126A	N3 Culverts, Clonee	62.3	62.332	0.032
XS156AD	D/S of confluence, Clonee	63.7	63.765	0.065
XS205AU	Castle Stream, near Loughsallagh	63.9	63.965	0.065
XS214A	Castle Stream	64.6	64.486	-0.114
XS218A	Castle Stream	65	64.755	-0.245
XS222A	Castle Stream	65.5	65.334	-0.166
XS229AU	Bridge d/s of Beechdale	66.4	66.155	-0.245
XS236A	Larchfield Estate, Dunboyne	67.3	67.302	0.002
XS243A	Larchfield Estate, Dunboyne	67.5	67.432	-0.068
XS250AD	Rooske Rd Bridge	67.8	67.809	0.009
XS265A	Maynooth Road Bridge	68.5	68.422	-0.078

It can be seen from the table that the largest difference is an underestimation of 245mm. The Mean Absolute Error of the data set is 95mm. This gives the correct indication of how accurate the calibration is.

### 8.2.2 November 2000

The calibration levels available for the November 2000 storm are generally for the upper Tolka region. They proved quite beneficial as there were no calibration levels available in this region for the November 2002 event due to difficulty in obtaining access. The calibration for this event mainly involved adjusting mannings roughness coefficient for certain lengths of the river and altering the calibration coefficient of individual structures. Details of adjustments during calibration are shown in Appendix C2 – Flow Control Structures. Table 8.3 shows a comparison of calibration levels to modelled levels used to calibrate the November 2000 event.

**Table 8.3 Calibration Comparison for 6<sup>th</sup> November 2000**

Cross Section	Location	Observed (mAD)	Modelled (mAD)	Difference (m)
T-615	Macetown Rd Bridge (Pinkeen)	59.77	59.571	-0.199
T-624	Powerstown Rd Bridge (Pinkeen)	62.32	61.771	-0.549*
T-137U	Scribblestown Rd Bridge	31.86	31.367	-0.493*
T-243	Culverts at Huntstown	59.7	59.282	-0.418*
XS125A	N3 Culverts, Clonee	61.39	61.665	0.275
XS126A	N3 Culverts, Clonee	61.782	61.824	0.042
T-260D	Clonee Bridge	62.42	62.675	0.255
XS1-48-A	Downstream of Loughsallagh	63.4	63.375	-0.025
XS1-63-AU	Loughsallagh Bridge	64.3	64.278	-0.022
XS1-139-AU	Bennetstown Bridge	70	69.666	-0.334
XS1-161-AU	Old Railway Bridge	70.43	70.494	0.064
XS1A-2-AU	Flat House Bridge	72.9	72.813	-0.087
XS1A-38-A	Black Bull Bridge	74.1	74.5	0.4

The November 2000 calibration is not as accurate as the November 2002 calibration. The Mean Absolute Error of the data set is 243mm. However 3 calibration levels marked \* are based on anecdotal levels supplied and may be overstated.