

South Western CFRAM Study

Final Hydrology Report
Unit of Management 22
June 2016

The Office of Public Works

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Executive Summary

The Office of Public Works (OPW) is undertaking six catchment-based flood risk assessment and management (CFRAM) studies to identify and map areas across Ireland with existing and potential future risk of flooding. Mott MacDonald Ireland Ltd. has been appointed by the OPW to assess flood risk and develop flood risk management options in the South Western River Basin District. This hydrology report is one of a series of reports being produced as part of the South West Catchment Flood Risk Assessment and Management Study (SW CFRAM Study). This report details the assessment of the hydrological conditions across Unit of Management 22 (the Laune, Maine and Dingle catchments) which will form the inputs into the subsequent hydraulic modelling and mapping of the key areas at risk of flooding.

A review and analysis of historical flood events, hydrometric data and hydrogeomorphological processes has highlighted flooding issues to urban areas and nationally important infrastructure from the River Flesk, Lough Leane, River Maine and a number of smaller tributaries. The Flood Studies Update (FSU) methodologies have been used to determine the existing design peak flows, lough levels and characteristic flood hydrographs for eight specified flood probabilities across the sub-catchments. Corresponding coastal conditions have been developed for those areas at coastal flood risk. A number of calibration events were identified in the Laune and Maine catchments where there was sufficient historical flood data.

Potential future catchment changes relevant to the Laune, Maine and Dingle catchments have been assessed, including changes in urban development, land use and hydrology related to global climate change. Two future scenarios have been developed from this analysis, a Mid Range Future Scenario and High End Future Scenario, which have been used to develop potential future flows and extreme sea levels.

The resultant design flood hydrographs and coastal conditions will be input into the hydraulic models. The knowledge of the hydrological processes and the historical flooding issues in the Laune, Maine and Dingle catchments established in this report will support the development of sustainable and appropriate flood risk management options in those areas at greatest flood risk.

1 Introduction

1.1 Context of the CFRAM Study

Flooding is a natural process that occurs throughout Ireland as a result of extreme rainfall, river flows, storm surges, waves, and high groundwater. Flooding can become an issue where the flood waters interact with people, property, farmland and protected habitats.

Flood risk in Ireland has historically been addressed through the use of structural or engineered solutions (arterial drainage schemes and / or flood relief schemes). In line with internationally changing perspectives, the Government adopted a new policy in 2004 that shifted the emphasis in addressing flood risk towards:

- A catchment-based context for managing risk;
- More pro-active flood hazard and risk assessment and management, with a view to avoiding or minimising future increases in risk, such as that which might arise from development in floodplains;
- Increased use of non-structural and flood impact mitigation measures.

A further influence on the management of flood risk in Ireland is the 'Floods' Directive [2007/60/EC]. The aim of this Directive is to reduce the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity.

The Office of Public Works (OPW) is the lead agency in implementing flood management policy in Ireland. The OPW have commissioned a number of Catchment Flood Risk Assessment and Management Studies in order to assess and develop Flood Risk Management Plans (FRMPs) to manage the existing flood risk and also the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

Mott MacDonald Ireland Ltd. has been appointed by the OPW to undertake the Catchment Flood Risk Assessment and Management Study (CFRAM Study) for the South Western River Basin District, henceforth referred to as the SW CFRAM Study. Under the project, Mott MacDonald will produce FRMPs which will set out recommendations for the management of existing flood risk in the Study Area, and also assess the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

1.2 SW CFRAM Study Process

The overarching aims of the SW CFRAM Study are as follows:

- Identify and map the existing and potential future flood hazard;
- Assess and map the existing and potential future flood risk; and,
- Identify viable structural and non-structural options and measures for the effective and sustainable management of flood risk in the South Western River Basin District.

In order to achieve the overarching aims, the study is being undertaken in the following stages:

- Data collection;
- Hydrological analysis;
- Hydraulic analysis;
- Development of flood maps;
- Strategic Environmental Assessment and a Habitats Directive Appropriate Assessment;
- Flood risk assessment of people, economy and environment;
- Development and assessment of flood risk mitigation options; and,
- Development of the Flood Risk Management Plan (FRMP).

The resultant FRMP will set out recommendations for the management of existing flood risk and the potential for significant increases in this risk due to climate change, ongoing development and other pressures that may arise in the future.

The South Western River Basin District is split into five Units of Management (UoM). These Units follow watershed catchment boundaries and do not relate to political boundaries. The Units are as follows;

- The Blackwater catchment (UoM18)
- The Lee / Cork Harbour Catchment (UoM19)
- The Bandon / Skibbereen Catchment (UoM20)
- The Dunmanus / Bantry / Kenmare Bay Catchment (UoM21)
- The Laune / Maine / Dingle Bay Catchment (UoM22)

1.3 Report Structure

This report aims to assess the hydrological conditions across the Laune, Maine and Dingle Bay catchments and derive design peak flows, levels and hydrographs to be used in subsequent hydraulic modelling and mapping of key areas at risk.

Table 1.1 outlines the report structure and scope of work with a description of the key contents.

Table 1.1: Report Structure

Chapter	Key Contents of Chapter
1. Introduction	<ul style="list-style-type: none"> Context of the Study The SW CFRAM process and aims Scope of Work Flood Probabilities
2. Description of Study Area	<ul style="list-style-type: none"> Description of study area Description of hydrological characteristics of study area
3. Data Collection and Review	<ul style="list-style-type: none"> Overview of data used in the hydrological analysis Review and quality assessment of river level and flow data Review and quality assessment of rainfall data Review and quality assessment of coastal data
4. Review and Analysis of Historical Floods	<ul style="list-style-type: none"> Review of historical flood events Review of significant sources, pathways and receptors of flooding Estimation of flood probability for key historical events
5. Gauging Station Reviews	<ul style="list-style-type: none"> Analysis of spot gaugings at review gauge locations Hydraulic modelling used to extend rating curves Modelled rating curve extension Application of revised rating curves
6. Derivation of Design Flows and Levels	<ul style="list-style-type: none"> Definition of sub-catchments Derivation of the index flood, design peak flows and flow hydrographs Derivation of extreme sea levels and tidal curves
7. Hydrological Calibration, Sensitivity and Uncertainty	<ul style="list-style-type: none"> Review of historical data and selection of calibration events Derivation of calibration conditions Hydrological sensitivity and uncertainty in design hydrology
8. Summary of Design Flows	<ul style="list-style-type: none"> Principal outputs and findings of design hydrology Preliminary design flows and hydrographs for hydraulic modelling
9. Consideration for Hydrological and Hydraulic Model Integration	<ul style="list-style-type: none"> Full methodological approach to integrate hydrological outputs and hydraulic models
10. Hydrogeomorphology	<ul style="list-style-type: none"> Assessment of existing hydrogeomorphological processes Consideration of flood risk impacts
11. Joint Probability Analysis	<ul style="list-style-type: none"> Joint probability of fluvial events Joint probability of coastal events
12. Future Scenarios	<ul style="list-style-type: none"> Potential impacts of climate change on rainfall, river flows, sea level and land movement Potential catchment changes to land use and urbanisation Derivation of hydrology under future scenarios
13. Conclusions, Key Findings and Recommendations	<ul style="list-style-type: none"> Conclusions and key findings from the hydrological analysis and assessment Summary of Design Existing and Future Hydrology Recommendations for hydraulic modelling and the FRMP Recommendations for future improvements in the hydrological analysis

1.4 Flood Probabilities

The SW CFRAM Study refers to flood probabilities in terms of annual exceedance probability in preference to the use of “return periods” as used in previous reports. The probability or chance of a flood event occurring in any given year can be a useful tool to better understand the rarity of specific magnitude events for flood risk management. Due to popular descriptors of floods involving terms like the “1 in 100 year flood” there can be a public misunderstanding that a location will be safe from a repeat event of the same magnitude, extent and volume for the duration of the term (100 years in the above example). In reality, flood events of a similar or greater magnitude can occur again at any time.

Annual Exceedance Probability, henceforth referred to as AEP, is a term used throughout this report and the wider CFRAM studies to refer to the rarity of a flood event. The probability of a flood relates to the likelihood of an event of that size or larger occurring within any one year period. For example, a one in hundred year flood has a one chance in a hundred of occurring in any given year; 1:100 odds of occurring in any given year; or a 1% likelihood of occurring. This is described as a 1% annual exceedance probability (AEP) flood event.

Table 1.2 converts the ‘return periods’ to %AEP for key flood events as a reference to previous studies.

Table 1.2: Flood Probabilities

% Annual Exceedance Probability (%AEP)	Odds of a Flood Event in Any Given Year	Chance of a Flood Event in Any Given Year or Previous ‘Return Period’
50%	1:2	1 in 2
20%	1:5	1 in 5
10%	1:10	1 in 10
5%	1:20	1 in 20
2%	1:50	1 in 50
1%	1:100	1 in 100
0.5%	1:200	1 in 200
0.1%	1:1000	1 in 1000

The hydrological analysis uses a number of other acronyms and technical terminology which are defined in the glossary of this report.

2 Description of the Study Area

2.1 Extent

The South Western River Basin District covers an area of approximately 11,160 km². The Study Area includes most of county Cork, large parts of counties Kerry and Waterford along with small parts of the counties of Tipperary and Limerick. The Study Area contains over 1,800 km of coastline along the Atlantic Ocean and the Celtic Sea. There are five Units of Management within the South Western River Basin District, which are listed below:

- The Blackwater catchment (UoM18)
- The Lee / Cork Harbour Catchment (UoM19)
- The Bandon / Skibbereen Catchment (UoM20)
- The Dunmanus / Bantry / Kenmare Bay Catchment (UoM21)
- The Laune / Maine / Dingle Bay Catchment (UoM22)

This report covers the Laune, Maine and Dingle Bay catchment in Unit of Management 22. It includes the River Laune, Flesk and Maine; the major lake of Lough Leane and a large number of smaller coastal catchments (Map 2.1). Unit of Management 22 contains six Areas for Further Assessment (AFAs) and over 134km of high and medium priority watercourse associated with the AFAs (Table 2.1).

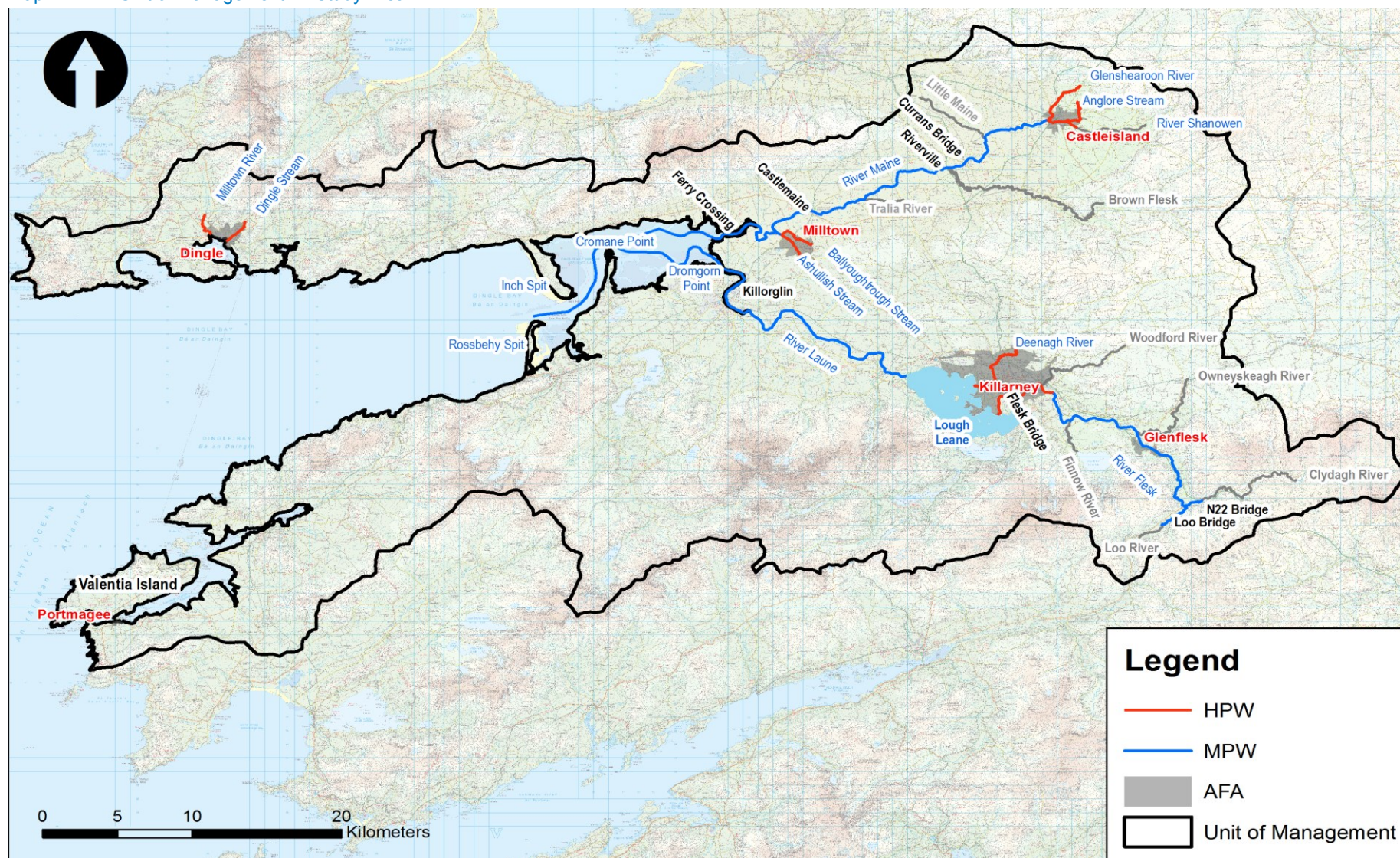
Table 2.1: Areas for Further Assessment

Name	Unique ID	Fluvial Flood Risk	Coastal Flood Risk	County	Easting	Northing	Total Contributing Area Draining to AFA (km ²)
Castleisland	220323	Yes	No	Kerry	97750	110000	60
Dingle	220327	Yes	Yes	Kerry	44500	101000	34
Glenflesk	225502	Yes	No	Kerry	106621	85316	131
Killarney	220337	Yes	No	Kerry	97000	90500	360
Milltown	220339	Yes	No	Kerry	82500	101000	9
Portmagee	220340	No	Yes	Kerry	36500	73000	N/A (Coastal only)

2.2 Rivers and Lakes

The Study considers 32km of the River Maine from Castleisland to its tidal outfall into Castlemaine Harbour. The River Shanowen rises near Mount Eagle (109350, 110135) and flows westwards towards Castleisland where it joins with the Anglore Stream to form the River Maine at Castleisland. The River Maine then continues to flow westwards joining with the Glanshearoon Stream at the downstream of Castleisland and the Little Maine River at Springmount (95190, 108320) before flowing south-westwards to Currans Bridge.

Map 2.1: Unit of Management 22 Study Area



Downstream of Currans Bridge, the River Maine becomes increasingly embanked above the surrounding floodplain. The major tributary of the Brown Flesk joins the River Maine near the N22 crossing at Riverville gauge. A portion of the Brown Flesk is diverted through a bypass channel at 92825,105940 to join the River Maine downstream of the old Maine Bridge. Downstream of the Tralia River, the River Maine becomes increasingly tidally-influenced and is tidally-dominated downstream Castlemaine. The River Maine continues to meander across the tidal floodplain where it is joined by a number of embanked tributaries notably Ashullish Stream from Milltown. The River Maine outfalls into the Castlemaine natural harbour at the ferry crossing, before flowing out into Dingle Bay.

Ashullish Stream is a steep watercourse rising at 83770, 99130 before flowing north-westwards through the centre of Milltown, under the N70 to outfall via a penstock into the River Maine at 81150,101480. The main tributary Sruhaun Ballyoughtragh Stream (henceforth referred to as Ballyoughtrough) rises at 83570, 100570, and flows in a north-westerly direction to Chapel Bridge, flowing past the GAA grounds and alongside Old Station Road before turning west into embanked sections to join Ashullish Stream at 81550,101260.

There are two watercourses within the Dingle AFA; Dingle Stream and Milltown River. Dingle Stream rises at 45800,104130 before flowing in a south-westerly direction into central Dingle along Spa Road, under Bridge Street and along the Mall to outfall at the eastern end of the marina. Milltown River rises near 42805,105865 before flowing southwards to Ballinabooly where the Ballyeabought River joins from the east. Milltown River then becomes increasingly tidally influence as it continues southwards where a minor tributary joins under the R559 at 42905,101585 and then outfalls into Dingle Harbour at Milltown Bridge.

The Study also considers 73km of river in the River Laune catchment from the N22 Bridge the to tidal outfall downstream of Killorglin. The River Clydagh rises near Mullaghanish and flows over steep ground to join with the Loo River downstream of Loo Bridge to form the River Flesk. The River Flesk flows in a north-westerly direction across shallow gradients to Glenflesk and joins with the Owenyskeagh River 2km downstream of the town. Downstream of Flesk Bridge, the River Flesk has a steeper gradient until it reaches Mill Road Bridge and flows west along the southern edge of Killarney before outfalling into Lough Leane at 96130,88170. The River Deenagh flows along the North of Killarney before turning southwards along Port Road, and then westwards through the Killarney National Park to outfall into Lough Leane. A number of other rivers flow into Lough Leane including Owenreagh River and Muckcross Lake outfall. These inflows combine with River Flesk and Deenagh to form the River Laune at the outfall. The River Laune then flows in a north-westerly direction to Killorglin where it outfalls into Castlemaine Harbour at Dromgorn Point (76710, 99885).

2.3 Coastal Features

The River Maine and River Laune both outfall into the naturally formed Castlemaine Harbour. Castlemaine Harbour is a complex estuary that extends west from the Maine and Laune into Dingle Bay. A series of complex sand bars and key spit features at the estuary outfall divert the tidal currents and protect the harbour from extreme storm waves.

The key features include:

- Cromane Point (70235,100114)
- Inch Point (67660,96865)
- Rossbehy Point (65705,94730)

These large expanses of sand dunes, sand bars and shallow water are essential habitats designated under Natura 2000 and protected under EU legislation. The Maine and Laune low-tide channels are between 300m to 400m wide, combining into one channel near Aughill's Bridge which is 1.7km wide at low tide.

2.4 Topography

Map 2.2 displays the variation in elevation and topography of UoM22.

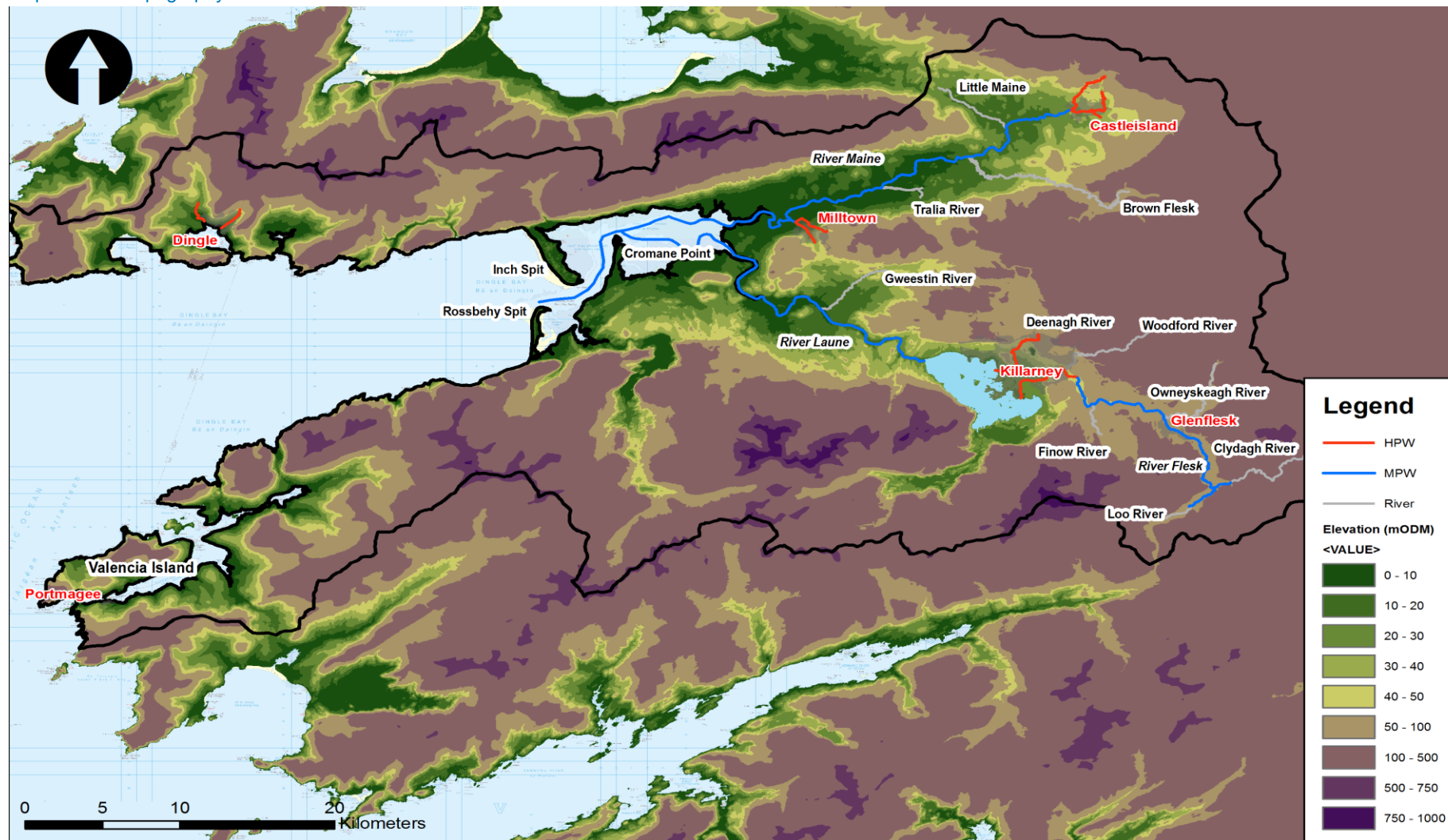
The River Maine catchment is relatively low lying with elevations ranging from <1mODM at the tidal outfall to over 400mODM in the headwaters of the River Shanowen upstream of Castleisland. The River Maine has a typical gradient of approximately 1 in 770 until Currans Bridge and Riverville. The major tributaries of the Little Maine River and Brown Flesk River have similar gradients and meander planforms.

The River Maine then flattens out into the embanked reaches downstream where Castlemaine and a number of smaller settlements lie below the flood embankments. Therefore, these populations are vulnerable to prolonged river and coastal flooding if water overtops the embankments as the flood waters become trapped on the floodplain. The surrounding hills including the Dingle catchment and the tributaries of the lower Maine are typically very steep as the rivers flow through the steep valley sides of the Dingle Peninsula Mountains. However, the gradient of these tributaries flattens out significantly as these tributaries enter the sea or enter the Maine floodplain.

The River Laune catchment and tributaries' elevations range from sea level at Killorglin to over 1000m at Carrauntoohill, the highest peak in Ireland. However, the upper Flesk is relatively flat until Glenflesk (1 in 3600) before the gradient increases towards Killarney and Lough Leane. Lough Leane itself is surrounded by mountainous terrain which reaches over 1000mODM.

Lough Leane outfalls into the River Laune which has a relatively constant 1 in 100 gradient to its outfall into Castlemaine Harbour downstream of Killorglin. The Laune valley is relatively narrow and surrounded by steep mountainous terrain to the North and South.

Map 2.2: Topography



2.5 Rainfall

Map 2.3 shows the variation in Standard Average Annual Rainfall across UoM22. The River Laune catchment has some of the highest standard average rainfall values in Ireland due to the relatively high relief of the upper catchment and location on the west coast. Rainfall tends to be greater in the west of the Maine catchment than the east. The Maine catchment as a whole tends to have less rainfall than the Laune catchment due to the lower elevations in the Maine.

Prolonged frontal Atlantic storm events dominate the rainfall events in both the River Laune and Maine catchments, tracking from west to east. This can mitigate peak flows as rain falls and drains from the lower reaches before the peak flows from the upper reaches. However, intense summer storm rainfall events can also occur, causing overland flow and flooding issues in the steep small catchments that have a fast time to peak.

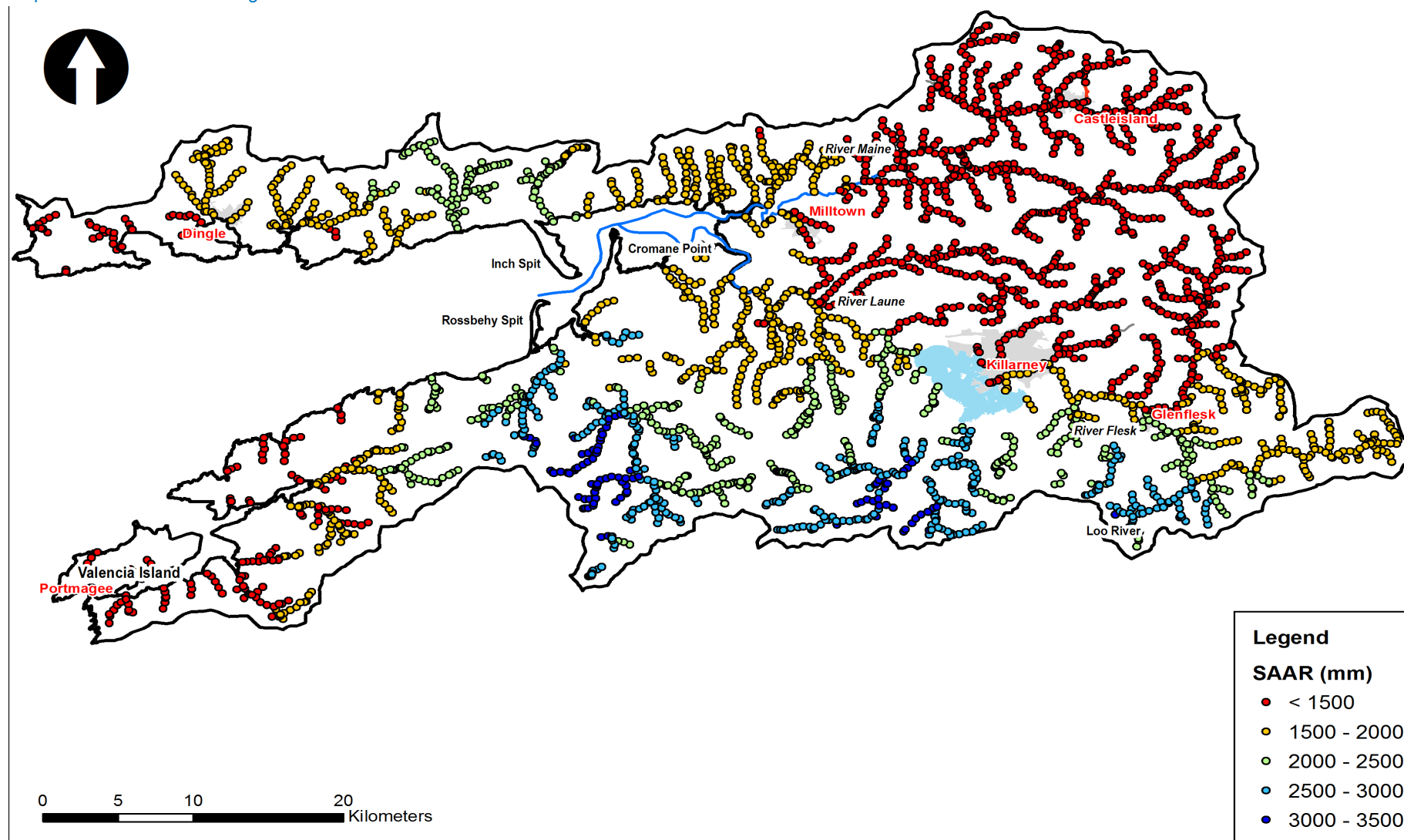
2.6 Geology

Map 2.4 provides the underlying geology of UoM22.

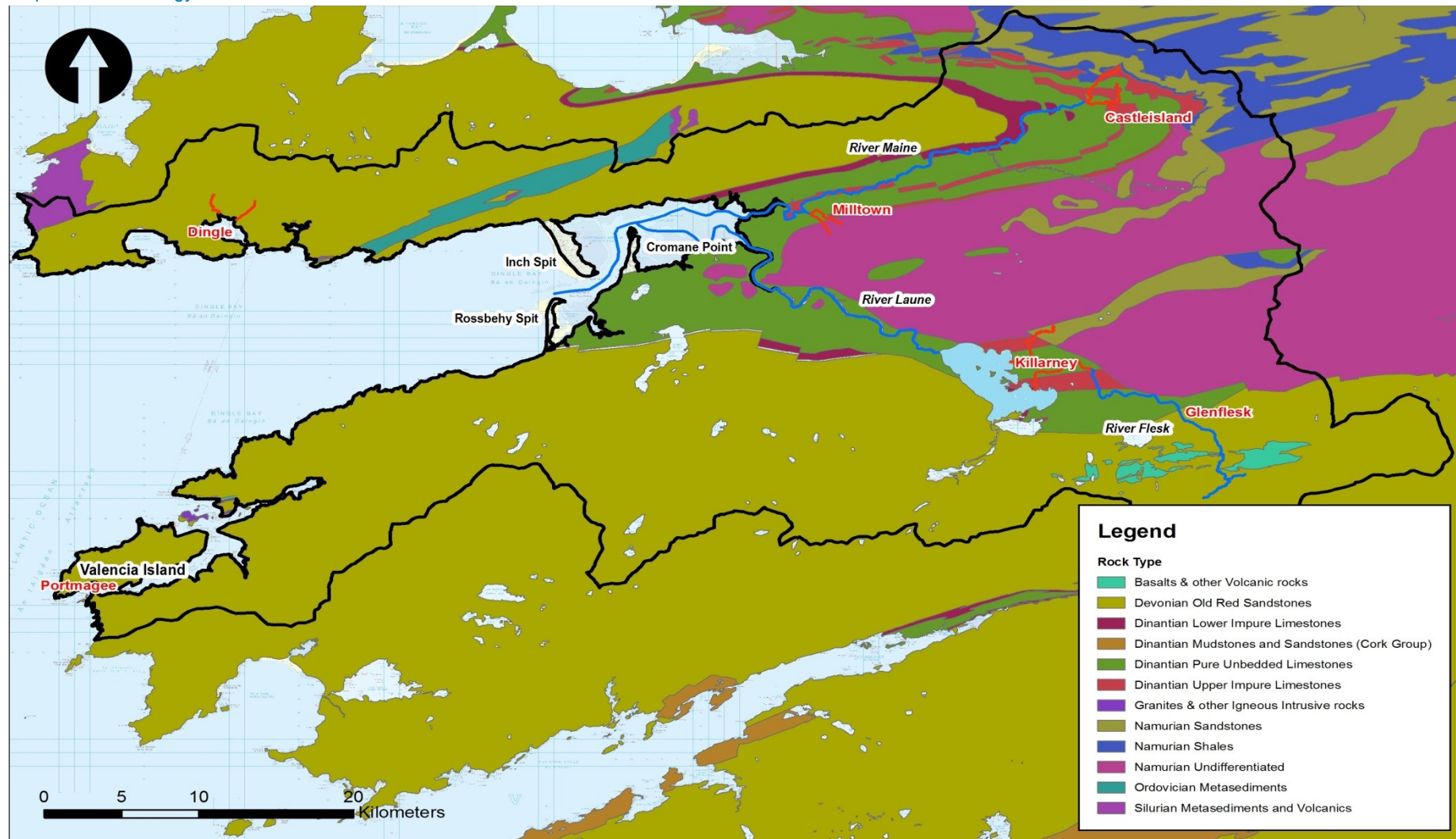
The upper catchment of the River Maine is dominated by underlying nationally important karst features which can increase infiltration and therefore reduce peak flow when the ground is not saturated. However, the karst geology can also amplify flooding when the karst is saturated from preceding rainfall by providing subterranean flow routes and or groundwater flooding in addition to the river flooding.

The River Flesk upstream of Glenflesk is underlain by Devonian Old Red Sandstones which forms the relatively flat valley floodplain surrounded by basalt which forms the steep valley sides. Downstream of Glenflesk, the underlying geology changes to karstified Dinantian limestones with the joining of the Owenskeagh River which increases the river gradient and narrows the valley. The land immediately next to Lough Leane is formed of fluvial and lacustrine deposits from the Lough and tributaries. The outfalls of Lough Leane and the River Laune floodplain are underlain by Dinantian limestone but surrounded by Dinantian shales, sandstones and limestones forming the steeper valley sides.

Map 2.3: Standard Average Annual Rainfall



Map 2.4: Geology



2.7 Land Use

Land use comprises pastoral and agriculture, with pastoral focussed on the steep relief along the valley sides. Farmland along the lower Maine is heavily drained in these flat low lying areas to maintain agricultural production.

There are areas of coniferous plantation around Milltown and along the lower Maine in the flat floodplain. There are also a number of Natura 2000 classified boglands along the lower Maine, particularly Inchinveema bog by the Brown Flesk confluence which naturally attenuate and store flood flows. The delta area downstream of Killarney forms part of the Killarney National Park and is an important recreational and tourism attraction.

The major urban areas are located at Killarney (population 37250 including Castleisland), Killorglin (population 24750) and Dingle areas (population 15600). The remaining smaller settlements tend to be located at the edge of the floodplains or along the coast, away from the main rivers considered in this study.

3 Data Collection and Review

3.1 Data Register

A range of different data sources have been used to undertake the hydrological data analysis for Unit of Management 22. The use of local hydrometric data can greatly improve and validate flood flows for historic events and design flood events. The following sources of data have been reviewed in Unit of Management 22 (Table 3.1).

Table 3.1: Summary of Available Data

Type	Details	Owner	Period of Available Data
River Flows	15 minute interval data series at 12 gauges with flow converted from water level	The OPW EPA (operated by Kerry County Council)	Various up to 2012
River Levels	15 minute interval data series at 15 gauges	The OPW EPA (operated by Kerry County Council)	Various up to 2012
Rainfall Gauges	Daily rainfall values at 36 gauges Hourly rainfall series at Valentia Observatory	Met Eireann	Various up to 2012
Extreme sea level	Irish Coastal Protection Strategy Study Total tide +surge design levels at 11 points within Dingle Bay	The OPW	Calculated for 2012
Wave conditions	Water levels, wave heights and wave periods at Dingle Harbour.	The OPW	Calculated for 2013
Tidal Prediction Points	Admiralty Tide Tables Volume 1	UKHO Admiralty	Calculated for 2013

There are no active tidal gauges within Dingle Bay from either the OPW or the Marine Institute of Ireland. Section 6.6 discusses the use of Admiralty Prediction points to inform water level profiles for less extreme events. A full data register can be found in Appendix A.

3.2 River Gauge Data

Map 3.1 shows the locations of river gauges in UoM22 with available water level and flow data. The existing hydrometric data from the wider area has been assessed for the following common issues:

- Anomalous spikes or dips in water level and/or flow from the continuous data records;
- Capping of water level and/or flow;
- Trends in water level or flow over time that might be caused by systematic error of gauging equipment or erosion/sedimentation;
- Sudden shifts in level of the gauging datum;
- Comparison of AMAX flows and levels from digital gauged data with manually extracted AMAX series;
- Anomalous AMAX flood peaks in the AMAX series at each gauge;
- Consistency of concurrent high flows downstream for AMAX events;
- Length of data record to enable hydrological analysis; and,
- Any significant data gaps.

A summary of the gauges on modelled reaches is given below:

Stations 22001 and 22003

The Riverville gauge (22003) provides long term records over 40 years for the River Maine. The OPW rating curves have been investigated and found to be representative of total flow at Riverville for the period 1962 to 2004. The period from 1972 to 2004 is marked caution due to scatter in the spot gaugings. However, there is a singular relationship in the spot gaugings for high flow and the OPW accept the rating curve for extrapolation. In 2007 the gauge was changed with the construction of the bypass channel. The Riverville bypass gauge (22001) has been used to monitor high flows since the construction of the bypass channel but this data is not incorporated into the total flow at Riverville. However, further survey by OPW is ongoing to incorporate these flows into the main Riverville flow series. Therefore the period from 2007 onwards has been discounted.

Stations 22014 and 22061

The Castleisland gauge was relocated to its current site in 2002. Therefore, the records previous to 2002 cannot be used as a continuous series with data recorded after 2002. The high flow rating for the Castleisland gauge will be reviewed in the hydrological study when more detailed topographic data becomes available to assess the by-pass flows. Following this rating review and subject to the review being satisfactory, both of these gauges will be suitable for the assessment of design flows.

The tidal gauge at Castlemaine (22061) has anomalous spikes in early 2008 which have been corrected for the hydrological study so that the gauge can be used to inform water level profiles up Castlemaine Harbour and typical tidal curves for this location.

Station 22022

The Milltown gauge located to the west of Dingle AFA provides 11 years of flow and level data for the Milltown River. The flow record was found to be consistent and deemed to be of reliable quality with exception of the missing data between January 2011 and March 2011 due to equipment malfunction. Therefore, the 2010 hydrological year was excluded from the AMAX series for further analysis.

Stations 22006, 22009, 22039 and 22041

The Flesk Bridge on the Flesk, White Bridge on the Deenagh, Clydagh Bridge on the Upper Flesk and Dromickbane on the Finow provide longer term records between 12 and 64 years for the River Flesk catchment. There were a number of data gaps found at Clydagh Bridge (22039) between 2001 and 2011 which led to the rejection of 4 years in the statistical analysis. Data records prior to 1982 at Flesk Bridge were found to be of poor data quality with significant gaps. Data recording issues at White Bridge limited the quality of the data records. However, the annual maximum floods were found to be largely unaffected by these issues, so these gauges have been deemed fit for the assessment of QMED.

White Bridge gauge (22009) was deemed of reasonable quality in-bank with no significant data gaps. However, there was concern over the applicability of the rating curve for out-of-bank flows, which did not necessarily account for the large increase in flow for a small change in level across the wide floodplain area at the site or back-water from Lough Leane. Therefore, this gauge was found to be suitable for fluvial assessment of the index flood but not flood frequency analysis of more extreme events which would be out-of-bank.

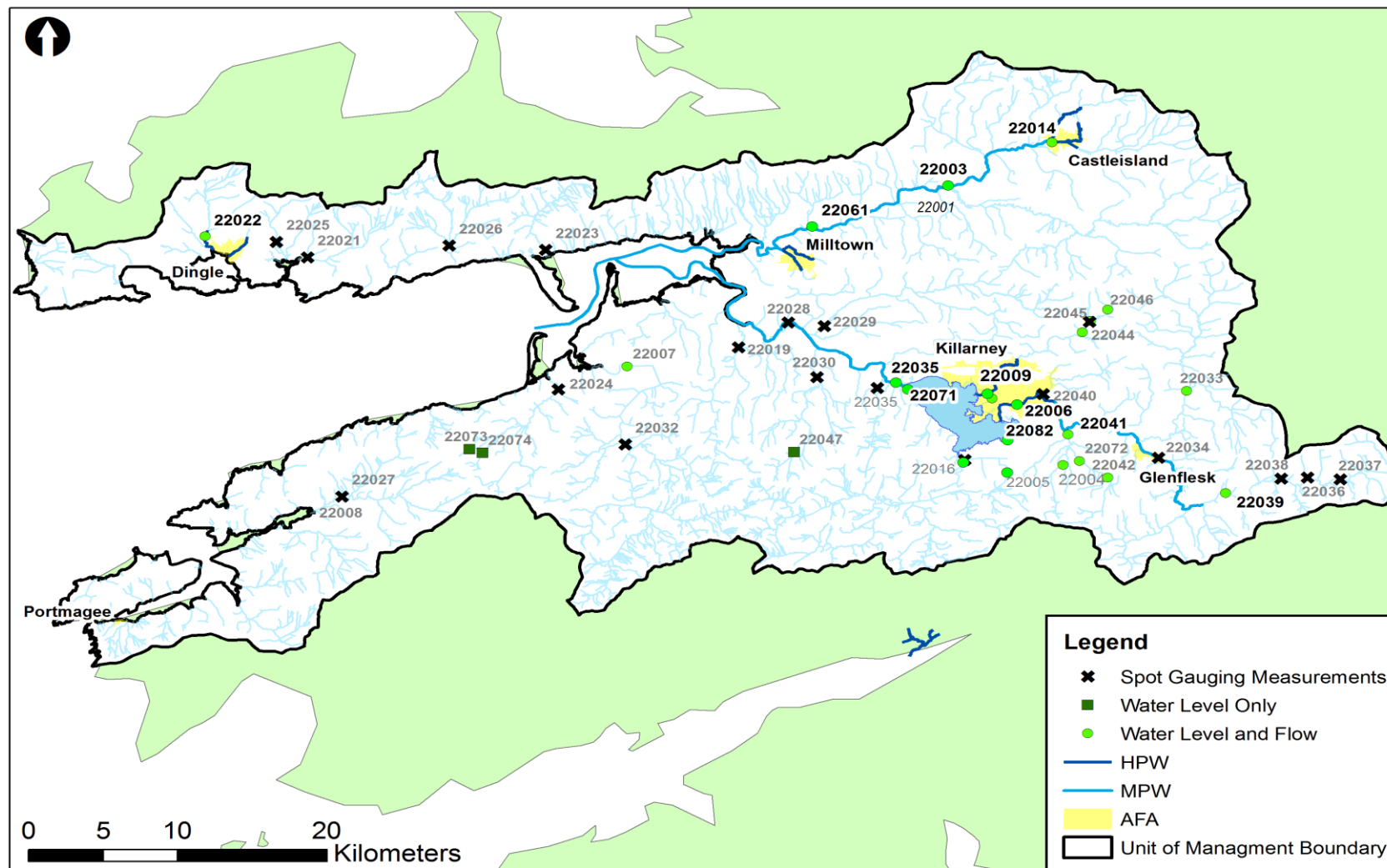
Stations 22035, 22071 and 22082

The Laune Bridge on the River Laune, Tomies Pier and BVM park gauges on Lough Leane provide water level data and in the case of Laune Bridge, flow data for Lough Leane and downstream reaches of the River Laune. There was a 3 m datum shift found in the water level records at Tomies Pier which was corrected to create a continuous 39 year record for assessment of extreme water levels across the Lough. The flow records at Laune Bridge have been edited by Kerry County Council based on the existing rating curve which is deemed suitable for the derivation of extreme flows due to the constrained nature of the river valley at this location. Following the corrections to the data records, all these gauges were deemed suitable for the assessment of extreme Lough levels and in the case of Laune Bridge, extreme flow assessment downstream.

Appendix A contains a list of the selected gauges for the hydrological analysis.

There is no hydrometric data for Portmagee. However, this AFA is only at coastal flood risk and does not require estimation of fluvial inflows as agreed with OPW at the flood risk review stage.

Map 3.1: Available Hydrometric Data



3.3 Rainfall Data

Available meteorological data from rain gauges and synoptic stations in and near to the catchment are shown in Map 3.2.

The existing meteorological data has been assessed for the following common issues:

- Spatial distribution of intensity loggers and respective storage gauges (event based);
- Identification of gaps or erroneous data which have been cross-referenced with the Met Eireann climate stations to assess if significant events have been omitted;
- Identification of shifts in rainfall records using temporal and cumulative plots; and,
- Analysis of cumulative rainfall for key historic events.

Appendix A contains a list of the selected gauges for the hydrological analysis.

Detailed hourly rainfall is limited to the Valentia synoptic station (305), which is located in the far west of the area. However, this detailed hourly gauge can inform the rainfall profile in UoM22 where the storm event is deemed to be of similar magnitude and pattern. The long term rainfall record at Valentia was plotted against daily rain gauges in Killarney, Castleisland and Dingle to provide geographical spread. The plots are provided in Appendix A. There is generally a positive correlation with high rainfall events at Valentia correlating to more extreme events in the AFAs. Valentia was most representative of rainfall at Killarney and the greatest scatter was observed at Castleisland. Therefore, the relationship between Valentia and the AFA will be assessed on an event by event basis for calibration purposes.

Rainfall-runoff modelling is not necessary for the derivation of design flows given the relatively good geographical coverage of hydrometric data for the majority of the River Laune and Maine. The rainfall-runoff approach assumes a catchment wide design storm, which is not realistic across >800 km² of the Laune catchment, and does not fully consider permeable catchment hydrology such as found in the Maine catchments.

Radar analysis for these mountainous and coastal catchments is not necessarily appropriate because the accuracy of radar will be limited by the rain-shadow effect in mountainous areas, and the Valentia Observatory and daily rainfall gauge network was sufficient to establish rainfall for events. It was agreed with OPW that the daily storage gauges within the catchments would be representative of conditions on the ground. Therefore, radar data has not been considered further in the hydrological analysis.

3.4 Coastal Data

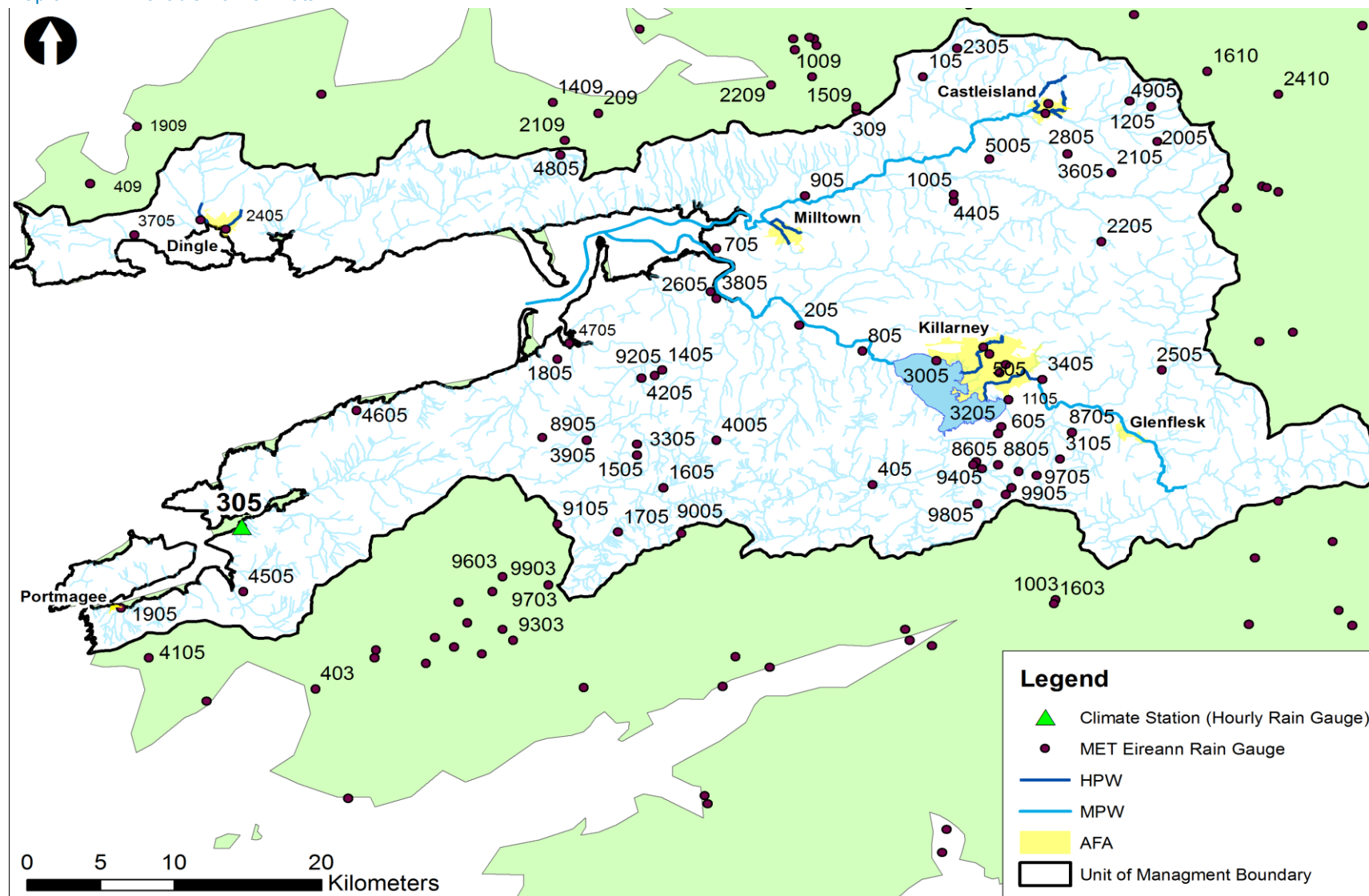
Map 3.3 shows the extreme coastal water level points and locations of other available coastal data. There was no tidal gauge data available for historical flood events for calibration or verification purposes.

The Irish Coastal Protection Strategy Study (ICPSS) data has been approved by OPW for use directly as the coastal boundaries for the South Western CFRAM models. The extreme sea levels will be used to

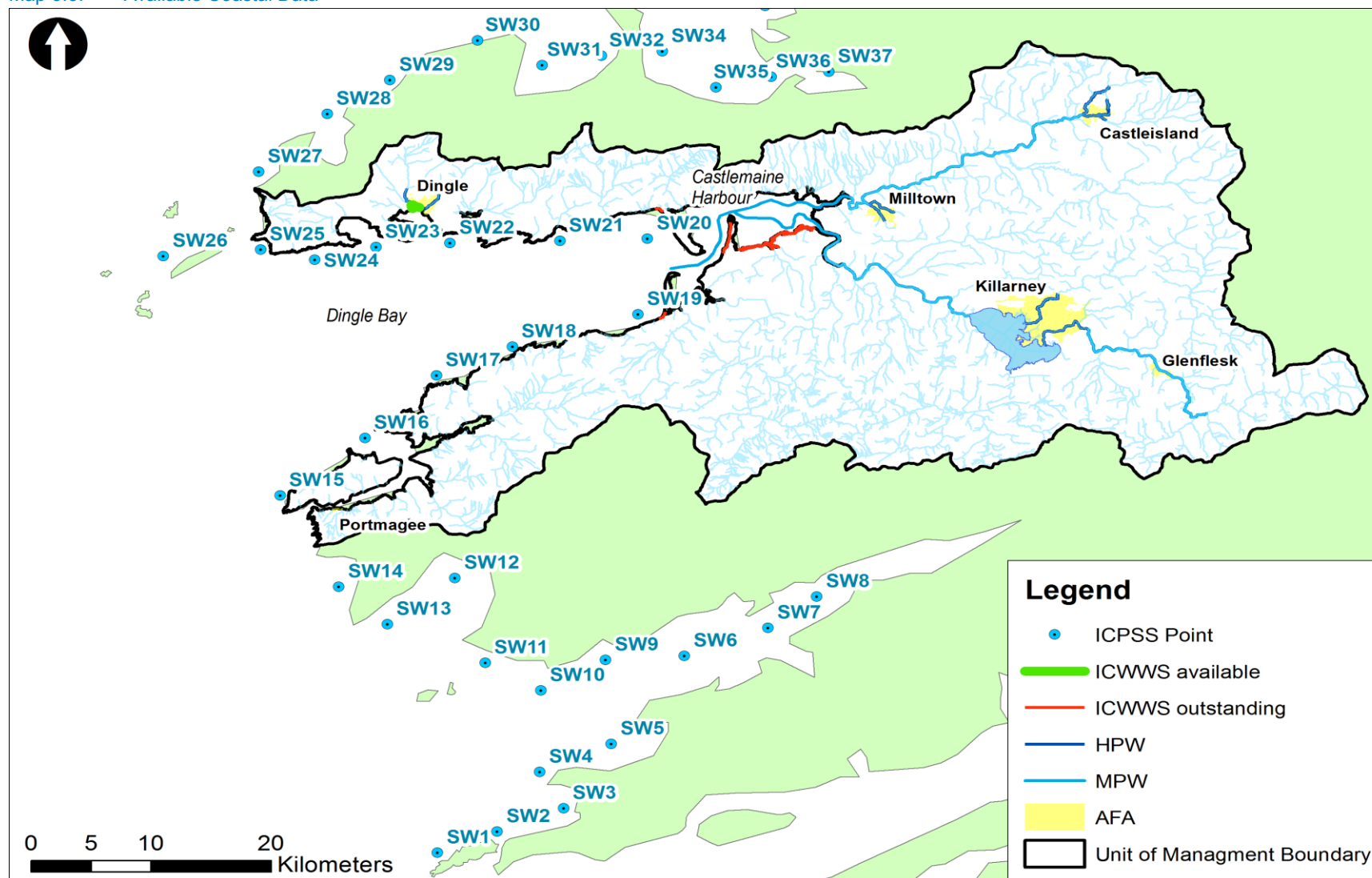
define the magnitude of the tidal events along the coast for all AFAs. The extreme sea levels are calculated for near shore points but do not necessarily consider variation in water level around islands such as in the Portmagee Channel. No paired water level gauges or buoys were available for this study in order to assess water level difference between Portmagee and Dingle Bay. Therefore, it has been assumed that the water level in Dingle Bay was representative of water levels in the Portmagee channel as a conservative estimate.

The Irish Coastal Water Level and Wave Study (ICWWS) will also provide extreme wave heights, wave periods and mean wave direction for those areas highlighted red in Map 3.3. The ICWWS data for Dingle Harbour has been available for this report. However, the ICWWS data in Castlemaine Harbour was not available at the time of writing

Map 3.2: Available Rainfall Data



Map 3.3: Available Coastal Data



4 Historical Flood Review

4.1 Historical Flood Events

Table 4.1 summarises the source, extent and impact of flooding for the historic events identified where sufficient evidence was available. Historic flood events in UoM22 were identified from the floods database (www.floods.ie), previous reports, and interviews with Local Authority personnel and residents during the Flood Risk Review. There were limited details available for historic flood events, as detailed records of impacts for events more than 20 years ago were scarce. There was no tidal gauge data available for historical flood events for calibration or verification purposes.

Flood Event of 15th January 2011

Intense rainfall over a few hours caused river levels in the Flesk to rise and flood the adjoining floodplain in Killarney and Killarney National Park. However, flooding was restricted to open fields and recreation grounds next to the river and no properties in the southern side of Killarney were affected.

Flood Event of 19th November 2009

After a month of prolonged rainfall, over 80mm of rain fell within 48 hours, flooding parts of Killarney along the River Deenagh as well the River Flesk. The saturated antecedent conditions meant that Lough Leane levels were already high prior to the event and significant inflows from the other rivers entering the lake. The intense rainfall on the 19th November 2011 further raised levels which caused significant flooding to the Killarney National Park area, parts of the N70 and the local road network. The tourist area around Muckcross and the Lake Hotel were extensively flooded to depths of over 0.5m in some areas. This was the first recorded flooding of the Lake Hotel in the past 190 years.

Flood Event of 4th October 2008

Flooding at Tullig, Castlemaine resulted from a complex interaction of river flooding and subterranean flow paths. Initially, river levels in the Glanshearoon River overtopped the left bank whereupon the flood water entered the Crag Cave complex to flood areas downstream on the Anglore Stream. Several properties were flooded along Anglore Stream at Cordal Road. An additional commercial property was also affected by the flooding. However, interviews with local residents indicated that the River Maine was in bank through the town.

Flood Event of 4th January 2008

Anecdotal reports of flooding from the Kerry County Council Engineer and informal discussions with residents of Milltown during the previous study¹ suggest that heavy rainfall on the 4th January 2008 caused water levels to rise and spill out of Ballyoughtrough Stream along Old Station Road due to potentially undersized culverts under access bridges along this reach. Additional flooding was also experienced around the N70 Bridge on Ashullish Stream where water bypassed the bridge, possibly due to siltation reducing the capacity of this reach.

¹ JBA(2011) Milltown Village Flood Relief Pre-Feasibility Study.

Table 4.1: Key Historical Flood Events

Date	Flooding Mechanisms	Areas Affected	Properties Flooded	Reported Peak Level (mODM)	Reported Duration of Flooding (hrs)
02/11/1980	Fluvial/pluvial flooding due to intense, heavy rainfall causing the River Flesk to overtop.	Glenflesk/River Flesk	23 houses 3009 acres of land	27.2 at Flesk Bridge Up to 1.2m at properties	36 hours
06/08/1986	Fluvial/pluvial flooding due to intense, heavy rainfall causing the River Flesk to overtop.	Killarney/River Flesk	Number not reported	26.99 at Flesk Bridge Gauge	Not Recorded
01/01/1988	Tidal surge – high tides and heavy rainfall causing surcharging of sewers.	Dingle Bridge Street, Hudson's Bridge,	Number not reported	Not Recorded	Not Recorded
17/02/1997	Fluvial/pluvial flooding due to heavy rainfall over a sustained period prior to flood. Overtopping of the River Flesk and River Laune.	Killarney/River Flesk River Laune	Number not reported	26.25 at Flesk Bridge Gauge & 21.73 at Laune Bridge Gauge	Estimated to be ~26 hours upstream of Killarney 11 days downstream of Lough Leane
01/02/2002	Fluvial flooding on the River Maine.	Castlemaine/River Maine Annagh Tributary of River Maine	Number not reported	26.56 at Castlemaine Gauge	Estimated to be ~ 24 hours
04/01/2008	Fluvial flooding from undersized culverts and bridge.	Milltown/Ashullish-Ballyoutragh Old Station Road, N71 Bridge	Seven properties	Not recorded	Estimated to be 12 hours
04/10/2008	Fluvial flooding from intense, heavy rainfall causing the Glanshearoon to overtop and flow into a nearby swallow hole, causing water to rise into the Anglore Stream.	Castleisland/River Maine- Glanshearoon Cordal Road	Several properties and one commercial property	24.03 at Castleisland Not Recorded	Estimated to be 10 hours
19/11/2009	Fluvial/pluvial flooding due to heavy rainfall over a sustained period prior to flood. Lack of maintenance of the River Flesk.	Killarney/River Flesk	Number not reported	27.07 at Flesk Bridge Gauge	29 hours upstream of Killarney >11.5 days downstream of Lough Leane
15/01/2011	Fluvial flooding due to rising level of Lough Leane.	Killarney/River Flesk N71 National Secondary Road	Number not reported. N71 road impassable for 300m	26.73 at Flesk Bridge Gauge	Estimated to be up to 48 hours

Flood Event of 1st February 2002

A combination of high tidal level on the River Maine and flood flows on the adjoining tributary downstream of Castlemaine caused river levels to overtop the raised embankments and flood the surrounding farmland at Castlemaine. Fields were flooded for several days, and the flood waters were unable to return to the river because the floodplain is below the embankments.

Flood Event of 17th February 1997

Similar to the 2011 event, intense rainfall caused the River Flesk levels to rise and flood the adjoining floodplain in Killarney and Killarney National Park. However no properties were affected. High flows were recorded downstream at Laune Bridge but no flooding issues were reported on the River Laune.

Flood Event of January 1988

From what limited data there is available for this event, it is believed that a combination of a tidal surge and intense rainfall resulted in significant flooding along Dingle Stream. Flood waters spilled out-of-bank at Bridge Street and Hudson's Bridge and flowed rapidly down the Mall and Dykegate Street flooding properties adjacent to the road. Furthermore, the extreme sea level and intense rainfall overwhelmed the urban drainage network, causing surcharging of the sewers which added to the flooding along the streets.

Flood Event of August 1986

An intense summer rainfall event on 5th and 6th August 1986 resulted in 87mm of rain within 15 hours at nearby Valentia Observatory. This resulted in a rapid rise in the River Flesk levels causing flooding of the recreational grounds along the River Flesk in Killarney, but no properties were reported as being affected.

Flood Event of November 1980

The November 1980 event was the largest flow on record at Flesk Bridge. There was over 90mm of rain over 48 hours on the 1st and 2nd November 1980 causing Lough Leane levels to rise and limiting discharge of the prolonged fluvial flood along the River Flesk. There was no gauge data for this event at White Bridge on the River Deenagh. However, it is likely that the flood on the Deenagh was a similar %AEP to the Flesk as the rainfall amount is between the catchments. The River Flesk levels spilled out-of-bank to flood Killarney National Park as well as fields and recreational grounds adjacent to the river in Killarney. The River Deenagh was also reported as flooding but no precise locations were provided. However, no properties were reported as being affected.

There was also flooding upstream along the N22 between Loo Bridge and Glenflesk by the River Loo and River Flesk as reported by Kerry County Council which resulted in the flooding of 23 houses, 3009 acres, the loss of 209 livestock, and 322 road access disruptions.

Other Events

There are a number of anecdotal reports of flooding in UoM22. These provide useful insight into the locations of flooding issues and the relative frequency of flooding when combined with the formally reported events above. These include:

- Laune Catchment
 - Regular flooding of the N71 from Lough Leane between Killarney and Molls Gap as reported on floodmaps.ie
- Maine Catchment
 - Local engineers at Castleisland reported flooding in August 2008 of similar magnitude to the event on 4th October 2008, but the flooding mechanism and extent was not provided.
- Dingle and Coastal Catchments
 - Recurring flooding at Mill Bridge in Dingle from Milltown Stream once or twice a year due to high tidal levels as reported by Kerry County Council.
 - Recurring flooding along The Mall in Dingle from Dingle Stream caused by heavy rainfall combined with high tide occurs once every 5 years on average. However, Kerry County Council reported that no properties were affected by the most recent event.
 - Flooding at Stealroe (2km downstream of Killorglin) from the River Laune due to high tides once every 10 years on average as reported by Kerry County Council.
 - Recurring flooding of the R565 road east of Portmagee from high tides on average twice a year as reported in floodmaps.ie. However, there are no records of flooding within Portmagee itself.

4.2 Historical Flood Mechanisms

The total rainfall at the daily storage gauges has been mapped for historic events, both spatially and temporally. Map 4.1 displays the total rainfall plot for the recent 2009 event across UoM22. The rainfall is greatest over the mountains, but the rainfall at Valentia is similar to the daily total at Killarney. However, the more detailed flow records show that the Finnow peaked before the Clydagh and Flesk, indicating that the storm moved in a south-westerly track.

Fluvial or river flooding

Fluvial flooding can occur when the capacity of the river channel is exceeded due to excess flow from heavy rainfall or releases from reservoirs upstream. Flood waters typically overtop river banks at low sections or where water is constricted by bridges or culverts, forcing water levels to rise upstream and flood surrounding areas.

Fluvial flooding affects Glenflesk, Killarney, Castleisland, Dingle and Milltown AFAs. The attenuation of the floodplain and larger lakes, such as Lough Leane, is significant in the progression of the flow down the larger River Maine and River Laune catchments. An example for a high flow event from 19th November 2009 is provided in Figure 4.1. Flood events such as this can prolong flooding in the lower reaches of these catchments.

Map 4.1: Variation of Rainfall on 19 November 2009

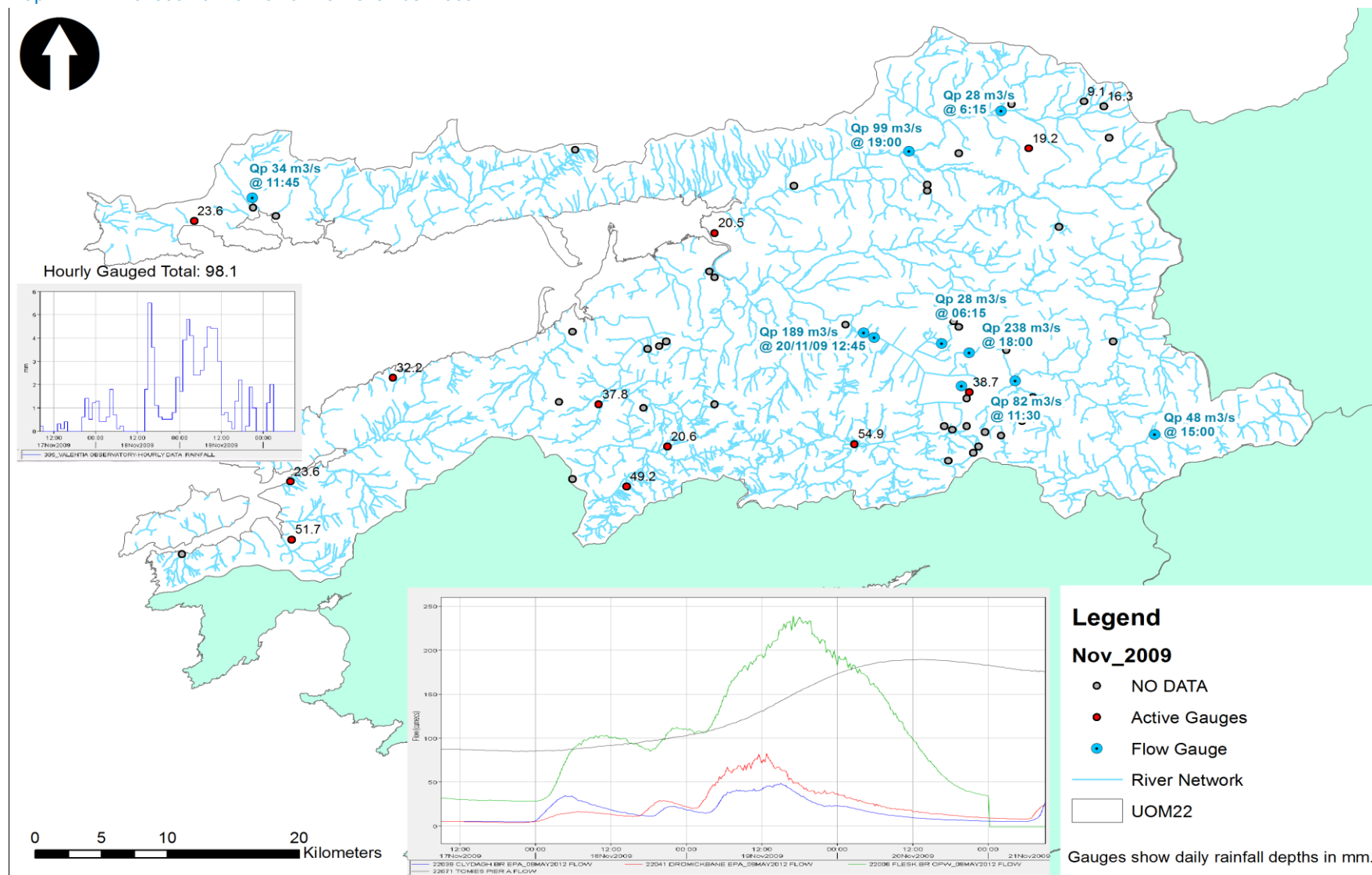
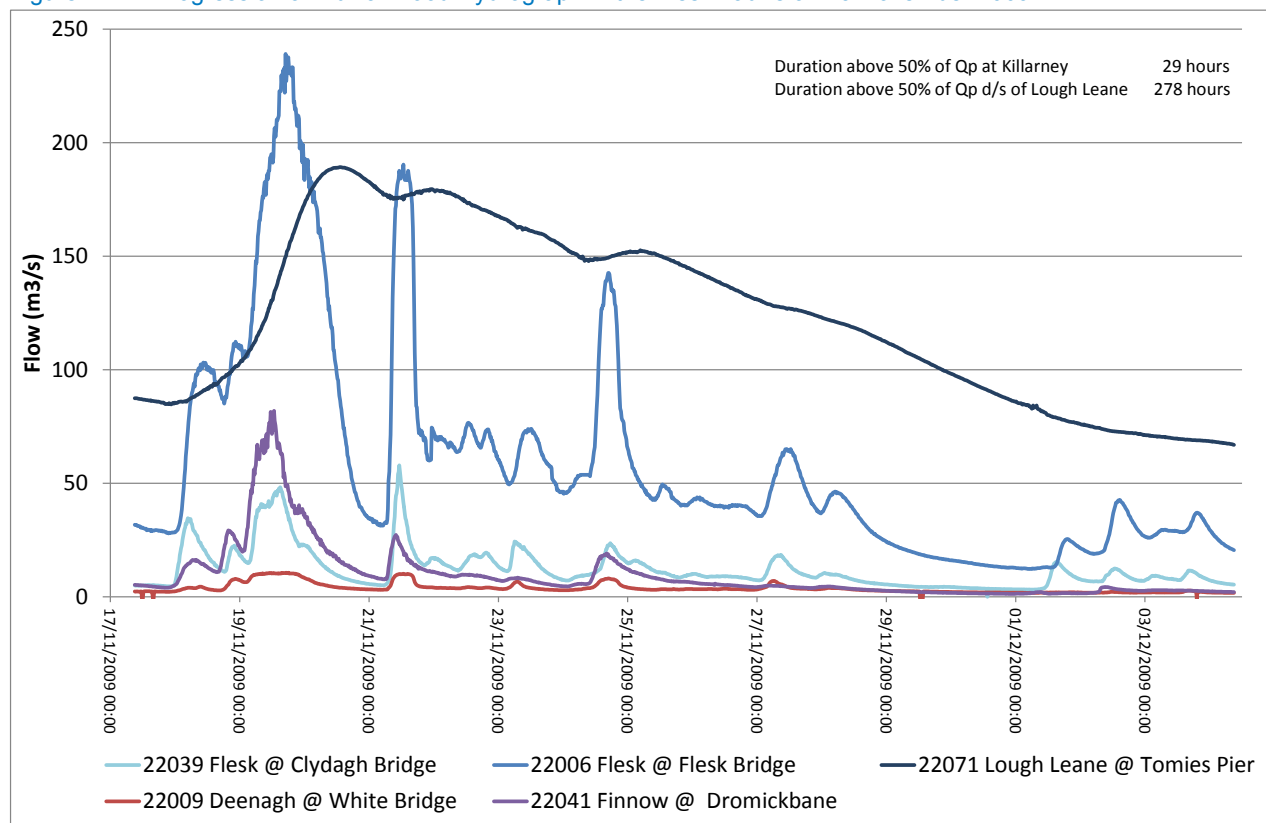


Figure 4.1: Progression of Fluvial Flood Hydrograph in the Flesk/Laune on 19 November 2009



Pluvial or surface water flooding

Pluvial flooding can occur when overland flow from intense rainfall or prolonged heavy rainfall is unable to enter the urban drainage network or river channel either because the capacity of the system is exceeded and/or outfall is “tide-locked” preventing discharge. Pluvial flooding is exacerbated by the increase of impermeable areas (such as concrete or tarmac) associated with urbanisation which increases the amount of overland flow.

Pluvial flooding is reported to affect Dingle AFA where intense rainfall overwhelms the urban drainage network capacity due to the steep topography and the exposed location to Atlantic storms. It should be noted that the study of pluvial flooding is not included in the scope of the CFRAM Study.

Coastal or tidal flooding

Extreme sea levels, waves and storm surges overtop coastal defences and river banks in tidally influenced reaches, particularly when combined with high river flows for tidal rivers. The risk to people can be very high from this form of flooding as the flood waters can be fast-flowing.

Dingle has been identified as being at risk from coastal flooding based on interviews with the local authority staff during the Flood Risk Review. High tide levels are reported to overtop the harbour front as well as “tide-lock” the Dingle and Milltown Stream, causing water to back-up upstream and flood low-lying areas by the rivers.

Groundwater flooding

Groundwater flooding can occur when water levels rise above the ground to flood low-lying fields and property basements. Subterranean cave systems can form an alternative flow path and remove water from the surface-water system and catchment.

Castleisland has been identified as being at risk from groundwater flooding in combination with fluvial flooding. Properties at Tullig have been identified as being at risk from this second form of groundwater flooding as experienced in 2008 when river flood water entered the Crag Cave complex which then added to flooding along Anglore Stream. It should be noted that the study of groundwater flooding is not included in the scope of the CFRAM Study.

Based on the historical flood evidence, the key mechanisms for each of the AFAs are as follows:

- **Glenflesk:** Flooding occurs from the overtopping of the River Flesk banks. The channel cannot contain extreme flows and as a result houses, land and roads become flooded once every two years.
- **Killarney:** The Lough Leane levels rise after high rainfall causing increased backwater along the River Flesk and Deenagh, and flooding the low-lying Killarney National Park. The transport routes into and out of Killarney are affected on “regular” basis, particularly the roads around Muckross.
- **Castleisland:** Flooding occurs from the overtopping of the River Maine banks to surrounding properties. However, recent flood events have highlighted that river flooding along the Glanshearoon Stream can also contribute to flooding along Anglore Stream and the River Maine downstream via subterranean flow routes. Flood waters from the upper reaches of Glanshearoon Stream can enter underground cave complexes which transport the flood water to the Anglore Stream resulting in flooding to riverside properties near Tullig.²
- **Dingle:** Flooding occurs during high flows on Dingle Stream due to under capacity at key structures resulting from the accretion of silt, such as at Hudson’s Bridge. Dingle is also identified as at risk from coastal flooding, occasionally flooding coastal roads.
- **Portmagee:** This AFA has been identified as at risk from tidal flooding however there are no historic reports of flooding within the AFA.
- **Milltown:** Flooding occurs along the Ballyoughtragh and Ashullish Streams through the AFA. The N70 road bridge constricts flows on the Ballyoughtragh Stream causing water to spill out of bank and flood properties by the bridge. The Ashullish Stream spills out of bank due to under capacity culverts along Kilcolman Road and a skewed culvert under the N70, affecting properties along the left bank.

² It is important to note that this is fluvial flooding in origin and not groundwater flooding which is not considered under the scope of CFRAM STUDY.

4.3 Historical Flood Frequency Estimates

An estimate has been made of the flood frequency for the historical events where there was recorded rainfall and river flows.

For all fluvial events, rainfall records were assessed across the region in order to establish whether each reported historic flood event was part of a region-wide storm event or a localised event. All the recorded events were found to be caused by catchment-wide storm events or even region-wide storm events in the case of the November 2009 flood. The analysis supports the Atlantic depression being the dominant mechanism for storm events and any subsequent flooding in UoM22.

The recorded peak flow at the nearby gauges was compared to their annual maximum series and the relative frequency of each event was derived using the Gringorten formula:

$$Fi = \frac{i - 0.44}{n + 0.12}$$

Where i is the relative rank in the annual maximum flow series (AMAX) and n is the number of values in the AMAX series. The resultant %AEP estimates were refined against the design %AEP flows provided in Chapter 6.

The resultant %AEP and rank estimates are presented in Table 4.2.

Table 4.2: Estimation of Flood Frequency for Historical Flood Events with Records of Flooding

AFA/MPW	Nearest Gauging Station		Historical Flood Event				
	Station No.	Location	Date	Peak Flow (m ³ /s)	Rank	AEP (%)	Catchment Wide/ Localised Rainfall
Glenflesk/Flesk	22006	Flesk Bridge	02/11/1980	277	2	3%	Catchment wide rainfall event. 24 hours of continuous rainfall recorded at Valentia
	22071	Tomies Pier					
Killarney/Flesk	22082	BVM Park	06/08/1986	224	4	6%	Catchment wide high rainfall event
			17/02/1997	184	18	3%	Catchment wide rainfall event after 2-3 weeks of consistent rainfall
			19/11/2009	224	3	4% (increase to 1% in Lough Leane due to other inflows)	Large catchment wide event with 30 hours of rainfall recorded at Valentia
			15/01/2011	195	10	20%	Catchment wide rainfall event
Castleisland/Glanshearoon	22014	Castleisland	04/10/2008	43	3	23%	Large catchment wide rainfall event
Dingle/Milltown Stream	N/A	N/A	01/01/1988	-	-	-	Catchment wide rainfall event
Castlemaine/Maine	22061	Castlemaine	01/02/2002	N/A tidal			N/A Tidal event
Milltown/Ashullish-Ballyoutragh	N/A	N/A	04/01/2008	No Data†	-	-	Catchment wide rainfall event

†No data due to lack of gauged data at or near Milltown, data gap in 22003 Riverville

5 Gauging Station Review

5.1 Gauge Review Selection

Extreme flood flows can be estimated at gauging stations where a stage-discharge relationship is known. Historically, rating curves have been derived from in-bank gaugings and extrapolated to estimate extreme flood flows. If the gauge is by-passed, the use of an in-bank rating curve may significantly underestimate flows. However, it is not always safe or practical to observe level and flow during out-of-bank conditions. Therefore, hydraulic modelling has been used in the CFRAM study to simulate out-of-bank conditions and extend the rating curves for high flows.

In UoM22, the Castleisland gauging station has been identified as requiring further review at this stage of the CFRAM study.

5.2 Gauging Station 22014 – River Maine at Castleisland

Location

The gauge at Castleisland is located on the River Maine immediately (3m) upstream of the low-flow weir structure opposite the wastewater treatment works (99609, 109506). The channel is over 3m below the floodplain at this location but is subject to backwater from the Glanshearoon Stream 150m downstream and in extreme high flows, the gauge could potentially be bypassed on the right bank at Herbert's Bridge. The highest gauged flow is only 33% of the estimated Q_{MED} , warranting further investigation to review and verify the high flow rating curves at this gauge.

Spot Gaugings

The Environment Protection Agency has provided over 90 spot gaugings of level and flow at the gauge between 1985 and 2011. Figure 5.1 indicates there is no apparent hysteresis effect as spot gaugings on the rising and falling limb are similar. Figure 5.2 confirms winter flows (October to March) are typically higher than summer flows (April to September) but there is no evidence of a different stage-discharge relationship between the seasons. However, Figure 5.3 clearly shows that the scatter of spot gaugings can largely be attributed to different gauging periods. Those spot gaugings recorded between 1985 and 1988 are clearly to a different datum and gauge configuration compared with those recorded after 2002. This was confirmed by the stage zero history on EPA's hydronet.ie where the gauge datum changed from 15/02/1983 to 09/04/2002. Therefore, spot gaugings prior to 2002 have been discounted from further analysis as they are not consistent with the current rating section.

Figure 5.1: Spot Gauging Hysteresis

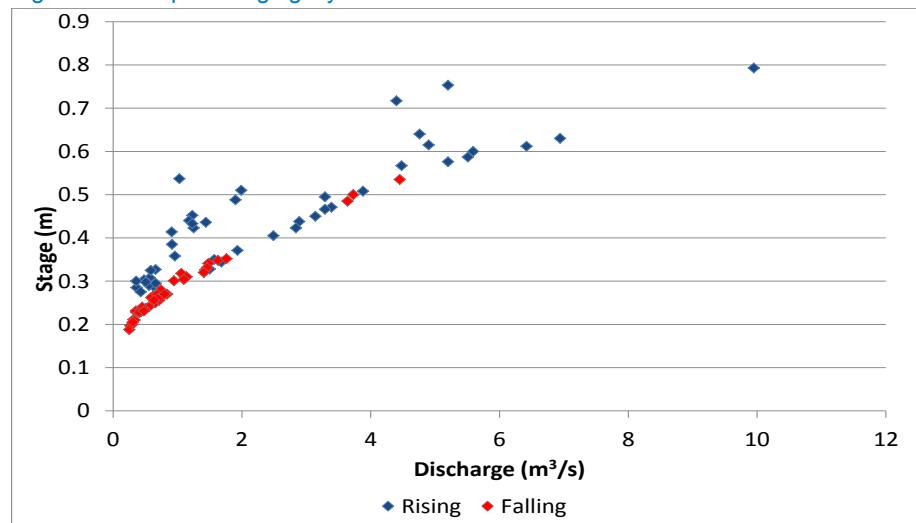


Figure 5.2: Spot Gauging Seasonality

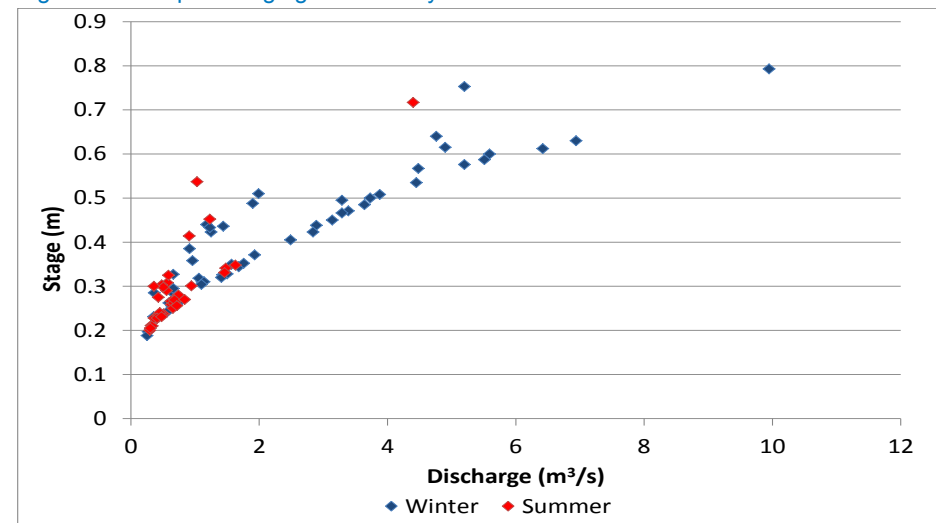
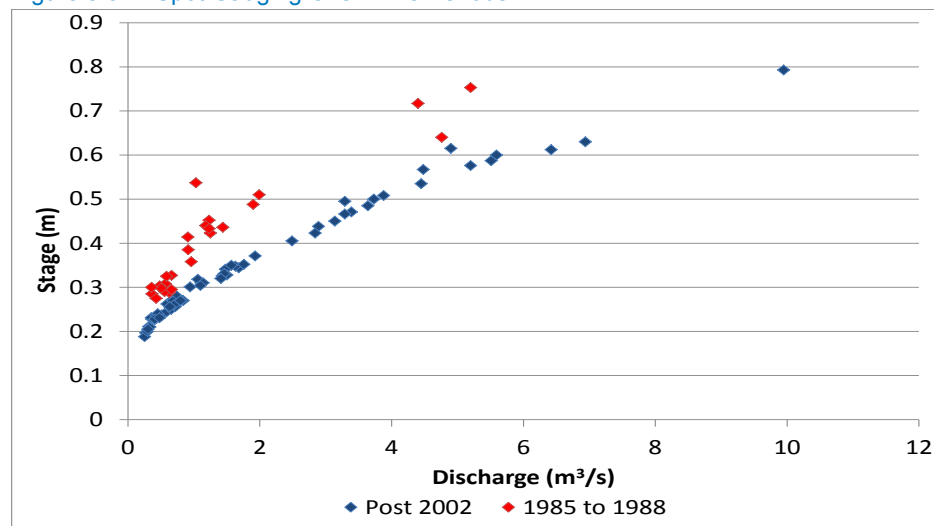


Figure 5.3: Spot Gauging Over Time Periods



Hydraulic Modelling

A site walkover of Castleisland and the gauge was undertaken prior to modelling to identify likely flow paths as discussed above. This knowledge was combined with the detailed river channel survey of the River Maine and Glanshearoon tributary to develop a fully hydrodynamic 1D-2D ISIS-TUFLOW model. A 1D-2D approach was deemed appropriate to accurately model head loss across the low flow weir and through the bridges and the complex flow paths of any by-pass flows across the urban floodplain.

Survey cross-sections were taken at 100m intervals through Castleisland and at 300m intervals downstream of the Maine-Glanshearoon confluence. The structure dimensions of the weir and numerous bridges were captured along with photographs to inform the 1D model of the channel. The in-channel Manning's 'n' values, weir and bridge coefficients were calibrated to the November 2008 event and the relevant spot gaugings at the gauge.

Detailed LiDAR data was captured at a 2m resolution and post-processed to remove man-made features. The LiDAR data was compared with the river channel survey along the roads and was found to be within the 0.2 RMSE accuracy quoted by the supplier. The LiDAR data was then used to develop a digital terrain model of the urban areas to inform the 2D model of the floodplain. The variation in roughness and resistance to flow across the floodplain was explicitly represented by assigning recommended Manning's 'n' values to road surfaces, buildings and areas of dense vegetation such as field boundaries. Raised barriers, such as the N21 road embankment and dismantled railway to the west of the gauge, were explicitly enforced as a 3D breakline based on topographic survey and LIDAR elevations. The culvert under the N21 for the Kealgorm Stream was represented as a stage-discharge relationship based on the downstream channel and floodplain slope to enable flows to realistically exit the model at this location.

Further details of the modelling process can be found in Appendix B.

Revised High Flow Rating

The calibrated model was then run to simulate 0.1%AEP + 30% for HEFS climate change under the following scenarios to assess the change on the rating curve at the gauge:

- Design scenario with calibrated parameters
- Increased Manning's 'n' to upper recommended limit
- Reduced Manning's 'n' to lower recommended limit
- Raised downstream boundary stage-discharge relationship
- Greater distribution of flow through Crag Cave system e.g. November 2008 event.

The model results were converted to relative stage based on the surveyed gauge datum and compared with the spot gaugings. Figure 5.4 presents the resultant rating curve for the entire range of levels and Figure 5.5 focusses on the range of levels for which the spot gaugings apply.

Figure 5.4: Proposed Rating Curve at Castleisland Gauge- Full Modelled Range

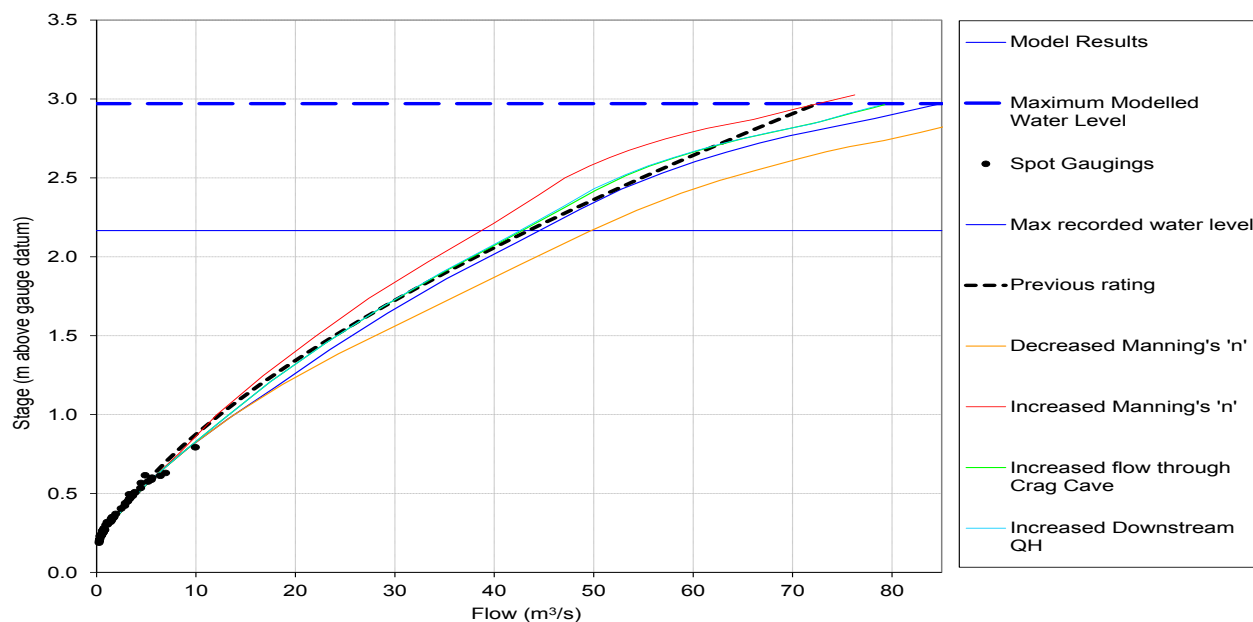
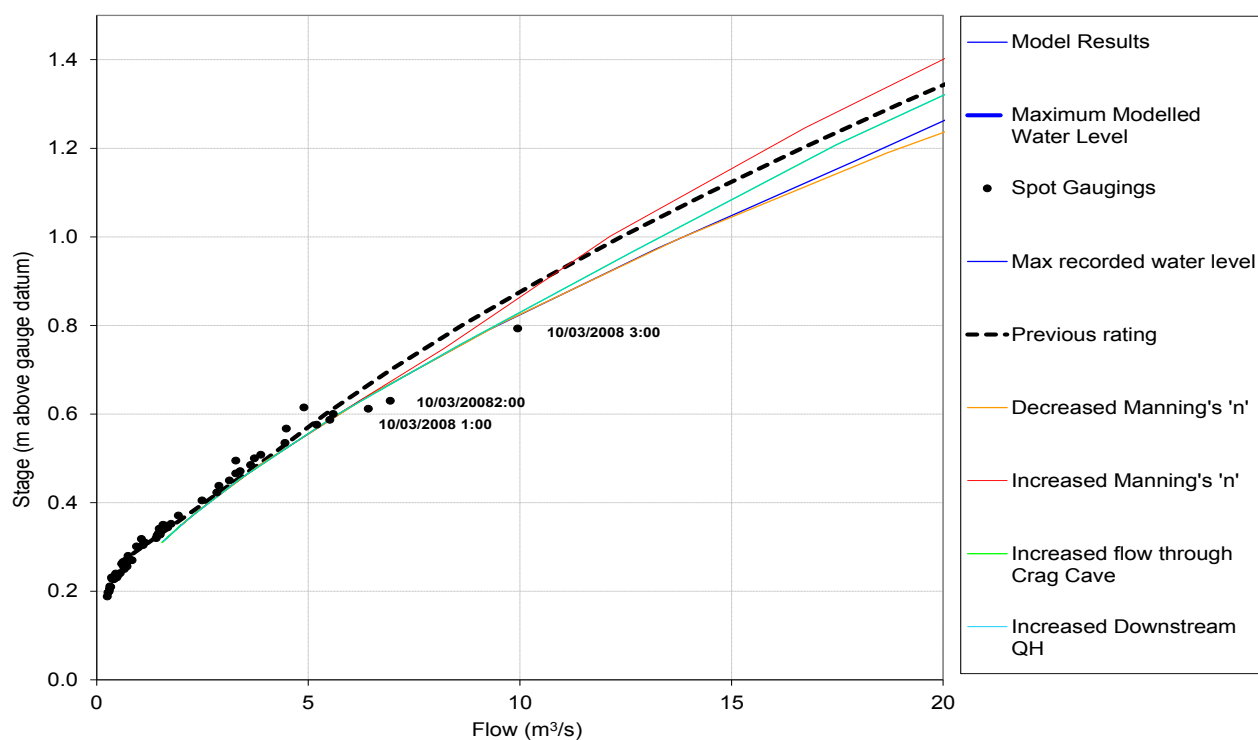


Figure 5.5: Proposed Rating Curve at Castleisland Gauge- Focus on Spot Gaugings



The modelled stage-discharge matched well with the spot gaugings below 0.7m, and was within 0.02m of the higher spot gaugings up to 0.8m (the highest gauged flow). However, the model predicts a 4m³/s (46%) increase in flow at the highest gauged level (0.8m stage) compared with existing low flow rating. The model results better match the spot gaugings because the hydraulic model accounts for the drowning of the weir. The difference to the existing EPA rating curve reduces to 10% for larger flows in-bank as the effect of the weir lessens.

Above 2.5m stage there is a definite increase in flows where flow begins to bypass the gauge at Herbert's Bridge. The sensitivity modelled stage-discharge curves diverge from the design scenario principally due to the level at which the weir at the gauge becomes drowned out. The variation from the design scenario represents an uncertainty of $\pm 5\text{m}^3/\text{s}$ (11 %) at the maximum recorded stage (2.17m) and 11 m³/s (14%) at the maximum modelled stage (2.97m).

Based on the spot gaugings and model results, it is recommended that the original rating curve be used for low flows up to 0.425m but the modelled stage-discharge is used to revise the rating curve from 0.425m to 2.97m stage to more accurately consider the hydraulic drowning of the weir and any bypass flow. The modelled stage-discharge was split up into 3 segments to represent the following changes in gradient:

- 0.426m to 1.702m – transition weir flow
- 1.703m to 2.624m – full drowned weir flow in-bank
- 2.625m to 2.971m – bypass flow at Herbert's Bridge.

Regression analysis was then carried out for each section to derive the rating curve equation with the best fit where the correlation coefficients (R^2) for all the segments were all greater than 0.999. The resultant regression curves were then interpolated to find the upper transition stage and rating curve parameters derived. The revised high flow rating is presented in the power law format $Q=C(h-e)^\beta$ where Q is discharge;

- h is the gauge height of the water surface;
- e is the gauge height of zero flow for a control of regular shape, or of effective zero flow control for a control of irregular shape;
- C (constant) is the discharge when the head (h-e) equals 1.0;
- β (constant) is the slope of the rating curve when plotted on a log scale (ratio of the horizontal distance to the vertical distance).

Table 5.1: Recommended Revised Rating Curve Parameters for Castleisland Gauge (22014)

Segment	Lower Limit (m stage)	Upper Limit (m stage)	C	e	β
1 (Original Low Flow)	0.188	0.425	47.591	0	3.195
2	0.426	1.702	17.914	0.188	1.243
3	1.703	2.624	23.739	0.488	1.223
4	2.625	2.971	65.437	1.700	1.085

The resultant rating curve is provided in Table 5.2. Further details on the modelling decisions and rating development can be found in Appendix B.

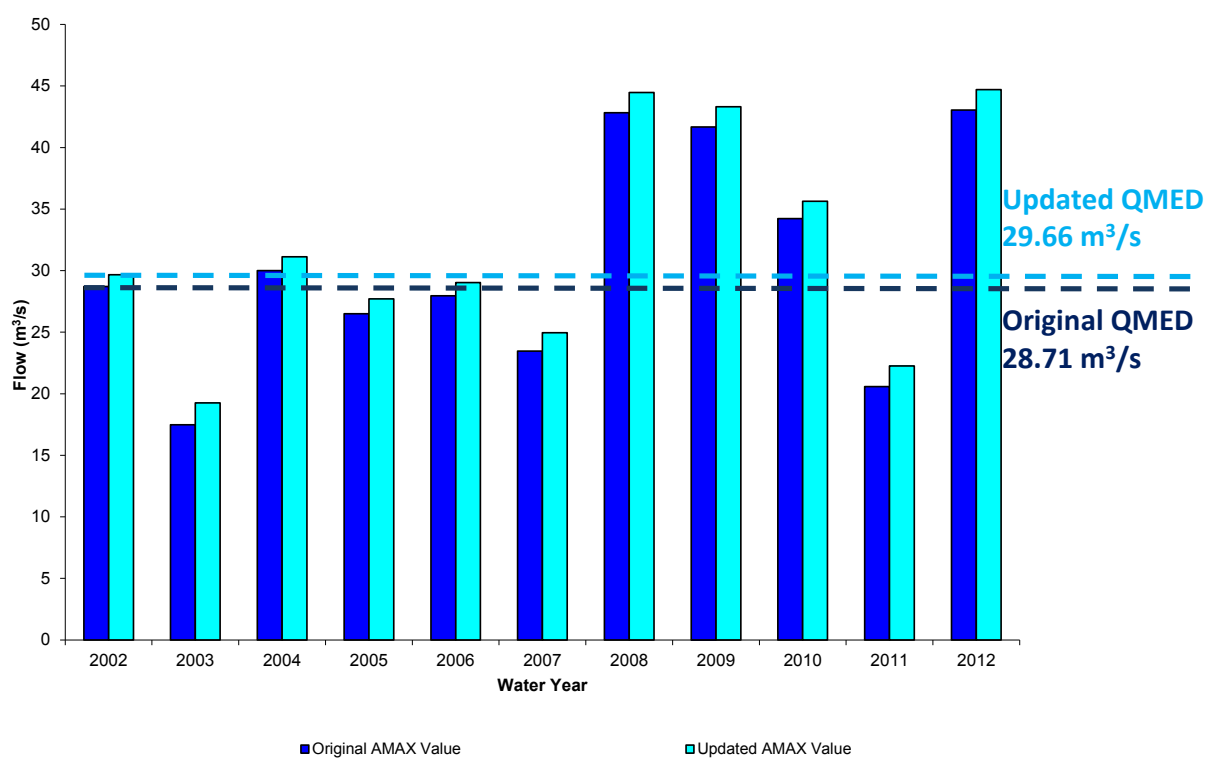
Table 5.2: Recommended Revised Rating Curve at Castleisland Gauge (22014)

Stage (m above Gauge Datum)	Flow (m ³ /s)
0.29	0.87
0.40	2.55
0.50	4.21
0.60	5.94
0.70	7.79
0.80	9.72
0.90	11.74
1.00	13.82
1.10	15.97
1.20	18.17
1.30	20.43
1.40	22.74
1.50	25.09
1.60	27.49
1.70	29.93
1.80	33.09
1.90	36.20
2.00	39.36
2.10	42.56
2.20	45.81
2.30	49.10
2.40	52.44
2.50	55.81
2.60	59.22
2.70	65.44
2.80	72.56
2.90	79.75
2.97	84.81

Note: Revised rating curve shown for modelled range 0.29m to 2.97m only

Figure 5.6 displays the suggested updated AMAX series based on the revised rating curve above.

Figure 5.6: Recommended Updated AMAX Series at Castleisland Gauge (22014)



6 Design Flows

6.1 Overview

The hydrological approach draws on the data review described in Chapters 3, 4 and 5 of this report and the latest Flood Studies Update (FSU) guidance. The hydrological analysis to derive design fluvial hydrographs for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP has been undertaken as follows:

- Define the sub-catchments and locations at which to calculate design flows (Section 6.2);
- Estimate the index flood flow for the 50% AEP flood (Section 6.3);
- Estimate the flood growth curve to derive more extreme flood events (Section 6.3);
- Estimate the typical flood hydrograph shape (Section 6.4).
- A similar approach has been taken to estimate extreme water levels at Lough Leane in Section 6.5.

The hydrological analysis to derive design coastal conditions for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP has been undertaken as follows:

- Transformation of total tide plus surge levels along the coast to the model outfalls into the open sea (Section 6.6.1);
- Estimate the typical tide plus surge profile (Section 6.6.1);
- Estimate wave overtopping discharges at vulnerable locations (Section 6.6.2).

6.2 Definition of Sub-Catchments

6.2.1 Hydrological Estimation Points

Hydrological estimation points (HEPs) have been chosen at key locations in the River Maine, Laune and Dingle catchments to form the hydraulic model inflows, intermediate target flows for the model to achieve, and downstream conditions for the model.

The HEPs were identified through a GIS analysis based on the following principles from Section 6.5.3 of the Generic CFRAM Specification:

- A central location within the AFA;
- Flow gauging stations used in the hydrological analysis;
- Upstream and downstream limits of each hydraulic model reach;
- Major confluences which contribute significant flow to the modelled reach; and,
- Locations where the physical catchment descriptors (PCD) significantly change from the upstream catchment i.e. catchment centroid more than 25km away, ± 0.15 change in BFI and ± 0.07 change in FARL.

Table 6.1 summarises the selected HEPs prior to hydraulic modelling. Individual maps and catchment descriptors for each AFA and MPW reach are given in Appendix C.

There are no HEPs identified in Portmagee as the AFA was not assessed to be at fluvial flood risk.

Table 6.1: Selected HEPs

HEP Type	Number in UoM22
Gauged	7
Model Inflow	26
Target	61
Downstream	6
TOTAL	99

6.2.2 Sub-Catchment Boundary Delineation

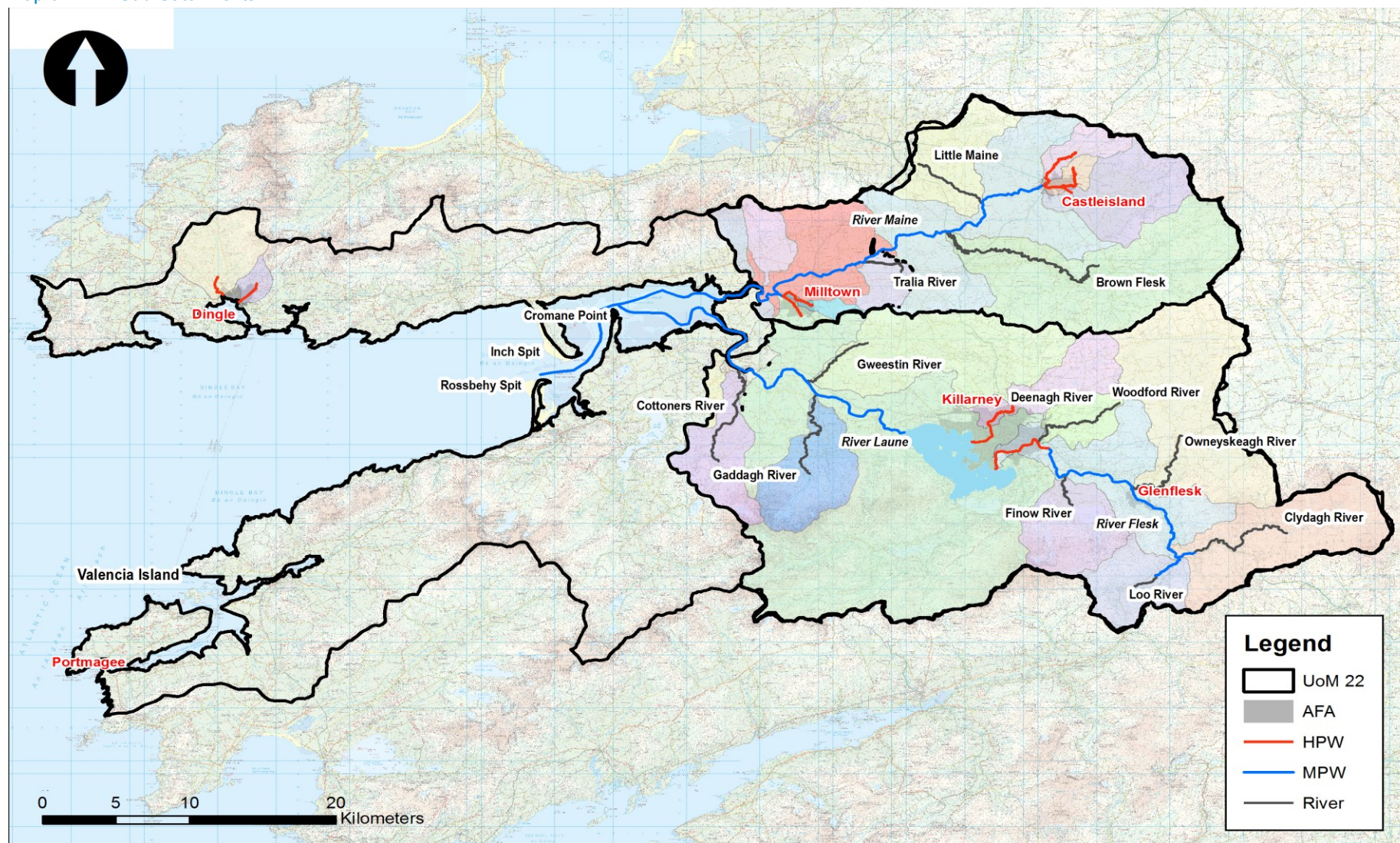
The River Maine, Laune and Dingle catchments were conceptualised into 99 sub-catchments based on the latest Flood Studies Update (FSU) database (supplied 2011). Map 6.1 displays the key sub-catchments for the River Maine, Laune and coastal areas at Dingle.

GIS spatial analysis was undertaken on the national digital elevation model to determine slope aspect and subsequently identify the watersheds for each catchment. The output from this GIS analysis was compared with the automated FSU catchment boundaries and verified against manual interpretation from Ordnance Survey mapping at 1:50,000 scale, previous hydrological reports, and observations from site visits. The other physical catchment descriptors were also reviewed including; average slope (S1085); average rainfall (SAAR); runoff indicators (SPR); permeability indicators (BFI); and attenuation (FARL). Information from the Geological Survey of Ireland (GSI) was also used to assess the impact of underlying geology and aquifers on permeability and groundwater dominance, as well as to inform those catchments influenced by karstic systems.

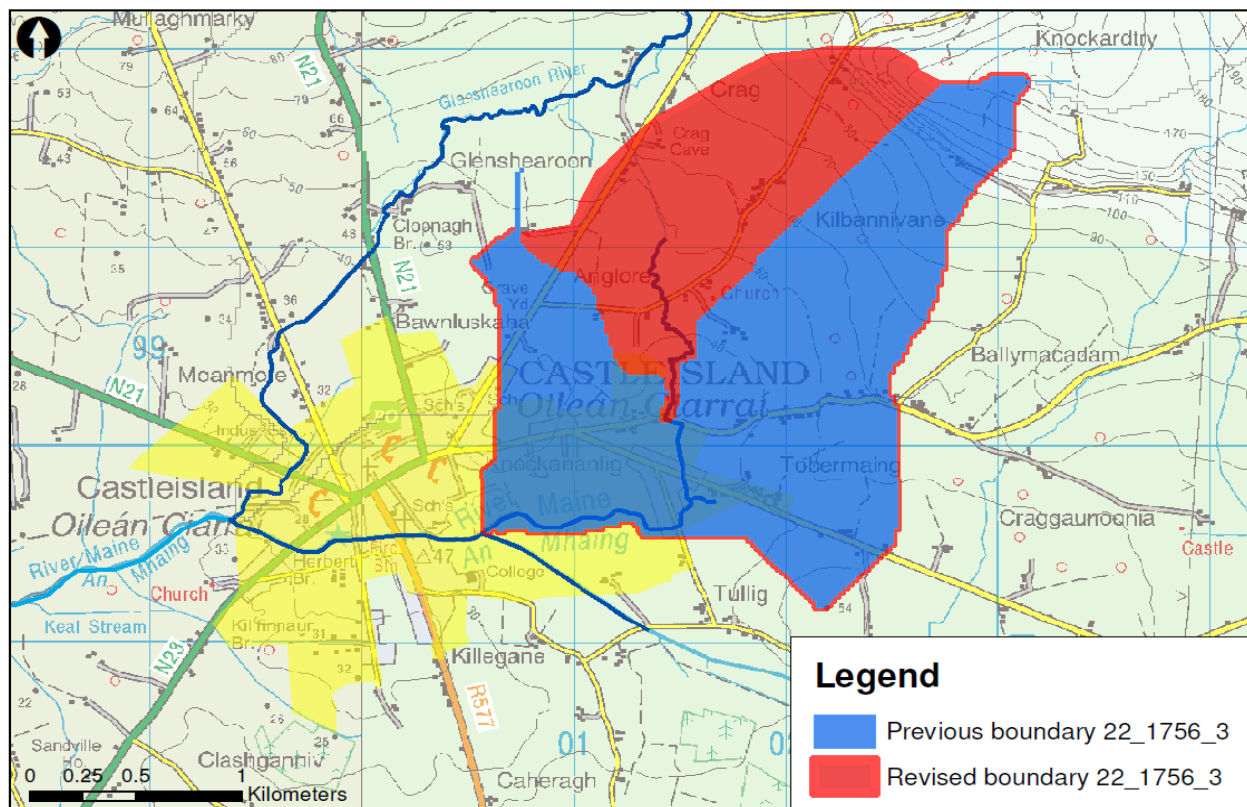
Overall, the automated FSU catchment boundaries were found to match the ordnance survey mapping well in areas of steep relief. The catchment area for Anglore Stream in Castleisland has been significantly modified so that it now flows south into the River Maine instead of the Glanshearoon Stream. The baseflow of Anglore Stream is fed by groundwater from the Crag Cave complex. The physical catchment descriptors have been adjusted accordingly (Map 6.2). The BFIsoils parameter was checked against the underlying geology and adjusted along the main River Flesk using the area weighting to improve the progression of QMED along the catchment.

The physical catchment descriptors for each of the HEPs are provided in Appendix C.

Map 6.1: Sub-Catchments



Map 6.2: Modifications to Anglore Stream Catchment, Castleisland



Where the terrain is flatter along the lower reaches of the River Maine the watershed is less distinctive. The analysis of the detailed LIDAR DTM and comments from the Local Authority indicated similar watersheds to the FSU catchments for the major tributaries within the embanked scheme, i.e. Inchiveema, Coolmealane, Traia, Ballygamboon, Annagh, Ashullish, Bootleans and Groin Streams. The smaller drained sub-catchments are considered as intervening flows along the Maine for the purposes of flood mapping. It was noted that extreme flood flows along the Ashullish Stream exited the defined catchment during flood. However, the area to the north-west was not deemed to contribute to the flows in the Ashullish Stream, therefore the catchment boundary was not altered.

Analysis of the catchment parameters for UoM 22 indicates that:

- The River Glen and River Maine through Castleisland are influenced by the underlying karstic system which not only controls baseflows but also provides subterranean flood routes during extreme events.
- The lower reaches of the River Maine have a higher proportion of artificial drainage in order to discharge agricultural drains during high tide on the River Maine.

- Flows along the River Laune downstream of Lough Leane are heavily attenuated by the Lough and have correspondingly low FARL values.
- The highest standard average rainfall is in the southern areas of UoM 22 which flows into Lough Leane; these are the areas of highest elevation.
- The fastest responding catchments are associated with steep slopes in and around Milltown causing rapid response to rainfall as seen in the past flood events.

All the modifications made to the original FSU database are highlighted in Appendix C.

6.3 Flood Frequency Analysis for Fluvial Flows

6.3.1 Methodology

The following sections discuss the analysis undertaken to derive the design fluvial hydrographs for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events as boundary conditions for the hydraulic modelling.

Gauged Sites

The index flood flow was derived from the median value of the Annual Maximum Flood Series (AMAX) at gauged sites within or linked to the AFAs, and compared with the FSU 7-variable QMED rural estimate (FSU WP2.3). Previous research for the FSR indicated that the index flood is proportional to $AREA^{0.77}$. This relationship was applied as a check to identify atypical QMED flows for catchment size.

The Extreme Values (EV1), logistic (LO), generalised logistic (GLO) and generalised extreme value (GEV) distributions were then fitted to the AMAX series to establish the most appropriate flood growth curve for %AEP up to twice the record length at the gauged location (FSU WP2.2). For rarer, more extreme events, hydrologically similar gauge sites were selected to form a pooling group based on the Euclidian distance measure (d_{ij}) between catchment characteristics at the gauged site. Descriptors considered include AREA, SAAR, BFISOILS, the ratio of the highest gauged flow to QMED, the presence of underlying karstic features and any issues highlighted by the OPW hydrometric team.

There were a limited number of appropriate gauged sites available to form the pooling sites for the smaller UoM22 catchments. Therefore, it was not always possible to find sufficient pooling sites of a similar size, BFI and SAAR, and the selection criteria had to be relaxed in order to achieve the target record length of 500 years (5 times the target 1%AEP). The selection of the pooling group was a balance between selecting hydraulically similar sites, maintaining homogeneity across the group and achieving the required record length. The pooled L-Moment average for each pooling group was then compared with the various distributions to guide the selection of the most appropriate flood growth curve.

Ungauged Sites

At ungauged locations, the $QMED_{rural}$ values were estimated using the 7 variable equation (FSU WP 2.3) based on gauged data from 190 sites across Ireland:

$$QMED_{rural} = 1.237 \times 10^{-5} AREA^{0.937} BFISOILS^{-0.922} SAAR^{1.306} FARL^{2.217} DRAIN2^{0.341} S1085^{0.185} (1 + ARTDRAIN2)^{0.408}$$

Where:

- AREA is the total contributing area of the catchment
- BFISOILS is an index of permeability
- SAAR is the Standard Annual Average Rainfall between 1961 and 1990
- FARL is an index of floodplain attenuation
- S1085 is the typical slope between 10% and 85% along the river reach
- ARTDRAIN2 is a proportion of the catchment which is artificially drained.

Pivotal gauged sites were then used to adjust the $QMED_{rural}$ as recommended by FSU WP 2.3. The pivotal gauged sites were selected from hydrologically similar gauges across Ireland with a preference for geographically close locations to better represent rainfall characteristics in the South West area. Hydrological similarity was guided by the similarity of physical catchment descriptors based on FSU hydrological guidelines:

- Area of pivotal site within a factor of 5 of the target ungauged HEP
- BFI soils index within 0.18 of the target ungauged HEP
- SAAR within a factor of 1.25 of the target ungauged HEP
- FARL within 0.05 of the target ungauged HEP

Grade A gauges were assumed to be of reliable quality unless otherwise stated by the FSU report or identified from a low highest gauged flow to $QMED$ factor. Grade B gauges were further assessed for the presence of lakes/reservoirs, significant karstified features and FSU quality of the gauge, to ensure the gauge was suitable to inform the adjustment of $QMED$ at the ungauged target HEP. The criteria for hydrological similarity were relaxed for smaller catchments or where FARL was abnormally high downstream of Lough Leane as such characteristics are not well represented in the current FSU database. The selection of the pooling group was a balance between selecting hydraulically similar sites, maintaining homogeneity across the group and achieving the required record length. The final pooled L-Moment average for each pooling group was used to identify discordant sites and select the most appropriate statistical distribution.

It should be noted that the FSU 7 variable equation was not developed for catchments less than $5km^2$ in size due to the lack of reliable gauge records for such small catchments in Ireland. Alternative methods, including the rational method, were found to better represent small catchments on average but tended to over predict peak flows for small lowland catchments (Institute of Hydrology 1978). The modified rational method (1981) is also not suitable to estimate greenfield runoff as it was developed specifically for sewer

design. The consensus from an exhaustive literature review was that it was not possible to verify the most appropriate methodology without gauged records. The FSU approach has been compared with the Rational method for catchments under 5km² in UoM22, taking into account the limitations with estimating reliable parameters and the routing of flows through the catchment.

6.3.2 Estimation of the Index Flood

The index flood flow was derived from the median value of the Annual Maximum Flood Series (AMAX) as provided by OPW at gauged locations (Table 6.2). The revised AMAX series at Castleisland gauge (22014) was used as derived from the revised rating curve in Chapter 5. It should be noted the QMED_{AMAX} at Riverville was calculated using the latest AMAX series provided by OPW which is significantly different to the flow series used in the FSU (2009).

Table 6.2: Gauged QMED Values

Gauge ID	Name	Watercourse	QMED	Years Data
22014	Castleisland	Maine	30	11
22003	Riverville	Maine	144	41
22022	Milltown	Milltown (Dingle)	23	11
22039	Clydagh Bridge	Clydagh	58	11
22006	Flesk Bridge	Flesk	173	57
22071	Tomies Pier	Lough Leane	108	39
22035	Laune Bridge	Laune	114	19
22009	White Bridge	Deenagh	12	28

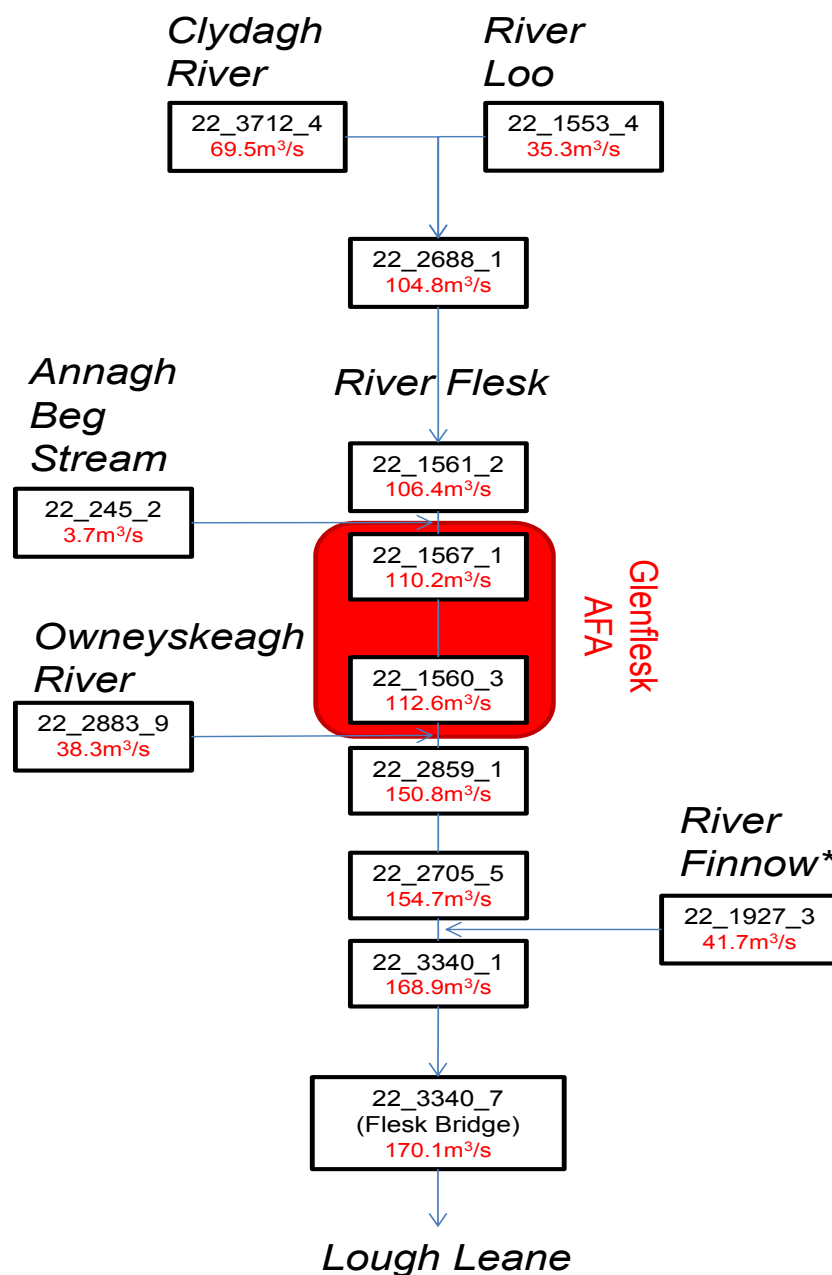
It is important to note that QMED decreases downstream in the case of Lough Leane. Flesk Bridge gauge has a higher QMED value at the inflow to Lough Leane, than Tomies Pier and Laune Bridge gauge at the outfall of Lough Leane. Whilst there is some uncertainty in the recording of high flows at Laune Bridge due to bypassing, this reduction in peak flow is principally due to the significant attenuation of Lough Leane itself which reduces peak flow and prolongs flood duration at the outfall for all events.

For ungauged sites, the QMED was calculated using the FSU 7 variable approach and adjusted using pivotal sites. Gauges 22003, 22022, and 22014 were typically used as pivotal sites in the Maine catchments. This was because they were hydrologically similar to the majority of HEPs and geographically located within the catchment meaning that their rainfall characteristics were similar as well. Gauges 22006, 22009, 22035, 22039 were typically used as pivotal sites for QMED in the Laune-Flesk catchment as they were hydrologically and geographically similar. It should be noted that 22009 (White Bridge) was deemed suitable for informing QMED but was rejected from pooling analysis for more extreme floods due to the suspected underestimation of out-of-bank flows.

Figure 6.1 provides the progression of QMED through the Flesk catchment as an example. The details of the selected pivotal sites, QMED estimate and schematics for all HEPs are provided in Appendix D along

with the 95th percentile upper limit. The upper confidence limit of QMED (95th percentile) has been calculated for each HEP based on the factorial standard error of 1.37 (see WP 2.3).

Figure 6.1: Example Schematic of QMED for the River Flesk



*Please refer to the following text for the explanation of the design inflow from the River Finnow

QMED was also checked to ensure the flows increase downstream with contributing area. An example schematic of the final QMED values for the Flesk catchment upstream of Killarney (Figure 6.1). The inflow from the River Finnow is greater than the difference between the QMED estimates upstream and downstream on the River Flesk. This discrepancy occurs because the River Finnow statistically peaks earlier than the River Flesk at this location as shown in Table 6.2 due to the storm track movement from northwest to southeast (Map 4.1). Therefore the inflows will be phased based on the typical travel time of 7 hours to meet the design target flows.

Table 6.3: Phasing of Inflows

Date	Time of Peak Flesk at Clydagh Bridge	Time of Peak Finnow at Dromickbane	Estimated time of peak on the Flesk @ Finnihy confluence (based on preliminary hydraulic model)	Time difference between Finnow and Flesk (Hours)
27/02/2000	07:30	07:15	13:30	-5.75
03/02/2004	08:00	05:30	14:00	-7.75
08/01/2005	21:15	19:30	03:15	-7.00
13/01/2006	05:00	22:00	11:00	-12.25
03/12/2006	23:15	23:45	05:15	-5.75
09/01/2008	17:00	15:15	23:00	-7.00
23/10/2008	14:00	12:45	20:00	-6.50
16/11/2009	02:45	04:30	08:45	-7.00
19/11/2009	15:00	12:45	21:00	-7.50
16/01/2011	19:30	17:15	01:30	-7.55
29/11/2011	09:45	07:45	15:45	-7.25

The recorded QMED values at gauges were also indexed to $AREA^{0.77}/10$ and factors were typically found to be between 8 and 29 across UoM22. The ungauged QMED values were also indexed and compared with the gauged factors in Appendix D. The White Bridge (22009), Laune Bridge (22035) and Tomies Pier (22071) gauges around Killarney tended to be lower than the typical ratio range. The lower than expected QMED values relative to area are partly caused by their relatively permeable catchments underlain by karstified limestone in this region. However, the lower ratios at Laune Bridge and White Bridge are likely to be caused by uncertainty in the AMAX series above bankfull as the current rating curves do not necessarily capture all bypass flows. The confidence limits and QMED:Area ratios will guide sensitivity tests on peak flow during the hydraulic modelling phase.

6.3.3 Derivation of Flood Growth Curves

Pooling groups of hydrologically similar sites were developed for each HEP and the pooled record was used in flood frequency analysis to develop the design flood growth curves as described in Section 6.3.1. The pooling group sites aimed to have AREA within a factor of 5; SAAR within a factor of 1.25 to 2 and BFI within ± 0.18 . The criteria were lowered for selection of pooling group sites in the smallest sub-catchments of Milltown and HEPs downstream of Laune Bridger to account for the low FARL values associated with Lough Leane. This more lenient approach was taken in order to achieve a balance between finding hydrologically similar sites and achieving the 500 years pooled record length from the target 1%AEP.

For each potential pooling group site, the presence of karstic geology was checked from the Geological Survey of Ireland data and compared with the BFIsoils parameter. Sites influenced by karst were not necessarily rejected as HEPs on the Maine, Flesk and Laune are also influenced by karst and were found to be hydrologically similar. However, gauges 19001, 19020, 21004 and 22009 were also rejected from pooling analysis due to the OPW's hydrometric team's concerns with the estimation of high flows at these sites.

Figure 6.2 provides an example of the flood growth plot at each HEP using the Flesk Bridge gauge on the River Flesk as an example. Figure 6.3 provides the corresponding L Moment plot of the pooled average. The full pooling group details used to derive the flood growth curves are provided in Appendix D.

Figure 6.2: Example Flood Growth Curve at Flesk Bridge Gauge (22006)

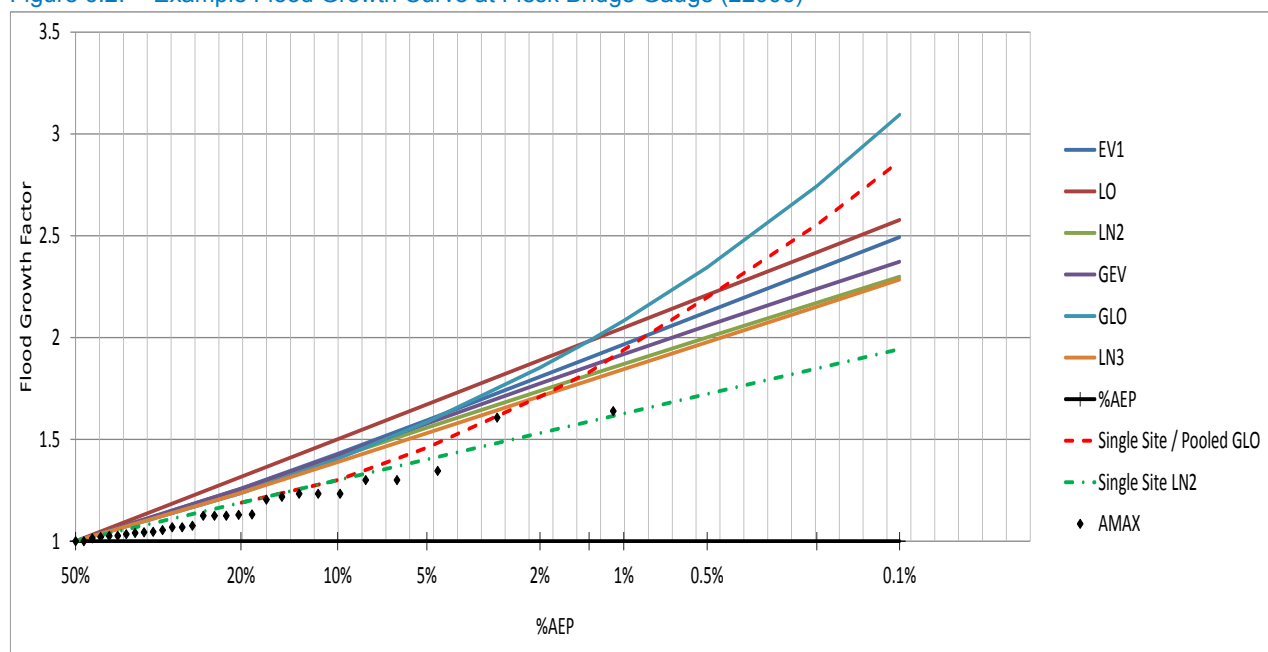
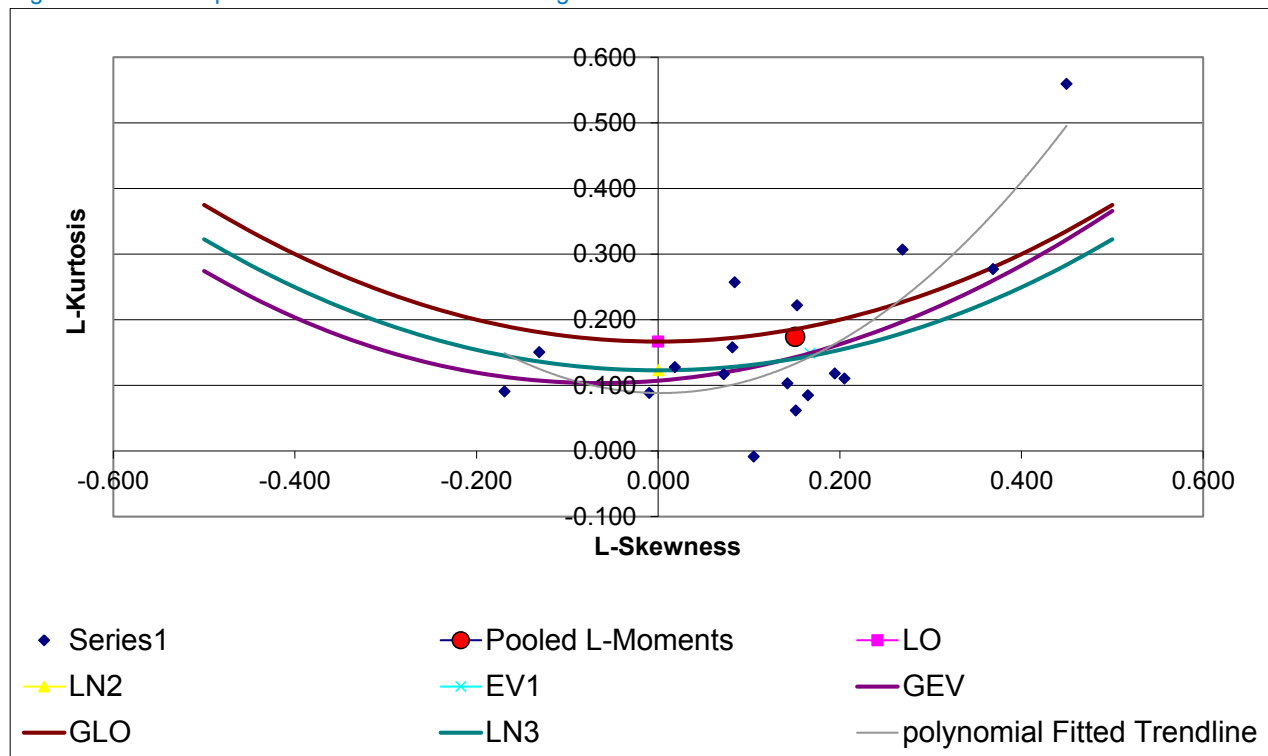


Figure 6.3: Example L Moment Plot for Flesk Bridge



The two largest AMAX events from 1978 and 1980 indicate a tendency towards the GLO distribution. The GLO is also the closest distribution to the pooled averaged. Therefore, a combination of the single site and pooled GLO flood curve was applied. In principle, the GLO curve was selected for the more extreme 0.5%AEP and 0.1%AEP as it was deemed to provide a more conservative estimate of peak flow which accounts for the uncertainty in the flood growth curve generation.

Appendix D summarises the detailed flood frequency analysis for the other reached in UoM22.

6.4 Hydrograph Generation

Flood extent, depth, velocity and hazard are governed by the shape and duration of a flood flow hydrograph as well as the magnitude of the peak flow. Therefore, design inflow hydrographs were derived at each HEP as follows.

At gauged locations, the hydrograph width analysis approach was used to derive the median flood hydrograph as the characteristic flood hydrograph for subsequent use in the hydraulic modelling and development of flood risk management options. The 15 minute flow data was extracted for each of the AMAX events at each fluvial gauge, standardised by the peak flow, and the width exceedance for each event derived at specified percentiles of the peak flow. The median of the width exceedance was then used to compile the design flood hydrograph. The design flow hydrograph could not be assessed at Castlemaine gauge (22002) because it is tidally dominated.

Figure 6.4 shows the progression of the design flood hydrograph shape between Castleisland gauge and Riverville gauge downstream in the River Maine catchment. The flood hydrograph duration increases from Castleisland to Riverville as would be expected with increasing contributing area. The rising and falling limb also become more prolonged and less flashy as the flood progresses down the catchment as there is greater attenuation of flow.

Figure 6.4: Progression of the Median Flood Hydrograph in the River Maine Catchment

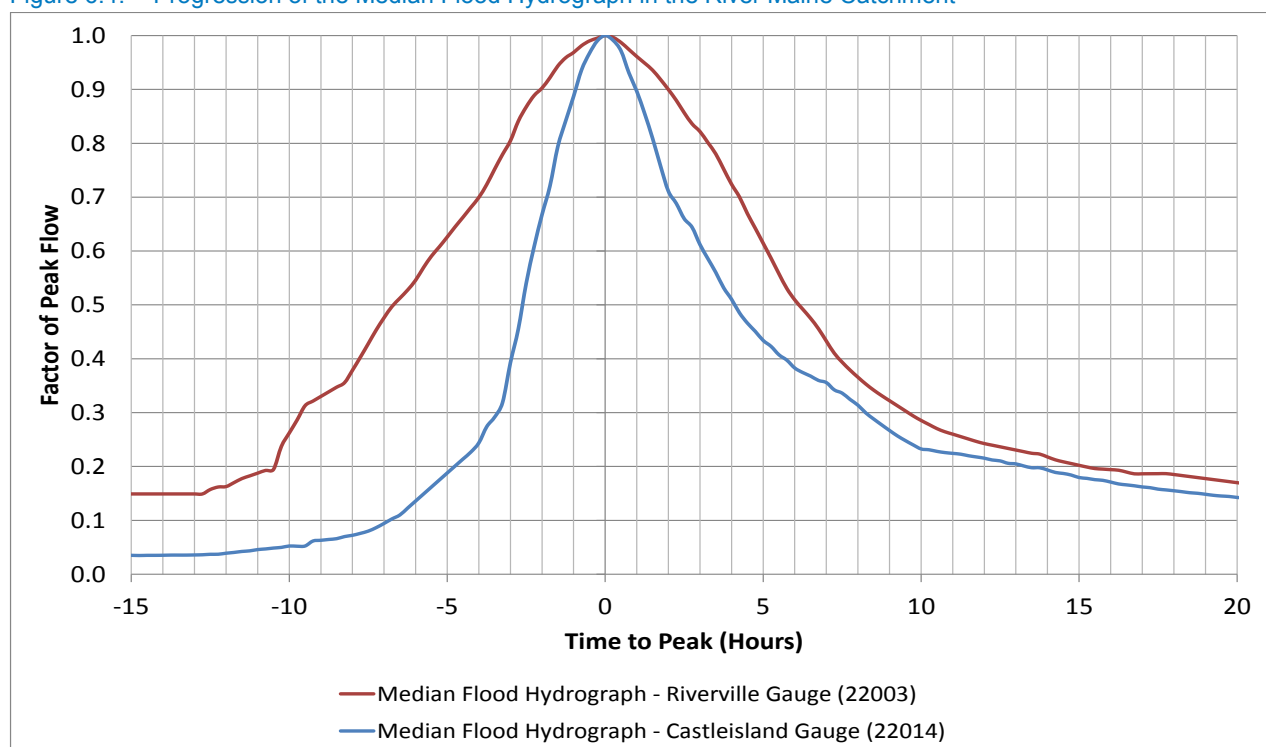
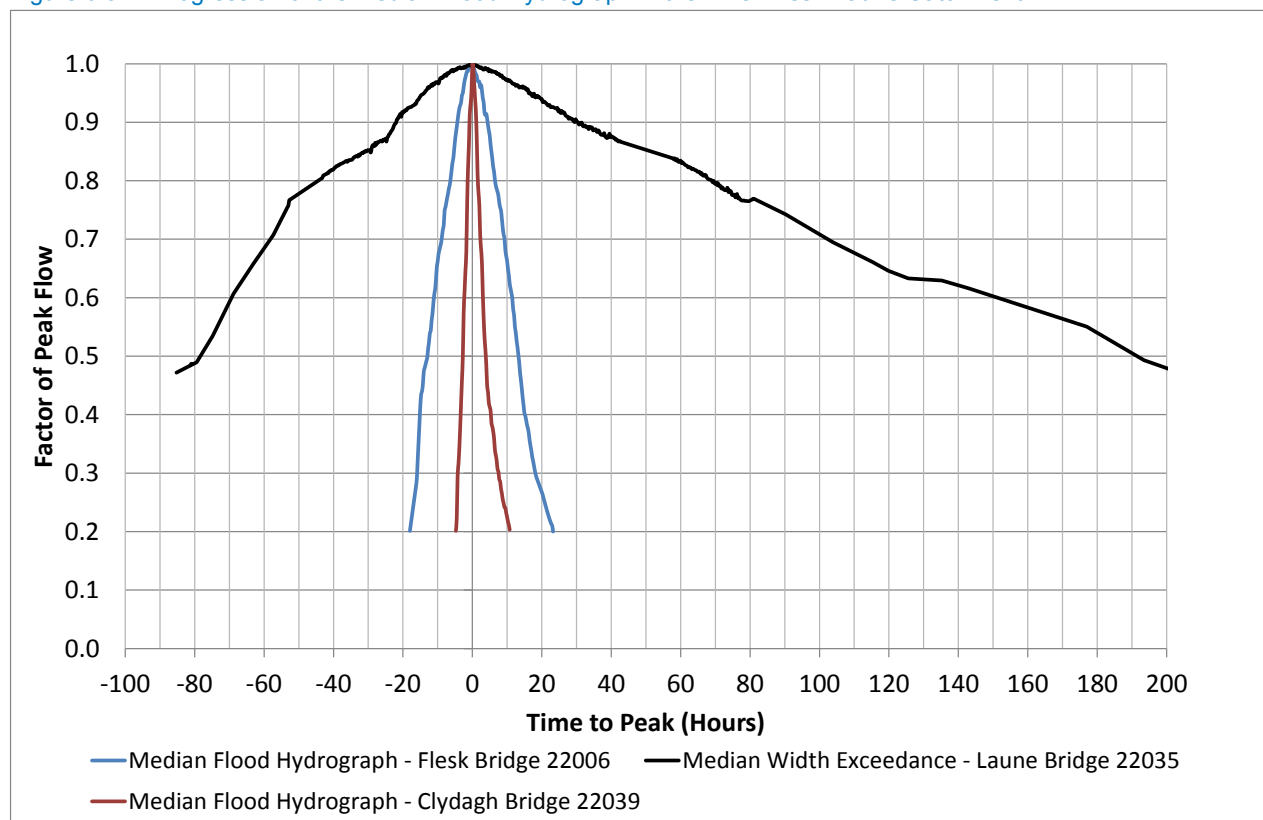


Figure 6.5 shows the progression of the design median flood hydrograph shape down the River Flesk and Laune catchment. The median flood hydrograph duration above 50% of peak flow increases from 6.5 hours in the upper reaches of the Flesk/Clydagh to 27 hours at Killarney to over 200 hours downstream of Lough Leane. The floodplain areas of the Flesk modify the hydrograph from an asymmetrical steep rising limb and longer falling limb at Clydagh Bridge to a more symmetrical rising and falling limb at Flesk Bridge. The large volume of Lough Leane has a significant attenuation effect on the flood hydrograph, prolonging high flows downstream on the River Laune.

It is important to note that Figure 6.5 compares the shape of the hydrograph as a factor of peak flow but in real terms, the attenuation of Lough Leane also reduces the peak as well as prolonging the duration (refer to Figure 4.1).

Figure 6.5: Progression of the Median Flood Hydrograph in the River Flesk-Laune Catchment



For the ungauged HEPs, the regression-based UPO-ERR-gamma curve was calculated from the physical catchment descriptors in accordance with FSU WP 3.1. The three components of the hydrograph are:

- Gamma Curve (Rising Limb) - n

$$y = \left(\frac{x + T_r}{T_r} \right)^{n-1} \left[\text{Exp} \left(-\frac{x(n-1)}{T_r} \right) \right]$$

- Inflection Point (Starting point of Recession Limb) - T_r

$$x_o = \frac{T_r}{\sqrt{n-1}} \quad y_o = \left(\frac{x_o + T_r}{T_r} \right)^{n-1} \text{Exp} \left(\frac{x_o(n-1)}{T_r} \right)$$

- Exponential Decay Curve (Recession Limb) - C

$$y = y_o \text{Exp} \left(-\frac{x - x_o}{C} \right)$$

The n , T_r and C parameters were estimated from the physical catchment descriptors for the study area and were used to derive an initial estimate of the flow hydrograph. The T_r and C values were subsequently adjusted based on hydrograph pivotal sites from the FSU database. Hydrologically similar sites were selected based on slope, attenuation and permeability and compared to the target sites catchment area, SAAR and critical duration to ensure similar responses to rainfall. However, the hydrograph pivotal site is not always the same as the QMED pivotal site, as the site available in the hydrograph database is smaller than the database used in the flood frequency analysis.

Pivotal sites 15003, 16005 or 36021 were typically selected for ungauged HEPs with smaller catchment areas and coastal locations, as these pivotal sites better reflected the flashy response with a steep rising limb. Pivotal site 23012 was typically selected for the larger main rivers as it best represented the median flood duration of over 200 hours at Laune Bridge.

The details of the selected pivotal sites and resultant design flood hydrographs for each reach are provided in Appendix D.

6.5 Lough Leane

The assessment for Lough Leane is a special case. Extreme value flood frequency analysis has been undertaken to determine design lake levels for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events. This approach provides an accurate estimate of design water levels without the need for extensive bathymetric survey of the Lough itself. Furthermore, this analysis of gauge level is preferred over 1D and 2D hydraulic modelling which take assumptions that simplify lake storage and complex lake currents. The design water levels will subsequently be used to inform the hydraulic model of Killarney and flood mapping of Lough Leane itself.

Over 38 years data was available at Tomies Pier and BVM Park following the revision of the water level series at Tomies Pier to remove the 3m datum shift described in Chapter 3. This represents a sufficiently long record that captures a range of extreme flood levels to enable statistical analysis. The index flood levels have been determined as the median annual maximum water level at each level gauge. The resultant index flood level for each applicable gauge is provided in Table 6.3 below. There is no appreciable variation in water level across Lough Leane at the 50%AEP (index flood level).

Table 6.4: Index Lough Leane Flood Level

Gauge ID	Gauge Name	Location	Index Flood Level	Years Data
22071	Tomies Pier	Lough Leane Outfall	19.23	37
22082	BVM Park	Lough Leane Muckross	19.23	38

Extreme value flood frequency analysis has been undertaken on the AMAX level series to derive a single site flood level growth curve using the 2-parameter and 3-parameter statistical distributions described in Section 6.3. Figure 6.3 presents the flood growth curves considered at Tomies Pier. The plot for BVM Park is included in Appendix D.

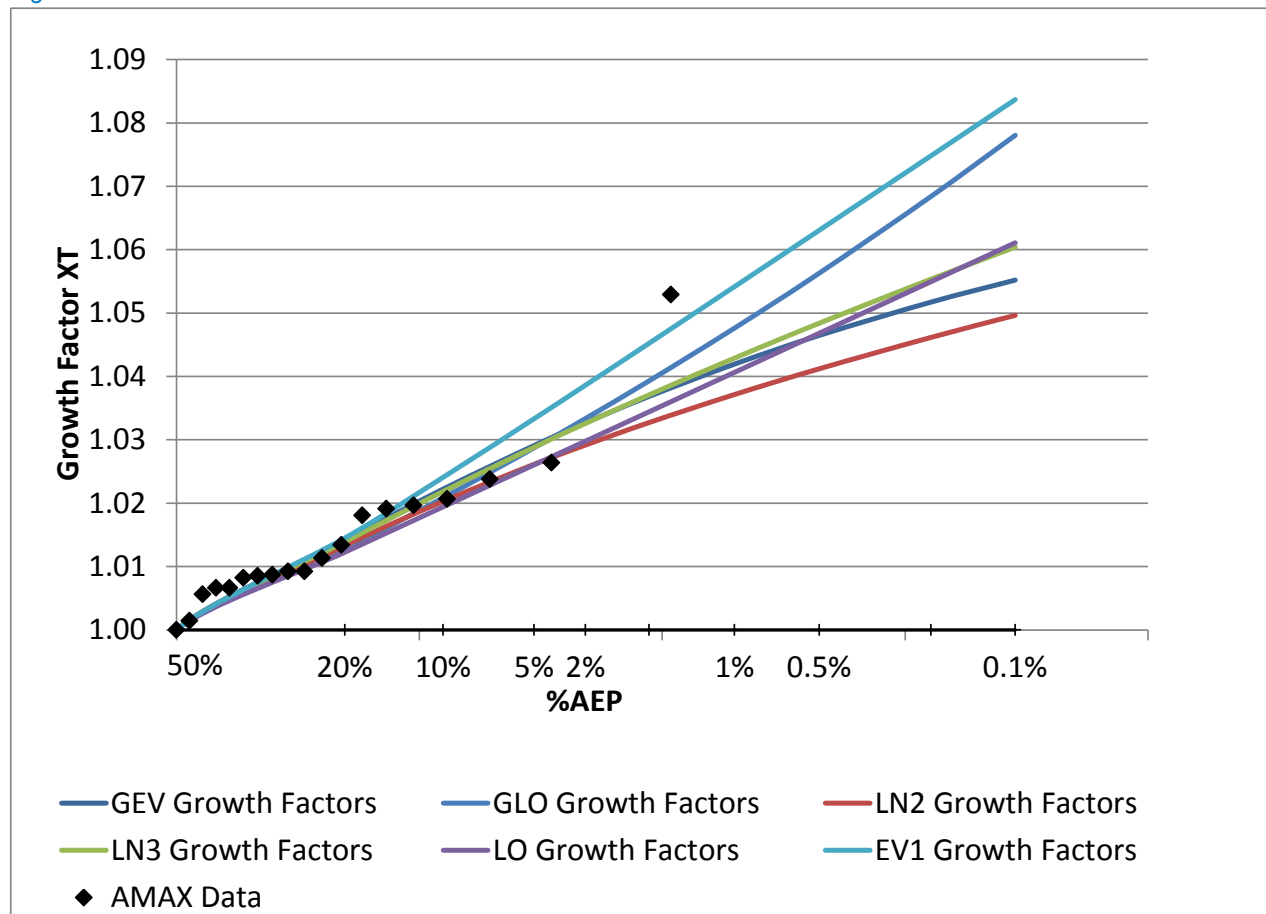
The 2009 event has a determining effect on the selection of the flood growth curve as the largest recorded flood level. The 2009 event could be described as an outlier. However, there is a large body of anecdotal records, photos and videos to validate this extreme flood level in the historic flood evidence. Therefore, the 2009 event has been included in the analysis. The gauge date for the 2009 event indicated a 0.02m rise from 20.24m at BVM Park to 20.26m at Tomies Pier.

Including the extreme 2009 event, the EV1 flood growth curve is the best fit to observed data as a conservative estimate of flood levels and therefore flood risk around Lough Leane. It is important to note that there is a lack of extreme water levels to verify the flood growth for extreme events such as occurred in November 2009. Analysing the confidence limits of the single site flood growth curves, the November 2009 event water level could vary anywhere between the 3%AEP and the 0.2%AEP estimate. However uncertainty for the 50%AEP to 5%AEP is much less (< 0.2m) as this is within the 38 year record.

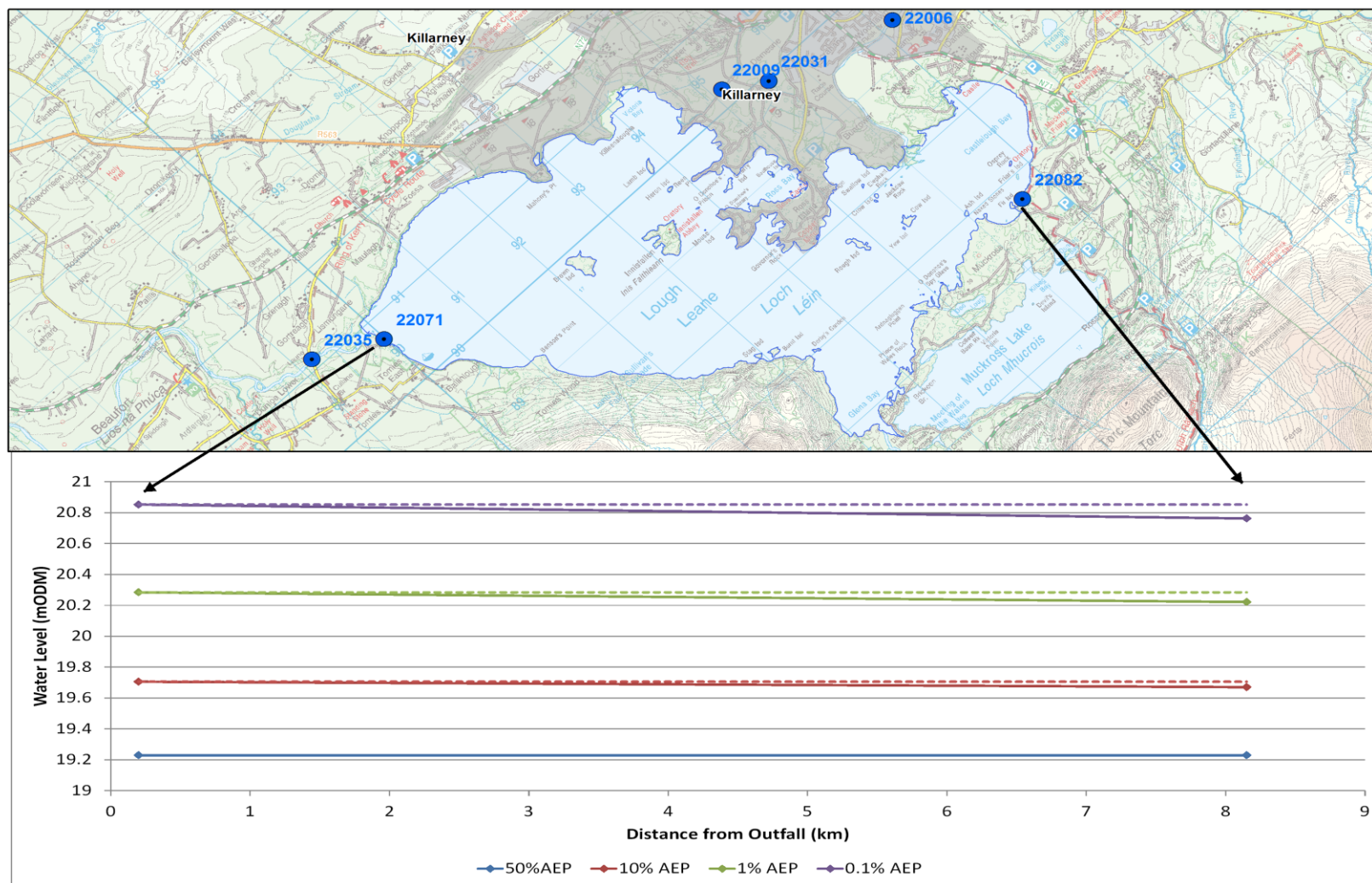
Map 6.3 presents the final extreme water level profiles for Lough Leane. Appendix D contains the detailed flood frequency analysis at each gauge. Given the scatter in the data and limited data on other large

events, a flat water level profile between BVM Park and Tomies Pier has been assumed as a conservative estimate for extreme events (represented by the dashed lines in Map 6.3).

Figure 6.6: Flood Growth Curves at Tomies Pier



Map 6.3: Design Water Level Profile for Lough Leane



6.6 Coastal Conditions

6.6.1 Total Tide plus Surge Levels

Extreme sea levels around the Irish coastline incorporate both the astronomic tide (caused by planetary forcing) and storm surge elements (caused by atmospheric pressure), henceforth referred to as “total tide plus surge levels”. The flood frequency analysis for extreme sea levels has already been undertaken as part of ICPSS (2012) for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events.

Dingle AFA

In Dingle, the ICWWS assumed the same total tidal plus surge levels within Dingle Harbour as the ICPSS point SW22 in Dingle Bay. In the absence of gauged data, the CFRAM Study has assumed the same transformation and used ICPSS point SW22 to define the total tide plus surge levels at Dingle AFA.

Portmagee AFA

There is very limited gauge or port data about the variation in water level from Dingle Bay around Valentia Island to the Memorial Bridge Crossing at Portmagee. Therefore, the CFRAM Study has assumed the greater total tide plus surge levels at ICPSS point SW16 near Knightstown as a conservative estimate of coastal risk for Portmagee.

Castlemaine Harbour (Maine and Laune MPW)

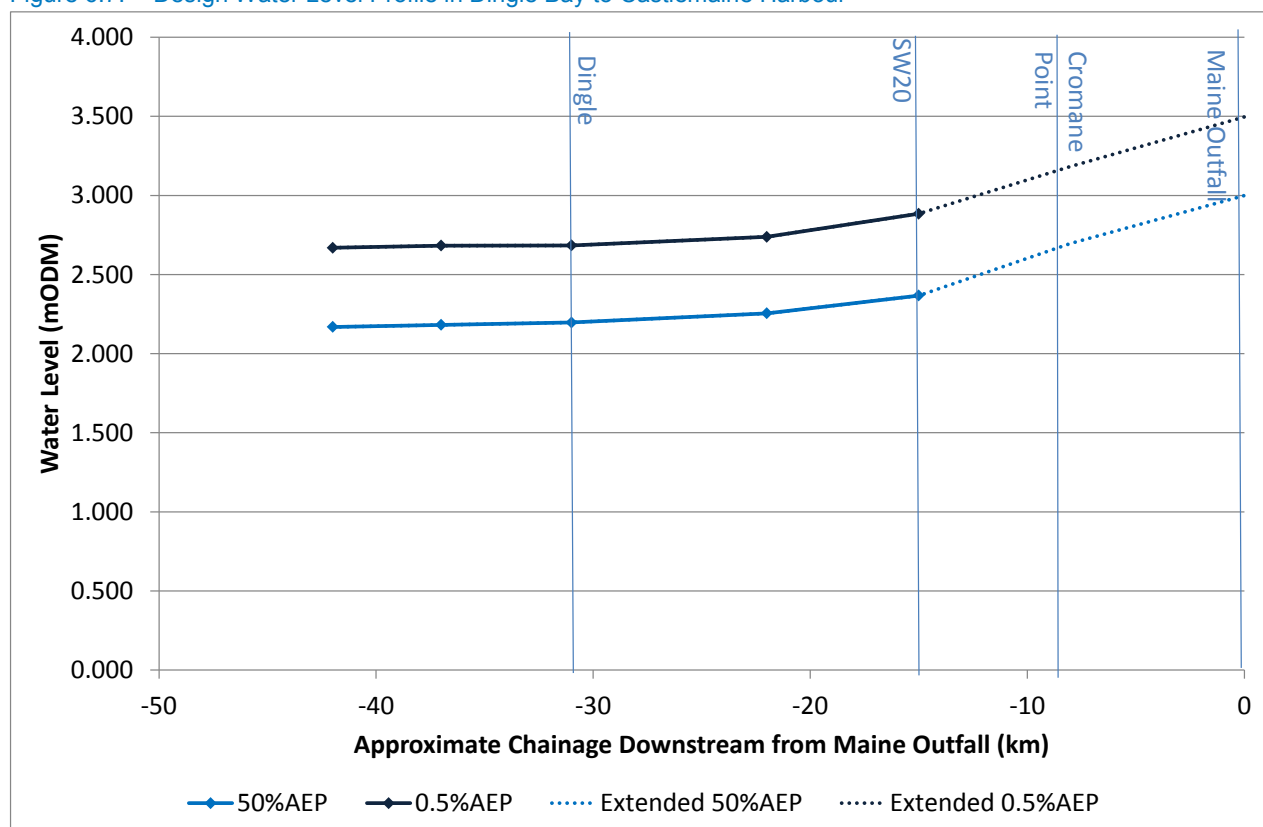
Castlemaine Harbour forms the downstream reach of the River Maine and River Laune from Roscullen Point at the river outfalls to the open sea at Inch Point and Rossbehy Point. It was agreed that horizontal projection of design water levels provided sufficient details to map flood extent and depth without the need for detailed bathymetric survey to inform extensive two or three dimensional modelling which would otherwise be required to simulate the variable flow currents within the harbour.

Estimates of the total tide plus surge levels are not currently available for inside of Castlemaine Harbour. Therefore, the MHWS water level profile has been estimated from analysis of the following:

- Admiralty prediction points at Dingle and Cromane Point.
- The median water level of the annual maximum series at the tidally dominated Castlemaine gauge, 9km upstream of the Maine outfall.
- The calibration of tidal progression up the Maine to achieve the October 2008 event levels at Castlemaine gauge which indicates a 0.2m difference in water levels to the Maine outfall for frequent tidal events.
- However a larger increase of up to 0.5m is required to match the frequency of water levels at Castlemaine gauge.

Figure 6.7 presents the MHWS water level profile which shows an increase of approximately 0.7m from Dingle to Cromane Point to the Maine outfall to meet the frequency of levels at Castlemaine gauge for larger magnitude events. It should be noted that the tidal river banks from the Maine outfall to Castlemaine Bridge have a variable standard of protection. Therefore the water increase between AEP events at Castlemaine gauge lessens with larger magnitude events as water overtops the tidal banks.

Figure 6.7: Design Water Level Profile in Dingle Bay to Castlemaine Harbour



6.6.2 Design Tidal Curve

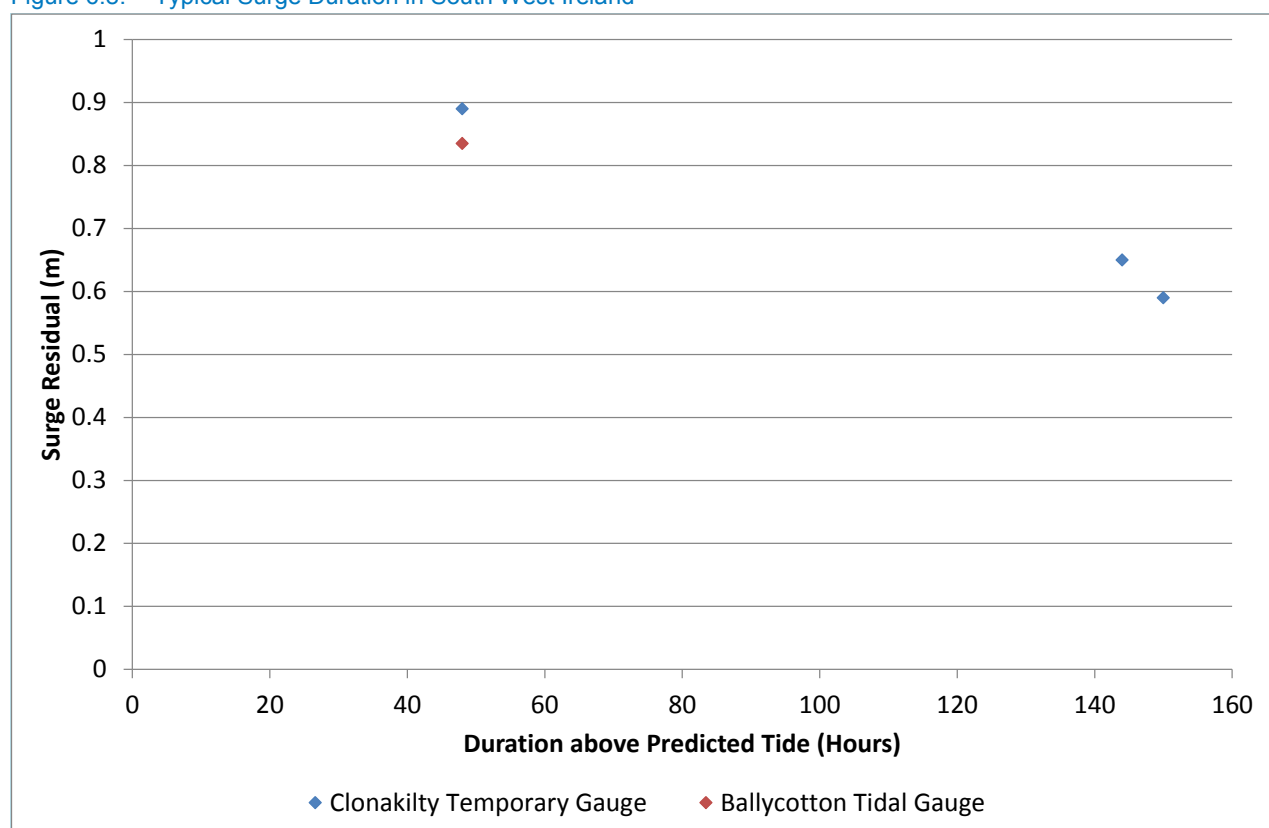
The shape of the astronomic curve defines the duration of the rising (flood) and falling (ebb) tide. In deep water the astronomic curve can be assumed to be largely symmetrical depending on the relative phasing of the various harmonic components. However, the shoaling of the tide in shallow estuarine areas can modify the shape.

The admiralty tide tables³ were used to inform time differences in mean high water and low water between the primary port (Cobh) and the local prediction points at Dingle, Cromane Point and Knightstown to modify

³ United Kingdom Hydrographic Office (2013) Admiralty Tidal Tables Volume 1, 2013.

the astronomic tidal curve. Storm surges caused by Atlantic storms can often cause elevated sea levels over several diurnal tidal cycles. Surge residuals were calculated from the tidal gauge data along the south west coast for the most extreme events (Figure 6.8). The larger surge residual has a duration of approximately 48 hours or 4 tidal cycles. The 48 hour duration has been assumed as a credible duration for an extreme surge event and a symmetrical surge profile assumed in the absence of detailed gauge data in Dingle Bay.

Figure 6.8: Typical Surge Duration in South West Ireland



The design surge profile was then standardised by the peak surge residual and scaled on top of the astronomic curve to achieve the design extreme sea levels (Figure 6.9). It was assumed that the peak of the surge and the peak of the spring astronomical high tide coincide. This provided a conservative estimate of the combined tidal curve. It is recognised that the peak of the astronomic tide does not necessarily correspond with the peak surge as they are governed by different mechanisms. However, without long term tidal and surge residual data along the South West coast it is not possible to assess the joint probability between these two elements

Figure 6.10 displays the combined tidal curves for the design 50%AEP event in Dingle Bay.

Figure 6.9: Example Tide Plus Surge Curve Generation at Knightstown

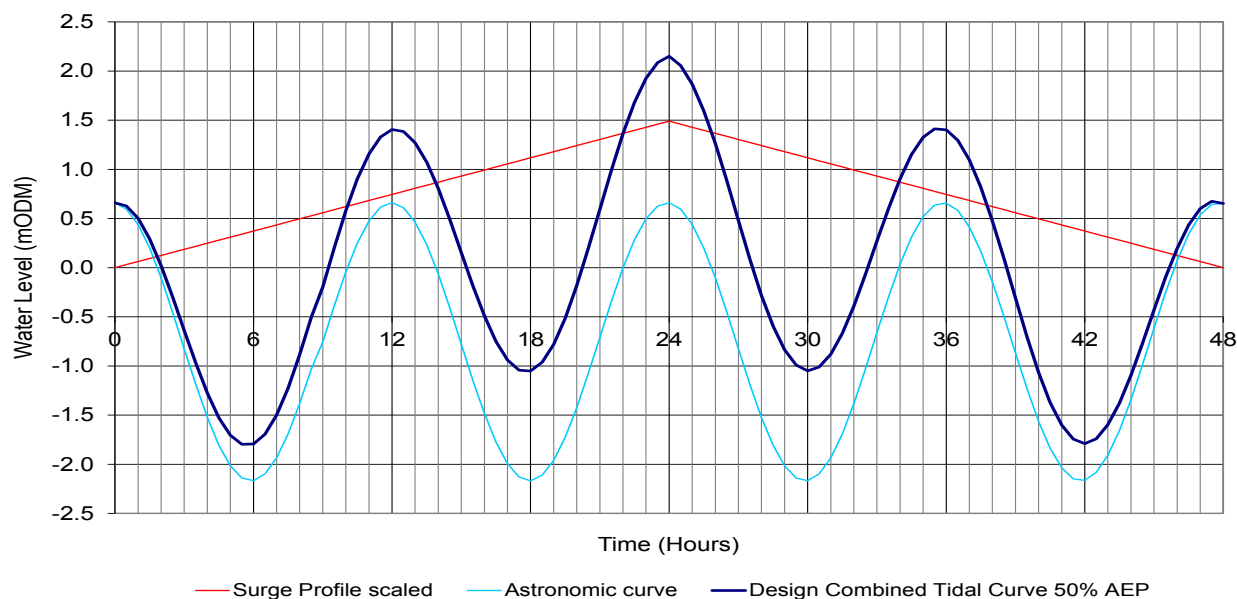
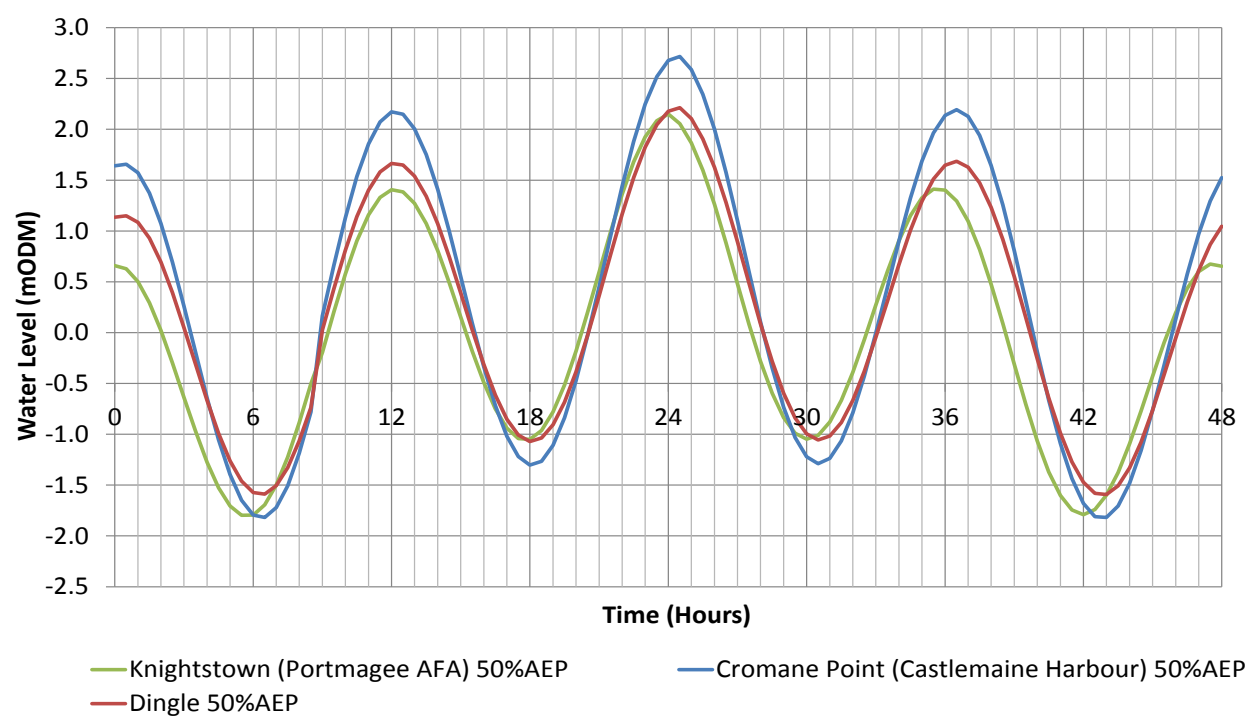


Figure 6.10: 50%AEP Design Total Tide Plus Surge Curves



6.6.3 Wave Overtopping

The ICWWS identified one reach that was potentially vulnerable to wave overtopping within Dingle AFA. No other AFA in UoM22 was found to be potentially vulnerable to wave overtopping according to the ICWWS data.

The source-pathway-receptor model can be readily applied to wave overtopping:

- Source – wave overtopping volumes based on wave run-up spilling over the coastal frontage
- Pathway – flow path of the wave overtopping discharge from the coastal defence to the receptors considering topography behind the defence.
- Receptors – roads, properties, environmental designations etc. affected by the wave overtopping and their relative location to the wave overtopping.

A screening process was undertaken for the vulnerable reaches and three approaches to assessing wave overtopping were developed for the CFRAM study:

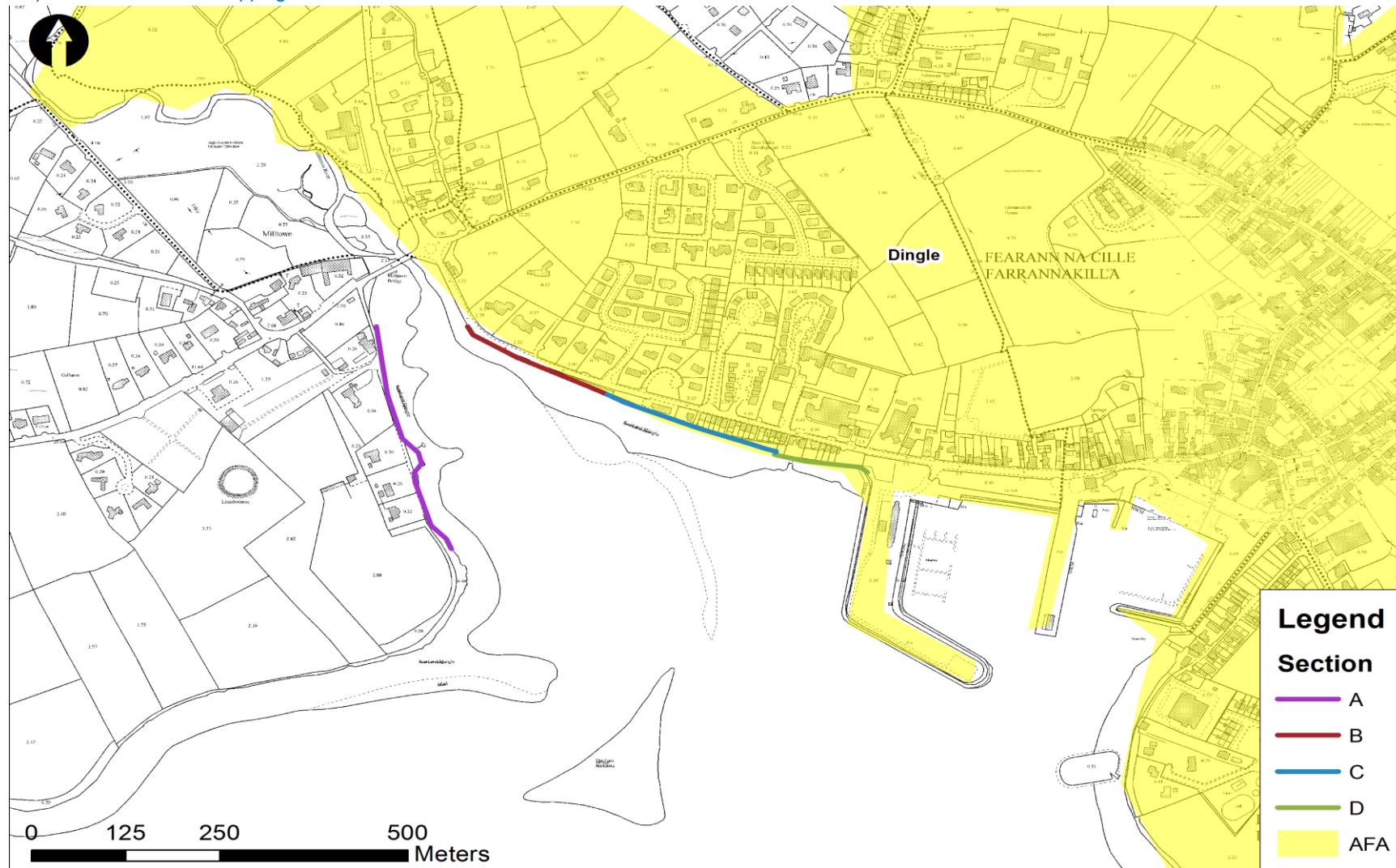
- Wave overtopping unit discharges – the calculation of unit discharge is sufficient to inform flood risk where wave overtopping volume is insufficient to flow down the backslope of coastal defences or the water would immediately drain back to the sea due to high relief inland.
- Mapping of wave overtopping volumes – the mapping of total wave overtopping volumes is required where wave overtopping discharges are able to flow down the backslope of coastal defences to affect receptors, often in locations where the defences are above the coastal floodplain.
- No consideration of wave overtopping – wave overtopping calculations are not required where still water overtopping (Mechanism1) dominates as the additional volume from wave overtopping can be considered negligible in comparison with the limitless volume of the incoming tide.

The ICWWS split Dingle into four sections of similar crest height and defence type (Map 6.4). Table 6.5 outlines the approach for each section based on the criteria above.

Table 6.5: Wave Overtopping Approach

Reach	Source	Pathway	Receptors	Approach
A	Wave overtopping of a stone block near vertical slope	No coastal floodplain present – Flows along the road and drains immediately back to the sea	Road adjacent. Properties located significantly upslope.	Wave overtopping unit discharge
B	Wave overtopping of a stone block near vertical slope	No coastal floodplain present – Flows along the road and drains immediately back to the sea	Road adjacent. Properties located significantly upslope.	Wave overtopping unit discharge
C	Wave overtopping of a vertical concrete wall	No coastal floodplain present – Flows along the road/adjacent properties and drains immediately back to the sea	Road and a few properties adjacent. Urban area of Dingle located upslope.	Wave overtopping unit discharge
D	Wave overtopping of a vertical concrete wall	No coastal floodplain present – Flows along the road/adjacent properties and drains immediately back to the sea	Road and a few properties adjacent. Urban area of Dingle located upslope.	Wave overtopping unit discharge

Map 6.4: Wave Overtopping Reaches



The wave overtopping discharges were calculated for the Dingle sections using empirical equations of wave run up for vertical walls and general hydraulic principles to fully account for the transition from the valid limit of the empirical equations (mechanism 2) to full still water overtopping (mechanism 1). The six different combinations of total tide plus surge levels and wave heights from the ICWWS were assessed to find the critical scenario for wave overtopping for each AEP. Table 6.6 summarises the critical discharges for the target %AEP events. Full details of the analysis for all scenarios can be found in Appendix D.

Table 6.6: Critical Wave Overtopping Unit Discharges for Key %AEP

Reach	Defence Type	Effective Crest Level (mODM)	10%AEP	Unit Discharge (l/s/m)	
				0.5%AEP	0.1%AEP
A	Stone block vertical with ineffective wall Road assumed to be effective crest	2.52	0.12	Tide plus surge overtops crest Mechanism 1 dominant	Tide plus surge overtops crest Mechanism 1 dominant
B	Stone block vertical with ineffective wall Road assumed to be effective crest	2.53	0.12	Tide plus surge overtops crest Mechanism 1 dominant	Tide plus surge overtops crest Mechanism 1 dominant
C	Concrete vertical wall	3.75	<0.001	0.17	0.52
D	Concrete vertical wall	3.47	<0.001	1.38	1.63

7 Hydrological Calibration, Sensitivity Testing & Limitations

7.1 Calibration Events

7.1.1 Selection of Events

Historical flood evidence was collated for those events listed in Chapter 4 from previous studies, post-flood surveys and anecdotal evidence from local residents during the Flood Risk Review. Table 7.1 scores each of these events based on a number of criteria related to the location, hydrology and data availability on a scale of 0 to 3 where:

- 0 is not available
- 1 is poor or unlikely
- 2 is fair or possible
- 3 is good or likely

These scores are then combined to create an indicative calibration score for the available historical flood evidence in accordance with Guidance Note 23⁴. The following events have been considered for the calibration based on the indicative calibration score:

- 2nd November 1980 – extreme fluvial event in Killarney and Lough Leane.
- 4th October 2008 – extreme fluvial event in Castleisland and along the River Maine.
- 19th November 2009 – extreme fluvial event in Killarney, Lough Leane and the River Laune.

In all cases, there are limited spot levels, wracks marks and photos to calibrate the floodplain in AFAs limiting full 1D-2D calibration to those events stated above. However, there are a number of in-bank events which can be calibrated along the Maine and Laune catchments based on the gauged data only. These include:

- 12th January 2010 – River Maine Catchment
- 1st February 2002 – River Maine Catchment
- 4th January 2008 – River Maine Catchment
- 26th October 2008 – River Laune Catchment

The calibration in the Killarney and the Laune catchment and Castleisland and the Maine catchment will be supplemented by verifying the modelled outline such that there is “reasonable” representation of the historical flood frequency and sensitivity analysis on the key hydraulic parameters used in accordance with GN23.

The calibration of Dingle, Milltown and Portmagee will be based entirely on the verification of modelled outline to historical flood frequency (where available) and sensitivity analysis on the key hydraulic parameters.

The following section details the hydrology derived for the three events identified for the full AFA calibration. The inflows for the in-bank events have been derived directly from the gauged records which are provided in Appendix E.

⁴Jacobs, (January 2013) Guidance Note 23 Model Calibration. Version 1.

Table 7.1: Selection of Calibration Events

Event	Location/ Watercourse	Likely Accuracy of Flow Estimate ¹	Likely Accuracy of Gauged Level Estimate	Known Hydraulic Conditions ²	Likely Accuracy of Spot Check ³	Reliable Flood History ⁴	Indicative Calibration Score	Calibration Approach
02/11/1980	Glenflesk, Killarney/River Flesk No records of flooding on the Deenagh	3	3	2	0	1	9	Largest flood on record at Flesk Bridge. Calibrate main channel to large event data. Smaller tributaries such as Woodford River should take note of uncertainties due to blockage.
06/08/1986	Killarney/River Flesk	3	3	0	0	1	7	Reasonable quality. However, use more recent events with known hydraulic conditions
01/01/1988	Dingle/Dingle Stream	1	0	0	1	2	4	Significant hydraulic structures changes assumed since 1988. Modelled outline to reflect reasonable historic flood frequency otherwise use sensitivity tests to assess hydraulic parameters.
17/02/1997	Killarney/River Flesk River Laune	3	3	0	0	1	7	Reasonable quality. However, use more recent events with known hydraulic conditions.
01/02/2002	Castlemaine/River Maine	N/A Tidal	3	1	0	0	4	Insufficient evidence for this event to calibrate flood level and extent beyond channel. Use sensitivity tests to assess hydraulic parameters.
04/01/2008	Milltown/Ashullish- Ballyoutragh	1	0	2	1	2	6	Modelled outline to reflect reasonable historic flood frequency otherwise use sensitivity tests to assess hydraulic parameters.
04/10/2008	Castleisland/River Maine-Glanshearoon	3	3	2	0	2	10	Calibrate main channel to large event data. Flows along Anglore stream should take note of uncertainties with % of Glanshearoon flow through the Crag Cave complex.
19/11/2009	Killarney/River Flesk and Deenagh Lough Leane	3	3	2	0	2	10	Calibrate main channel to large event data. Smaller tributaries such as Woodford River should take note of uncertainties due to blockage.
15/01/2011	Killarney/River Flesk	3	3	0	0	1	7	Latest gauge data has not been fully approved by hydrometrics and hydraulic conditions of bridges are unknown.

Note 1: 3 = gauged flows are available in the catchment, 2 = gauged flows used from pivotal gauges nearby, 1 = rainfall data used to estimate flows and 0 = no flow estimate available

Note 2: Hydraulic conditions relate to controls on water levels during a flood e.g. level of blockage, wall collapse etc.

Note 3: Levels during a known flood event NOT at a gauged location that represents a true flood level rather than a localised issue.

Note 4: Any information that includes date/time, precise location and mechanism of flooding.

7.1.2 Calibration Hydrology Approach

The general approach to derive representative flow hydrographs for the selected calibration events at gauged locations was undertaken in the following steps:

- Derive the flood frequency estimate (%AEP) for the event based on reliable gauge data within the catchment and at nearby gauges based on the process discussed in Chapter 6.
- Extract the recorded flow hydrograph at reliable gauges and apply at gauged inflows.
- Adjust the phasing of the tributary inflows to achieve the flow hydrograph at known gauged points.

The following steps were undertaken to derive the hydrographs for the ungauged HEPs:

- Transfer the representative rainfall profile from the hourly data at Valentia Observatory to the gauged locations based on the ratio of the 24hour rainfall total at each AFA.
- Derive the FSSR16 catchment average rainfall parameters for the gauged catchment from Met Eireann DDF results and physical catchment descriptors.
- Apply the transferred rainfall profile and derived parameters to estimate the flow hydrograph at the gauge.
- Adjust percentage runoff and catchment wetness index to calibrate the rainfall-runoff flow hydrograph to the recorded flow hydrograph at the gauge.
- Derive the FSSR16 catchment average rainfall parameters for the ungauged HEPs from Met Eireann DDF results and physical catchment descriptors.
- Apply the calibrated percentage runoff, transferred rainfall profile and derived parameters to derive the rainfall-runoff flow hydrograph at the ungauged HEPs.
- Adjust the phasing of the ungauged HEPs to achieve the flow hydrograph at reliable gauged points.

It should be noted that a Theissen polygon approach was not feasible due to the limited rainfall data as presented in Appendix A. However, every effort has been made to account for spatial and temporal variability based on the available daily rain gauges and the more detailed output from the river flow gauges. The calibrated rainfall-runoff flow hydrograph at Castleisland gauge for the October 2008 event is shown in Figure 7.1 and calibrated rainfall parameters are presented in Table 7.2 as an example. The details of the rainfall-runoff parameters for the ungauged HEPs for the other calibration events are provided in Appendix E and variability of rainfall presented in Appendix A.

The peak flow and phasing of the FSSR16 hydrograph matches well with the recorded gauge data at the peak. However, the falling limb or flood recession recorded at the gauge is affected by the Glanshearoon inflow 105m downstream of the gauge which is not considered in the FSSR16 rainfall runoff methodology. The hydrograph at Castleisland gauge will be further calibrated by phasing the Glanshearoon inflow hydrograph to reflect the impacts of backwater.

Figure 7.1: FSSR16 Calibrated October 2008 Hydrograph

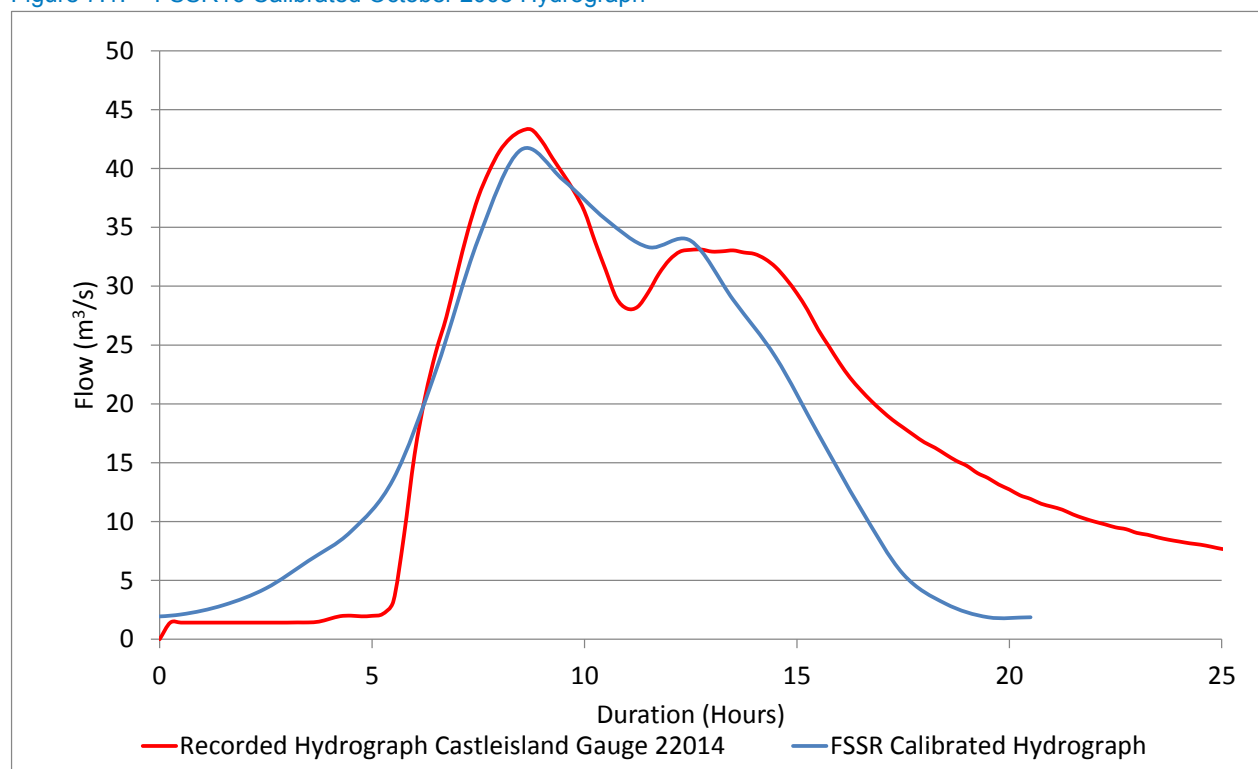


Table 7.2: Calibrated FSSR16 Parameters for 4th October 2008

FSSR 16 Parameter	Default Parameters at Castleisland Gauge (22014)	Calibrated Parameters at Castleisland Gauge (22014)
M5 - 2 day (mm)	68.400	68.400
M5 -25 day (mm)	247.100	247.100
Jenkinson's <i>r</i>	0.251	0.251
Catchment Wetness Index (CWI)	125	125
Standard Percentage Runoff	32%	60%
Storm Duration, D (hours)	15	15
Time to peak, T _p (hours)	4.35	3.09

7.2 Sensitivity and Uncertainty Testing

The SW CFRAM study requires an understanding of sensitivity in hydrological and hydraulic parameters in order to inform the uncertainty analysis in the flood mapping process. The key areas of uncertainty in the hydrological analysis of UoM22 are:

- Uncertainty in the QMEDrural regression equation;
- Uncertainty in the pooling group and statistical distribution used to estimate the flood growth curve;
- Uncertainty in the water levels representing Lough Leane in combination with the river flows;
- Uncertainty in the transformation of water levels from offshore to nearshore point where there is no gauge data.

All sensitivity analysis has been assessed at the 1%AEP as this is the target fluvial AEP for the CFRAM study and the AEP event used in planning decisions. Uncertainty in flow and level for more frequent events are considered within the error bounds for the 1%AEP.

Sensitivity in Peak Flow

The FSU WP 2.3 states a factorial standard error (FSE) of 1.37 in the QMED rural regression equation based on the 190 gauges across Ireland used to derive the equation coefficients. Approximate 95% upper confidence limits for QMED were then calculated as follows:

$$95\% \text{ confidence limit} = QMED * FSE^2$$

The uncertainty in the flood growth curves and pooling groups selected for a sample of 85 gaugings stations across Ireland was investigated as part of the FSU WP 2.2. The percentage standard error in design peak flow varied from 4.0 to 9.0 at the target fluvial 1%AEP.

The upper confidence limits from each source of peak flow uncertainty were combined to estimate overall uncertainty in design peak flow at the target 1%AEP for ungauged HEPs. This resultant upper limit of the 1%AEP flow was typically within 10% to 30% of the design 1%AEP peak flow (see Appendix D). Therefore, it was deemed that a sensitivity test of a 30% increase in peak flow at the target 1%AEP should be considered in the subsequent hydraulic modelling of all HEPs in UoM22.

Sensitivity in Water Levels in Lough Leane

The Lough level is inherently linked to the inflow from the River Flesk, River Deenagh and other tributaries contributing to the lake. There is uncertainty associated with the growth curve used to estimate the design peak water levels from the gauge data at two gauges located in the Lough as discussed in Section 6.5 of this report. The 95% confidence interval was derived from the single site analysis growth curves at BVM Park and Tomies Pier gauge. Table 7.3 presents the resultant upper limits of the design 1%AEP peak water levels of + 0.33m which will be used to inform the subsequent hydraulic modelling and mapping.

Table 7.3: Uncertainty in 1%AEP Water Level Estimate at Lough Leane

Location	Design 1%AEP Peak Water Level (mODM)	Lower Limit (mODM)	Upper Limit (mODM)	Range (m)
22082 BVM Park	20.28	19.92	20.53	±0.31
22071 Tomies Pier	20.28	19.95	20.61	±0.33

Sensitivity in Transformation of Total Tide Plus Surge Level

Due to the lack of observed data within Castlemaine Harbour there is a high degree of uncertainty in the water levels that have been derived. Any observed data that becomes available should be used to improve the level of confidence in the water levels. Sensitivity testing will be carried out using the hydraulic model to assess the impact of varying the downstream boundary conditions (water level) on the predicted flood extent. The sensitivity test should consider a water level 0.5 m higher than the design level in Castlemaine Harbour. The 0.5 m value is consistent with current guidance on confidence intervals and is the level of increase used for the climate change scenarios.

8 Summary of Design Flows

The design flows from this hydrology report inform the inflows to the hydraulic model to assess flood risk from the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP fluvial and tidal flood events. The key hydrological findings for design flows in UoM22 are as follows:

- Historic flood events
 - Major flood events were identified in UoM22 since 1980 from fluvial sources and extreme storm surges.
 - The flood events in November 2009 and in November 1980 were the largest observed river floods on the River Laune and are estimated to be in the range 4% AEP to 1% AEP depending on the location within the catchment.
 - The calibration in the Killarney and the Laune catchment and Castleisland and the Maine catchment will be based on the following events where there is sufficient information:
 - 2nd November 1980 – extreme fluvial event (largest on record) in Killarney.
 - 4th October 2008 – extreme fluvial event in Castleisland and along the River Maine.
 - 19th November 2009 – extreme fluvial event in Killarney, Lough Leane and the River Laune.
 - The calibration of Dingle, Milltown and Portmagee will be based entirely on the verification of modelled outline to historical flood frequency (where available) and sensitivity analysis on the key hydraulic parameters, because there is insufficient evidence to undertake full calibration.
- Design flood flows
 - Peak flood flows were derived along the River Maine, River Laune, Dingle and Milltown catchments for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP events using the recommended FSU methodology outlined in Work Package 2.2 and 2.3.
 - The annual maximum flood hydrographs were standardised and compared to derive the width exceedance for specific percentage flows at gauges on the River Maine, Flesk, Deenagh, Laune and Milltown (Dingle) Rivers. The design median flood hydrograph was derived from the width exceedance analysis.
 - The FSU WP 3.2 UPO-ERR-gamma curve was selected as the design hydrograph shape for the ungauged HEPs. The design unit hydrograph was adjusted based on gauges for hydrologically similar catchments.
- Design coastal conditions
 - The design extreme sea levels were extracted from the ICPSS for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1% AEP tidal events. These levels were then transformed to Dingle, Portmagee and Castlemaine Harbour based on available ICWWS data and admiralty prediction points.
 - The astronomic curve and surge profile were derived from the admiralty predicted astronomic tide and typical duration of surge events in the South West.
 - The final design tidal curve was derived from the combined astronomic tide and design surge profile scaled to meet the design extreme sea levels.
- Uncertainty and Sensitivity
 - The uncertainty of the 1% AEP target peak flow was estimated to range up to 30% in UoM22 ungauged HEPs which will inform the sensitivity tests in the hydraulic modelling.
 - The uncertainty of peak water level in Lough Leane was estimated to be within 0.33m at the target 1% AEP event.
 - The water level profile in Dingle Bay and Castlemaine Harbour has a reasonable level of uncertainty associated with it given the lack of gauge data to verify the progression of the tide. Therefore, a 0.5m increase in water level was recommended in accordance with GN22.

Table 8.1 and 8.2 provide the design peak flows and total tide plus surge levels respectively. These flows and levels are subject to change following the subsequent integration into the hydraulic model and calibration processes.

Table 8.1: UoM22 Design Peak Flood Flows at Key Locations

HEP	Gauge	50%AEP (m³/s)	20%AEP	10%AEP	5%AEP	2%AEP	1%AEP	0.5%AEP	0.1%AEP
River Laune catchment									
22_3712_1	22039 (Clydagh Bridge Gauge)	57.9	72.0	82.1	92.8	108.8	122.6	138.2	182.9
22_3372_6	22006 (Flesk Bridge Gauge)	172.6	205.2	224.4	251.9	295.1	334.8	379.3	494.6
22_510_2	22035 (Laune Bridge Gauge)	114.2	132.1	148.9	168.4	201.8	225.5	252.4	329.4
22_4001_4+	Laune downstream	186.0	215.2	242.4	274.2	328.6	367.3	411.0	536.4
22_4003_14	22009 (White Bridge Gauge)	12.0	13.6	15.4	17.4	21.1	24.3	28.0	36.9
River Maine Catchment									
22_1587_3	22014 (Castleisland Gauge)	29.7	38.0	43.6	48.9	55.5	61.9	69.6	91.9
22_3101_1	22003 (Riverville Gauge)	144.0	181.8	210.5	242.6	292.7	338.2	392.0	558.5
22_3958_1+	Maine Downstream	203.6	257.1	297.8	343.2	414.0	478.4	554.4	790.0
Milltown Catchment									
22_3116_4	Ashullish –Ballyoughtragh U/s Confluence	3.8	4.8	5.4	6.1	7.2	8.1	9.1	12.0
22_3958_2	Ashullish Stream Downstream	6.7	8.3	9.5	10.7	12.6	14.1	15.9	21.1
22_3425_9	Ballyoughtragh Stream Downstream	7.3	9.0	10.3	11.6	13.6	15.3	17.2	22.8
Dingle Catchment									
22_1712_2	Milltown Gauge (22022)	23.0	32.0	40.9	49.0	61.0	70.8	81.4	109.9
22_3437_1	Dingle Stream Downstream	5.1	6.5	7.4	8.4	9.9	11.2	12.7	16.9

Table 8.2: UoM22 Design Water Levels

Location	Type	50%AEP (mODM)	20%AEP	10%AEP	5%AEP	2%AEP	1%AEP	0.5%AEP	0.1%AEP
22082 BVM Park Lough Leane	Lake	19.23	19.52	19.71	19.88	20.11	20.28	20.46	20.85
22071 Tomies Piers Lough Leane	Lake	19.23	19.52	19.71	19.88	20.11	20.28	20.46	20.85
Portmagee Harbour (ICPSS point SW_16)	Coastal	2.15	2.25	2.32	2.38	2.46	2.52	2.59	2.73
Dinge Harbour (ICPSS Point SW_22)	Coastal	2.20	2.30	2.38	2.45	2.54	2.61	2.68	2.85
Dingle Bay at Inch Point (ICPSS point SW_20)	Coastal	2.37	2.48	2.56	2.63	2.73	2.81	2.88	3.06
Cromane Point Castlemaine Harbour	Coastal	2.70	2.80	2.88	2.95	3.04	3.11	3.18	3.35
Ferry Crossing, River Maine and Laune Outfall-Castlemaine Harbour	Coastal	3.00	3.11	3.19	3.26	3.35	3.42	3.49	3.66

9 Considerations for Hydrological and Hydraulic Model Integration

9.1 Integration of Inflows

Design hydrographs have been derived at HEPs to represent the hydrological processes across the River Laune, Maine and Dingle catchments as discussed in Chapter 6 of this report. The HEPs will be integrated with the subsequent hydraulic models as follows:

- Point inflows at the upstream model extents;
- Point inflows at key tributary inflows;
- Lateral inflows representing the inflow from the intervening areas between target HEPs.

The point inflows representing the upstream model extents and tributary inflows will be integrated with the relevant cross-section in the hydraulic model accounting for a significant displacement from the HEP calculated location. The lateral inflows will be integrated with the relevant cross-sections at locations which fit the following criteria:

- Natural inflows from minor watercourses which are not considered explicitly within the hydrology;
- Overland flow paths identified from surveyed low points in the river bank and site walkover.

The lateral inflows will be calculated from the difference between the design flow hydrographs from the upstream and downstream HEPs for a reach. The resultant hydrograph will be distributed evenly across those locations where the contributing area increases linearly downstream, or area weighted where the contributing area increases disproportionately downstream such as the lower reaches of the River Laune. Table 9.1 outlines the total number of inflows based on the criteria above for each model. These will be further refined and discussed in the hydraulics report.

Table 9.1: Model Inflows

Model	Number of Inflows
Upper Flesk – Glenflesk	9
Lower Flesk – Killarney	12
Laune	12
Castleisland	8
Maine	24
Milltown	6
Dingle	5
Portmagee	N/A Coastal only

In order to enhance the modelling outputs and ensure hydrological continuity along the larger catchments, the hydraulic models will be calibrated to the design peak flows derived at the target HEPs. The hydrological inflows will be iteratively scaled and phased such that the hydraulic model maintains the design peak flows along the reach as part of the hydraulic modelling process. However, it should be noted that the design fluvial flows do not consider the following hydraulic processes:

- Backwater effect at confluences;
- Exchange of flows between tributaries at confluences; and,
- Significant modification to the hydrograph shape due to floodplain attenuation and /or hydraulic structures.

Therefore, it is not appropriate to calibrate the hydraulic model to HEPs upstream of confluences where there are significant out-of-bank flows.

In UoM22, the median width hydrographs have been derived at the gauged locations to establish the design storm duration at target HEPs across each catchment. The duration of the tributary inflows are based on the gauged duration but will be iteratively refined to achieve the flow at the gauges as part of the hydraulic modelling. The intermediate inflows account for the difference in duration between the target HEPs within the same hydrological catchment. Table 9.2 outlines preliminary design storm durations for UoM22.

Table 9.2: Preliminary Design Storm Duration

Gauge ID	Name	Watercourse	Applicable Reach/AFA	Design Duration (Hours)
22014	Castleisland	Maine	Castleisland	13
22003	Riverville	Maine	Maine Milltown	24
22022	Milltown	Milltown (Dingle)	Dingle	11
22039	Clydagh Bridge	Clydagh	Flesk (upstream of Oweneskagh) Glenflesk	15
22006	Flesk Bridge	Flesk	Flesk (downstream of Oweneskagh) Killarney (tributaries to the Laune)	29
22009	White Bridge	Deenagh	Killarney	23
22035	Laune Bridge	Laune	Laune	237*

*Significant affected by attenuation of Lough Leane. Therefore Flesk Bridge used to inform tributary inflows

9.2 Integration of Downstream Conditions

The downstream conditions will be defined for each model as outlined in Table 9.3 to fully account for the relevant fluvial, lake and tidal backwater effects as appropriate.

Table 9.3: Downstream Boundary Conditions

Model	Downstream Condition
Upper Flesk – Glenflesk	Stage-discharge relationship based on the downstream channel and floodplain slope
Lower Flesk – Killarney	Stage-discharge relationship calibrated to meet the design lough levels set out in Table 8.2
Laune	Full tidal boundary using the design tidal curves set out in Chapter 6
Castleisland	Stage-discharge relationship based on the downstream channel and floodplain slope
Maine	Full tidal boundary using the design tidal curves set out in Chapter 6
Milltown	Full tidal boundary using the results from the River Maine model design tidal curves set out in Chapter 6
Dingle	Full tidal boundary using the design tidal curves set out in Chapter 6
Portmagee	Full tidal boundary using the design tidal curves set out in Chapter 6

An iterative approach will be used to phase the design tidal curves so that the peak tide coincides with the peak flow as a conservative estimate of flood risk.

10 Hydrogeomorphology

10.1 Approach

The hydrogeomorphological processes ongoing in the river channels can have a significant impact on flood flows and the resultant flood risk. The assessment of hydrogeomorphological features focuses on whether the processes appear to be in equilibrium and whether there are any processes taking place at present which are likely to affect the flood risk indicators. This may include:

- Recent interventions to the channel/hydrology to control flood risk which have accelerated erosion or deposition;
- The use of inappropriate bank protection which may transfer erosion downstream; or
- Straightening or reprofiling the channel which may cause the watercourse to attempt to revert back to a more natural state.

This has included an assessment of:

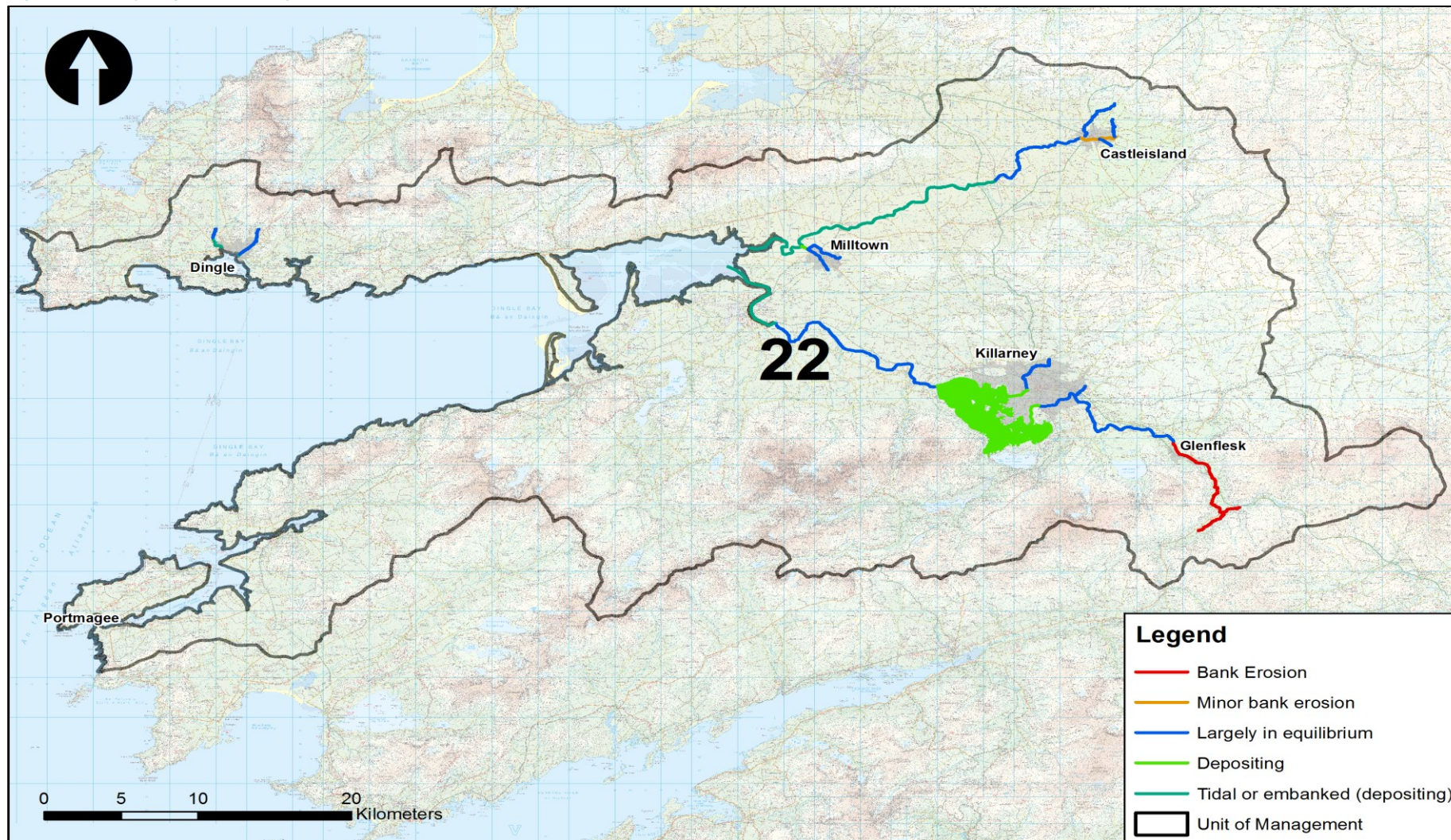
- Typical land use, soils and geology as provided in Chapter 2;
- Channel gradient based on the river channel survey;
- Bank and bed material and condition based on site visits, aerial photographs and survey photographs;
- Channel planform based on Ordnance Survey maps and aerial photography; and
- The presence of structures (bridges, weirs, culverts) /channel modifications (e.g. straightening, bank protection, bank reprofiling).

The survey data and photographs are provided in a separate survey report which will become available in mid-2013.

10.2 Assessment

The HPW and MPW were split into broad reaches of similar hydrogeomorphological characteristics based on the approach above, and an assessment made on the current erosion and deposition features (Map 10.1).

Figure 10.1: Hydrogeomorphological Reaches



Source: MMD-296241-UoM22-D1001-A

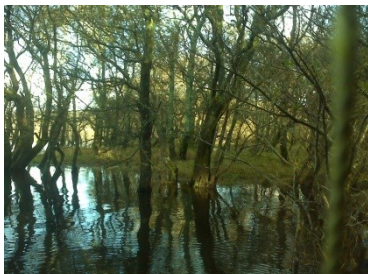
River Laune Catchment

Photo 10.1: Bank Erosion on the River Flesk



Captured: 21/03/2013

Photo 10.2: Killarney Alluvial Forest



Captured: 21/03/2013

Photo 10.3: Riverville Bypass Culvert



Captured: 14/09/2012

The River Laune, River Flesk, River Deenagh and Lough Leane were assessed for current hydrogeomorphological processes. The areas of greatest deposition were at the outfall of the River Flesk and River Deenagh where the silts and fines from the river form an alluvial fan as the flows enter the flat standing body of water in Lough Leane. Accumulation of sediment was also observed upstream of bridge constrictions such as at Loo Bridge on the Flesk. Erosion processes were observed under the majority of bridge structures where increased velocities around the bridge piers and constrictions resulted in increased scour. However, the most significant erosion was along the outside banks of meander bends on the Flesk and Laune where there were access issues with cattle and/or footpath erosion causing undermining and slumping of the bank.

The increased sediment load from bank erosion at these locations forms in-channel deposition bars further downstream forming an alluvial fan into the Lough. This fan is wooded and forms an alluvial forest. However, the hydrogeomorphological processes within the River Flesk and Laune catchments appear to generally be at equilibrium – erosion upstream and deposition of sediment at Lough Leane are taking place at a similar rate, and the channels are not readily adjusting their planform or long profile in response to recent natural or artificial change.

River Maine Catchment

The River Maine has been artificially straightened and embanked downstream of Currans Bridge thus increasing velocities and bed erosion to reduce erosion processes at the banks and lateral migration of the river planform. However, the rate of bed erosion was observed to be largely in equilibrium with deposition in tidal reaches downstream. The most significant deposition was observed downstream of culverts which discharge at right angles to the main channel because the inefficiencies of the adjoining flow reduce velocities and increase the deposition of sediment. This process was greatest downstream of the Riverville Bypass where it joins the River Maine downstream of Maine Bridge, Inchinveema.

Other Small Catchments

There were a number of structures on the Dingle Stream, Ashullish Stream (Milltown) and Ballyoughtrough Stream (Milltown) with localised scour under the structures where velocities increased and deposition occurred in areas of slack water upstream of the structures. However, the hydrogeomorphological processes within the Dingle and Milltown (Ashullish and Ballyoughtrough Streams) catchments appear to generally be at equilibrium – erosion and deposition of sediment are taking place at a similar rate and the channels are not readily adjusting their planform or long profile in response to recent natural or artificial change.

10.3 Impact on Flood Risk

The rate of deposition at the outfall of the Riverville Bypass and other outfalls located normal to the main channel is likely to reduce capacity of the culverts over time without human intervention. The reduction in culvert capacity could contribute to increased flood risk to the road and upstream of these culvert structures.

Within the urban AFAs of Castleisland, Killarney and Glenflesk, the channels have been overwidened and constrained at bridges so they cannot form a more natural meandering planform. Riffles have formed within the straightened channel in response to this. However, this process would only control levels at very low flows. During periods of high flow, this sediment will be entrained by the flood flow and flushed downstream. Therefore, this deposition is unlikely to contribute to increased flood risk to these AFAs. The rate of bank erosion around Glenflesk was significant although this sediment was trapped in Lough Leane downstream, balancing the system. Land use management, cattle exclusion and bank protection should be considered to manage hydrogeomorphological processes locally for any flood risk management measures in this reach.

The artificial straightening of the River Maine downstream of Currans Bridge has similarly resulted in riffle creation as the channel cannot return to its natural meandering planform. This results in accretion of in-channel sediment overtime, especially in the slack water of the tidal reaches at Castlemaine. Whilst the rate of deposition was not deemed to be unsustainable, the river bed could be raised in the future scenarios making it increasingly difficult to drain the low-lying catchments and remove flood waters. Therefore, dredging and maintenance of the embankment reaches should be considered for future scenarios.

11 Joint Probability

11.1 Overview

The design flows on each river reach and total tide plus surge levels provided in Chapter 8 have been derived independently of each other. In reality, there can be dependency between sources of flooding which can be described by the joint probability to achieve a target %AEP event. The CFRAM study considers the following joint probabilities:

- Fluvial-fluvial – Where a range of combinations of flow on a main river combines with flow on a tributary to generate a specific %AEP flood downstream.
- Fluvial-coastal – Where an approaching depression generates a storm surge which combines with a river flood to generate a specific %AEP at the coast.

The joint probability between total tide plus surge levels and extreme waves has been considered separately under the ICWWS study. The resultant combinations have been assessed in Chapter 6 to establish the critical scenario for wave overtopping for each target %AEP. Therefore, this will not be re-examined in the following sections.

11.2 Fluvial-Fluvial Dependence

The joint probability between fluvial flows on the main watercourse and its tributaries was guided by the methodology set out in Flood Studies Update Work Package 3.4. The FSU methodology assessed the dependence between fluvial inflows based on the distance between catchment centroids; the ratio in catchment area; and, the difference in FARL, a measure of floodplain attenuation. Table 11.1 sets out the different combinations in UoM22 for tributary inflows to achieve the target %AEP on the main watercourse.

In UoM22, the joint probability of tributaries was found to be largely dictated by the size of the incoming catchment relative to the main watercourse. The joint probability %AEP on the smaller tributary inflows tended to be the more frequent smaller events in order to achieve the target flow on the main watercourse.

The exception was the Brown Flesk and Owenyskeagh Rivers which tend to have a similar probability to the River Maine and River Flesk as they contribute approximately half of the flow to the downstream reach.

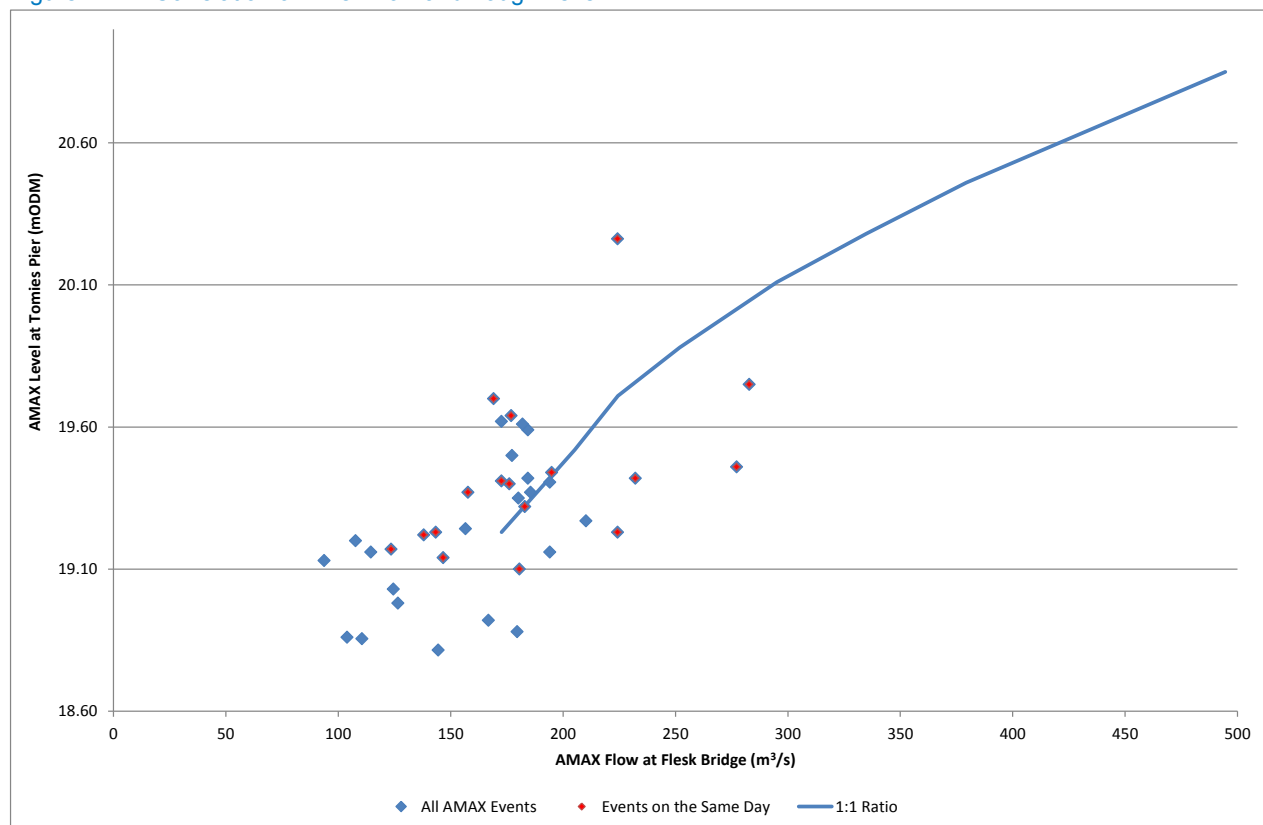
Table 11.1: Fluvial-Fluvial Dependence Combinations

AFA.MPW			Target %AEP at downstream HEP on main watercourse							
			50%	20%	10%	5 %	2 %	1%	0.5%	0.1%
	Reach inflow	WP 3.4 Table 13.1 Scenario	Associated %AEP of Tributary Inflow							
Glenflesk /Flesk	Loo -Flesk	Catchment centroid within 25km	71.0	46.0	35.0	23.0	10.0	6.1	3.8	1.2
	Annagh Beg-Flesk	Significantly smaller catchment (Ratio of area greater than 2.7)								
	Finow-Flesk	Difference in FARL less than 0.07								
	Oweneyskeagh-Flesk	Catchment centroid within 25km	57.0	30.0	17.0	9.4	4.3	2.3	1.2	0.3
		Similar sized catchment (Ratio of area within 2.7)								
		Difference in FARL less than 0.07								
Killarney/Flesk	Woodford-Flesk	Catchment centroid within 25km	71.0	46.0	35.0	23.0	10.0	6.1	3.8	1.2
		Significantly smaller catchment (Ratio of area greater than 2.7)								
		Difference in FARL less than 0.07								
	The River Flesk and Deenagh are not connected in the river network therefore have not been considered in fluvial-fluvial dependence, but are considered through the connection with Lough Leane.									
Laune	Loe-Laune	Catchment centroid within 25km	71.0	46.0	35.0	23.0	10.0	6.1	3.8	1.2
	Gaddagh-Laune	Significantly smaller catchment (Ratio of area greater than 2.7)								
	Gweestin-Laune	Difference in FARL less than 0.07								
Castleisland/ Maine	Glanshearoon-Maine	Catchment centroid within 25km	71.0	46.0	35.0	23.0	10.0	6.1	3.8	1.2
		Significantly smaller catchment (Ratio of area greater than 2.7)								
		Difference in FARL less than 0.07								
Maine	Kealgorm-Maine	Catchment centroid within 25km	71.0	46.0	35.0	23.0	10.0	6.1	3.8	1.2
	Brogheen-Maine	Significantly smaller catchment (Ratio of area greater than 2.7)								
	Ballymacpierce-Maine	Difference in FARL less than 0.07								
	Little Maine-Maine									
	Incheiveema-Maine									
	Collmealane-Maine									
	Annagh &Tralia-Maine									
	Ashullish & Bootleens-Maine									
	Brown Flesk-Maine	Catchment centroid within 25km	57.0	30.0	17.0	9.4	4.3	2.3	1.2	0.3
	Similar sized catchment (Ratio of area within 2.7)									
	Difference in FARL less than 0.07									

			Target %AEP at downstream HEP on main watercourse							
Milltown	Ballyoughtrough-Ashullish	Catchment centroid within 25km Similar sized catchment (Ratio of area within 2.7) Difference in FARL less than 0.07	57.0	30.0	17.0	9.4	4.3	2.3	1.2	0.3
Dingle	Dingle Stream and Milltown Stream are not connected in the river network therefore have not been considered in fluvial-fluvial dependence									
Portmagee	No fluvial risk has been identified or considered in Portmagee									

The joint probability between the river flows and Lough Leane levels have also been considered based on the AMAX flows at Flesk Bridge and AMAX levels records at Tomies Pier gauges. Figure 11.1 indicates that extreme river flows on the Flesk correlated to extreme levels in Lough Leane. The Blue line indicates the relationship between the design peak flows and levels if Lough level was completely dependent on the river flow from the Flesk, i.e. a 1:1 ratio. The scatter from the 1:1 relationship is indicative that extreme lough levels are caused by a combination of the Flesk, other tributaries and preceding conditions to the event.

Figure 11.1: Correlation of River Flow and Lough Level

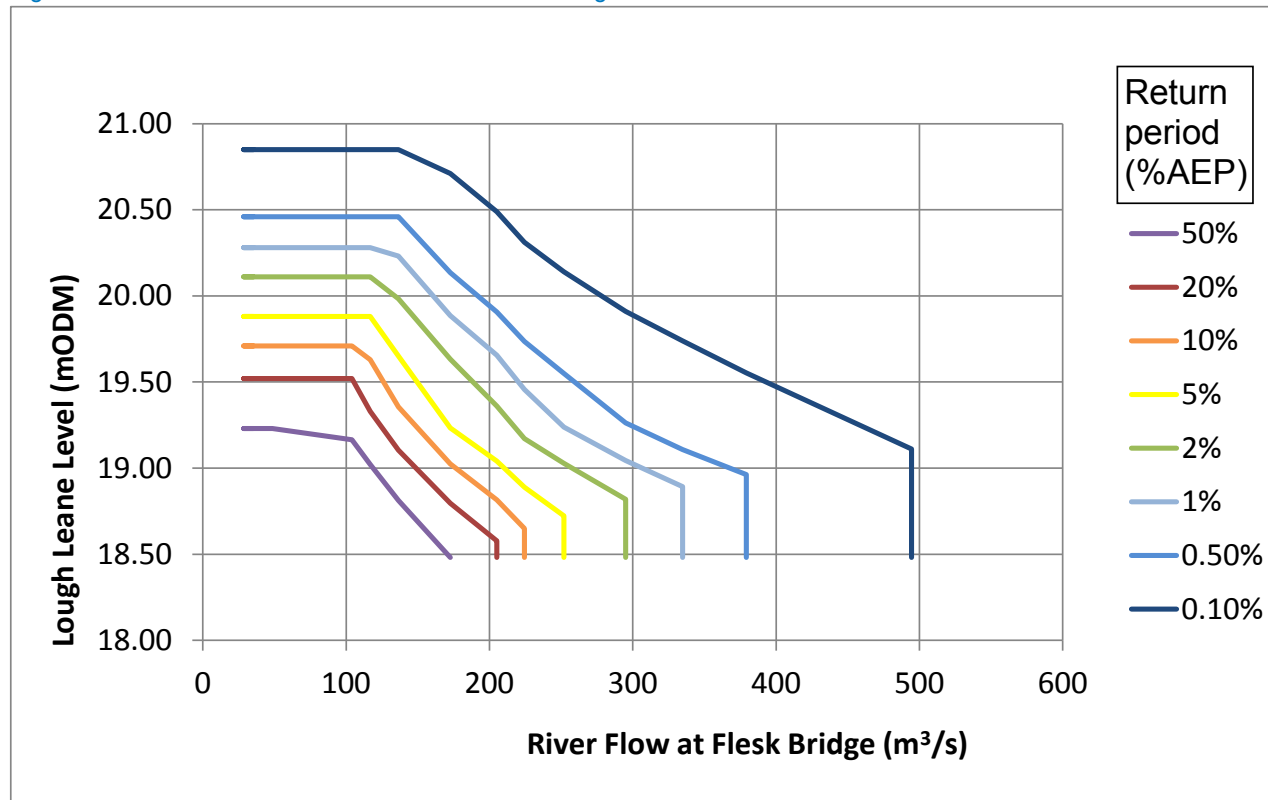


The FD2308 desk-based approach has been used to derive the joint-probability combinations based on well correlated coefficients (Figure 11.2). The two main critical scenarios to be as follows:

- Target flow and the water level that occur more frequently than the 50%AEP; and
- Target lough level combined with river flows that occur more frequently than the 50%AEP.

This approach ensures easy interpretation of the sources of risk at Killarney and around Lough Leane. However, it is recommended to undertake sensitivity tests on alternative combinations to achieve the target 1%AEP in order to assess the impact on flood risk, such as experienced in the 2009 event.

Figure 11.2: Joint Exceedance Curves River Flow-Lough Level



11.3 Fluvial-Coastal Dependence

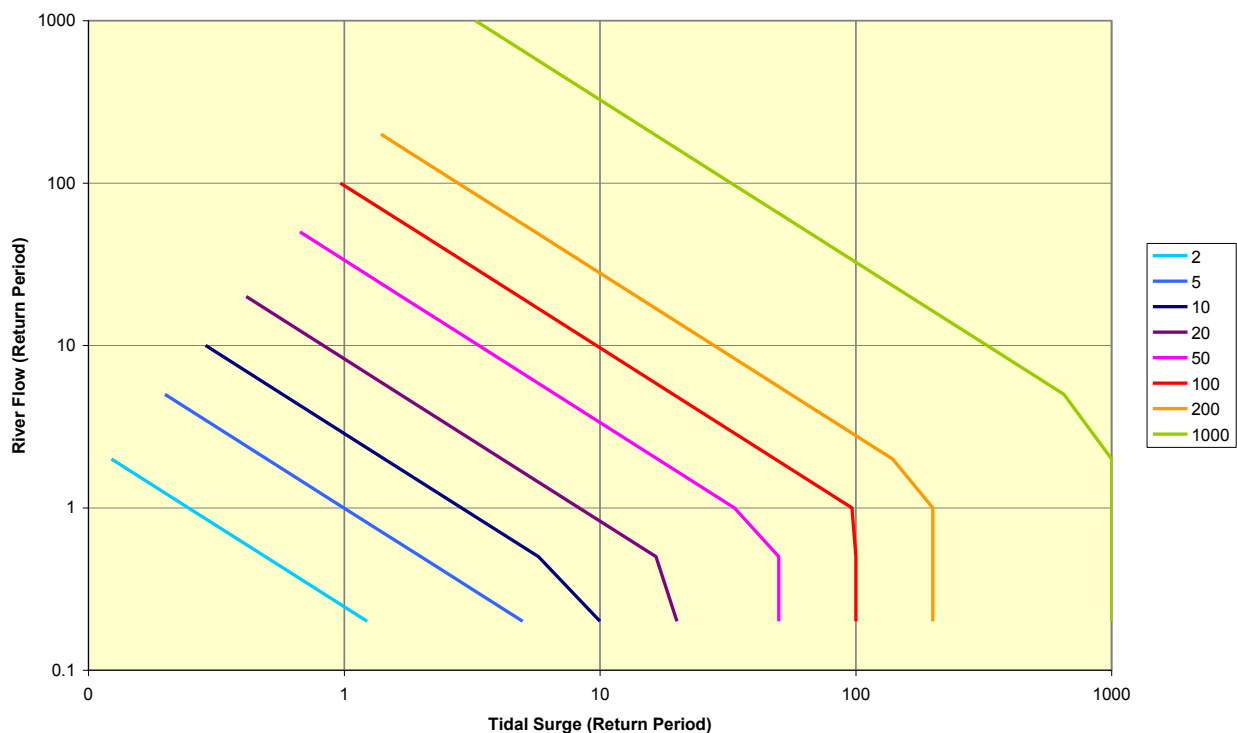
It is not possible to statistically assess the joint probability between fluvial and tidal events along the South West coast as there is limited concurrent river flow and tidal gauge data available at the same location. Therefore, the DEFRA FD2308_TR1 desk-based assessment was used to estimate the fluvial-tidal joint probability combinations.

The extreme fluvial flow estimates at the outfall of the Maine; outfall of the Laune; and, the Milltown gauge in Dingle were combined with the relevant ICPSS total tide plus surge levels and applied to the DEFRA FD2308_TR1 desk-based assessment tool in accordance with GN20⁵ based on the design hydrology outlines in Chapter 5. It was assumed that Dingle Harbour was similar to estuaries along the south and south-west coast of England in terms of orientation to the dominant storm track. Castlemaine Harbour was assumed to be similar to estuaries of large river catchments along the west coast of Wales and England. Based on the FD2308 research, the dependence of river flow and storm surge in these estuaries tended to be “well” to “strongly” correlated. Figure 11.1 outlines the resultant joint probabilities.

⁵ RPS(2012) CFRAM Guidance Note 20, Joint Probability Guidance.

Based on this analysis, there was some correlation between high flows and higher storm surges as the storm events that caused the surge. This agrees with the more detailed gauge analysis undertaken for

Figure 11.3: Joint Probability Curves of Tidal and Fluvial Events for Strongly Correlated Estuaries



Based on this analysis, there was some correlation between high flows and higher storm surges as the storm events that caused the surge. This agrees with the more detailed gauge analysis undertaken for nearby Cork Harbour as part of the Lee CFRAM pilot Study. Extensive sensitivity analysis was undertaken on the 0.5% AEP event as part of the pilot study and found the two main critical scenarios to be as follows:

- Target flow and the MHWS tide; and
- 50%AEP Flow and the target Total tide plus surge level.

This approach ensures easy interpretation of the maximum fluvial dominant flood and maximum coastal dominant flood for the design scenario. However, it is recommended to undertake sensitivity tests for Dingle and Castlemaine Harbour on alternative combinations to achieve the target 1%AEP in order to assess the impact on flood risk.

12 This approach ensures easy

12.1 Potential Climate Changes

The range of potential impacts of climate change varies as there are significant uncertainties associated with global climate predictions and local hydrological variation for periods more than 20 years in the future. Therefore, two scenarios have been assessed to quantify the sensitivity of flood risk to potential climate change namely, the Mid-Range future scenario (MRFS) and the High-Range future scenario (HRFS) as detailed in Table 12.1.

Table 12.1: Allowance for Climate Change in Catchment Parameters

Catchment Parameter	MRFS	HRFS
Extreme Rainfall Depth	+20%	+30%
Flood Flows	+20%	+30%
Mean Sea Level Rise	+0.5m	+1.0m
Land Movement	-0.5mm/year i.e. +0.05m relative sea level rise over 100 years	-0.5mm/year i.e. +0.05m relative sea level rise over 100 years

Source: Reproduced from Appendix F of National Flood Risk Assessment and Management Programme, Catchment-Based Flood Risk Assessment and Management (CFRAM) Studies, Stage I Tender Documents: Project Brief.

The land movements quoted in Table 6.1 refer to postglacial readjustment of the underlying tectonic plate since the last glacial period in Southern Ireland. This readjustment is not a climatic change but it does alter the effective rate of sea level rise predicted with climate change.

It is important to note that the increase in sea level and flood flows applies to the entire tidal curve and flood hydrograph, not just the peak.

12.2 Potential Catchment Changes

12.2.1 Urban Development

The way in which the land is used can significantly impact the flow routes across the catchment, how much rainfall is stored, how much infiltrates into the ground, and how much evaporates. Future urban development is likely to influence hydrology and flood risk in the following ways:

- Increase the surface runoff from the catchment by increasing the area covered by impermeable surfaces on previously undeveloped ("Greenfield") sites;
- Increase the proportion of surface runoff draining to urban drainage networks; and,
- Increase the proportion of the population, properties and infrastructure within areas of flood risk.

All of these changes cause more water to reach the river channels quicker and affect more people, property and environments.

The greatest concentration of urban development is located in and around Killarney. However, there has been significant growth in smaller towns such as Milltown over the past decade. Furthermore, the regional plans identify the area between Tralee and Killarney as a “hub” of growth over the next 20 years.

Table 12.2 outlines the urban growth in housing units according to the South West Regional Authority (SWRA) Planning Guidelines and linear extrapolation to estimate urban growth for the MRFS and HEFS. The SWRA data is based on a 2010 baseline and accounts for the economic downturn in forecasts beyond 2010. The MRFS growth rate has been estimated on the projected increase in housing units between 2016 and 2022 accounting for the economic downturn. The HEFS growth rate has been estimated on the average projected increase from 2010 to 2022 as set out in the plan.

Table 12.2: Future Urban Growth

SWRA Plan Area	Housing Units Required				MRFS % Growth	HEFS % Growth
	2006	2010	2016	2022		
Cork Gateway	111,581	127,749	153,000	182,044	3.16%	3.54%
Mallow Hub	4,191	5,341	7,500	10,498	6.66%	8.05%
Ring towns and Rural areas	42,951	46,472	50,317	54,160	1.27%	1.38%
Greater cork area	154,532	174,221	203,317	236,203	2.70%	2.96%
Tralee Killarney Hub area	15,284	17,099	20,318	23,573	2.67%	3.16%
Kerry linked hub	29,565	33,541	39,855	46,239	2.67%	3.15%
Northern Area	33,497	37,993	43,885	46,186	0.87%	1.80%
Western area	36,606	41,745	47,989	50,729	0.95%	1.79%

Source: South West Regional Plan

In agreement with OPW, the forecast growth in housing units was assumed to be on previously undeveloped land as a conservative estimate of urbanisation over a 100 year timeframe. The MRFS and HEFS do not account for any beneficial impacts of Sustainable Drainage Systems in the future.

12.2.2 Land Use Change

The majority of the Laune and Maine catchment areas are currently rural and dedicated to agricultural or pastoral use. The type of crops that are grown, the way the land is prepared and changes in land drainage practice all affect how quickly rainfall reaches the watercourses. Land management practices also affect the amount of silt that gets washed from the fields into the rivers during rainfall events. Given that these processes can influence flood risk, both in a positive and negative way, we need to consider how land use and land management may change in the future.

There are many uncertainties surrounding the future of agriculture within the catchment. Land use will depend upon society's aspirations and needs, and will be driven by policies being implemented by both the Irish government and the EU. The pressures and drivers that will affect how land is used in UoM22 include:

- change to agricultural policy and land management subsidies in the EU;
- opening of world markets making agriculture and pastoral activity less economically viable;
- growth in world population increasing demand for food production;
- change in typical annual temperatures with climate change resulting in changes in crop types grown;
- diversification to other land uses, particularly for tourist related attractions;
- drive to enhance and restore environmental habitats and landscapes;
- drive to reduce carbon dioxide emissions through the use of carbon sinks and biofuels; and,
- increasing energy prices could lead to increased biofuel use or make importing of produce uneconomic.

All of these changes can either lead to intensification of activities and associated increased land drainage and runoff or reduction in activities with associated increased infiltration and reduced runoff. There is very limited information on most of these land cover changes as they are often driven by economic factors which are rarely predicted beyond 5 years.

Deforestation to increase productivity of agricultural land can be a significant on rural land use in Europe under the EU Common Agricultural Policies. Forested areas intercept rainfall, increase storage and infiltration and slow surface water runoff into the river channels. The removal of natural forests can encourage greater runoff. There is only limited evidence to suggest the extent of forest cover is a significant controlling parameter on the regression equations used to estimate peak flood flows⁶. However, the OPW guidelines identify commercial afforestation to increase productivity as the significant pressure on rural land use in Ireland. Increased irrigation and drainage for the commercial forests can route more water to the rivers thus reducing the time to peak. The OPW future scenarios guidelines recommend that changes in forest cover can be reflected in a reduced time to peak due to these associated drainage works.

Less than 10% of the Maine catchment is covered by forest as defined by the Floods Studies Update. Any change in forested area is unlikely to impact future flood hydrographs as forest covers such a small proportion of the catchment at present. Therefore, changes to the hydrographs due to forestry cover have been discounted for the Maine catchments.

Forest cover increases to 40% on the Laune-Flesk catchment in the upper reaches and on some tributaries. The projected change in forest cover could reduce the time to peak by 17% and 33% for the MRFS and HEFS respectively. The hydrographs for the upper Flesk catchment with over 40% forest cover have been changed accordingly.

⁶ Institute of Hydrology (1991). Plynlimon research: The first two decades. Report No. 109, Institute of Hydrology.

12.3 Design Future Scenario Conditions

The present day design hydrology (derived in Chapter 5 of this report) was modified to consider the relevant catchment and climate changes discussed in the previous sections. Table 12.3 summarises the final Mid-Range and High-End Future Scenarios.

Table 12.3: Allowance for Future Condition in Catchment Parameters

Catchment Parameter	MRFS	HEFS
Flood Flows	+20%	+30%
Mean Sea Level Rise	+0.5m	+1.0m
Land Movement	-0.5mm/year i.e. -0.05m over 100 years	-0.5mm/year i.e. -0.05m over 100 years
Urbanisation	0.95%/year	1.79%/ year
Deforestation	-1/6 Tp	-1/3Tp + 10% PR

The design hydrology under future conditions has been adjusted for the predicted decrease in forest cover in the relevant Flesk and Laune tributary catchments only. The resultant future peak flood flows and future extreme sea levels based on the Mid-Range and High End Future Scenarios are provided in Appendix F.

The predicted increase in river flows and sea level rise attributed to predicted climate change is the most significant factor that influences design peak flows and levels in UoM22. Urbanisation has a relatively small impact on design peak flows as the catchment remains predominately rural in both the MRFS and HEFS.

The degree to which the increased river flows and sea levels change flood risk to the AFAs will be assessed as part of the subsequent hydraulic modelling and mapping. The relative increase in flows and period of any tide-locking associated with the impacts of climate change should be considered in the sizing of any floodplain storage options and frequency of maintenance activities.

13 Conclusions, Key Findings and Recommendations

13.1 Conclusions and Key Findings

The design flows from this hydrology report inform the inflows to the hydraulic model to assess flood risk from the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1%AEP fluvial and tidal flood events. The key hydrological findings in UoM22 are as follows:

Historic flood events

- Major flood events were identified in UoM22 since 1980 from fluvial sources and extreme storm surges.
- The flood events in November 2009 and in November 1980 were the largest observed river floods on the River Laune and are estimated to be in the range 4%AEP to 1%AEP depending on the location within the catchment.
- The calibration in the Killarney and the Laune catchment and Castleisland and the Maine catchment will be based on the following events where there is sufficient information:
 - 2nd November 1980 – extreme fluvial event in Killarney.
 - 4th October 2008 – extreme fluvial event in Castleisland and along the River Maine.
 - 19th November 2009 – extreme fluvial event in Killarney, Lough Leane and the River Laune.
- The calibration of Dingle, Milltown and Portmagee will be based entirely on the verification of modelled outline to historical flood frequency (where available) and sensitivity analysis on the key hydraulic parameters because there is insufficient evidence to undertake full calibration.

Design flood flows

- The peak flood flows were derived along the River Maine, River Laune, Dingle and Milltown catchments for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1%AEP events using the recommended FSU methodology outlined in Work Package 2.2 and 2.3.
- The antecedent ground conditions are important for peak flows in Castleisland and to some extent along the Maine and along Flesk catchment downstream of the Owenyskeagh River as they are influenced by the underlying karstified geology. The selection of pooling groups reflects this.
- Lough Leane is an important hydrological feature in the Flesk-Laune catchment as it significantly attenuates floods reducing flood peaks downstream but prolonging flood duration.
- The median width hydrographs have been derived at the gauged locations to establish the design storm duration which was found to vary between 11 and 29 hours for fluvial-dominated gauges and over 237 hours downstream of Lough Leane.
- The duration of the tributary inflows are based on the gauged duration, but will be iteratively refined to achieve the flow at the gauges as part of the hydraulic modelling.
- The joint probability between tributary inflows and the main watercourse was informed by FSU WP3.4. The joint probability of tributaries was found to be largely dictated by the size of the incoming catchment in UoM22.
- The exception was the Brown Flesk and Owenyskeagh Rivers which tend to have a similar probability to the River Maine and River Flesk as they contribute approximately half of the flow to the downstream reach.

- The Lough Leane levels were found to be well to strongly correlated to river flows on the Flesk as the major tributary to the lake. However, there was uncertainty in the joint probability exceedance curves due to the phasing of inflows from the other tributaries. Therefore, alternative combinations will be investigated as a sensitivity test.

Design coastal conditions

- The design total tide plus surge level and design tidal curves were extracted from the ICPSS for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.1%AEP tidal events. These levels were then transformed to Dingle, Portmagee and Castlemaine Harbour based on available ICWWS data and admiralty prediction points.
- An assessment of wave overtopping discharge was found to be sufficient for the coastal frontage at risk in Dingle because any wave overtopping discharge would drain back to the sea rather than progress inland due to the topography.
- The critical wave overtopping discharges for different combinations of water level and wave height were calculated for each %AEP from empirical equations and extended with hydraulic principles to better represent the transition to still water overtopping.
- Storm surge events Dingle Harbour and Castlemaine Harbour were deemed to be strongly correlated to rainfall-river flood events due to their location on the west coast and orientation to incoming storms.
- Joint probability between the storm surge and river flood was calculated using the DEFRA FD2308 desk-based approach as per GN 22.

Uncertainty and Sensitivity

- For ungauged HEPs, the upper confidence limit is between 10% and 30% greater than the design %AEP peak flow due to uncertainties in the QMED equation, selection of the pooling group and the derivation of the flood growth curve.
- The uncertainty of peak water level in Lough Leane was estimated to be within 0.33m at the target 1%AEP event.
- The water level profile in Dingle Bay and Castlemaine Harbour has a reasonable level of uncertainty (between 0.4m and 0.5m) associated with it given the lack of gauge data to verify the progression of the tide.

Hydrogeomorphology

- The current erosion and deposition processes were assessed for all HPW and MPW reaches.
- The fastest rate of erosion was observed in the upper Flesk reach and largest deposition features located at the fluvial outfalls into Lough Leane.
- Localised increased deposition at the Riverville Bypass and other outfalls located normal to the main channel is likely to reduce capacity of the culverts over time without human intervention. The reduction in culvert capacity could contribute to increased flood risk upstream of these culvert structures.

Future conditions

- Two future scenarios were developed to assess potential future changes namely, the Mid-Range future scenario (MRFS) and the High-Range future scenario (HRFS).
- River flows were predicted to increase by 20% and 30% due to climatic changes under MRFS and HEFS respectively.
- Sea levels were predicted to rise by 0.55m and 1.05m for the MRFS and HEFS respectively, accounting for 0.5mm/year post-glacial rebound land movements.
- Urban extent was predicted to increase between 0.95% and 2.67% per year, and 1.79% and 3.1% year for the MRFS and HEFS respectively, based on the forecasted rates in the South West Regional Authority planning guidelines.
- Time to peak was predicted to reduce by 17% and 33% for the MRFS and HEFS respectively along the Flesk and Laune catchment tributaries with over 40% forest cover due to predicted change in forest cover due to afforestation.
- The design peak flood flows and total tide plus surge levels were adjusted to represent the climatic and catchment changes above for the MRFS and HEFS future scenarios accordingly.

13.2 Recommendations

The following recommendations can be drawn from the key findings above for the subsequent hydraulic modelling, flood risk assessment, preliminary option development and FRMP:

- The design peak flows and design total tidal levels presented in Table 8.1 and 8.2 should be used to inform the subsequent hydraulic modelling in UoM22.
- Inflows for intervening catchments should be distributed across minor watercourses and overland flow paths identified from the survey based on the proportional increase in contributing area.
- The joint probability approach and analysis in Chapter 11 should be used to inform the combinations of inflows, lough levels and coastal conditions for the model boundaries.
- The relevant hydraulic models should be calibrated as far as possible to these historic flood events;
 - 2nd November 1980 – extreme fluvial event (largest on record) in Killarney.
 - 4th October 2008 – extreme fluvial event in Castleisland and along the River Maine.
 - 19th November 2009 – extreme fluvial event in Killarney, Lough Leane and the River Laune.
- The remaining models which do not have sufficient historic information or gauge information should use reasonable hydraulic parameters and the modelled flood outline compared with the relative historical flood frequency.
- The following sensitivity tests should be considered to assess the impact of hydrological assumptions on flood extent and levels in the subsequent hydraulic modelling:
 - Peak flow
 - Downstream tide plus surge levels
 - Joint-probability combinations of fluvial and coastal %AEP event to achieve the target %AEP.
- The uncertainty in flow and downstream water level conditions in Lough Leane and the tidal outfalls should be considered in the flood risk assessment, economic analysis and subsequent development of preliminary options. This will be of particular importance where the uncertainty in flow leads to a large change in level and extent; this will be quantified during the hydraulic modelling.

- The wave overtopping discharges provided in Chapter 6 should be considered in relation to critical discharges for pedestrians, vehicles and property damages as provided in industry guidance (EurOtop and the Rock Manual).
- Land use management, cattle exclusion and bank protection should be considered to manage hydrogeomorphological processes locally in Glenflesk for any flood risk management measures in this reach.
- Dredging and the maintenance of the embanked reaches of the River should be considered for future scenarios as river bed levels rise with sedimentation and sea levels rise with predicted climate change.

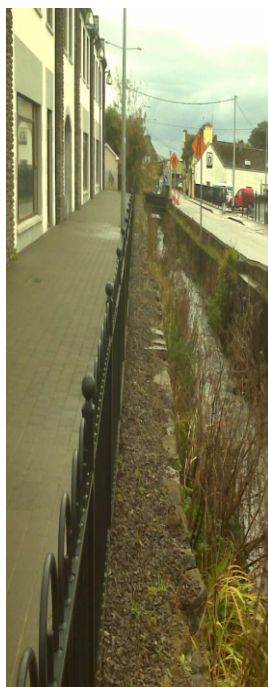
The following recommendations can be drawn from the hydrological analysis for future analysis in the catchment:

- A full review of the high flows rating at White Bridge Gauge on the River Deenagh should be undertaken to assess the out-of-bank relationship and the impact on extreme flow analysis at this gauge.
- A rating review at Laune Bridge may be beneficial to assess the impact of bypassing flows on the rating curve and consequently extreme flows downstream on the Laune.
- The installation of long term tidal gauges in Dingle Bay and within Castlemaine Harbour would significantly reduce uncertainty in the water level profile in this location and. The benefit of hydrometric monitoring will be informed by the results of the flood modelling and mapping of the design tide plus surge levels in this reach.
- The installation of long term tidal gauges in Dingle Bay and within the Portmagee Channel would significantly reduce uncertainty in the water level profile in this location and thus the assessment of coastal flood risk. The benefit of hydrometric monitoring will be informed by the results of the flood modelling and mapping of the design tide plus surge levels in this reach.
- The rate of deposition at the downstream side of the Rivesville Bypass and other culvert outfalls which are orientated normal to the main watercourse should be considered in the ongoing and future maintenance of these structures.
- Continued efforts to collate historic flood evidence for past and any new flood events is critical to improve the hydrological and hydraulic outputs in Dingle, the lower Maine, Milltown, the lower Laune and Portmagee.

Glossary

AEP	Annual Exceedance Probability; this represents the probability of an event being exceeded in any one year and is an alternative method of defining flood probability to 'return periods'. The 10%, 1% and 0.1% AEP events are equivalent to 10-year, 100-year and 1000-year return period events respectively.
AFA	Area for Further Assessment – Areas where, based on the Preliminary Flood Risk Assessment and the CFRAM Study Flood Risk Review, the risks associated with flooding are potentially significant, and where further, more detailed assessment is required to determine the degree of flood risk, and develop measures to manage and reduce the flood risk.
AMAX	Annual Maximum Flood
BFISOILS	Baseflow index from Irish Geological Soils dataset. Often used as a permeability indicator.
CFRAM	Catchment Flood Risk Assessment and Management – The 'CFRAM' Studies will develop more detailed flood mapping and measures to manage and reduce the flood risk for the AFAs.
DAD	Defence Asset Database
DAS	Defence Asset Survey
EU	European Union
EPA	Environmental Protection Agency
FARL	Index of flood attenuation due to reservoirs and lakes
FRMP	Flood Risk Management Plan. This is the final output of the CFRAM study. It will contain measures to mitigate flood risk in the AFAs.
FRR	Flood Risk Review – an appraisal of the output from the PFRA involving on site verification of the predictive flood extent mapping, the receptors and historic information.
FSU (WP)	Flood Studies Update (Work Package) (2008 to 2011)
FSR	Flood Studies Report (HR Wallingford, 1975)
GIS	Geographical Information Systems
HA	Hydrometric Area. Ireland is divided up into 40 Hydrometric Areas.
HEFS	High-End Future Scenario to assess climate and catchment changes over the next 100 years assuming high emission predictions from the International Panel on Climate Change.
HEP	Hydrological Estimation Point
HPW	High Priority Watercourse. A watercourse within an AFA.
ICPSS	Irish Coastal Protection Strategy Study (2012)
ICWWS	Irish Coastal Water Level and Wave Study (2013)
ING	Irish National Grid system, Ordnance Survey of Ireland
MPW	Medium Priority Watercourse. A watercourse between AFAs, and between an AFA and the sea.
MRFS	Mid-Range Future Scenario to assess climate and catchment changes over the next 100 years assuming medium emission predictions from the International Panel on Climate Change.

ODM	Ordnance Datum Malin. The current geodetic datum of Irish National Grid which references the mean sea level at Malin Head between 1960 and 1969.
OPW	Office of Public Works, Ireland
OSi	Ordnance Survey Ireland
PFRA	Preliminary Flood Risk Assessment – A national screening exercise, based on available and readily-derivable information, to identify areas where there may be a significant risk associated with flooding.
QMED	Median annual flood used as the index flood in the Flood Studies Update. The QMED flood has an approximate 50%AEP.
QMED_{amax}	QMED derived from the annual maximum series at a gauged location
QMED_{rural}	QMED derived from physical catchment descriptors according to the Flood Studies Update methodology.
QMED_{adj}	QMED adjusted by the ratio of QMED _{amax} :QMED _{rural} at a hydrologically similar Pivotal site.
QMED_{urban}	QMED adjusted to account for the impacts of urban areas according to the Flood Studies Update methodology.
S1085	Typical slope of the river reach between 10%ile and 85%ile along its length.
SAAR	Standard average annual rainfall 1961 to 1990
SEA	Strategic Environmental Assessment. A high level assessment of the potential of the FRMPs to have an impact on the Environment within a UoM.
SW CFRAM	South Western Catchment Flood Risk Assessment and Management study
UoM	Unit of Management. The divisions into which the RBD is split in order to study flood risk. In this case a HA.
WFD	Water Framework Directive. A European Directive for the protection of water bodies that aims to, prevent further deterioration of our waters, to enhance the quality of our waters, to promote sustainable water use, and to reduce chemical pollution of our waters.



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Appendix A. Available Data

Table A.1: Selected Hydrometric Gauge Data

ID	Station_Name	Gauge Type	Easting	Northing	Record_Start	Years Data	Owner	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
22001	Riverville Bypass	Water level	92950	105725	12/11/2008	3	OPW	Short record, no rating curve provided to convert level to flow. Further survey being undertaken by OPW to incorporate these bypass flows into 22003 Riverville gauge.	No	No
22003	Riverville	Flow and water level	92650	106201	01/01/1971	40	OPW	Majority of flows have been edited to be suitable for use, data since 2007 does not consider bypass flows and therefore should be discounted from statistical analysis.	Yes	Yes, use with caution
22005	Torc Weir	Flow and water level	96604	84219	01/08/1942	70	OPW	Long record, but with significant data gaps. Potential pivotal site.	No	Yes, post 2000 data
22006	Flesk Br.	Flow and water level)	97283	89452	08/01/1947	64	OPW	Numerous data gaps or poor data quality periods. Significant data gaps in the 1970's, 1980's and in 2006. Missing data during the November 2009 event but not over the peak. Infilled based on neighbouring gauges.	Yes	Yes, use with caution
22009	White Br.	Flow and water level	95291	90260	11/01/1982	29	OPW	Numerous data gaps particularly in 1989, and post 2000. Suspect rating curve above bankfull where a small increase in level does not significantly increase flow despite the wide flat floodplain at this location.	Yes for events post-1982, use with caution above bankfull.	Yes below bankfull, use with caution above bankfull
22014	Castleisland	Flow and water level	99609	109506	04/02/2002	10	EPA	Data gaps in 15 min data during 2006, 2007 and 2010. Peak flows available from 1985 to 1988 but data not at regular intervals. Potentially affected by backwater from nearby tributary. Subject to rating review. Rating curve will be reviewed during hydrological study.	Yes, following rating review	Yes, following rating review
22022	Milltown	Flow and water level	93769	106440	24/01/2002	10	EPA	Data gaps in 2006, 2007 and 2010. Rating from low flow gaugings only, use with out of bank. However most flows in bank at this location.	Yes	Yes, use with caution above bankfull
22033	Kilquane	Flow and water level	108628	90490	02/12/1999	13	EPA	Karstified catchment but AMAX series of reasonable quality.	No	No
22035	Laune Br.	Flow and water level	89143	91131	22/07/1991	20	OPW	Data gap in 2010. Rating curve suspect above bankfull as there are reports of by-passing in extreme floods. Some flows have been edited to make suitable for use. However water level of good quality for assessment of Lough Leane	Yes, use with caution above bankfull	Yes, use with caution above bankfull
22039	Clydagh Br.	Flow and water level	93769	106440	26/01/2000	12	EPA	Reasonable water level and flow but significant data gaps in 2001, 2004, 2007 and 2011. Discontinued after 2011	Yes	Yes, use with caution
22041	Dromickbane	Flow and water level	93769	106440	02/12/1999	13	EPA	Good quality and complete data record	Yes	Yes
22044	Rahanane Weir	Flow and water level	101646	94969	23/10/1999	11	EPA	AMAX series of reasonable quality with no significant data gaps in winter flows.	No	Awaiting data
22061	Castlemaine	Water level (tidal)	83544	103064	04/10/1989	23	OPW	Reasonable AMAX series but digital records of 15 min water level data only available since 2007. Anomalous spike in early 2008 to be removed from data series and several months' data gap in late 2008.	Yes	Yes, tidal and hydrograph shape analysis only.
22071	Tomies Pier	Flow and water level	89959	90589	01/10/1973	38	OPW	3 metre datum shift in 1990. Data series adjusted by -3 m prior to 1990 to match similar levels across the Lough. Significant data gaps in 1988, 2000 and post-2007	Yes (after processing)	Yes (after processing)
22082	Bvm Park	Water level	96640	86719	25/11/2004	7	OPW	Short record with significant data gaps in 2007, 2008 and 2011	Yes	Yes, use with caution
305	Valentia Observatory	Hourly Rainfall	45700	78800	1866	144	Met Eireann	Data quality reasonable and covers periods of calibration events- Transformation needs to be considered for remote AFAs No significant gaps identified and no localised trend (from urbanisation, tree cover etc) identified from record	Yes- with caution	Not required - FSU approach applied
105	Ballymacelligot Rectory	Daily Rainfall	91900	112100	1929	15	Met Eireann	Data quality reasonable and covers periods of calibration events No significant gaps identified and no localised trend (from urbanisation, tree cover etc) identified from record	Use to inform daily total only for transfer	Not required - FSU approach applied
2505	Barraduff G.S.	Daily Rainfall	108100	90400	1951	37	Met Eireann	Significant periods missing in 1978-1980 including the large 1980 storm event.	No	No
3605	Bawnaskehy Castleisland	Daily Rainfall	101700	106400	1982	28	Met Eireann	Data quality reasonable and covers period of the significant 2008 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
805	Beaufort G.S.	Daily Rainfall	87800	91800	1941	54	Met Eireann	Significant data gaps in winter period of 1970 to 1979 and 1980-1981 missing. Does not cover calibration events	No	No
4205	Cappanalea Glencar	Daily Rainfall	72800	89800	1986	3	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied

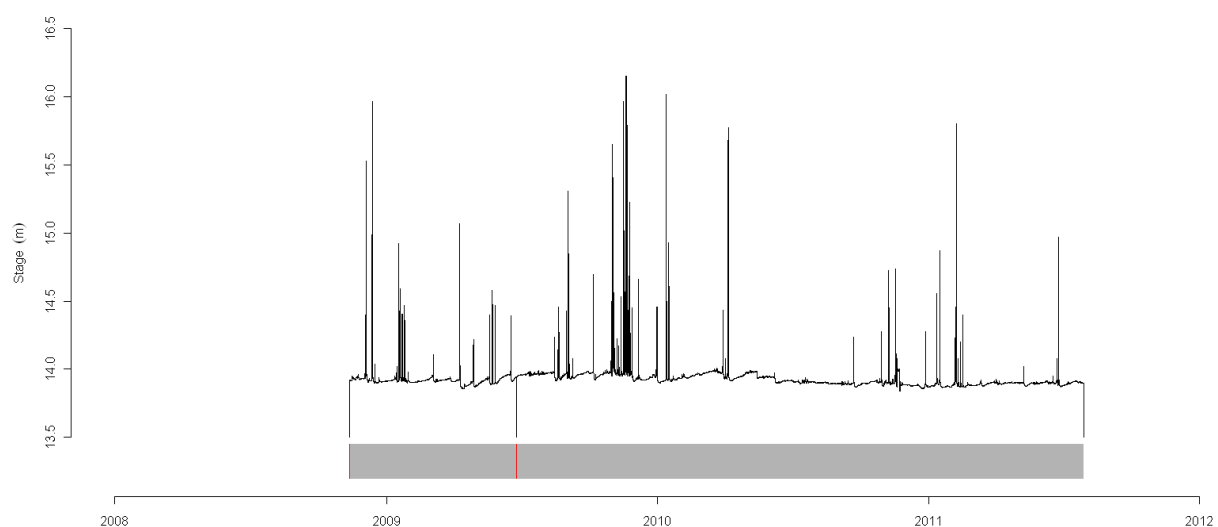
ID	Station_Name	Gauge Type	Easting	Northing	Record_Start	Years Data	Owner	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
1205	Castleisland (Coom)	Daily Rainfall	107400	109900	1944	66	Met Eireann	Data quality reasonable and covers period of the significant 2008 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
2005	Castleisland (Glountaine)	Daily Rainfall	107800	107300	1950	60	Met Eireann	Data quality reasonable and covers period of the significant 2008 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
4905	Castleisland (Kilmurry)	Daily Rainfall	105900	110300	1998	12	Met Eireann	Data quality reasonable and covers period of the significant 2008 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
1305	Castleisland (Voc.Sch.)	Daily Rainfall	100400	110100	1944	44	Met Eireann	Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
2805	Castleisland O.P.W.	Daily Rainfall	100200	109400	1959	3	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
905	Castlemaine G.S.	Daily Rainfall	83900	103300	1941	45	Met Eireann	Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
4305	Dingle (Milltown)	Daily Rainfall	42900	101500	1989	6	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
2405	Dingle G.S.	Daily Rainfall	44600	100800	1950	38	Met Eireann	Data quality reasonable and covers period of the significant 1988 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
2205	Farranfore (Clounlea)	Daily Rainfall	104000	99900	1950	60	Met Eireann	Longer periods missing in winter months throughout series up to 2000. Good data quality from 2000 onwards. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
4405	Farranfore (Knockaderry)	Daily Rainfall	94000	102900	1993	8	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
2105	Farranfore (Scartaglin)	Daily Rainfall	104700	105000	1950	21	Met Eireann	Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
1005	Farranfore G.S.	Daily Rainfall	94000	103400	1941	50	Met Eireann	Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
405	Gap Of Dunloe	Daily Rainfall	88500	81900	1885	125	Met Eireann	Data of good quality expect for missing periods in 1992, 2000, 2007 and 2008. Covers the recent 2009 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer.	No
605	Killarney (B.V.M.Park)	Daily Rainfall	97000	85700	1924	67	Met Eireann	Data quality reasonable and covers period of the significant 1980 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
2905	Killarney (Drom Aulinn)	Daily Rainfall	97100	90200	1966	6	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
3505	Killarney (Farm Centre)	Daily Rainfall	96000	92100	1976	16	Met Eireann	Data quality reasonable and covers period of the significant 1980 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
3005	Killarney (Golf Club)	Daily Rainfall	92800	91100	1967	5	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
3105	Killarney (Gortdromakier y)	Daily Rainfall	101200	83800	1968	27	Met Eireann	Data quality reasonable and covers period of the significant 1980 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
2705	Killarney (Gt.Southern Hotel)	Daily Rainfall	97500	90800	1958	10	Met Eireann	Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
3405	Killarney (Lissivigeen N.S.)	Daily Rainfall	100000	89700	1969	15	Met Eireann	Data quality reasonable and covers period of the significant 1980 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
1105	Killarney (Muckcross For.Stn.)	Daily Rainfall	97700	88200	1941	35	Met Eireann	Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
3205	Killarney (Muckcross Hse.)	Daily Rainfall	97200	86200	1968	42	Met Eireann	Data quality reasonable and covers period of the significant 2009 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
505	Killarney (St.Finan's Hosp.)	Daily Rainfall	96400	91600	1889	99	Met Eireann	Reasnable quality since 1941 but longer periods of missing data in 1976, 1981 and 1982, 86 and 87.	Use to inform daily total only for transfer	No
205	Killarney (The Reeks)	Daily Rainfall	83500	93700	1956	1	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
705	Killorglin	Daily	77900	99400	1921	89	Met	Minor data gaps of less than 3 days. Longer periods missing in winter 1979 and summer 1987. Data of	Use to inform daily total only for	Not required - FSU

ID	Station_Name	Gauge Type	Easting	Northing	Record_Start	Years Data	Owner	Comments	Fit for Calibration Purposes?	Fit for Statistical Analysis?
	(Callinafercy)	Rainfall					Eireann	good quality after 1990 covering calibration events. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	transfer	approach applied
2605	Killorglin (Voc.Sch.)	Daily Rainfall	77500	96200	1952	30	Met Eireann	Minor data gaps of less than 3 days. Data quality reasonable and covers periods significant 1980 event. However the daily interval will only provide total rainfall and will need to be correlated with Valentia Observatory	Use to inform daily total only for transfer	Not required - FSU approach applied
3805	Killorglin V.S. li	Daily Rainfall	77900	95700	1982	6	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
8705	M.Killarney (Dromdiralough)	Daily Rainfall	102000	85800	1968	24	Met Eireann	No daily rainfall available for entire period.	Use to inform daily total only for transfer	Not required - FSU approach applied
4005	Macgillicuddy (L.Eighter)	Daily Rainfall	77900	85200	1983	12	Met Eireann	Short record. Does not cover calibration events	Use to inform daily total only for transfer	Not required - FSU approach applied
1905	Portmagee G.S.	Daily Rainfall	37500	72800	1949	34	Met Eireann	1971 to 1979 missing. Otherwise data of reasonable quality and coverage.	Not required - coastal risk only	Not required - coastal risk only

The following figures have classified gauge data into the following categories:

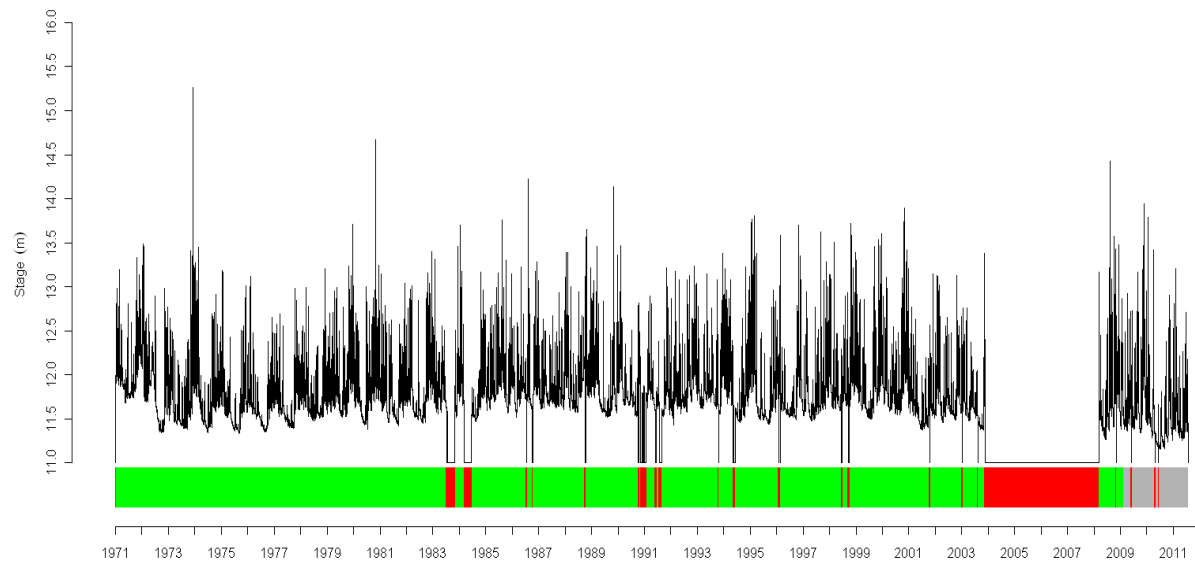
Missing	Data is missing, erroneous or of unacceptable quality for use (e.g. equipment error or readings during drainage works).
Suspect	Data may contain a significant degree of error due to extrapolation using a poor rating curve or extrapolated beyond reliable data range as identified by OPW or EPA. Alternatively data that has been derived from incomplete records.
Fair	Data derived from a corrected water level series or a fair rating curve as identified by OPW or EPA.
Good	Data has been inspected and is deemed consistent and without significant error as identified by OPW and EPA.
Unchecked	Unchecked data – Data is provisional only and must be used with caution. Frequently applies to most recent data.

Figure A.1: Water Level Data Quality Plot for Bypass Channel @ Riverville Bypass Gauge (OPW - 22001)



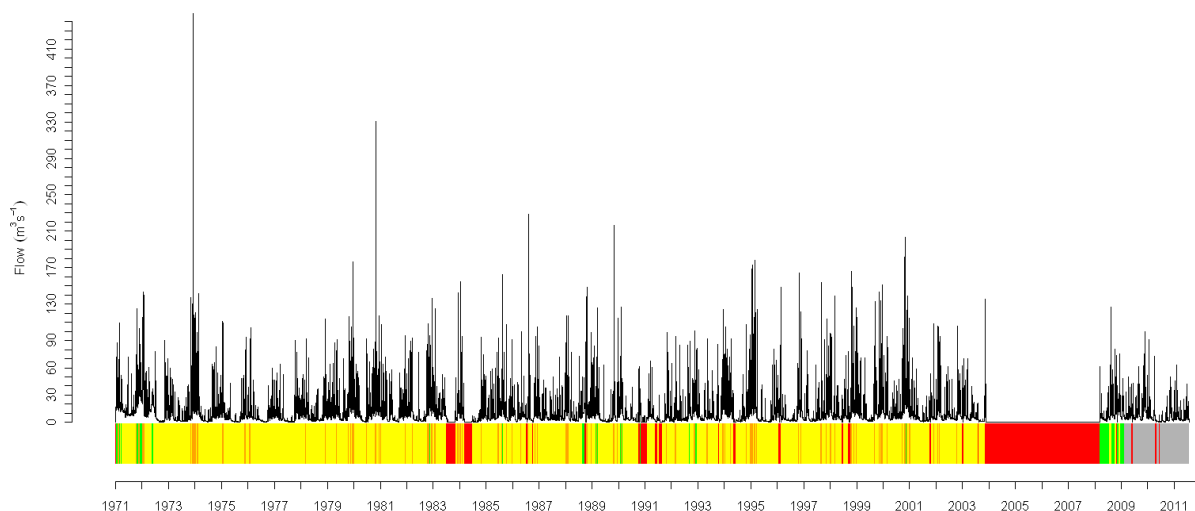
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.2: Water Level Data Quality Plot for Maine @ Riverville Gauge (OPW - 22003)



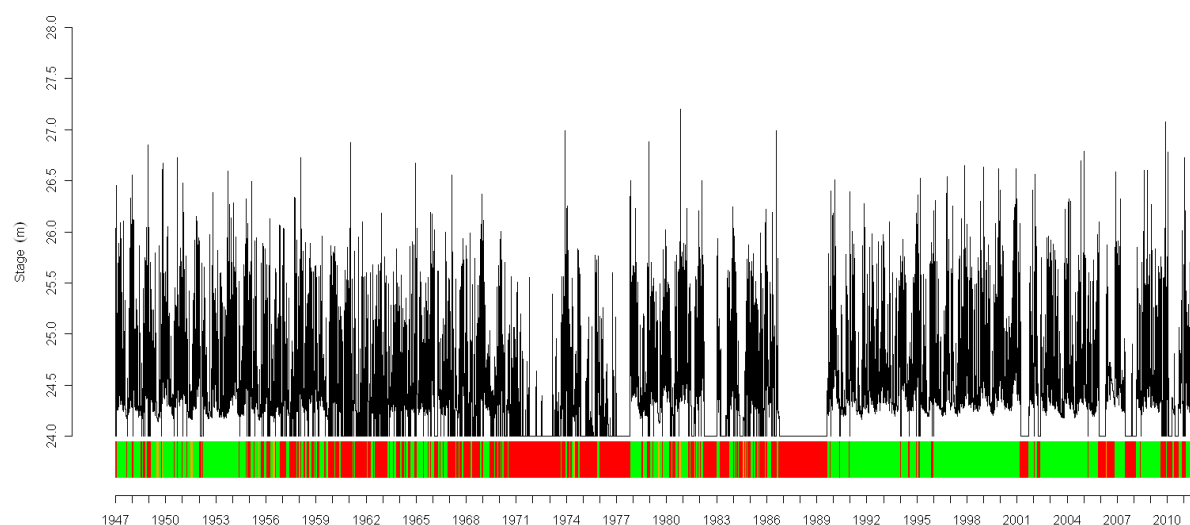
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on data quality flags.

Figure A.3: Flow Data Quality Plot for Maine @ Riverville Gauge (OPW - 22003)



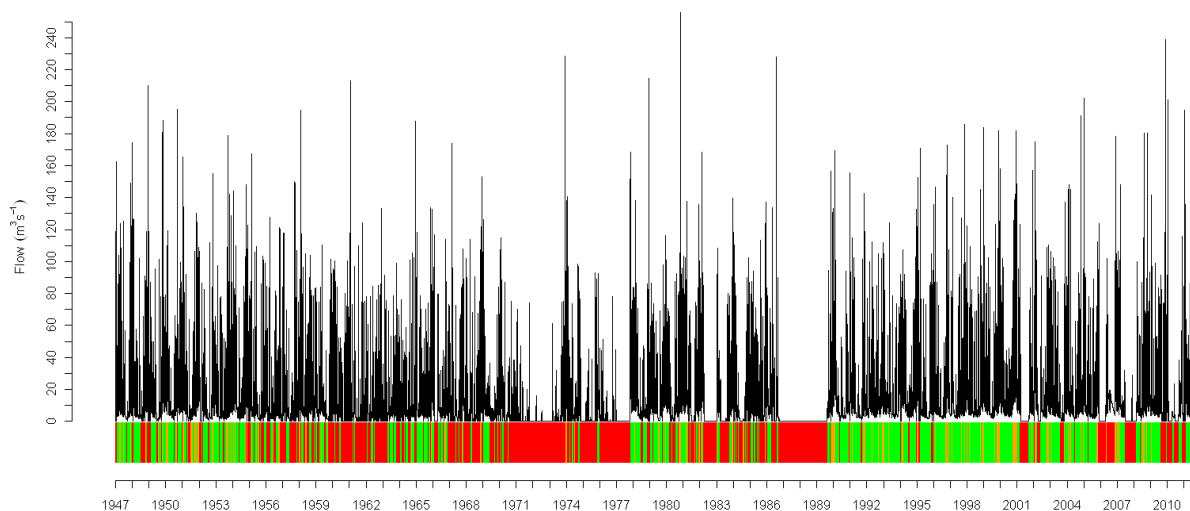
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.4: Water Level Data Quality Plot for Flesk @ Flesk Bridge Gauge (OPW - 22006)



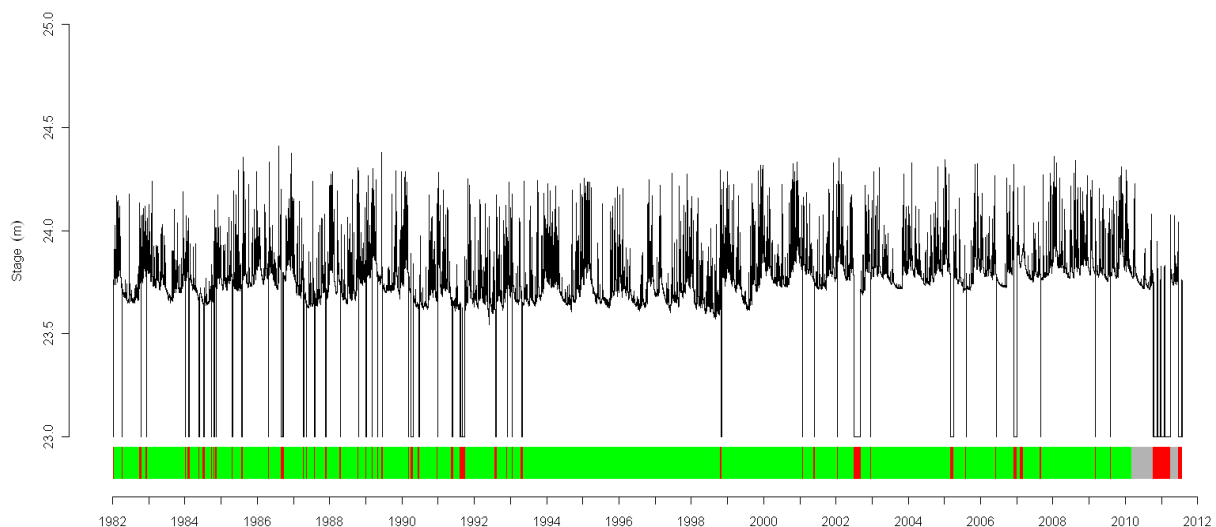
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.5: Flow Data Quality Plot for Flesk @ Flesk Bridge Gauge (OPW - 22006)



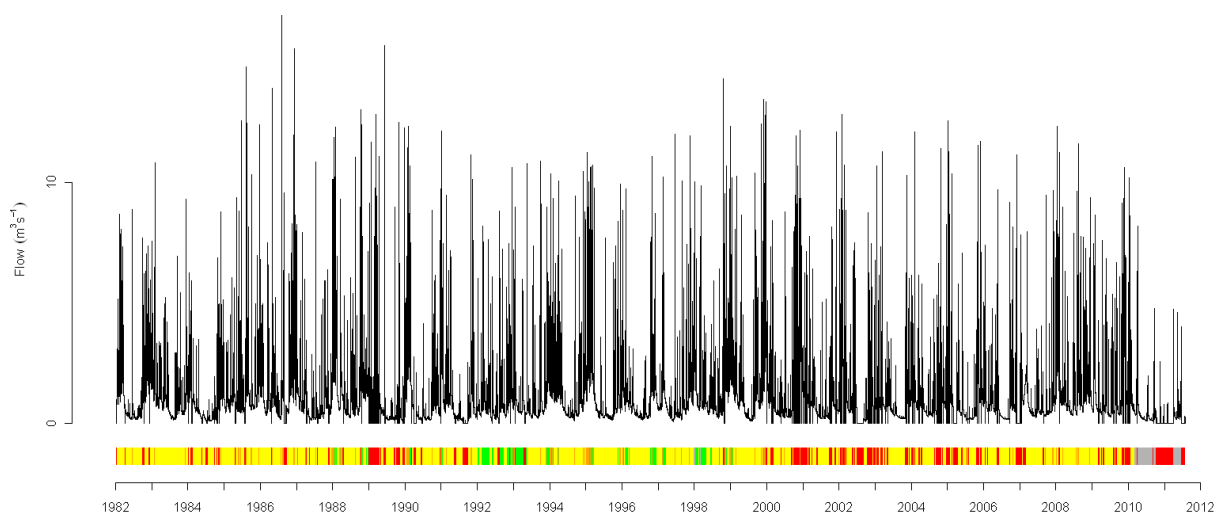
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.6: Water Level Data Quality Plot for Deenagh @ White Bridge Gauge (OPW - 22009)



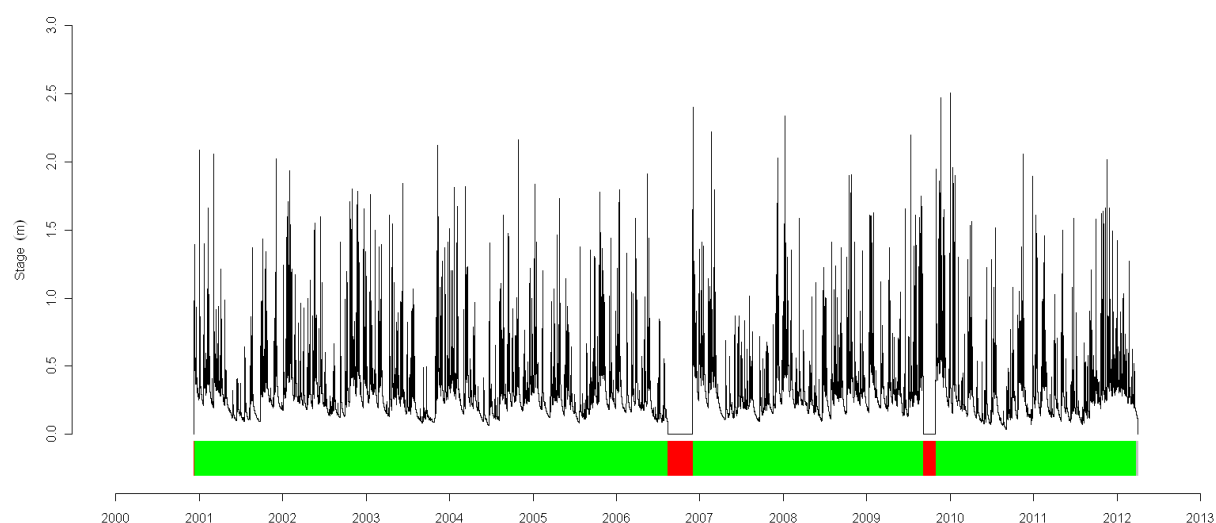
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.7: Flow Data Quality Plot for Deenagh @ White Bridge Gauge (OPW - 22009)



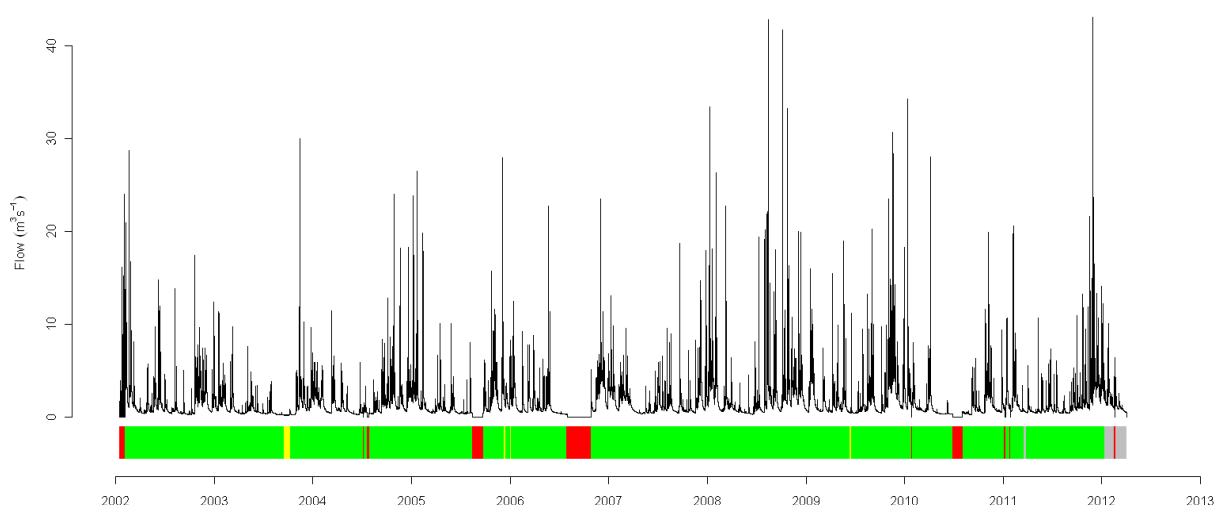
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.8: Water Level Data Quality Plot for Maine @ Castleisland Gauge (EPA - 22014)



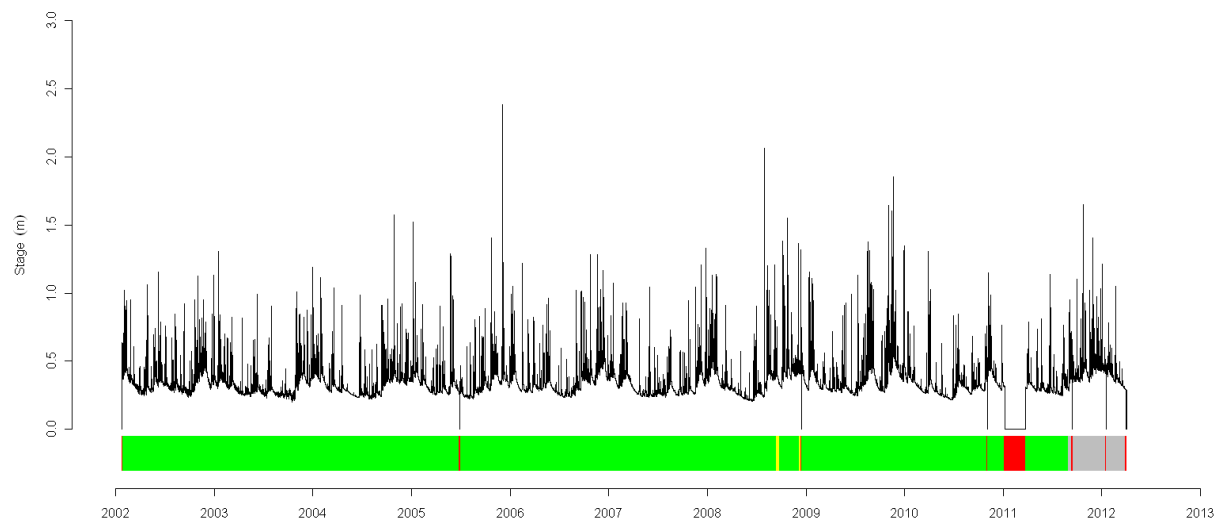
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.9: Flow Data Quality Plot for Maine @ Castleisland Gauge (EPA - 22014)



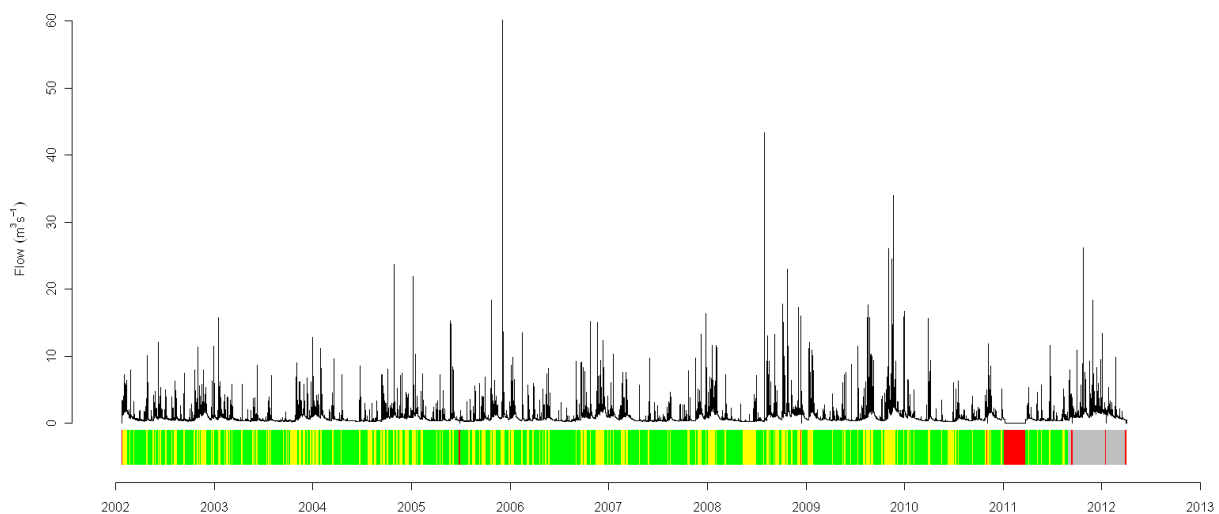
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.10: Water Level Data Quality Plot for Milltown @ Milltown (Dingle) Gauge (EPA - 22022)



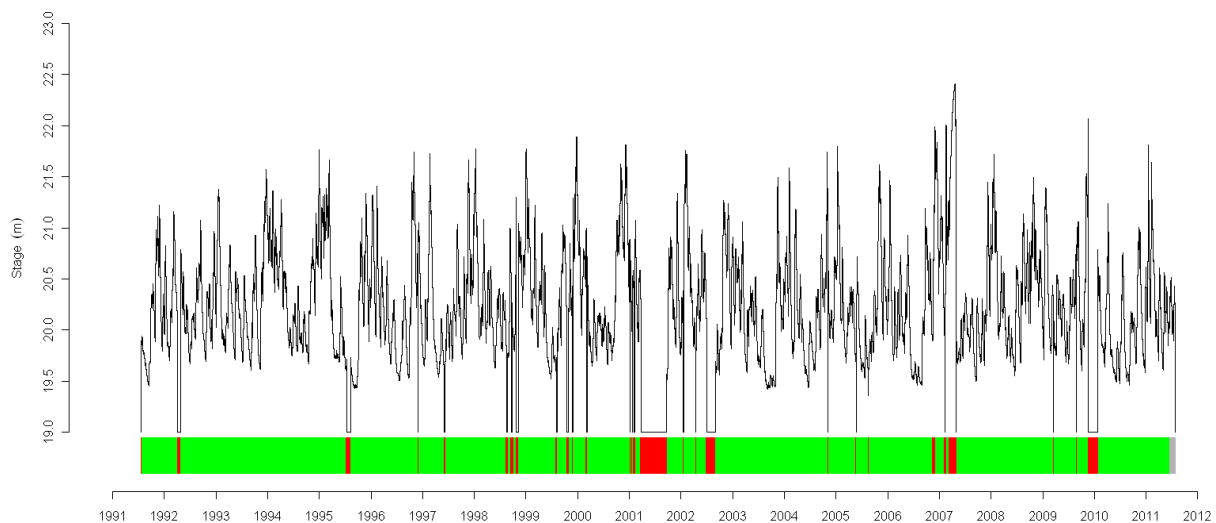
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.11: Flow Data Quality Plot for Milltown @ Milltown (Dingle) Gauge (EPA - 22022)



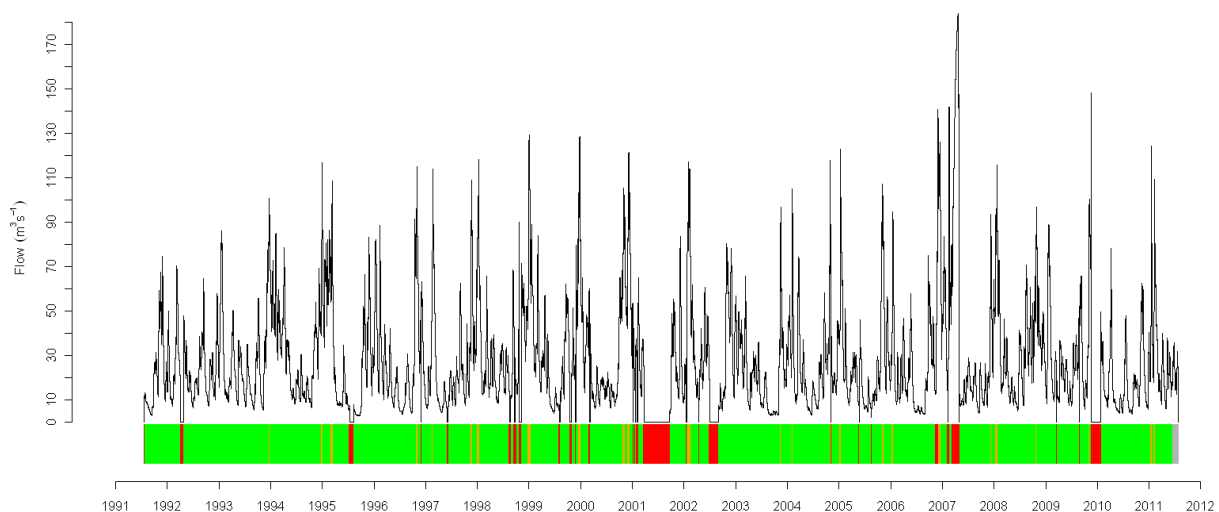
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.12: Water Level Data Quality Plot for Laune @ Laune Bridge Gauge (OPW - 22035)



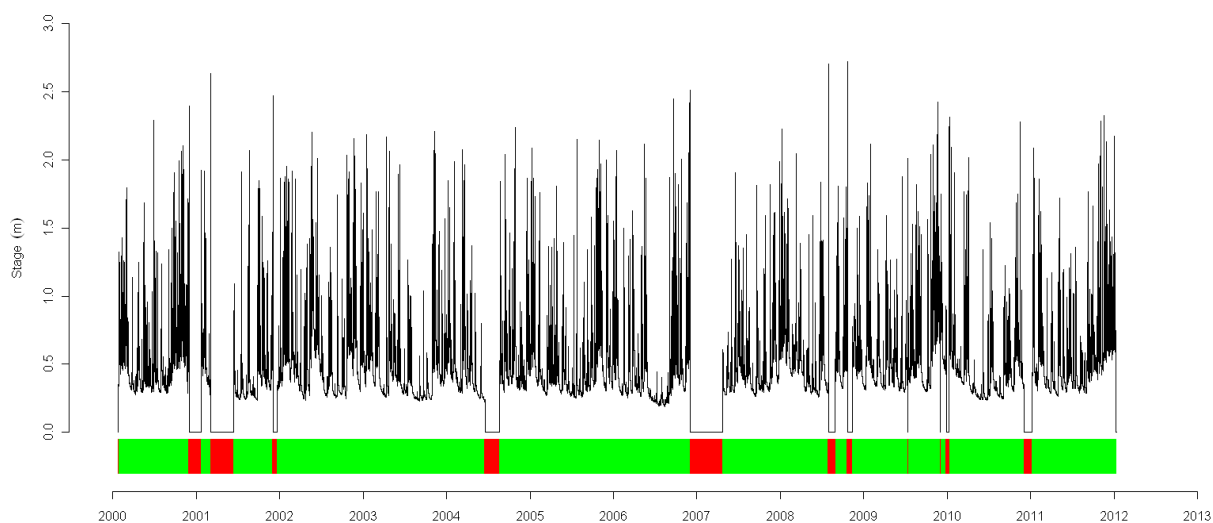
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.13: Flow Data Quality Plot for Laune @ Laune Bridge Gauge (OPW - 22035)



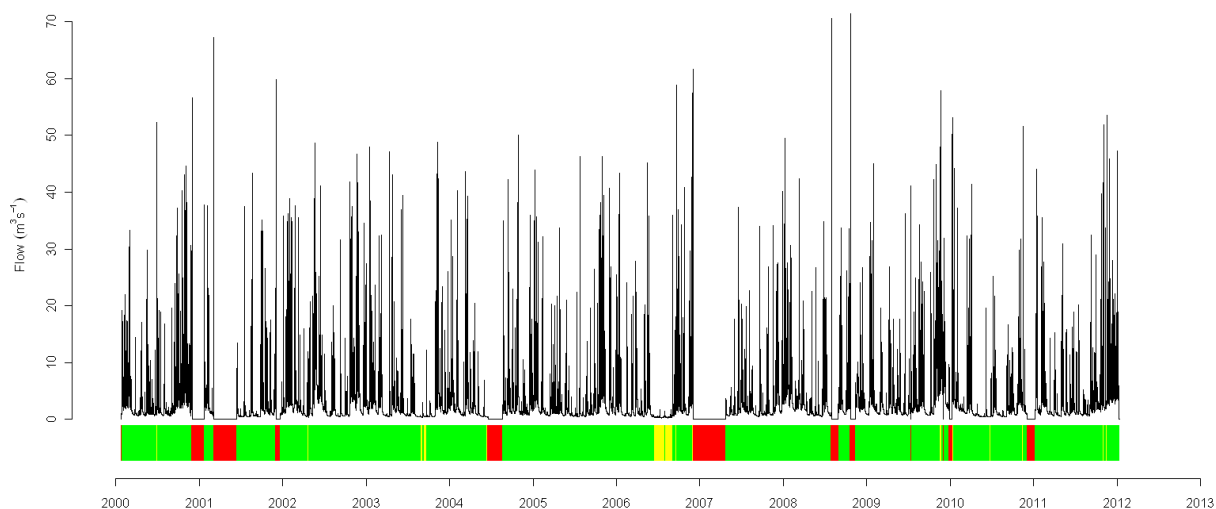
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.14: Flow Data Quality Plot for Flesk @ Clydagh Bridge Gauge (EPA - 22039)



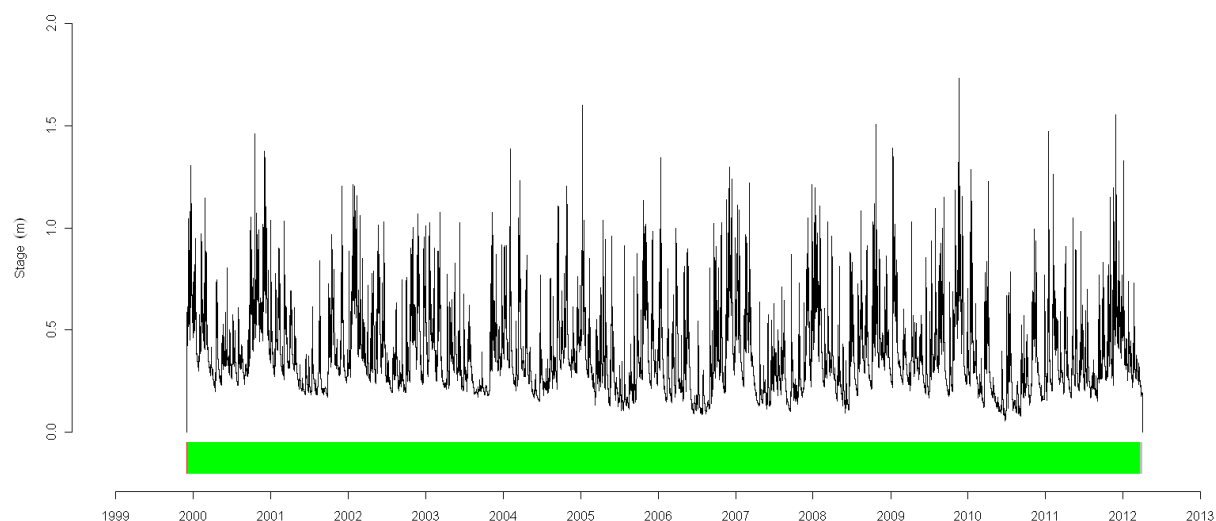
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.15: Flow Data Quality Plot for Flesk @ Clydagh Bridge Gauge (22039)



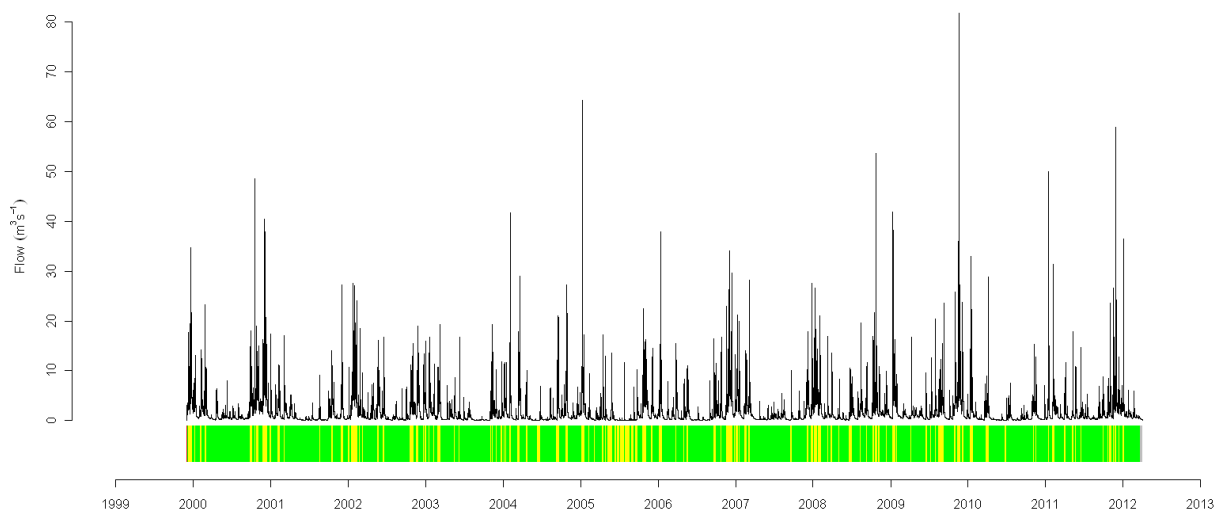
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.16: Water Level Data Quality Plot for Finow @ Dromickbane Gauge (EPA - 22041)



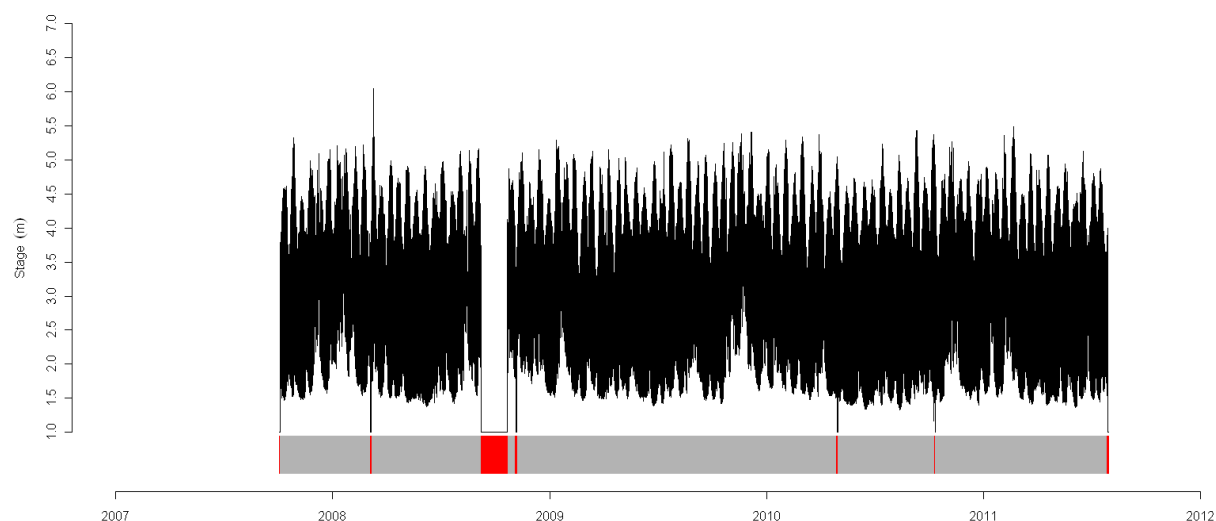
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.17: Flow Data Quality Plot for Finow @ Dromickbane Gauge (EPA - 22041)



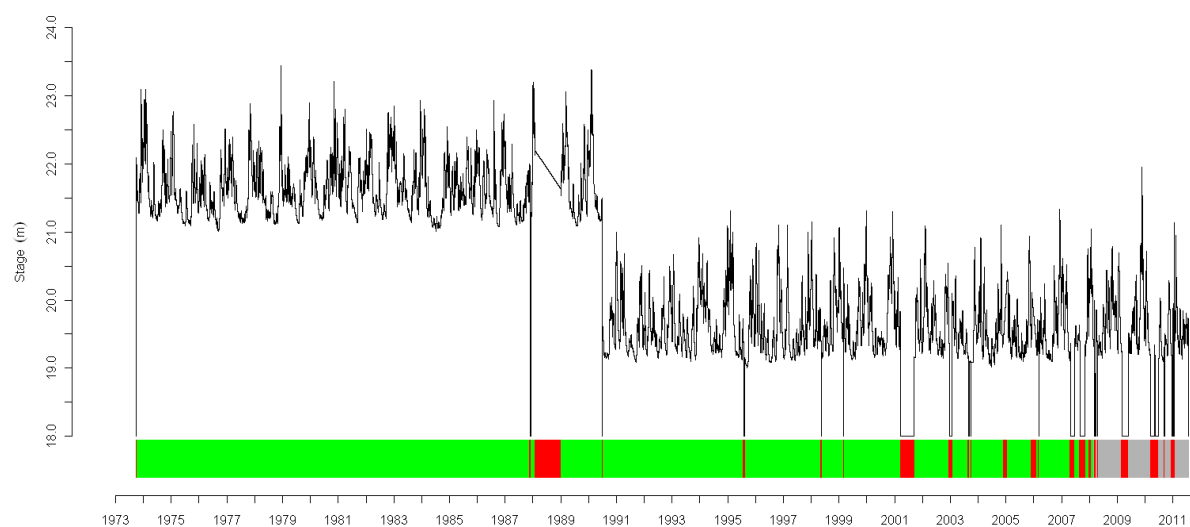
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.18: Water Level Data Quality Plot for Maine Estuary @ Castlemaine Gauge (OPW - 22061)



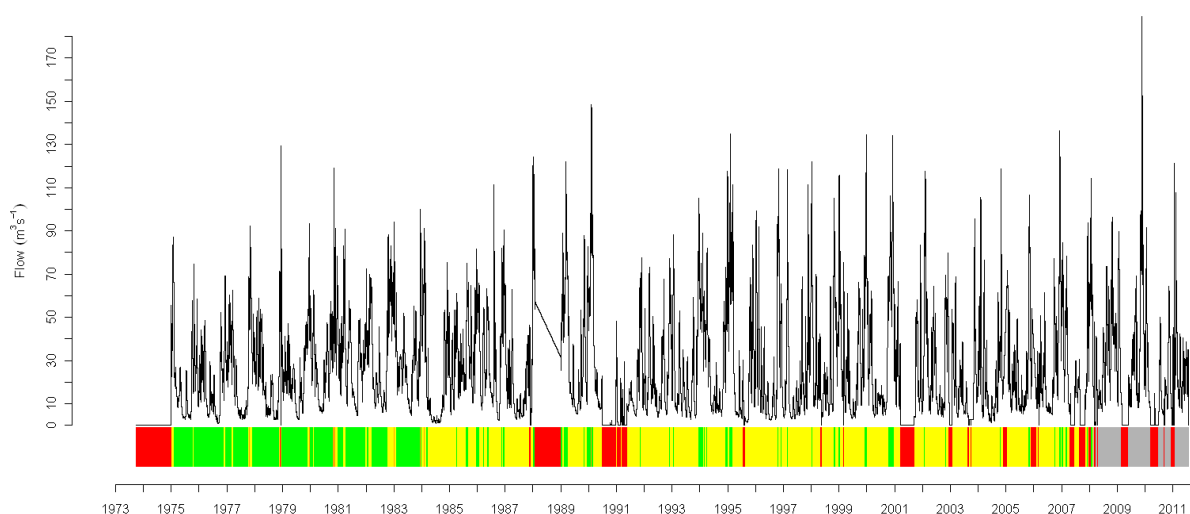
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.19: Water Level Data Quality Plot for Lough Leane @ Tomies Pier Gauge (OPW - 22071)



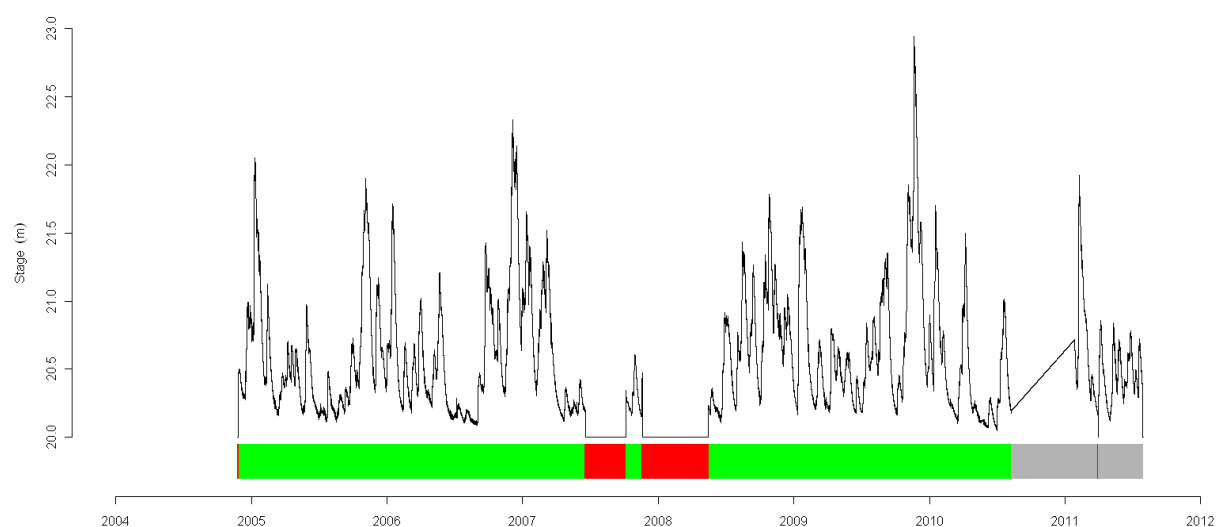
Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.20: Flow Data Quality Plot for Lough Leane @ Tomies Pier Gauge (OPW - 22071)



Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.21: Water Level Data Quality Plot for Lough Leane @ Bvm Park Gauge (OPW - 22082)



Where: Red is missing, Orange is suspect, Yellow is Edited, Green is good and Grey is unchecked based on OPW and EPA data quality flags.

Figure A.22: Correlation of Rainfall Between Valentia Observatory and Dingle AFA

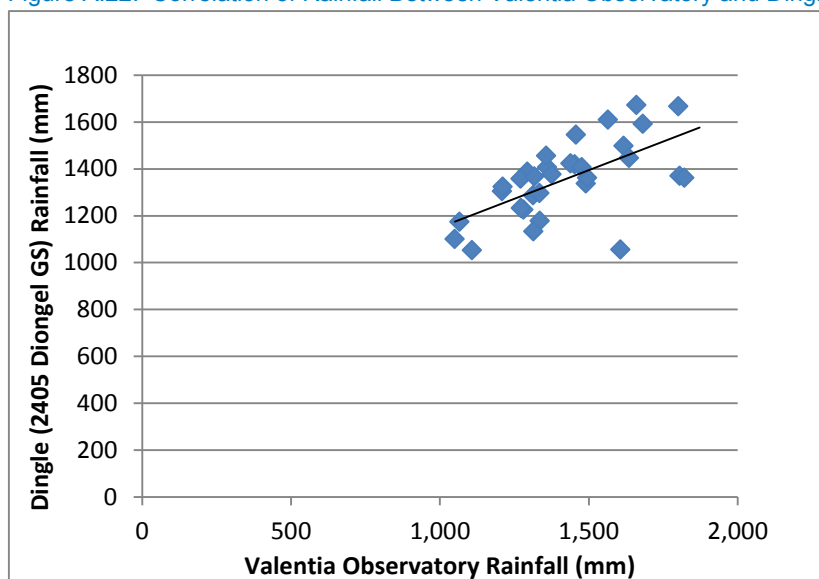


Figure A.23: Correlation of Rainfall Between Valentia Observatory and Castleisland AFA

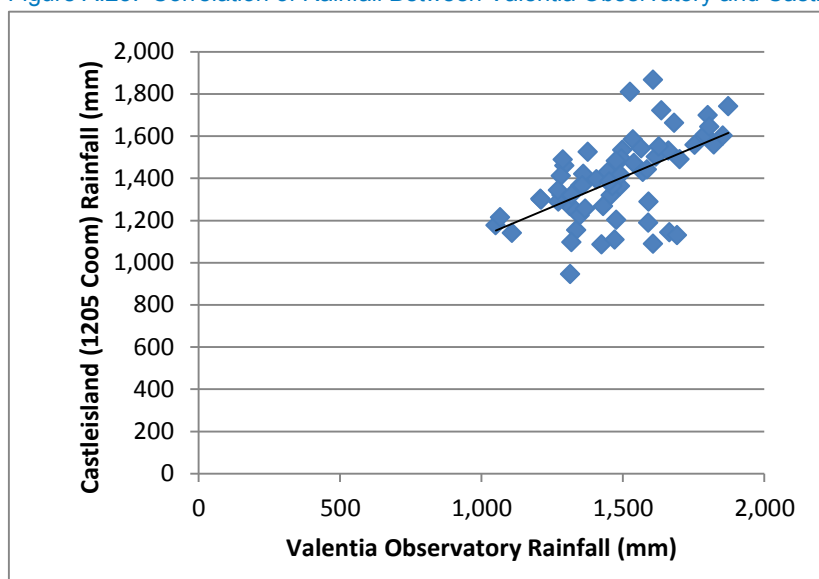
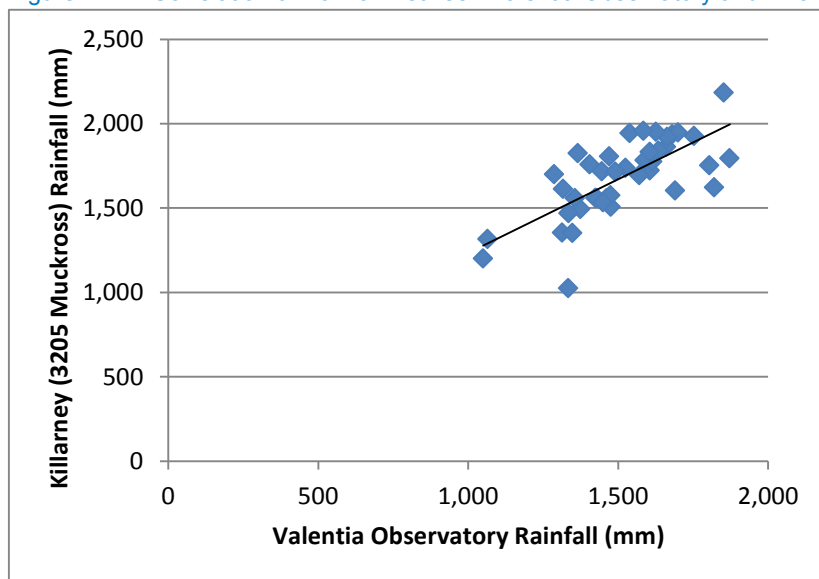
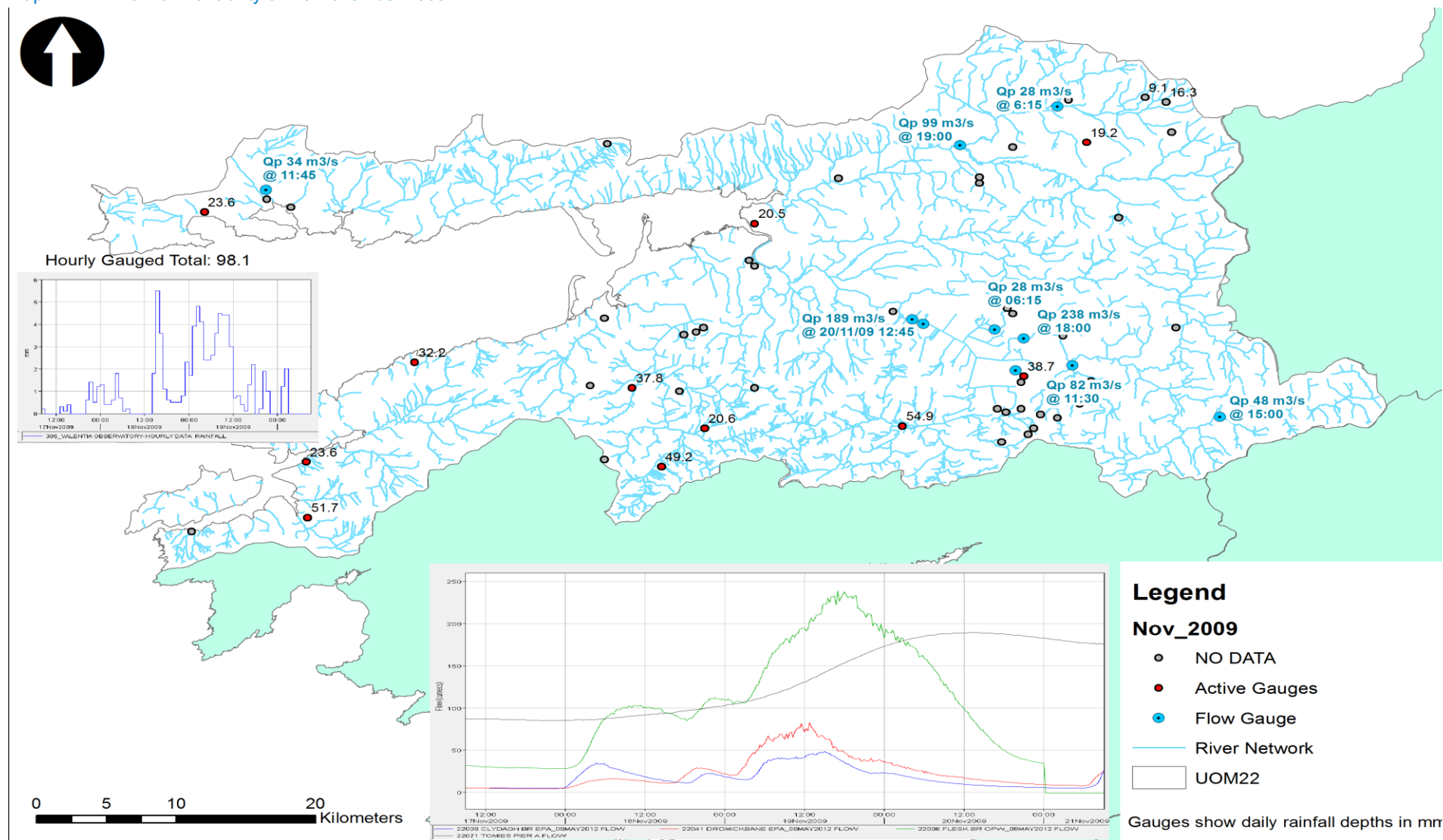


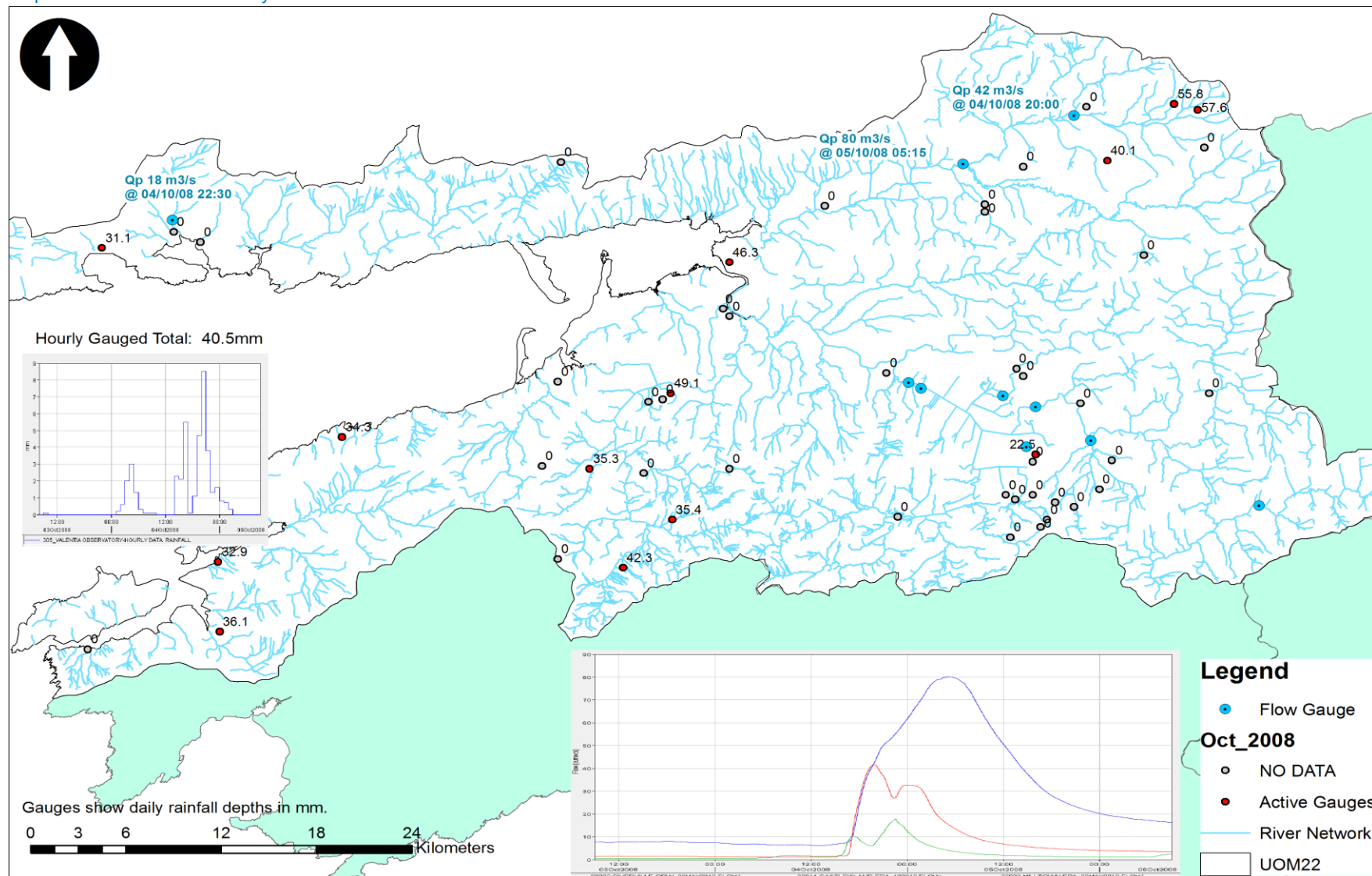
Figure A.24: Correlation of Rainfall Between Valentia Observatory and Killarney AFA



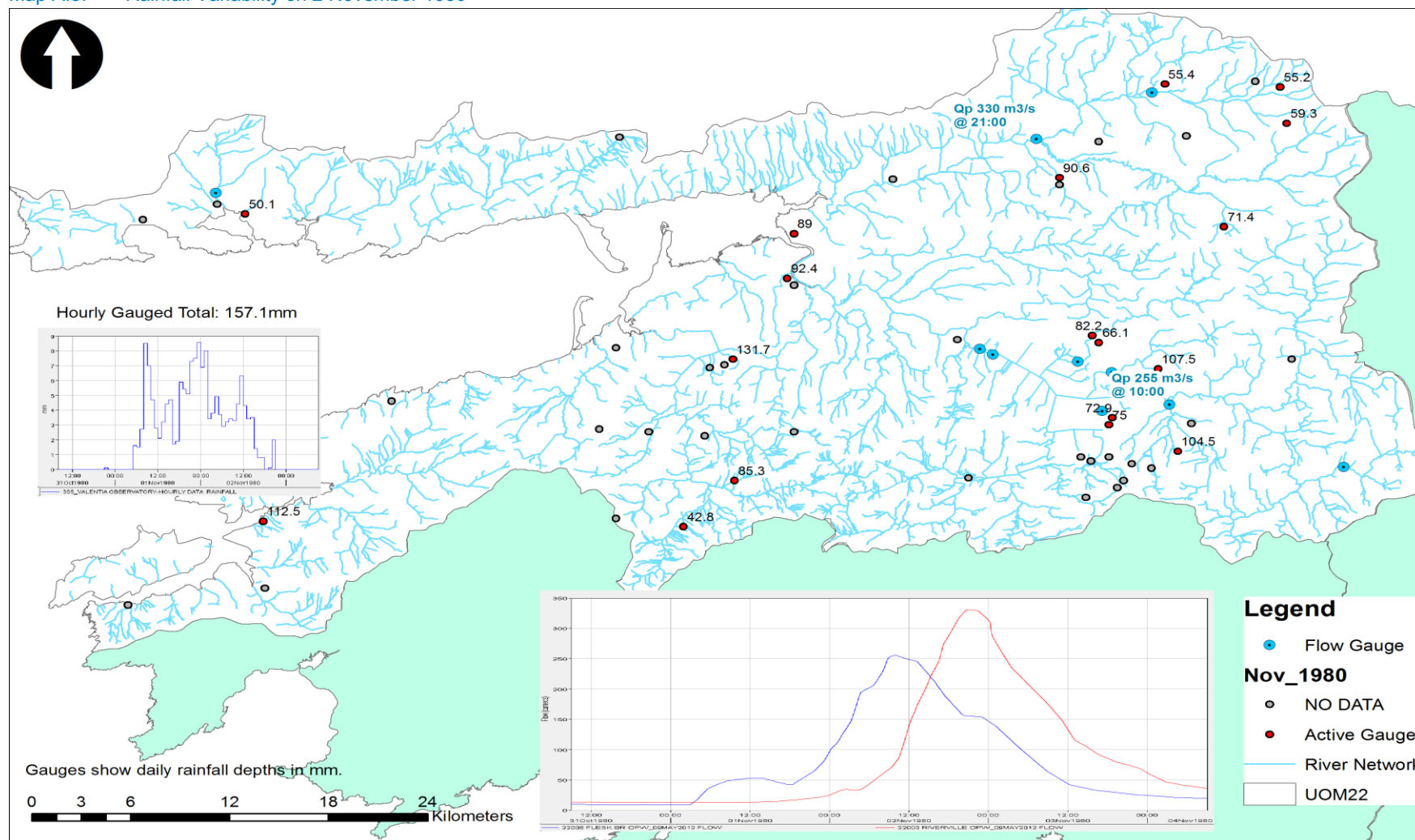
Map A.1: Rainfall Variability on 19 November 2009



Map A.2: Rainfall Variability on 4 October 2008



Map A.3: Rainfall Variability on 2 November 1980



Appendix B. Gauging Station Review Profomas

Appendix C. Hydrological Estimation Points

Table C.1: Castleisland AFA Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFAQ	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Glanshearoon upstream	22_191_1	7.8	4.369	10.036	12	1.282	39.2120	0.0	1	103300	113190	1411	0.64	0.000	12.90	1.82	5.82	83.55	0.462
Glanshearoon downstream	22_360_2	12.6 (14.1)	8.723	18.826	20	1.312	19.5516	5.8	1	102340	112160	1411	0.64	0.008	7.18	1.72	3.74	89.19	0.475 (0.427)
Shanowen upstream	22_1589_1	40.4	9.43	53.227	39	1.311	20.9401	12.3	1	105650	109190	1326	0.64	0.003	19.64	6.00	13.55	70.65	0.463
Shanowen downstream	22_1589_3	41.5	10.43	54.227	39	1.303	18.6038	13.9	1	105240	109190	1327	0.64	0.003	19.81	6.42	13.58	70.71	0.463
Anglore Stream	22_1331_3	3.1 (1.7)	1.747 (2.268)	1.747 (2.268)	1	0.736	4.2496 (0.1)	41.2	1	101730	111059	1354	0.64	0.071	0.00	4.69	0.00	95.31	0.389
Maine Upper downstream	22_1756_3	4.5 (3.1)	1.338	1.338	1	0.455	3.3028	90.5	1	101830	110520	1357	0.64	0.154	0.00	6.50	0.00	82.65	0.447
Maine mid upstream	22_1587_1	46.0 (41.6)	10.43	55.565	42	1.22	16.7000	17.8	1	105210	109190	1330	0.64	0.017	18.44	6.43	12.64	71.54	0.462
22014 (Castleisland)	22_1587_3	46.9 (45.6)	11.434	56.567	42	1.238	16.7020	17.8	1	104670	109190	1329	0.64	0.021	18.09	6.51	12.40	71.05	0.463
Maine Mid downstream	22_1587_4	47.2 (45.9)	11.706	56.841	42	1.24	16.5050	17.8	1	104630	109190	1329	0.64	0.022	17.94	6.52	12.30	70.53	0.463
Maine Lower upstream	22_2098_1	59.8	11.706	75.668	63	1.258	15.2449	15.8	1	104550	109790	1347	0.64	0.019	15.42	5.54	10.29	74.91	0.459
Maine Downstream	22_2098_3	60.3	12.336	76.297	62	1.265	14.8942	16.1	1	104350	109790	1349	0.64	0.028	15.35	5.58	10.24	74.93	0.464

Highlighted text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows. (Value in brackets is the original parameter)

Map C.1: Castleisland AFA Sub-Catchments

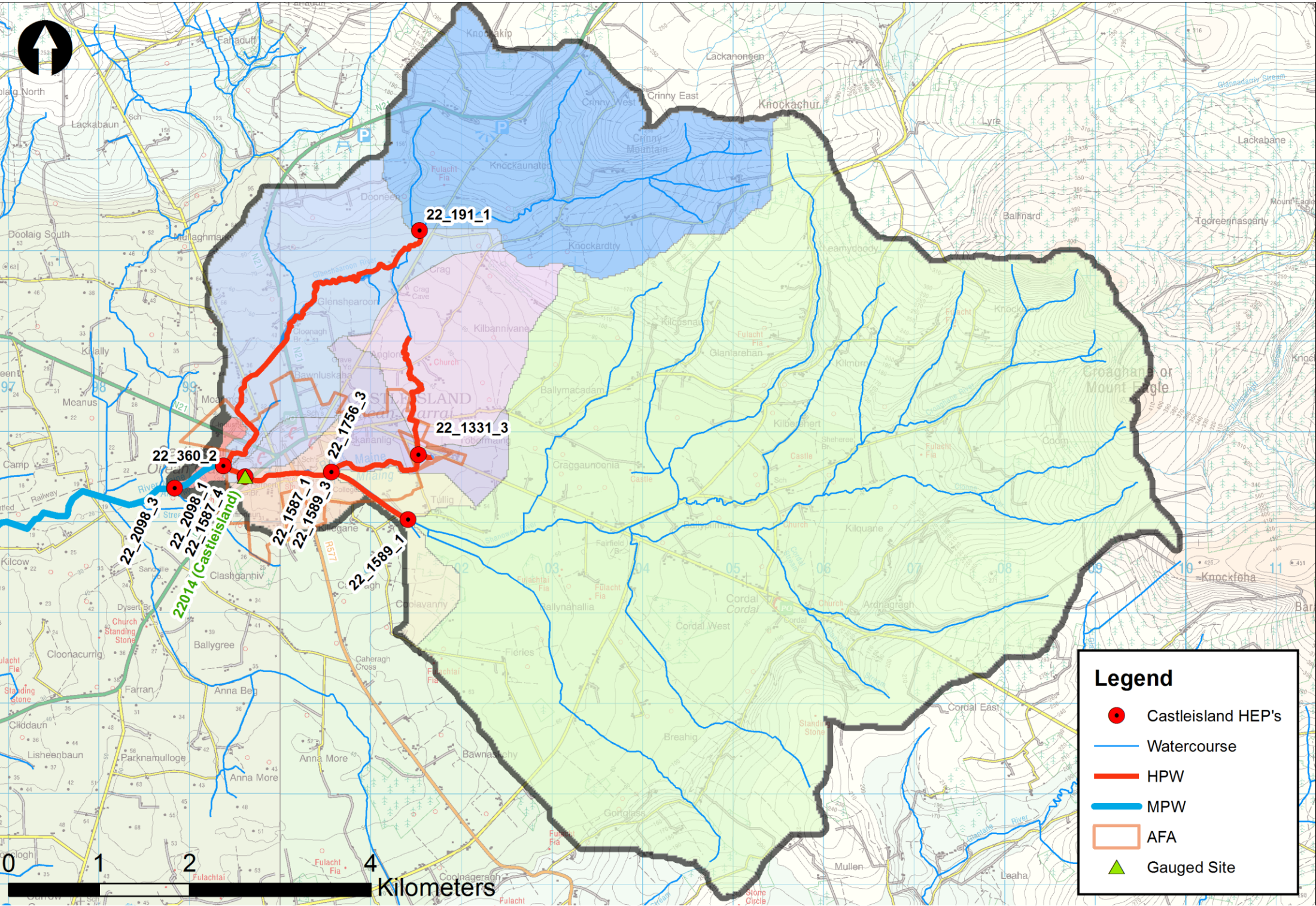


Table C.2: Dingle AFA Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFAQ	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Dingle Stream Upstream	22_3437_1	1.1	1.92	1.92	1	1.784	189.61	0.00	1.000	45630	103330	1596	0.680	0.000	11	0.000	0.00	37.81	0.466
Dingle Stream Downstream	22_3437_5	5.2	3.82	3.82	1	0.727	73.56	0.00	1.000	45500	102580	1547	0.680	7.460	2	0.000	0.00	68.57	0.563
Milltown River UPSTREAM	22_1712_1	20.6	7.71	26.26	29	1.277	35.03	0.00	1.000	43590	105210	1590	0.670	0.000	43	2.660	7.57	45.37	0.438
Milltown Gauge (22022)	22_1712_2	20.9	8.21	26.76	29	1.280	31.80	0.00	1.000	43590	105150	1588	0.670	0.000	43	2.730	7.54	46.26	0.439
Milltown River-Ballymoreareagh Tributary Upstream	22_1712_4	21.3	9.22	27.76	29	1.306	27.31	0.00	1.000	43590	104750	1587	0.670	0.000	42	2.970	7.42	47.15	0.439
Milltown River-Ballymoreareagh Tributary Downstream	22_3998_1	27.6	9.22	33.64	35	1.221	27.31	0.00	1.000	43270	104460	1567	0.670	0.000	33	2.750	6.58	55.69	0.445 (0.472)
Milltown River Downstream	22_3999_2	28.9	9.91	34.34	36	1.190	25.36	0.00	1.000	43270	104460	1562	0.680	0.360	32	2.990	6.29	56.30	0.445 (0.532)
Ballymoreareagh Tributary Downstream	22_1196_5	6.3	4.96	5.88	5	0.935	21.43	0.00	1.000	41460	103280	1499	0.680	0.000	1	1.970	3.77	84.54	0.445 (0.582)

Highlighted text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows. (Values in brackets denote the original parameter)

Map C.2: Dingle AFA Sub-Catchments

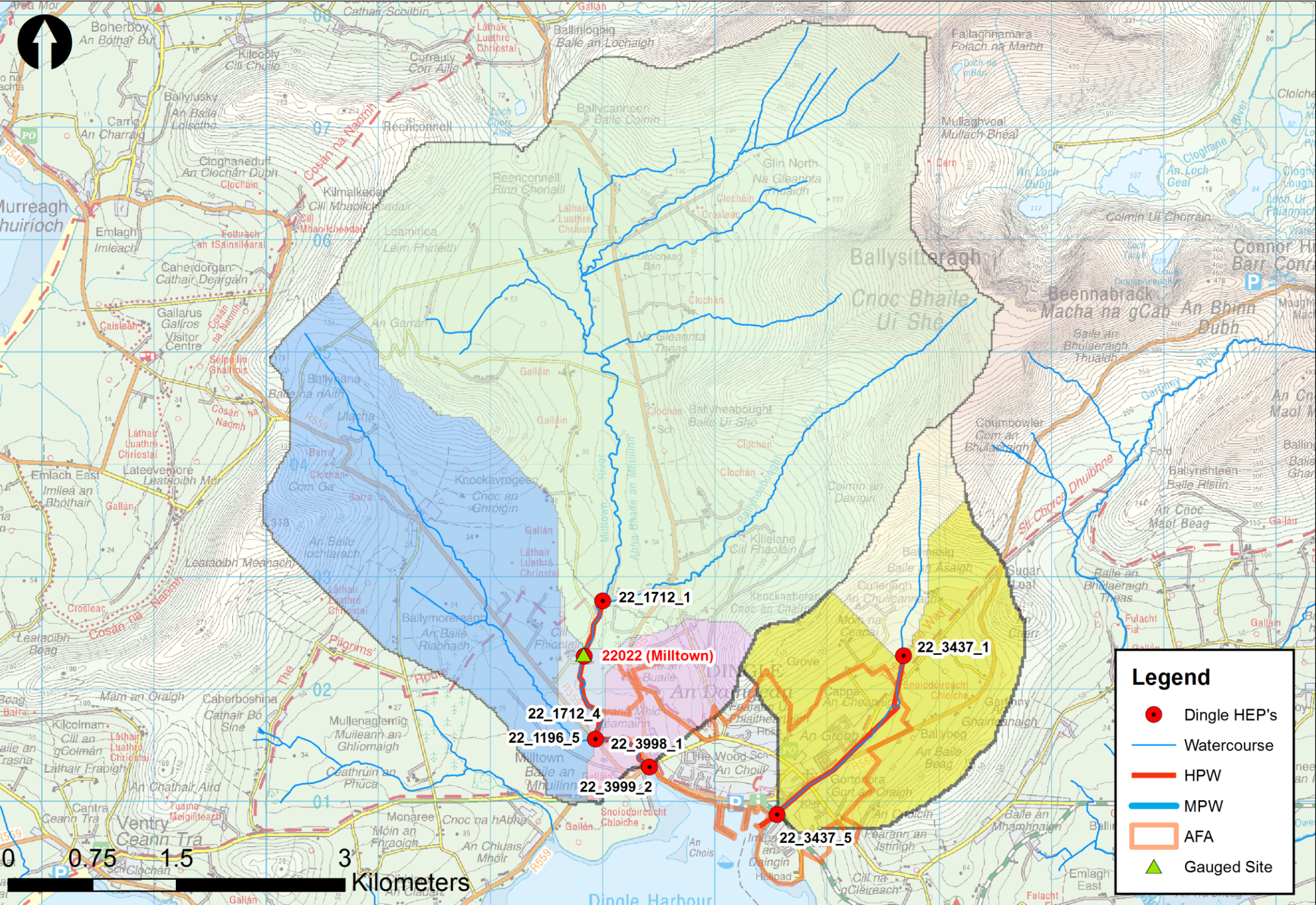


Table C.3: Killarney AFA Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFQ	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Deenagh upstream Survey Extent	22_4003_4	24.6	11.547	32.453	59	1.317	11.05	0	0.993	101100	95560	1125	0.66	0.00	17.95	1.43	6.68	79.83	0.609
22009 (White Bridge)	22_4003_14	31.1 (35.4)	16.489	38.341	59	1.083	10.55	0	0.995	99783	94399	1172	0.66	1.46	15.13	2.75	9.26	72.72	0.601
Deenagh downstream Survey Extent & AFA Boundary	22_4003_16	31.3	17.434	38.341	59	1.224	10.15	0	0.994	99520	94370	1154	0.66	1.45	14.12	3.66	8.54	79.28	0.595
Woodford upstream Survey Extent	22_2197_1	15.2	7.401	19.654	27	1.297	14.08	0	1.000	102020	91740	1257	0.66	0.00	9.10	3.16	5.42	72.64	0.588
Woodford upstream Flesk	22_2197_3	15.7	8.489	20.742	27	1.320	16.33	0	1.000	101890	91740	1260	0.66	0.34	8.77	3.45	6.28	72.49	0.588
Flesk UPSTREAM	22_3340_8	307.9	42.251	389.740	515	1.266	9.93	0	0.958	110430	89040	1855	0.66	0.00	52.38	4.07	15.99	31.15	0.415 (0.381)
Flesk upstream Woodford	22_3340_10	308.6	42.879	390.368	515	1.265	9.95	0	0.958	110430	89040	1854	0.66	0.00	52.26	4.09	15.99	31.26	0.415 (0.381)
Flesk downstream Woodford	22_3372_1	324.4	42.879	411.11	543	1.267	9.95	0	0.960	110430	89040	1825	0.66	0.02	50.15	4.06	15.52	33.26	0.409 (0.390)
22006 (Flesk Bridge)	22_3372_6	328.8	45.138	415.886	543	1.265	9.42	0	0.961	109850	89040	1819	0.66	0.54	49.47	4.14	15.57	33.50	0.388
Flesk downstream Survey Extent & AFA Boundary	22_3372_11	330.1	47.655	415.886	543	1.260	9.40 (9.02)	0	0.961	109550	89040	1818	0.66	0.66	49.28	4.28	15.61	33.50	0.389

Highlighted text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows. (Values in brackets denote the original parameter)

Map C.3: Killarney AFA Sub-Catchments

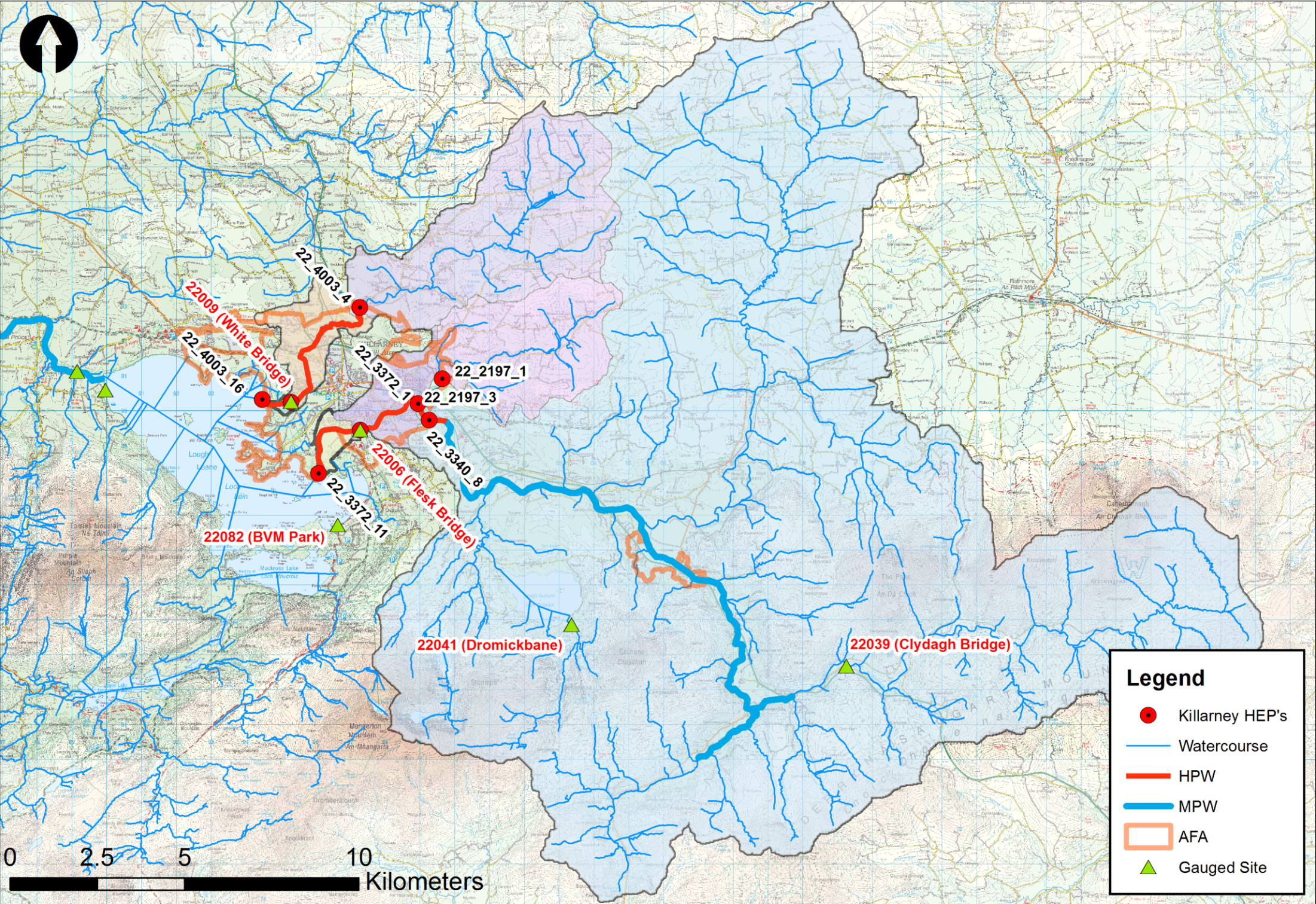


Table C.4: Milltown AFA Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFIQ	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Ashullish Stream Upstream	22_3093_3	2.28	1.644	1.643	1	0.722	15.04	0.00	1	83600	99460	1410	0.60	0.830	0.00	0.26	0.00	99.17	0.61
Ashullish-Ashullish Tributary upstream	22_3093_4	2.45	1.991	1.991	1	0.814	12.20	0.00	1	83600	99530	1448.17	0.67	2.34	0	0.52	0	97.66	0.61
Ashullish-Ashullish Tributary downstream	22_3116_1	3.53	1.991	3.191	3	0.905	12.20	0.00	1	82970	99530	1497.75	0.67	1.63	0	0.45	0.04	98.37	0.62
Ashullish-Ballyoughtragh Upstream	22_3116_4	4.68	3.542	4.742	3	1.013	13.89	9.79	1	82970	100010	1642.28	0.67	5.44	0	0.76	1.15	94.56	0.62
Ashullish-Ballyoughtragh Downstream	22_3617_1	8.96	3.744	8.486	5	0.947	17.02	10.13	1	84100	100180	1577.94	0.67	4.33	0	1.4	2.28	95.62	0.61
Ashullish Stream downstream	22_3958_2	9.47	4.157	9.202	7	0.972	14.93	17.11	1	84100	100180	1602.78	0.67	4.1	0	1.33	2.35	94.15	0.61
Knokavota Stream downstream at tributary	22_3094_2	1.07	1.2	1.2	1	1.122	33.77	0.00	1	81700	99620	1606.11	0.67	0	0	0.03	0.15	100	0.62
Ballyoughtragh Stream UPSTREAM	22_3425_3	3.28	1.137	1.137	1	0.347	23.15	0.00	1	85440	100180	1400.06	0.67	0	0	2.75	0.52	100	0.63
Ballyoughtragh Stream Downstrema	22_3425_9	4.28	3.744	3.744	1	0.875	17.02	10.56	1	84460	100400	1506.23	0.67	3.12	0	2.11	3.52	96.78	0.61

Highlighted text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows.. (Values in brackets denote the original parameter)

Map C.4: Milltown AFA Sub-Catchments

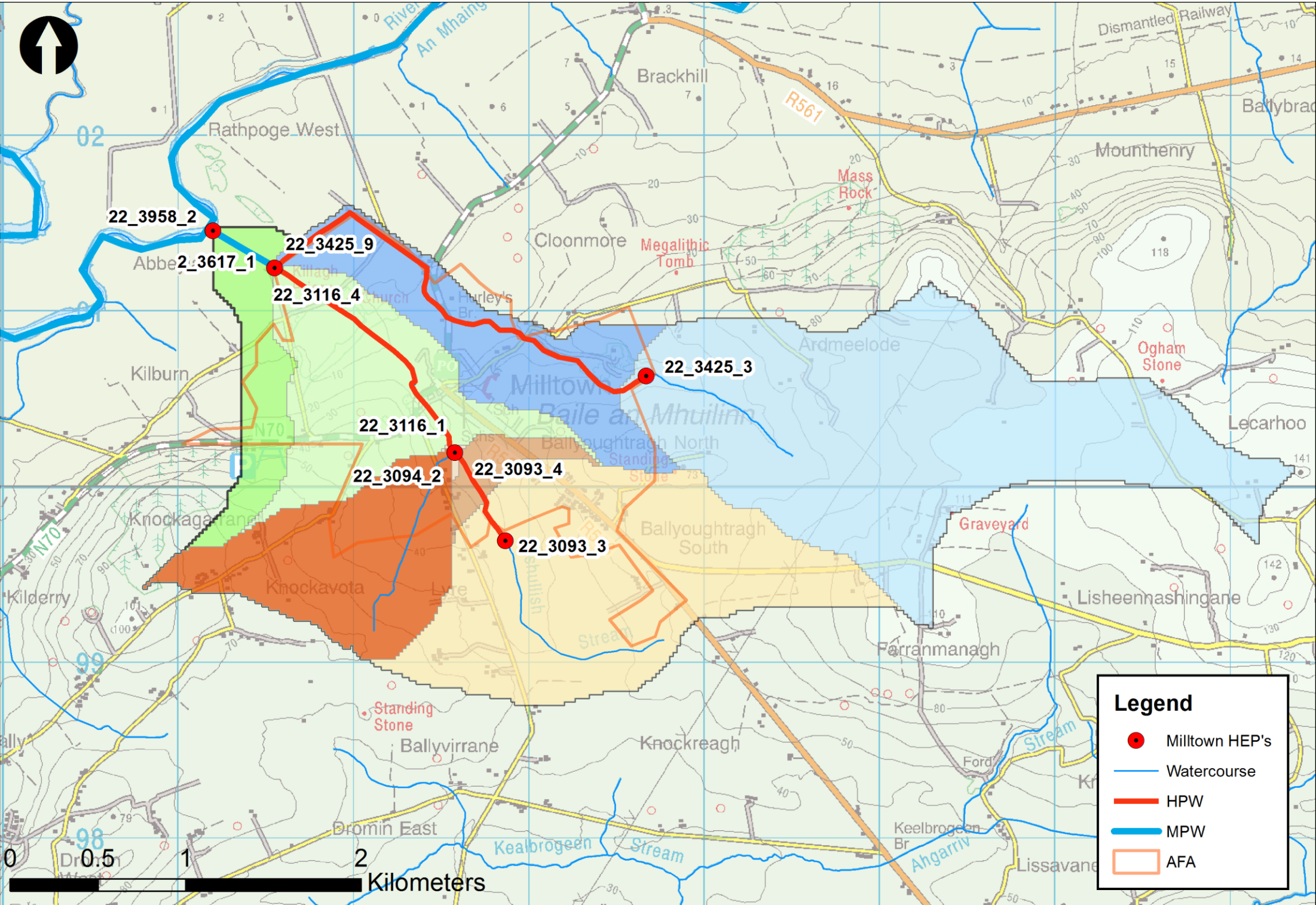


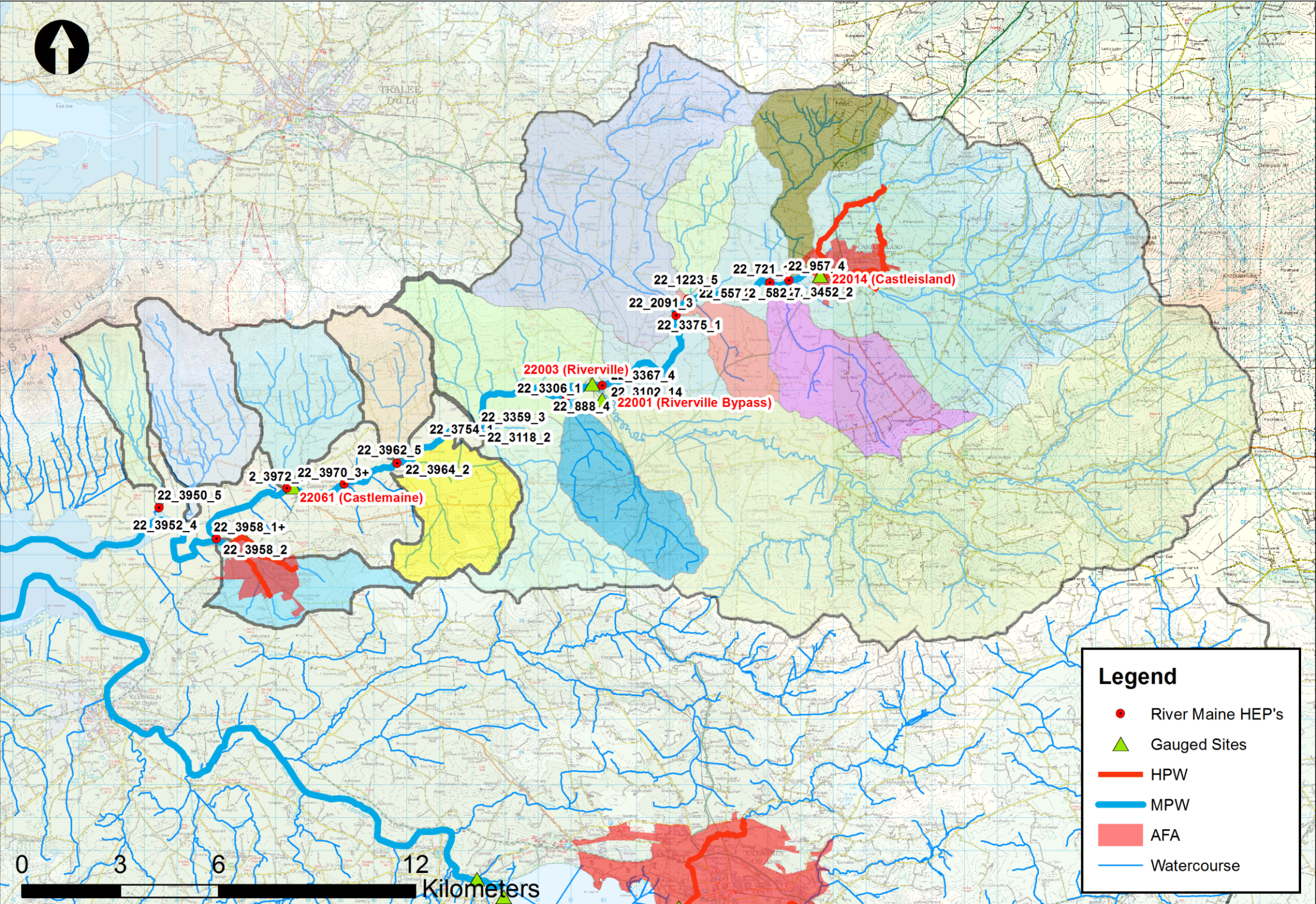
Table C.5: Maine MPW Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFQ	DRAIN2	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFI SOILS
Maine upstream Kealgorm	22_3452_2	60.35	12.54	76.87	64	1.27	14.54	16.21	1	104290	109790	1349	0.640	2.780	15.33	5.66	10.23	74.95	0.464
Maine downstream Kealgorm	22_576_1	71.99	12.54	98.60	104	1.37	14.54	15.42	1	103710	110080	1361	0.640	2.340	14.67	5.25	10.86	75.72	0.466
Maine upstream Brogheen	22_583_2	75.27	13.18	101.11	106	1.34	13.22	17.52	1	103710	110080	1361	0.640	2.330	14.03	5.39	10.52	75.91	0.466
Maine downstream Brogheen	22_721_1	91.81	13.22	114.07	120	1.24	12.86	22.45	1	103710	109540	1352	0.640	1.910	14.83	4.50	9.39	76.93	0.463
Maine upstream Loughnagore	22_557_2	98.59	15.99	118.43	122	1.20	9.73	25.24	1	102770	109540	1357	0.640	1.780	14.48	4.97	8.94	77.84	0.466
Maine downstream Ballymacpierce	22_2090_1	111.58	16.04	132.99	136	1.19	8.60	27.29	1	102260	109540	1363	0.640	1.570	14.17	4.50	8.05	78.67	0.466
Maine upstream Little Maine	22_2090_3	111.89	16.72	133.67	136	1.20	8.29	27.66	1	102260	109540	1363	0.640	1.570	14.14	4.64	8.03	78.72	0.466
Maine downstream Little Maine	22_3375_1	150.23	16.72	179.12	196	1.19	8.29	29.59	1	99450	110170	1367	0.640	1.490	12.75	4.01	8.08	79.09	0.462
Maine upstream Brown Flesk	22_3367_4	157.45	20.95	184.40	200	1.17	5.95	31.04	1	99450	110170	1369	0.640	1.420	12.16	4.50	7.71	80.05	0.461
22003 (Riverville)	22_3101_1	271.29	35.91	310.87	322	1.15	5.00	18.85	1	100970	107320	1349	0.64	1.720	14.30	5.07	10.42	75.64	0.471
Maine upstream Inchinveema	22_3101_4	272.00	36.95	310.87	322	1.14	4.97	18.85	1	100970	107320	1349	0.640	1.720	14.31	5.13	10.52	75.59	0.464
Maine downstream Inchinveema	22_3306_1	283.81	36.95	327.92	338	1.16	4.97	19.73	1	100970	107320	1349	0.650	1.710	13.79	4.96	10.41	76.27	0.479
Maine upstream Coolmealane & Ballyfinnane	22_3359_3	296.65	40.72	341.93	352	1.15	4.39	20.77	1	100460	107320	1351	0.650	1.640	13.86	5.28	10.55	75.85	0.479
Maine downstream Coolmealane & Ballyfinnane	22_3754_1	315.78	40.72	366.10	381	1.16	4.39	20.97	1	99620	107320	1352	0.650	1.540	13.42	5.40	10.16	76.62	0.479
HEP on Maine	22_3970_3+	344.35	59.47	400.89	414	1.16	5.60	22.71	1	0	0	1357	0.651	1.410	13.28	6.10	9.51	77.50	0.481
HEP on Maine	22_3958_1+	367.54	69.71	431.87	448	1.18	6.14	22.70	1	0	0	1372	0.650	1.440	13.73	6.09	8.98	7.47	0.480
Kealgorm upstream Maine	22_957_4	11.62	8.16	21.73	39	1.87	23.77	12.63	1	99040	112330	1422	0.640	0.020	11.22	3.04	14.11	79.66	0.458 (0.459)
Brogheen upstream Maine	22_582_7	15.47	7.38	9.74	7	0.63	6.70	70.00	1	101200	106530	1322 (1301)	0.650	0.000	19.74	0.28	4.52	80.26	0.486 (0.489)

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFG	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Ballymacpierce upstream Maine	22_1223_5	7.95	6.38	10.63	9	1.34	20.24	42.11	1	96160	111420	1363 (1408)	0.640	0.000	11.91	1.30	0.89	82.89	0.458
Little Maine upstream Maine	22_2091_3	38.32	12.86	45.45	59	1.19	14.27	35.28	1	93570	111860	1379	0.640	1.270	8.67	2.13	8.22	80.16	0.461 (0.405)
Brown Flesk upstream Maine	22_3102_14	113.73	35.61	125.13	121	1.10	5.07	0.00	1	102820	103510	1322	0.650	2.140	17.27	5.84	14.17	69.52	0.515
Inchinveema upstream Maine	22_888_4	11.81	7.93	17.05	15	1.44	20.74	35.79	1	93900	103020	1334	0.660	1.540	1.98	1.08	7.90	91.95	0.534
Coolmealane upstream Maine	22_3118_2	14.16	8.68	18.55	25	1.31	14.90	22.84	1	91930	102490	1349	0.660	0.000	2.00	6.64	0.34	97.69	0.504
Ballygamboon Lower upstream Maine	22_3962_5	9.34	5.66	12.38	11	1.33	33.59	33.56	1	86200	106170	1465	0.65	0.000	35.78	7.23	5.56	61.14	0.458
Annagh downstream Maine	22_3972_3	13.73	6.09	21.78	27	1.59	13.55	26.26	1	83500	105580	1584	0.66	0.300	34.48	9.14	0.36	65.22	0.379
Tralia upstream of Maine	22_3964_2	12.06	5.89	14.19	13	1.18	14.74	37.96	1	88530	102370	1360	0.66	0.000	0.00	16.25	0.60	100.00	0.526
Ashullish Stream downstream at Maine	22_3958_2	9.47	4.16	9.20	7	0.97	14.93	17.11	1	84100	100180	1603	0.67	4.100	0.00	1.33	2.35	94.15	0.614
Boolteens Stream downstream at Maine	22_3952_4	14.40	8.07	31.13	43	2.16	51.13	25.20	1	80650	105410	1737	0.66	0.000	48.71	10.56	0.45	43.72	0.376
Groin downstream at Maine	22_3950_5	7.28	6.51	16.68	17	2.29	60.86	8.99	1	78060	105280	1663	0.66	0.000	76.26	7.26	0.00	22.24	0.370

Yellow text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows or combined catchments. (Values in brackets denote original parameters). Green text denotes new HEPs derived from the combined inflow parameters, typically in tidal reaches.

Map C.5: Maine MPW Sub-Catchments



HEPs with + denotes combined intervening catchment descriptors for tidal reaches.

Table C.6: Flesk MPW-Glenflesk AFA-Flesk MPW Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFQ	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Flesk Upstream	22_3712_1	70.89	24.02	94.00	133	1.326	13.7	0	0.999	116110	82520	1974	0.66	0.000	55.52	2.44	39.90	8.43	0.349
Flesk Upstream @ Flesk/Loo Confluence	22_3712_4	72.39	25.38	95.36	133	1.317	14.7	0	0.999	115580	82520	1978	0.66	0.000	55.10	3.30	39.07	9.59	0.350
Loo Downstream @ Flesk/Loo Confluence	22_1553_4	31.72	8.86	43.31	57	1.365	8.3	0	0.985	105520	79590	2757	0.67	0.000	73.65	2.28	25.33	3.00	0.406
Flesk Downstream @ Loo/Flesk Confluence	22_2688_1	104.14	25.38	138.67	191	1.332	14.7	0	0.994	112420	81860	2216	0.66	0.000	60.76	2.99	34.89	7.58	0.367 (0.368)
Flesk Upstream @ Flesk/A.B Confluence	22_1561_2	118.26	30.19	158.07	215	1.337	14.5	0	0.994	112420	81860	2205	0.66	0.000	63.99	4.23	31.02	8.13	0.367 (0.368)
Annagh Beg Stream Downstream @ Flesk/A.B. Confluence	22_245_2	5.20	3.80	8.40	11	1.615	77.1	0	1.000	109530	85890	1783	0.66	0.000	73.94	0.23	3.05	0.32	0.423 (0.377)
Flesk Downstream @ Flesk/A.B. Confluence	22_1567_1	123.51	30.19	166.47	227	1.348	14.5	0	0.995	112420	81860	2187	0.66	0.000	64.40	4.07	29.84	7.82	0.369 (0.368)
Flesk Upstream Ownesyskeagh	22_1560_3	130.97	33.26	175.02	235	1.336	13.0	0	0.994	112420	81860	2174	0.66	0.000	64.18	4.68	28.36	9.30	0.369
Ownesyskeagh Downstream @ Ownesyskeagh /Flesk Confluence	22_2883_9	105.86	23.92	124.02	129	1.172	5.6	0	0.996	109590	93660	1437	0.65	0.000	40.75	2.89	7.74	53.75	0.452 (0.385)
Flesk Downstream Ownesyskeagh	22_2859_1	236.83	33.26	299.04	365	1.263	13.0	0	0.995	112420	89040	1845	0.66	0.000	53.70	3.88	19.14	29.17	0.381
Flesk Upstream @Finnow	22_2705_5	264.46	38.75	326.15	385	1.233	10.7	0	0.995	111870	89040	1805	0.66	0.000	52.03	4.23	18.16	32.08	0.383
Finow Downstream @ Flesk/Finnow Confluence	22_1927_3	38.99	12.73	60.08	129	1.541	43.4	0	0.736	101470	83790	2242	0.67	0.000	60.41	0.94	2.41	18.53	0.622
Flesk Downstream @Finnow	22_3340_1	303.45	38.75	386.24	515	1.273	10.7	0	0.958	110430	89040	1861	0.66	0.000	53.11	3.81	16.14	30.34	0.415 (0.379)
Flesk Downstream	22_3340_7	307.01	41.75	389.24	515	1.268	10.7	0	0.958	110430	89040	1857	0.66	0.000	52.54	4.06	16.01	30.97	0.415 (0.380)

Red text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows.

Map C.6: Flesk MPW-GlenfleskAFA-FleskMPW Sub-Catchments

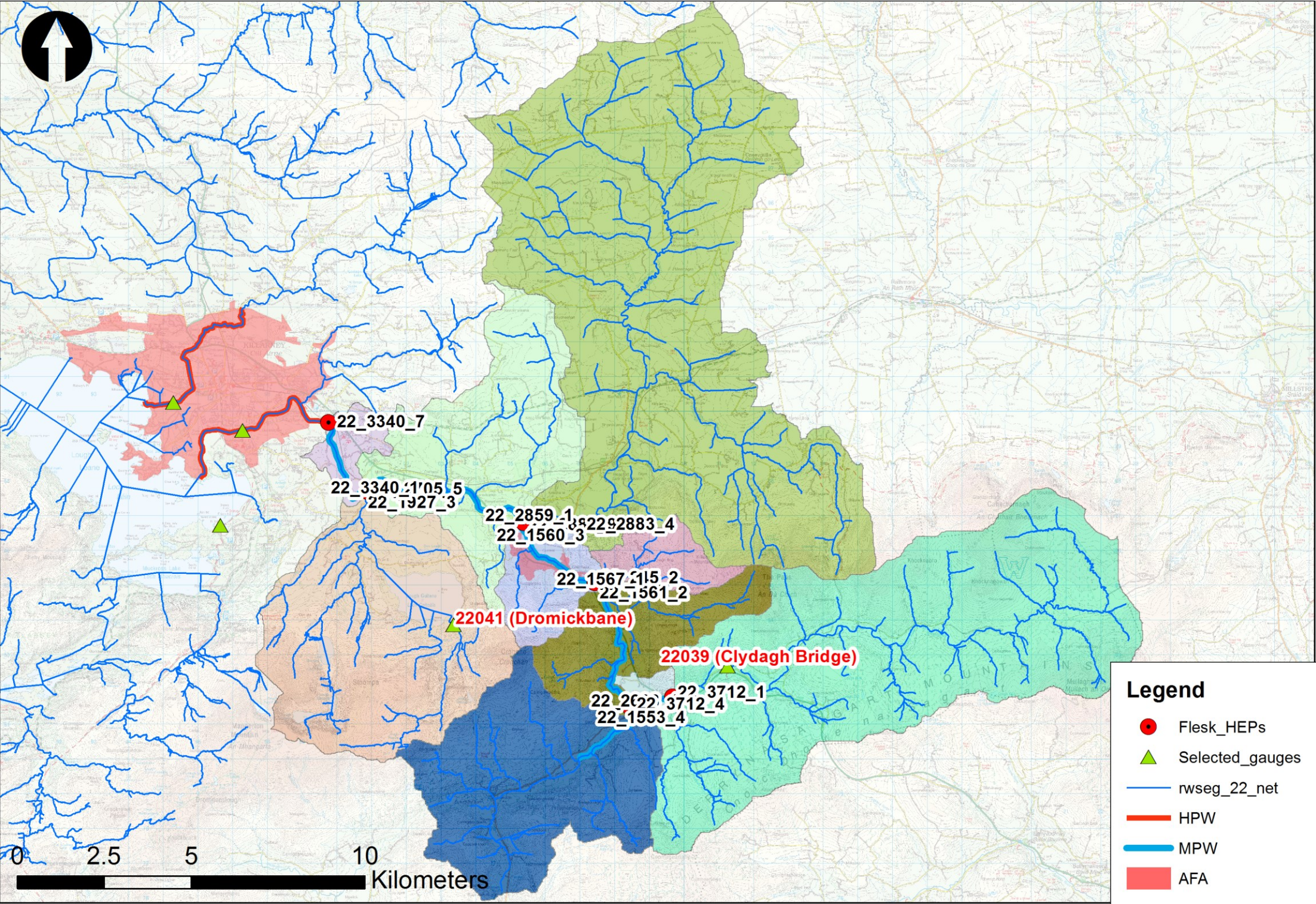
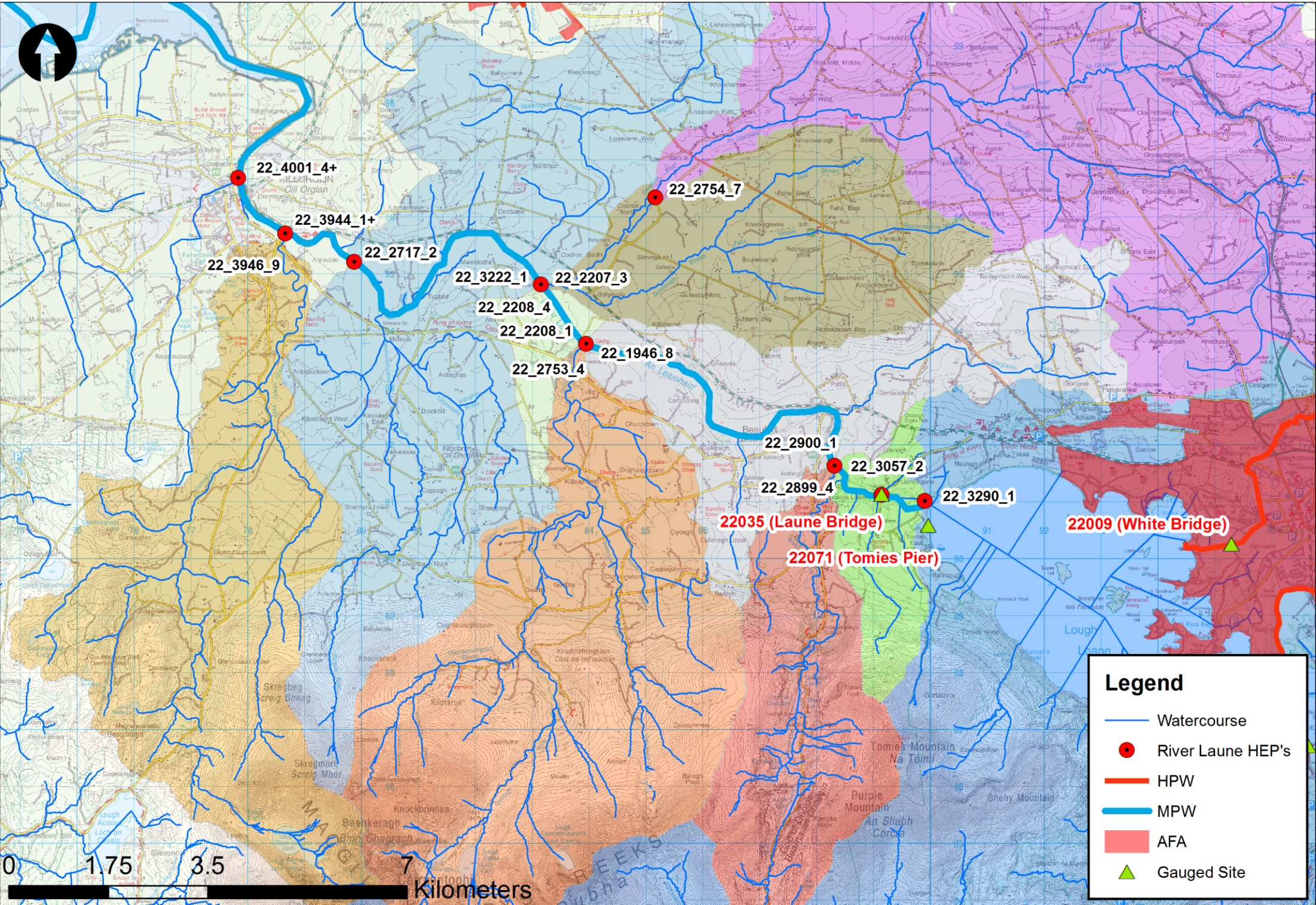


Table C.7: Laune MPW Physical Catchment Descriptors

LOCATION	HEP	DTM_AREA	MSL	NETLEN	STMFQ	DRAIND	S1085	ARTDRAIN2	FARL	CENTROID E	CENTROID N	SAAR	FORMWET	URBEXT	PEAT	ALLUV	FOREST	PASTURE	BFISOILS
Laune upstream Survey Extent (Lake)	22_3290_1	557.70	55.40	761.82	1335	1.366	7.70	0.00	0.730	100940	89040	2011	0.670	0.970	48.26	3.15	16.37	26.95	0.64
22035 (Laune Bridge)	22_510_2	559.66	56.30	762.98	1332	1.363	7.58	0.00	0.731	100940	89040	2011	0.67	0.970	48.23	3.20	16.37	27.02	0.65
Laune upstream Loe	22_3057_2	563.22	57.51	772.11	1353	1.371	7.42	0.00	0.733	100940	89040	2008	0.670	0.960	48.14	3.22	16.32	27.21	0.64
Loe upstream Laune	22_2899_4	16.25	10.64	31.46	72	1.935	18.72	0.00	0.860	87670	87650	2254	0.680	0.000	75.80	3.19	4.73	12.44	0.48
Laune downstream Loe	22_2900_1	579.50	57.51	803.57	1426	1.387	7.42	0.00	0.736	100940	89040	2015	0.670	0.930	48.92	3.22	16.00	26.80	0.65
Laune upstream Gaddagh	22_1946_8	601.54	64.01	823.11	1436	1.368	6.52	0.00	0.744	100940	89040	1992	0.670	0.900	47.21	3.43	15.62	29.00	0.65
Gaddagh upstream Laune	22_2753_4	42.31	14.59	71.59	131	1.692	27.85	0.00	0.964	83200	88510	1903	0.690	0.000	53.74	9.51	1.51	36.67	0.43
Laune downstream Gaddagh	22_2208_1	643.86	64.01	894.70	1568	1.390	6.52	0.00	0.757	100940	89040	1986	0.670	0.840	47.64	3.83	14.69	29.51	0.66
Laune upstream Gweestin	22_2208_4	646.71	65.34	896.03	1568	1.386	6.35	0.00	0.758	100940	89040	1984	0.670	0.840	47.43	3.88	14.67	29.80	0.66
Gweestin UPSTREAM (Survey extent)	22_2754_7	64.91	22.48	90.01	107	1.387	7.35	0.00	1.000	93380	96620	1237	0.660	0.000	6.72	10.62	2.98	92.60	0.61
Gweestin downstream Laune	22_2207_3	84.25	25.71	109.37	119	1.298	6.14	0.00	1.000	92400	96620	1901 (1261)	0.670	0.000	6.10	13.76	2.74	93.38	0.61
Laune downstream Gweestin	22_3222_1	730.96	65.34	1005.40	1688	1.375	6.35	0.00	0.783	100940	89040	1901	0.670	0.740	42.67	5.01	13.29	37.12	0.62
HEP on Laune	22_2717_2	777.34	70.47	1061.34	1758	1.365	5.79	0.00	0.794	100880	89040	1877	0.67	0.70	40.99	5.35	12.57	39.86	0.61
HEP on Laune	22_3944_1+	813.07	89.05	1116.11	1865	1.373	6.83	0.00	0.801	0	0	1871	0.67	0.66	41.98	5.28	12.23	39.41	0.61
Laune Downstream	22_4001_4+	817.93	95.91	1122.98	1868	1.373	6.83	0.00	0.801	0	0	1869	0.67	0.70	41.94	5.25	12.16	39.52	0.61
Cottoners River downstream at Laune	22_3946_9	33.64	17.94	52.12	105	1.549	31.78	0.00	0.930	77060	89800	1768	0.69	0.00	67.48	3.41	5.07	25.36	0.50

Yellow text denotes values changed as part of the hydrological analysis to achieve consistency in downstream flows or combined catchments. (Values in brackets denote original parameters). Green text denotes new HEPs derived from the combined inflow parameters, typically in tidal reaches.

Map C.7: Laune MPW Sub-Catchments



N.B. There are no design peak flows for Portmagee AFA as there has been no fluvial flood risk identified.

Appendix D. Design Hydrology

D.1 Castleisland AFA

Figure D.1: Castleisland AFA Schematic of QMED

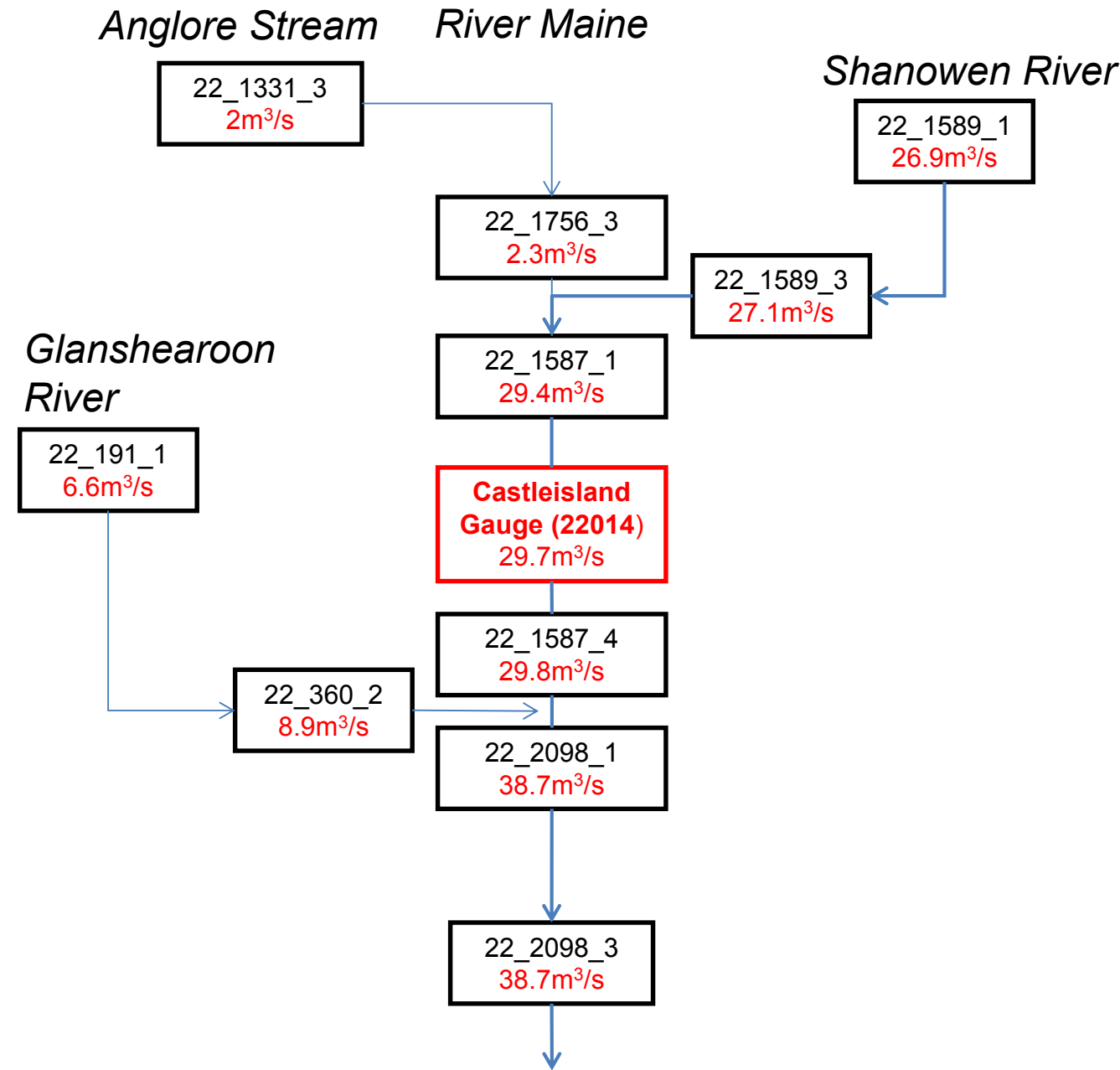


Table D.1: Glanshearoon Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	23012	18	18	18	1.544	18	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
2	36021	27	45	45	0.174	54	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
3	34009	33	78	78	0.076	99	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
4	1041	32	110	110	0.193	128	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
5	30020	16	126	126	0.095	80	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
6	16005	30	156	156	0.169	180	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
7	20006	35	191	191	0.378	245	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
8	25044	40	231	231	0.085	320	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
9	26009	35	266	266	0.210	315	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
10	26010	35	301	301	0.107	350	0.937	0.000	0.69	1.906	94.53	0.578	1064	B	Locally Important Aquifer	0.919	N/A
11	25038	17	318	318	0.090	187	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
12	29001	40	358	358	0.114	480	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
13	16051	13	371	371	0.874	169	1.000	0.000	0.58	1.615	34.19	0.593	895	B	Locally Important Aquifer	0.945	N/A
14	24022	20	391	391	0.103	280	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
15	26020	33	424	424	0.496	495	1.000	0.070	0.67	7.477	122.44	0.560	1003	A1	Locally Important Aquifer	1.592	N/A
16	30037	21	445	445	0.778	336	0.987	0.920	0.71	0.960	210.20	0.566	1169	A1	Regionally Important Aquifer - Karstified	18.771	N/A
17	18050	24	469	469	0.390	408	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
18	23001	33	502	502	0.124	594	1.000	0.300	0.62	3.290	191.74	0.328	1084	A2	Locally Important Aquifer	1.171	Small catchment, gauge situated within Karstic zone (lower reaches). Upper is aquifer.

Figure D.2: Flood Growth Curve Plot

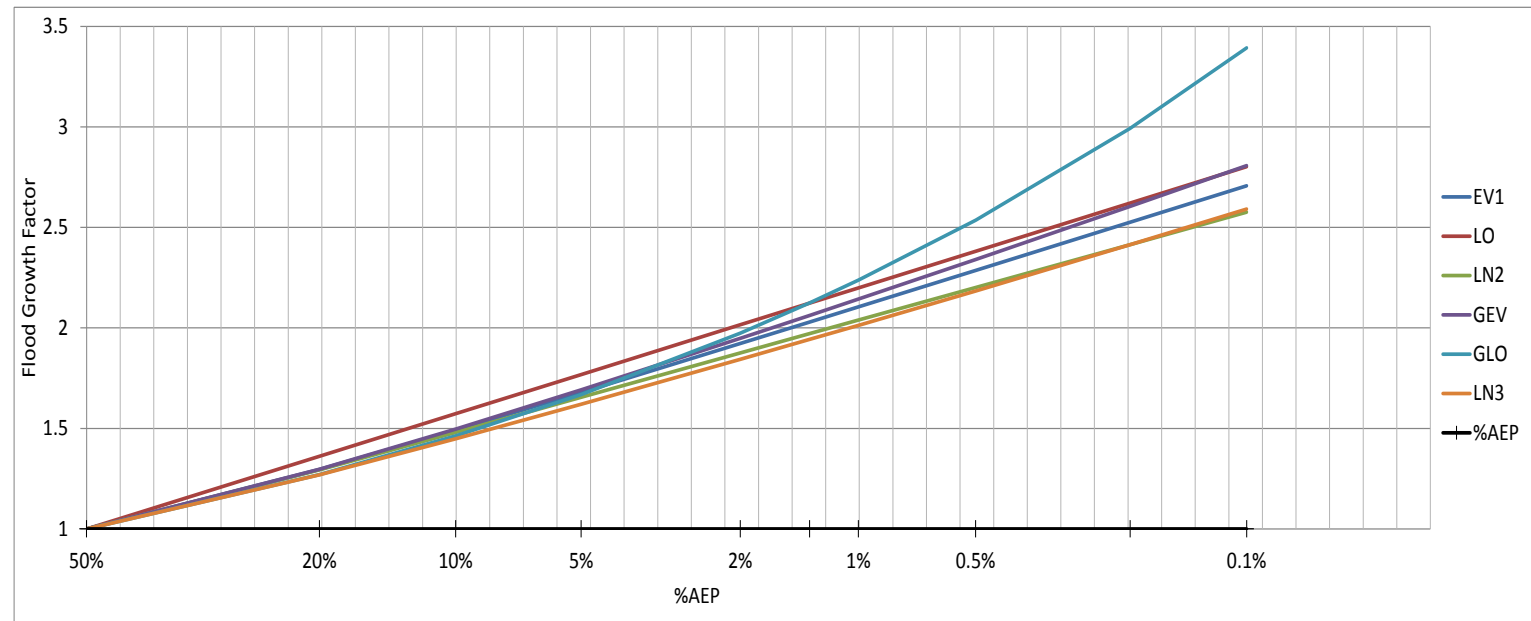


Figure D.3: L Moment Plot

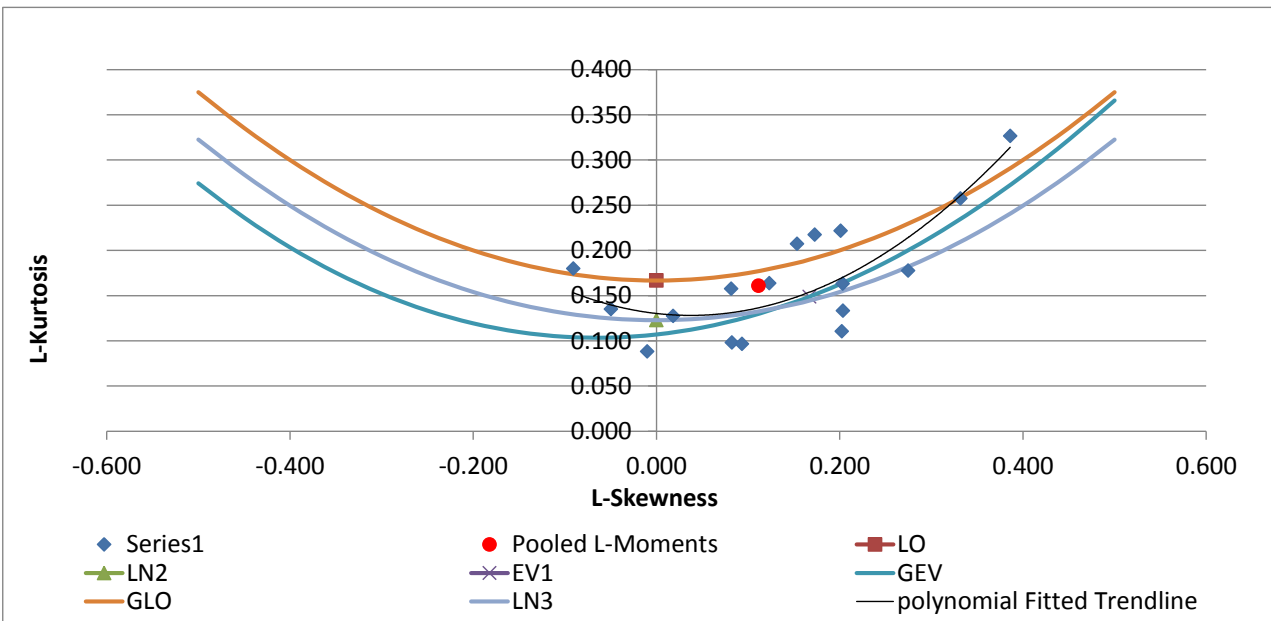


Table D.2: Shanowen River Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	23012	18	18	18	0.972		0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
2	34009	33	51	51	0.048		1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
3	25158	18	69	69	0.643		1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
4	16005	30	99	99	0.107		1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
5	35004	14	113	113	0.543		0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
6	1041	32	145	145	0.122		1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
7	25044	40	185	185	0.053		0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
8	20006	35	220	220	0.238		1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
9	16006	33	253	253	0.256		0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
10	26009	35	288	288	0.132		0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
11	16012	28	316	316	0.076		0.999	0.270	0.60	5.200	229.63	0.529	1321	B	Regionally Important Aquifer - Karstified	0.608	N/A
12	30020	16	332	332	0.060		1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
13	30001	18	350	350	1.009		0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
14	25038	17	367	367	0.056		1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
15	25002	51	418	418	0.819		0.999	0.180	0.59	6.877	221.61	0.542	1300	A2	Locally Important Aquifer	0.988	N/A
16	10002	46	464	464	0.461		0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
17	29001	40	504	504	0.072		0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
18	23012	18	18	18	0.972		0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
19	34009	33	51	51	0.048		1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A

Figure D.4: Flood Growth Curve Plot

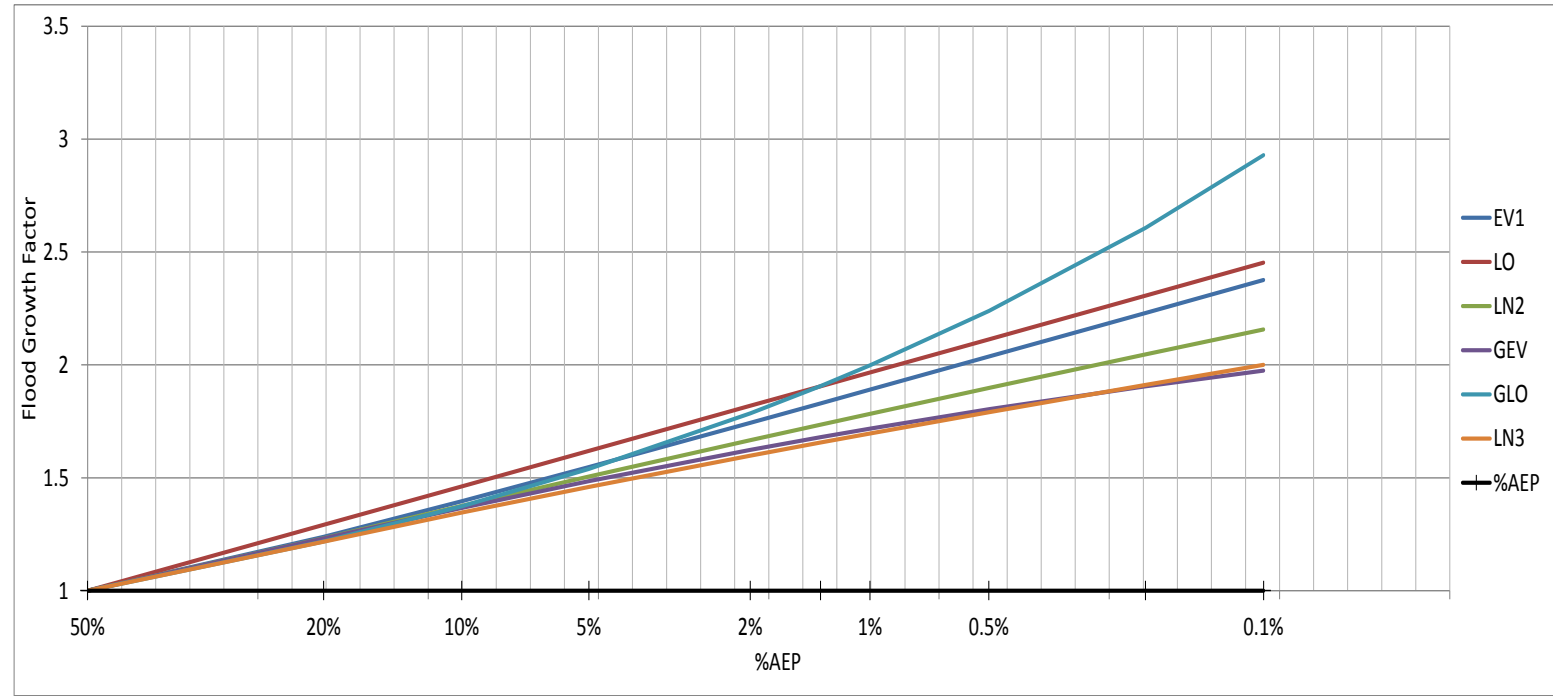


Figure D.5: L Moment Plot

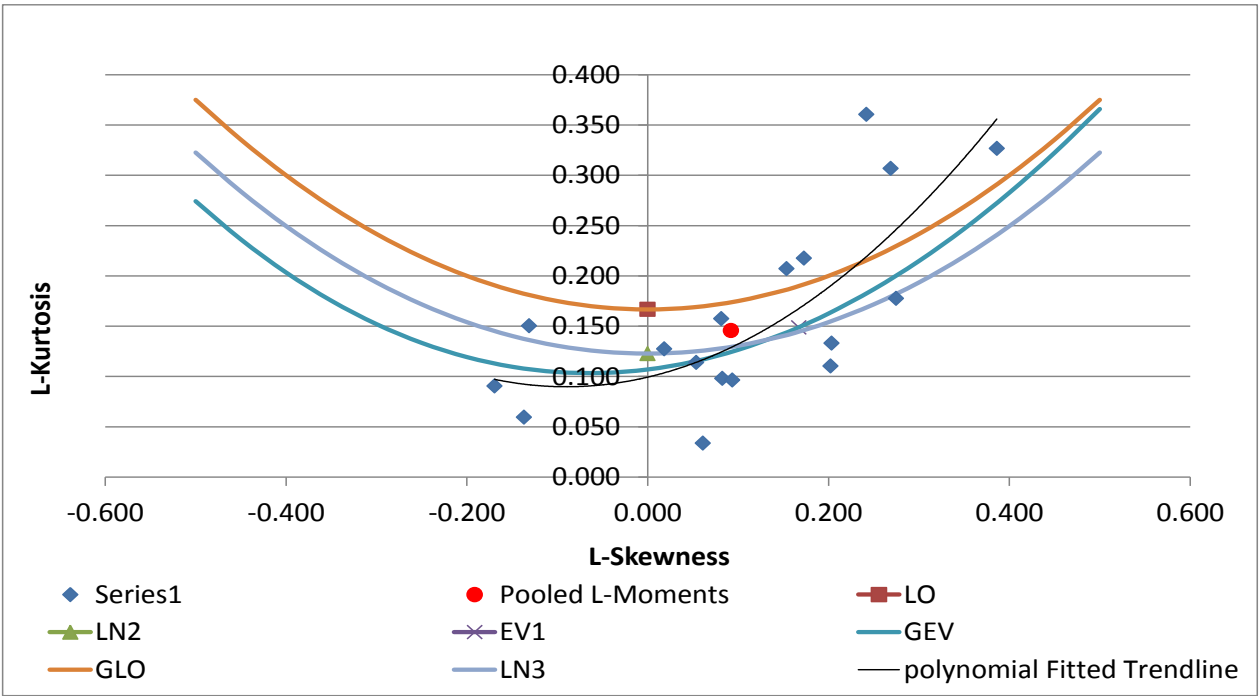


Table D.3: Anglore Stream Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	16013	33	51	51	0.212	66	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
2	35002	34	85	85	0.263	102	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
3	25158	18	103	103	0.888	72	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
4	10002	46	149	149	0.636	230	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
5	22006	57	206	206	0.065	342	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
6	32011	25	231	231	0.159	175	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
7	20006	35	266	266	0.328	280	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
8	39001	31	297	297	0.276	279	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
9	34007	53	350	350	0.085	530	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
10	34009	33	383	383	0.066	363	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
11	36021	27	410	410	0.151	324	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
12	1041	32	442	442	0.168	416	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
13	38001	33	475	475	0.206	462	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
14	16012	28	503	503	0.104	420	0.999	0.270	0.60	5.200	229.63	0.529	1321	B	Regionally Important Aquifer - Karstified	0.608	N/A
15	16013	33	51	51	0.212	66	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
16	35002	34	85	85	0.263	102	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
17	25158	18	103	103	0.888	72	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
18	10002	46	149	149	0.636	230	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
19	22006	57	206	206	0.065	342	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
20	32011	25	231	231	0.159	175	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
21	20006	35	266	266	0.328	280	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A

Figure D.6: Flood Growth Curve Plot

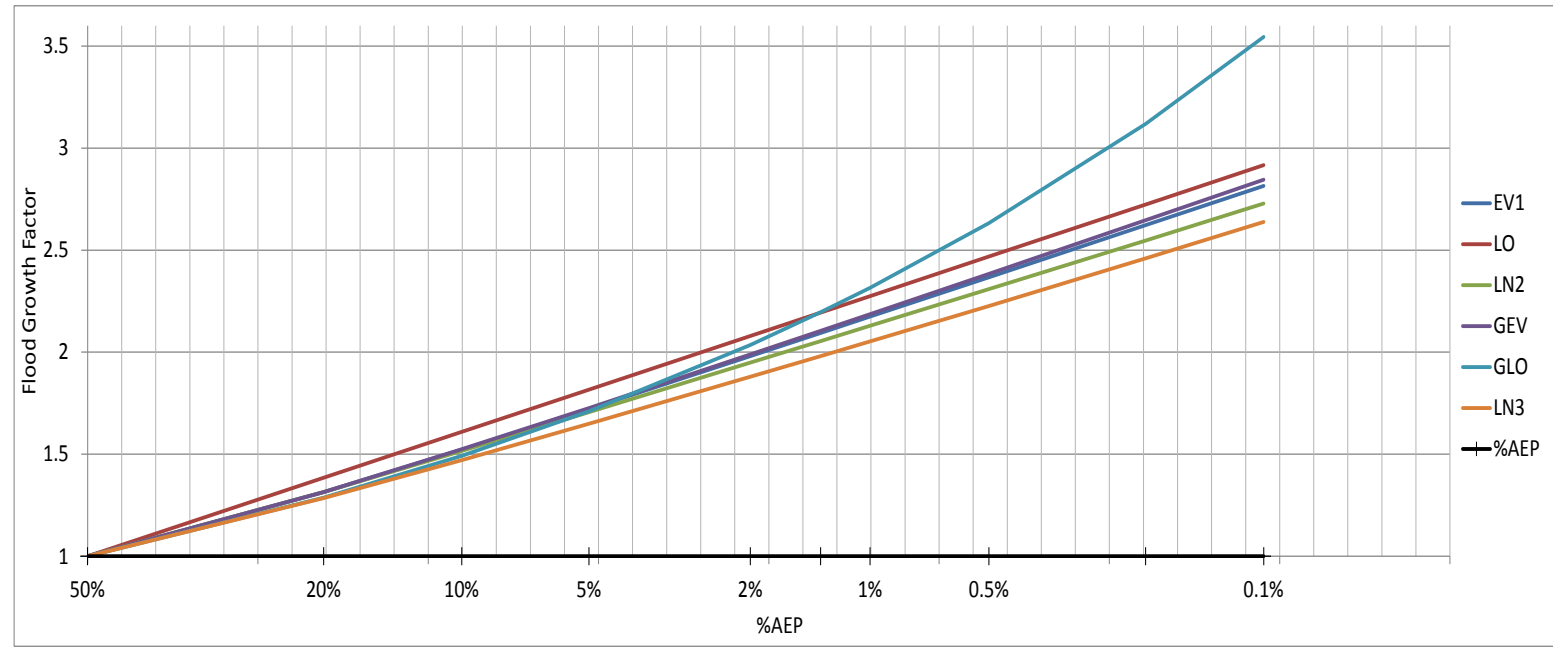


Figure D.7: L Moment Plot

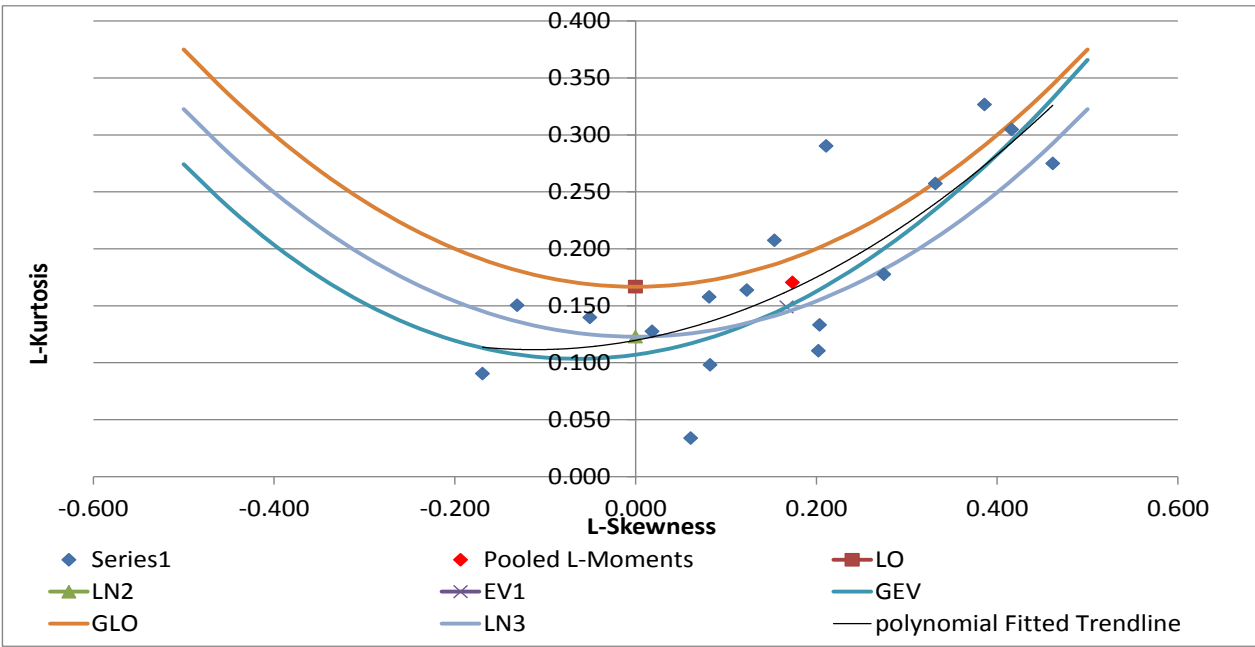


Table D.4: River Maine (Castleisland Gauge) Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	23012	18	18	18	0.587	18	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
2	34009	33	51	51	0.029	66	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
3	25158	18	69	69	0.389	54	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
4	16005	30	99	99	0.064	120	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
5	10004	14	113	113	1.271	70	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
6	1041	32	145	145	0.074	192	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
7	25044	40	185	185	0.032	280	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
8	20006	35	220	220	0.144	280	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
9	16012	28	248	248	0.046	252	0.999	0.270	0.60	5.200	229.63	0.529	1321	B	Regionally Important Aquifer - Karstified	0.608	N/A
10	26009	35	283	283	0.080	350	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
11	25002	51	334	334	0.495	561	0.999	0.180	0.59	6.877	221.61	0.542	1300	A2	Locally Important Aquifer	0.988	N/A
12	30001	18	352	352	0.610	216	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
13	25038	17	369	369	0.034	221	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
14	10002	46	415	415	0.278	644	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
15	30020	16	431	431	0.036	240	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
16	29001	40	471	471	0.043	640	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
17	9010	19	490	490	1.092	323	0.958	24.040	0.54	20.977	94.26	0.530	955	A1	Locally Important Aquifer	2.079	Including large areas of Poor Aquifer strata.
18	36031	30	520	520	0.695	540	0.958	6.000	0.67	4.251	63.77	0.497	910	A2	Locally Important Aquifer	1.140	N/A
19	23012	18	18	18	0.587	18	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A

Figure D.8: Flood Growth Curve Plot

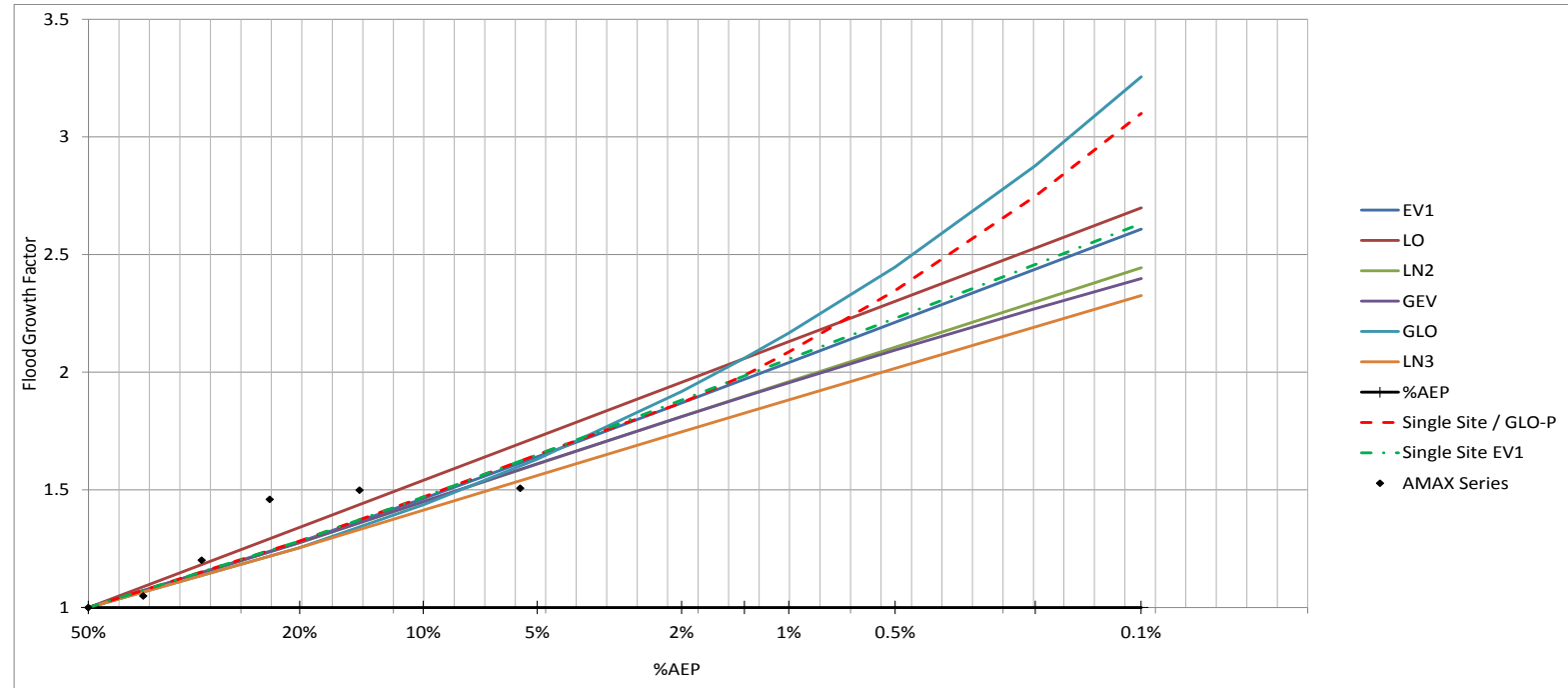


Figure D.9: L Moment Plot

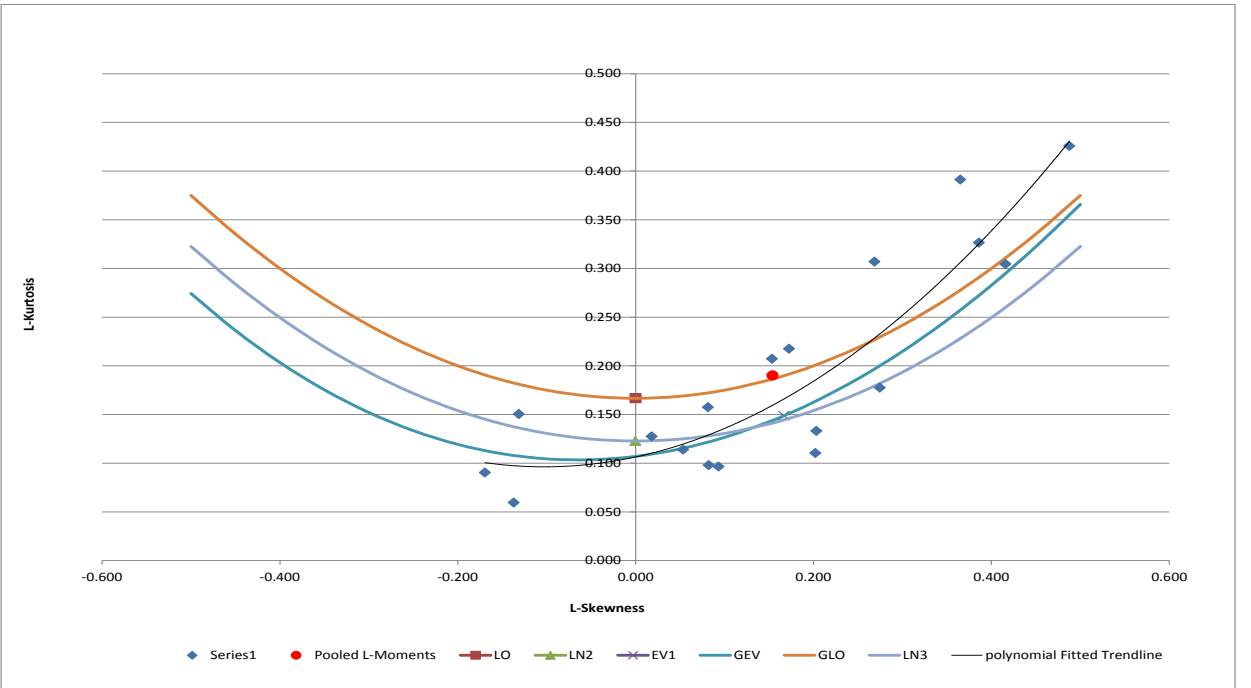


Figure D.10: Castleisland Gauge Median Flood Hydrograph

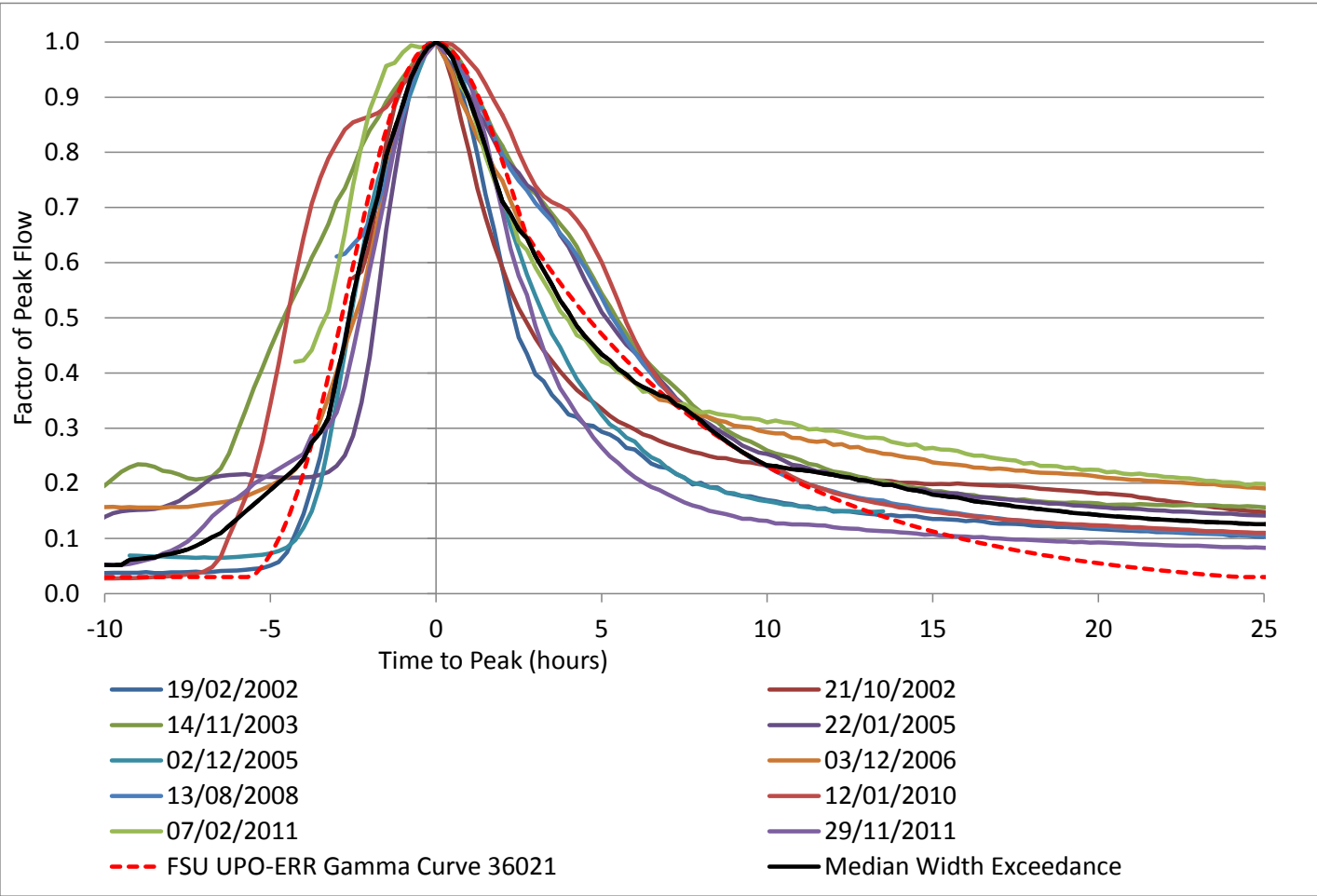
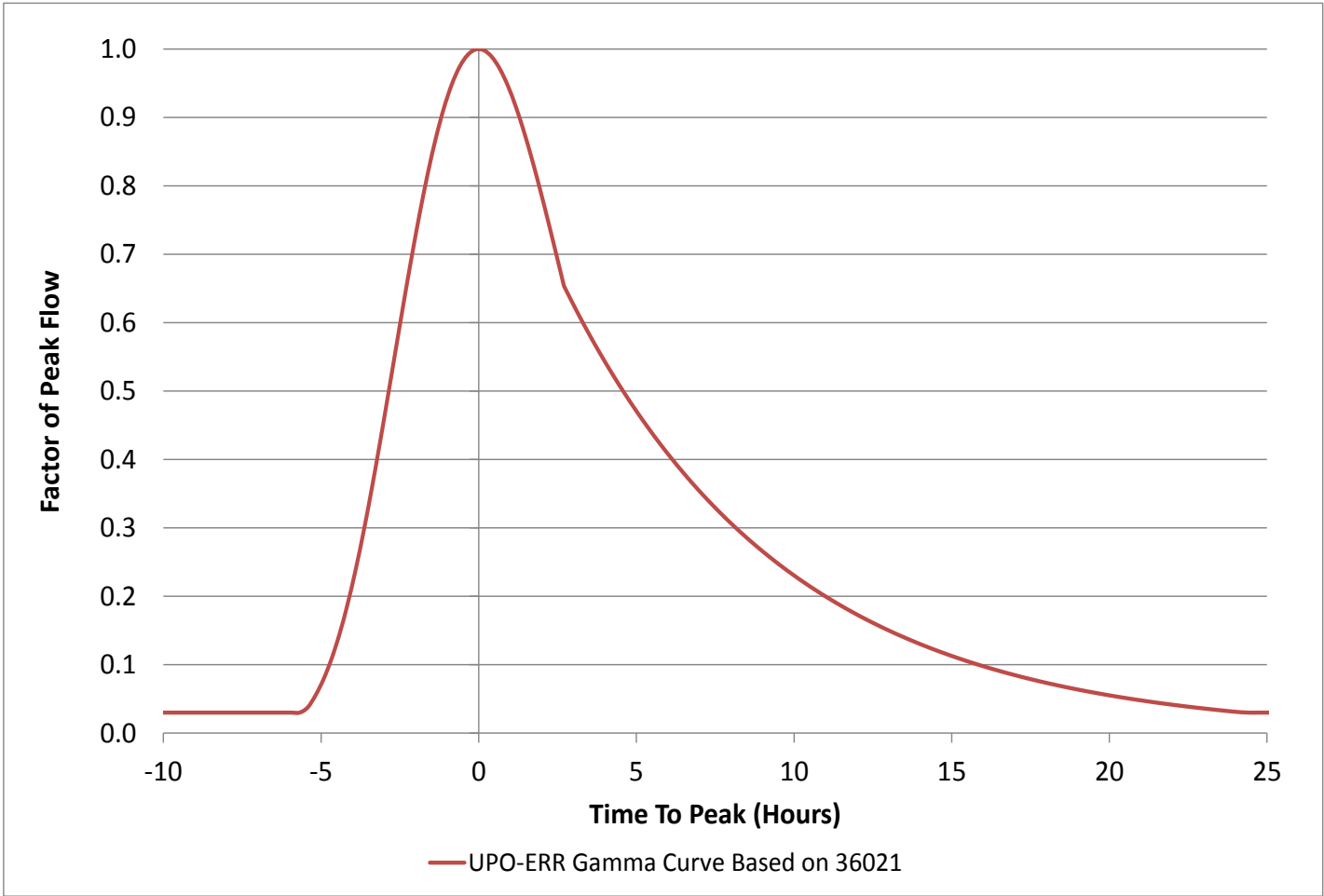


Figure D.11: UPO-ERR Gamma Hydrograph Based on Pivotal Site 36021



N.B. Hydrograph pivotal site 36021 was selected as it was most similar to the Castleisland Gauge 22014. Castleisland Gauge 22014 is hydrologically similar to all HEPs but is not within the FSU database.

Table D.5: Castleisland AFA Design Peak Flows

LOCATION	HEP	AREA	SAAR	BFI	Pivotal Site	QMED	95% Confidence Limit	QMED ^{0.077} /AREA	Flood Growth Curve	Flood Growth Factor								Design Flows								Hydrograph Pivotal Site
										50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1	
Glanshearoon upstream	22_191_1	7.8	1411	0.462	22014	6.63	12.44	14	GLO-P	1.00	1.24	1.41	1.59	1.85	2.09	2.35	3.10	6.6	8.2	9.3	10.5	12.3	13.8	15.6	20.6	36021
Glanshearoon downstream	22_360_2	12.6	1411	0.475	22014	10.24	19.23	13	GLO-P	1.00	1.24	1.41	1.59	1.85	2.09	2.35	3.10	9.0	11.1	12.6	14.2	16.6	18.7	21.0	27.8	36021
Shanowen upstream	22_1589_1	40.4	1326	0.463	22014	26.94	50.56	16	GLO-P	1.00	1.22	1.37	1.54	1.79	2.00	2.24	2.93	26.9	32.8	37.0	41.5	48.1	53.8	60.3	78.9	36021
Shanowen downstream	22_1589_3	41.5	1327	0.463	22014	27.11	50.87	15	GLO-P	1.00	1.22	1.37	1.54	1.79	2.00	2.24	2.93	27.1	33.0	37.2	41.7	48.4	54.2	60.7	79.4	36021
Anglore Stream	22_1331_3	3.1	1354	0.389	22014	1.95	3.66	8	GLO-P	1.00	1.29	1.49	1.71	2.04	2.32	2.63	3.54	2.0	2.5	2.9	3.3	4.0	4.5	5.1	6.9	36021
Maine Upper downstream	22_1756_3	4.5	1357	0.447	22014	2.78	5.22	7	SS+GLO-P	1.00	1.28	1.47	1.65	1.87	2.09	2.35	3.10	2.3	2.9	3.3	3.7	4.2	4.7	5.3	7.0	36021
Maine mid upstream	22_1587_1	46.0	1330	0.462	22014	29.41	55.21	15	SS+GLO-P	1.00	1.28	1.47	1.65	1.87	2.09	2.35	3.10	29.4	37.7	43.2	48.5	55.0	61.4	69.1	91.2	36021
22014 (Castleisland)	22_1587_3	46.9	1329	0.463	Gauged	29.66	55.68	15	SS+GLO-P	1.00	1.28	1.47	1.65	1.85	2.08	2.34	3.09	29.7	38.0	43.6	48.9	54.9	61.8	69.5	91.8	Gauged Median
Maine Mid downstream	22_1587_4	47.2	1329	0.463	22014	30.83	57.87	15	SS+GLO-P	1.00	1.28	1.47	1.65	1.87	2.09	2.35	3.10	29.8	38.2	43.8	49.2	55.7	62.2	70.0	92.4	36021
Maine Lower upstream	22_2098_1	59.8	1347	0.459	22014	38.58	72.41	17	SS+GLO-P	1.00	1.28	1.47	1.65	1.87	2.09	2.35	3.10	38.7	49.6	56.8	63.7	72.3	80.6	90.7	119.8	36021
Maine DOWNSTREAM	22_2098_3	60.3	1349	0.464	22014	38.70	72.64	16	GLO-P	1.00	1.28	1.47	1.65	1.87	2.09	2.35	3.10	38.7	49.6	56.9	63.8	72.4	80.7	90.9	119.9	36021

D.2 Dingle AFA

Figure D.12: Dingle AFA Schematic of QMED

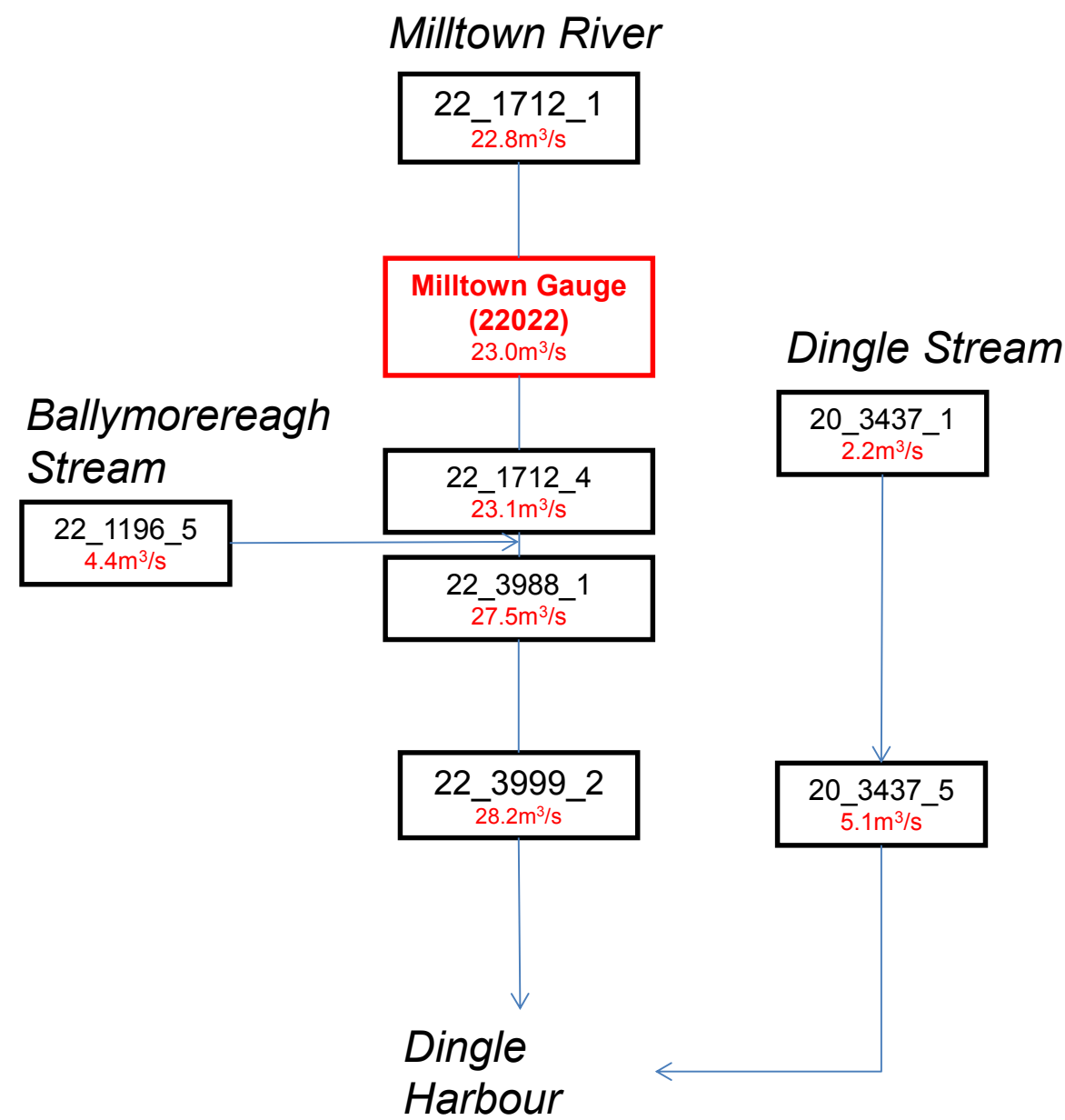


Table D.6: Dingle Stream (East) Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	6030	27	27	27	0.532	27	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
2	10004	14	41	41	1.682	28	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
3	20006	35	105	105	0.190	140	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
4	25034	26	131	131	0.513	130	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
5	25040	19	150	150	0.082	114	1.000	6.180	0.60	13.494	28.02	0.576	990	A2	Locally Important Aquifer	1.322	N/A
6	16013	33	183	183	0.123	231	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer - Bedrock	0.488	N/A
7	35002	34	217	217	0.152	272	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer - Bedrock	0.792	N/A
8	25158	18	235	235	0.515	162	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
9	16005	30	265	265	0.085	300	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
10	16006	33	298	298	0.205	363	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
11	25044	40	338	338	0.043	480	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
12	19020	28	366	366	0.211	364	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
13	24022	20	386	386	0.052	280	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
14	13002	19	405	405	0.024	285	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
15	6031	18	423	423	0.867	288	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
16	25038	17	440	440	0.045	289	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
17	19016	15	455	455	0.900	270	1.000	0.070	0.66	4.554	117.82	0.687	1267	ESB stn	Locally Important Aquifer	1.001	Gauge seated on Karstic area. 40% Karstic.

Figure D.13: Flood Growth Curve Plot

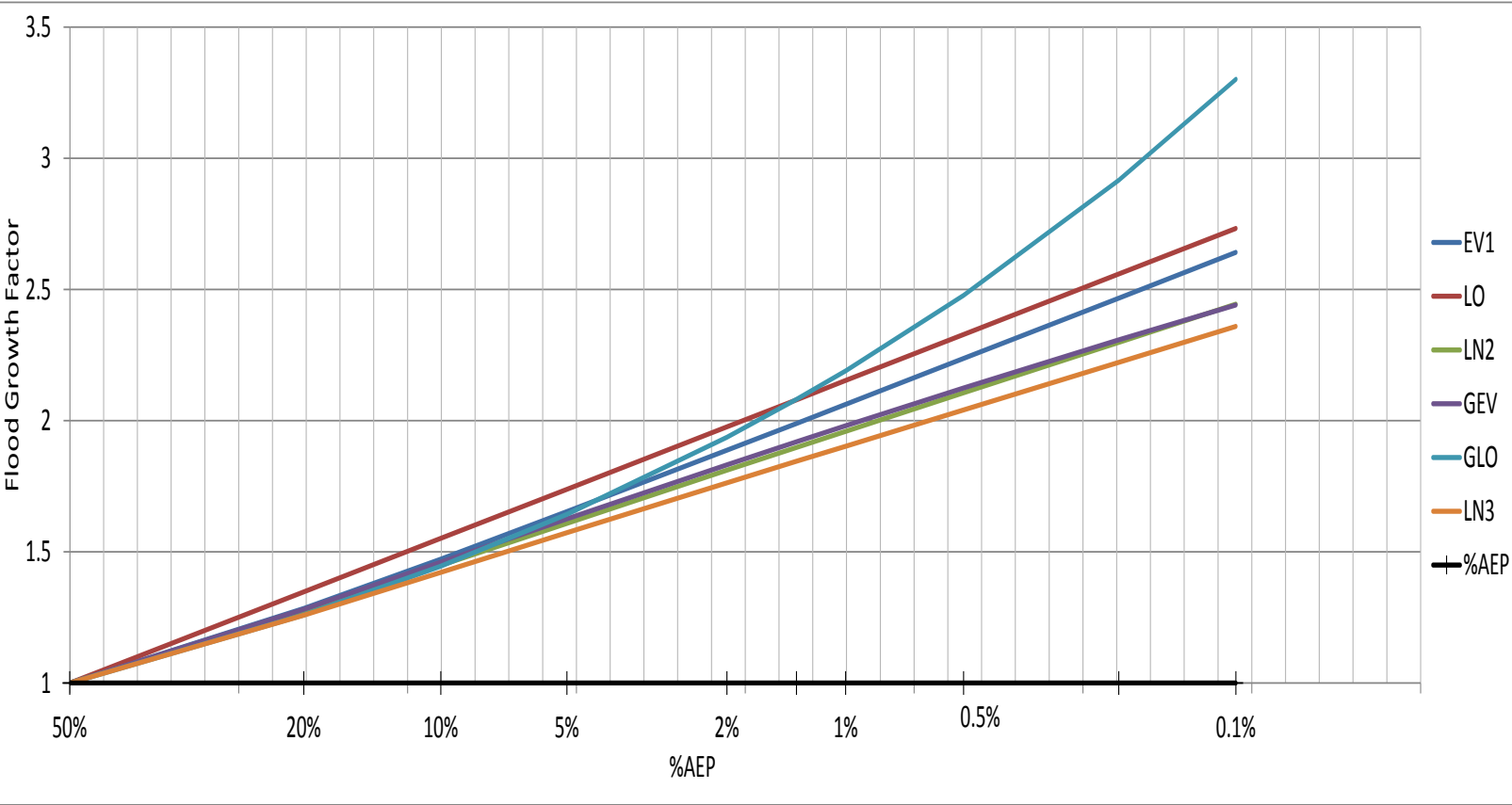


Figure D.14: L Moment Plot

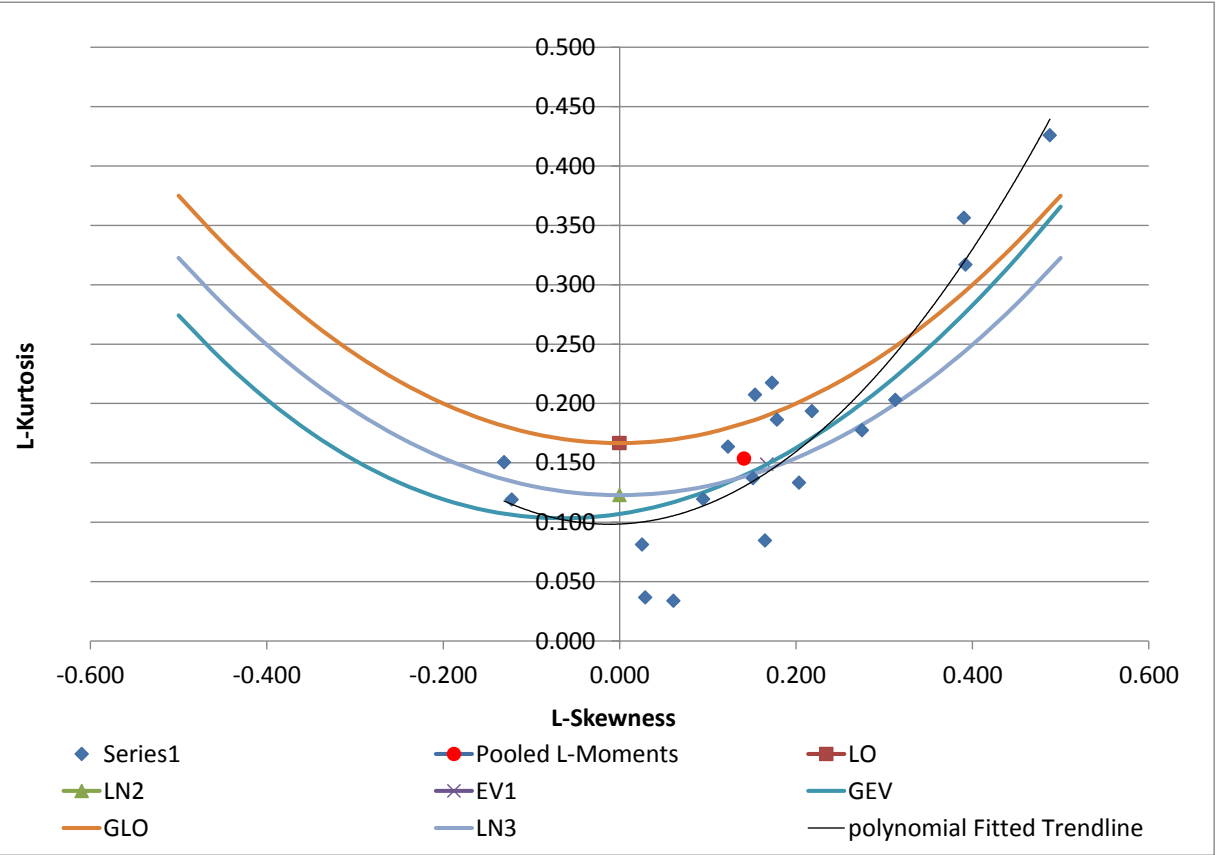


Table D.7: Milltown River Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	36021	27	27	27	0.109	27	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
2	35002	34	61	61	0.190	68	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
3	34009	33	94	94	0.048	99	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
4	39001	31	125	125	0.200	124	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
5	34007	53	178	178	0.062	265	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
6	16005	30	208	208	0.106	180	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
7	10002	46	254	254	0.459	322	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
8	35004	14	268	268	0.541	112	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
9	25044	40	308	308	0.053	360	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
10	29071	26	334	334	0.013	260	0.804	0.000	0.62	5.230	123.84	0.565	1212	A2	Poor Aquifer	0.815	N/A
11	28001	17	351	351	2.655	187	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	Only minor Karstic coverage, vast majority is of locally important aquifer.
12	6030	27	378	378	0.663	324	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
13	34011	30	408	408	0.089	390	0.867	0.890	0.72	0.630	143.01	0.572	1248	A2	Regionally Important Aquifer - Karstified	1.078	Only minor Karstic coverage, vast majority is of locally important aquifer.
14	19031	9	417	417	0.022	126	0.999	0.670	0.66	4.732	216.11	0.558	1775	ESB stn	Poor Aquifer	0.874	N/A
15	16012	28	445	445	0.075	420	0.999	0.270	0.60	5.200	229.63	0.529	1321	B	Regionally Important Aquifer - Karstified	0.608	Only minor Karstic coverage, vast majority is of locally important aquifer.
16	22006	57	502	502	0.047	912	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
17	36021	27	27	27	0.109	27	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.

Figure D.15: Flood Growth Curve Plot

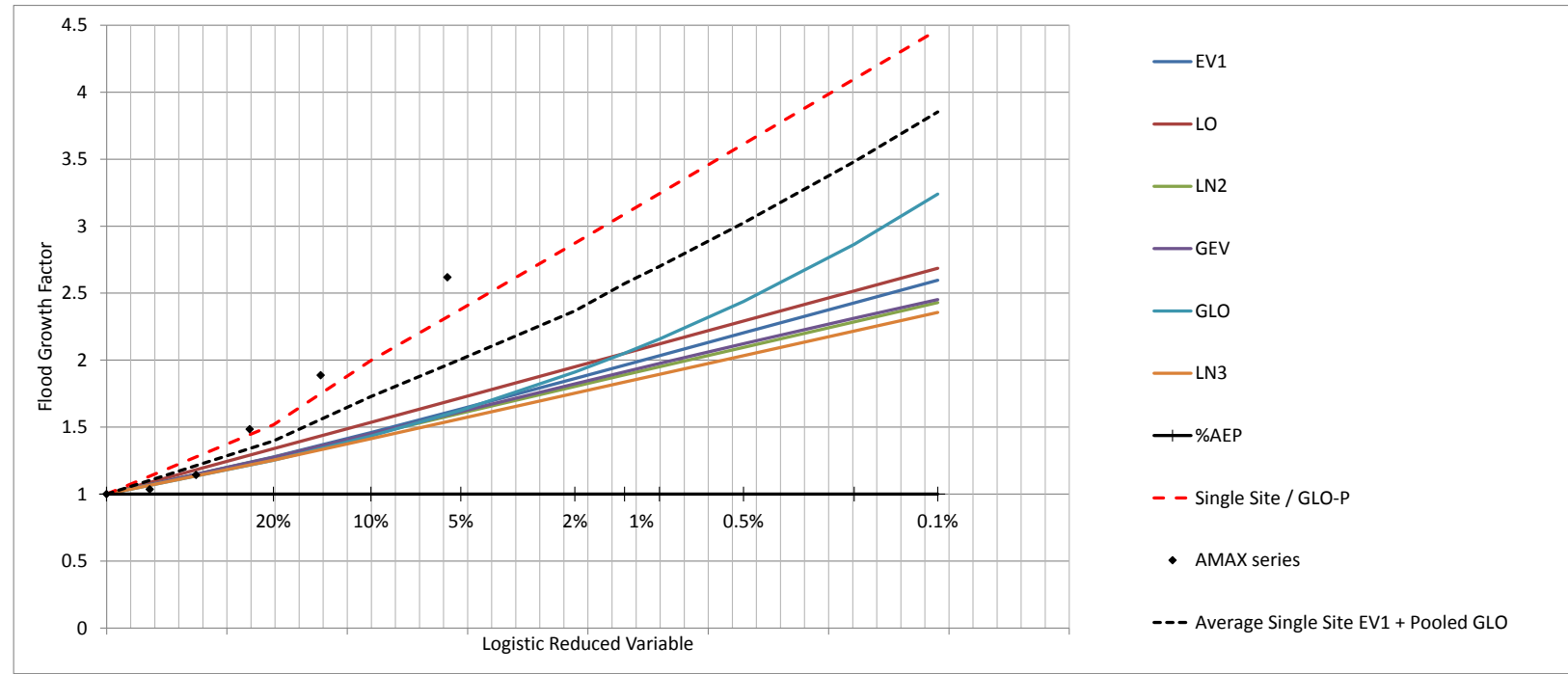
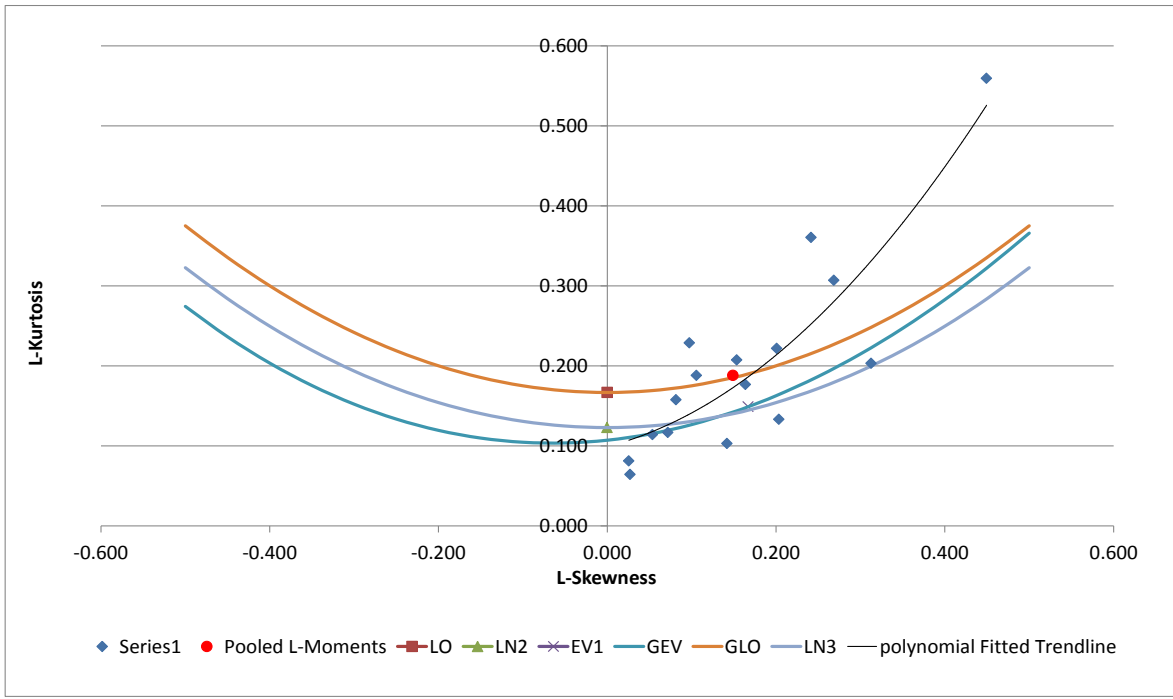


Figure D.16: L Moment Plot



N.B. There is limited confidence in extrapolating the single site flood growth curve beyond the relatively short record length of 22 years. The pooled FSU gauges do not give a satisfactory fit to the gauged flows for more extreme %AEP. Therefore an average between the two has been adopted.

Table D.8: Ballymoreagh Stream Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	6030	27	27	27	0.521	27	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
2	10004	14	41	41	1.647	28	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
3	20006	35	76	76	0.186	105	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer Zones	0.574	N/A
4	25034	26	102	102	0.502	104	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
5	16013	33	135	135	0.120	165	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
6	35002	34	169	169	0.149	204	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
7	16006	33	202	202	0.201	231	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
8	19020	28	230	230	0.207	224	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
9	25044	40	270	270	0.042	360	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
10	16005	30	300	300	0.083	300	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
11	25158	18	318	318	0.504	198	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
12	13002	19	337	337	0.024	228	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
13	24022	20	357	357	0.051	260	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
14	6031	18	375	375	0.849	252	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
15	25038	17	392	392	0.044	255	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
16	19016	15	407	407	0.881	240	1.000	0.070	0.66	4.554	117.82	0.687	1267	ESB stn	Locally Important Aquifer	1.001	Gauge seated on Karstic area. 40% Karstic.
17	29001	40	495	495	0.056	720	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
18	26058	24	519	519	0.220	456	0.995	1.040	0.65	5.535	59.98	0.697	974	B	Locally Important Aquifer	0.548	Gauge situated on very minor Karstic zone within catchment.

Figure D.17: Flood Growth Curve Plot

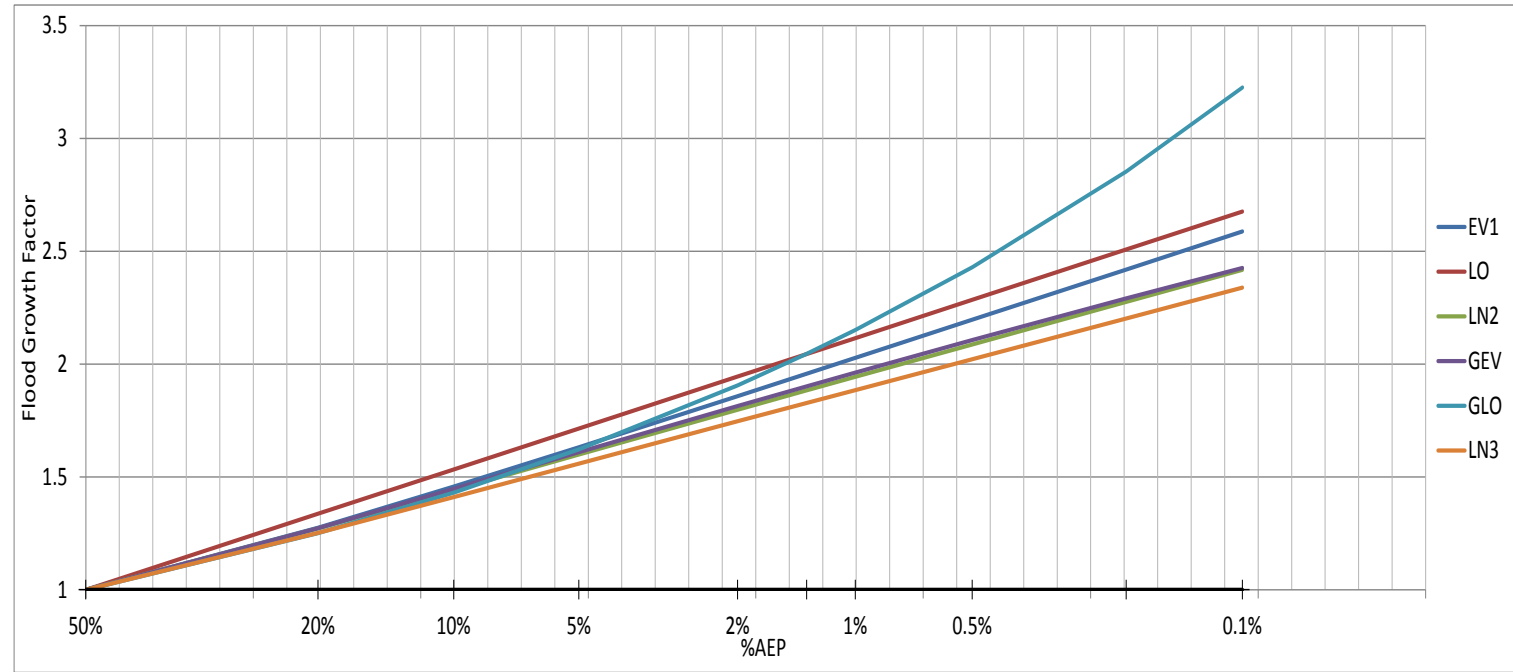


Figure D.18: L Moment Plot

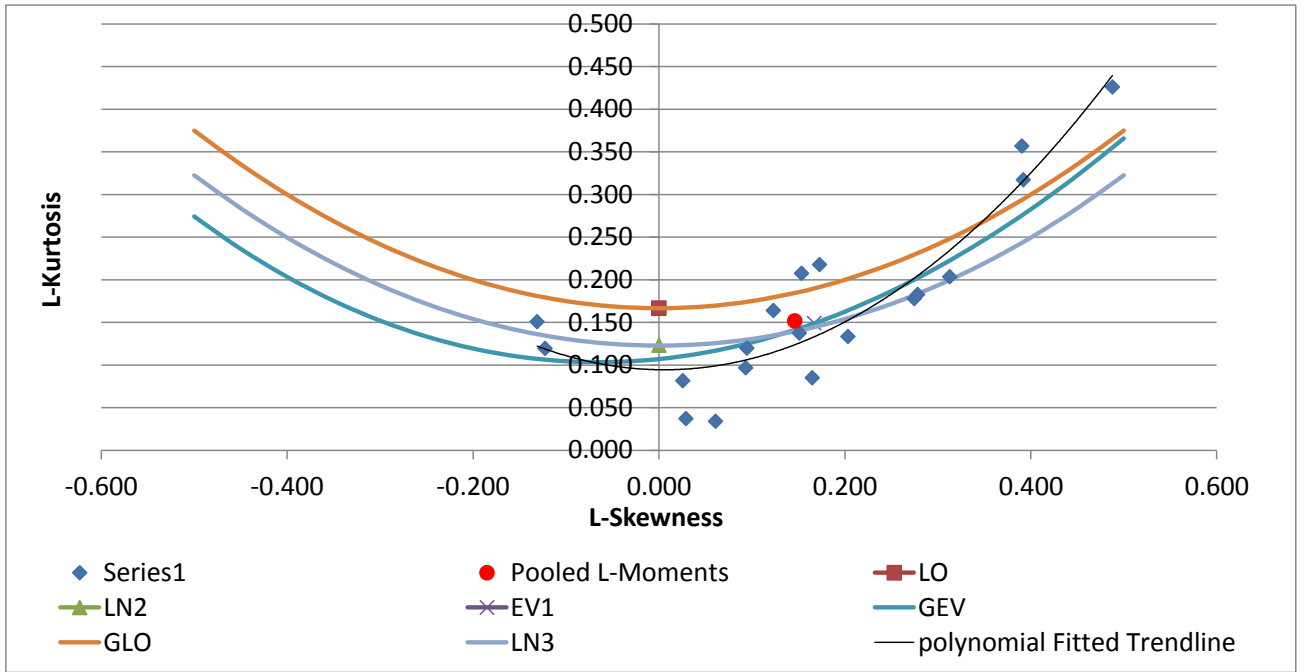


Figure D.19: Median Flood Hydrograph Milltown Gauge

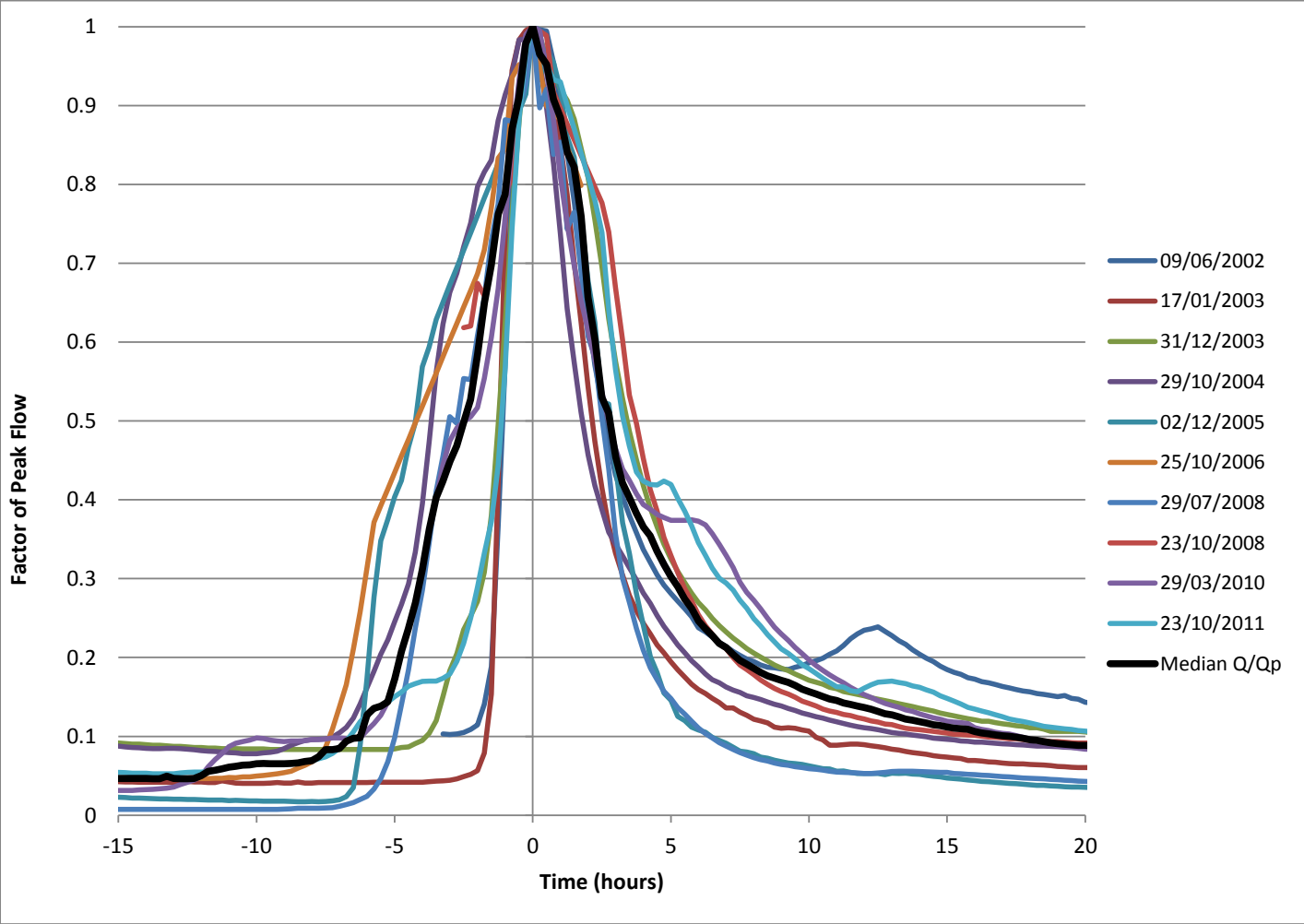


Figure D.20: Typical Flood Hydrograph based on Pivotal Site 36021

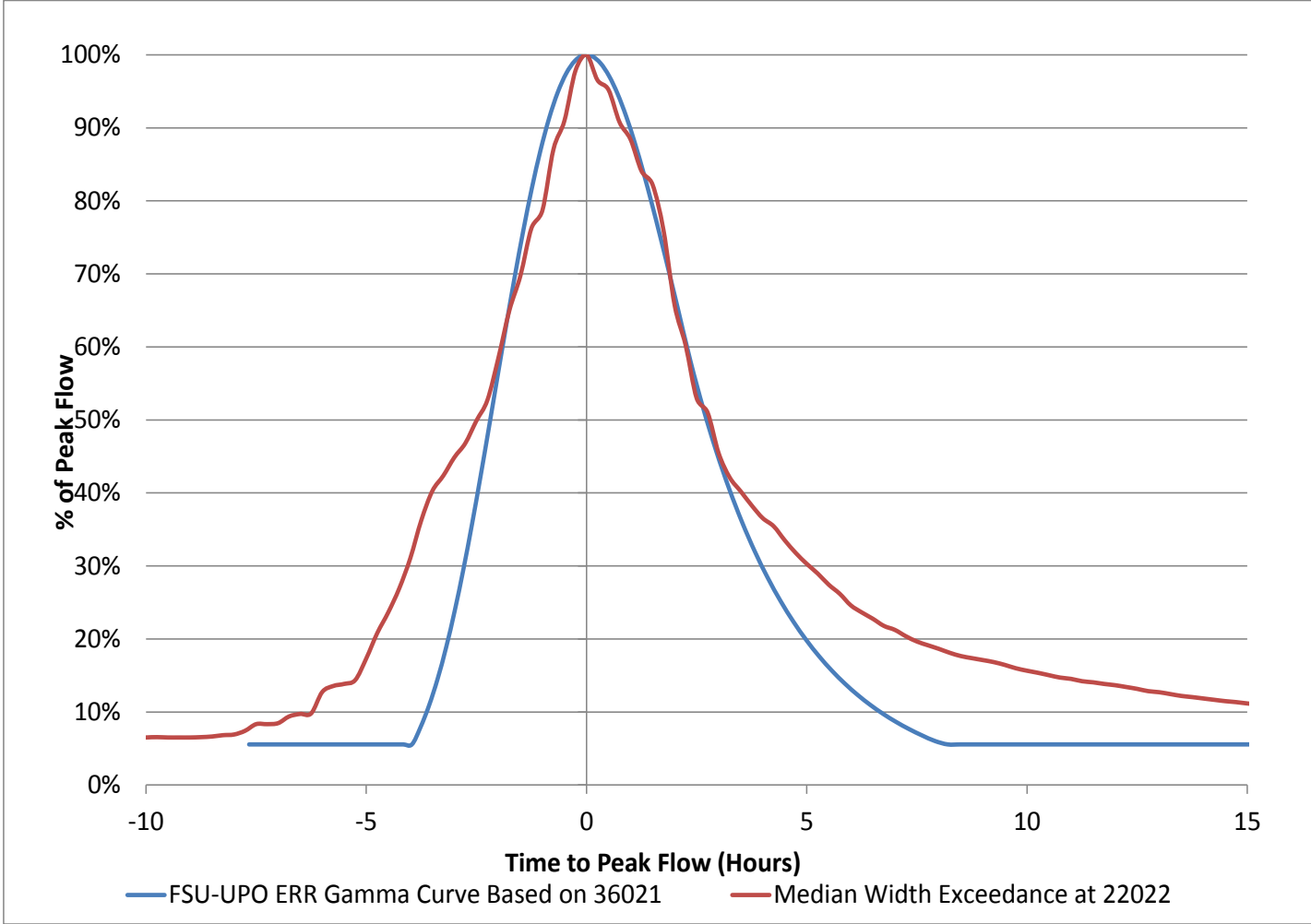


Table D.9: Dingle AFA Design Peak Flows

LOCATION	HEP	AREA	SAAR	BFI	Pivotal Site	QMED	95% Confidence Limit	QMED ^{0.077} /AREA	Flood Growth Curve	Flood Growth Factor								Design Flows								Hydrograph Pivotal Site
										50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1	
Dingle Stream Upstream	22_3437_1	1.1	1.92	1.92	22022	2.16	4.05	20	GLO-P	1	1.26	1.45	1.64	1.94	2.19	2.48	3.30	2.16	2.72	3.12	3.55	4.18	4.73	5.35	7.13	36021
Dingle Stream Downstream	22_3437_5	5.2	3.82	3.82	22022	5.1	9.63	14	GLO-P	1	1.26	1.45	1.64	1.94	2.19	2.48	3.30	5.13	6.46	7.42	8.43	9.94	11.24	12.71	16.94	36021
Milltown river Upstream	22_1712_1	20.6	7.71	26.26	22022	22.8	42.83	22	SS+LN2-P	1.00	1.40	1.73	2.01	2.37	2.70	3.02	3.85	22.82	31.88	39.46	45.82	54.05	61.63	69.02	87.92	36021
Milltown Gauge (22022)	22_1712_2	20.9	8.21	26.76	Gauged	23.0	43.09	22	SS+LN2-P	1	1.40	1.73	2.01	2.37	2.70	3.02	3.85	22.96	32.07	39.70	46.09	54.37	62.01	69.44	88.45	Gauged Median
Milltown River-Ballymoreareagh Tributary Upstream	22_1712_4	21.3	9.22	27.76	22022	23.1	43.31	22	SS+LN2-P	1.00	1.40	1.73	2.01	2.37	2.70	3.02	3.85	23.08	32.24	39.90	46.33	54.65	62.32	69.80	88.90	36021
Milltown River-Ballymoreareagh Tributary Downstream	22_3998_1	27.6	9.22	33.64	22022	27.5	51.65	21	GLO-P	1.00	1.40	1.73	2.01	2.37	2.70	3.02	3.85	27.52	38.44	47.58	55.25	65.17	74.32	83.23	106.01	36021
Milltown River-Downstream	22_3999_2	28.9	9.91	34.34	22022	28.2	52.96	21	SS+LN2-P	1.00	1.40	1.73	2.01	2.37	2.70	3.02	3.85	28.22	39.42	48.79	56.65	66.83	76.21	85.35	108.71	36021
Ballymoreareagh Tributary Downstream	22_1196_5	6.3	4.96	5.88	22022	4.4	8.31	11	SS+LN2-P	1	1.25	1.43	1.62	1.91	2.15	2.43	3.23	4.43	5.54	6.34	7.19	8.44	9.53	10.76	14.29	36021

D.3 Killarney AFA

Figure D.21: Killarney AFA Schematic of QMED

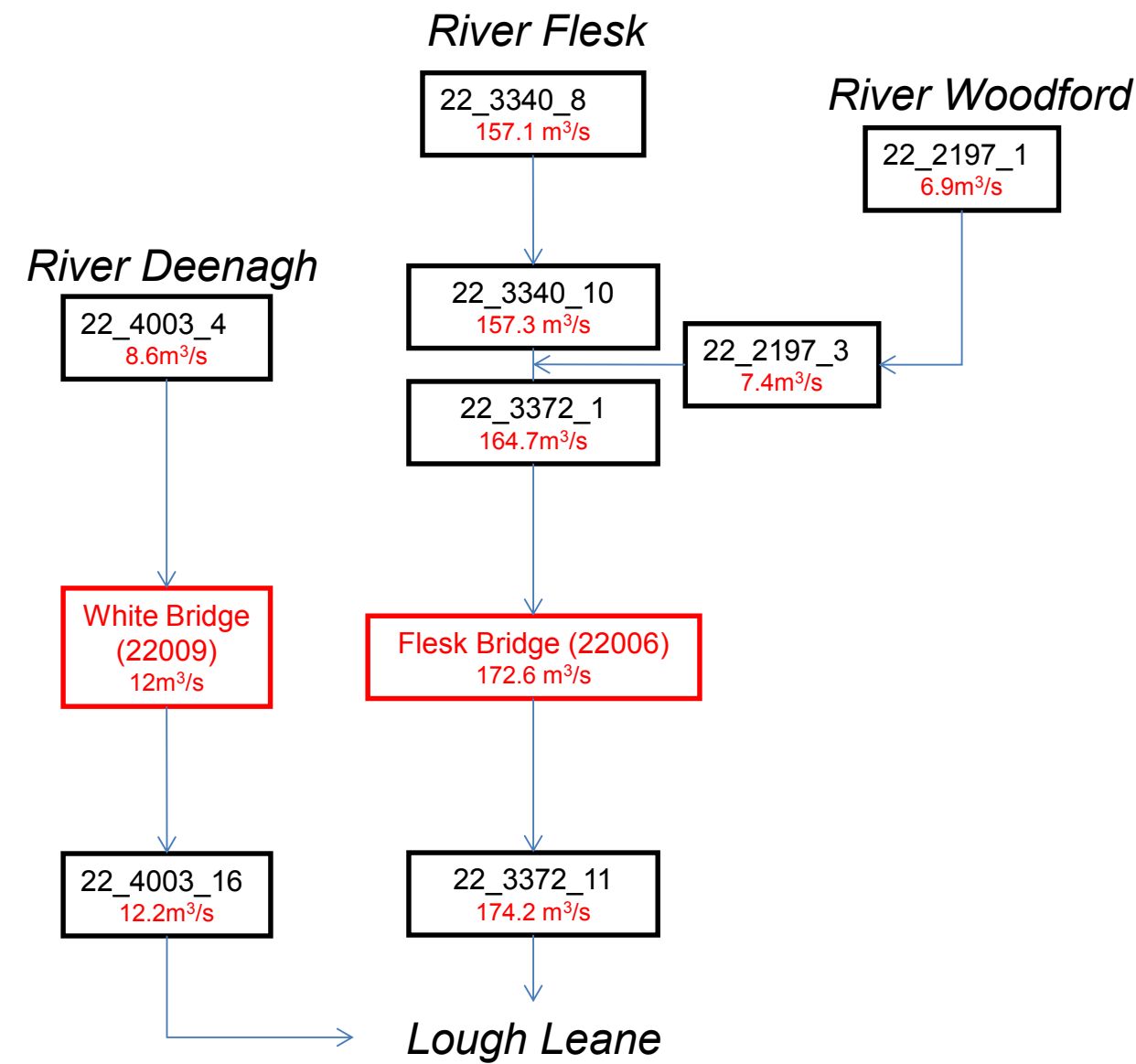


Table D.10: Killarney 22006 Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Recod Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effectiv e record length	FARL	URBEX T	FLATW ET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	22006	57	57	57	0.037	57	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
2	30001	18	75	75	0.798	36	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
3	34007	53	128	128	0.049	159	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
4	34010	12	140	140	0.080	48	0.988	0.850	0.73	3.957	484.35	0.401	1386	B	Locally Important Aquifer	1.477	Mix of geology with minor karstic influence.
5	10002	46	186	186	0.364	230	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
6	18050	24	210	210	0.194	144	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
7	18048	23	233	233	0.127	161	0.999	0.480	0.64	2.353	867.74	0.474	1383	B	Locally Important Aquifer	0.650	N/A
8	18016	20	253	253	0.240	160	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
9	1041	32	285	285	0.096	288	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
10	28001	17	302	302	2.106	170	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
11	38001	33	335	335	0.118	363	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
12	32011	25	360	360	0.091	300	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
13	18006	27	387	387	0.102	351	0.999	0.470	0.63	1.918	1054.78	0.462	1332	B	Locally Important Aquifer	0.885	N/A
14	34009	33	420	420	0.038	462	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
15	20002	37	457	457	0.596	555	0.987	0.810	0.67	2.087	423.74	0.592	1669	B	Locally Important Aquifer	0.484	N/A
16	25158	18	475	475	0.509	288	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
17	16013	33	508	508	0.121	561	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
18	22006	57	57	57	0.037	57	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.

Figure D.22: Flood Growth Curve Plot

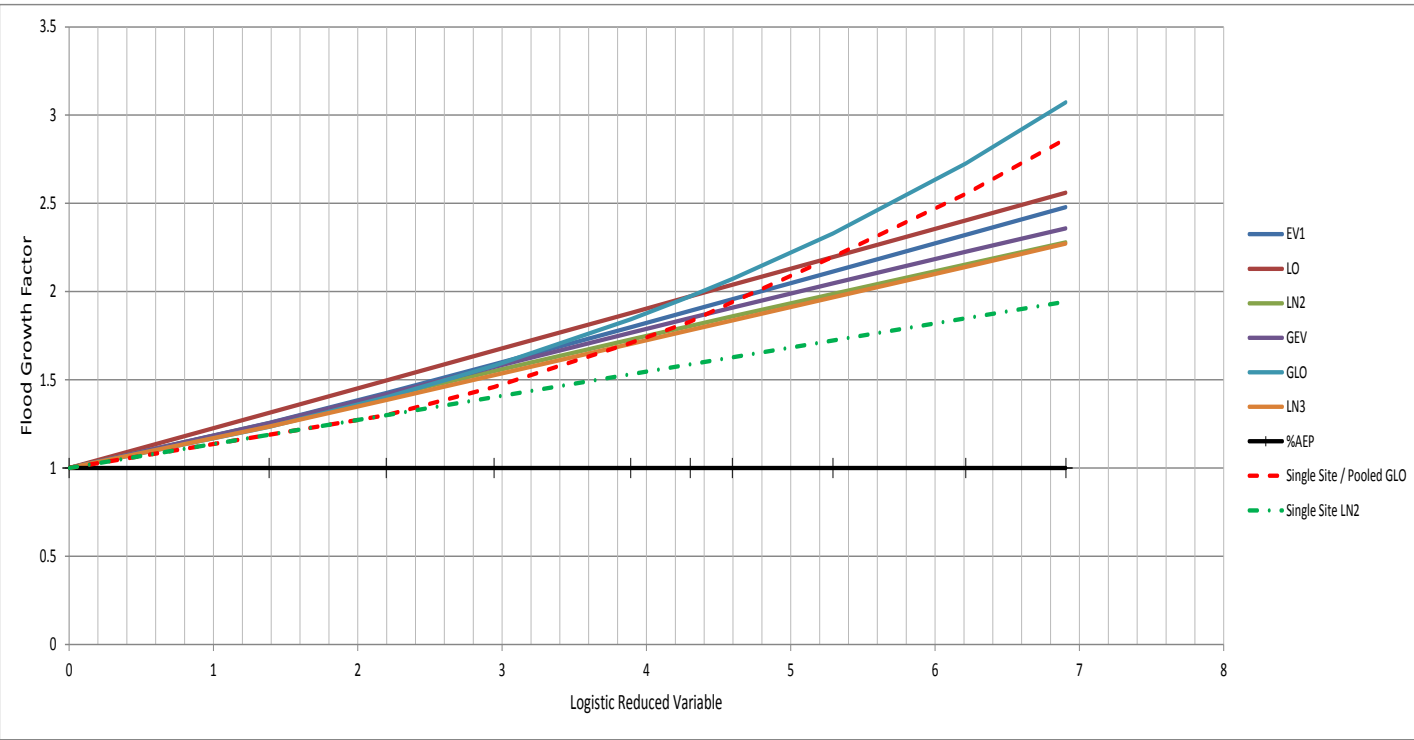


Figure D.23: L Moment Plot

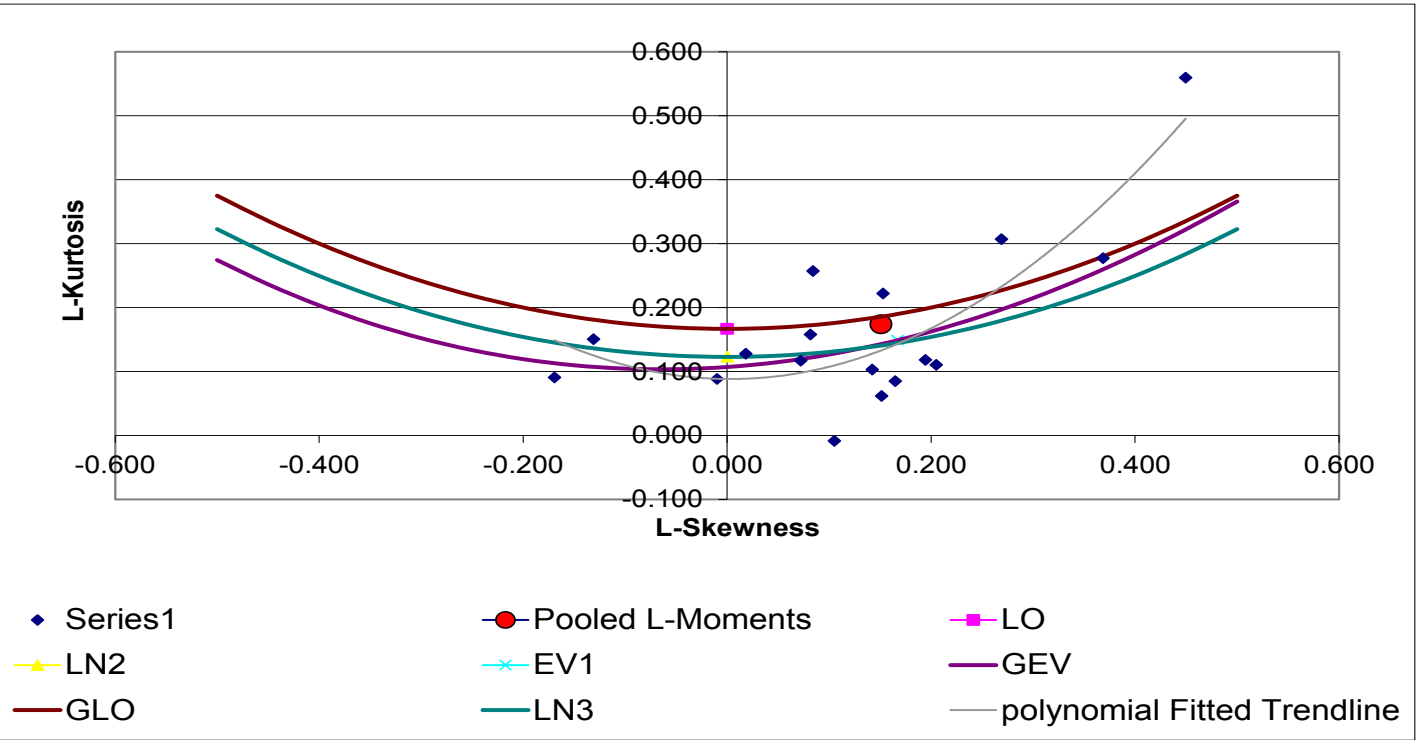


Figure D.24: Median Flood Hydrograph Flesk Bridge Gauge

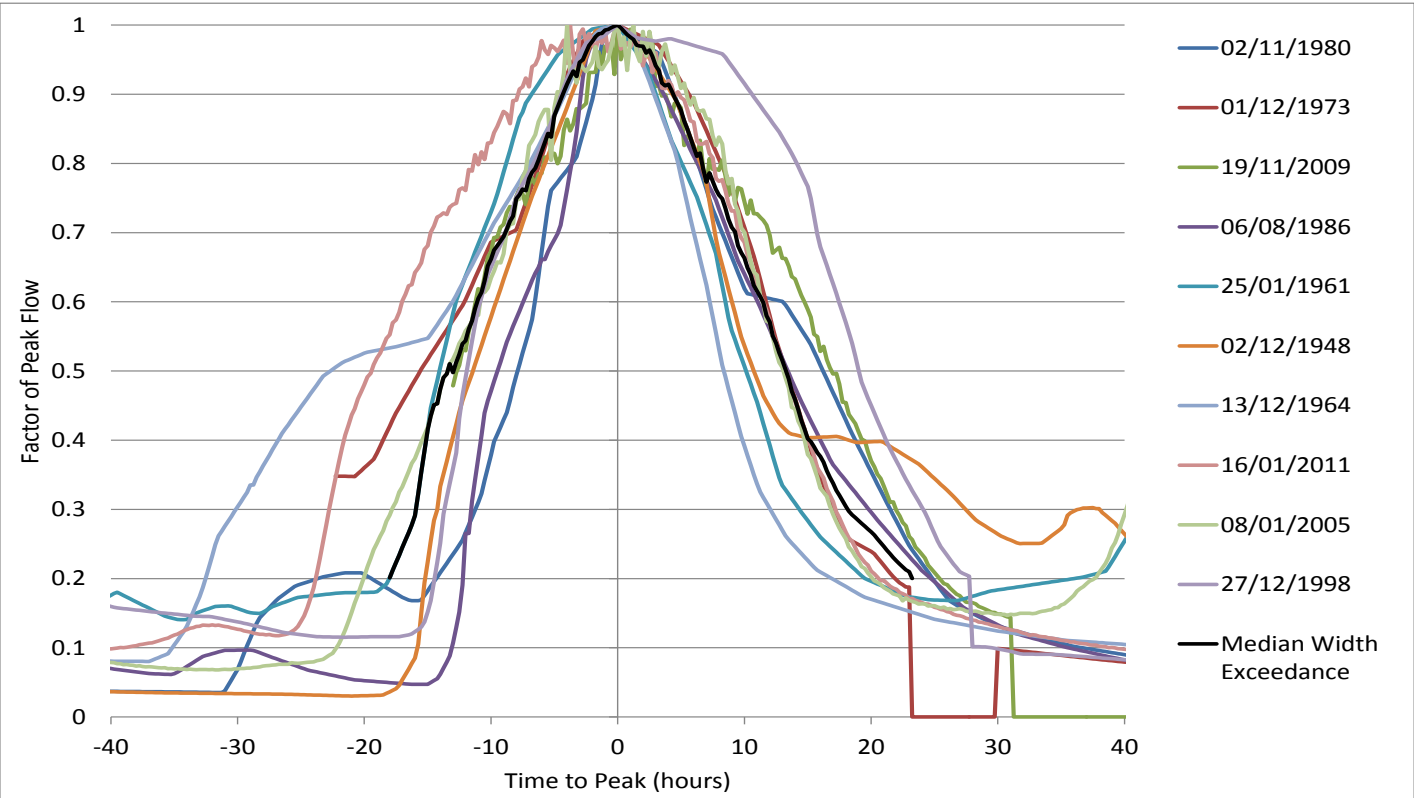


Figure D.25: Typical UPO-ERR Gamma Hydrograph Based on Pivotal Site 16005

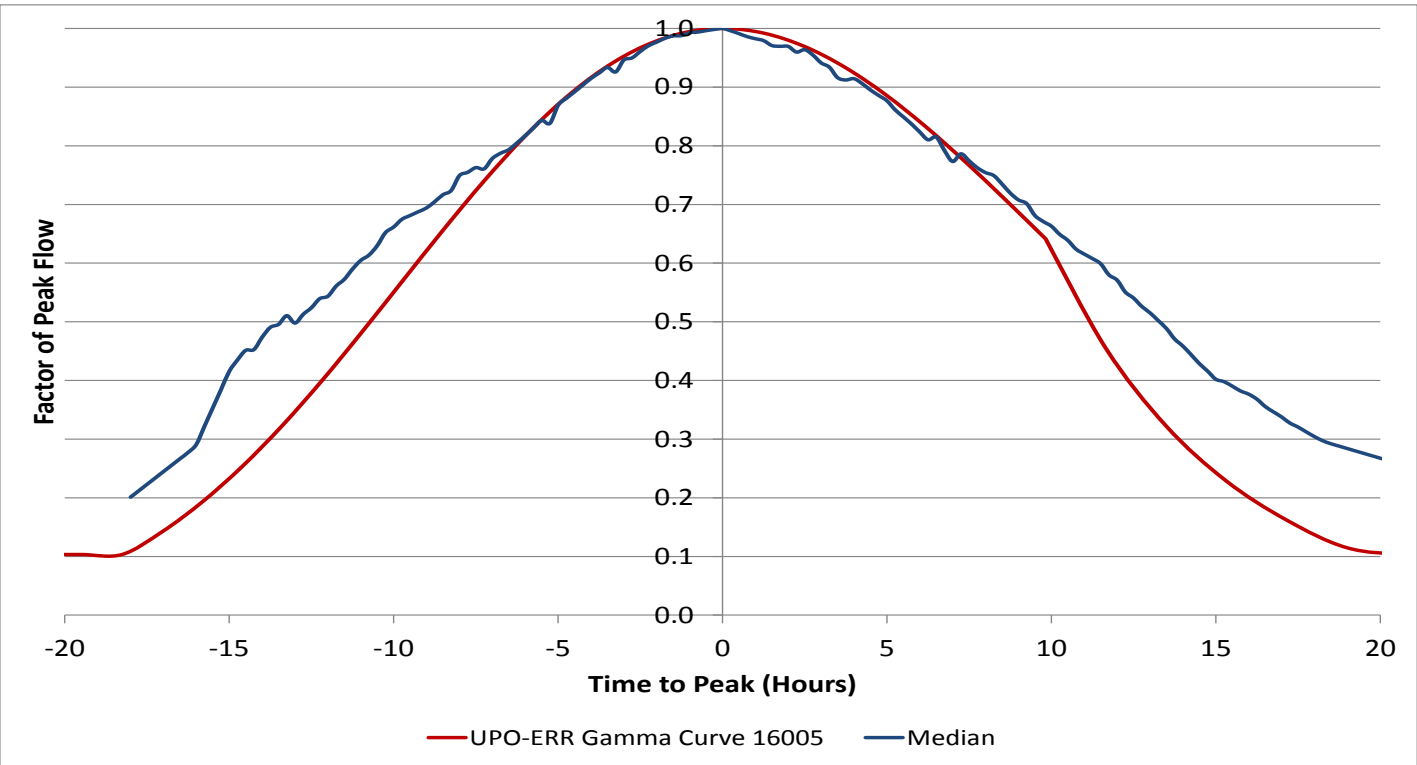


Figure D.26: Typical UPO-ERR Gamma Hydrograph Based on Pivotal Site 23012

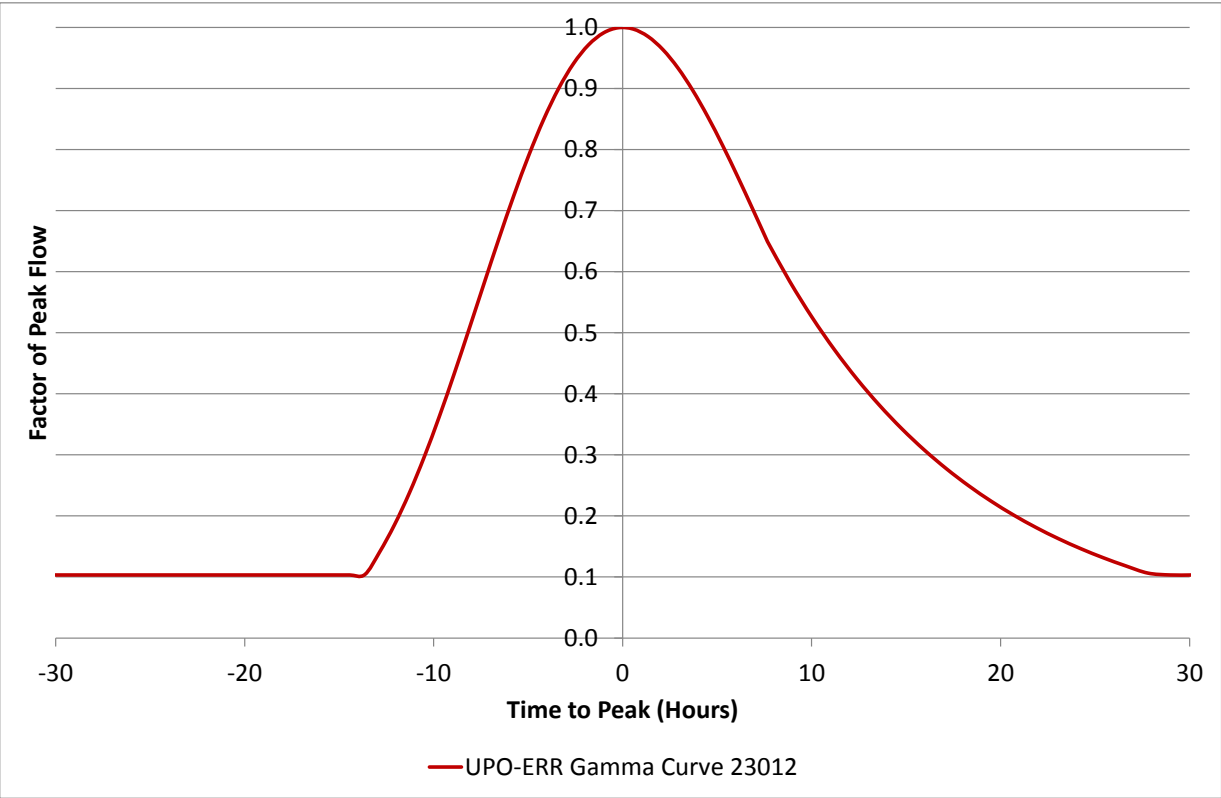


Table D.11: Killarney AFA Design Peak Flows

							95% Confidence Limit	QMED0.0 77/ AREA	Flood Growth Factor								Flows (m3/s)										Pivotal Site
LOCATION	HEP	AREA	SAAR	BFI	Pivotal Site for QMED	QMED			Flood Growth Curve	50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1		
Deenagh upstream Survey Extent	22_4003_4	24.6	1125	0.609	22009*	8.6	16.1	7	GLO-P	1.00	1.13	1.28	1.44	1.75	2.02	2.32	3.06	8.6	9.7	11.0	12.4	15.0	17.3	19.9	26.3	2301 2	
22009 (White Bridge)	22_4003_14	31.1	1172	0.601	22009*	12.0	22.6	9	GLO-P	1.00	1.13	1.28	1.44	1.75	2.02	2.32	3.06	12.0	13.6	15.4	17.4	21.1	24.3	28.0	36.9	2301 2*	
Deenagh downstream Survey Extent & AFA Boundary	22_4003_16	31.3	1154	0.595	22009*	12.2	22.8	9	GLO-P	1.00	1.13	1.28	1.44	1.75	2.02	2.32	3.06	12.2	13.7	15.6	17.6	21.3	24.5	28.2	37.2	2301 2	
Woodford upstream Survey Extent	22_2197_1	15.2	1257	0.588	22009	6.9	12.9	8	GLO-P	1.00	1.25	1.43	1.62	1.90	2.14	2.42	3.21	6.9	8.6	9.8	11.1	13.0	14.7	16.6	22.0	2301 2	
Woodford upstream Flesk	22_2197_3	15.7	1260	0.588	22009	7.4	13.9	9	GLO-P	1.00	1.25	1.43	1.62	1.90	2.14	2.42	3.21	7.4	9.3	10.6	12.0	14.1	15.9	17.9	23.8	2301 2	
Flesk UPSTREAM	22_3340_8	307.9	1855	0.415	22006	170.1	319.2	19	SS+ GLO-P	1.00	1.19	1.30	1.46	1.71	1.94	2.20	2.87	157.1	186.8	204.2	229.3	268.6	304.7	345.2	450.2	1600 5	
Flesk upstream Woodford	22_3340_10	308.6	1854	0.415	22006	170.2	319.5	19	SS+ GLO-P	1.00	1.19	1.30	1.46	1.71	1.94	2.20	2.87	157.3	187.1	204.5	229.7	269.0	305.2	345.8	450.9	1600 5	
Flesk downstream Woodford	22_3372_1	324.4	1825	0.409	22006	171.8	322.4	19	SS+ GLO-P	1.00	1.19	1.30	1.46	1.71	1.94	2.20	2.87	164.7	195.9	214.2	240.5	281.7	319.6	362.0	472.1	1600 5	
22006 (Flesk Bridge)	22_3372_6	328.8	1819	0.388	22006	172.6	323.9	20	SS+ GLO-P	1.00	1.19	1.30	1.46	1.71	1.94	2.20	2.87	172.6	205.2	224.4	251.9	295.1	334.8	379.3	494.6	Median	
Flesk downstream Survey Extent & AFA Boundary	22_3372_11	330.1	1818	0.389	22006	174.3	327.1	20	SS+ GLO-P	1.00	1.19	1.30	1.46	1.71	1.94	2.20	2.87	174.2	207.2	226.5	254.3	297.9	338.0	382.9	499.3	1600 5	
*(Gauged not used in pooling to generate flood growth curve)																											

D.4 Milltown AFA

Figure D.27: Milltown AFA Schematic of QMED

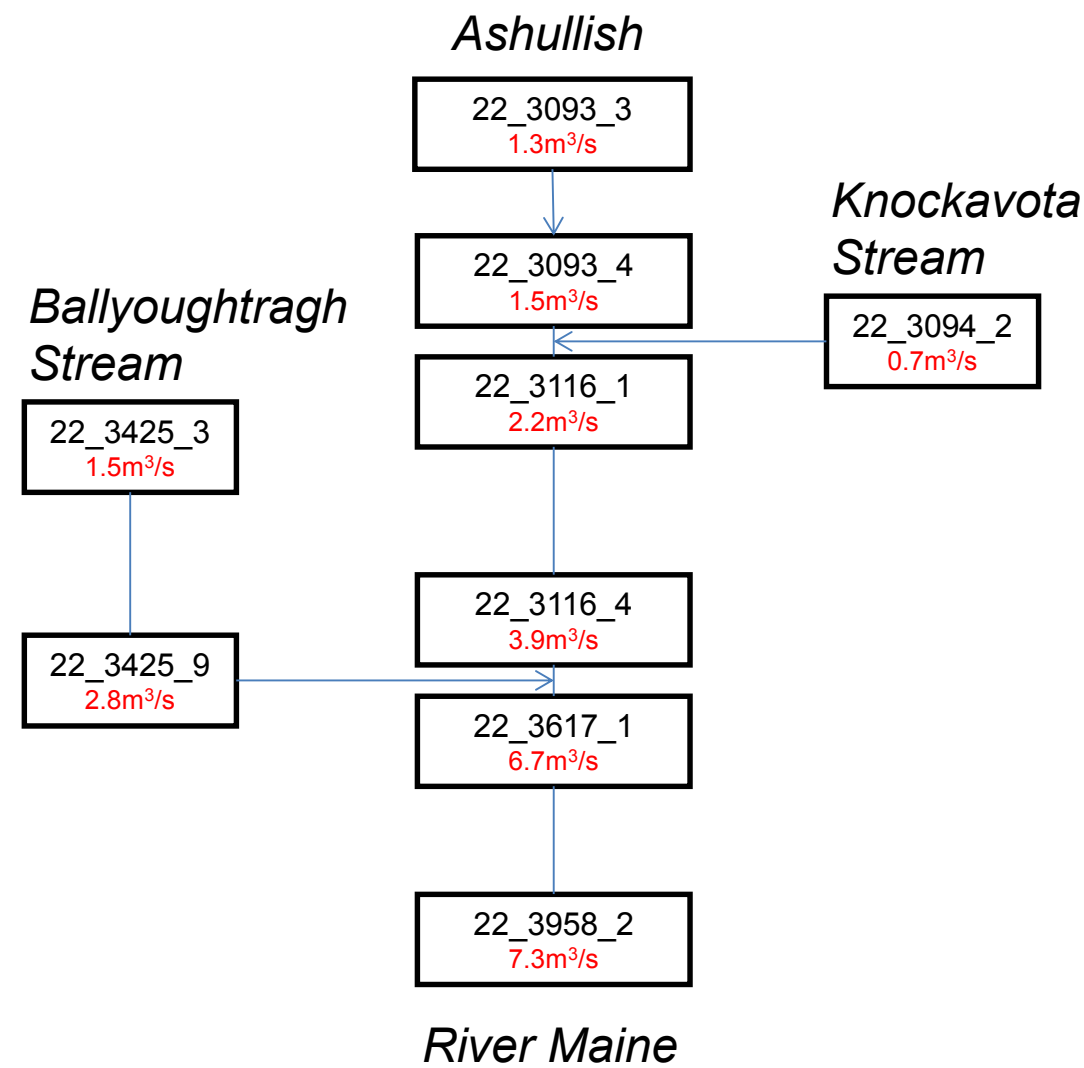


Table D.12: Ashullish Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEX T	FLATW ET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	10004	14	14	14	1.929	14	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
2	6030	27	41	41	0.610	54	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
3	20006	35	105	105	0.218	140	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
4	16013	33	138	138	0.141	165	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
5	35002	34	172	172	0.175	204	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
6	19020	28	200	200	0.242	196	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
7	25034	26	226	226	0.588	208	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
8	25040	19	245	245	0.095	171	1.000	6.180	0.60	13.494	28.02	0.576	990	A2	Locally Important Aquifer	1.322	N/A
9	25044	40	285	285	0.049	400	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
10	25158	18	303	303	0.590	198	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
11	16006	33	336	336	0.235	396	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
12	16005	30	366	366	0.098	390	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
13	19016	15	381	381	1.032	210	1.000	0.070	0.66	4.554	117.82	0.687	1267	ESB stn	Locally Important Aquifer	1.001	Gauge seated on Karstic area. 40% Karstic.
14	13002	19	448	448	0.028	304	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
15	25038	17	465	465	0.052	289	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
16	24022	20	485	485	0.059	360	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
17	29001	40	525	525	0.066	760	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.

Figure D.28: Flood Growth Curve Plot

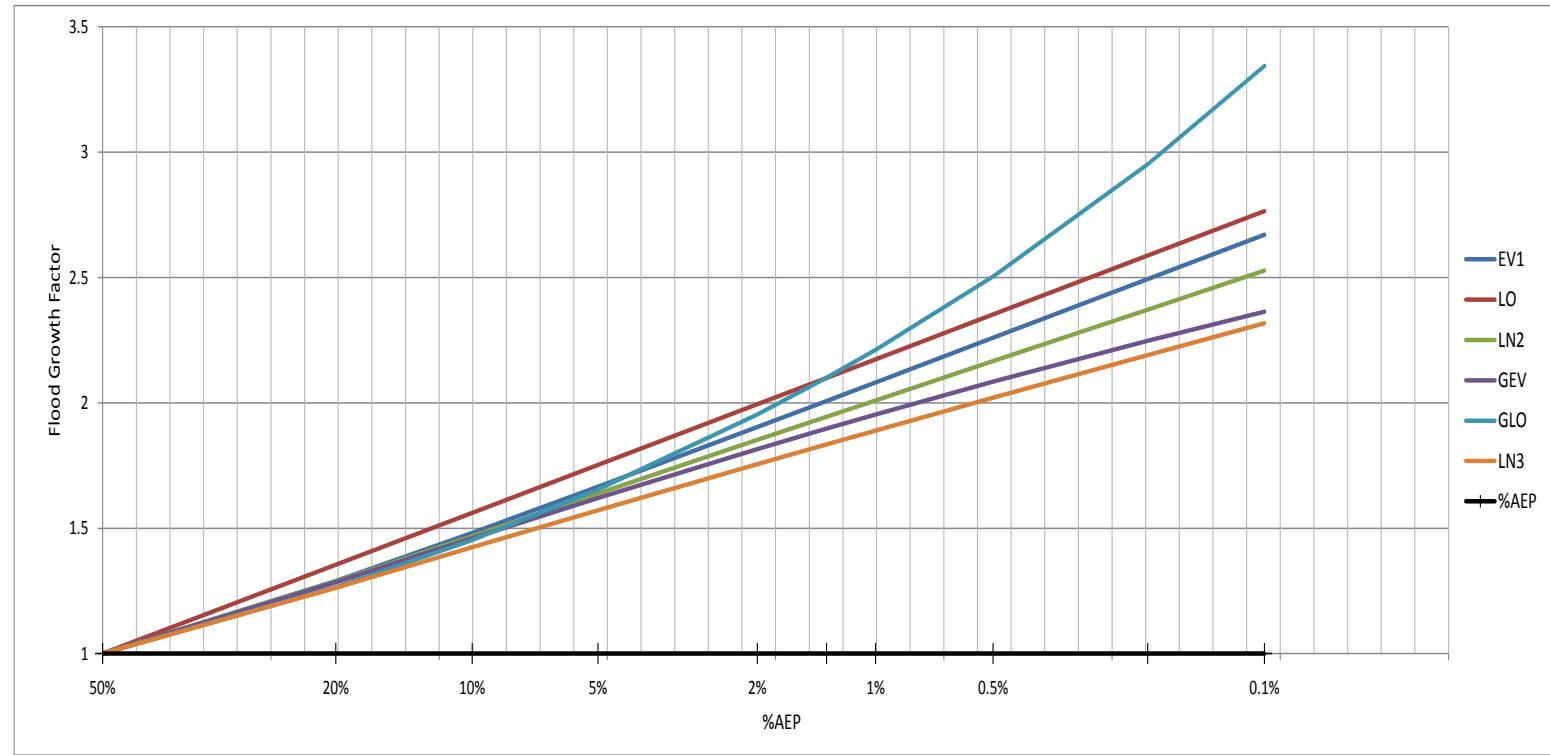


Figure D.29: L Moment Plot

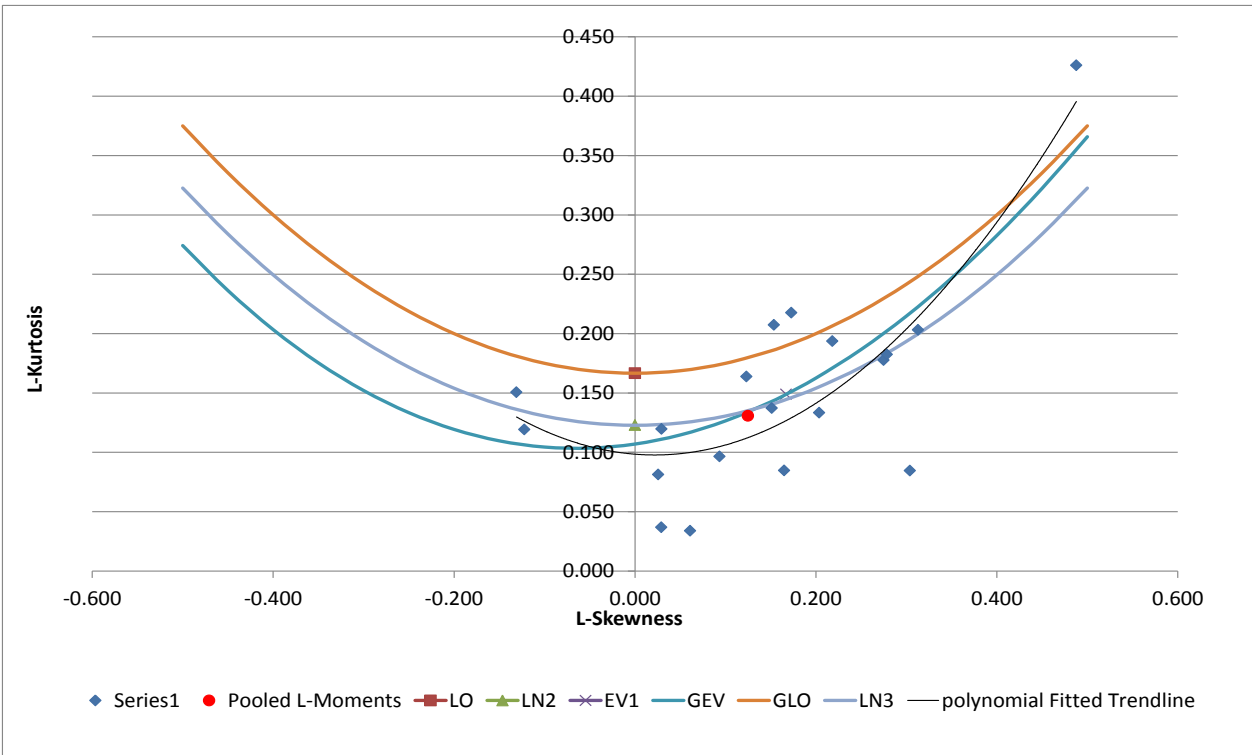


Table D.13: Ballyoughtragh Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumulat ive Years	Pooling Years Count	Discord ancy (Di)	Effectiv e record length	FARL	URBEX T	FLATW ET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	6030	27	27	27	0.52	27	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
2	10004	14	41	41	1.66	28	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
3	25034	26	67	67	0.50	78	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
4	20006	35	102	102	0.19	140	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
5	25040	19	121	121	0.08	95	1.000	6.180	0.60	13.494	28.02	0.576	990	A2	Locally Important Aquifer	1.322	N/A
6	19020	28	149	149	0.21	168	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
7	16013	33	182	182	0.12	231	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
8	35002	34	216	216	0.15	272	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
9	16006	33	249	249	0.20	297	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
10	13002	19	268	268	0.02	190	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
11	24022	20	288	288	0.05	220	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
12	25044	40	328	328	0.04	480	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
13	16005	30	358	358	0.08	390	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
14	16051	13	371	371	0.43	182	1.000	0.000	0.58	1.615	34.19	0.593	895	B	Locally Important Aquifer	0.945	N/A
15	25158	18	389	389	0.51	270	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
16	6031	18	407	407	0.85	288	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
17	26058	24	431	431	0.22	408	0.995	1.040	0.65	5.535	59.98	0.697	974	B	Locally Important Aquifer	0.548	N/A
18	23012	18	449	449	0.77	324	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	Gauge situated on very minor Karstic zone within catchment.
19	29071	26	475	475	0.01	494	0.804	0.000	0.62	5.230	123.84	0.565	1212	A2	Poor Aquifer	0.815	N/A
20	25038	17	492	492	0.04	340	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A

Figure D.30: Flood Growth Curve Plot

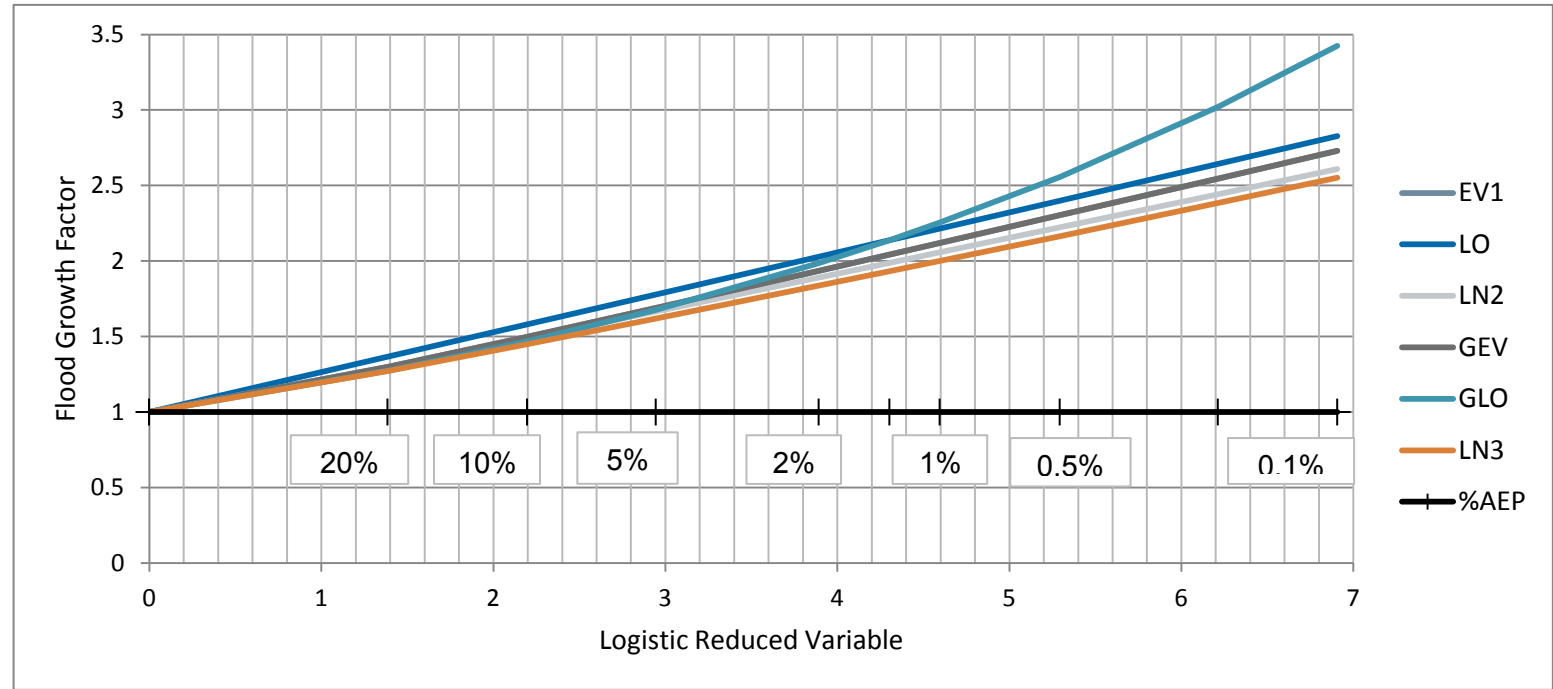


Figure D.31: L Moment Plot

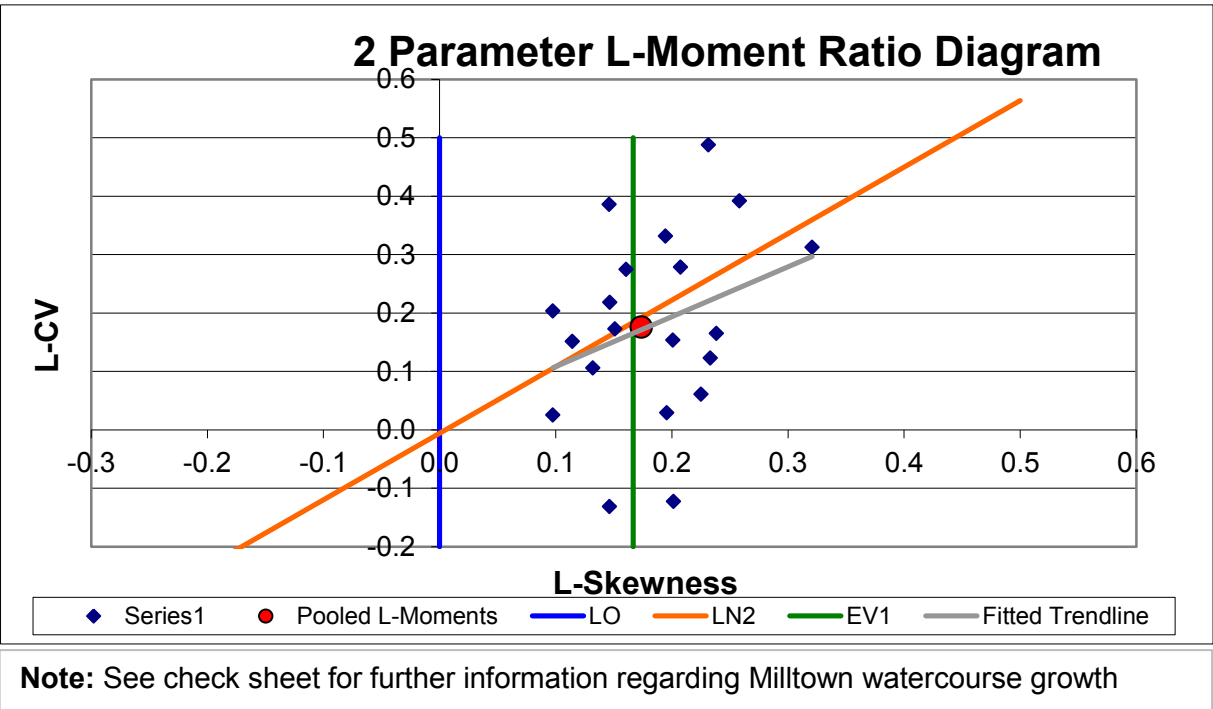


Figure D.32: Typical UPO-ERR Gamma Hydrograph Based on Pivotal Site 36012

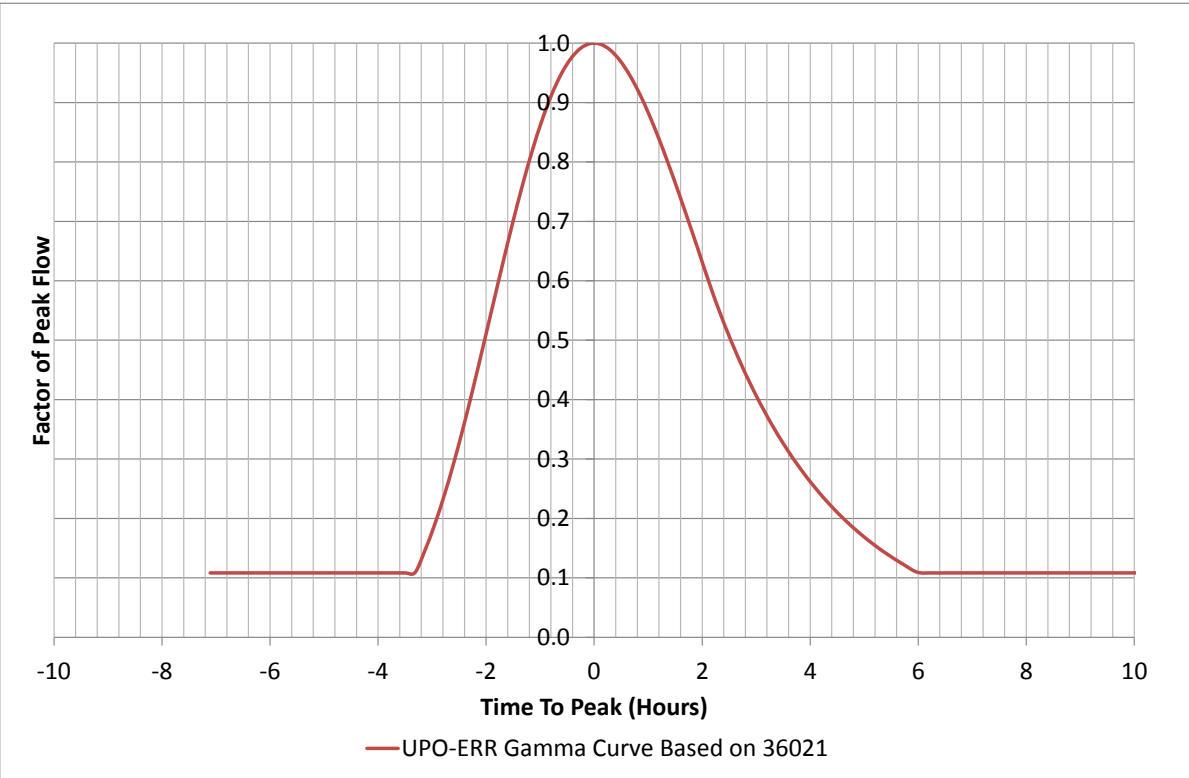


Table D.14: Milltown AFA Design Peak Flows

LOCATION	HEP	AREA	SAAR	BFI	Pivotal Site	QMED	95% Confidence Limit	QMED ^{0.077} / AREA	Flood Growth Curve	Flood Growth Factor								Design Flows								Hydrograph Pivotal Site
										50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1	
Ashullish Stream Uptsream	22_3093_3	2.28	1410	0.612	22022	1.31	2.47	7	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	1.3	1.7	1.9	2.2	2.6	2.9	3.3	4.4	36021
Ashullish-Ashullish Trib u/s	22_3093_4	2.45	1448	0.613	22022	1.49	2.79	7	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	1.5	1.9	2.2	2.5	2.9	3.3	3.7	5.0	36021
Ashullish-Ashullish Trib d/s	22_3116_1	3.53	1498	0.615	22022	2.24	4.21	8	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	2.2	2.8	3.3	3.7	4.4	5.0	5.6	7.5	36021
Ashullish-Ballyoughtragh Uptsream	22_3116_4	4.68	1642	0.616	22022	3.85	7.22	12	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	3.8	4.9	5.6	6.4	7.5	8.5	9.6	12.9	36021
Ashullish-Ballyoughtragh Downstream	22_3617_1	8.96	1578	0.614	22022	6.73	12.63	12	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	6.7	8.5	9.8	11.1	13.1	14.9	16.8	22.5	36021
Ashullish Stream Downstream	22_3958_2	9.47	1603	0.614	22022	7.27	13.65	13	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	7.3	9.2	10.6	12.0	14.2	16.1	18.2	24.3	36021
Knokavota Stream d/s at trib	22_3094_2	1.07	1606	0.640	22022	0.74	1.40	7	GLO	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	0.7	0.9	1.1	1.2	1.5	1.6	1.9	2.5	36021
Ballyoughtragh Stream Uptsream	22_3425_3	3.28	1400	0.629	22022	1.49	2.80	6	GLO	1.00	1.27	1.47	1.68	1.99	2.25	2.56	3.43	1.5	1.9	2.2	2.5	3.0	3.4	3.8	5.1	36021
Ballyoughtragh Stream Downstream	22_3425_9	4.28	1506	0.623	22022	2.85	5.35	9	GLO	1.00	1.27	1.47	1.68	1.99	2.25	2.56	3.43	2.9	3.6	4.2	4.8	5.7	6.4	7.3	9.8	36021

D.5 Maine MPW

Figure D.33: River Maine Schematic of QMED

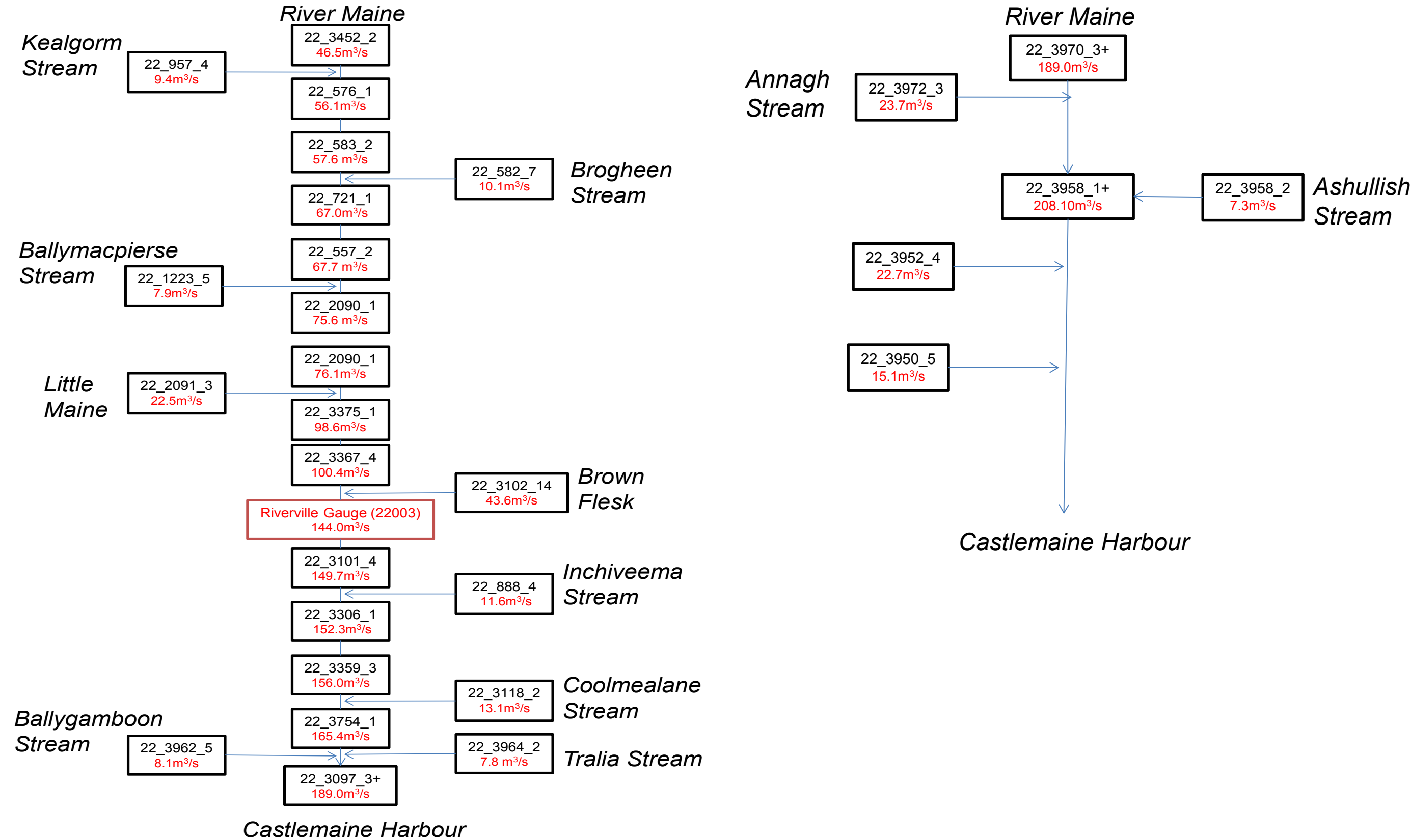


Table D.15: River Maine (Riverville 22003) Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	22003	10	10	10	0.840	10	1.000	1.720	0.64	5.002	271.29	0.471	1349	B	Locally Important Aquifer	0.882	N/A
2	16012	28	38	38	0.056	56	0.999	0.270	0.60	5.200	229.63	0.529	1321	B	Regionally Important Aquifer - Karstified (diffuse)	0.608	N/A
3	10002	46	84	84	0.340	138	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
4	25002	51	135	135	0.605	204	0.999	0.180	0.59	6.877	221.61	0.542	1300	A2	Locally Important Aquifer	0.988	N/A
5	34009	33	168	168	0.035	165	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
6	35011	15	183	183	0.026	90	0.978	0.160	0.70	4.071	293.23	0.534	1534	B	Regionally Important Aquifer - Karstified (conduit)	0.617	N/A
7	25158	18	201	201	0.475	126	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
8	26006	53	254	254	1.022	424	0.970	0.550	0.71	0.970	184.76	0.488	1121	A1	Regionally Important Aquifer - Karstified (conduit)	2.460	N/A
9	34010	12	266	266	0.075	108	0.988	0.850	0.73	3.957	484.35	0.401	1386	B	Locally Important Aquifer	1.477	Mix of geology with minor karstic influence.
10	18048	23	289	289	0.119	230	0.999	0.480	0.64	2.353	867.74	0.474	1383	B	Locally Important Aquifer	0.650	N/A
11	34024	28	317	317	0.280	308	0.922	0.750	0.73	1.518	127.23	0.522	1177	A2	Locally Important Aquifer	0.962	N/A
12	24012	41	358	358	0.246	492	1.000	1.590	0.61	2.253	366.28	0.469	1073	B	Locally Important Aquifer	0.729	N/A
13	30005	49	407	407	0.060	637	0.985	0.820	0.71	1.026	237.82	0.557	1172	A1	Regionally Important Aquifer - Karstified (conduit)	1.119	N/A
14	25001	27	434	434	0.477	378	0.999	0.530	0.59	4.073	647.56	0.513	1166	A2	Locally Important Aquifer	1.129	N/A
15	24011	33	467	467	0.547	495	1.000	1.220	0.61	2.309	281.23	0.489	1058	B	Regionally Important Aquifer - Karstified (diffuse)	0.737	Gauge situated on Karstic zone. Moderately influenced. Caution
16	24013	36	503	503	0.130	576	1.000	1.600	0.61	1.939	438.79	0.469	1072	A1	Locally Important Aquifer	1.378	N/A

Figure D.34: Flood Growth Curve Plot

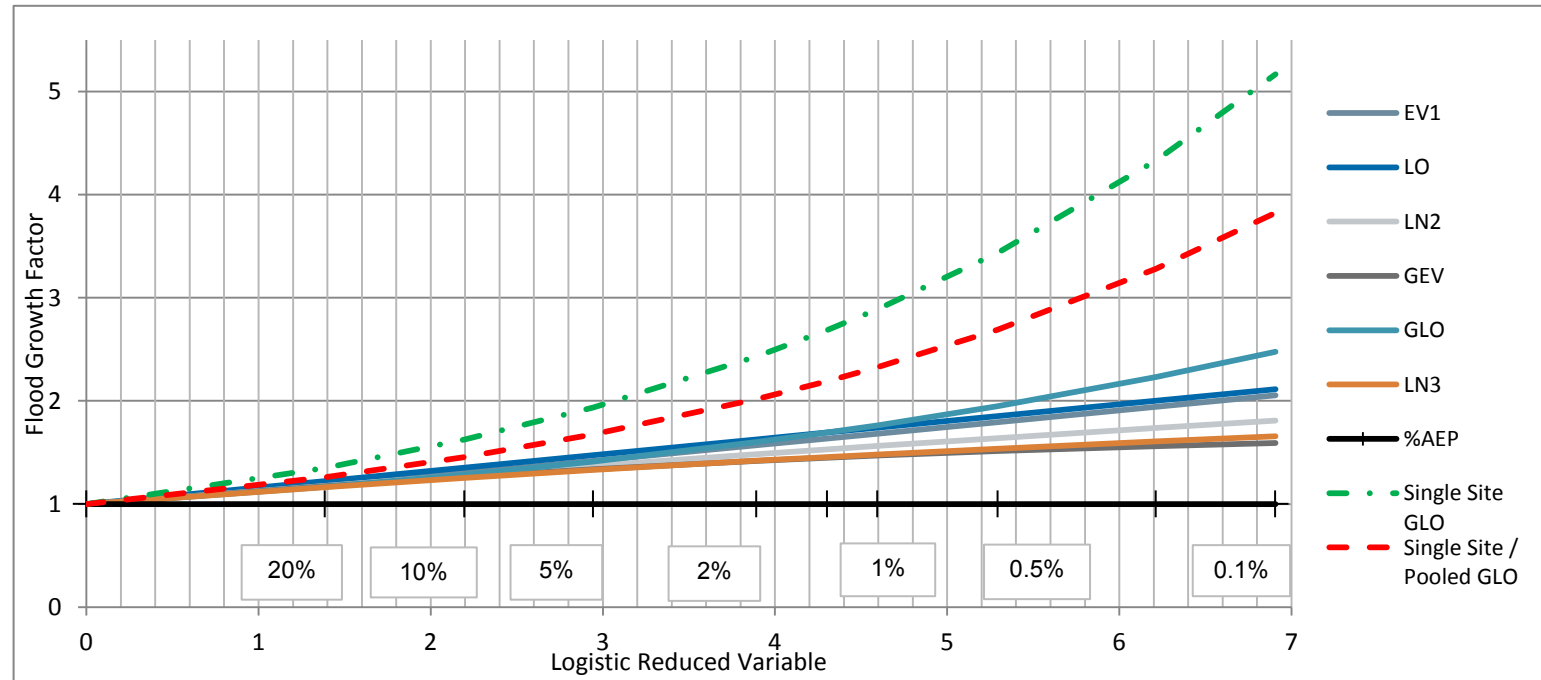


Figure D.35: L Moment Plot

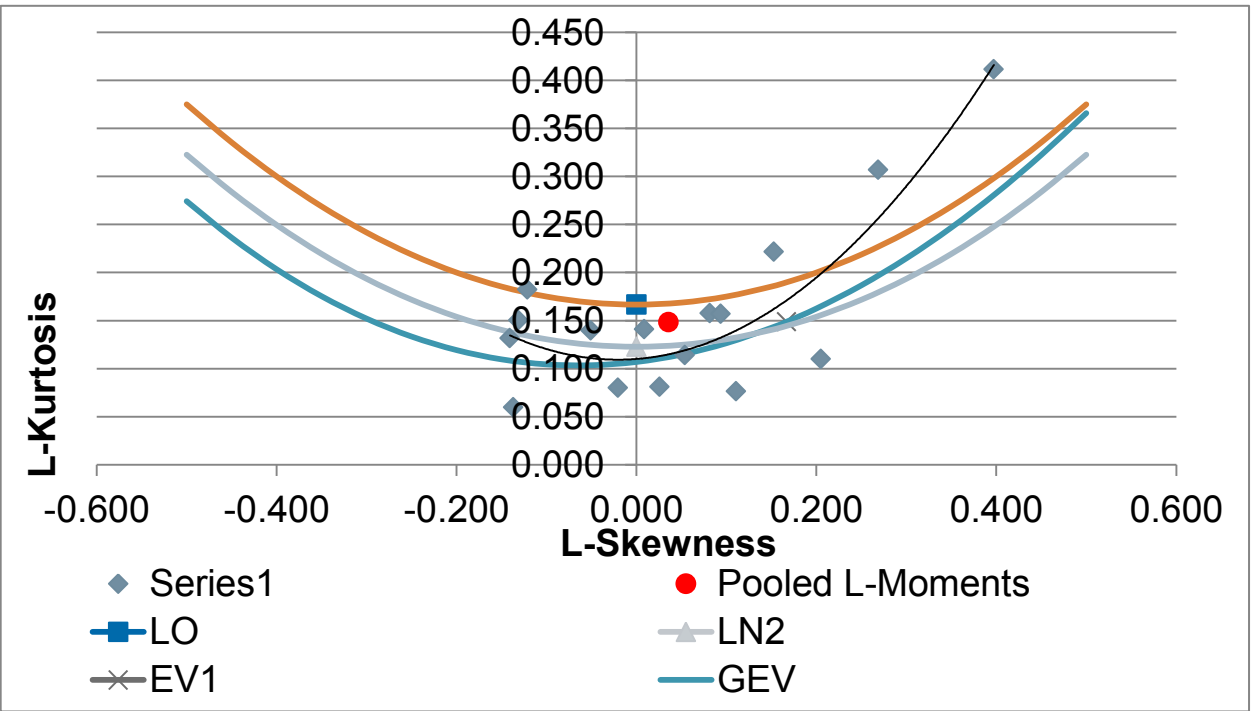


Table D.16: Kealgorm Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	10004	14	14	14	1.004	14	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
2	23012	18	32	32	0.464	36	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
3	30020	16	48	48	0.029	48	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
4	6030	27	75	75	0.318	108	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
5	36021	27	102	102	0.052	135	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
6	35002	34	136	136	0.091	204	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
7	25158	18	154	154	0.307	126	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
8	34009	33	187	187	0.023	264	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
9	16005	30	217	217	0.051	270	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
10	20006	35	252	252	0.113	350	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
11	30001	18	270	270	0.482	198	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
12	25044	40	310	310	0.025	480	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
13	35004	14	324	324	0.259	182	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
14	16006	33	357	357	0.122	462	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
15	6031	18	375	375	0.518	270	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
16	18016	20	395	395	0.145	320	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
17	3051	15	410	410	1.718	255	0.953	3.260	0.68	7.581	143.19	0.472	1083	A2	Locally Important Aquifer	0.863	N/A
18	36031	30	440	440	0.549	540	0.958	6.000	0.67	4.251	63.77	0.497	910	A2	Locally Important Aquifer	1.140	N/A
19	26009	35	475	475	0.063	665	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A

Figure D.36: Flood Growth Curve Plot

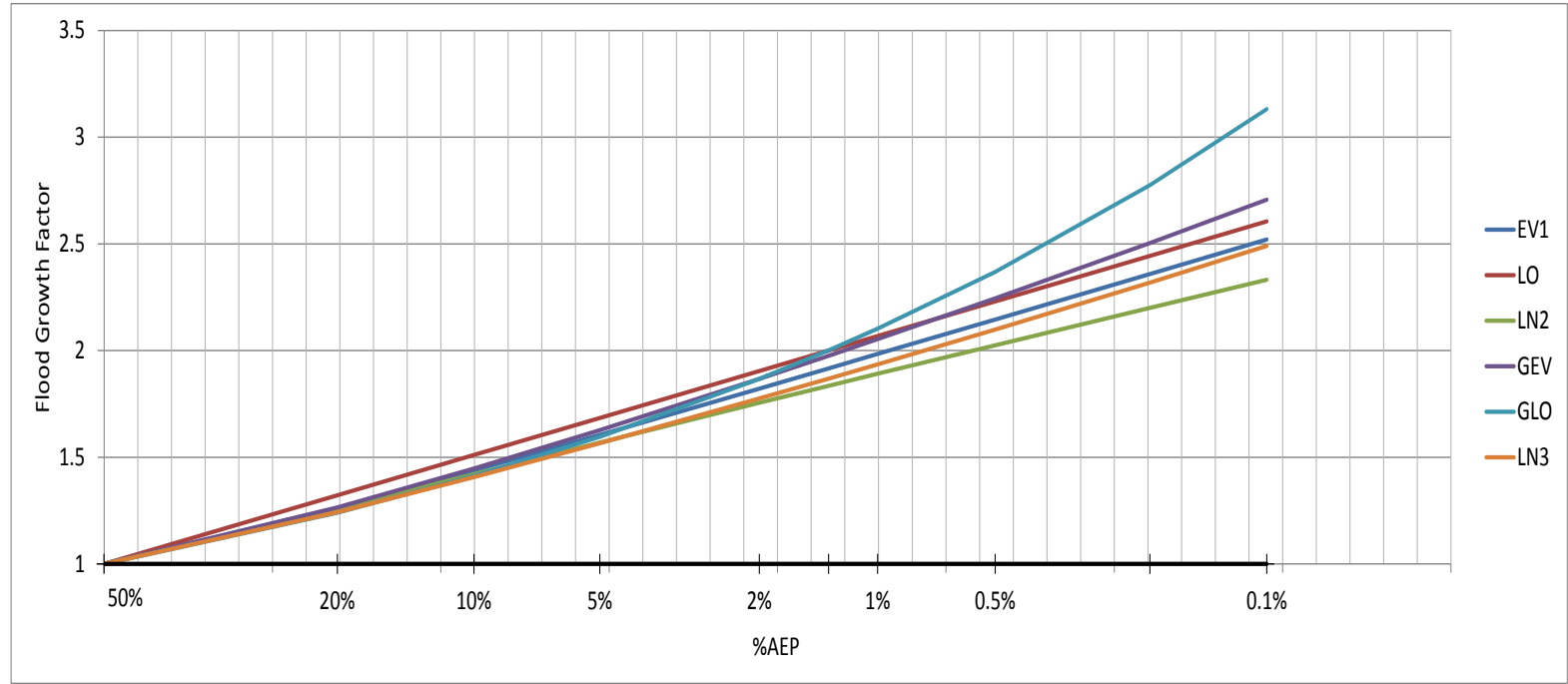


Figure D.37: L Moment Plot

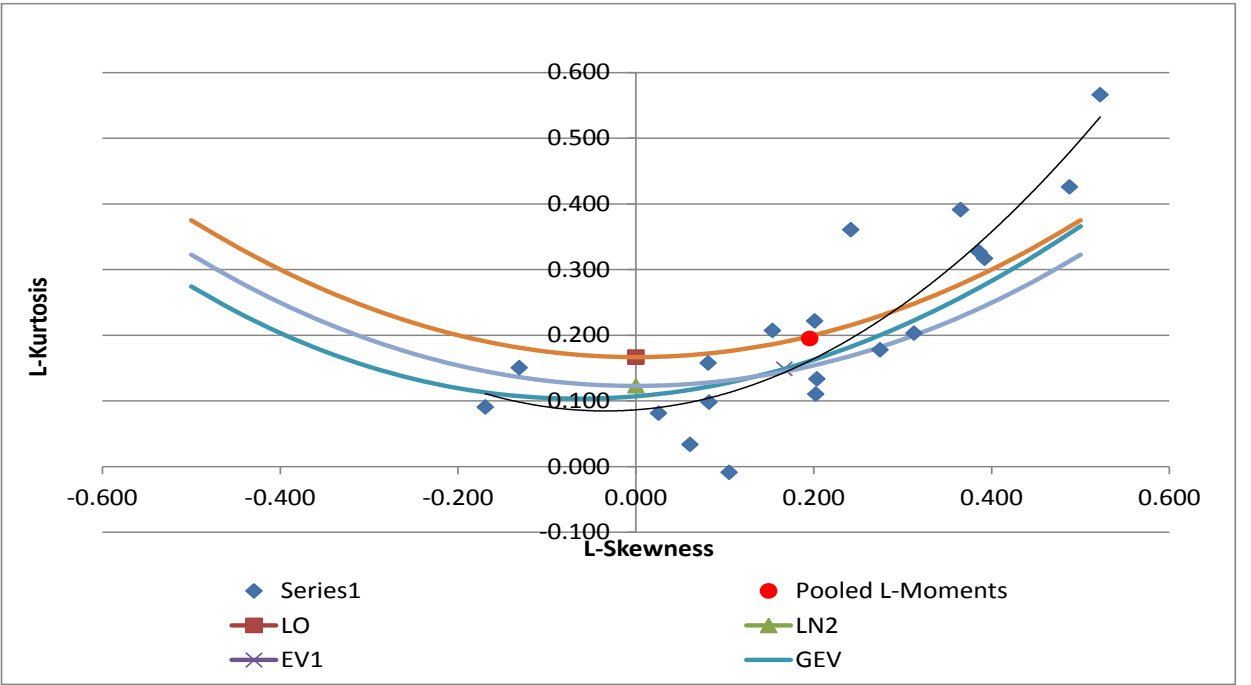


Table D.17: Brogheen Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	30020	16	16	16	0.034	16	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified (conduit)	0.882	N/A
2	10004	14	30	30	1.206	28	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
3	23012	18	48	48	0.557	54	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
4	6030	27	75	75	0.382	108	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
5	35002	34	109	109	0.109	170	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
6	16005	30	139	139	0.061	180	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
7	16013	33	172	172	0.088	231	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
8	25158	18	190	190	0.369	144	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
9	25044	40	230	230	0.031	360	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
10	34009	33	263	263	0.027	330	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
11	16006	33	296	296	0.147	363	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
12	20006	35	331	331	0.136	420	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
13	6031	18	349	349	0.622	234	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
14	35004	14	363	363	0.311	196	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
15	26009	35	398	398	0.076	525	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
16	3051	15	413	413	2.064	240	0.953	3.260	0.68	7.581	143.19	0.472	1083	A2	Locally Important Aquifer	0.863	N/A
17	24022	20	433	433	0.037	340	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
18	7033	25	458	458	0.034	450	0.893	0.620	0.64	2.138	124.94	0.526	1032	A2	Poor Aquifer	1.136	N/A
19	29001	40	498	498	0.041	760	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.

Figure D.38: Flood Growth Curve Plot

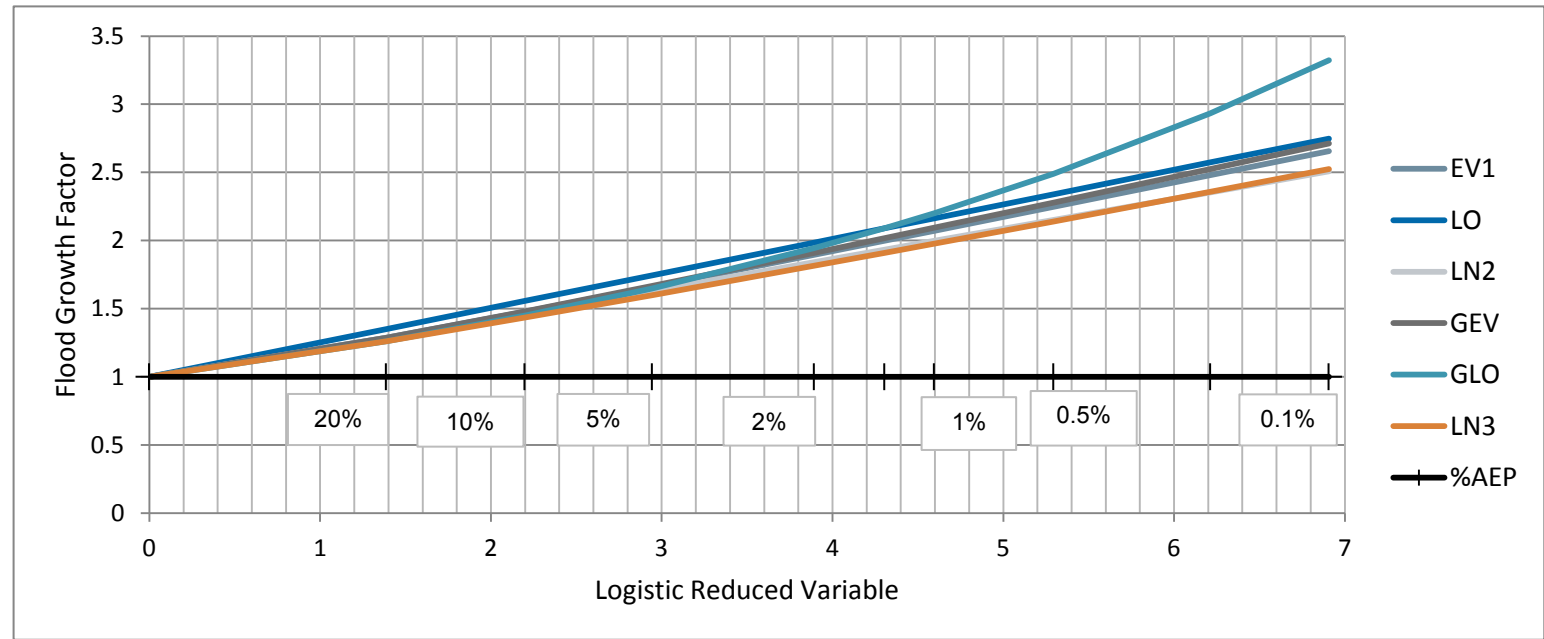


Figure D.39: L Moment Plot

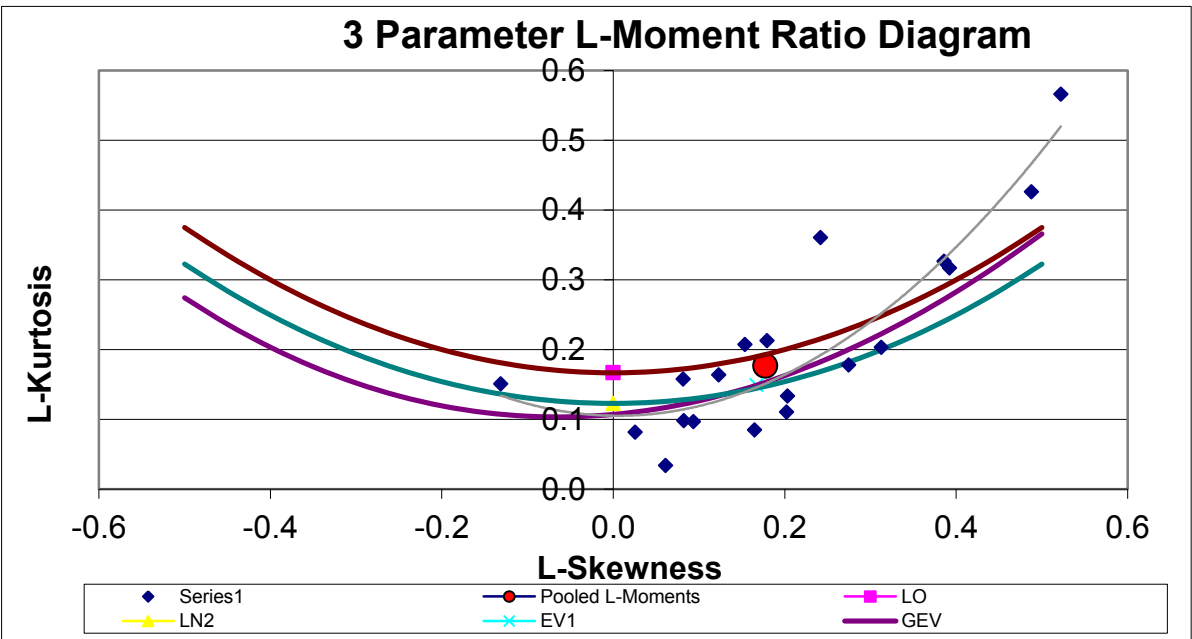


Table D.18: Ballymacpierre Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	10004	14	14	14	1.562	14	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
2	23012	18	32	32	0.722	36	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
3	6030	27	59	59	0.494	81	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
4	30020	16	75	75	0.045	64	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified (conduit)	0.882	N/A
5	36021	27	102	102	0.081	135	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
6	35002	34	136	136	0.141	204	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
7	16013	33	169	169	0.114	231	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
8	25158	18	187	187	0.478	144	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
9	34009	33	220	220	0.036	297	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
10	16005	30	250	250	0.079	300	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
11	20006	35	285	285	0.177	385	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
12	1041	32	317	317	0.090	384	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
13	25044	40	357	357	0.040	520	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
14	32011	25	382	382	0.086	350	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
15	16006	33	415	415	0.190	495	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
16	35004	14	429	429	0.403	224	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
17	6031	18	447	447	0.805	306	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
18	30001	18	465	465	0.749	324	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
19	8012	19	484	484	0.564	361	0.999	0.600	0.55	5.543	25.95	0.465	799	B	Locally Important Aquifer	0.508	N/A
20	26009	35	519	519	0.094	700	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A

Figure D.40: Flood Growth Curve Plot

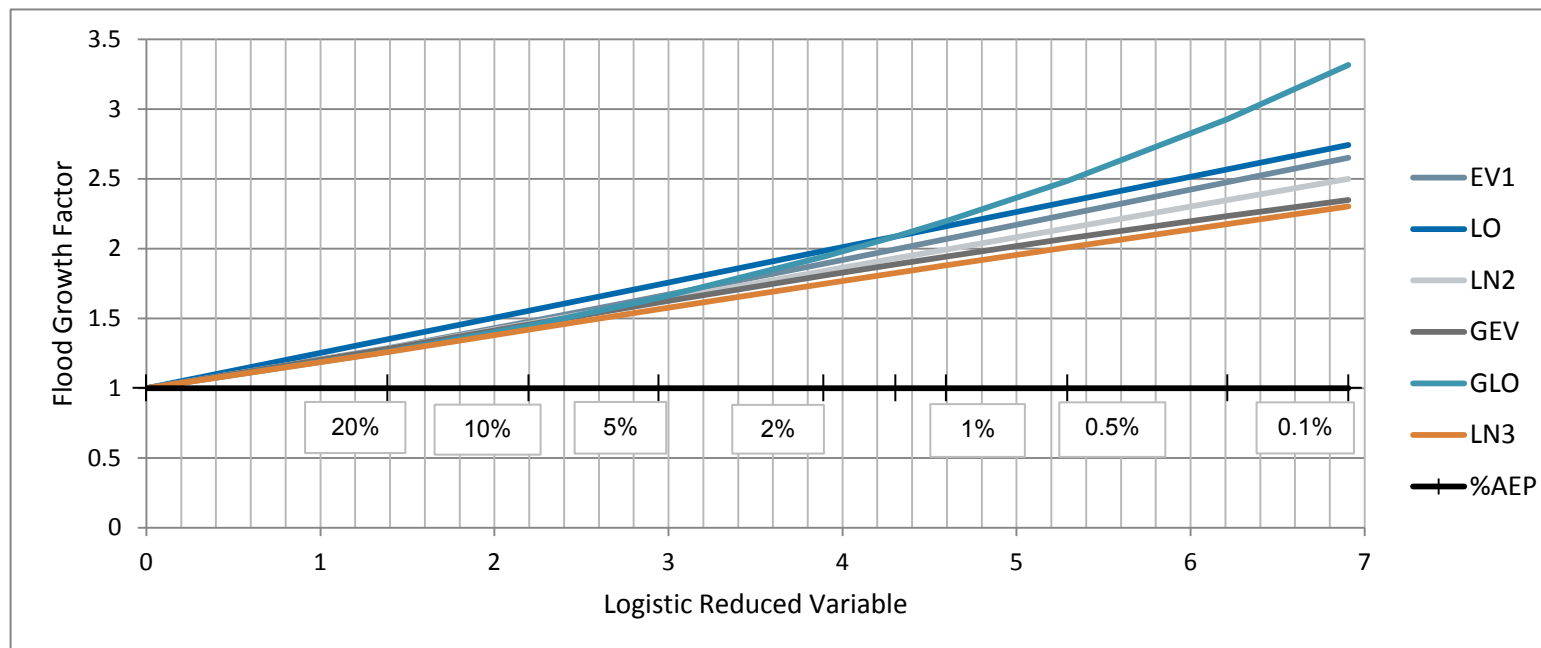


Figure D.41: L Moment Plot

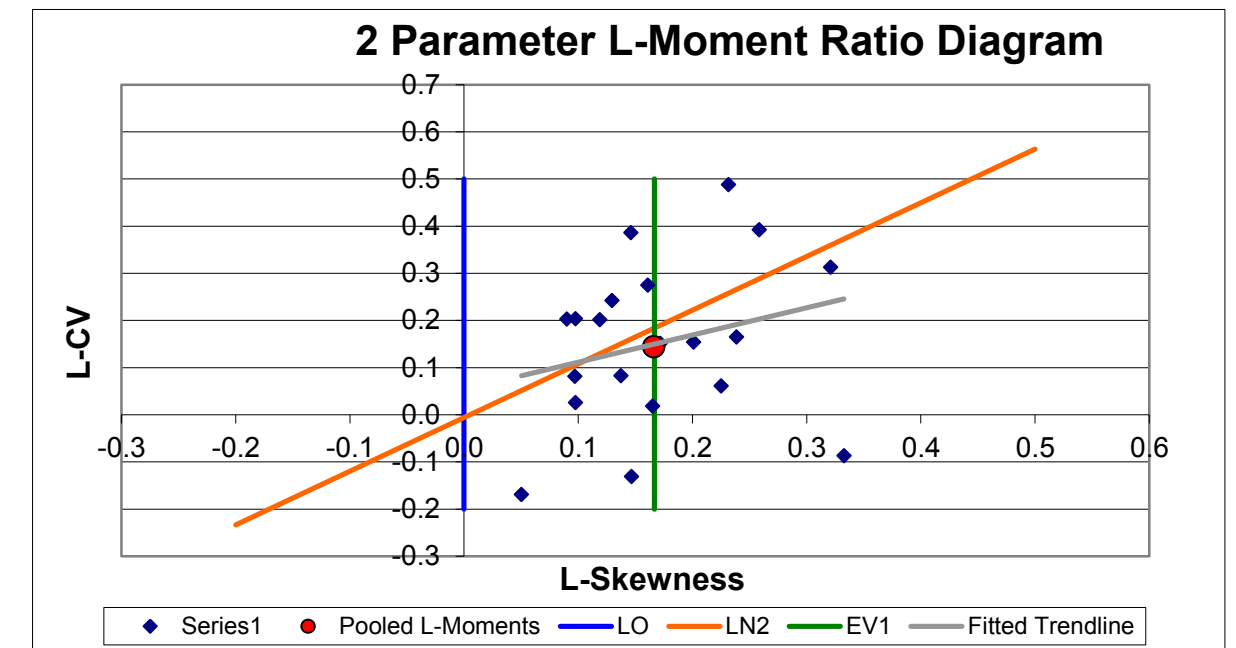


Table D.19: Little Maine Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	23012	18	18	18	0.592	18	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
2	1041	32	50	50	0.074	64	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
3	34009	33	83	83	0.029	99	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
4	18016	20	103	103	0.185	80	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
5	36021	27	130	130	0.067	135	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
6	32011	25	155	155	0.070	150	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
7	35002	34	189	189	0.116	238	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
8	25158	18	207	207	0.392	144	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
9	34007	53	260	260	0.038	477	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
10	30001	18	278	278	0.615	180	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
11	10004	14	292	292	1.281	154	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
12	16013	33	325	325	0.093	396	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
13	39001	31	356	356	0.122	403	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
14	28001	17	373	373	1.623	238	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
15	35004	14	387	387	0.331	210	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
16	33001	25	412	412	0.040	400	0.998	0.000	0.73	10.449	76.12	0.294	1467	B	Poor Aquifer	0.708	N/A
17	16005	30	442	442	0.065	510	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
18	22003	10	452	452	0.693	180	1.000	1.720	0.64	5.002	271.29	0.471	1349	B	Locally Important Aquifer	0.882	N/A
19	38001	33	485	485	0.091	627	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
20	18050	24	509	509	0.150	480	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A

Figure D.42: Flood Growth Curve Plot

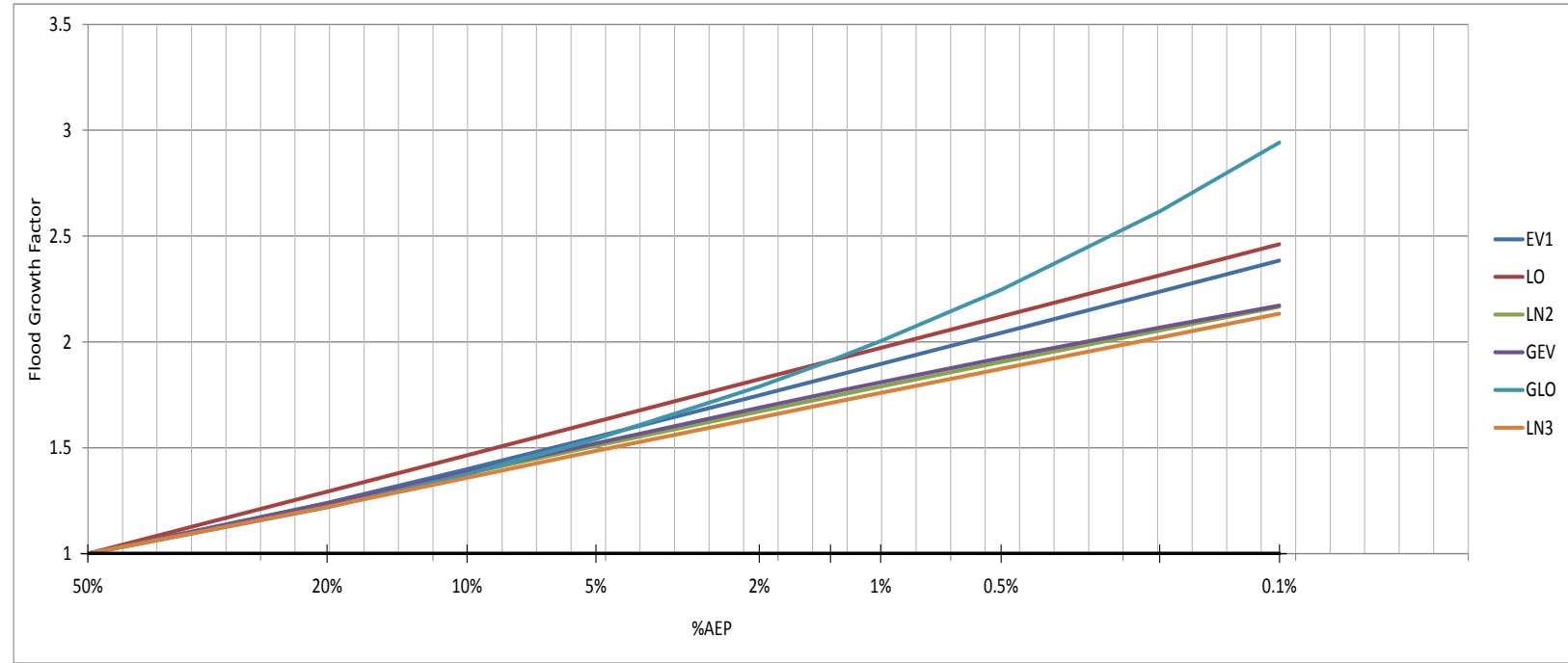


Figure D.43: L Moment Plot

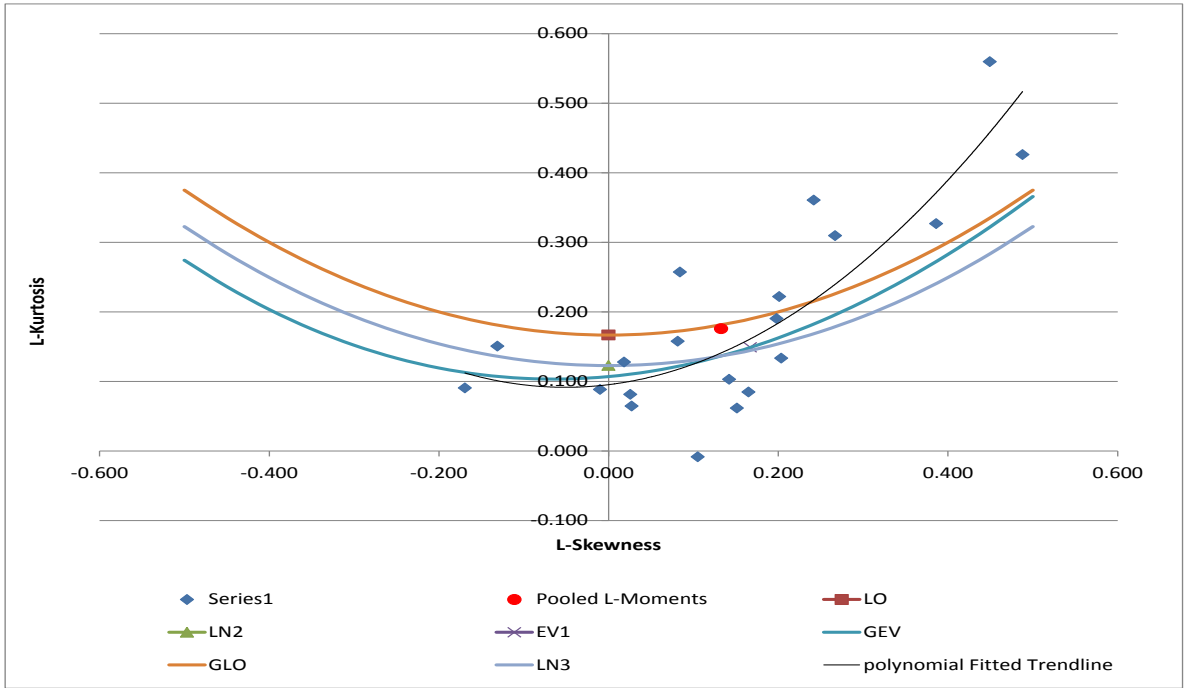


Table D.20: Brown Flesk Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	25158	18	18	18	0.564	18	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
2	35002	34	52	52	0.167	68	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
3	16013	33	85	85	0.135	99	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
4	34024	28	113	113	0.333	112	0.922	0.750	0.73	1.518	127.23	0.522	1177	A2	Locally Important Aquifer	0.962	N/A
5	16012	28	141	141	0.066	140	0.999	0.270	0.60	5.200	229.63	0.529	1321	B	Regionally Important Aquifer - Karstified (diffuse)	0.608	N/A
6	25002	51	192	192	0.718	306	0.999	0.180	0.59	6.877	221.61	0.542	1300	A2	Locally Important Aquifer	0.988	N/A
7	16005	30	222	222	0.093	210	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
8	25044	40	262	262	0.047	320	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
9	25038	17	279	279	0.049	153	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
10	34009	33	312	312	0.042	330	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
11	35004	14	326	326	0.476	154	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
12	22003	10	336	336	0.997	120	1.000	1.720	0.64	5.002	271.29	0.471	1349	B	Locally Important Aquifer	0.882	N/A
13	10002	46	382	382	0.404	598	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
14	20006	35	417	417	0.208	490	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
15	35011	15	432	432	0.031	225	0.978	0.160	0.70	4.071	293.23	0.534	1534	B	Regionally Important Aquifer - Karstified (conduit)	0.617	N/A
16	29001	40	472	472	0.063	640	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
17	14033	9	481	481	1.304	153	1.000	0.850	0.59	11.379	78.89	0.441	1145	B		0.515	N/A

Figure D.44: Flood Growth Curve Plot

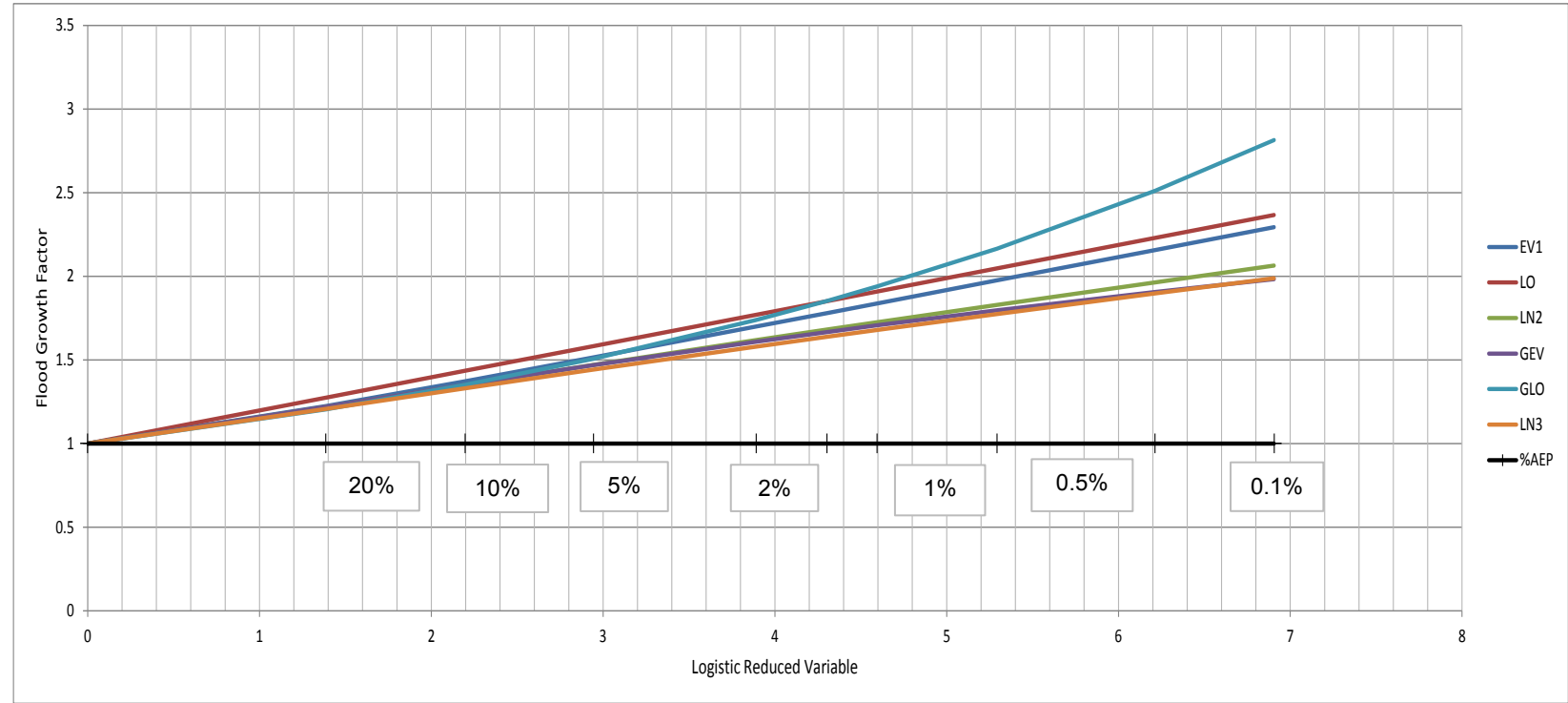


Figure D.45: L Moment Plot

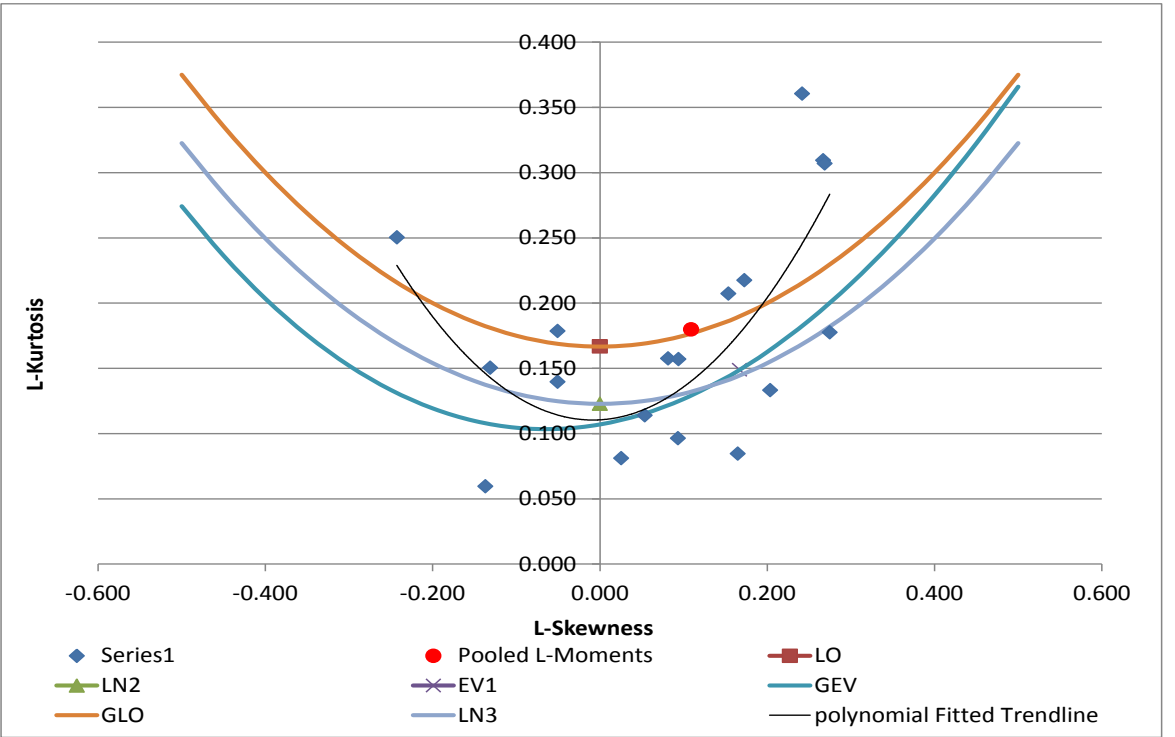


Table D.21: Inchiveema Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	30020	16	16	16	0.048	16	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified (conduit)	0.882	N/A
2	6030	27	43	43	0.533	54	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
3	10004	14	57	57	1.683	42	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
4	35002	34	91	91	0.152	136	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
5	20006	35	126	126	0.190	175	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
6	16005	30	156	156	0.085	180	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
7	16013	33	189	189	0.123	231	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
8	23012	18	207	207	0.778	144	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
9	16006	33	240	240	0.205	297	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
10	25044	40	280	280	0.043	400	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
11	25158	18	298	298	0.515	198	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
12	6031	18	316	316	0.868	216	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
13	25034	26	342	342	0.513	338	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
14	24022	20	362	362	0.052	280	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
15	13002	19	381	381	0.024	285	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
16	19020	28	409	409	0.211	448	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
17	26009	35	444	444	0.106	595	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
18	25038	17	461	461	0.045	306	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
19	35004	14	475	475	0.435	266	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
20	29001	40	515	515	0.058	800	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.

Figure D.46: Flood Growth Curve Plot

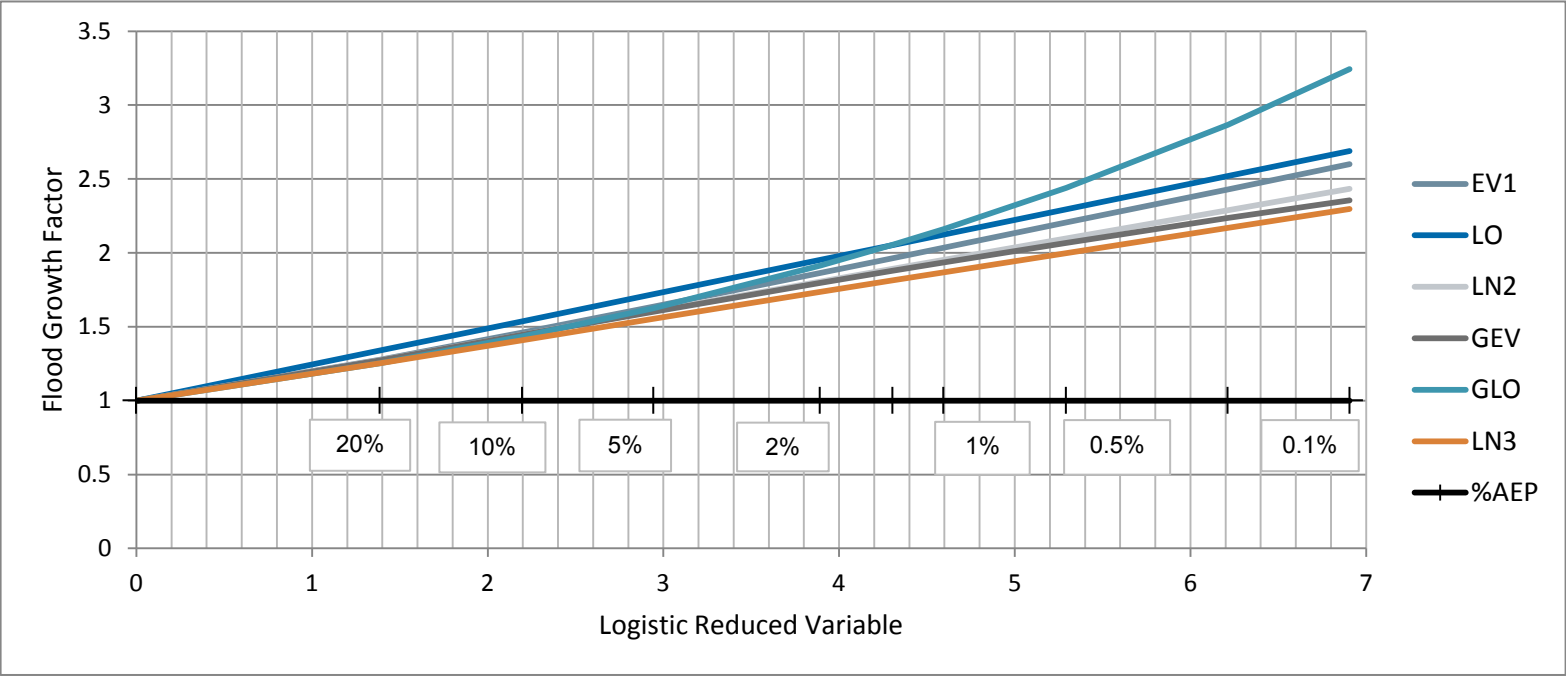


Figure D.47: L Moment Plot

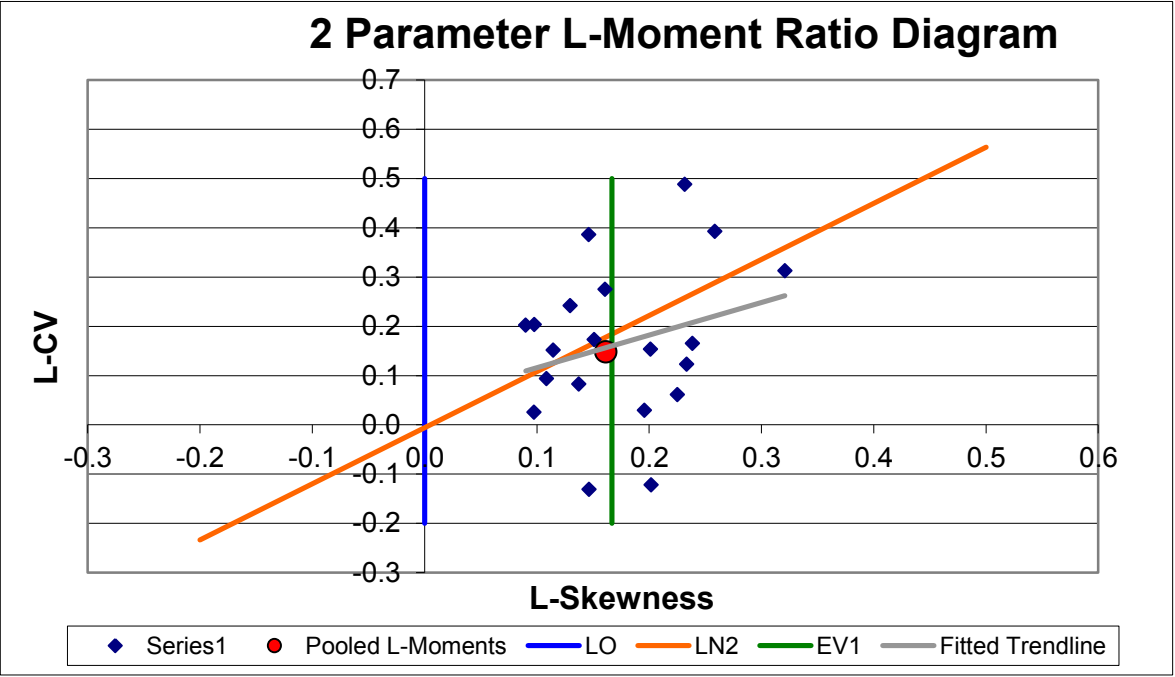


Table D.22: Coolmealane Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumulat ive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	30020	16	16	16	0.054	16	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
2	10004	14	30	30	1.906	28	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
3	6030	27	57	57	0.603	81	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
4	23012	18	75	75	0.881	72	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
5	35002	34	109	109	0.173	170	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
6	16013	33	142	142	0.139	198	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
7	16005	30	172	172	0.097	210	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
8	25158	18	190	190	0.583	144	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
9	20006	35	225	225	0.215	315	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
10	25044	40	265	265	0.048	400	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
11	16006	33	298	298	0.232	363	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
12	34009	33	331	331	0.043	396	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
13	6031	18	349	349	0.983	234	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
14	26009	35	384	384	0.120	490	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
15	25038	17	401	401	0.051	255	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
16	24022	20	421	421	0.059	320	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
17	29001	40	461	461	0.065	680	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
18	13002	19	480	480	0.027	342	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
19	7033	25	505	505	0.053	475	0.893	0.620	0.64	2.138	124.94	0.526	1032	A2	Poor Aquifer	1.136	N/A

Figure D.48: Flood Growth Curve Plot

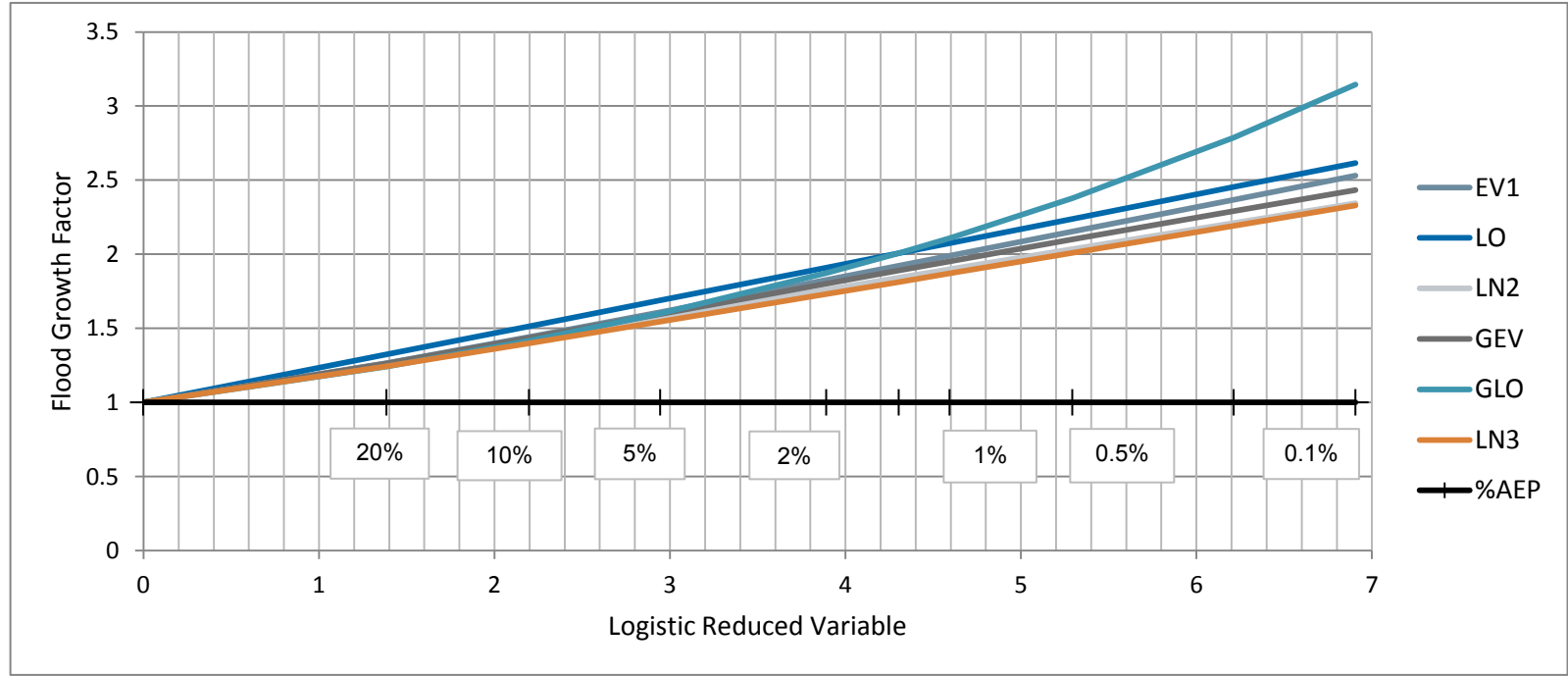


Figure D.49: L Moment Plot

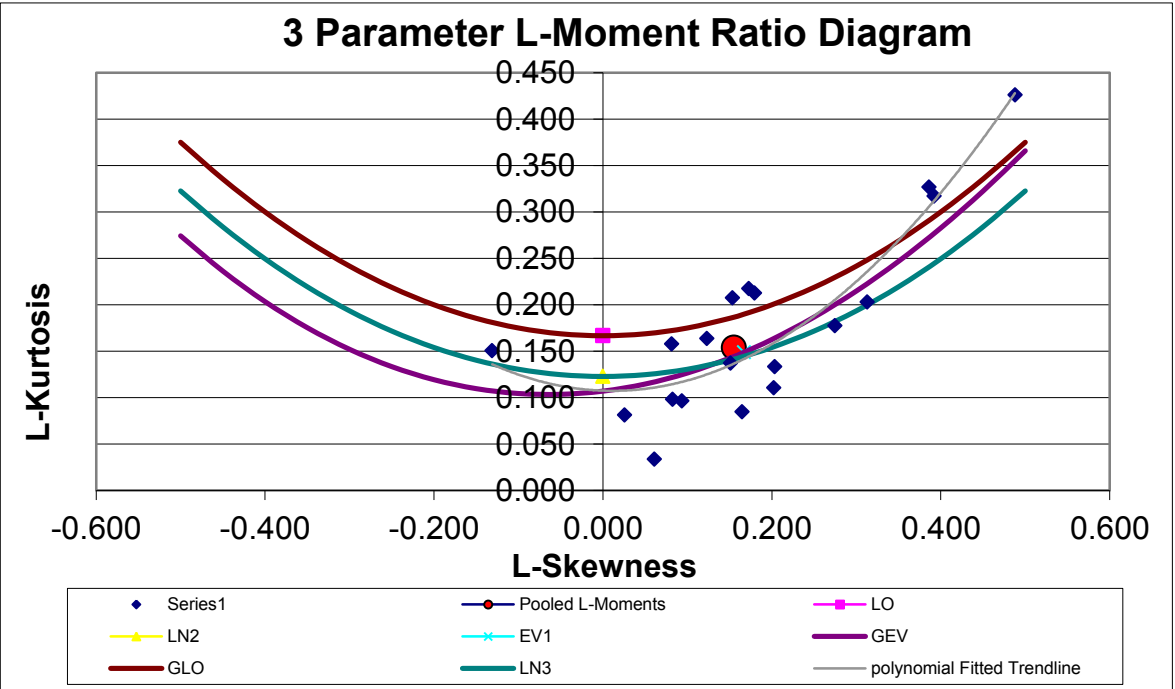


Table D.23: Ballygamboon Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	10004	14	14	14	1.687	14	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
2	23012	18	32	32	0.780	36	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
3	36021	27	59	59	0.088	81	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
4	30020	16	75	75	0.048	64	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified (conduit)	0.882	N/A
5	6030	27	102	102	0.534	135	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
6	35002	34	136	136	0.153	204	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
7	16013	33	169	169	0.123	231	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
8	25158	18	187	187	0.516	144	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
9	34009	33	220	220	0.038	297	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
10	20006	35	255	255	0.191	350	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
11	16005	30	285	285	0.085	330	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
12	30001	18	303	303	0.810	216	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
13	32011	25	328	328	0.093	325	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
14	1041	32	360	360	0.098	448	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
15	25044	40	400	400	0.043	600	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
16	39001	31	431	431	0.161	496	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
17	35004	14	445	445	0.436	238	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
18	16006	33	478	478	0.206	594	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
19	18016	20	498	498	0.244	380	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A

Figure D.50: Flood Growth Curve Plot

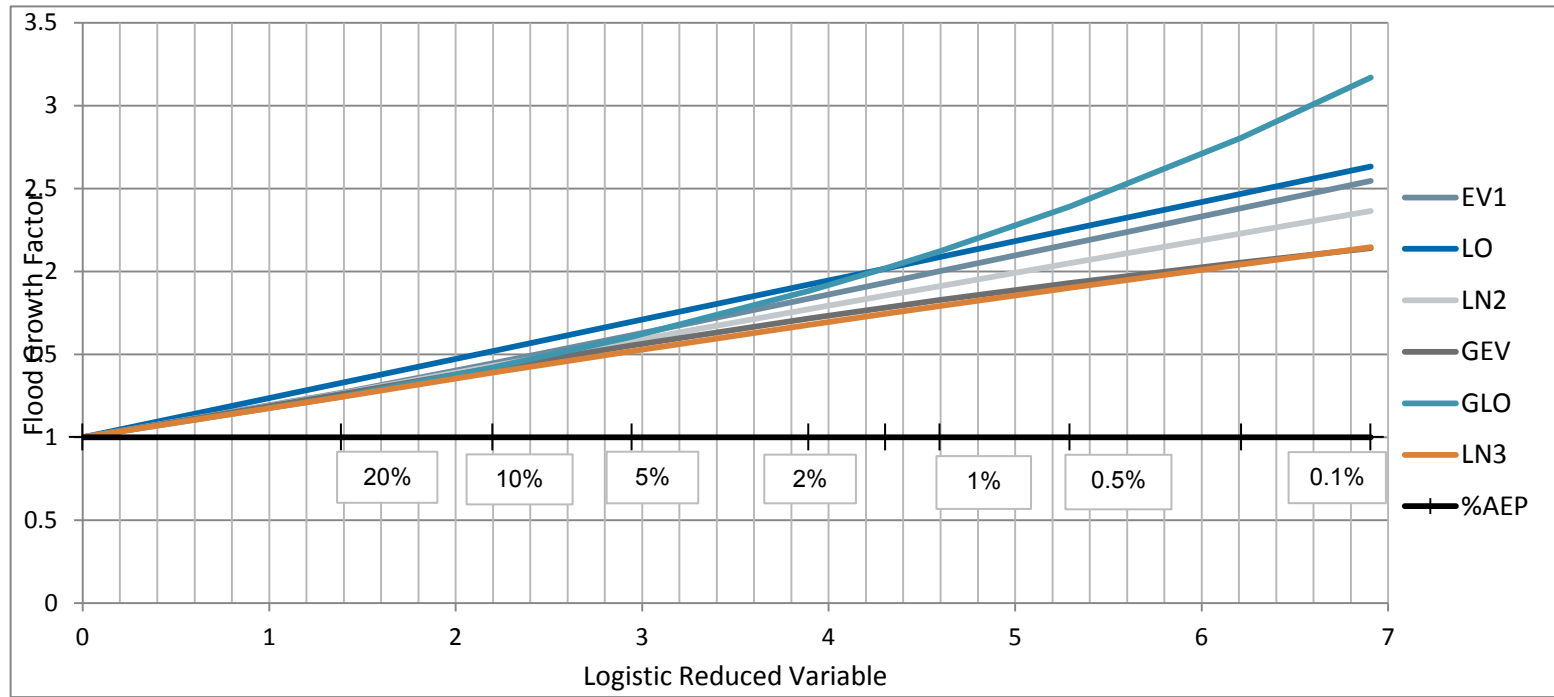


Figure D.51: L Moment Plot

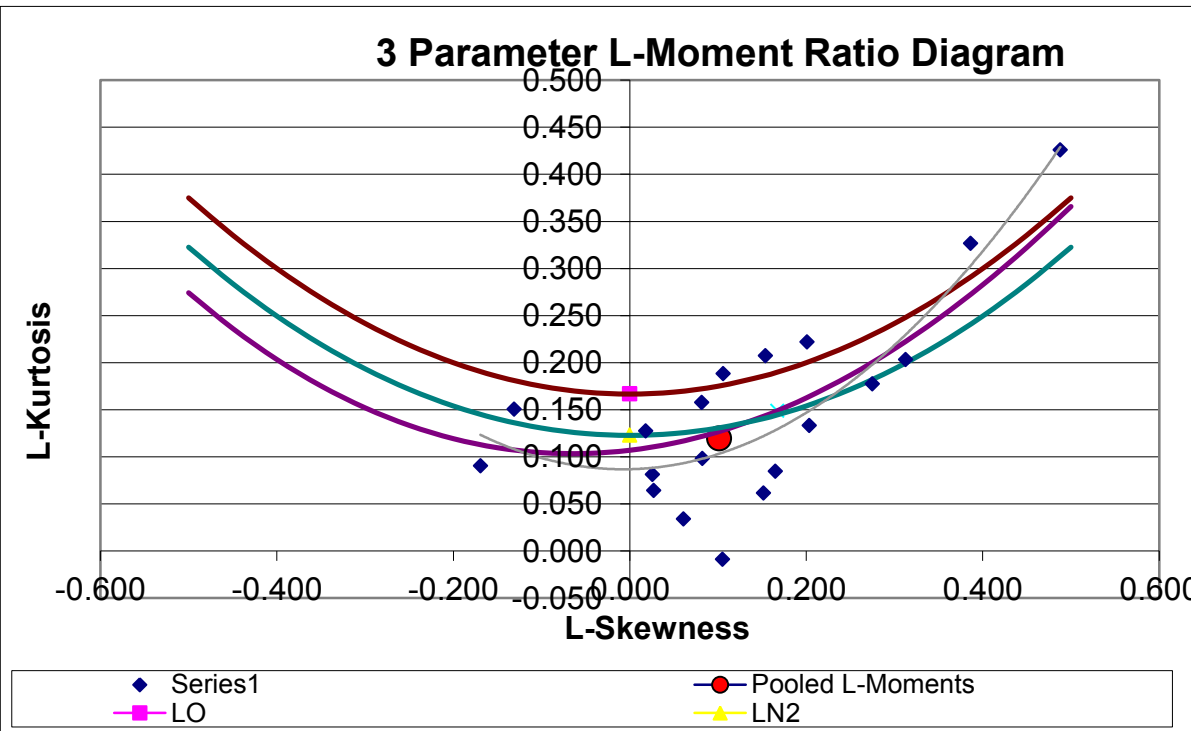


Table D.24: Annagh Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumulat ive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	30020	16	16	16	0.051	16	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
2	6030	27	43	43	0.566	54	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
3	10004	14	57	57	1.789	42	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
4	35002	34	91	91	0.162	136	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
5	20006	35	126	126	0.202	175	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
6	16013	33	159	159	0.131	198	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
7	23012	18	177	177	0.827	126	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
8	16005	30	207	207	0.091	240	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
9	25158	18	225	225	0.548	162	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
10	16006	33	258	258	0.218	330	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
11	25044	40	298	298	0.045	440	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
12	6031	18	316	316	0.923	216	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
13	25034	26	342	342	0.546	338	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
14	24022	20	362	362	0.055	280	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
15	34009	33	395	395	0.041	495	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
16	13002	19	414	414	0.026	304	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
17	19020	28	442	442	0.225	476	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
18	25038	17	459	459	0.048	306	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
19	26009	35	494	494	0.113	665	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A

Figure D.52: Flood Growth Curve Plot

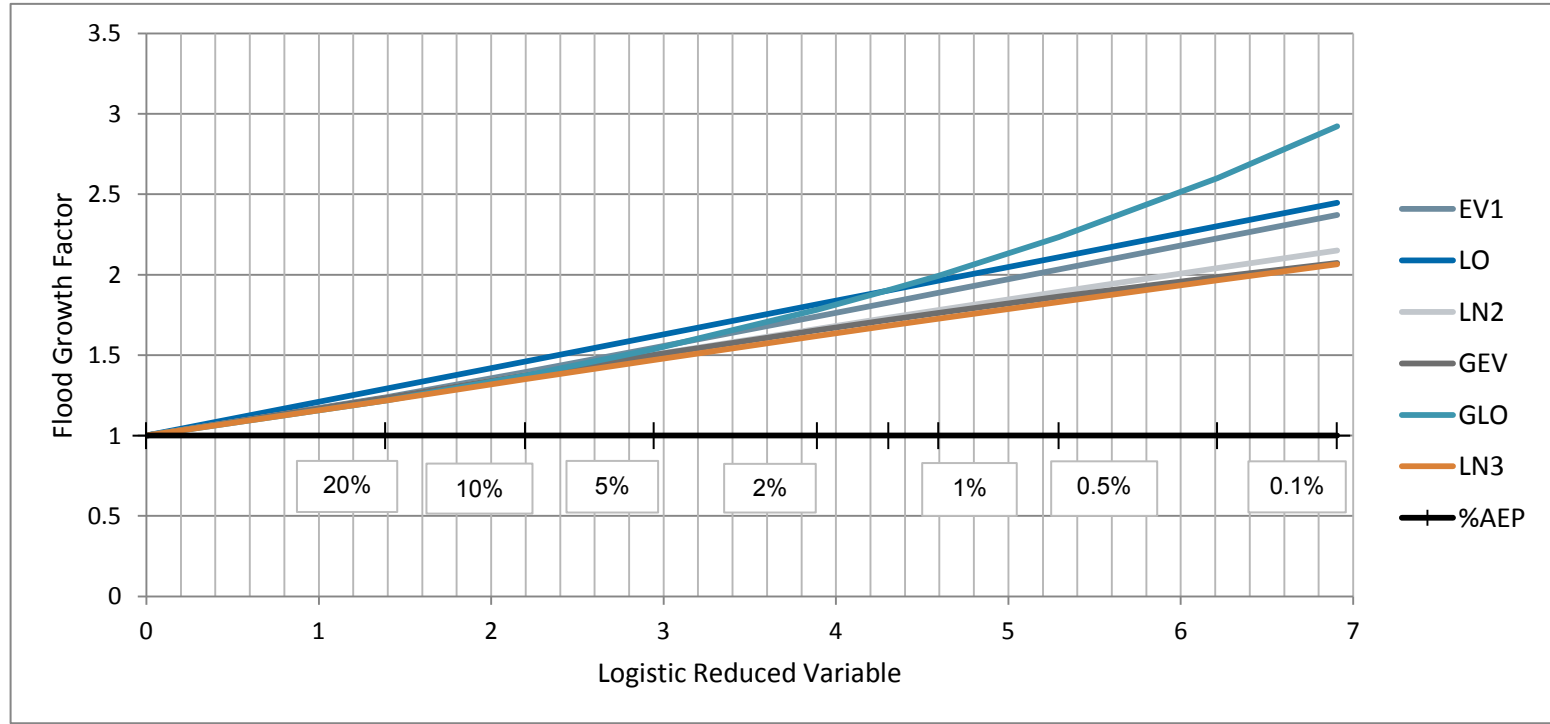


Figure D.53: L Moment Plot

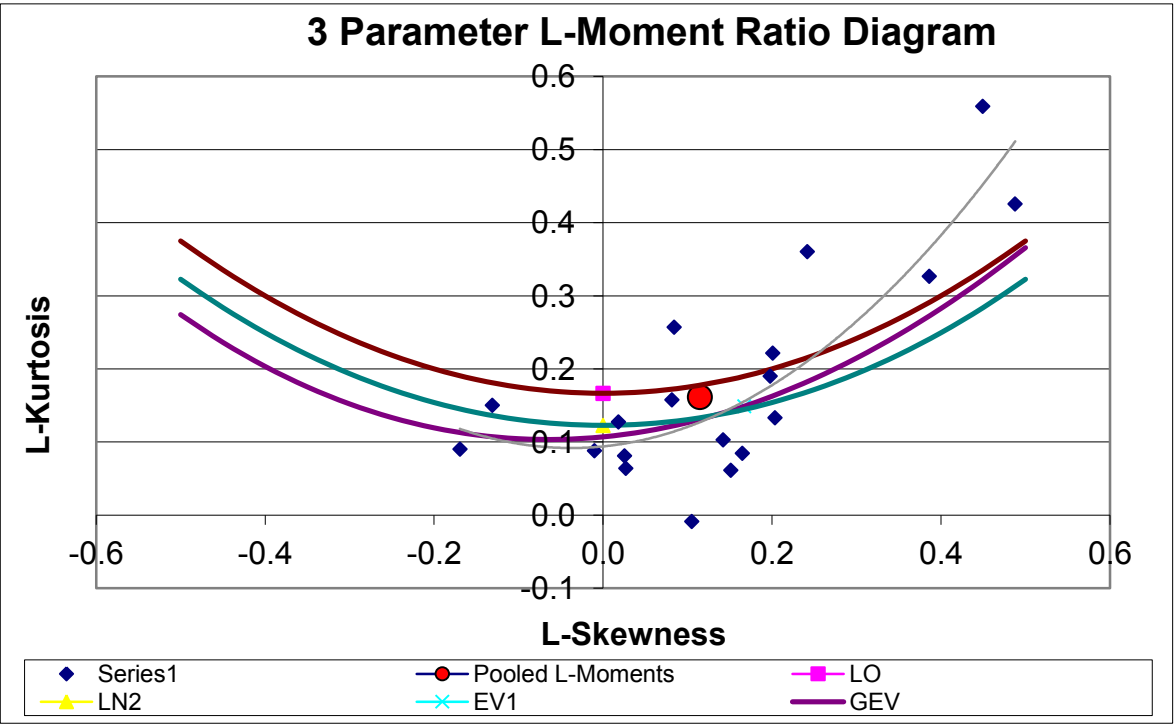


Table D.25: Tralia Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumulat ive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	30020	16	16	16	0.051	16	1.000	0.990	0.72	2.891	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified	0.882	N/A
2	6030	27	43	43	0.566	54	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
3	10004	14	57	57	1.789	42	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
4	35002	34	91	91	0.162	136	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
5	20006	35	126	126	0.202	175	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
6	16013	33	159	159	0.131	198	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
7	23012	18	177	177	0.827	126	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
8	16005	30	207	207	0.091	240	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
9	25158	18	225	225	0.548	162	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
10	16006	33	258	258	0.218	330	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
11	25044	40	298	298	0.045	440	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
12	6031	18	316	316	0.923	216	1.000	1.540	0.63	8.102	46.17	0.552	931	A2	Poor Aquifer	1.049	N/A
13	25034	26	342	342	0.546	338	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182	N/A
14	24022	20	362	362	0.055	280	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791	N/A
15	34009	33	395	395	0.041	495	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
16	13002	19	414	414	0.026	304	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
17	19020	28	442	442	0.225	476	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116	N/A
18	25038	17	459	459	0.048	306	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
19	26009	35	494	494	0.113	665	0.936	0.000	0.68	2.994	98.22	0.538	1019	A2	Locally Important Aquifer	1.058	N/A
20	29001	40	534	534	0.061	800	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.

Figure D.54: Flood Growth Curve Plot

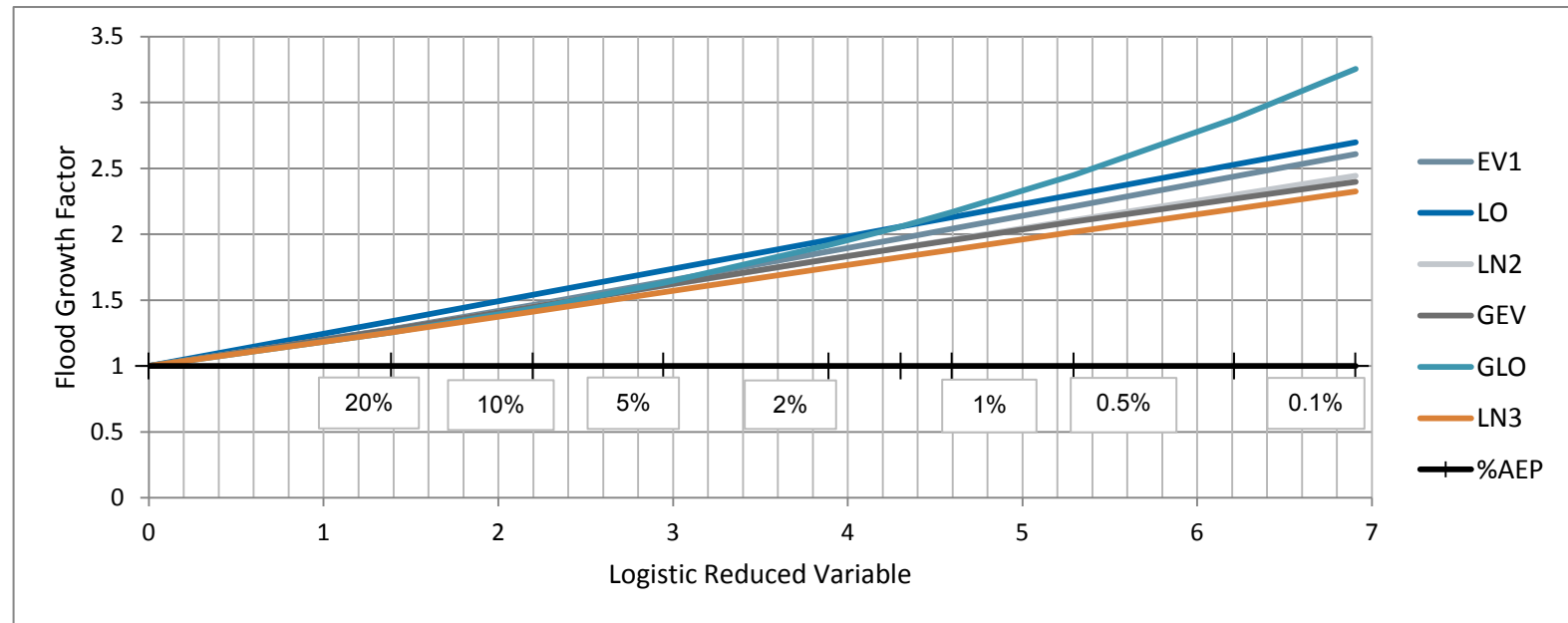


Figure D.55: L Moment Plot

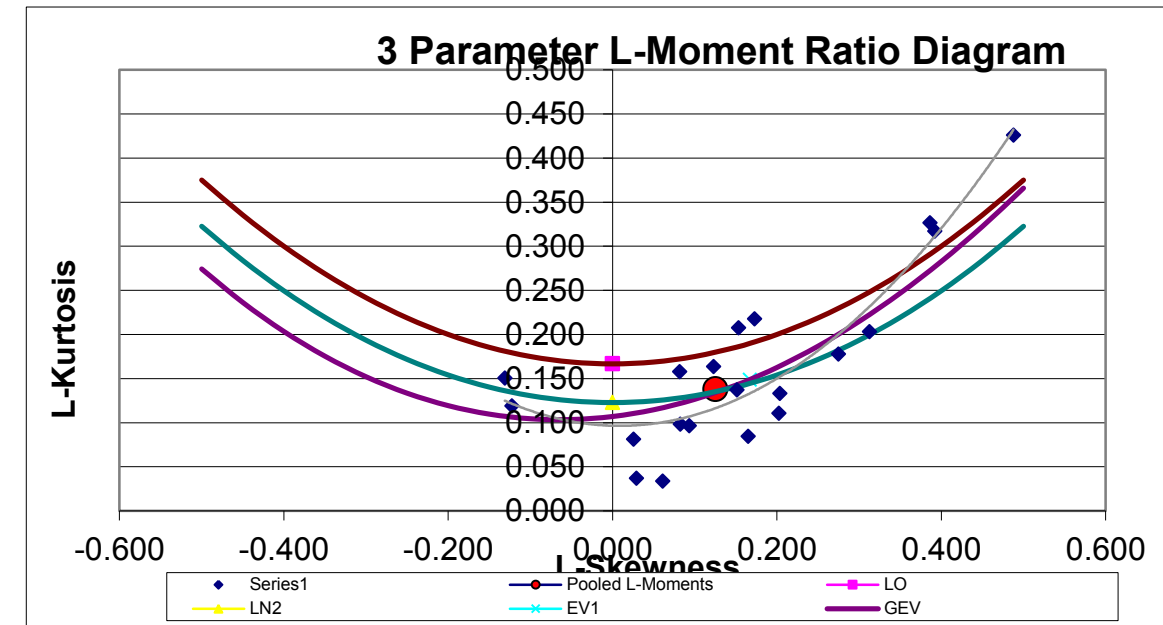


Table D.26: Ashullish Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED		Additional Comments
1	10004	14	14	14	2.063	14	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705		N/A
2	6030	27	41	41	0.653	54	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701		N/A
3	20006	35	76	76	0.233	105	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574		N/A
4	16013	33	109	109	0.151	132	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488		N/A
5	35002	34	143	143	0.187	170	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792		N/A
6	19020	28	171	171	0.259	168	1.000	0.000	0.63	11.017	73.95	0.687	1179	A2	Locally Important Aquifer	1.116		N/A
7	25034	26	197	197	0.629	182	1.000	0.000	0.65	2.572	10.77	0.698	969	A2	Locally Important Aquifer	1.182		N/A
8	25040	19	216	216	0.101	152	1.000	6.180	0.60	13.494	28.02	0.576	990	A2	Locally Important Aquifer	1.322		N/A
9	25044	40	256	256	0.052	360	0.997	0.000	0.59	2.666	92.55	0.575	1187	A2	Locally Important Aquifer	1.256		N/A
10	25158	18	274	274	0.631	180	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364		N/A
11	16006	33	307	307	0.251	363	0.994	0.000	0.59	5.763	75.80	0.591	1116	B	Locally Important Aquifer	0.562		Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
12	16005	30	337	337	0.105	360	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071		N/A
13	13002	19	356	356	0.030	247	1.000	0.000	0.56	4.953	62.96	0.657	1044	B	Poor Aquifer	0.645		N/A
14	25038	17	373	373	0.055	238	1.000	0.210	0.59	7.336	136.10	0.591	1249	B	Locally Important Aquifer	0.725		N/A
15	24022	20	393	393	0.064	300	1.000	0.330	0.60	3.291	41.21	0.620	942	A2	Locally Important Aquifer	0.791		N/A
16	29001	40	433	433	0.071	640	0.998	0.660	0.65	2.220	115.48	0.581	1090	A1	Locally Important Aquifer	1.560		Gauge on Karstic Zone. Majority of catchment is not permeable.
17	10028	16	449	449	0.421	272	1.000	0.480	0.54	7.901	202.92	0.695	1397	B	Poor Aquifer	0.567		N/A
18	26058	24	473	473	0.275	432	0.995	1.040	0.65	5.535	59.98	0.697	974	B	Locally Important Aquifer	0.548		Gauge situated on very minor Karstic zone within catchment.
19	12013	30	503	503	0.102	570	0.999	0.470	0.54	3.850	204.39	0.707	1383	B	Locally Important Aquifer	0.905		N/A

Figure D.56: Flood Growth Curve Plot

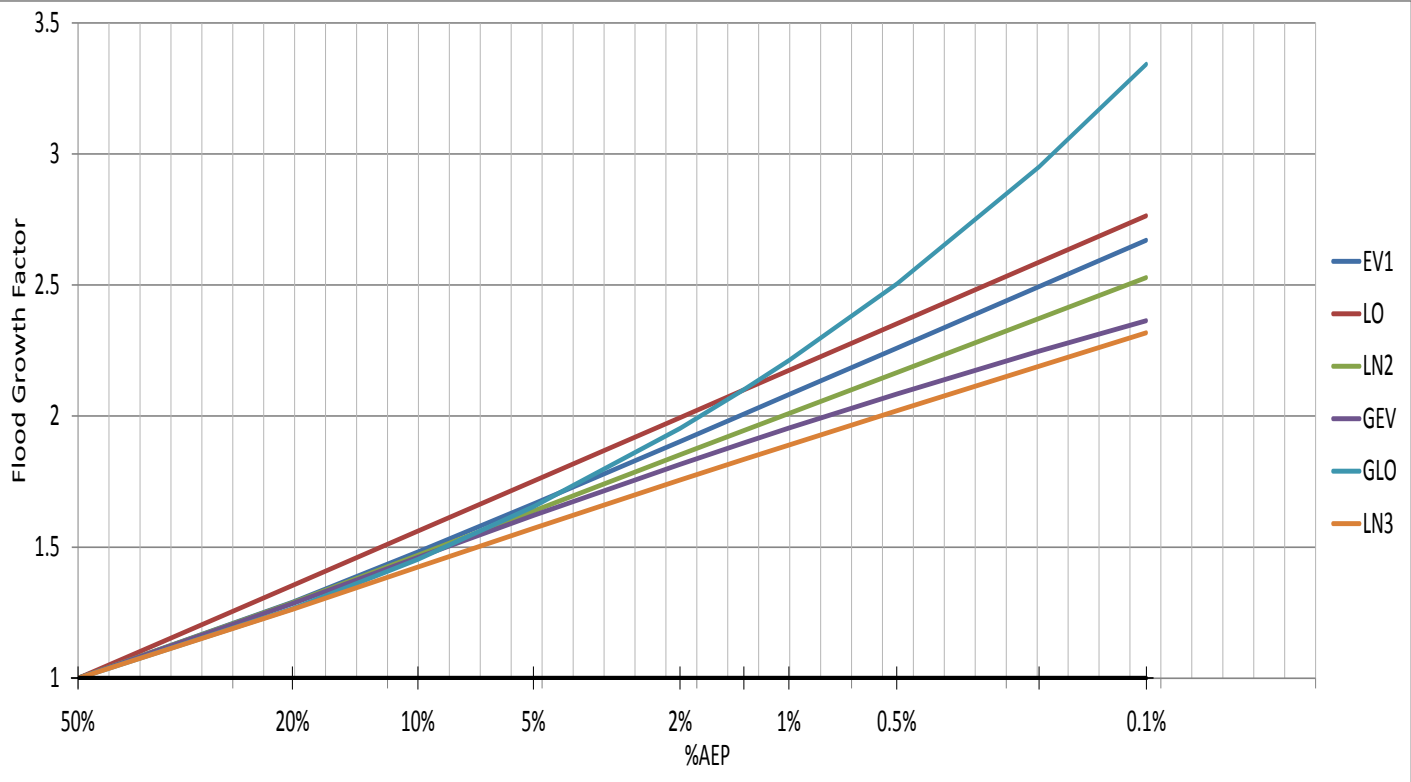


Figure D.57: L Moment Plot

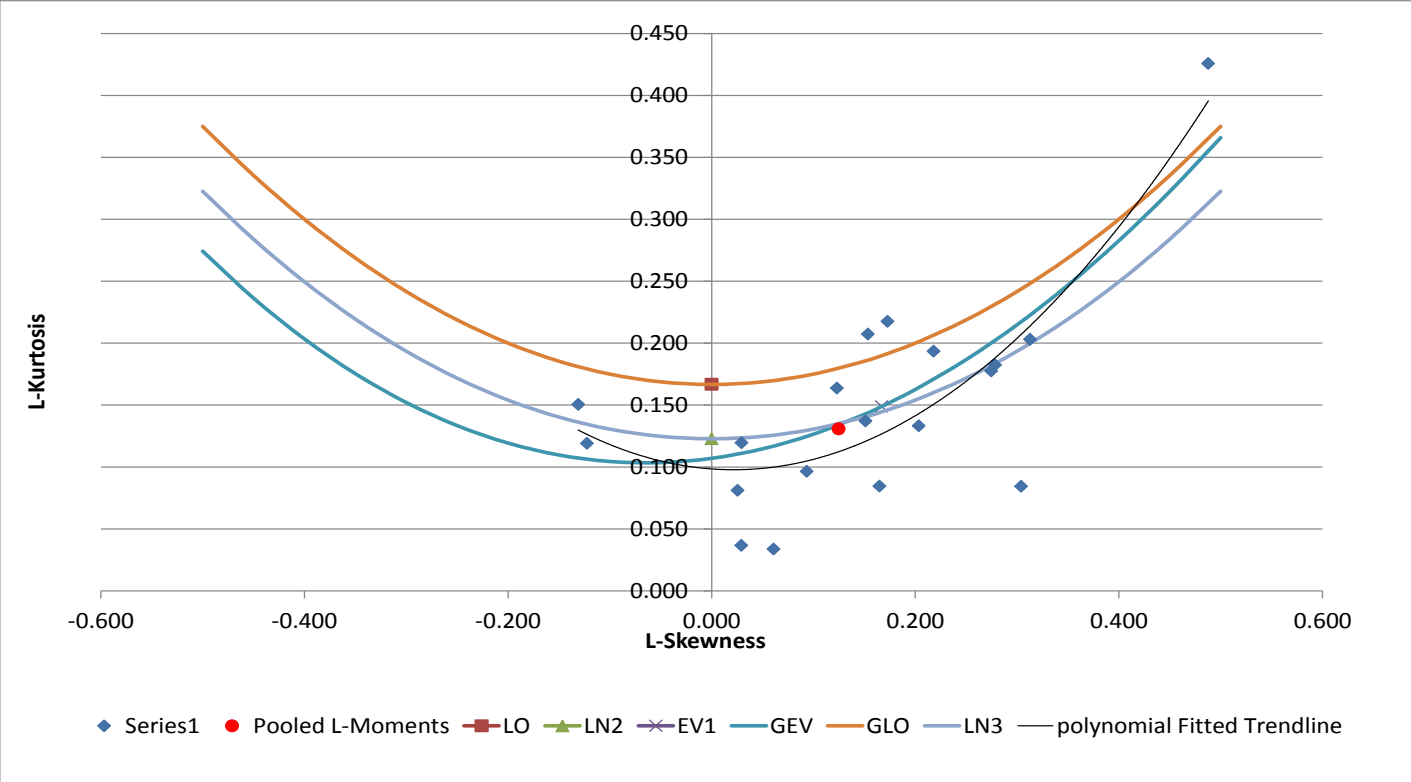


Table D.27: Boolteens Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumula tive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	36021	27	27	27	0.071	27	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
2	39001	31	58	58	0.131	62	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
3	32011	25	83	83	0.075	75	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
4	10004	14	97	97	1.371	56	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
5	30001	18	115	115	0.658	90	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
6	23012	18	133	133	0.634	108	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
7	38001	33	166	166	0.097	231	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
8	18016	20	186	186	0.198	160	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
9	33001	25	211	211	0.043	225	0.998	0.000	0.73	10.449	76.12	0.294	1467	B	Poor Aquifer	0.708	N/A
10	34007	53	264	264	0.040	530	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
11	1041	32	296	296	0.079	352	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
12	28001	17	313	313	1.736	204	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
13	34009	33	346	346	0.031	429	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
14	16013	33	379	379	0.100	462	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
15	35002	34	413	413	0.124	510	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
16	25158	18	431	431	0.420	288	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
17	18050	24	455	455	0.160	408	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
18	22006	57	512	512	0.031	1026	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.

Figure D.58: Flood Growth Curve Plot

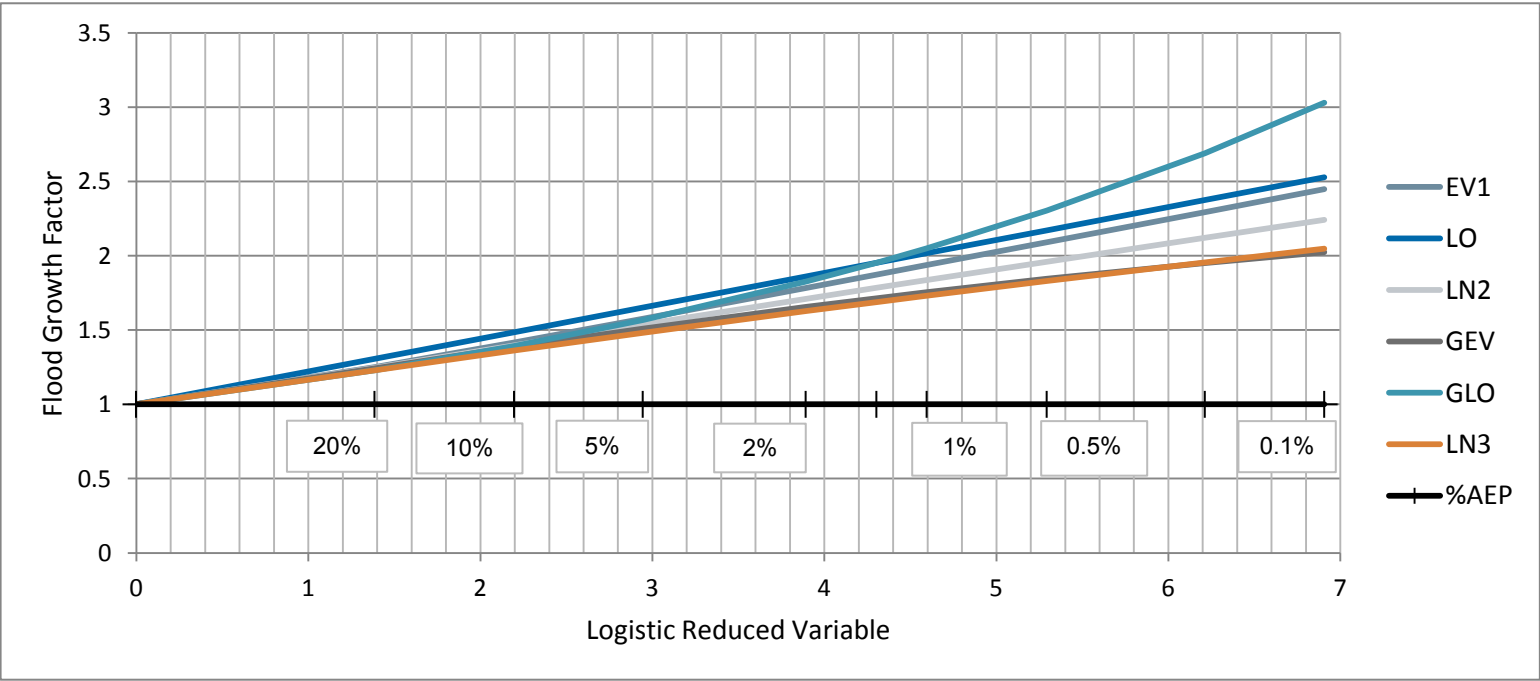


Figure D.59: L Moment Plot

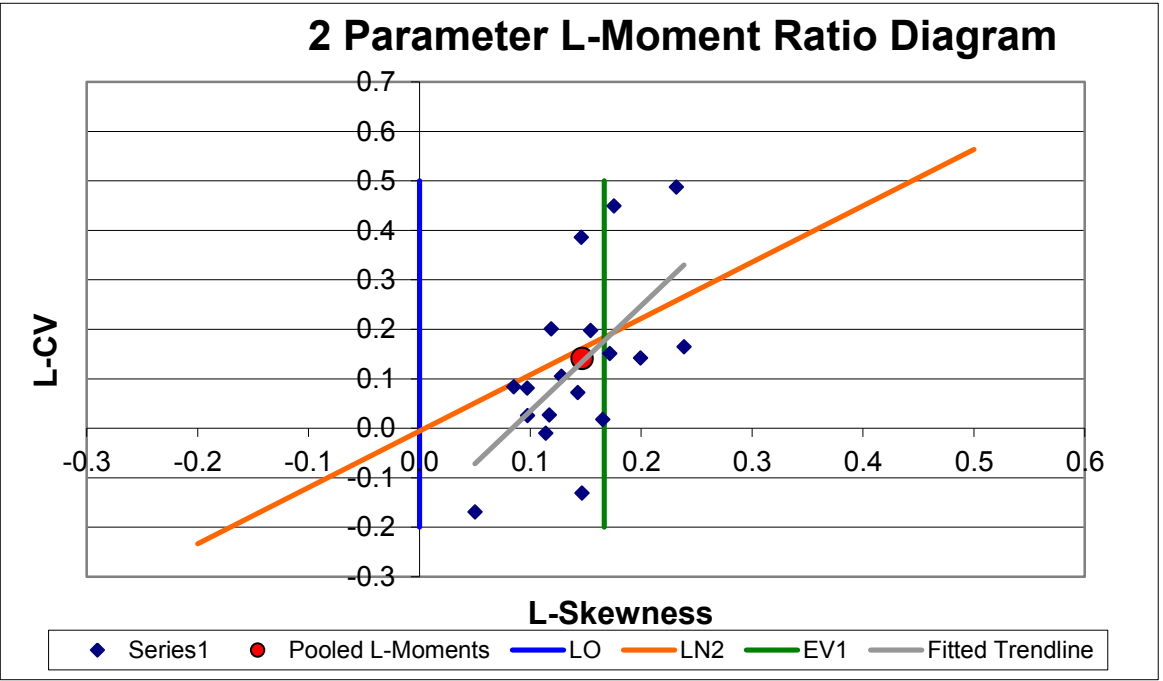


Table D.28: Groin Reach Flood Frequency Analysis

Ra nk	Pooling Station No.	Record Length	Cumulat ive Years	Pooling Years Count	Discord ancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	36021	27	27	27	0.067	27	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
2	39001	31	58	58	0.123	62	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
3	32011	25	83	83	0.071	75	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
4	10004	14	97	97	1.294	56	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
5	23012	18	115	115	0.598	90	0.999	2.430	0.64	11.674	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
6	33001	25	140	140	0.041	150	0.998	0.000	0.73	10.449	76.12	0.294	1467	B	Poor Aquifer	0.708	N/A
7	18016	20	160	160	0.187	140	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
8	38001	33	193	193	0.092	264	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
9	30001	18	211	211	0.621	162	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
10	34009	33	244	244	0.029	330	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
11	28001	17	261	261	1.639	187	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
12	35002	34	295	295	0.117	408	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
13	25158	18	313	313	0.396	234	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
14	18050	24	337	337	0.151	336	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
15	16005	30	367	367	0.066	450	1.000	0.330	0.59	6.524	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
16	35004	14	381	381	0.334	224	0.994	0.290	0.72	2.285	116.96	0.488	1103	A1	Locally Important Aquifer	1.289	N/A
17	22006	57	438	438	0.029	969	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
18	31072	26	464	464	0.244	468	0.636	0.000	0.66	3.636	111.83	0.507	2465	B	Poor Aquifer	0.694	N/A
19	34024	28	492	492	0.233	532	0.922	0.750	0.73	1.518	127.23	0.522	1177	A2	Locally Important Aquifer	0.962	N/A

Figure D.60: Flood Growth Curve Plot

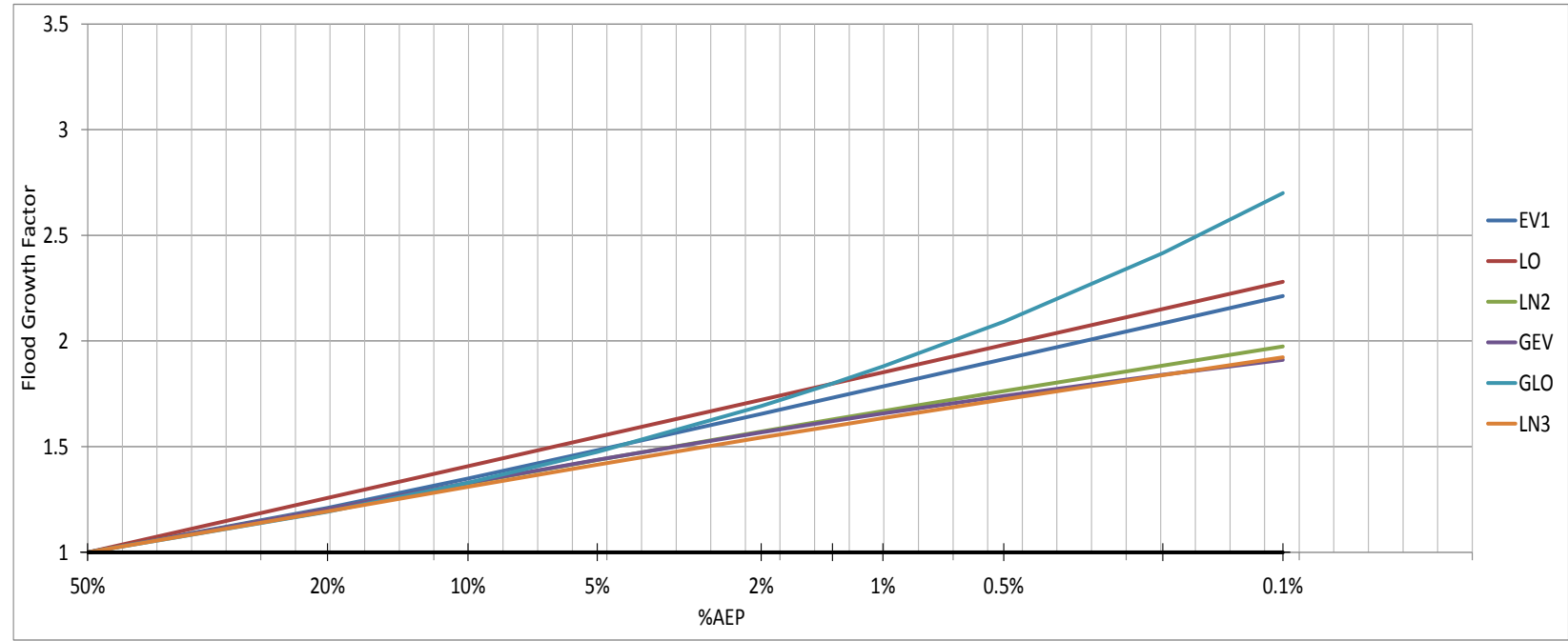


Figure D.61: L Moment Plot

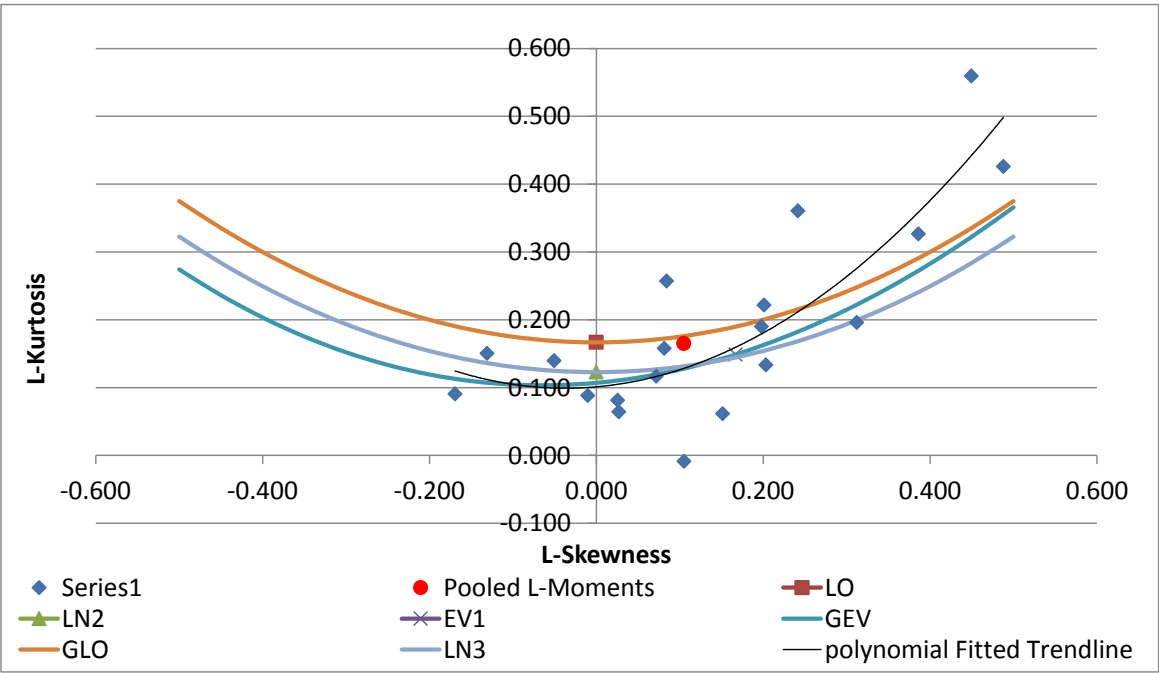


Figure D.62: Median Flood Hydrograph Riverville Gauge

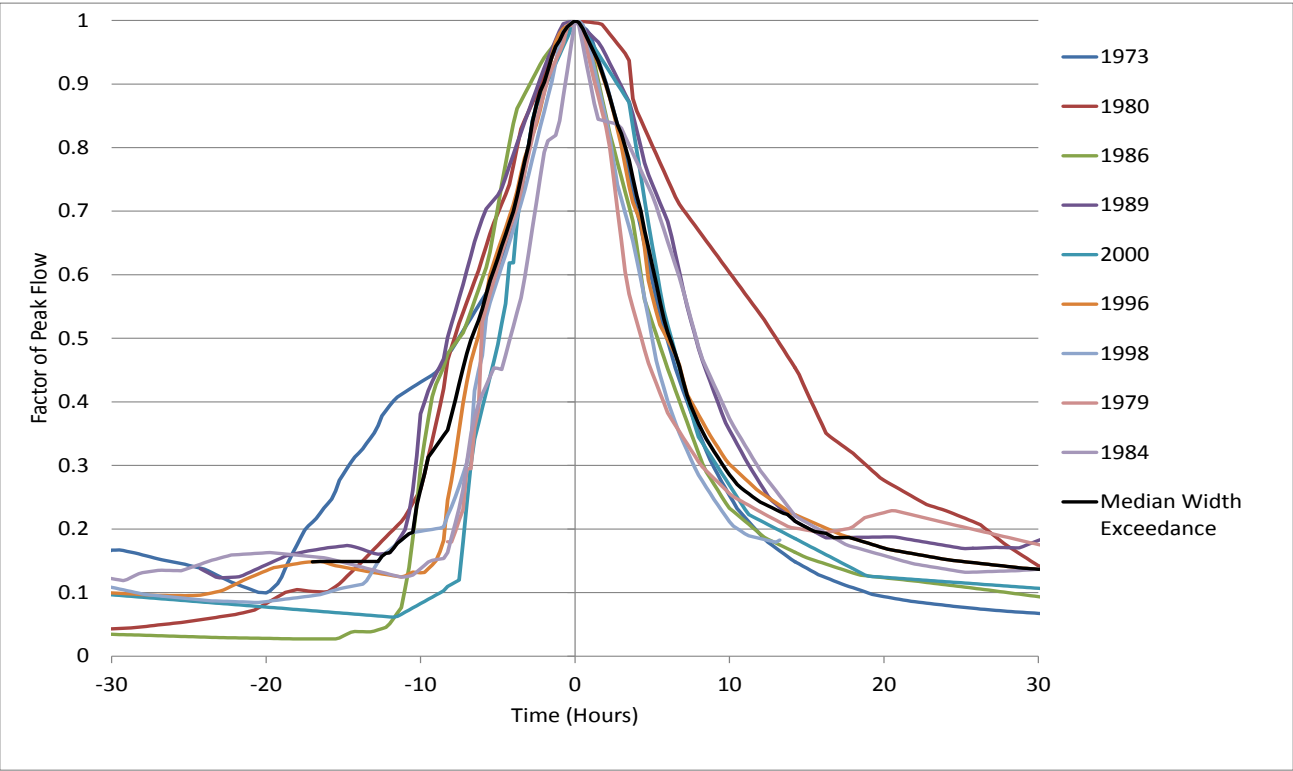


Figure D.63: UPO-ERR Gamma Hydrograph Based on Pivotal Site 16005

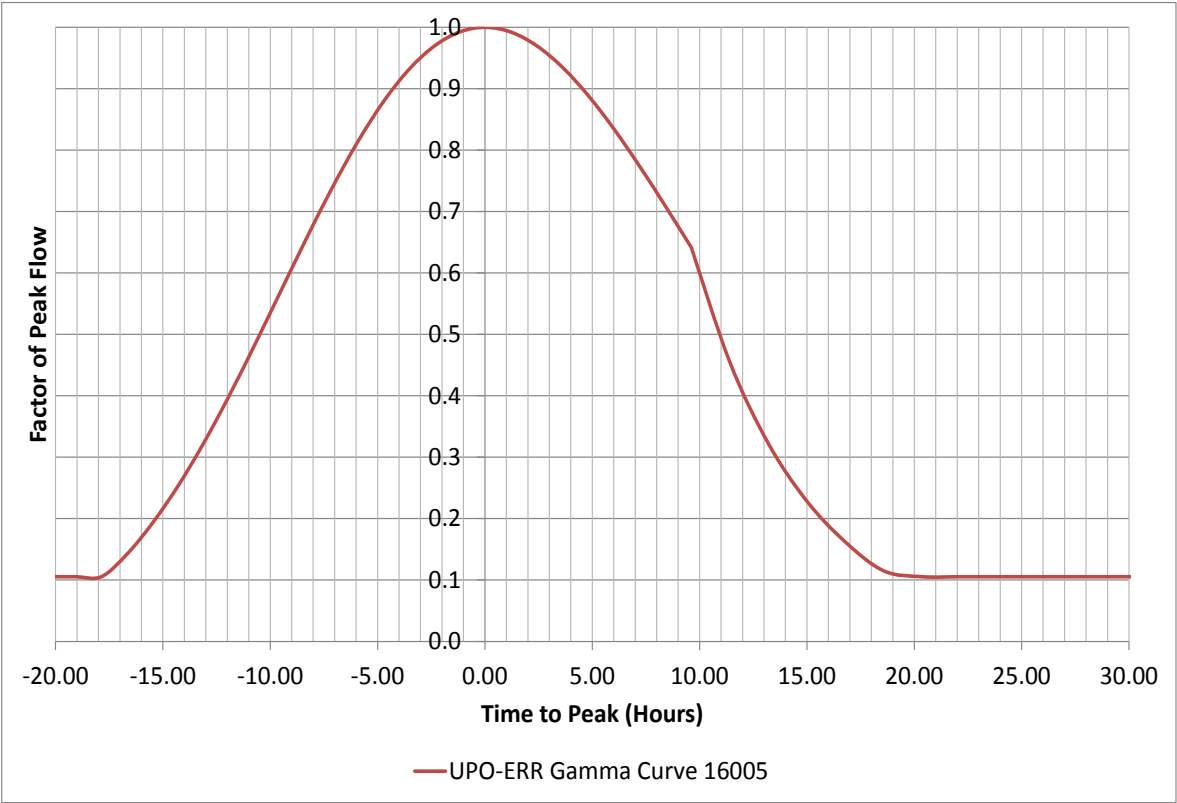


Figure D.64: UPO-ERR Gamma Hydrograph Based on Pivotal Site 15003

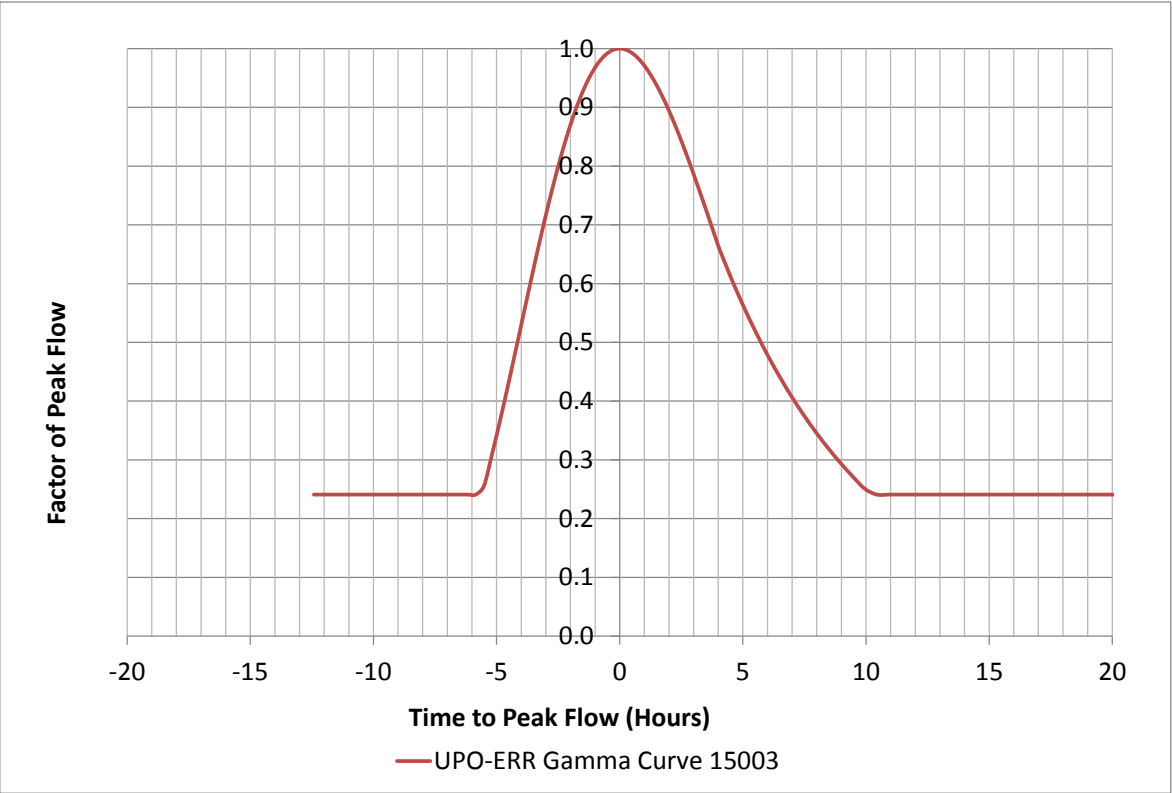


Figure D.66: UPO-ERR Gamma Hydrograph Based on Pivotal Site 23012

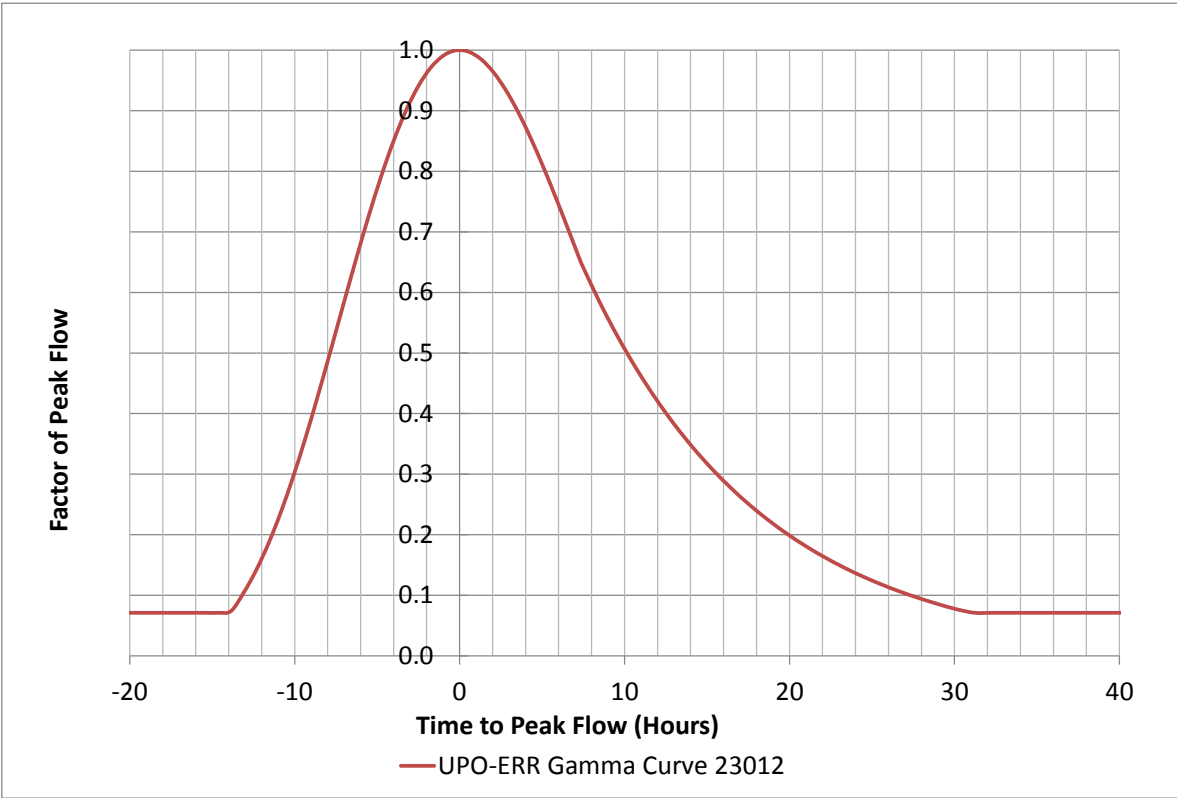


Figure D.65: UPO-ERR Gamma Curve Based on Pivotal Site 36021

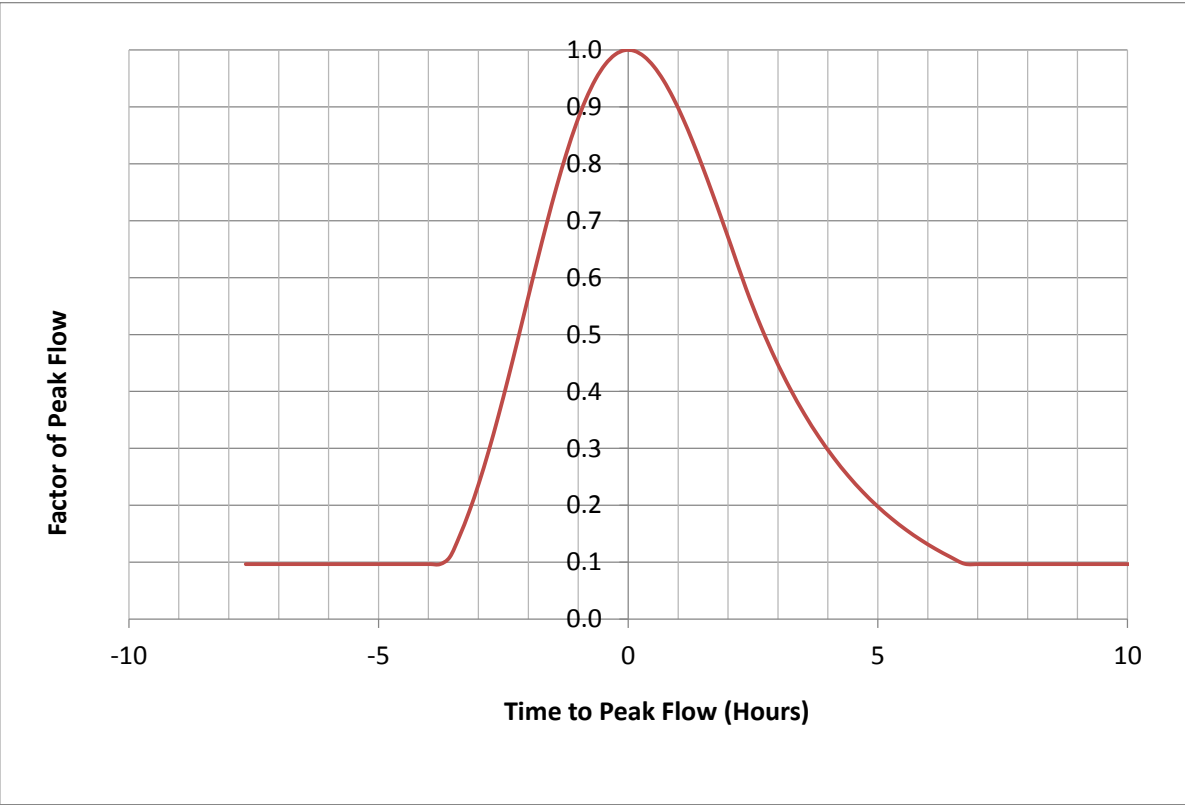


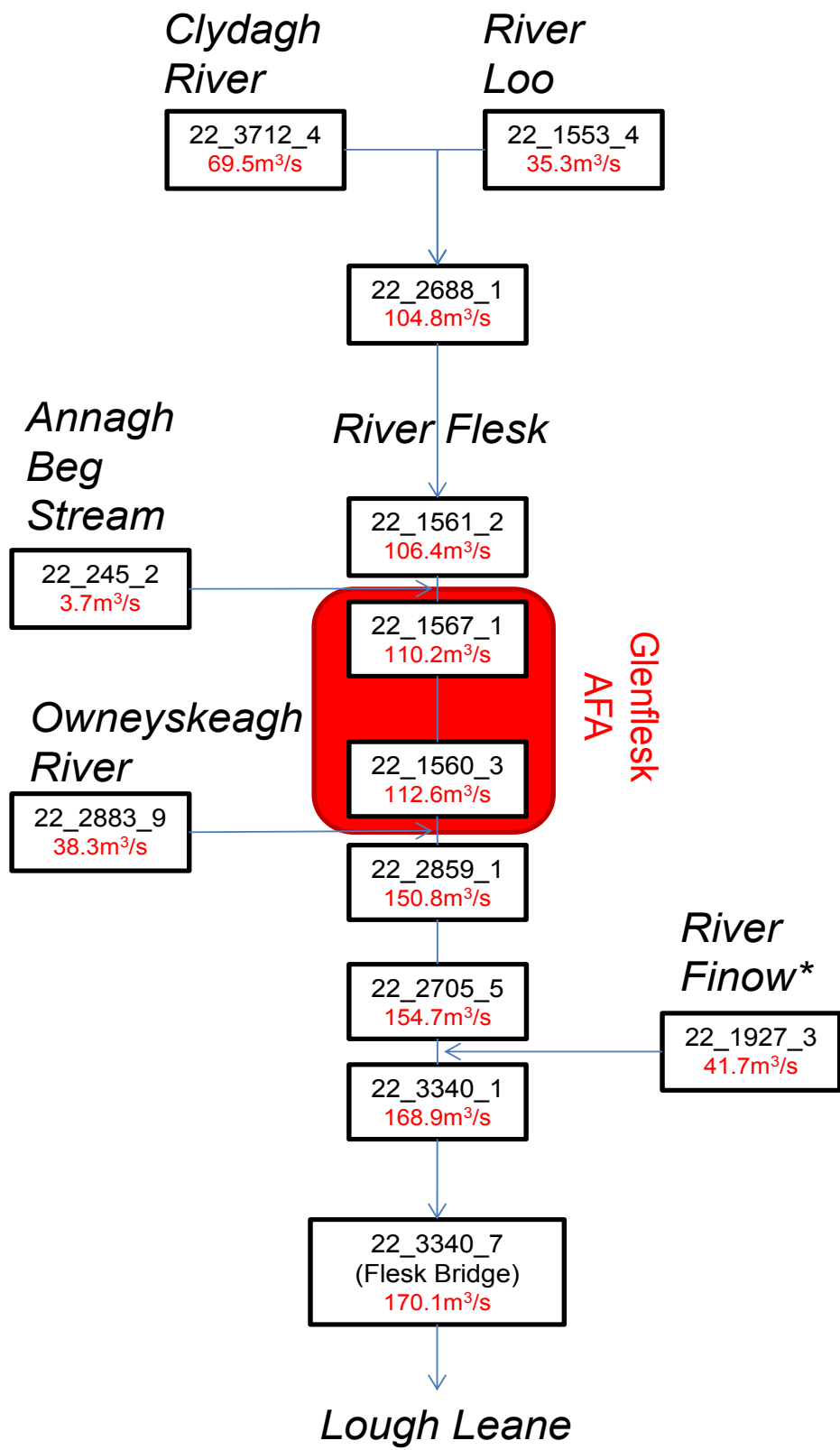
Table D.29: AFA Design Peak Flows

LOCATION	HEP	Pivotal Site	QMED	95% Confidence Limit	Flood Growth Curve	Flood Growth Factor								Design Flows								Hydrograph Pivotal Site
						50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1	
Maine upstream Kealgorm	22_3452_2	22003	46.52	85.43	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	46.52	58.73	68.03	78.39	94.57	109.28	126.65	180.45	23012
Maine downstream Kealgorm	22_576_1	22003	56.14	103.11	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	56.14	70.88	82.10	94.61	114.14	131.89	152.85	217.79	23012
Maine upstream Brogheen	22_583_2	22003	57.56	105.71	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	57.56	72.67	84.18	96.99	117.02	135.22	156.71	223.28	23012
Maine downstream Brogheen	22_721_1	22003	67.04	124.39	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	67.04	84.64	98.04	112.97	136.30	157.50	182.53	260.07	23012
Maine upstream Loughnagore	22_557_2	22003	67.73	125.82	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	67.73	85.51	99.05	114.14	137.70	159.12	184.41	262.75	23012
Maine downstream Ballymacpiersce	22_2090_1	22003	75.60	138.85	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	75.60	95.45	110.56	127.40	153.70	177.61	205.84	293.28	23012
Maine upstream Little Maine	22_2090_3	22003	76.06	139.69	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	76.06	96.03	111.23	128.17	154.63	178.68	207.08	295.05	23012
Maine downstream Little Maine	22_3375_1	22003	100.89	185.30	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	100.89	127.39	147.55	170.02	205.13	237.03	274.70	391.40	23012
Maine upstream Brown Flesk	22_3367_4	22003	102.64	188.51	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	102.64	129.59	150.11	172.97	208.68	241.13	279.46	398.17	16005
22003 (Riverville)	22_3101_1	Gauged	143.96	270.20	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	143.96	181.76	210.54	242.60	292.68	338.21	391.96	558.47	Gauged Median
Maine upstream Inchinveema	22_3101_4	22003	149.67	274.88	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	149.67	188.97	218.88	252.22	304.29	351.62	407.50	580.61	16005
Maine downstream Inchinveema	22_3306_1	22003	152.27	279.65	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	152.27	192.25	222.68	256.60	309.57	357.72	414.57	590.69	16005
Maine upstream Coolmealane & Ballyfinnane	22_3359_3	22003	156.02	286.54	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	156.02	196.98	228.17	262.92	317.20	366.53	424.79	605.24	16005
Maine downstream Coolmealane & Ballyfinnane	22_3754_1	22003	165.45	303.86	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	165.45	208.89	241.96	278.81	336.37	388.69	450.46	641.82	16005
HEP on Maine	22_3970_3+	22003	188.97	347.07	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	188.97	238.59	276.36	318.45	384.20	443.95	514.51	733.08	16005
Maine DOWNSTREAM	22_3958_1+	22003	208.10	382.20	SS+GLO-P	1.00	1.26	1.46	1.69	2.03	2.35	2.72	3.88	208.10	262.74	304.34	350.69	423.09	488.89	566.59	807.29	16005
Kealgorm upstream Maine	22_957_4	22014	10.70	20.07	GLO-P	1.00	1.26	1.45	1.65	1.95	2.21	2.50	3.34	10.70	13.52	15.54	17.69	20.88	23.64	26.76	35.72	36021

Brogheen upstream Maine	22_582_7	22014	6.12	11.48	GLO-P	1.00	1.26	1.45	1.65	1.94	2.20	2.49	3.32	6.12	7.72	8.87	10.09	11.90	13.47	15.24	20.33	15003
Ballymacpierce upstream Maine	22_1223_5	22014	6.11	11.47	GLO-P	1.00	1.25	1.42	1.61	1.89	2.13	2.40	3.18	6.11	7.61	8.68	9.83	11.52	12.99	14.65	19.42	36021
Little Maine upstream Maine	22_2091_3	22014	26.64	50.00	GLO-P	1.00	1.21	1.36	1.53	1.77	1.97	2.21	2.88	26.64	32.30	36.36	40.67	47.08	52.62	58.88	76.86	23012
Brown Flesk upstream Maine	22_3102_14	22014	45.46	85.32	GLO-P	1.00	1.20	1.35	1.51	1.74	1.94	2.16	2.81	45.46	54.76	61.42	68.51	79.03	88.13	98.42	127.96	16005
Inchinveema upstream Maine	22_888_4	22014	11.55	21.68	GLO-P	1.00	1.25	1.43	1.63	1.91	2.16	2.44	3.24	11.55	14.47	16.56	18.79	22.09	24.95	28.18	37.46	36021
Coolmealane upstream Maine	22_3118_2	22014	13.14	24.65	GLO-P	1.00	1.24	1.41	1.60	1.87	2.10	2.37	3.13	13.14	16.30	18.56	20.97	24.54	27.63	31.13	41.17	15003
Ballygamboon Lower upstream Maine	22_3962_5	36021	8.14	15.28	GLO-P	1.00	1.25	1.42	1.61	1.89	2.13	2.41	3.19	8.14	10.15	11.59	13.12	15.40	17.36	19.59	25.97	36021
Annagh downstream Maine	22_3972_3	22003	23.68	31.19	GLO-P	1.00	1.22	1.37	1.54	1.78	1.99	2.23	2.92	23.68	28.81	32.48	36.39	42.20	47.21	52.89	69.18	15003
Tralia upstream of Maine	22_3964_2	22014	7.80	14.64	GLO-P	1.00	1.25	1.43	1.63	1.91	2.16	2.44	3.25	7.80	9.78	11.19	12.70	14.93	16.87	19.05	25.33	36021
Ashullish Stream DOWNSTREAM @ Maine	22_3958_2	22022	7.27	13.65	GLO-P	1.00	1.24	1.41	1.59	1.87	2.10	2.37	3.13	7.27	9.02	10.27	11.60	13.58	15.29	17.22	22.77	36021
Boolteens Stream downstream at Maine	22_3952_4	36021	22.71	42.63	GLO-P	1.00	1.23	1.39	1.57	1.83	2.05	2.30	3.03	22.71	27.91	31.63	35.59	41.46	46.55	52.29	68.80	15003
Groin downstream	22_3950_5	22022	15.14	28.41	GLO-P	1.00	1.26	1.44	1.64	1.93	2.18	2.47	3.29	15.14	19.04	21.84	24.82	29.24	33.06	37.38	49.79	36021

D.6 Flesk MPW-Glenflesk AFA

Figure D.67: River Flesk MPW- Glenflesk AFA Schematic of QMED



*The River Finnow peaks 7 hours before the Flesk due to storm track moving in the opposite direction to flow. Therefore the phasing of inflows takes into account the discrepancy at the confluence with the Flesk.

Table D.30: Flesk Bridge (22006) Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	22006	57	57	57	0.034	57	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic cover, majority is of locally important aquifer.
2	30001	18	75	75	0.729	36	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
3	34007	53	128	128	0.045	159	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
4	34010	12	140	140	0.073	48	0.988	0.850	0.73	3.957	484.35	0.401	1386	B	Locally Important Aquifer	1.477	Mix of geology with minor karstic influence.
5	10002	46	186	186	0.333	230	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
6	22003	10	196	196	0.822	60	1.000	1.720	0.64	5.002	271.29	0.471	1349	B	Locally Important Aquifer	0.882	N/A
7	18050	24	220	220	0.177	168	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
8	18048	23	243	243	0.116	184	0.999	0.480	0.64	2.353	867.74	0.474	1383	B	Locally Important Aquifer	0.650	N/A
9	18016	20	263	263	0.220	180	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
10	1041	32	295	295	0.088	320	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
11	28001	17	312	312	1.924	187	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
12	38001	33	345	345	0.108	396	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
13	32011	25	370	370	0.083	325	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
14	18006	27	397	397	0.093	378	0.999	0.470	0.63	1.918	1054.78	0.462	1332	B	Locally Important Aquifer	0.885	N/A
15	34009	33	430	430	0.035	495	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
16	20002	37	467	467	0.545	592	0.987	0.810	0.67	2.087	423.74	0.592	1669	B	Locally Important Aquifer	0.484	N/A
17	25158	18	485	485	0.465	306	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
18	16013	33	518	518	0.111	594	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A

Figure D.68: Flood Growth Curve Plot

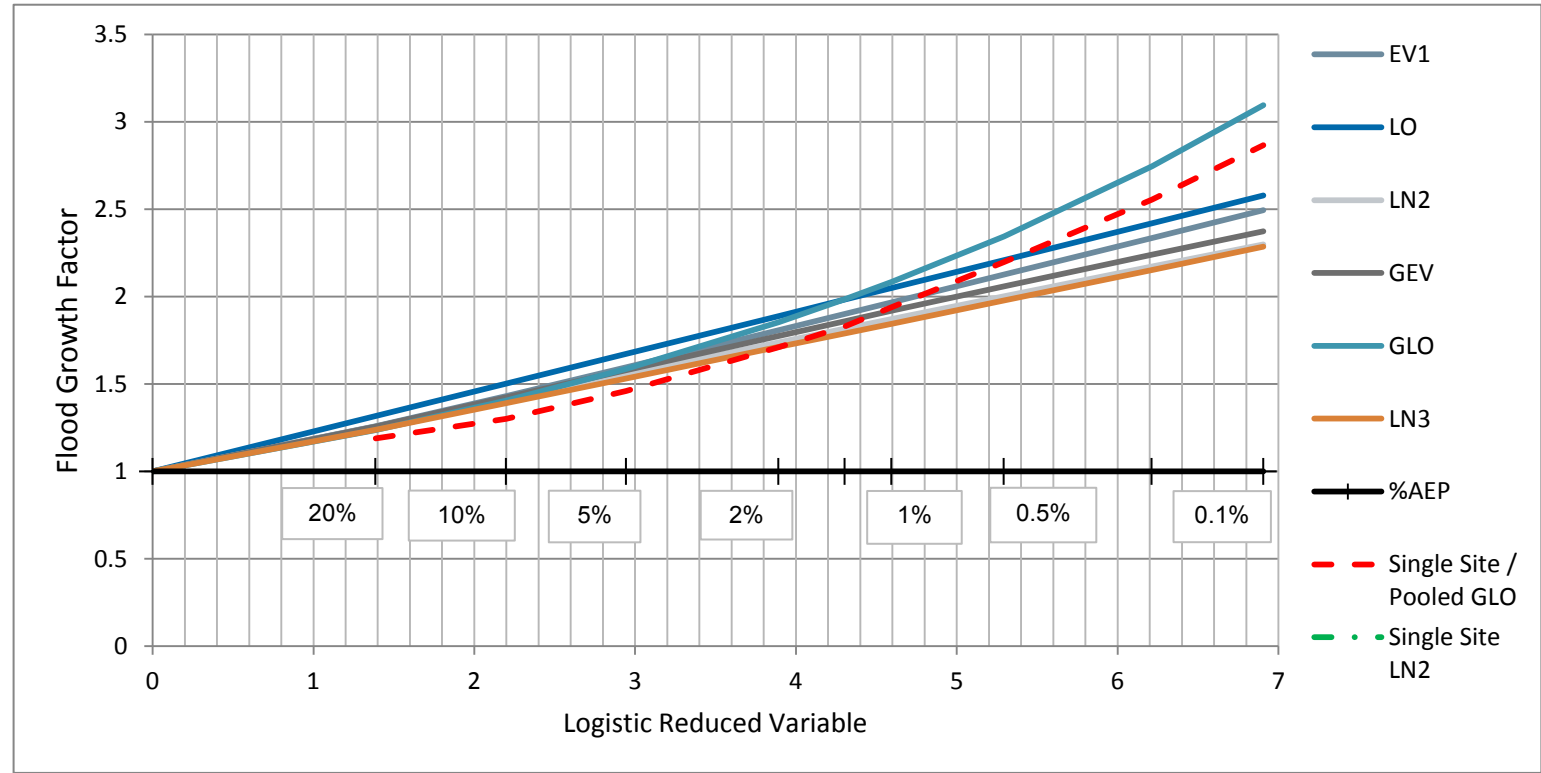


Figure D.69: L Moment Plot

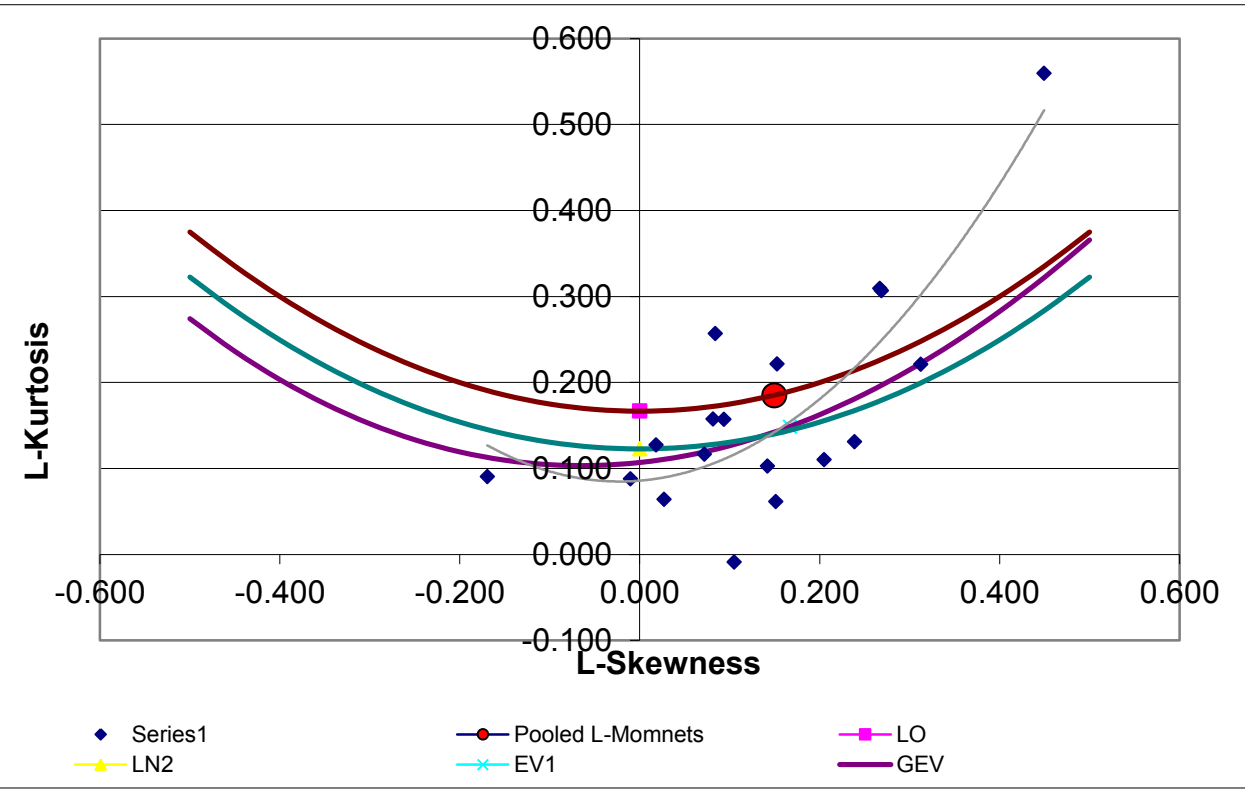


Table D.31: River Loo Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	30001	18	18	18	0.662	18	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important	1.022	N/A
2	39001	31	49	49	0.131	62	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
3	10004	14	63	63	1.378	42	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
4	38001	33	96	96	0.098	132	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
5	32011	25	121	121	0.076	125	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
6	22006	57	178	178	0.031	342	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
7	36021	27	205	205	0.072	189	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
8	34007	53	258	258	0.040	424	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
9	18016	20	278	278	0.199	180	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
10	16013	33	311	311	0.101	330	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
11	33001	25	336	336	0.043	275	0.998	0.000	0.73	10.449	76.12	0.294	1467	B	Poor Aquifer	0.708	N/A
12	10002	46	382	382	0.302	552	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
13	1041	32	414	414	0.080	416	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important	0.424	N/A
14	28001	17	431	431	1.746	238	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
15	35002	34	465	465	0.125	510	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
16	25158	18	483	483	0.422	288	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important	1.364	N/A
17	18050	24	507	507	0.161	408	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A

Figure D.70: Flood Growth Curve Plot

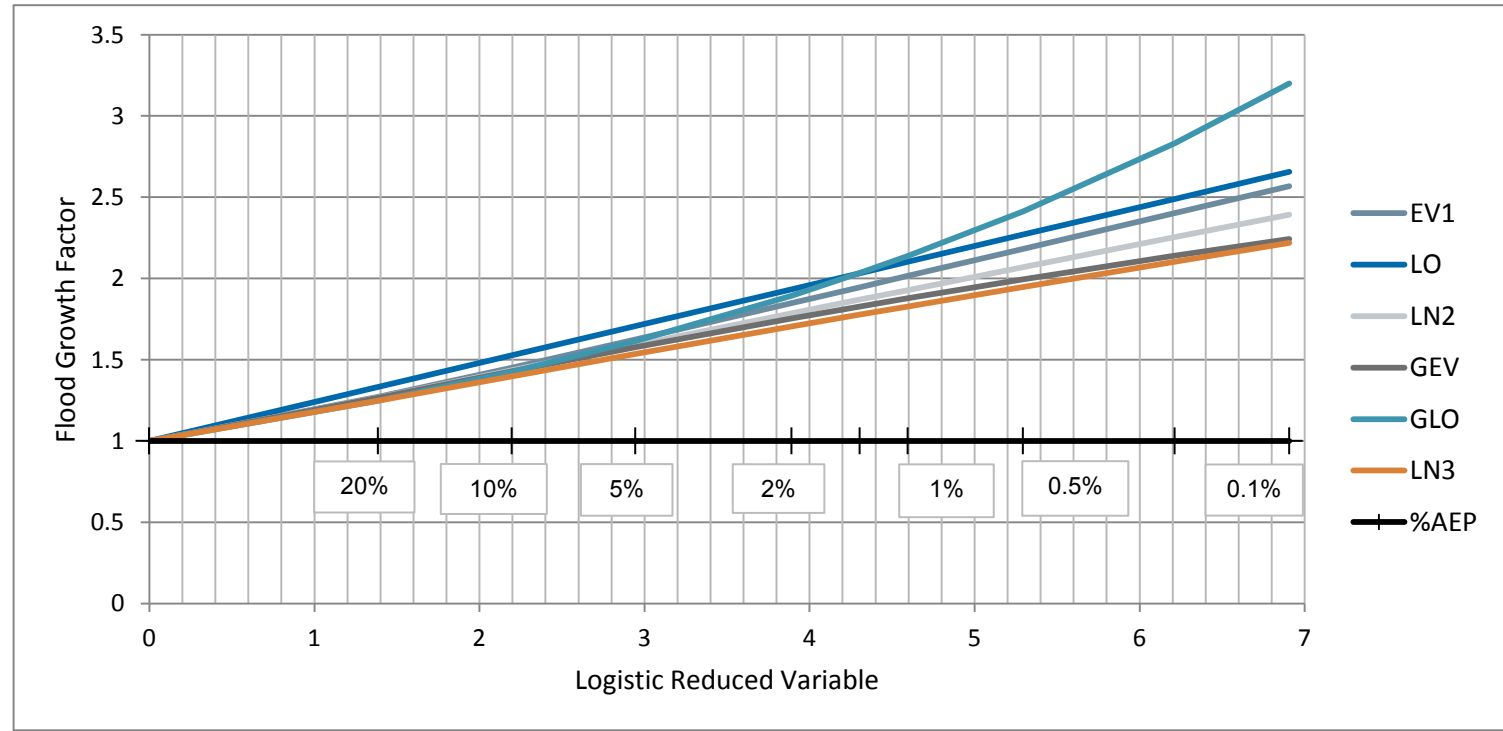


Figure D.71: L Moment Plot

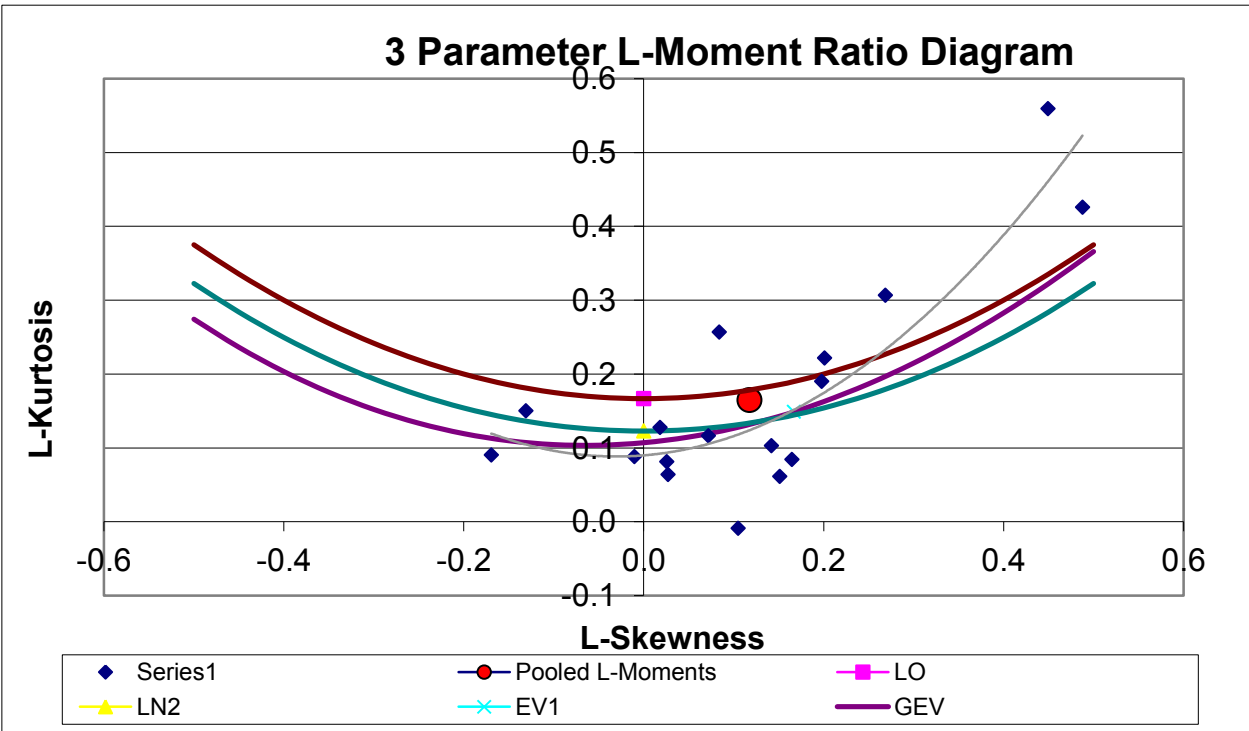


Table D.32: Annagh Beg Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	36021	27	27	27	0.076	27	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquife	0.749	Gauge situated on Karstic zone. Majority is of Poor Aquifer.
2	39001	31	58	58	0.139	62	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
3	10004	14	72	72	1.458	42	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
4	32011	25	97	97	0.080	100	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
5	33001	25	122	122	0.046	125	0.998	0.000	0.73	10.449	76.12	0.294	1467	B	Poor Aquifer	0.708	N/A
6	38001	33	155	155	0.104	198	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
7	30001	18	173	173	0.700	126	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important	1.022	N/A
8	18016	20	193	193	0.211	160	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
9	34007	53	246	246	0.043	477	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
10	1041	32	278	278	0.084	320	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
11	16013	33	311	311	0.106	363	0.993	0.000	0.58	24.556	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
12	35002	34	345	345	0.132	408	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
13	34009	33	378	378	0.033	429	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
14	28001	17	395	395	1.847	238	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
15	25158	18	413	413	0.446	270	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
16	6030	27	440	440	0.461	432	0.972	0.000	0.61	20.091	10.40	0.625	1157	B	Poor Aquifer	0.701	N/A
17	20006	35	475	475	0.165	595	1.000	0.000	0.67	6.390	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
18	18050	24	499	499	0.170	432	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
19	22006	57	556	556	0.033	1083	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.

Figure D.72: Flood Growth Curve Plot

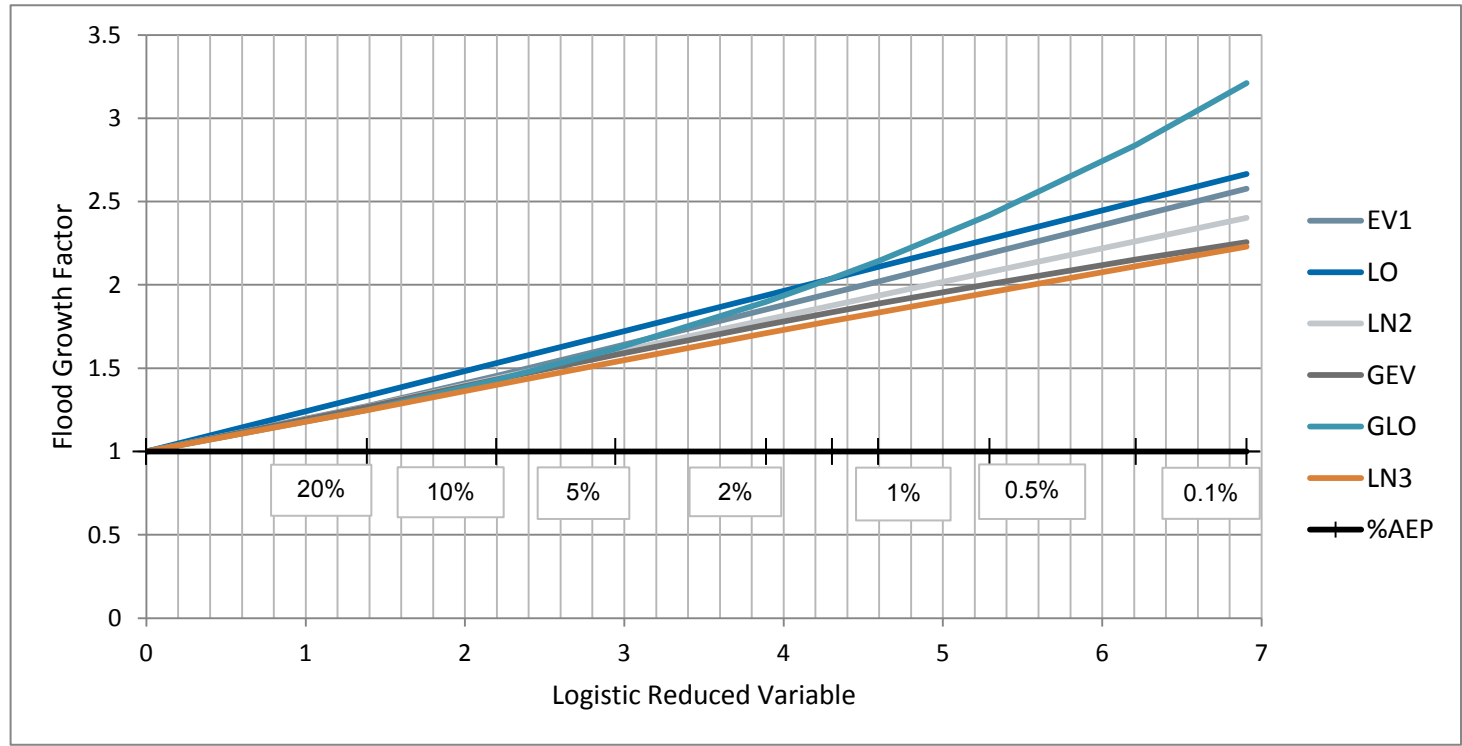


Figure D.73: L Moment Plot

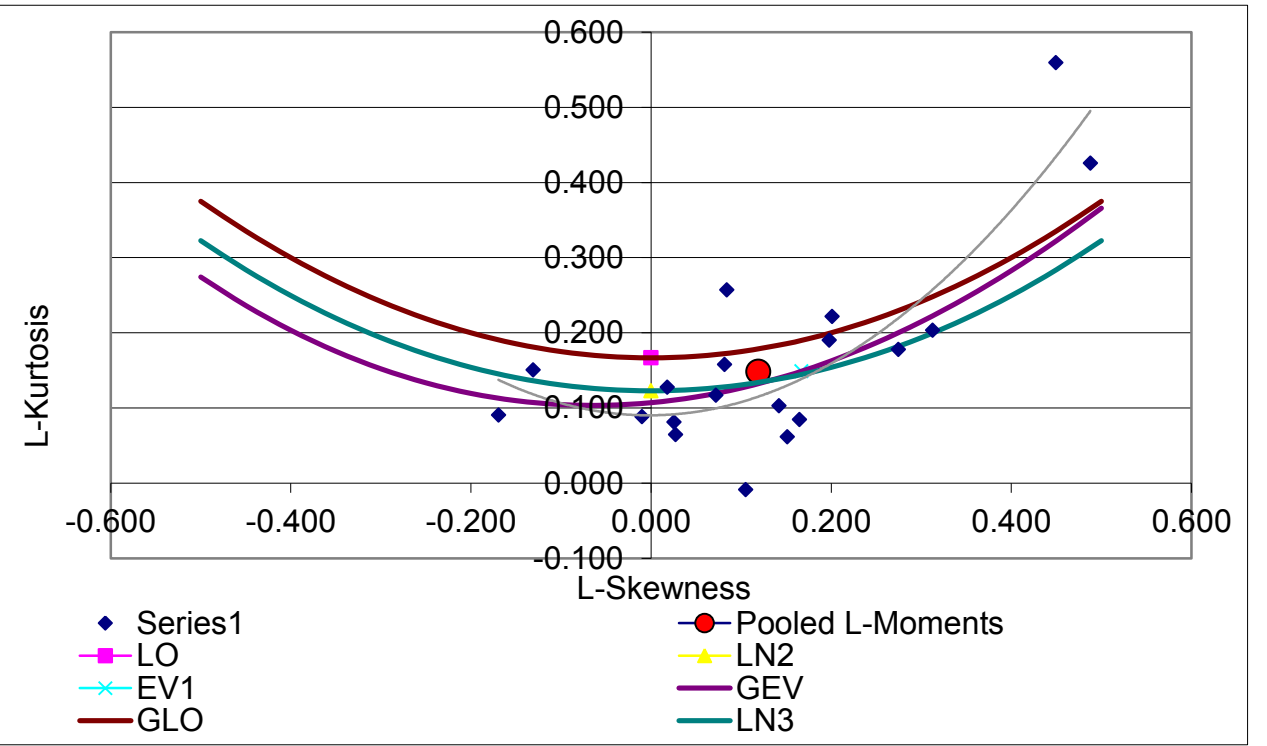


Table D.33: Owneskeagh Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	1041	32	32	32	0.100	32	1.000	0.860	0.69	7.227	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A
2	18016	20	52	52	0.250	40	1.000	0.780	0.64	4.884	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
3	34007	53	105	105	0.051	159	0.978	0.000	0.73	4.569	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
4	28001	17	122	122	2.191	68	0.938	0.050	0.62	2.199	169.42	0.329	1423	B	Locally Important Aquifer	0.608	N/A
5	32011	25	147	147	0.095	125	0.986	0.150	0.69	13.428	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
6	34009	33	180	180	0.039	198	1.000	1.070	0.73	3.325	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
7	18050	24	204	204	0.202	168	0.999	0.360	0.64	3.195	248.83	0.323	1469	B	Locally Important Aquifer	0.691	N/A
8	30001	18	222	222	0.830	144	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
9	34010	12	234	234	0.083	108	0.988	0.850	0.73	3.957	484.35	0.401	1386	B	Locally Important Aquifer	1.477	Mix of geology with minor karstic influence.
10	22003	10	244	244	0.936	100	1.000	1.720	0.64	5.002	271.29	0.471	1349	B	Locally Important Aquifer	0.882	N/A
11	38001	33	277	277	0.123	363	0.922	0.290	0.70	5.950	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
12	33001	25	302	302	0.054	300	0.998	0.000	0.73	10.449	76.12	0.294	1467	B	Poor Aquifer	0.708	N/A
13	39001	31	333	333	0.165	403	0.987	0.000	0.70	12.506	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
14	22006	57	390	390	0.039	798	0.961	0.540	0.66	9.421	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, majority of locally important aquifer
15	25158	18	408	408	0.530	270	1.000	0.000	0.59	6.973	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
16	36021	27	435	435	0.090	432	0.995	0.000	0.69	19.110	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority is of Poor Aquifer.
17	23001	33	468	468	0.064	561	1.000	0.300	0.62	3.290	191.74	0.328	1084	A2	Locally Important Aquifer	1.171	Gauged site situated on Karstic zone, only a very minor Karstic influence on catchment.
18	35002	34	502	502	0.157	612	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A

Figure D.74: Flood Growth Curve Plot

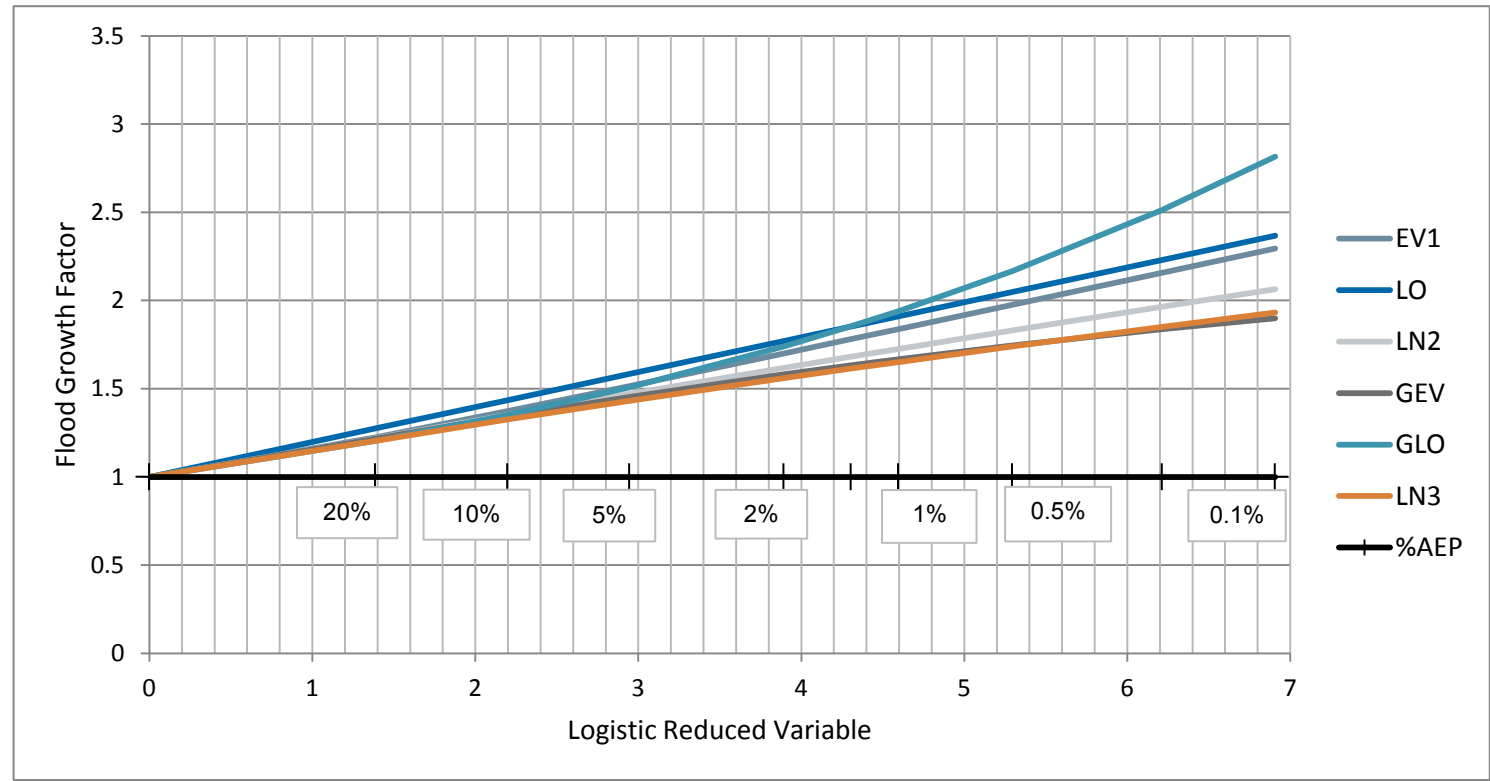


Figure D.75: L Moment Plot

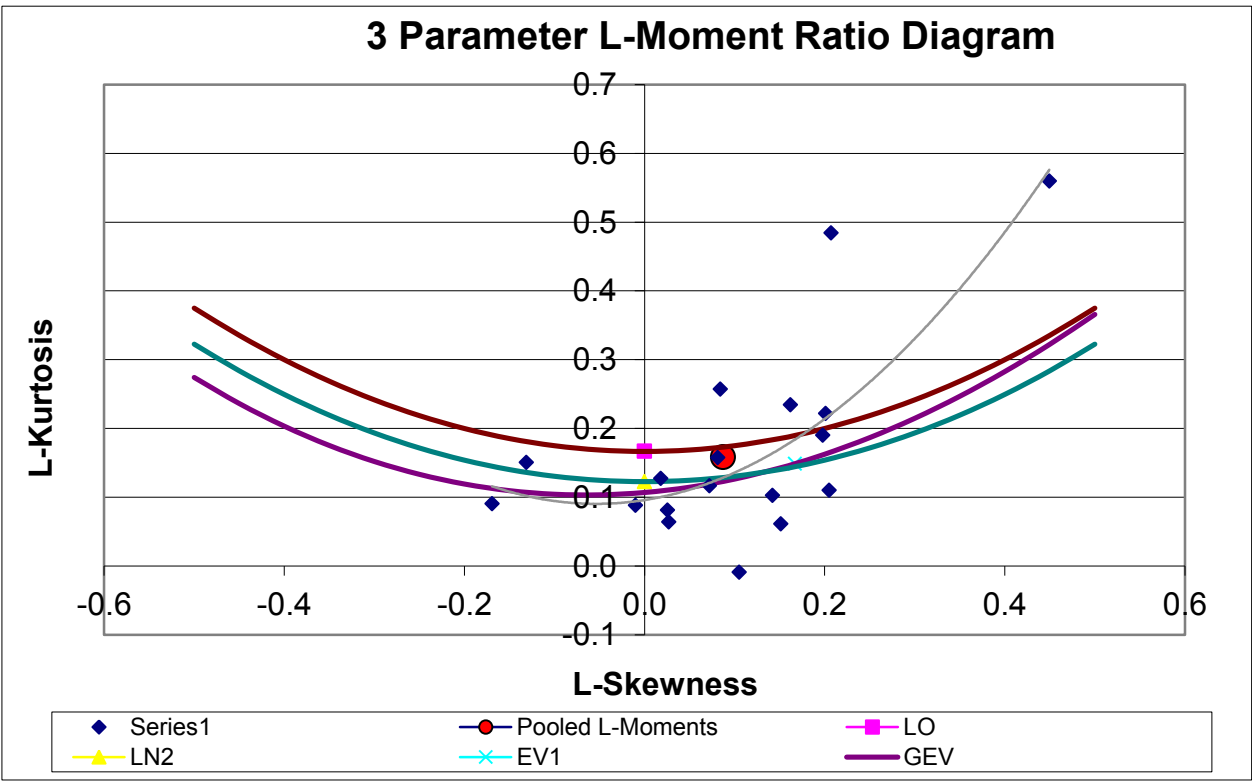


Table D.34: Finnow Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	21001	25	25	25	0.944	25	0.665	0.000	0.72	14.826	47.23	0.601	2275	B	Locally Important Aquifer	0.643	N/A
2	31072	26	51	51	0.252	52	0.636	0.000	0.66	3.636	111.83	0.507	2465	B	Poor Aquifer	0.694	N/A
3	32012	24	75	75	0.137	72	0.843	0.000	0.72	4.102	146.16	0.645	1784	A2	Locally Important Aquifer	1.106	N/A
4	10004	14	89	89	1.335	56	0.986	0.000	0.54	25.037	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
5	27070	29	118	118	0.281	145	0.912	0.000	0.62	4.646	143.58	0.642	1592	A2	Regionally Important Aquifer - Karstified (conduit)	1.147	N/A
6	27003	48	166	166	0.030	288	0.922	0.150	0.62	4.150	166.42	0.639	1567	A2	Regionally Important Aquifer - Karstified (conduit)	1.370	N/A
7	31002	26	192	192	0.225	182	0.632	0.000	0.65	9.590	71.35	0.503	1530	A1	Poor Aquifer	1.012	N/A
8	39008	33	225	225	0.028	264	0.781	0.000	0.70	10.543	77.39	0.441	1796	A2	Poor Aquifer	0.851	N/A
9	33070	28	253	253	0.030	252	0.677	0.000	0.73	2.804	87.90	0.526	1422	A1	Poor Aquifer	1.216	N/A
10	30001	18	271	271	0.641	180	0.935	0.000	0.70	5.168	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
11	22071	31	302	302	0.157	341	0.730	0.970	0.67	7.757	557.70	0.638	2011	A2	Locally Important Aquifer	1.278	Gauged site situated on Karstic zone, only a very minor Karstic influence on catchment.
12	22035	18	320	320	0.606	216	0.731	0.970	0.67	7.580	559.66	0.645	2010	B	Locally Important Aquifer	0.845	Gauged site situated on Karstic zone, only a very minor Karstic influence on catchment.
13	19014	47	367	367	0.234	611	0.892	0.000	0.67	3.462	170.76	0.426	2071	ESB stn	Poor Aquifer	0.801	N/A
14	36071	20	387	387	0.327	280	0.823	0.000	0.70	13.640	68.03	0.644	1315	B	Regionally Important Aquifer - Karstified (conduit)	0.939	Mix of geology. Majority Karstic.
15	35002	34	421	421	0.121	510	0.986	0.000	0.72	13.263	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
16	10002	46	467	467	0.293	736	0.932	0.170	0.54	6.899	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
17	35071	30	497	497	0.025	510	0.997	0.120	0.70	4.878	247.20	0.631	1364	A2	Locally Important Aquifer	1.144	N/A

Figure D.76: Flood Growth Curve Plot

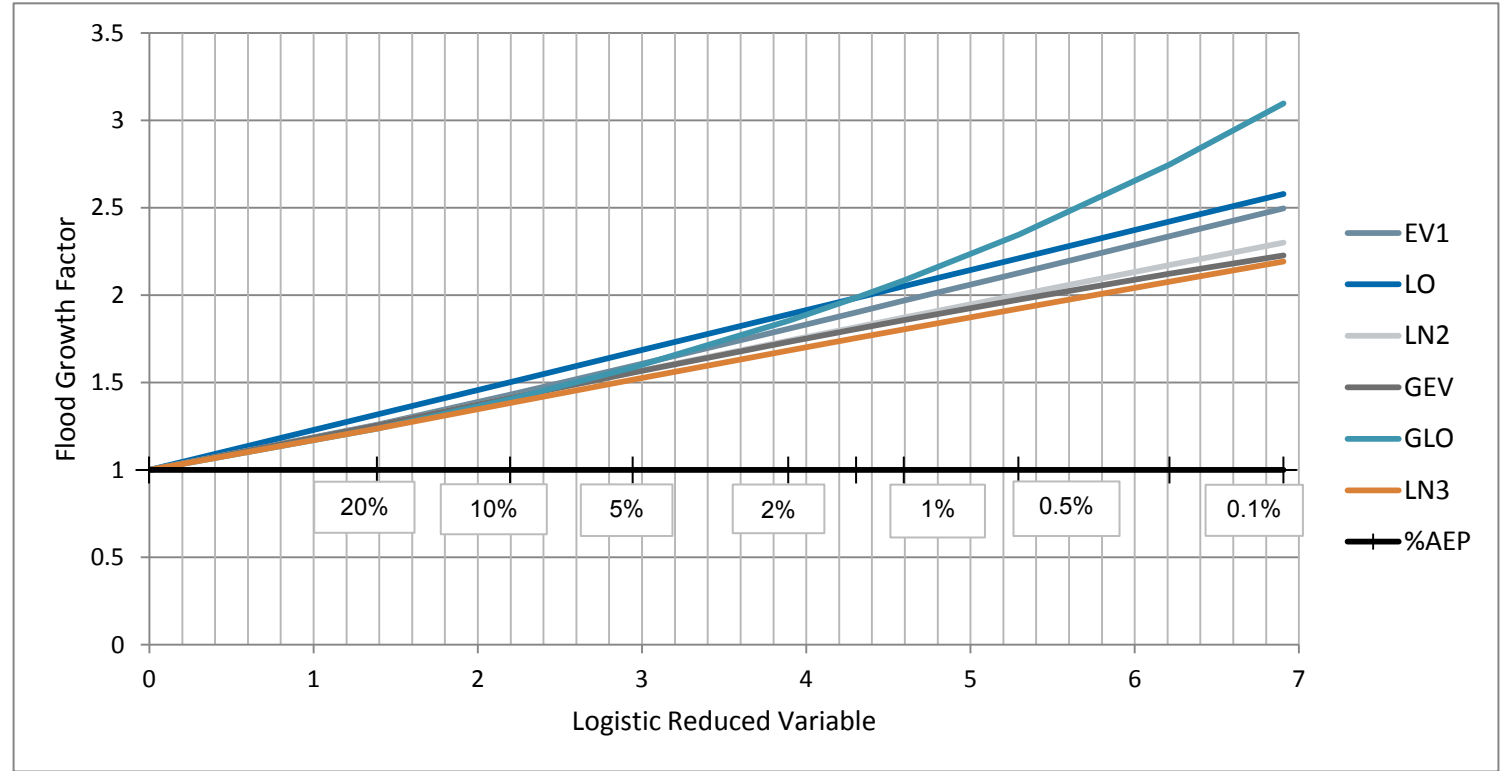


Figure D.77: L Moment Plot

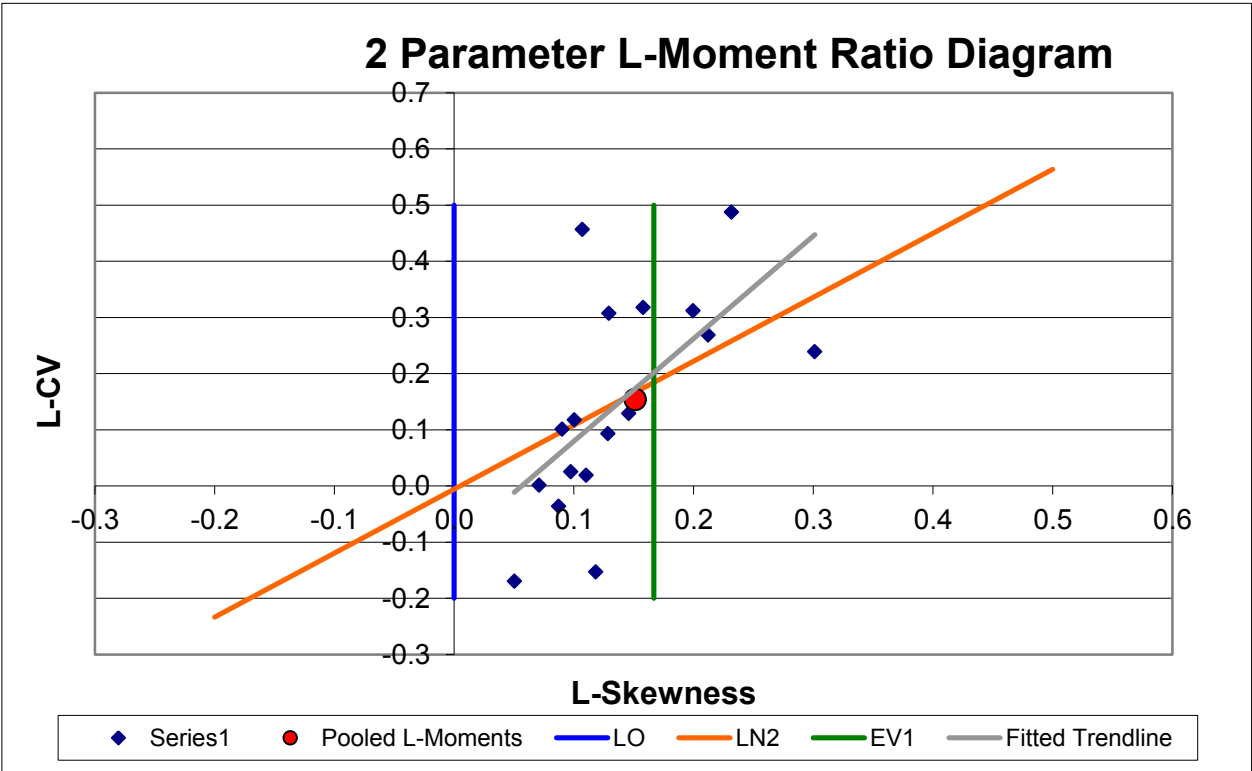
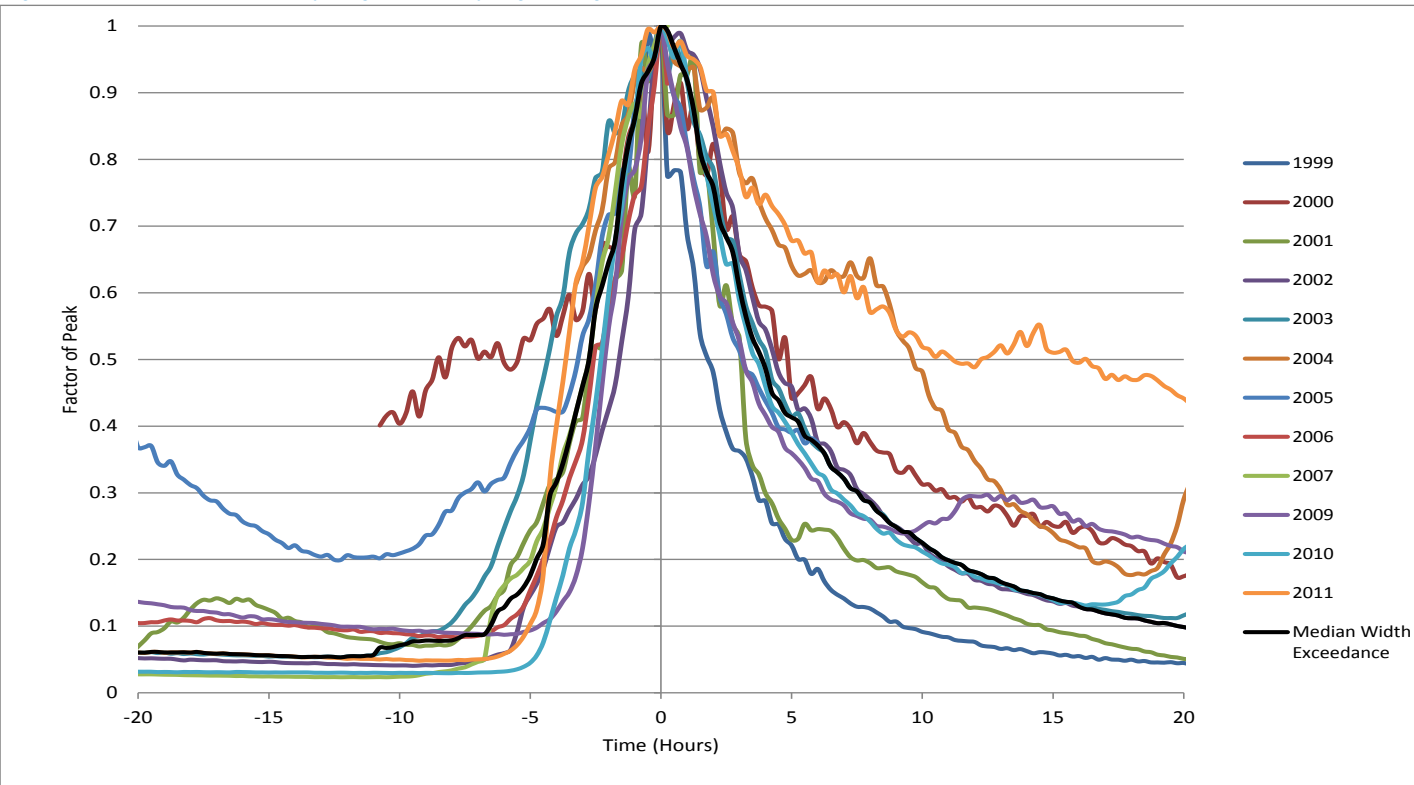


Figure D.78: Median Flood Hydrograph at Clydagh Bridge



N.B. The 15 minute flow records at Clydagh Bridge gauge demonstrate artificial oscillation due to equipment issues. Therefore hydrograph analysis has involved significant smoothing assumption. However, the peak flows have been independently verified and checked by OPW's hydrometric team and are deemed suitable for statistical analysis.

Figure D.79: UPO-ERR Gamma Hydrograph Based on Pivotal Site 23012

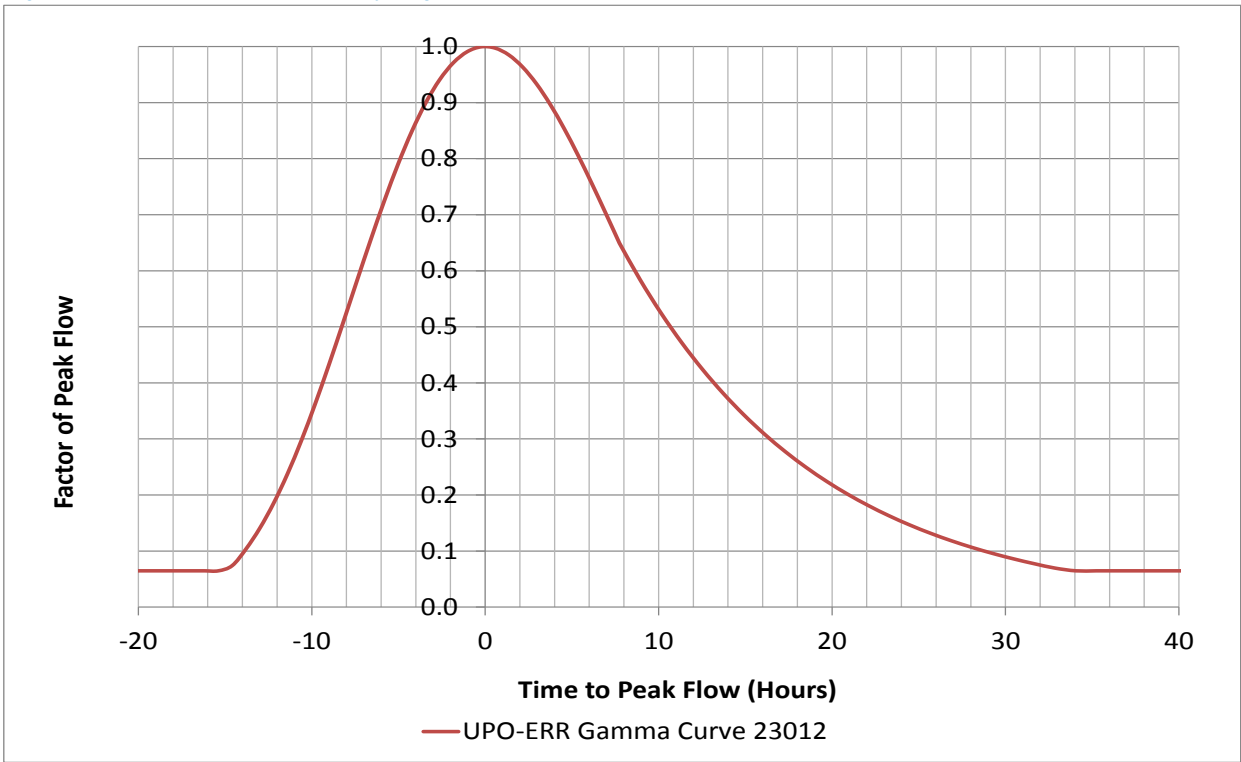


Figure D.80: UPO-ERR Gamma Hydrograph Based on Pivotal Site 36021

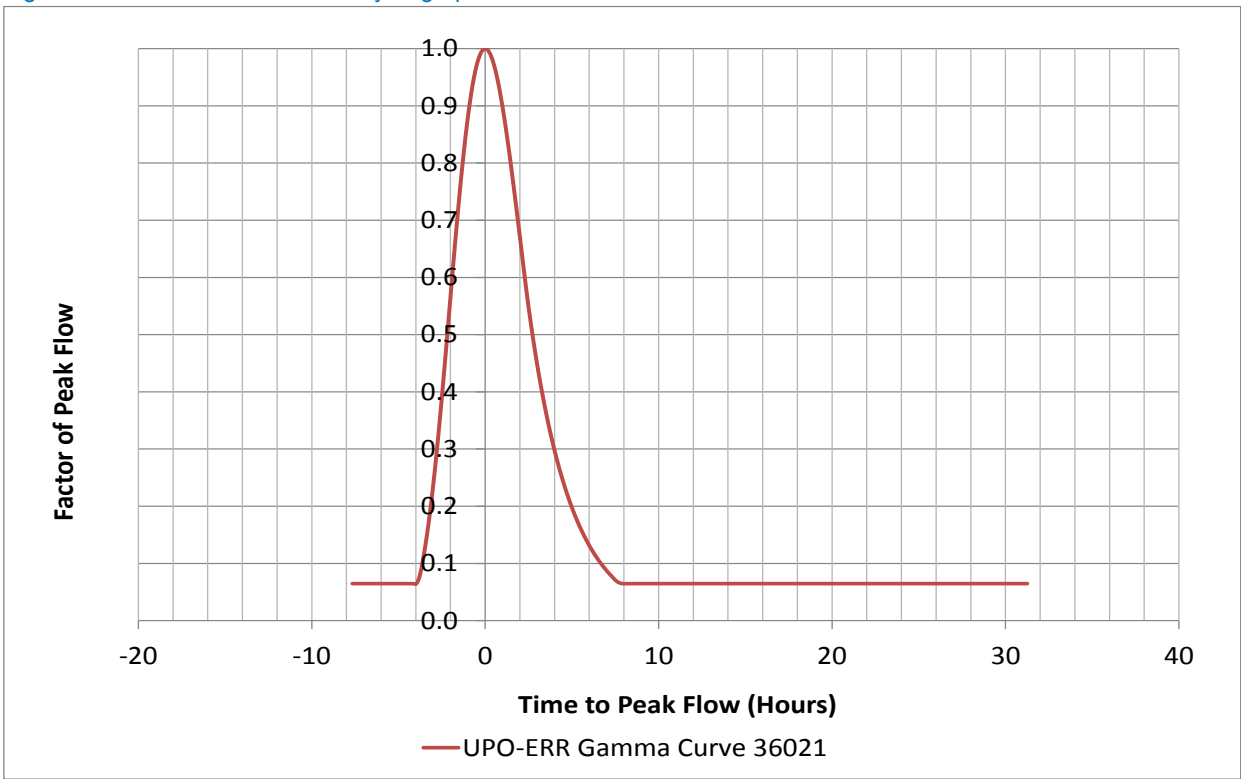


Table D.35: Flesk - Glenflesk AFA Design Peak Flows

LOCATION	HEP	Pivotal Site	QMED	95% Confidence Limit	Flood Growth Curve	Flood Growth Factor								Design Flows								Hydrograph Pivotal Site
						50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1	
Flesk Upstream	22_3712_1	22006	59.70	112.05	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	59.70	71.00	77.61	83.71	98.74	112.30	131.20	171.09	Clydagh Bridge gauged
Flesk upstream @ Flesk/Loo Confluence	22_3712_4	22006	63.13	118.50	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	63.13	75.09	82.08	88.53	104.43	118.77	138.76	180.94	23012
Loo downstream @ Flesk/Loo Confluence	22_1553_4	22039	42.79	80.32	GLO-P	1.00	1.25	1.43	1.61	1.89	2.14	2.41	3.20	42.79	53.41	61.00	69.09	81.09	91.47	103.21	136.91	23012
Flesk downstream @ Loo/Flesk Confluence	22_2688_1	22006	95.12	178.53	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	95.12	113.13	123.67	133.38	157.33	178.94	209.05	272.61	23012
Flesk upstream @ Flesk/A.B Confluence	22_1561_2	22006	106.44	199.78	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	106.44	126.60	138.39	149.25	176.06	200.23	233.93	305.06	23012
Annagh Beg Stream downstream @ Flesk/A.B. Confluence	22_245_2	22039	7.87	14.78	GLO-P	1.00	1.25	1.43	1.62	1.90	2.14	2.42	3.21	7.87	9.84	11.24	12.74	14.96	16.88	19.05	25.28	36021
Flesk downstream @ Flesk/A.B. Confluence	22_1567_1	22006	110.16	206.77	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	110.16	131.03	143.23	154.47	182.22	207.24	242.12	315.73	23012
Flesk upstream Owneyskeagh	22_1560_3	22006	112.58	211.31	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	112.58	133.90	146.38	157.87	186.22	211.79	247.44	322.67	23012
Owneyskeagh Upstream (Survey extent)	22_2883_4	22039	53.64	100.68	GLO-P	1.00	1.20	1.35	1.51	1.74	1.94	2.17	2.82	53.64	64.62	72.48	80.85	93.27	104.01	116.15	151.02	27001
Owneyskeagh downstream @ Owneyskeagh/ Flesk Confluence	22_2883_9	22039	53.75	100.89	GLO-P	1.00	1.20	1.35	1.51	1.74	1.94	2.17	2.82	53.75	64.75	72.63	81.01	93.46	104.22	116.39	151.33	27001
Flesk downstream Owneyskeagh	22_2859_1	22006	150.84	283.11	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	150.84	179.41	196.11	211.51	249.50	283.76	331.52	432.31	27001
Flesk upstream @Finow	22_2705_5	22006	154.67	290.30	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	154.67	183.96	201.09	216.88	255.83	290.96	339.93	443.28	23012
Finow downstream @ Flesk/Finow Clonfluence	22_1927_3	22041	41.74	78.35	GLO-P	1.00	1.24	1.41	1.59	1.85	2.08	2.35	3.10	41.74	51.61	58.68	66.20	77.36	87.01	97.92	129.26	36021
Flesk downstream @Finow	22_3340_1	22006	168.88	316.96	SS+GLO-P	1.00	1.19	1.30	1.40	1.65	1.88	2.20	2.87	168.88	200.86	219.56	236.80	279.33	317.69	371.16	484.00	23012
Flesk Downstream	22_3340_7	22006	170.08	319.23	SS+GLO-P	1.00	1.19	1.30	1.46	1.71	1.94	2.20	2.87	170.08	202.29	221.13	248.32	290.84	329.96	373.81	487.46	23012

D.7 Laune MPW

Figure D.81: River Laune MPW Schematic of QMED

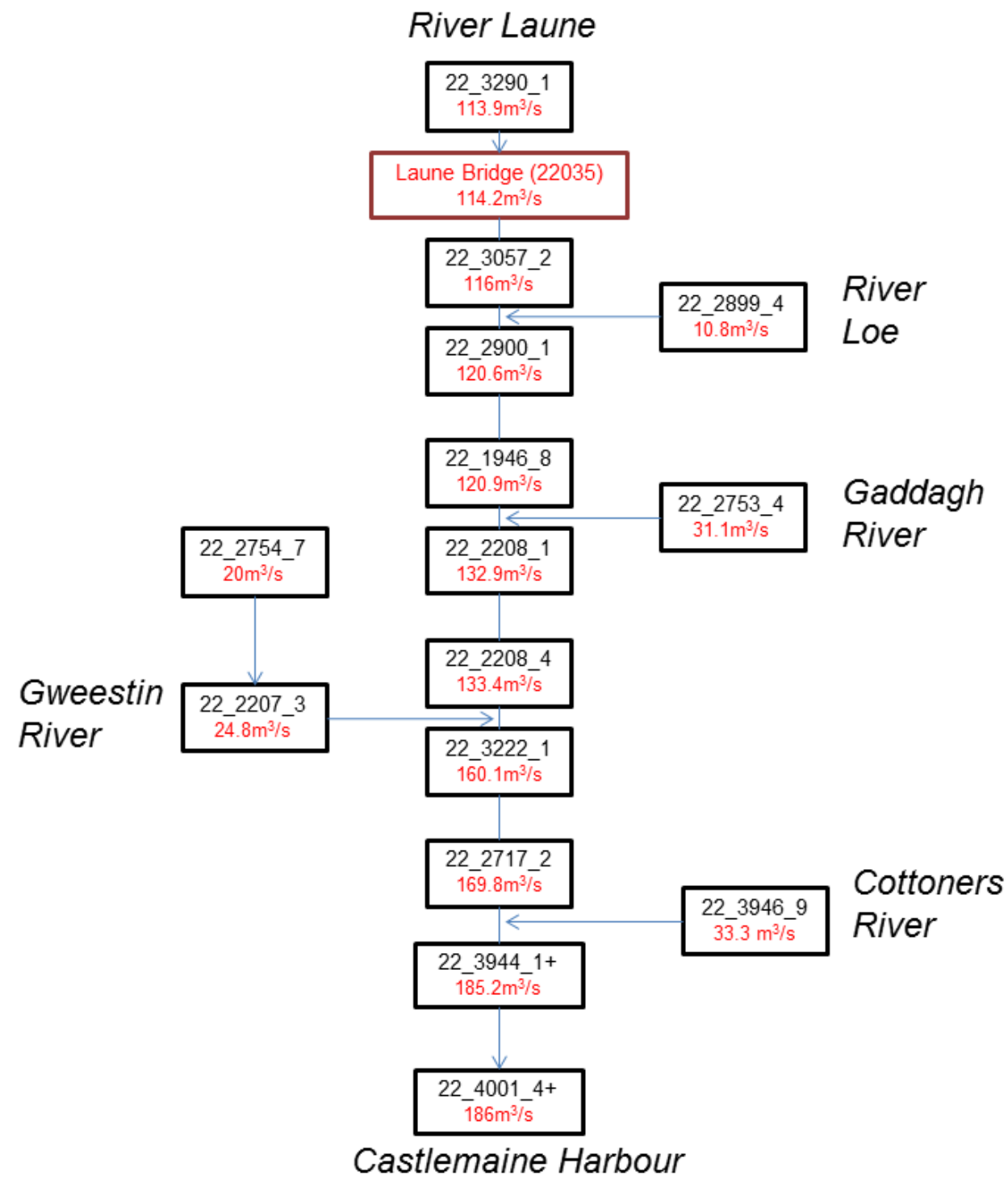


Table D.36: River Laune Reach Flood Frequency Analysis

Ran k	Poolin g Statio n No.	Recor d Lengt h	Cumul ative Years	Poolin g Years Count	Discor dancy (Di)	Effectiv e record length	FARL	URB EXT	FLATWE T	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QME D	Additional Comments
1	22071	31	31	31	0.328	31	0.730	0.970	0.67	7.7570	557.70	0.638	2011	A2	Locally Important Aquifer	1.278	Gauged site situated on Karstic zone, only a very minor Karstic influence.
2	35073	30	61	61	0.034	60	0.788	0.130	0.70	2.7436	362.60	0.721	1504	A2		1.068	N/A
3	27003	48	109	109	0.063	144	0.922	0.150	0.62	4.1497	166.42	0.639	1567	A2	Regionally Important Aquifer - Karstified	1.370	N/A
4	36027	15	124	124	2.040	60	0.720	0.110	0.69	1.1608	333.80	0.660	1373	A2	Regionally Important Aquifer - Karstified	1.173	Mix of geology. Majority Karstic.
5	27002	51	175	175	0.096	255	0.835	0.080	0.62	1.2183	564.27	0.652	1336	A1	Regionally Important Aquifer - Karstified	1.592	N/A
6	34003	29	204	204	0.157	174	0.817	0.820	0.73	0.9609	1802.38	0.747	1340	A2	Poor Aquifer	0.809	N/A
7	35005	55	259	259	0.098	385	0.898	0.200	0.71	1.1537	639.66	0.617	1198	A2	Locally Important Aquifer - Karstified	1.207	N/A
8	34001	31	290	290	0.192	248	0.825	0.830	0.73	0.7194	1974.76	0.763	1323	A2	Regionally Important Aquifer - Karstified	1.028	Varied mix of geology, Karstic influence present. Deemed suitable for Laune Bridge.
9	34005	13	303	303	0.101	117	0.901	0.870	0.73	1.6951	309.11	0.578	1193	B	Regionally Important Aquifer - Karstified	0.863	Varied mix of geology, Karstic influence present. Deemed suitable for Laune Bridge.
10	26014	16	319	319	0.185	160	0.944	0.320	0.72	0.3279	215.14	0.634	1199	B	Locally Important Aquifer	0.827	N/A
11	35001	29	348	348	0.255	319	0.923	0.330	0.72	0.1000	299.45	0.640	1173	A2	Locally Important Aquifer	1.082	N/A
12	16003	27	375	375	0.456	324	0.999	0.200	0.59	5.3729	243.20	0.595	1192	A2	Locally Important Aquifer	0.952	N/A
13	25030	48	423	423	0.074	624	0.850	0.130	0.61	3.9441	280.02	0.592	1184	A1	Locally Important Aquifer	1.093	N/A
14	25158	18	441	441	0.854	252	1.000	0.000	0.59	6.9728	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
15	6012	47	488	488	0.067	705	0.831	1.250	0.65	5.2249	162.80	0.708	1046	A1		1.240	N/A

Figure D.82: Flood Growth Curve Plot

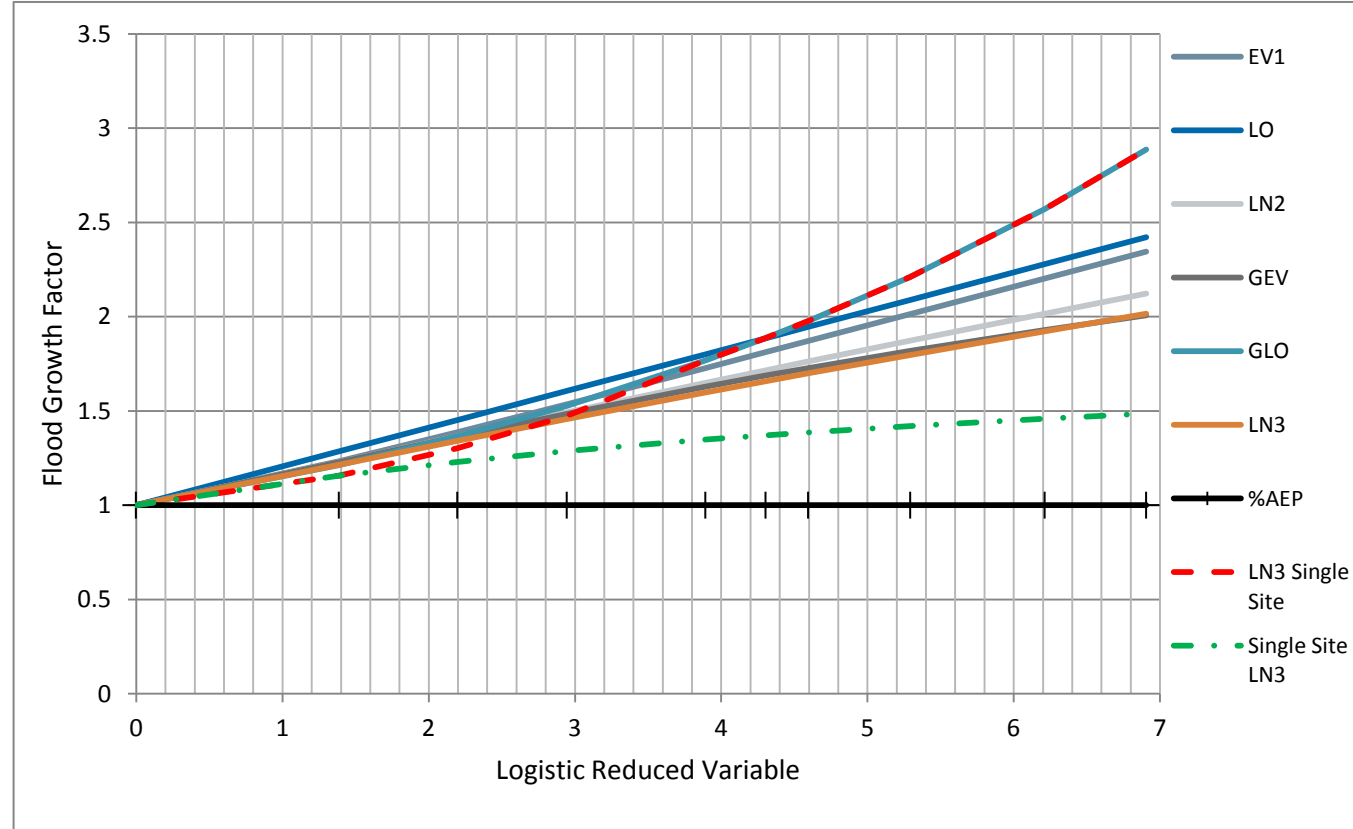


Figure D.83: L Moment Plot

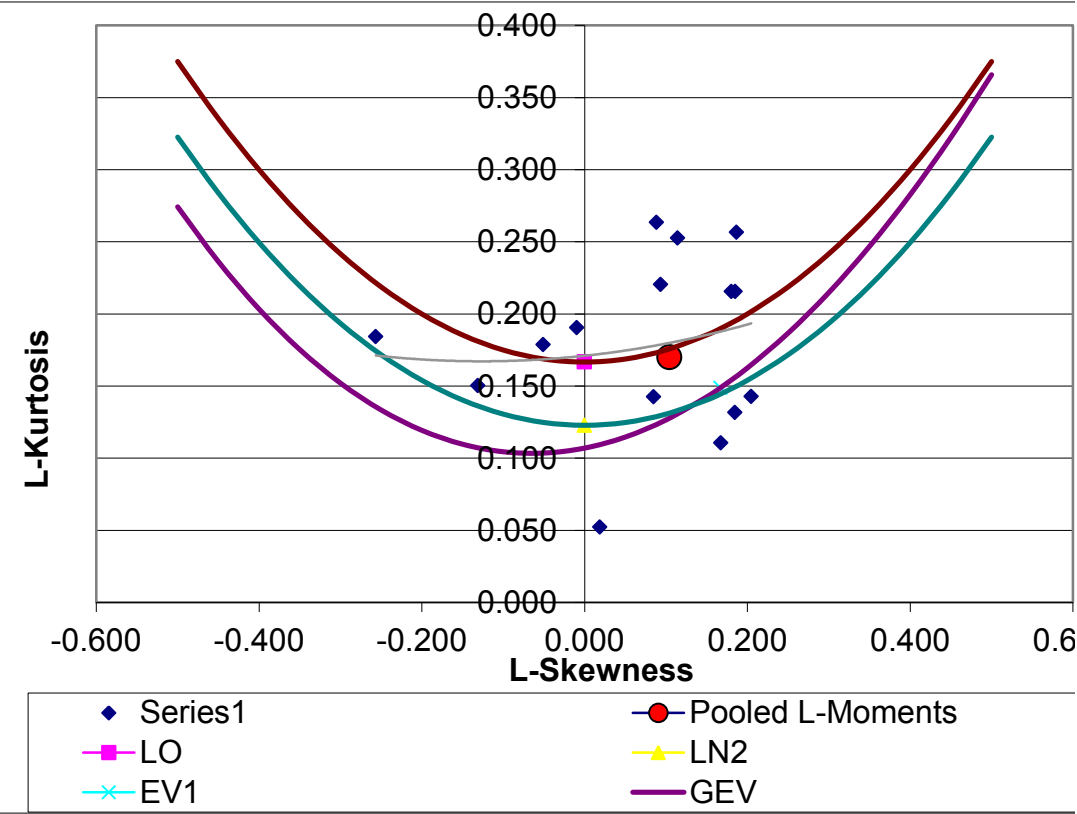


Table D.37: River Loe Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	10004	14	14	14	1.625	14	0.986	0.000	0.54	25.0367	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
2	39008	33	47	47	0.034	66	0.781	0.000	0.70	10.5429	77.39	0.441	1796	A2	Poor Aquifer	0.851	N/A
3	30001	18	65	65	0.780	54	0.935	0.000	0.70	5.1684	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
4	19014	47	112	112	0.285	188	0.892	0.000	0.67	3.4620	170.76	0.426	2071	ESB stn	Poor Aquifer	0.801	N/A
5	16013	33	145	145	0.119	165	0.993	0.000	0.58	24.5565	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
6	36021	27	172	172	0.085	162	0.995	0.000	0.69	19.1099	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority is of Poor Aquifer.
7	39001	31	203	203	0.155	217	0.987	0.000	0.70	12.5061	50.71	0.320	1764	B	Poor Aquifer	0.818	
8	20006	35	238	238	0.184	280	1.000	0.000	0.67	6.3896	77.55	0.600	1463	B	Locally Important Aquifer	0.574	
9	32011	25	263	263	0.089	225	0.986	0.150	0.69	13.4281	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
10	35002	34	297	297	0.147	340	0.986	0.000	0.72	13.2628	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
11	32012	24	321	321	0.167	264	0.843	0.000	0.72	4.1020	146.16	0.645	1784	A2	Locally Important Aquifer	1.106	N/A
12	25158	18	339	339	0.497	216	1.000	0.000	0.59	6.9728	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
13	22006	57	396	396	0.036	741	0.961	0.540	0.66	9.4206	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
14	39009	33	429	429	0.015	462	0.816	0.400	0.70	5.2225	206.83	0.404	1570	A2	Poor Aquifer	1.021	N/A
15	23012	18	447	447	0.751	270	0.999	2.430	0.64	11.6740	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified	1.022	N/A
16	27070	29	476	476	0.342	464	0.912	0.000	0.62	4.6464	143.58	0.642	1592	A2	Regionally Important Aquifer - Karstified	1.147	N/A
17	10002	46	522	522	0.356	782	0.932	0.170	0.54	6.8989	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.

Figure D.84: Flood Growth Curve Plot

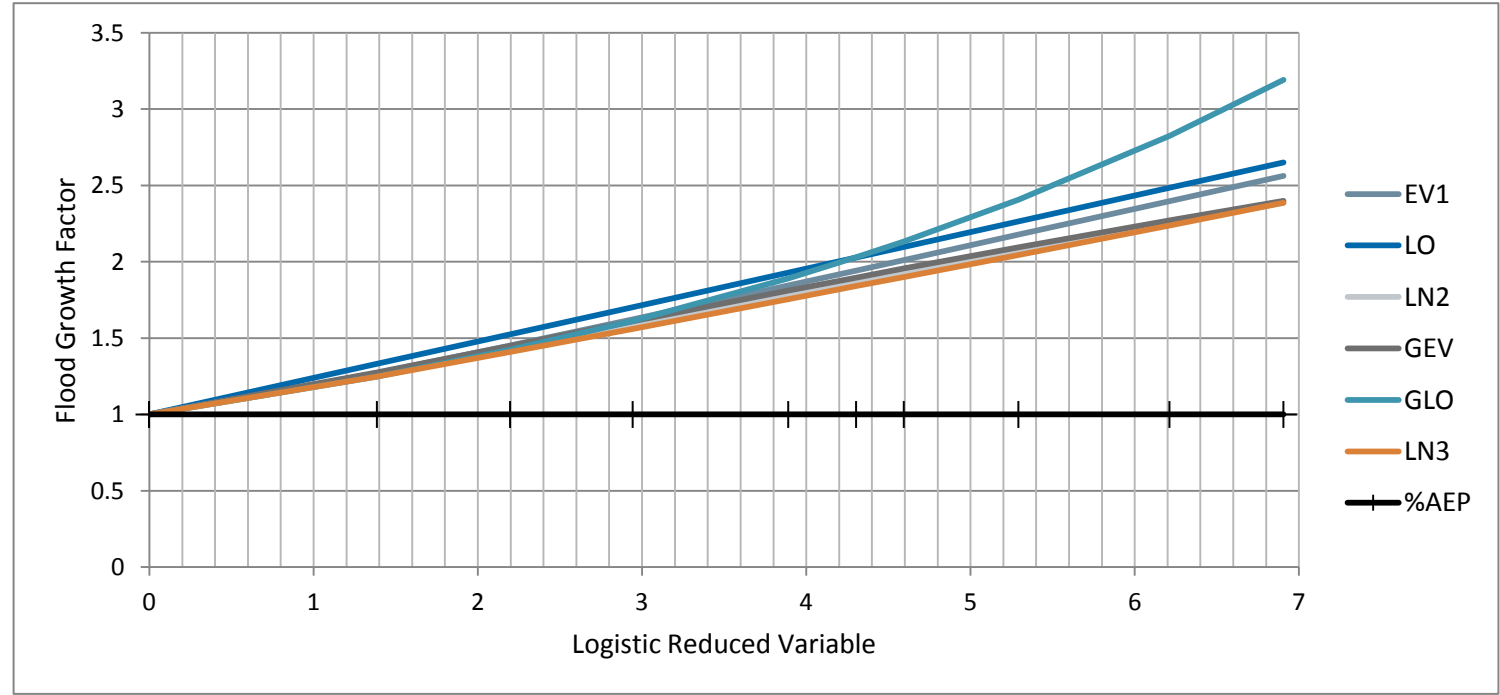


Figure D.85: L Moment Plot

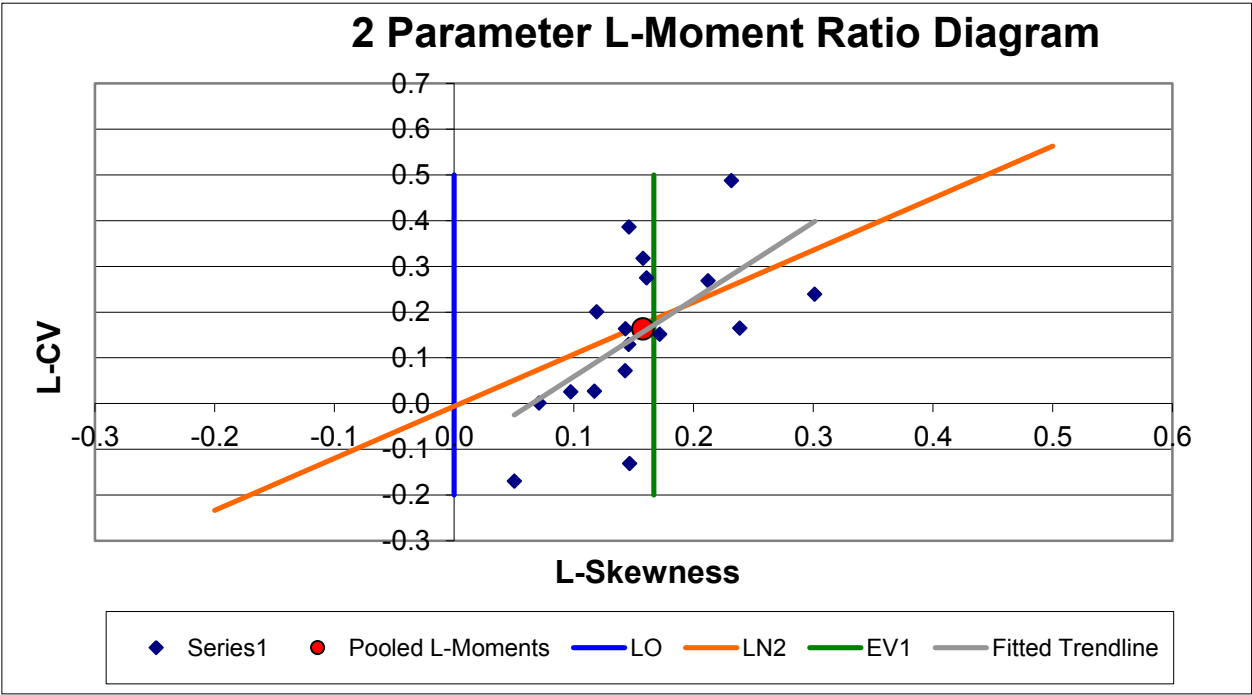


Table D.38: River Gaddagh Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	30001	18	18	18	0.819	18	0.935	0.000	0.70	5.1684	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
2	10004	14	32	32	1.707	28	0.986	0.000	0.54	25.0367	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
3	19014	47	79	79	0.299	141	0.892	0.000	0.67	3.4620	170.76	0.426	2071	ESB stn	Poor Aquifer	0.801	N/A
4	32011	25	104	104	0.094	100	0.986	0.150	0.69	13.4281	70.10	0.337	1613	B	Poor Aquifer	0.689	N/A
5	39001	31	135	135	0.163	155	0.987	0.000	0.70	12.5061	50.71	0.320	1764	B	Poor Aquifer	0.818	N/A
6	39009	33	168	168	0.016	198	0.816	0.400	0.70	5.2225	206.83	0.404	1570	A2	Poor Aquifer	1.021	N/A
7	36021	27	195	195	0.089	189	0.995	0.000	0.69	19.1099	23.41	0.330	1570	A2	Poor Aquifer	0.749	Gauge situated on Karstic zone. Majority of catchment is of Poor Aquifer.
8	34007	53	248	248	0.050	424	0.978	0.000	0.73	4.5686	151.71	0.349	1590	B	Poor Aquifer	0.489	Mix. Majority of region is of Poor quality aquifer. Gauge sits on Karstic zone.
9	16013	33	281	281	0.125	297	0.993	0.000	0.58	24.5565	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
10	22006	57	338	338	0.038	570	0.961	0.540	0.66	9.4206	328.81	0.414	1819	B	Locally Important Aquifer	0.625	Only minor Karstic coverage, vast majority is of locally important aquifer.
11	23012	18	356	356	0.789	198	0.999	2.430	0.64	11.6740	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
12	18016	20	376	376	0.247	240	1.000	0.780	0.64	4.8837	116.73	0.348	1441	B	Locally Important Aquifer	0.804	N/A
13	35002	34	410	410	0.155	442	0.986	0.000	0.72	13.2628	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
14	38001	33	443	443	0.121	462	0.922	0.290	0.70	5.9504	111.25	0.313	1753	B	Poor Aquifer	0.292	N/A
15	25158	18	461	461	0.523	270	1.000	0.000	0.59	6.9728	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
16	1041	32	493	493	0.099	512	1.000	0.860	0.69	7.2270	116.18	0.379	1329	B	Locally Important Aquifer	0.424	N/A

Figure D.86: Flood Growth Curve Plot

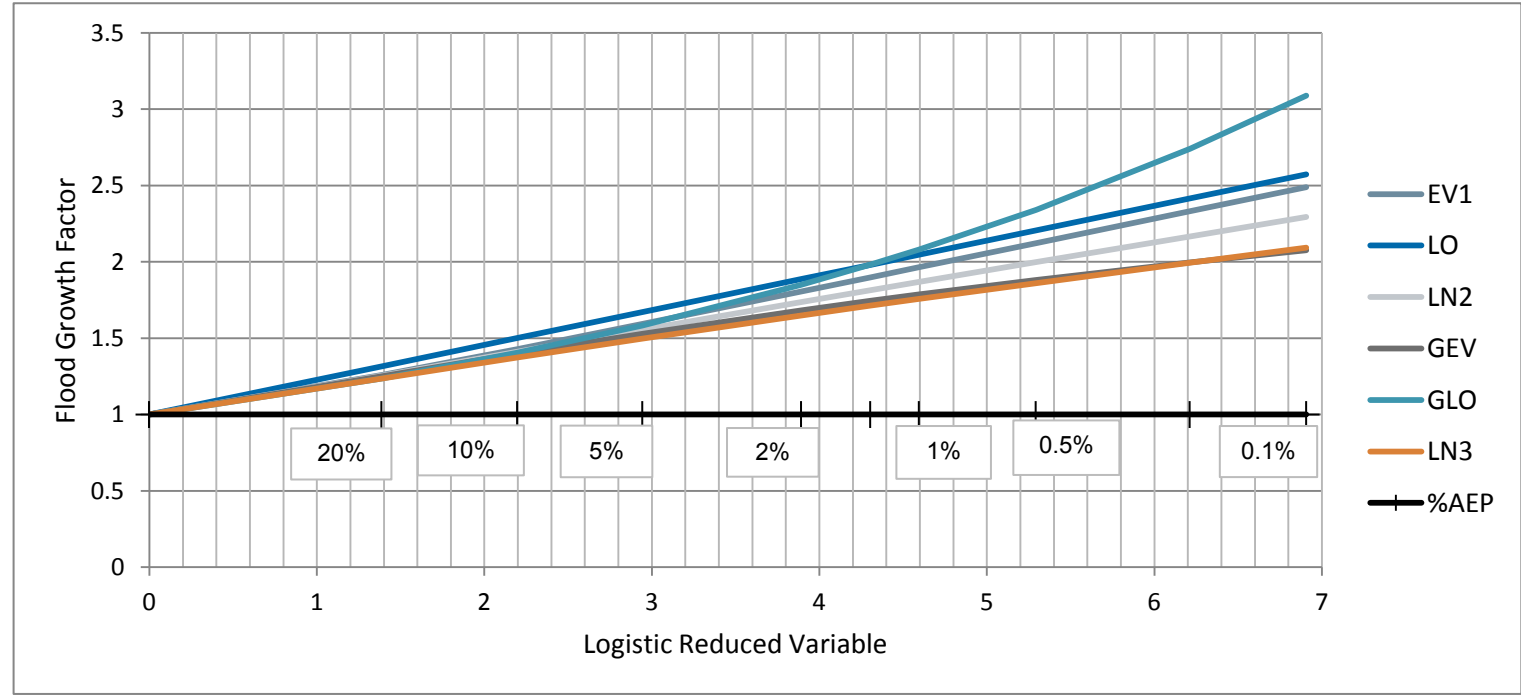


Figure D.87: L Moment Plot

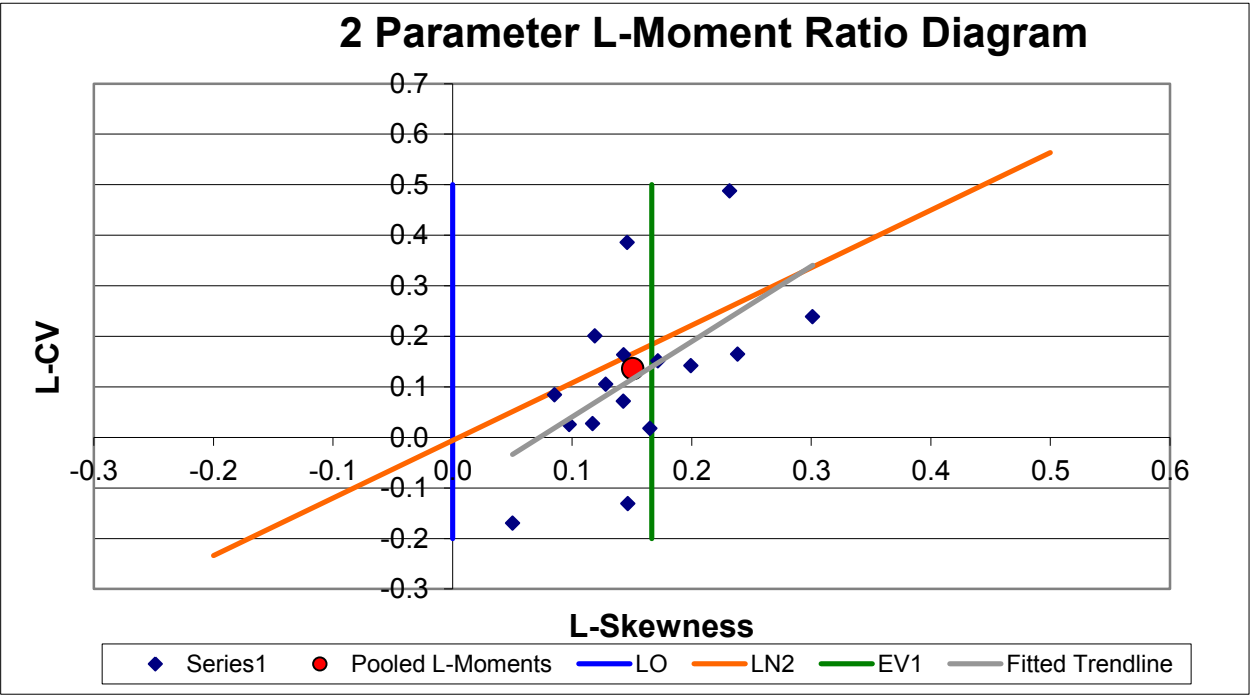


Table D.39: Gweestin River Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEX T	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/ QMED	Additional Comments
1	25044	40	40	40	0.068	40	0.997	0.000	0.59	2.6657	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A
2	25038	17	57	57	0.072	34	1.000	0.210	0.59	7.3358	136.10	0.591	1249	B	Locally Important Aquifer	0.725	N/A
3	16006	33	90	90	0.326	99	0.994	0.000	0.59	5.7628	75.80	0.591	1116	B	Locally Important Aquifer	0.562	Gauge within Karstic zone. But this makes up only a very small fraction of the catchment.
4	20006	35	125	125	0.302	140	1.000	0.000	0.67	6.3896	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
5	29004	32	157	157	0.146	160	0.993	1.310	0.65	2.5170	121.44	0.631	1107	A2	Regionally Important Aquifer - Karstified	0.903	N/A
6	19016	15	172	172	1.431	90	1.000	0.070	0.66	4.5539	117.82	0.687	1267	ESB stn	Locally Important Aquifer	1.001	Gauge seated on Karstic area. 40% Karstic.
7	16005	30	202	202	0.135	210	1.000	0.330	0.59	6.5236	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
8	29001	40	242	242	0.091	320	0.998	0.660	0.65	2.2204	115.48	0.581	1090	A1	Locally Important Aquifer	1.560	Gauge on Karstic Zone. Majority of catchment is locally important aquifer.
9	26010	35	277	277	0.086	315	0.937	0.000	0.69	1.9057	94.53	0.578	1064	B	Locally Important Aquifer	0.919	N/A
10	36015	33	310	310	0.764	330	0.955	0.020	0.68	3.0757	153.06	0.605	1091	A1	Poor Aquifer	1.893	N/A
11	26014	16	326	326	0.177	176	0.944	0.320	0.72	0.3279	215.14	0.634	1199	B	Locally Important Aquifer	0.827	N/A
12	35002	34	360	360	0.242	408	0.986	0.000	0.72	13.2628	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
13	34024	28	388	388	0.482	364	0.922	0.750	0.73	1.5181	127.23	0.522	1177	A2	Locally Important Aquifer	0.962	N/A
14	16003	27	415	415	0.437	378	0.999	0.200	0.59	5.3729	243.20	0.595	1192	A2	Locally Important Aquifer	0.952	N/A
15	26018	49	464	464	0.051	735	0.756	0.340	0.69	0.5534	119.48	0.649	1044	A2	Regionally Important Aquifer - Karstified	1.006	N/A
16	13002	19	483	483	0.038	304	1.000	0.000	0.56	4.9531	62.96	0.657	1044	B	Poor Aquifer	0.645	N/A
17	25158	18	501	501	0.818	306	1.000	0.000	0.59	6.9728	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A

Figure D.88: Flood Growth Curve Plot

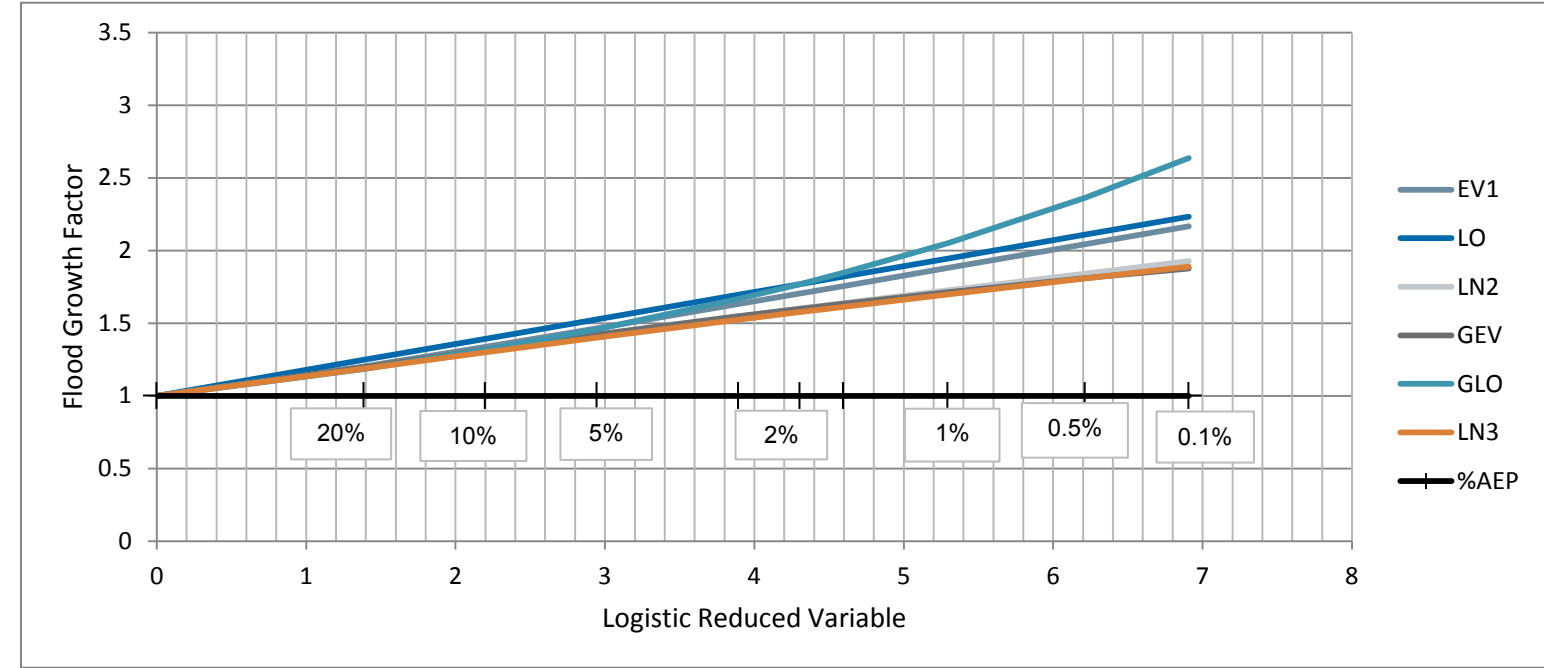


Figure D.89: L Moment Plot

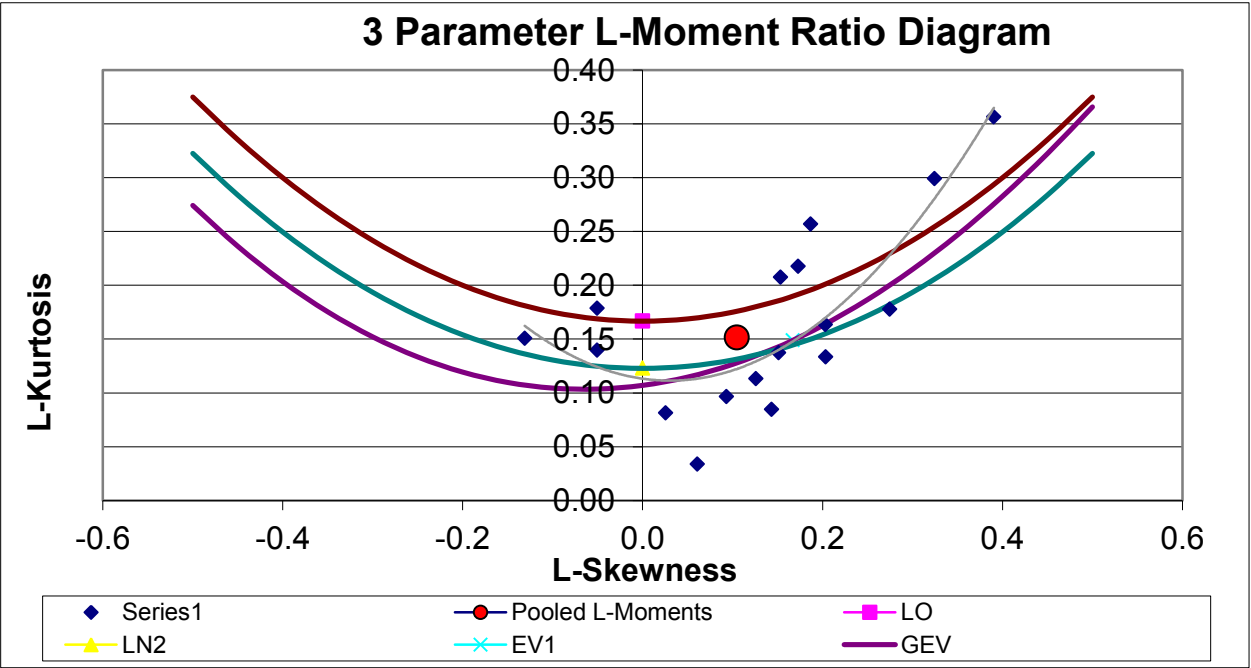


Table D.40: Cottoners River Reach Flood Frequency Analysis

Rank	Pooling Station No.	Record Length	Cumulative Years	Pooling Years Count	Discordancy (Di)	Effective record length	FARL	URBEXT	FLATWET	S1085	AREA	BFI	SAAR	FSU Class	Karstic Catchment?	HGF/QMED	Additional Comments
1	10004	14	14	14	1.647	14	0.986	0.000	0.54	25.0367	30.57	0.517	1700	B	Locally Important Aquifer	0.705	N/A
2	16013	33	47	47	0.120	66	0.993	0.000	0.58	24.5565	93.58	0.531	1471	B	Poor Aquifer	0.488	N/A
3	30001	18	65	65	0.790	54	0.935	0.000	0.70	5.1684	121.02	0.436	1787	A2	Locally Important Aquifer	1.022	N/A
4	35002	34	99	99	0.149	136	0.986	0.000	0.72	13.2628	88.82	0.523	1381	A2	Poor Aquifer	0.792	N/A
5	20006	35	134	134	0.186	175	1.000	0.000	0.67	6.3896	77.55	0.600	1463	B	Locally Important Aquifer	0.574	N/A
6	25158	18	152	152	0.504	108	1.000	0.000	0.59	6.9728	109.55	0.514	1377	A1	Locally Important Aquifer	1.364	N/A
7	19014	47	199	199	0.288	329	0.892	0.000	0.67	3.4620	170.76	0.426	2071	ESB stn	Poor Aquifer	0.801	N/A
8	10002	46	245	245	0.361	368	0.932	0.170	0.54	6.8989	230.89	0.516	1530	B	Locally Important Aquifer	0.721	Including large areas of Poor Aquifer strata.
9	23012	18	263	263	0.761	162	0.999	2.430	0.64	11.6740	61.63	0.427	1264	A2	Regionally Important Aquifer - Karstified (diffuse)	1.022	N/A
10	32012	24	287	287	0.169	240	0.843	0.000	0.72	4.1020	146.16	0.645	1784	A2	Locally Important Aquifer	1.106	N/A
11	27070	29	316	316	0.346	319	0.912	0.000	0.62	4.6464	143.58	0.642	1592	A2	Regionally Important Aquifer - Karstified (conduit)	1.147	N/A
12	27003	48	364	364	0.037	576	0.922	0.150	0.62	4.1497	166.42	0.639	1567	A2	Regionally Important Aquifer - Karstified (conduit)	1.370	N/A
13	34009	33	397	397	0.037	429	1.000	1.070	0.73	3.3251	117.11	0.443	1257	A2	Locally Important Aquifer	1.309	N/A
14	36071	20	417	417	0.403	280	0.823	0.000	0.70	13.6401	68.03	0.644	1315	B	Regionally Important Aquifer - Karstified (conduit)	0.939	Mix of geology. Majority Karstic.
15	35011	15	432	432	0.027	225	0.978	0.160	0.70	4.0710	293.23	0.534	1534	B	Regionally Important Aquifer - Karstified (conduit)	0.617	N/A
16	30020	16	448	448	0.047	256	1.000	0.990	0.72	2.8911	21.41	0.610	1191	B	Regionally Important Aquifer - Karstified (conduit)	0.882	N/A
17	16005	30	478	478	0.083	510	1.000	0.330	0.59	6.5236	84.00	0.542	1154	A2	Locally Important Aquifer	1.071	N/A
18	25044	40	518	518	0.042	720	0.997	0.000	0.59	2.6657	92.55	0.575	1187	A2	Locally Important Aquifer	1.256	N/A

Figure D.90: Flood Growth Curve Plot

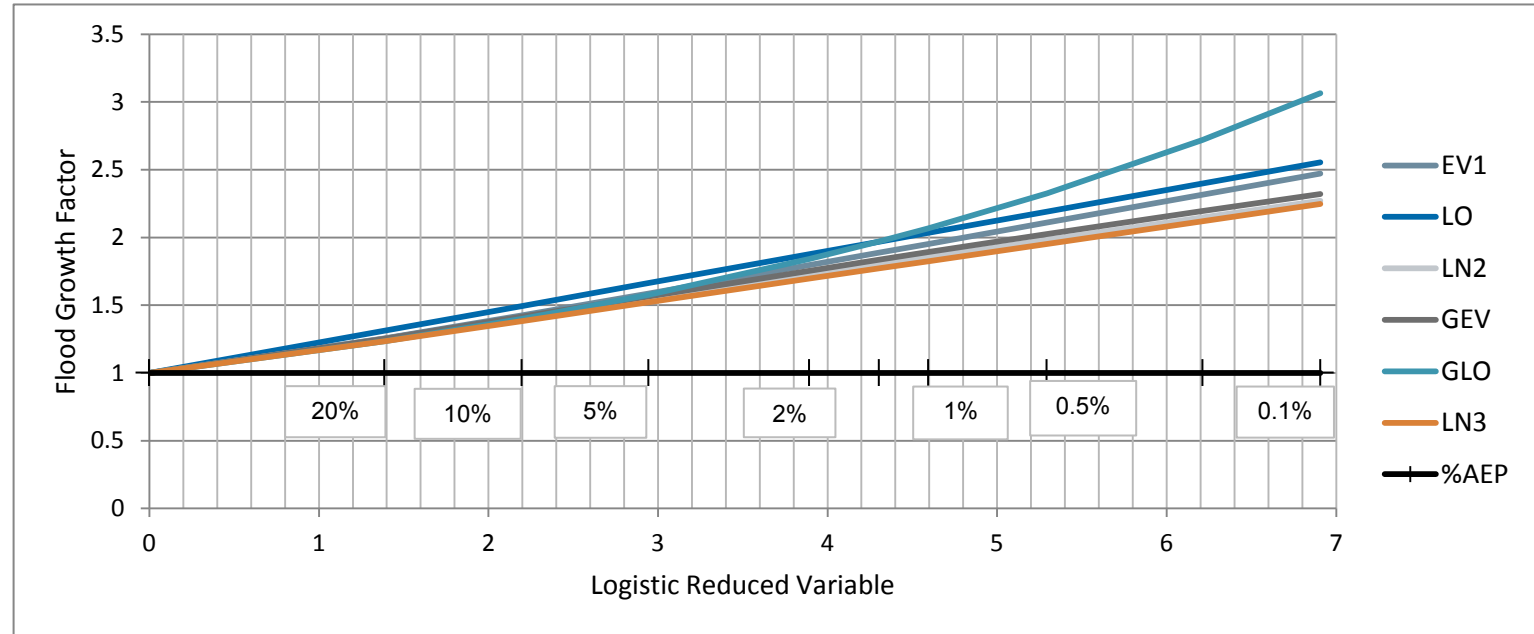


Figure D.91: L Moment Plot

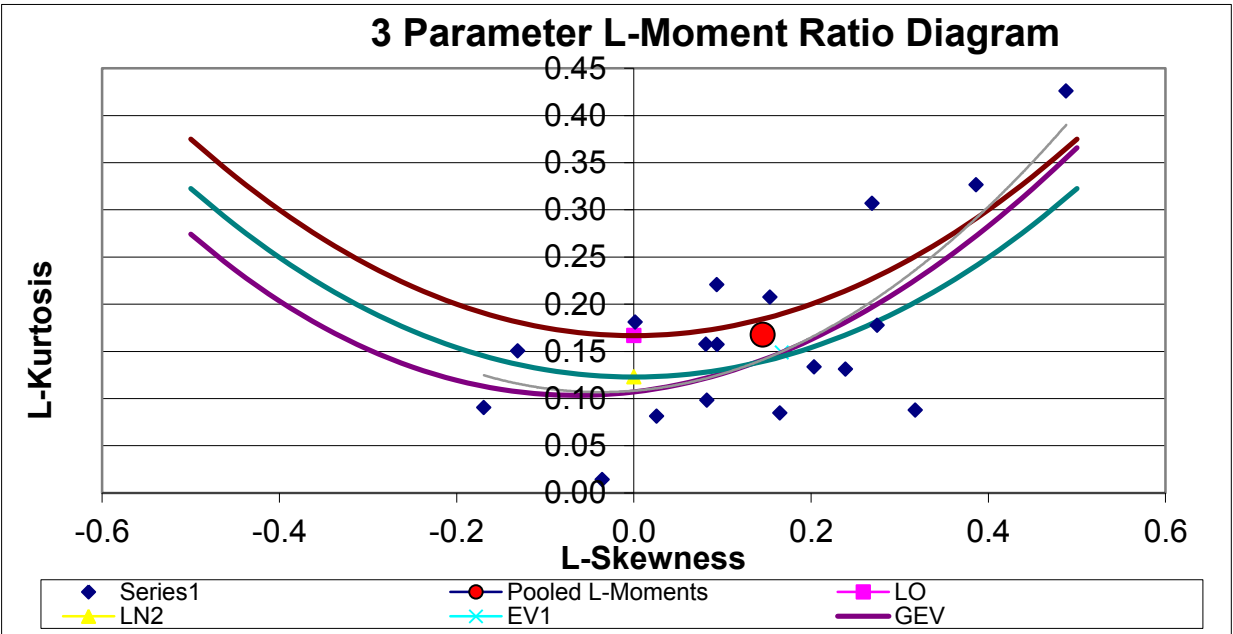
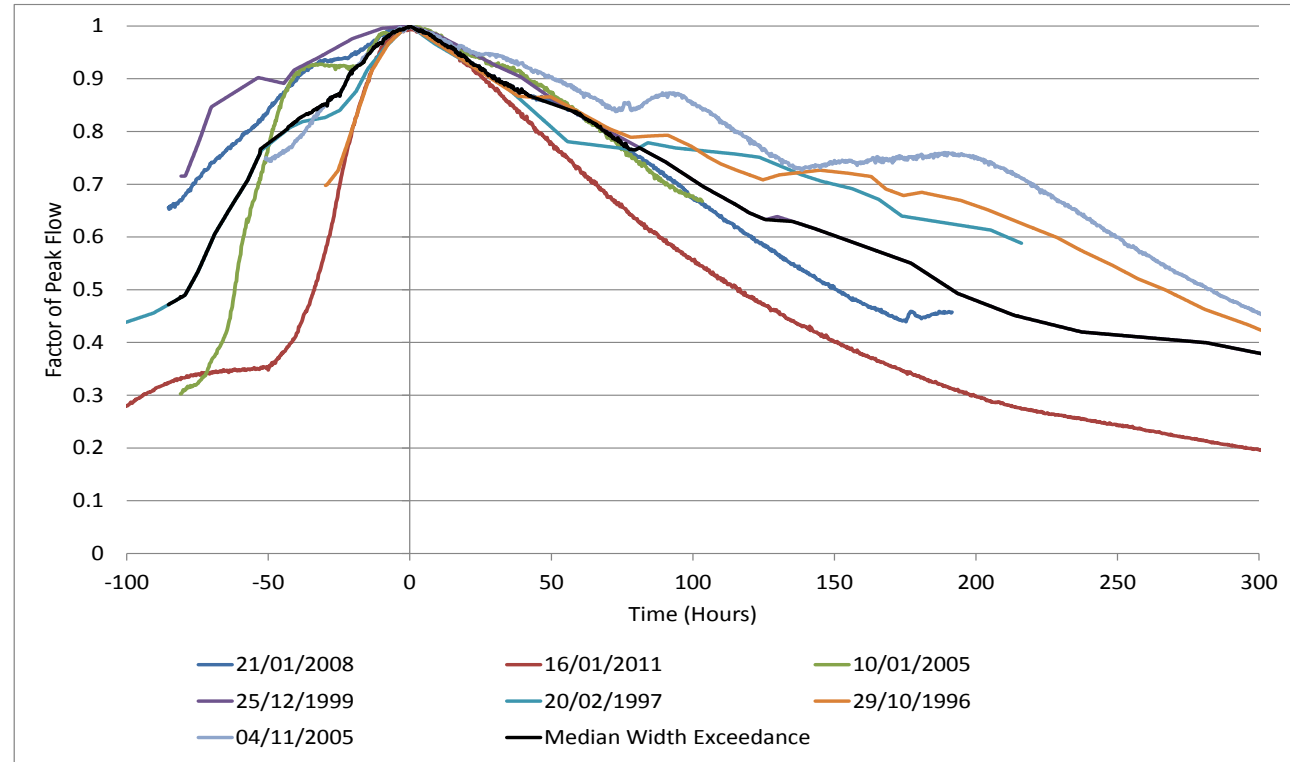


Figure D.92: Median Flood Hydrograph at Laune Bridge



Laune Bridge hydrograph extended to baseflow for hydraulic model based on FSU UPO-ERR Pivotal Sites below.

Figure D.94: UPO-ERR Gamma Hydrograph Based on Pivotal Site 22071

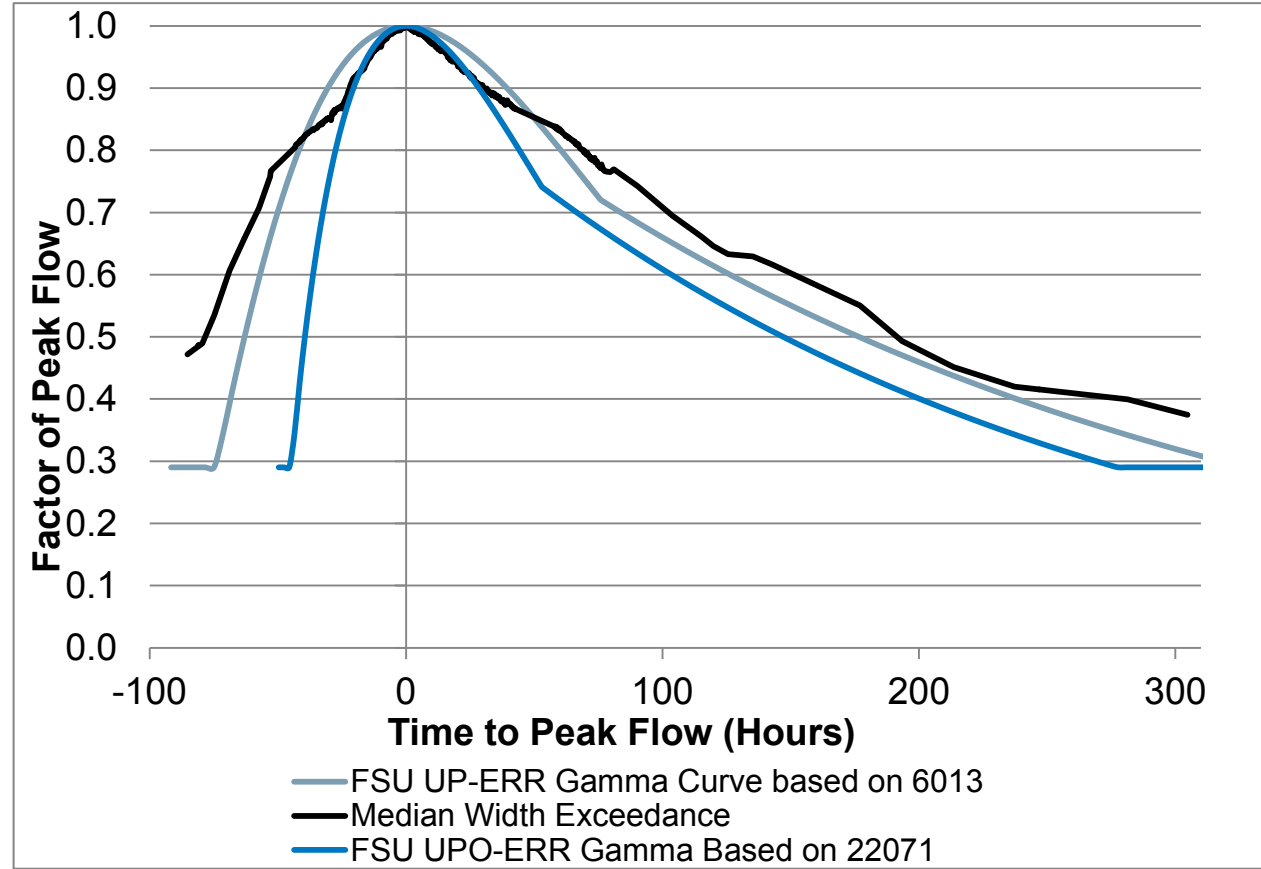


Figure D.93: UPO-ERR Gamma Hydrograph Based on Pivotal Site 16005

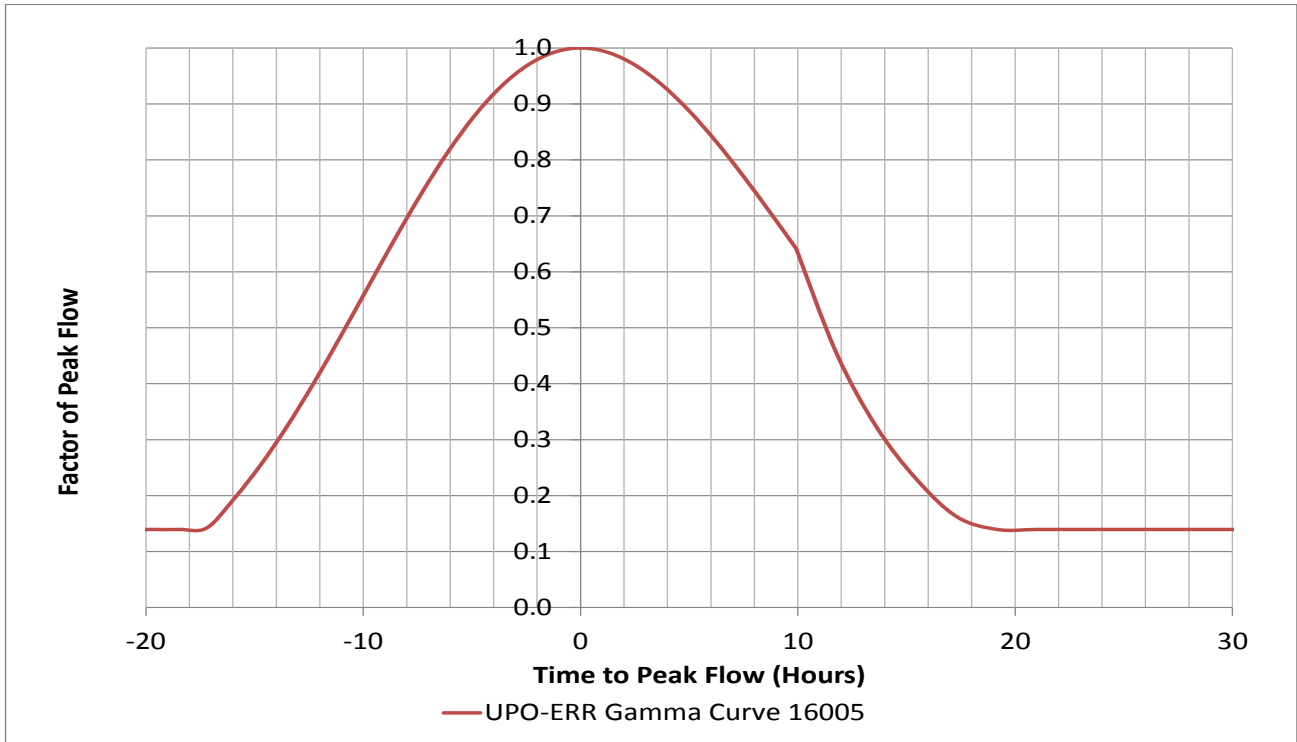


Figure D.95: UPO-ERR Gamma Hydrograph Based on pivotal Site 36021

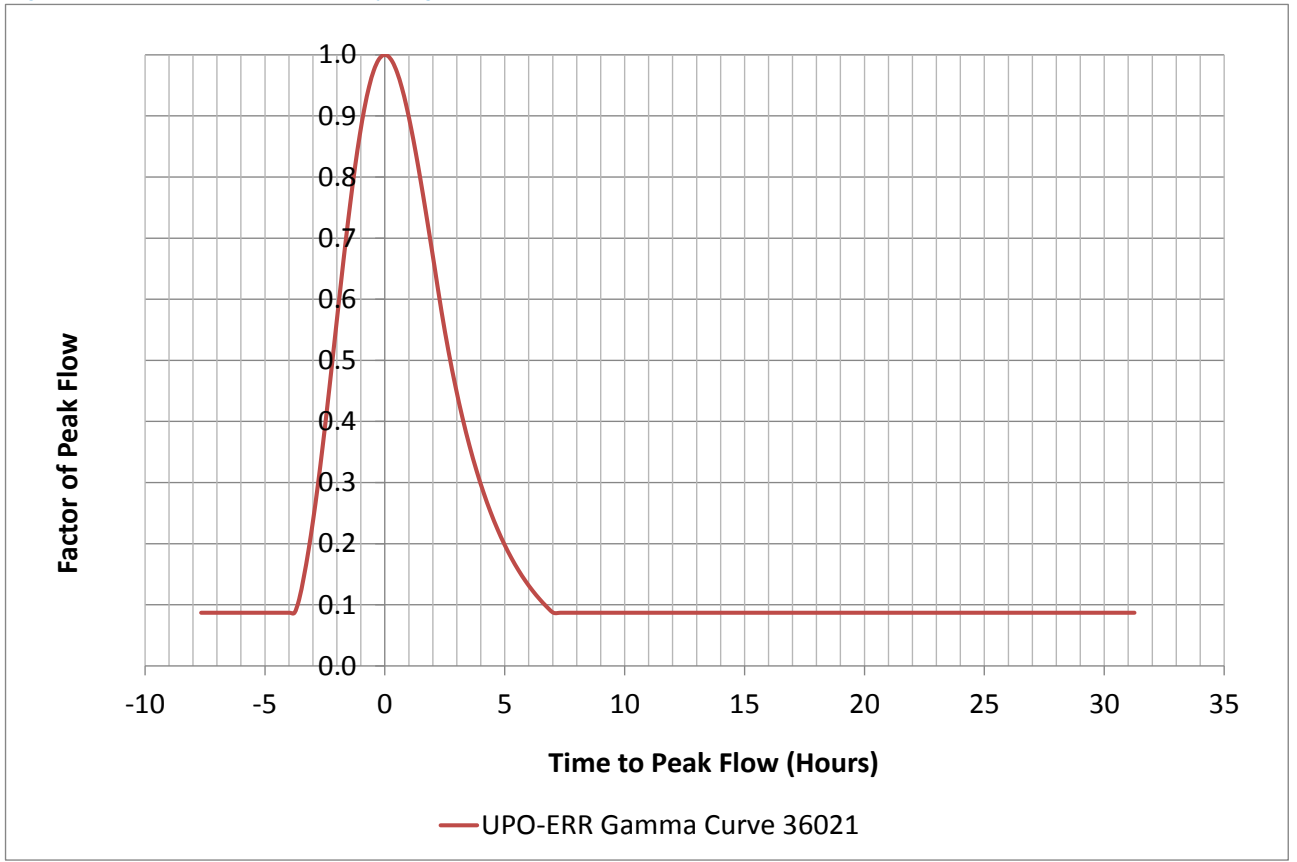


Table D.41: AFA Design Peak Flows

Design Flows																									Hydrograph Pivotal Site
LOCATION	HEP	Pivotal Site	QMED	95% Confidence Limit	Flood Growth Curve	50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1				
Laune upstream Survey Extent (Lake)	22_3290_1	22035	114	213.94	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	113.98	131.83	148.52	168.01	201.36	225.03	251.80	328.69	Transferred from Laune Bridge			
22035 (Laune Bridge)	22_510_2	Gauged	114	214.42	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	114.24	132.13	148.86	168.39	201.81	225.54	252.37	329.43	Gauged Median			
Laune upstream Loe	22_3057_2	22035	116	217.76	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	116.02	134.18	151.18	171.01	204.95	229.05	256.30	334.56	22071			
Loe upstream Laune	22_2899_4	19014	11	20.32	GLO-P	1.00	1.25	1.42	1.61	1.89	2.13	2.41	3.19	10.82	13.50	15.41	17.45	20.48	23.09	26.05	34.54	36021			
Laune downstream Loe	22_2900_1	22035	121	226.32	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	120.58	139.46	157.12	177.74	213.01	238.06	266.38	347.72	22071			
Luane upstream Gaddagh	22_1946_8	22035	121	227.01	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	120.95	139.89	157.60	178.28	213.66	238.79	267.19	348.77	22071			
Gaddagh upstream Laune	22_2753_4	19014	31	58.29	GLO-P	1.00	1.24	1.40	1.58	1.85	2.08	2.34	3.09	31.06	38.37	43.60	49.18	57.45	64.61	72.69	95.92	36021			
Luane downstream Gaddagh	22_2208_1	22035	133	249.53	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	132.95	153.76	173.23	195.97	234.85	262.47	293.70	383.37	22071			
Laune upstream Gweestin	22_2208_4	22035	133	250.33	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	133.38	154.26	173.79	196.60	235.61	263.31	294.64	384.60	22071			
Gweestin UPSTREAM (Survey extent)	22_2754_7	25044	20	37.48	GLO-P	1.00	1.21	1.36	1.52	1.76	1.97	2.21	2.88	19.97	24.20	27.22	30.45	35.23	39.36	44.04	57.46	16005			
Gweestin downstream Laune	22_2207_3	25044	25	46.54	GLO-P	1.00	1.21	1.36	1.52	1.76	1.97	2.21	2.88	24.80	30.04	33.80	37.80	43.74	48.87	54.68	71.35	16005			
Laune downstream Gweestin	22_3222_1	22035	160	300.44	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	160.07	185.13	208.57	235.95	282.77	316.02	353.61	461.58	16005			
HEP on Laune	22_2717_2	22035	170	318.70	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	169.80	196.38	221.25	250.29	299.95	335.23	375.10	489.64	22071			
HEP on Laune	22_3944_1+	22035	185	347.67	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	185.24	214.24	241.36	273.04	327.22	365.70	409.20	534.15	22071			
Laune Downstream	22_4001_4+	22035	186	349.17	SS+GLO-P	1.00	1.16	1.30	1.47	1.77	1.97	2.21	2.88	186.03	215.16	242.40	274.21	328.63	367.28	410.96	536.45	22071			
Cottoners River downstream at Laune	22_3946_9	22022	33	62.44	GLO-P	1.00	1.23	1.40	1.58	1.84	2.07	2.33	3.06	33.27	41.01	46.55	52.45	61.21	68.78	77.34	101.93	36021			

D.8 Lough Leane Water Level Analysis

Figure D.96: Tomies Pier Gauge Water Level Single Site Analysis

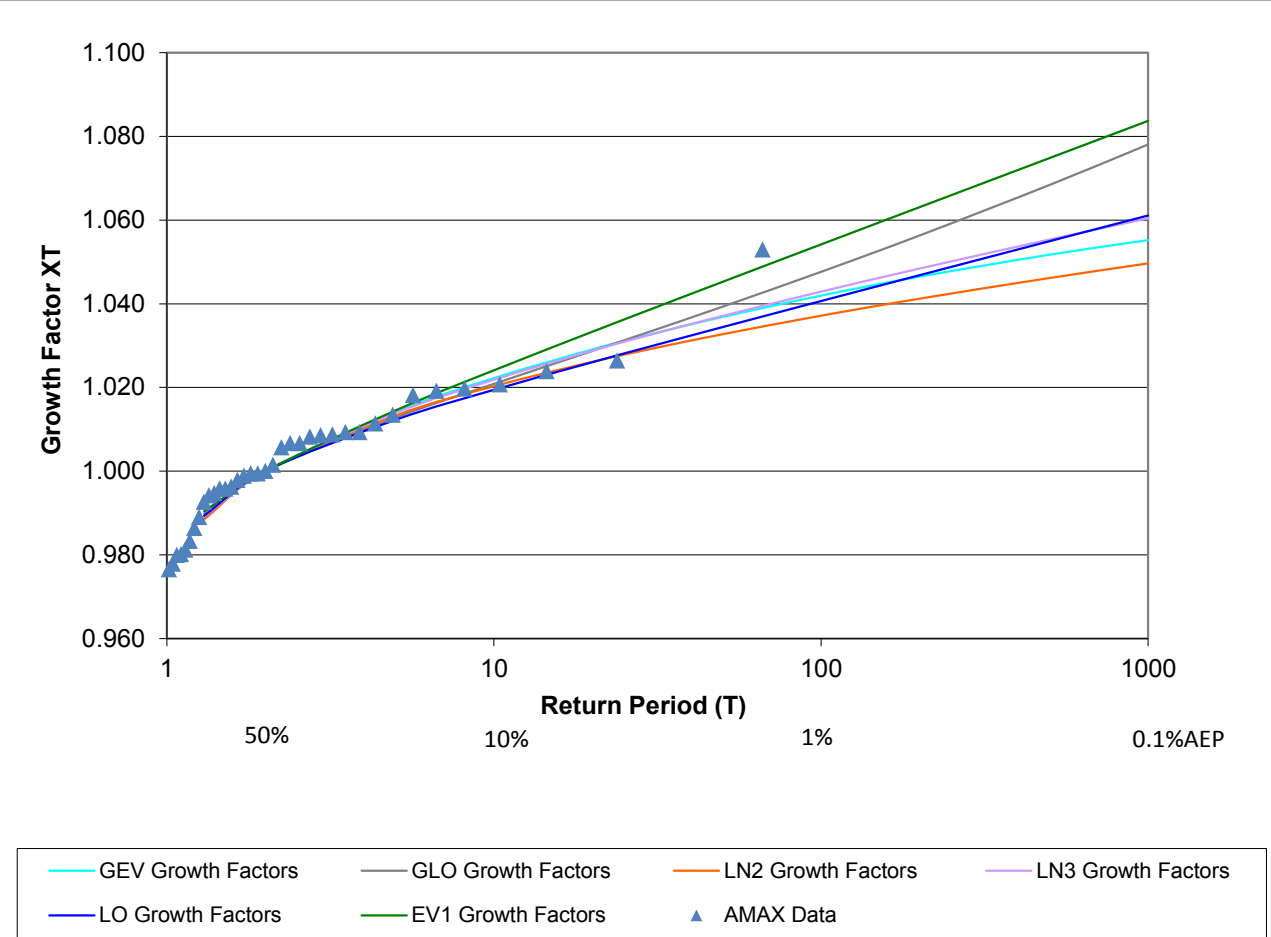


Figure D.97: BVM Park Gauge Water Level Single Site Analysis

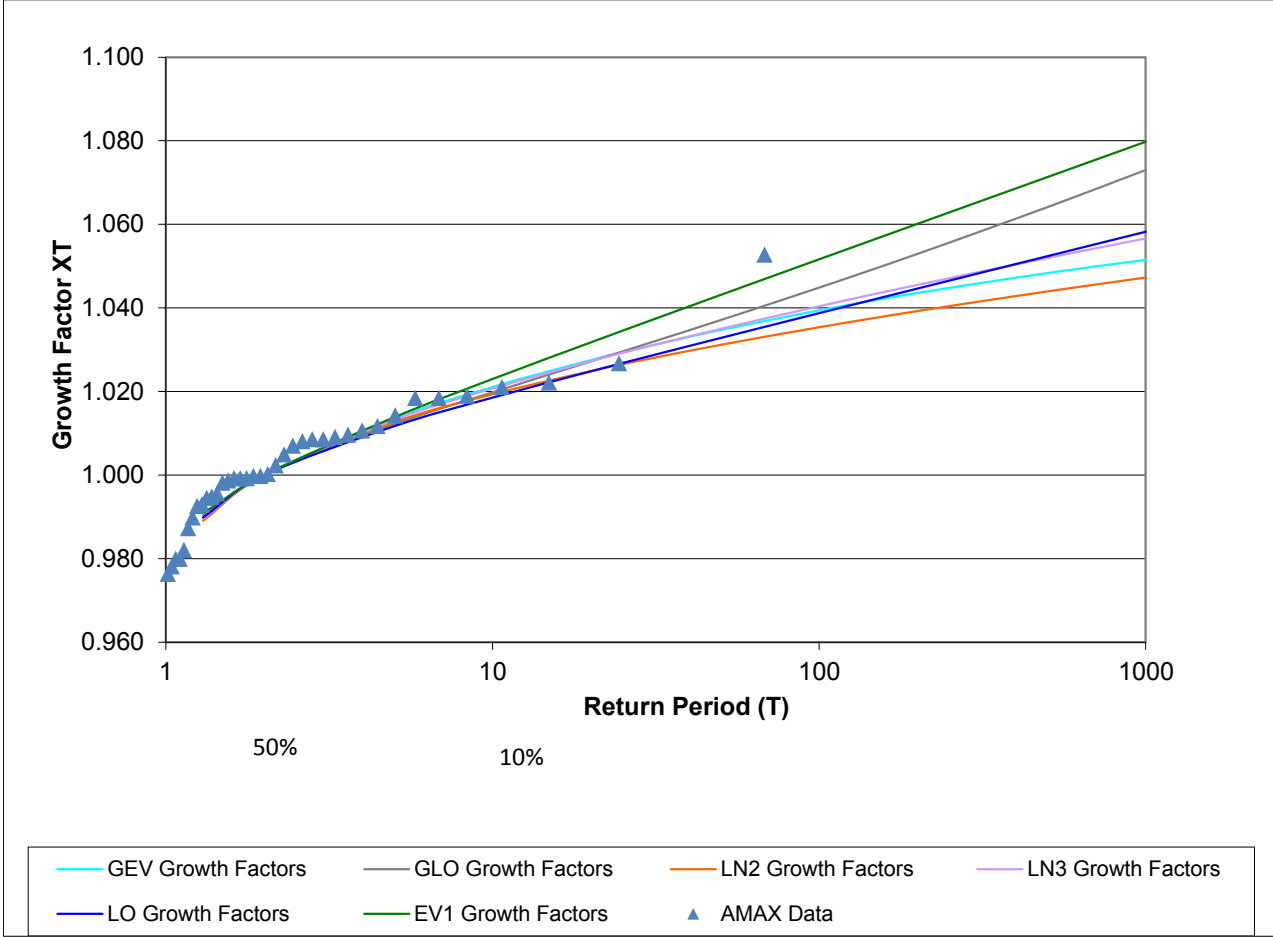


Table D.42: Lough Leane AFA Design Peak Flows

LOCATION	Gauge Number	Flood Growth Curve	Flood Growth Factor										Design Levels					
			50	20	10	5	2	1	0.5	0.1	50	20	10	5	2	1	0.5	0.1
Tomies Pier	22071	SS (EV1)	1.00	1.01	1.02	1.03	1.05	1.05	1.06	1.08	19.23	19.52	19.71	19.88	20.11	20.28	1.00	1.01
BVM Park	22082	SS (EV1)	1.00	1.01	1.02	1.03	1.05	1.05	1.06	1.08	19.23	19.52	19.71	19.88	20.11	20.28	1.00	1.01

D.9 Wave Overtopping Discharges

Provided on the next page.

Table D.43: Wave Overtopping Discharges - Dingle AFA *denotes critical overtopping scenario

Reach	Easting	Northing	Defence Type	Effective Crest Level (mODM)	Toe Level (mODM)	Length (m)	%AEP	Water Level (mODM)	Wave Height (m)	Wave Period(s)	Unit Discharge (m ³ /s/m)
A	43476	100889	Stone block vertical with ineffective wall Road assumed to be effective crest	2.52	0.92	366	50	1.79	0.30	2.52	0.00004
								1.86	0.29	2.53	0.00005
								1.94	0.28	2.53	0.00009
								2.05	0.26	2.54	0.00015
								2.12	0.25	2.54	0.00024
								2.20	0.22	2.55	0.00030 *
							20	1.79	0.34	2.53	0.00009
								1.94	0.33	2.54	0.00025
								2.05	0.31	2.55	0.00042
								2.12	0.30	2.55	0.00064
								2.20	0.27	2.56	0.00081
								2.30	0.24	2.57	0.00136 *
							10	1.79	0.37	2.55	0.00017
								1.94	0.35	2.56	0.00035
								2.12	0.32	2.57	0.00088
								2.20	0.29	2.58	0.00111
								2.30	0.27	2.58	0.00211
								2.38	0.24	2.58	0.00323 *
							5	1.79	0.40	2.57	0.00028
								1.94	0.39	2.58	0.00064
								2.12	0.36	2.59	0.00151
								2.30	0.31	2.60	0.00342
								2.38	0.28	2.60	0.00506
								2.45	0.24	2.60	0.00690 *
							2	1.86	0.43	2.59	0.00065
								2.05	0.41	2.60	0.00167
								2.20	0.38	2.61	0.00329
								2.38	0.32	2.61	0.00727
								2.45	0.27	2.61	0.00896
								2.54	0.23	2.60	Still water overtopping- Mechanism 1 dominates *
							1	1.86	0.46	2.62	0.000937
								2.05	0.44	2.62	0.002275
								2.20	0.42	2.63	0.004704
								2.38	0.36	2.64	0.009845
								2.54	0.30	2.63	Still water overtopping- Mechanism 1 dominates
								2.61	0.26	2.63	Still water overtopping- Mechanism 1 dominates *
							0.5	1.94	0.47	2.62	0.001632
								2.12	0.47	2.63	0.004416
								2.30	0.43	2.65	0.009341
								2.45	0.36	2.65	0.016323
								2.61	0.30	2.64	Still water overtopping- Mechanism 1 dominates
								2.68	0.24	2.63	Still water overtopping-Mechanism 1 dominates *
							0.1	1.94	0.54	2.70	0.003046
								2.12	0.54	2.70	0.007245
								2.30	0.51	2.71	0.014685
								2.45	0.46	2.71	0.026315
								2.61	0.38	2.69	Still water overtopping-Mechanism 1 dominates
								2.68	0.32	2.67	Still water overtopping-Mechanism 1 dominates *

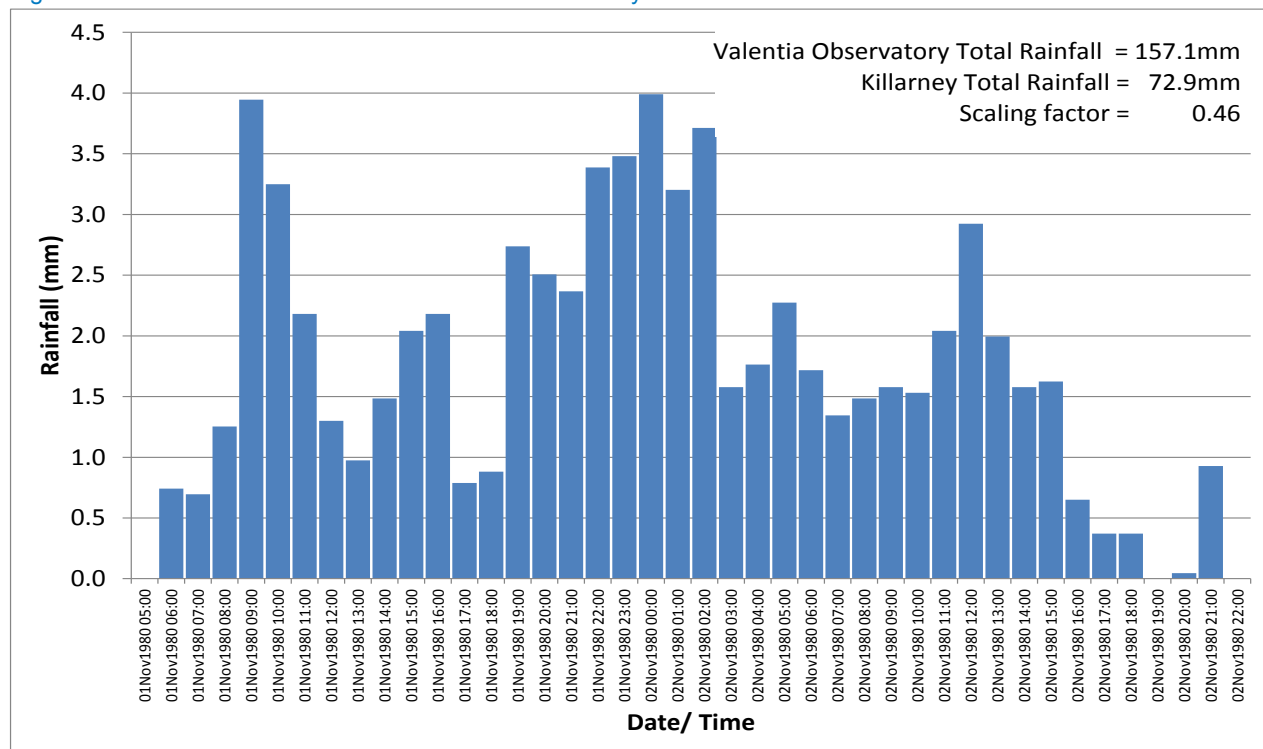
Reach	Easting	Northing	Defence Type	Effective Crest Level (mODM)	Toe Level (mODM)	Length (m)	%AEP	Water Level (mODM)	Wave Height (m)	Wave Period(s)	Unit Discharge (m3/s/m)	
B	43498	101211	Stone block vertical with ineffective wall Road assumed to be effective crest	2.53	0.97	214	50	1.79	0.34	2.56	0.00000	
								1.86	0.32	2.56	0.00000	
								1.94	0.29	2.57	0.00000	
								2.05	0.27	2.57	0.00001	
								2.12	0.24	2.58	0.00001	
								2.20	0.23	2.58	0.00003	*
							20	1.79	0.40	2.56	0.00000	
								1.94	0.37	2.57	0.00001	
								2.05	0.33	2.58	0.00001	
								2.12	0.32	2.58	0.00003	
								2.20	0.29	2.59	0.00006	
								2.30	0.25	2.59	0.00023	*
							10	1.79	0.44	2.57	0.00000	
								1.94	0.40	2.58	0.00001	
								2.12	0.36	2.59	0.00005	
								2.20	0.33	2.60	0.00010	
								2.30	0.28	2.60	0.00034	
								2.38	0.25	2.60	0.00121	*
							5	1.79	0.48	2.58	0.00000	
								1.94	0.45	2.60	0.00001	
								2.12	0.40	2.61	0.00007	
								2.30	0.32	2.62	0.00054	
								2.38	0.27	2.61	0.00152	
								2.45	0.25	2.61	0.00499	*
							2	1.86	0.51	2.59	0.00001	
								2.05	0.48	2.61	0.00006	
								2.20	0.43	2.62	0.00026	
								2.38	0.34	2.63	0.00269	
								2.45	0.29	2.62	0.00665	
								2.54	0.24	2.61	Still water overtopping -Mechanism 1 dominates	*
							1	1.86	0.55	2.61	0.00002	
								2.05	0.52	2.63	0.00009	
								2.20	0.47	2.64	0.00037	
								2.38	0.39	2.64	0.00373	
								2.54	0.30	2.63	Still water overtopping- Mechanism 1 dominates	
								2.61	0.24	2.62	Still water overtopping-Mechanism 1 dominates	*
							0.5	1.94	0.56	2.62	0.00004	
								2.12	0.54	2.63	0.00022	
								2.30	0.47	2.65	0.00170	
								2.45	0.39	2.65	0.01219	
								2.61	0.29	2.64	Still water overtopping - Mechanism 1 dominates	
								2.68	0.23	2.62	Still water overtopping-Mechanism 1 dominates	*
							0.1	1.94	0.66	2.66	0.00008	
								2.12	0.64	2.68	0.00042	
								2.30	0.58	2.70	0.00320	
								2.45	0.50	2.69	0.02011	
								2.61	0.40	2.68	Still water overtopping-Mechanism 1 dominates	
								2.68	0.37	2.67	Still water overtopping- Mechanism 1 dominates	*

Reach	Easting	Northing	Defence Type	Effective Crest Level (mODM)	Toe Level (mODM)	Length (m)	%AEP	Water Level (mODM)	Wave Height (m)	Wave Period(s)	Unit Discharge (m3/s/m)	
C	43683	101109	Concrete vertical wall	3.75	0.91	242	50	1.79	0.43	2.61	0.00000	
								1.86	0.40	2.62	0.00000	
								1.94	0.36	2.63	0.00000	
								2.05	0.32	2.64	0.00000	
								2.12	0.30	2.64	0.00000	
								2.20	0.26	2.65	0.00000	
							20	1.79	0.50	2.63	0.00003	*
								1.94	0.45	2.64	0.00000	
								2.05	0.40	2.65	0.00000	
								2.12	0.35	2.65	0.00000	
								2.20	0.32	2.65	0.00000	
								2.30	0.27	2.66	0.00000	
							10	1.79	0.56	2.64	0.00005	*
								1.94	0.50	2.65	0.00000	
								2.12	0.41	2.65	0.00000	
								2.20	0.38	2.65	0.00000	
								2.30	0.33	2.65	0.00000	
								2.38	0.28	2.65	0.00000	
							5	1.79	0.61	2.65	0.00007	*
								1.94	0.55	2.66	0.00005	
								2.12	0.48	2.66	0.00001	
								2.30	0.38	2.66	0.00000	
								2.38	0.34	2.65	0.00000	
								2.45	0.30	2.65	0.00000	
							2	1.86	0.66	2.66	0.00010	*
								2.05	0.60	2.67	0.00004	
								2.20	0.52	2.67	0.00002	
								2.38	0.42	2.67	0.00001	
								2.45	0.38	2.66	0.00000	
								2.54	0.31	2.66	0.00000	
							1	1.86	0.72	2.67	0.00014	*
								2.05	0.66	2.68	0.00012	
								2.20	0.59	2.67	0.00006	
								2.38	0.48	2.67	0.00003	
								2.54	0.36	2.65	0.00000	
								2.61	0.33	2.65	0.00000	
							0.5	1.94	0.74	2.68	0.00017	*
								2.12	0.69	2.69	0.00015	
								2.30	0.59	2.69	0.00010	
								2.45	0.49	2.68	0.00004	
								2.61	0.39	2.68	0.00000	
								2.68	0.31	2.69	0.00000	
							0.1	1.94	0.88	2.75	0.00038	
								2.12	0.82	2.75	0.00053	*
								2.30	0.72	2.72	0.00041	
								2.45	0.64	2.71	0.00033	
								2.61	0.54	2.70	0.00021	
								2.68	0.47	2.68	0.00011	

Reach	Easting	Northing	Defence Type	Effective Crest Level (mODM)	Toe Level (mODM)	Length (m)	%AEP	Water Level (mODM)	Wave Height (m)	Wave Period(s)	Unit Discharge (m3/s/m)	
D	43907	101021	Concrete vertical wall	3.47	0.91	131	50	1.79	0.51	2.57	0.00005	*
								1.86	0.49	2.58	0.00004	
								1.94	0.45	2.59	0.00001	
								2.05	0.40	2.60	0.00000	
								2.12	0.38	2.60	0.00000	
								2.20	0.34	2.61	0.00000	
							20	1.79	0.60	2.59	0.00009	*
								1.94	0.56	2.60	0.00008	
								2.05	0.51	2.60	0.00003	
								2.12	0.45	2.61	0.00002	
								2.20	0.42	2.61	0.00001	
								2.30	0.36	2.62	0.00001	
							10	1.79	0.67	2.61	0.00015	*
								1.94	0.62	2.61	0.00013	
								2.12	0.52	2.62	0.00006	
								2.20	0.49	2.62	0.00005	
								2.30	0.42	2.62	0.00002	
								2.38	0.37	2.62	0.00001	
							5	1.79	0.74	2.62	0.00023	*
								1.94	0.68	2.63	0.00020	
								2.12	0.60	2.63	0.00017	
								2.30	0.49	2.63	0.00009	
								2.38	0.44	2.63	0.00006	
								2.45	0.38	2.63	0.00003	
							2	1.86	0.78	2.64	0.00032	
								2.05	0.73	2.64	0.00035	
								2.20	0.65	2.65	0.00041	*
								2.38	0.54	2.65	0.00026	
								2.45	0.48	2.65	0.00017	
								2.54	0.40	2.65	0.00008	
							1	1.86	0.85	2.66	0.00046	
								2.05	0.80	2.67	0.00089	*
								2.20	0.73	2.67	0.00085	
								2.38	0.61	2.66	0.00057	
								2.54	0.46	2.65	0.00020	
								2.61	0.42	2.65	0.00017	
							0.5	1.94	0.88	2.67	0.00059	
								2.12	0.83	2.68	0.00138	*
								2.30	0.73	2.68	0.00121	
								2.45	0.61	2.67	0.00081	
								2.61	0.49	2.67	0.00045	
								2.68	0.40	2.67	0.00019	
							0.1	1.94	1.07	2.75	0.00144	
								2.12	0.99	2.76	0.00356	*
								2.30	0.88	2.74	0.00326	
								2.45	0.79	2.72	0.00307	
								2.61	0.67	2.70	0.00244	
								2.68	0.58	2.68	0.00163	

Appendix E. Calibration Hydrology

Figure E.1: 2nd November 1980 Rainfall Profile – Killarney AFA



Source: Profile transferred from Valentia Observatory Hourly Rainfall Series

Figure E.2: 2nd November 1980 Calibrated Rainfall-Runoff Hydrograph at Flesk Bridge Gauge (22006)

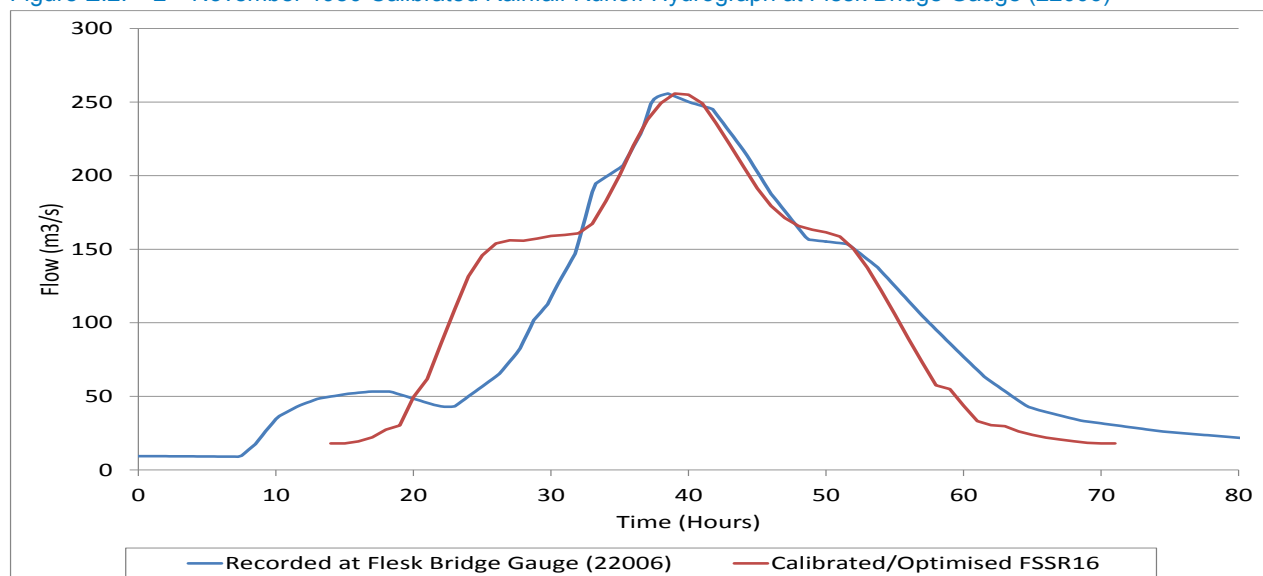
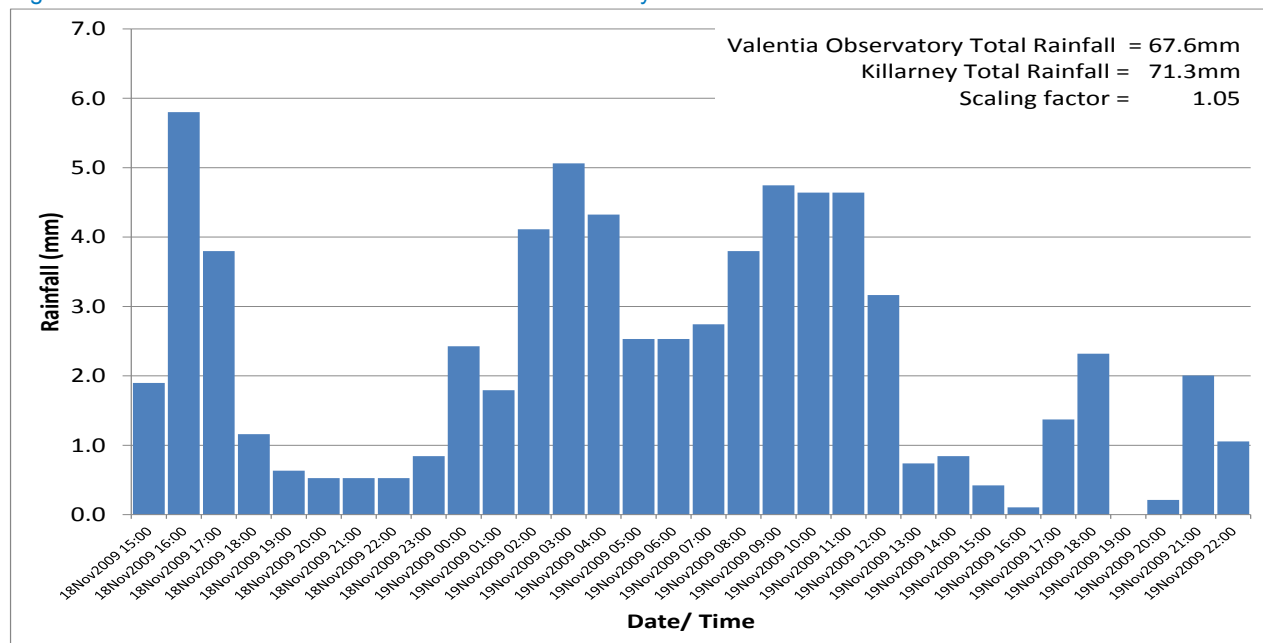


Table E.1: 2nd November 1980 Rainfall Runoff Parameters – Killarney AFA

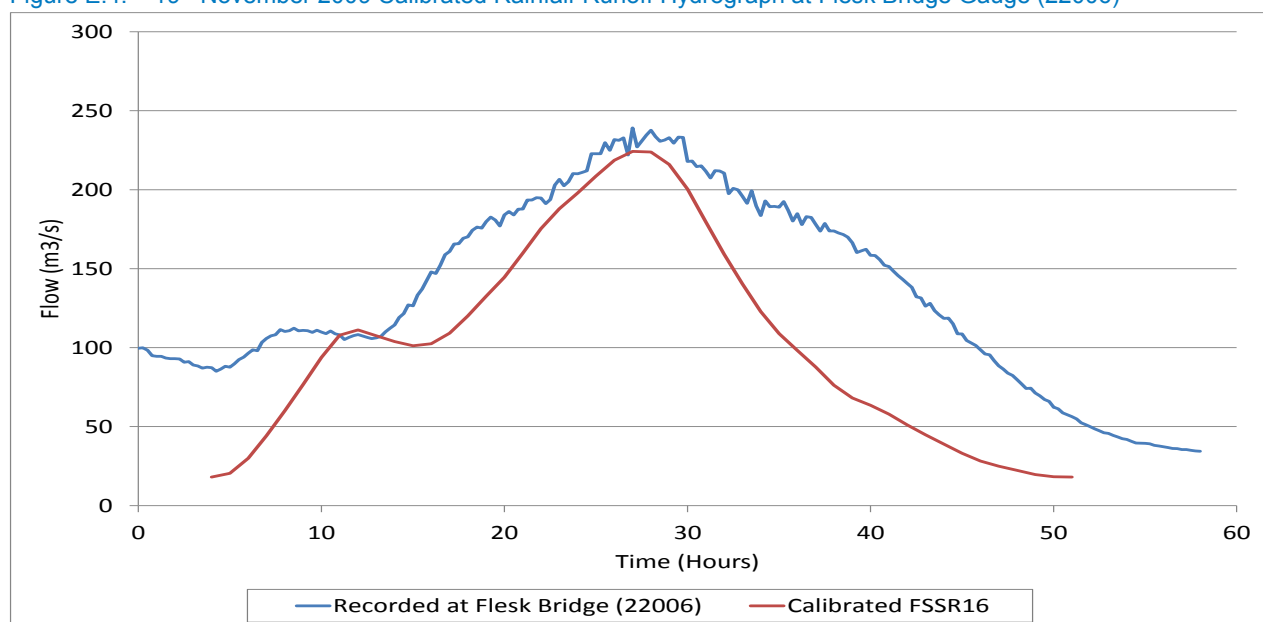
FSSR 16 Parameter	Flesk Bridge (22006)	HEP 22_4003_4	HEP 22_4003_14	HEP 22_2197_1	HEP 22_2197_1	HEP 22_2197_3
M5 - 2 day (mm)	92.3	92.3	92.3	92.3	92.3	92.3
M5 -25 day (mm)	350.2	350.2	350.2	350.2	350.2	350.2
Jenkinson's <i>r</i>	0.201	0.201	0.201	0.201	0.201	0.201
Catchment Wetness Index (CWI)	124	124	124	124	124	124
Standard Percentage Runoff	80% (original 46%)	80% (original 46%)	80% (original 46%)	80% (original 46%)	80% (original 46%)	80% (original 46%)
Storm Duration, D (hours)	42	42	42	42	42	42
Rainfall Depth (mm)	72.9	72.9	72.9	72.9	72.9	72.9

Figure E.3: 19th November 2009 Rainfall Profile – Killarney AFA



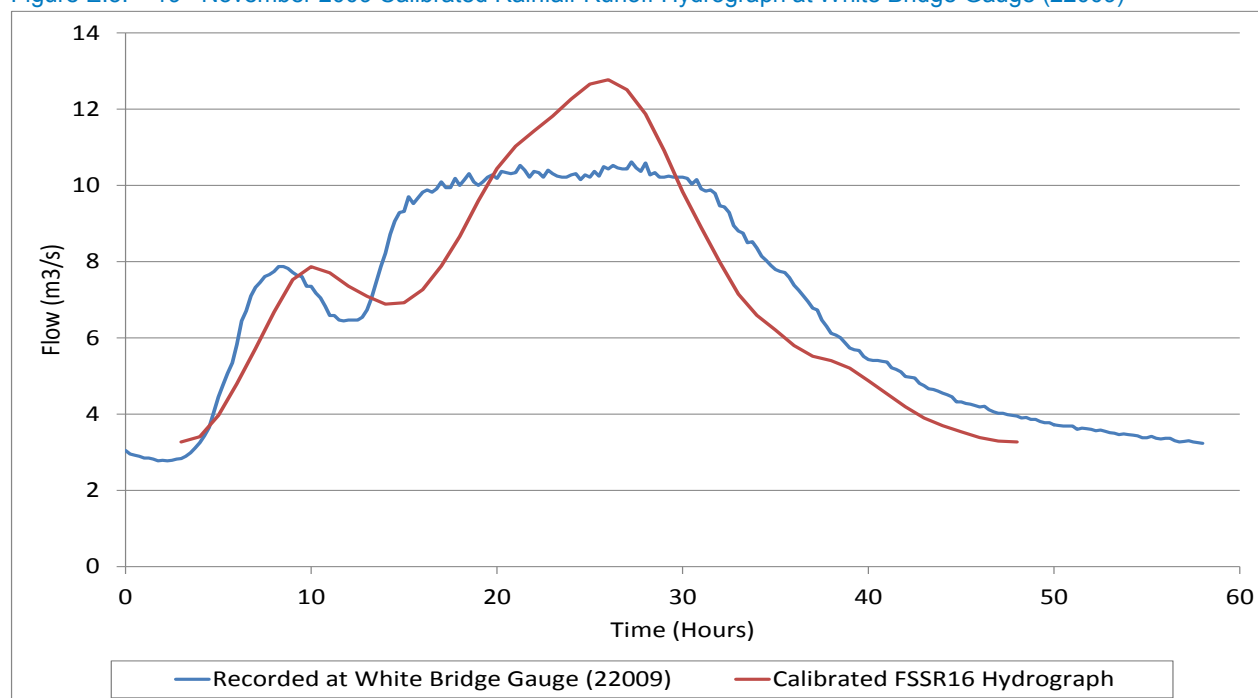
Source: Profile transferred from Valentia Observatory Hourly Rainfall Series

Figure E.4: 19th November 2009 Calibrated Rainfall-Runoff Hydrograph at Flesk Bridge Gauge (22006)



Note: The difference in rising and falling limb results from the backwater of the extreme Lough levels which is not reflected in the rainfall-runoff routing.

Figure E.5: 19th November 2009 Calibrated Rainfall-Runoff Hydrograph at White Bridge Gauge (22009)



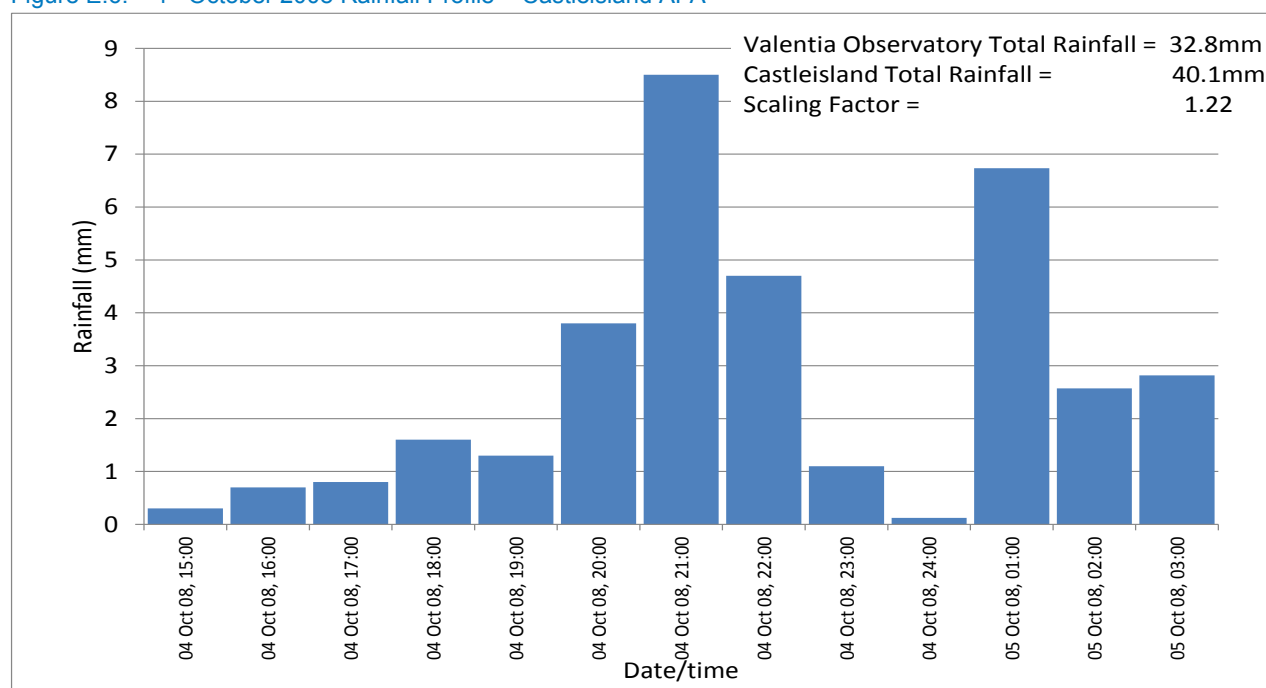
Note1: The flat peak may be attributed to a suspect rating curve once out of bank which does not necessarily reflect the large increase in flow for the small increase in level.

Note2: The difference in rising and falling limb results from the backwater of the extreme Lough levels which is not reflected in the rainfall-runoff routing.

Table E.2: 19th November 2009 Rainfall Runoff Parameters – Killarney AFA

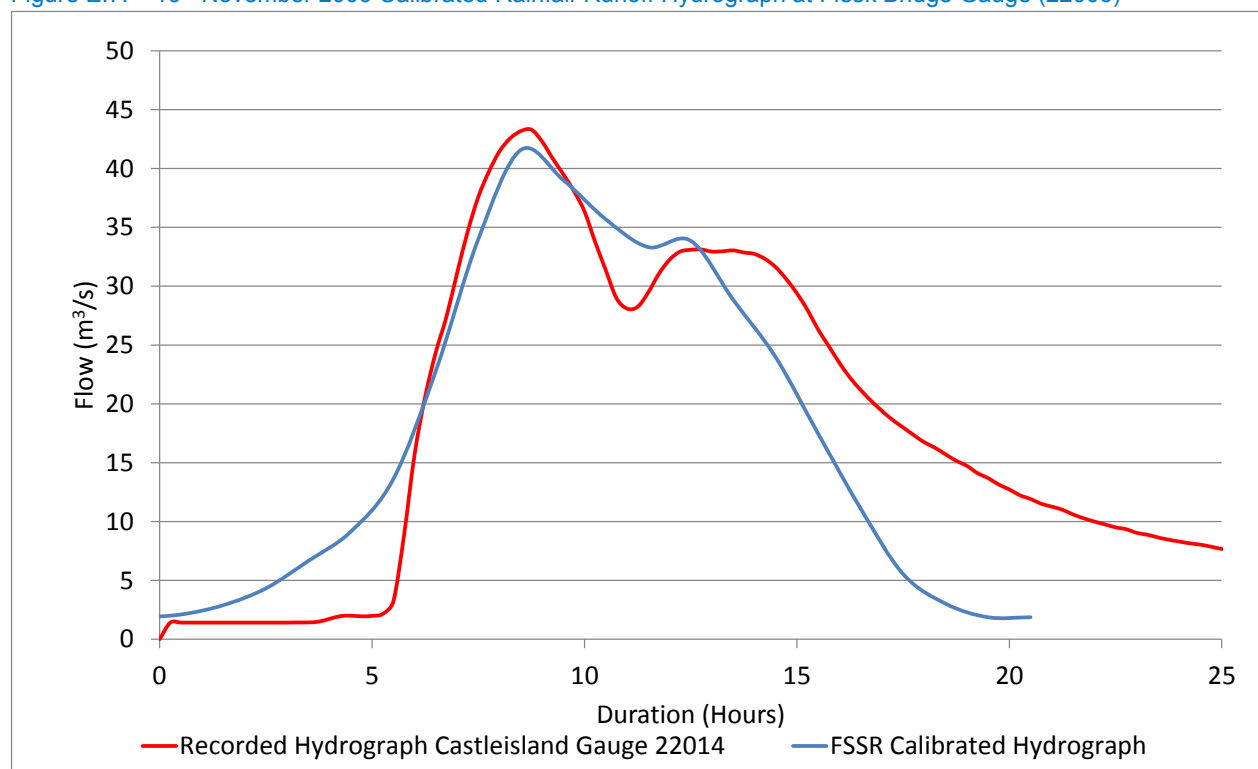
FSSR 16 Parameter	Flesk Bridge (22006)	HEP 22_4003_4	HEP 22_4003_14	HEP 22_2197_1	HEP 22_2197_1	HEP 22_2197_3
M5 - 2 day (mm)	92.3	92.3	92.3	92.3	92.3	92.3
M5 -25 day (mm)	350.2	350.2	350.2	350.2	350.2	350.2
Jenkinson's <i>r</i>	0.201	0.201	0.201	0.201	0.201	0.201
Catchment Wetness Index (CWI)	130	130	130	130	130	130
Standard Percentage Runoff	58% (original 46%)	58% (original 46%)	58% (original 46%)	58% (original 46%)	58% (original 46%)	58% (original 46%)
Storm Duration, D (hours)	32	32	32	32	32	32
Rainfall Depth (mm)	71.3	71.3	71.3	71.3	71.3	71.3

Figure E.6: 4th October 2008 Rainfall Profile – Castleisland AFA



Source: Profile transferred from Valentia Observatory Hourly Rainfall Series

Figure E.7: 19th November 2009 Calibrated Rainfall-Runoff Hydrograph at Flesk Bridge Gauge (22006)



Note: The difference on the falling limb results from the backwater from the Glenshearoon inflow 150m downstream of the gauge.

Table E.3: 4th October 2008 Event Calibrated Rainfall Runoff Parameters- Castleisland AFA

FSSR 16 Parameter	Castleisland Gauge (22014)	Glanshearoon inflow HEP 22_191_1	Shanowen inflow HEP 22_1589_3	Anglore inflow HEP 22_1331_3
M5 - 2 day (mm)	68.400	68.000	68.400	68.00
M5 -25 day (mm)	247.100	248.5000	247.100	248.500
Jenkinson's <i>r</i>	0.251	0.259	0.251	0.259
Catchment Wetness Index (CWI)	125	125	125	125
Standard Percentage Runoff	60% (original 32%)	60% (original 32%)	60% (original 32%)	60% (original 32%)
Storm Duration, D (hours)	15	15	15	15
Rainfall Depth (mm)	42.7	42.7	42.7	42.7

Appendix F. Future Peak Flows and Water Levels

Table F.1: Future Peak Flows

Location	MRFS Design Peak Flows (m³/s)									HEFS Design Peak Flows (m³/s)							
	HEP	50%AEP	20	10	5	2	1	0.5	0.1	50%AEP	20	10	5	2	1	0.5	0.1
Flesk UPSTREAM	22_3712_1	79.0	93.9	102.7	110.7	130.6	148.5	173.5	226.3	85.5	101.7	111.2	119.9	141.5	160.9	188.0	245.2
Flesk upstream @ Flesk/Loo Confluence	22_3712_4	83.5	99.3	108.6	117.1	138.1	157.1	183.5	239.3	90.5	107.6	117.6	126.8	149.6	170.2	198.8	259.3
Loo downstream @ Flesk/Loo Confluence	22_1553_4	42.4	52.9	60.4	68.4	80.3	90.6	102.2	135.6	45.9	57.3	65.4	74.1	87.0	98.1	110.7	146.9
Flesk downstream @ Loo/Flesk Confluence	22_2688_1	125.8	149.6	163.6	176.4	208.1	236.7	276.5	360.6	136.3	162.1	177.2	191.1	225.4	256.4	299.5	390.6
Flesk upstream @ Flesk/A.B Confluence	22_1561_2	127.7	151.9	166.1	179.1	211.3	240.3	280.7	366.1	138.4	164.6	179.9	194.0	228.9	260.3	304.1	396.6
Annagh Beg Stream downstream @ Flesk/A.B. Confluence	22_245_2	4.5	5.6	6.4	7.3	8.5	9.6	10.9	14.4	4.9	6.1	6.9	7.9	9.2	10.4	11.8	15.6
Flesk downstream @ Flesk/A.B. Confluence	22_1567_1	132.2	157.2	171.9	185.4	218.7	248.7	290.5	378.9	143.2	170.3	186.2	200.8	236.9	269.4	314.8	410.5
Flesk upstream Owneskeagh	22_1560_3	135.1	160.7	175.7	189.4	223.5	254.2	296.9	387.2	146.4	174.1	190.3	205.2	242.1	275.3	321.7	419.5
Owneskeagh downstream @ Owneskeagh/Flesk Confluence	22_2883_9	46.0	55.4	62.2	69.3	80.0	89.2	99.6	129.5	49.8	60.0	67.3	75.1	86.7	96.6	107.9	140.3
Flesk downstream Owneskeagh	22_2859_1	181.0	215.3	235.3	253.8	299.4	340.5	397.8	518.8	196.1	233.2	254.9	275.0	324.4	368.9	431.0	562.0
Flesk upstream @Finow	22_2705_5	185.6	220.7	241.3	260.3	307.0	349.2	407.9	531.9	201.1	239.1	261.4	281.9	332.6	378.2	441.9	576.3
Finow downstream @ Flesk/Finow Clonfluence	22_1927_3	50.1	61.9	70.4	79.4	92.8	104.4	117.5	155.1	54.3	67.1	76.3	86.1	100.6	113.1	127.3	168.0
Flesk downstream @Finow	22_3340_1	188.2	223.8	244.7	263.9	311.3	354.0	413.6	539.4	203.9	242.5	265.1	285.9	337.2	383.5	448.1	584.3
Deenagh upstream Survey Extent	22_4003_4	10.3	11.6	13.2	14.9	18.0	20.8	23.9	31.5	11.2	12.6	14.3	16.1	19.5	22.5	25.9	34.2
22009 (White Bridge)	22_4003_14	19.2	21.7	24.6	27.7	33.6	38.7	44.6	58.7	21.50	24.31	27.53	31.05	37.65	43.38	49.96	65.84
Deenagh downstream Survey Extent & AFA Boundary	22_4003_16	19.4	21.9	24.8	28.0	33.9	39.1	45.0	59.3	21.7	24.6	27.8	31.4	38.0	43.8	50.5	66.5
Woodford upstream Survey Extent	22_2197_1	8.2	10.3	11.8	13.3	15.6	17.7	19.9	26.4	8.9	11.1	12.7	14.4	16.9	19.1	21.6	28.6
Woodford upstream Flesk	22_2197_3	9.1	11.3	12.9	14.6	17.2	19.4	21.9	29.0	9.8	12.3	14.0	15.9	18.7	21.1	23.8	31.5
Flesk UPSTREAM	22_3340_8	188.5	224.2	245.1	275.2	322.3	365.7	414.3	540.2	204.2	242.9	265.5	298.1	349.2	396.1	448.8	585.2
Flesk upstream Woodford	22_3340_10	188.8	224.5	245.4	275.6	322.8	366.2	414.9	541.0	204.5	243.2	265.9	298.6	349.7	396.8	449.5	586.1
Flesk downstream Woodford	22_3372_1	197.9	235.4	257.3	288.9	338.4	383.9	434.9	567.1	214.4	255.0	278.8	313.0	366.6	416.0	471.2	614.5
22006 (Flesk Bridge)	22_3372_6	213.2	253.6	277.2	311.3	364.6	413.6	468.5	611.0	231.8	275.7	301.4	338.5	396.5	449.8	509.5	664.5
Flesk downstream Survey Extent & AFA Boundary	22_3372_11	216.6	257.6	281.6	316.2	370.4	420.2	476.0	620.8	235.7	280.4	306.5	344.2	403.1	457.3	518.1	675.7
Laune upstream Survey Extent (Lake)	22_3290_1	144.1	166.6	187.7	212.3	251.9	281.2	314.2	409.2	157.1	181.7	204.7	231.6	274.8	306.7	342.7	446.3
22035 (Laune Bridge)	22_510_2	144.4	167.0	188.1	212.8	252.5	281.8	314.9	410.1	157.5	182.1	205.2	232.1	275.4	307.4	343.5	447.3
Laune upstream Loe	22_3057_2	146.6	169.5	191.0	216.0	256.3	286.0	319.7	416.2	159.8	184.9	208.3	235.6	279.5	312.0	348.6	454.0
Loe upstream Laune	22_2899_4	13.0	16.2	18.5	20.9	24.6	27.7	31.3	41.4	14.1	17.5	20.0	22.7	26.6	30.0	33.9	44.9
Laune downstream Loe	22_2900_1	152.1	175.9	198.2	224.2	266.0	296.8	331.7	431.9	165.8	191.8	216.1	244.4	290.0	323.7	361.7	471.0
Laune upstream Gaddagh	22_1946_8	152.3	176.1	198.4	224.5	266.3	297.3	332.2	432.6	166.0	192.0	216.3	244.7	290.4	324.1	362.2	471.6
Gaddagh upstream Laune	22_2753_4	37.3	46.0	52.3	59.0	68.9	77.5	87.2	115.1	40.4	49.9	56.7	63.9	74.7	84.0	94.5	124.7
Laune downstream Gaddagh	22_2208_1	166.9	193.0	217.4	246.0	291.8	325.7	364.0	474.0	181.9	210.3	237.0	268.1	318.0	354.9	396.7	516.5
Laune upstream Gweestin	22_2208_4	167.4	193.6	218.1	246.8	292.8	326.8	365.2	475.5	182.4	211.0	237.7	268.9	319.1	356.1	397.9	518.2
Gweestin downstream Laune	22_2207_3	72.3	85.6	95.1	105.3	120.4	133.4	148.1	190.5	78.3	92.7	103.1	114.1	130.4	144.5	160.5	206.4
Laune downstream Gweestin	22_3222_1	199.9	231.2	260.4	294.6	349.5	390.1	435.9	567.7	217.7	251.7	283.6	320.8	380.6	424.8	474.8	618.2
HEP on Laune	22_2717_2	211.6	244.7	275.7	311.8	370.0	412.9	461.5	600.9	230.3	266.4	300.1	339.5	402.8	449.6	502.4	654.2
HEP on Laune	22_3944_1+	230.3	266.4	300.1	339.5	402.8	449.5	502.4	654.2	250.7	289.9	326.7	369.5	438.4	489.3	546.8	712.0
Laune DOWNSTREAM	22_4001_4+	231.8	268.1	302.1	341.7	405.4	452.5	505.7	658.5	252.4	291.9	328.9	372.1	441.4	492.7	550.6	716.9
Cottoners River downstream at Laune	22_3946_9	39.9	49.2	55.9	62.9	73.4	82.5	92.8	122.3	43.2	53.3	60.5	68.2	79.6	89.4	100.5	132.5
Glanshearoon upstream	22_191_1	8.0	9.8	11.2	12.6	14.8	16.6	18.7	24.7	8.6	10.7	12.1	13.7	16.0	18.0	20.2	26.7
Glanshearoon downstream	22_360_2	10.8	13.3	15.1	17.1	20.0	22.4	25.3	33.4	11.7	14.4	16.4	18.5	21.6	24.3	27.4	36.1
Shanowen upstream	22_1589_1	32.3	39.4	44.4	49.8	57.7	64.6	72.4	94.7	35.0	42.6	48.1	53.9	62.5	70.0	78.4	102.6
Shanowen downstream	22_1589_3	32.5	39.6	44.7	50.1	58.1	65.0	72.8	95.3	35.2	42.9	48.4	54.2	62.9	70.4	78.9	103.2
Anglore Stream	22_1331_3	2.3	3.0	3.5	4.0	4.8	5.4	6.2	8.3	2.5	3.3	3.8	4.4	5.2	5.9	6.7	9.0
Maine Upper downstream	22_1756_3	2.7	3.5	4.0	4.5	5.1	5.7	6.4	8.4	3.0	3.8	4.3	4.9	5.5	6.2	6.9	9.2
Maine mid upstream	22_1587_1	35.3	45.3	51.9	58.3	66.1	73.7	82.9	109.5	38.3	49.1	56.3	63.1	71.6	79.8	89.9	118.6
22014 (Castleisland)	22_1587_3	35.6	45.7	52.4	58.8	66.0	74.2	83.5	110.2	38.6	49.5	56.8	63.7	71.5	80.4	90.5	119.5

Location	MRFS Design Peak Flows (m³/s)									HEFS Design Peak Flows (m³/s)							
	HEP	50%AEP	20	10	5	2	1	0.5	0.1	50%AEP	20	10	5	2	1	0.5	0.1
Maine Mid downstream	22_1587_4	35.8	45.9	52.6	59.1	67.0	74.7	84.1	111.0	38.8	49.8	57.0	64.0	72.5	80.9	91.1	120.2
Maine Lower upstream	22_2098_1	46.4	59.6	68.2	76.6	86.8	96.8	109.0	143.9	50.3	64.5	73.9	83.0	94.1	104.9	118.1	155.9
Maine DOWNSTREAM	22_2098_3	46.5	59.7	68.4	76.7	87.0	97.0	109.2	144.2	50.4	64.6	74.1	83.1	94.2	105.1	118.3	156.2
Maine downstream Kealgorm	22_576_1	64.5	81.4	94.3	108.6	131.1	151.4	175.5	250.1	71.1	89.8	104.0	119.8	144.6	167.1	193.6	275.9
Maine upstream Brogheen	22_583_2	76.1	96.1	111.3	128.3	154.8	178.8	207.2	295.3	83.8	105.7	122.5	141.1	170.3	196.8	228.0	324.9
Maine downstream Brogheen	22_721_1	78.0	98.5	114.1	131.4	158.6	183.2	212.4	302.6	85.8	108.4	125.5	144.6	174.5	201.6	233.7	332.9
Maine upstream Loughnagore	22_557_2	89.9	113.4	131.4	151.4	182.7	211.1	244.6	348.6	98.6	124.5	144.2	166.2	200.5	231.7	268.5	382.5
Maine downstream Ballymacpiers	22_2090_1	98.6	124.5	144.2	166.1	200.4	231.6	268.4	382.4	107.9	136.3	157.9	181.9	219.5	253.6	293.9	418.7
Maine upstream Little Maine	22_2090_3	99.2	125.2	145.0	167.1	201.6	233.0	270.0	384.7	108.6	137.1	158.8	183.0	220.8	255.1	295.7	421.3
Maine downstream Little Maine	22_3375_1	128.1	161.7	187.3	215.8	260.4	300.9	348.7	496.9	140.2	177.0	205.0	236.2	285.0	329.3	381.7	543.8
Maine upstream Brown Flesk	22_3367_4	129.9	164.0	190.0	218.9	264.1	305.2	353.7	504.0	142.1	179.4	207.8	239.5	288.9	333.9	387.0	551.3
22003 (Riverville)	22_3101_1	189.2	238.1	275.3	316.7	381.3	440.0	509.1	723.0	207.3	261.0	301.7	347.1	417.9	482.2	558.0	792.5
Maine upstream Inchinveema	22_3101_4	196.7	248.3	287.6	331.4	399.8	462.0	535.4	762.9	215.6	272.1	315.2	363.2	438.2	506.4	586.9	836.2
Maine downstream Inchinveema	22_3306_1	200.0	252.5	292.4	337.0	406.6	469.8	544.4	775.7	219.2	276.7	320.5	369.3	445.6	514.9	596.7	850.2
Maine upstream Coolmealane & Ballyfinnane	22_3359_3	204.2	257.8	298.6	344.0	415.1	479.6	555.9	792.0	223.7	282.4	327.1	376.9	454.7	525.5	609.0	867.7
Maine downstream Coolmealane & Ballyfinnane	22_3754_1	215.4	271.9	315.0	363.0	437.9	506.0	586.4	835.6	235.8	297.7	344.9	397.4	479.4	554.0	642.0	914.8
HEP on Maine	22_3970_3+	244.4	308.5	357.4	411.8	496.8	574.1	665.4	948.0	267.3	337.5	390.9	450.5	543.5	628.0	727.8	1037.0
Outfall of Maine	22_3958_1+	269.5	340.3	394.2	454.2	548.0	633.2	733.8	1045.6	294.9	372.3	431.3	496.9	599.5	692.8	802.9	1144.0
Kealgorm upstream Maine	22_957_4	11.6	14.3	16.3	18.4	21.6	24.3	27.4	36.2	12.5	15.5	17.7	20.0	23.4	26.3	29.7	39.2
Brogheen upstream Maine	22_582_7	12.1	15.3	17.5	19.9	23.5	26.6	30.1	40.2	13.1	16.5	19.0	21.6	25.5	28.8	32.6	43.5
Ballymacpiers upstream Maine	22_1223_5	9.5	11.8	13.5	15.3	17.9	20.2	22.8	30.2	10.3	12.8	14.6	16.6	19.4	21.9	24.7	32.7
Little Maine upstream Maine	22_2091_3	28.9	35.1	39.5	44.2	51.1	57.1	63.9	83.5	31.6	38.3	43.2	48.3	55.9	62.5	69.9	91.2
Brown Flesk upstream Maine	22_3102_14	58.5	70.4	79.0	88.1	101.6	113.3	126.6	164.6	64.3	77.4	86.8	96.8	111.7	124.6	139.1	180.9
Inchinveema upstream Maine	22_888_4	15.0	18.8	21.6	24.5	28.8	32.5	36.7	48.8	16.5	20.6	23.6	26.8	31.5	35.6	40.2	53.4
Coolmealane upstream Maine	22_3118_2	15.8	19.6	22.3	25.2	29.5	33.2	37.4	49.4	17.1	21.2	24.1	27.3	31.9	35.9	40.5	53.5
Ballygamboon Lower upstream Maine	22_3962_5	9.8	12.2	13.9	15.7	18.5	20.8	23.5	31.2	10.6	13.2	15.1	17.1	20.0	22.6	25.5	33.8
Annagh downstream Maine	22_3972_3	28.9	35.1	39.6	44.4	51.5	57.6	64.5	84.4	31.4	38.1	43.0	48.2	55.9	62.5	70.0	91.6
Tralia upstream of Maine	22_3964_2	9.4	11.7	13.4	15.2	17.9	20.2	22.9	30.4	10.1	12.7	14.6	16.5	19.4	21.9	24.8	32.9
Ashullish Stream DOWNSTREAM @ Maine	22_3958_2	10.7	13.6	15.6	17.8	21.0	23.8	26.9	35.9	11.9	15.1	17.4	19.8	23.3	26.4	29.9	39.9
Boolteens Stream downstream at Maine	22_3952_4	27.3	33.5	38.0	42.7	49.8	55.9	62.8	82.6	29.5	36.3	41.1	46.3	53.9	60.5	68.0	89.4
Groin downstream	22_3950_5	18.2	21.6	24.1	26.8	30.7	34.1	38.0	49.1	19.7	23.5	26.2	29.0	33.3	37.0	41.2	53.1
Ashullish Stream UPSTREAM	22_3093_3	3.1	3.9	4.5	5.1	6.0	6.8	7.7	10.3	2.59	3.4	4.3	4.9	5.6	6.6	7.5	8.4
Ashullish-Ashullish Tributary upstream	22_3093_4	3.8	4.8	5.5	6.3	7.4	8.4	9.5	12.7	3.21	4.2	5.3	6.1	6.9	8.1	9.2	10.4
Ashullish-Ashullish Tributary downstream	22_3116_1	5.5	7.0	8.0	9.1	10.7	12.2	13.8	18.4	4.64	6.0	7.6	8.8	10.0	11.8	13.3	15.1
Ashullish- Ballyoughtragh Upstream	22_3116_4	11.3	14.3	16.5	18.8	22.2	25.1	28.4	37.9	9.77	12.7	16.1	18.5	21.0	24.8	28.1	31.8
Ashullish- Ballyoughtragh Downstream	22_3617_1	18.9	23.8	27.4	31.2	36.8	41.7	47.2	63.0	16.14	21.0	26.5	30.5	34.7	41.0	46.4	52.5
Ashullish Stream downstream	22_3958_2	20.2	25.5	29.3	33.4	39.4	44.6	50.5	67.4	17.24	22.4	28.3	32.6	37.1	43.8	49.6	56.1
Knokavota Stream downstream at tributary	22_3094_2	1.7	2.1	2.4	2.8	3.3	3.7	4.2	5.6	1.40	1.8	2.3	2.6	3.0	3.5	4.0	4.5
Ballyoughtragh Stream UPSTREAM	22_3425_3	3.4	4.3	4.9	5.6	6.7	7.6	8.6	11.5	2.80	3.6	4.6	5.3	6.1	7.2	8.2	9.3
Ballyoughtragh Stream DOWNSTREAM	22_3425_9	7.5	9.6	11.1	12.7	15.0	17.0	19.3	25.8	6.41	8.3	10.6	12.3	14.0	16.6	18.8	21.3
Dingle Stream UPSTREAM	22_3437_1	2.6	3.3	3.7	4.3	5.0	5.7	6.4	8.6	2.8	3.5	4.1	4.6	5.4	6.1	7.0	9.3
Dingle Stream DOWNSTREAM	22_3437_5	7.5	9.5	10.9	12.4	14.6	16.5	18.7	24.9	8.8	11.1	12.8	14.5	17.1	19.3	21.9	29.1
Milltown river UPSTREAM	22_1712_1	27.4	38.3	47.4	55.0	64.9	74.0	82.8	105.5	29.7	41.4	51.3	59.6	70.3	80.1	89.7	114.3
Milltown Gauge (22022)	22_1712_2	27.6	38.5	47.6	55.3	65.2	74.4	83.3	106.1	29.8	41.7	51.6	59.9	70.7	80.6	90.3	114.9
Milltown River-Ballymoreereagh Tributary UPSTREAM	22_1712_4	27.7	38.7	47.9	55.6	65.6	74.8	83.8	106.7	30.0	41.9	51.9	60.2	71.0	81.0	90.7	115.6
Milltown River-Ballymoreereagh Tributary DOWNSTREAM	22_3998_1	33.0	46.1	57.1	66.3	78.2	89.2	99.9	127.2	35.8	50.0	61.9	71.8	84.7	96.6	108.2	137.8
Milltown River Downstream	22_3999_2	34.2	47.8	59.2	68.7	81.0	92.4	103.5	131.8	37.2	52.0	64.4	74.7	88.2	100.5	112.6	143.4
Ballymoreereagh Tributary DOWNSTREAM	22_1196_5	5.3	6.7	7.6	8.6	10.1	11.4	12.9	17.2	5.8	7.2	8.2	9.3	11.0	12.4	14.0	18.6

Table F.2: Future Total Tide Plus Sea Levels

Location	MRFS Total Tide Plus Surge Levels (mODM)								HEFS Total Tide Plus Surge Levels (mODM)							
	50%AEP	20	10	5	2	1	0.5	0.1	50%AEP	20	10	5	2	1	0.5	0.1
Portmagee Harbour (ICPSS point SW_16)	2.7	2.8	2.87	2.93	3.01	3.07	3.14	3.28	3.2	3.3	3.37	3.43	3.51	3.57	3.64	3.78
Dinge Harbour (ICPSS Point SW_22)	2.75	2.85	2.93	3	3.09	3.16	3.23	3.40	3.25	3.35	3.43	3.5	3.59	3.66	3.73	3.90
Dingle Bay at Inch Point (ICPSS point SW_20)	2.92	3.03	3.11	3.18	3.28	3.36	3.43	3.61	3.42	3.53	3.61	3.68	3.78	3.86	3.93	4.11
Cromane Point Castlemaine Harbour	3.25	3.35	3.43	3.5	3.59	3.66	3.73	3.9	3.75	3.85	3.93	4	4.09	4.16	4.23	4.4
Ferry Crossing, River Maine and Laune Outfall-Castlemaine Harbour	3.25	3.35	3.43	3.5	3.59	3.66	3.73	3.9	3.75	3.85	3.93	4	4.09	4.16	4.23	4.4

