Spring 2021

National Water Resources Plan - Framework Plan

Technical Appendices

Appendix F
Climate Change Impacts on Supplies

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Data Disclaimer:
This document uses best available data at time of writing. Some sources may have been updated in the interim period. As data relating to population forecasts and trends are based on information gathered before the Covid 19 Pandemic, monitoring and feedback will be used to capture any updates. The National Water Resources Plan will also align to relevant updates in applicable policy.

1.1 Introduction

To ensure a resilient water service, climate change is a key consideration of for water resource planning. In Ireland, climate change is predicted to result in warmer summers and wetter winters. Extreme weather such as drought or heavy rainfall will become more frequent, intense and prolonged. This will have a significant impact on our water services.

Reduced rainfall with a growing population and economy will put increased pressure on our water supplies during drought events. More intense and prolonged rainfall may also damage infrastructure due to flooding, cause increased variability on source water quality and reduce the quality of treated drinking water supplies.

We are implementing measures to adapt to future climate change and develop a resilient, low carbon water and wastewater service. We are also committed to limiting our impacts on climate change by reducing our energy use by 33%.

We have considered climate change adaptation and impacts in our options assessment process. Adapting to the impact of climate change brings additional challenges to provide safe and reliable water supplies. Longer periods of drought and more high intensity rainfall events are predicted to result from climate change. These events will affect the reliability and quality of smaller water sources, which may become unavailable or suffer deterioration in water quality for periods of the year. In developing the 25-year National Water Resources Plan (NWRP), we need to take account of the potential impacts of climate change on both supply and demand.

1.2 Supply

1.2.1 Surface water sources

The projected increase in temperature globally will affect the amount, timing and intensity of local precipitation. In Ireland, this is expected to mean wetter winters but also drier springs and summers, meaning that by the 2050s, average annual rainfall will be significantly lower. The number of periods of what we would currently consider to be a drought will also increase significantly. The number of extended dry periods is also projected to increase substantially during autumn and summer.

Whilst there is recent work on potential climate effects including rainfall, there is less work on the projected impacts of climate change to river flow regimes across Ireland. There is also no Ireland-wide guidance available at present outlining the effects of future climate change. Recognising this, we commissioned the Climate Sensitive Catchments Project (see Section 1.6), which reported in 2019.

Whilst it is now complete, the Climate Sensitive Catchments Project was not available during the development of this Framework Plan. Given the significant uncertainties involved both in the climate change projections of rainfall and catchment hydrological response, we have chosen to make a simple estimate of change based upon a pragmatic interpretation of the data available. This allows us to start to factor the potential impact of climate change into the planning and decision-making process. We will update this element in a future iteration of the Framework Plan.

The assessment only considers the impacts from climate change on water quantities. The impacts of climate change will clearly be complex, and changing rainfall patterns could affect land use, agricultural demands and the concentrations of discharges. These areas carry more uncertainty than the estimate of impacts on flows and so at present we do not feel it is possible to include them. We will mitigate the uncertainty as far as possible by considering the adaptability and flexibility of the options, which we adopt to ensure we have robust and resilient system.

The key climate change documents that helped to steer the assessment are:

- Robust Adaptation to Climate Change in the Water Sector in Ireland, Julia Hall, Conor Murphy and John Sweeney (2012) Climate Change Research Programme 2007-2013 Report Series No. 1;
- Ensemble of regional climate model projections for Ireland, Paul Nolan (2016) Environmental Protection Agency Research Programme 2014-2020; and
- Climate change – Refining the Impacts for Ireland (2001-CD-C3-M1) STRIVE Report. Prepared for the Environmental Protection Agency by National University of Ireland, Maynooth (2008). Environmental Protection Agency STRIVE Programme 2007–2013.

In developing this approach, we were aware that there were ongoing studies likely to provide additional insights but could not fully address our needs. This includes the EDgE[1] – End-to-end Demonstrator Project for improved decision making in the water sector in Europe. This is an EU-funded project designed to make some of the latest pan-European projections of climate change impacts to river flow regimes readily available through an easy-to-use web based Geographical Information System (GIS) platform (available since early 2018). The underlying science uses several different climate change models, coupled to a range of rainfall-runoff models applied across all the rivers in Europe, including Ireland, to allow projections of stream flows, precipitation and evaporation, together with an indication of their uncertainties. The output of this project is freely available to all, allowing catchment-specific estimates of a range of hydrological indices over various future time horizons and emission scenarios to be obtained.

Of the existing published research, the most detailed assessment of river flow has been undertaken by the National University of Ireland, Maynooth (2008). In this work, percentage changes in monthly streamflow were produced for nine Irish catchments that were selected to sample the typical hydro-climatic range across the country. The monthly flow factors represent the projected percentage change in monthly river flows for the 2020, 2050 and 2080 future time horizons compared to the baseline 1961 to 1990 period. Our approach to assess the effects of future climate change, which is described in the next section, draws upon these flow factors for the 2050s. This work was based on medium – high emission scenarios taken from the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (2001).

1.3 Approach

Our approach to assess the effects of future climate changes consists of the three steps:

Step 1 – Derive monthly flow factors for the 2050-time horizon suitable for application across Ireland.

Step 2 – Apply these factors to the daily flow sequences developed for each of Irish Water's sources.

Step 3 – Use the projected changes to the hydrology to assess the potential change to the 2041 yields of the Irish Water sources. This is done in two different ways, depending on whether the hydrological yield is calculated, using the transposition method or by using a more complex water resource model.

[1] http://edge.climate.copernicus.eu/News/2017-08-24-New_EDgE_climate_projections/

1.3.1 Step 1 – Derivation of monthly flow factors

Figure 1-1 shows the location of the nine study catchments used in the Maynooth (2008) climate change work.

Figure 1-1 Location of the study catchment used in Maynooth (2008)

The projected percentage changes in monthly river flow for each of these catchments for the 2050-time horizon have been averaged to produce a central set of flow factors. To provide an indication of the uncertainty, we also applied an upper and a lower set based on plus and minus one standard deviation of the group of nine estimates. The resulting flow factors along with the group averages of the groundwater are given in Figure 1-2 and Table 1-1.

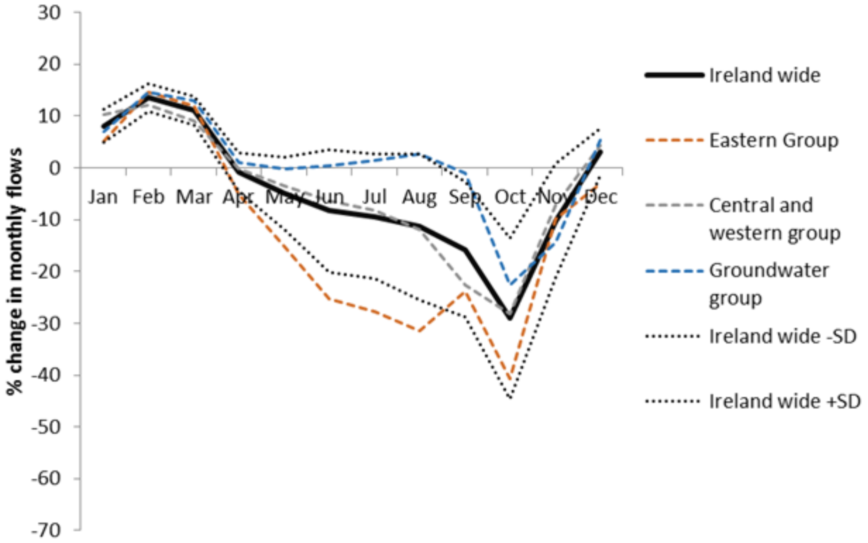


Figure 1-2 Summary of the 2050s climate change flow factors applied

Table 1-1 Flow factors per month

Month	Percentage change (from 1961–1990 baseline) (%)				
	Ireland-wide	Ireland-wide -1SD (lower)	Ireland-wide +1SD (upper)	Groundwater group	Eastern group
Jan	8.1	5.0	11.2	7.0	5.2
Feb	13.5	10.8	16.2	14.6	14.6
Mar	11.0	8.2	13.8	13.0	12.0
Apr	-0.9	-4.5	2.8	1.0	-5.2
May	-5.0	-12.0	2.0	-0.2	-15.2
Jun	-8.3	-20.2	3.5	0.5	-25.3
Jul	-9.4	-21.4	2.6	1.4	-27.8
Aug	-11.4	-25.4	2.7	2.6	-31.5
Sep	-15.7	-28.9	-2.6	-1.0	-24.0
Oct	-29.1	-44.6	-13.5	-22.6	-40.7
Nov	-10.2	-21.1	0.7	-14.5	-9.8
Dec	3.0	-1.5	7.5	5.3	-3.1

1.3.2 Step 2 – Application of monthly flow factors

For the sample sites within the NWRP study, the baseline yield assessments derive a flow estimate for each location. The flow estimate is derived by transposing the flow records from a hydrologically similar river gauging station to the target site. To account for climate change, the monthly flow factors for each climate change scenario are applied to the baseline daily time series flow sequences to create perturbed sequences. This results in adjusted Flow Duration Curves for each scenario, which can be used in the yield analysis.

For the more complex modelled systems, a similar approach has been followed, but the whole inflow time series sequence has been modified by the flow factors within the models themselves. In models where the Impounding Reservoirs or lakes have a large surface area, the projected changes to daily rainfall and evaporation, acting directly on the waterbody, were also incorporated. Monthly climate change factors for the rainfall were obtained from an interpretation of the seasonal projections given in Maynooth (2008). These were compared to output from the EDgE project and were shown to compare reasonably well. Maynooth (2008) does not provide projections for Potential Evaporation. Therefore, EDgE Potential Evaporation projections were selected that had similar associated temperature changes to those projected in the Maynooth (2008) work.

1.3.3 Step 3 – Yield assessments

The yield calculations for sample sites have been repeated for each climate change scenario using the adjusted Flow Duration Curve and, for lake or Impounding Reservoir sources, revised rainfall and evaporation estimates. The resulting model Deployable Output (DO) can then be compared with the baseline yield figure to examine any changes in water supply across a range of return periods.

The systems represented in the water resource system models have been re-run using the different inflow rainfall and evaporation sequences for each scenario, generating a new DO figure for each scenario.

The climate change factors are for the 2050-time horizon. We first calculated the impact to the yields for this time horizon and then linearly scaled the impacts between the baseline period and the 2050s and sampled the target 2041-time horizon for the end of the NWRP 25-year planning period.

1.4 Groundwater

At this stage, the baseline groundwater yields are not sufficiently well developed to be able to apply specific analysis to them. The aquifer characteristics supporting the groundwater sources are likely to be highly variable, which means their behaviour will be different. With the current level of understanding, we have assumed a reduction of 1% over the Framework Plan period, in line with projected changes in average precipitation, which drives groundwater recharge.

1.5 Results

An example of the change to the Flow Duration Curves for a single site is shown in Figure 1-3. At the lower end of the Flow Duration Curve, a reduction in flows is seen at nearly all sites. With respect to changes to Q95, the central estimates show some variability around an average reduction of 10% (the lowest and highest reductions are 5% and 15%). The upper scenario estimates more closely group around 0% change, whilst the lower estimates are more widely dispersed between 15% and 25% reductions in Q95.

Figure 1-4 and Figure 1-5 show the potential impacts of climate change for the 1 in 50-year yield estimates, relative to baseline for the central, upper and lower climate change (CC) estimates.

This shows the greatest degree of impact on direct abstractions from river sources, with sources with storage able to mitigate some of the effects by attenuating the changes in the timing of rainfall.

The results for the modelled integrated supply systems show the greatest resilience, with much smaller changes to DO, although the usage pattern of the sources to achieve this may be different to the current pattern of use. This highlights the benefits of the interconnection of sources of different types, as the responses to different rainfall patterns will differ. It also emphasises the need to consider raw water storage as an option to secure future supply in many locations.

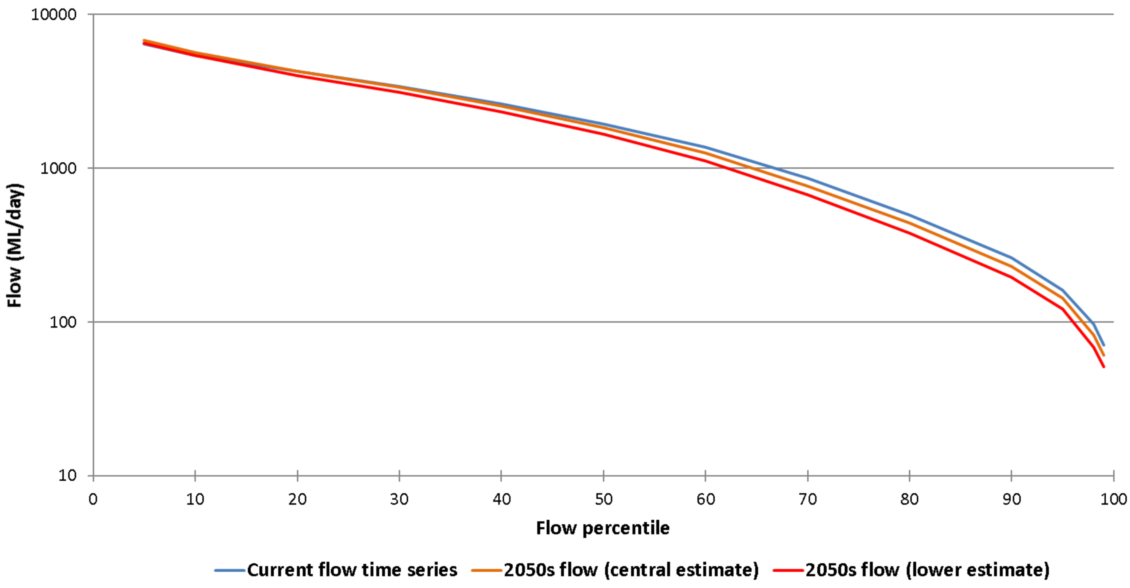


Figure 1-3 Example change to Flow Duration Curve for a single site

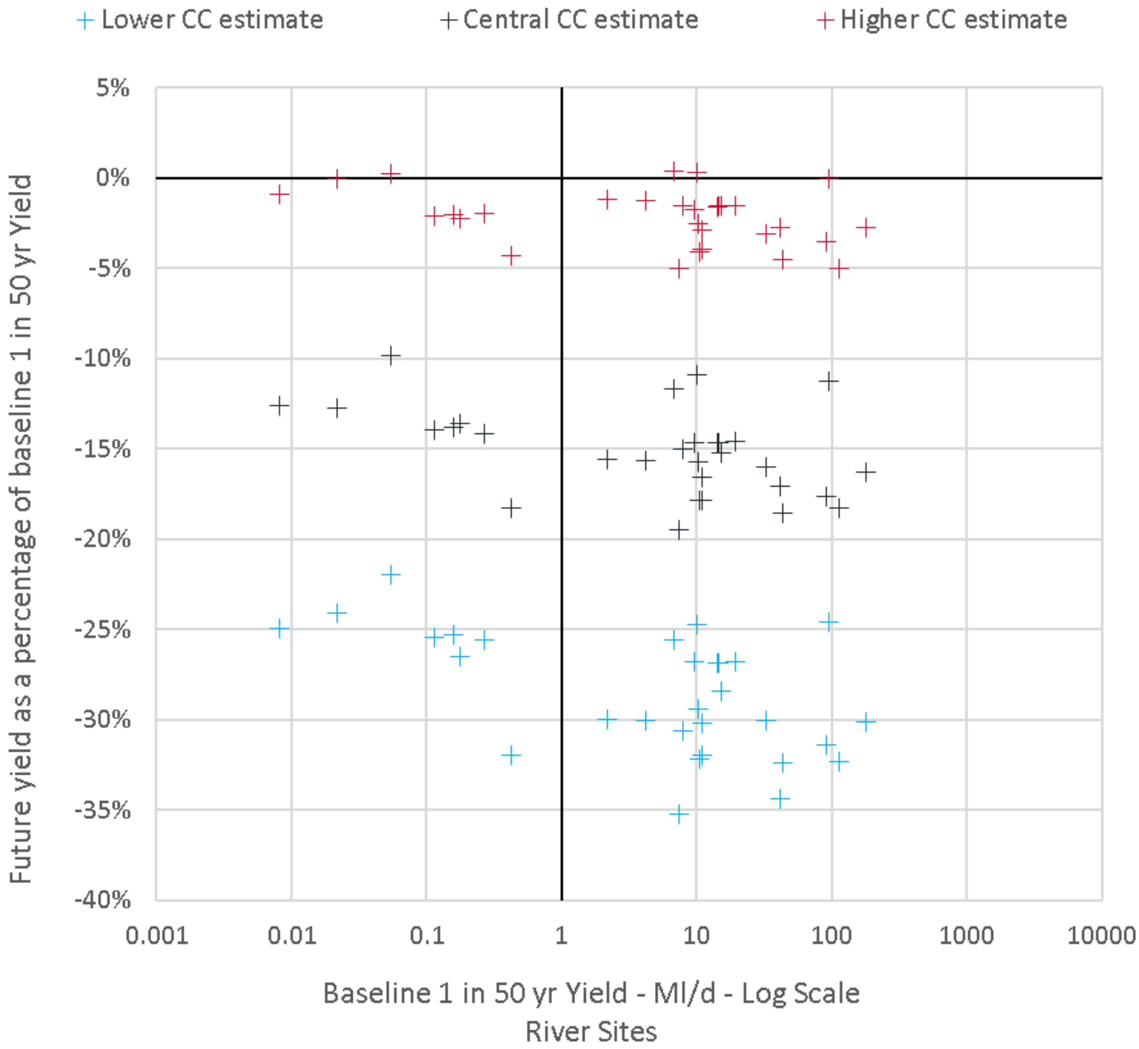


Figure 1-4 Change at river sites relative to baseline 1 in 50-year yield for central estimate and lower and upper bounds of uncertainty

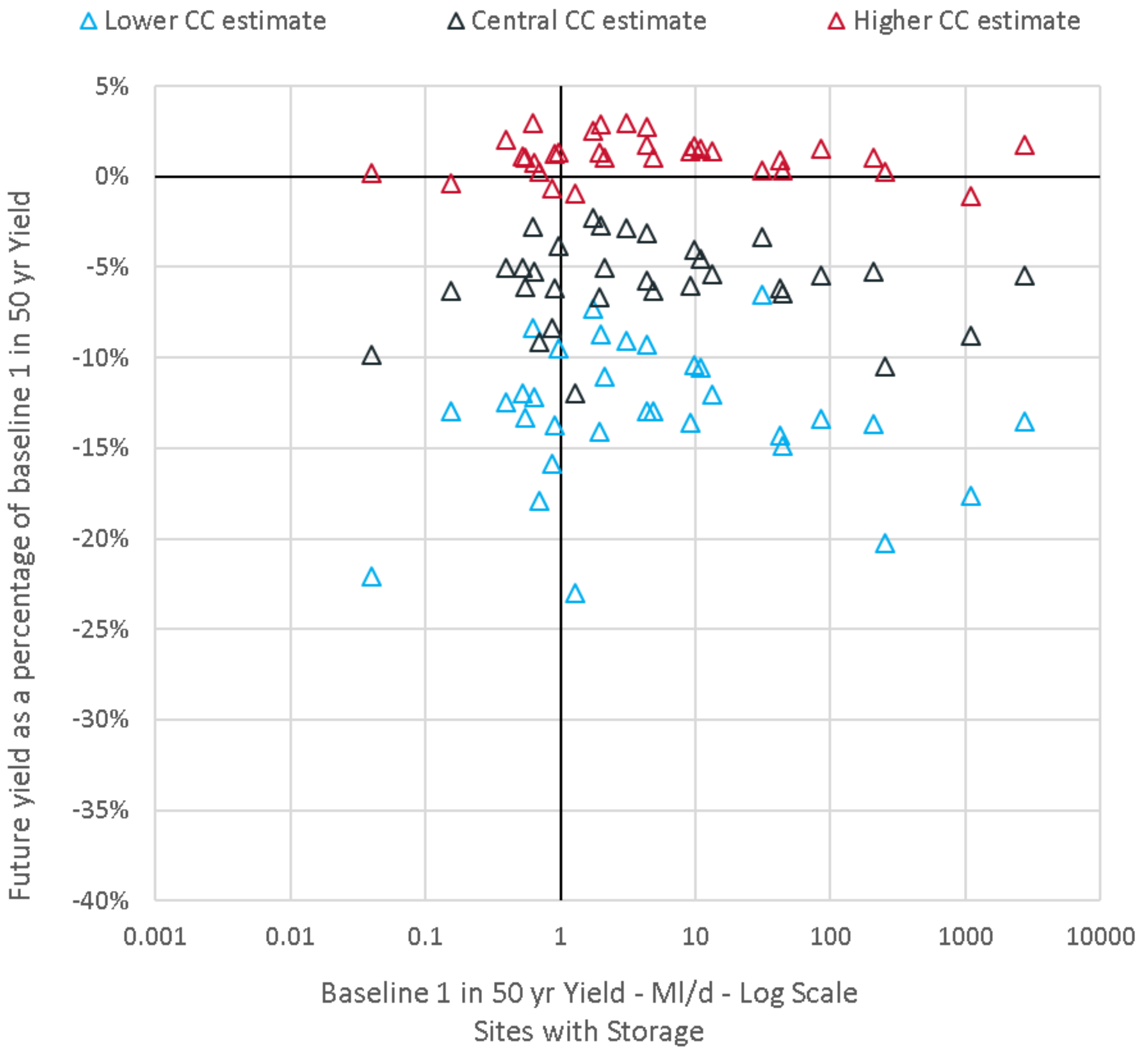


Figure 1-5 Change at sites with storage relative to baseline 1 in 50-year yield for central estimate and lower and upper bounds of uncertainty

To develop the supply forecast, we have assumed that the yields in 2041 are affected by the central estimate of climate change. We have assumed a linear rate of change for each year between the baseline values for 2017 and the 2041 value.

The uncertainty, described by the range from the lower to upper estimates, is used in the headroom analysis. This potential range is shown in Figure 1-6 and, again, is greater for river sources than sources with storage.

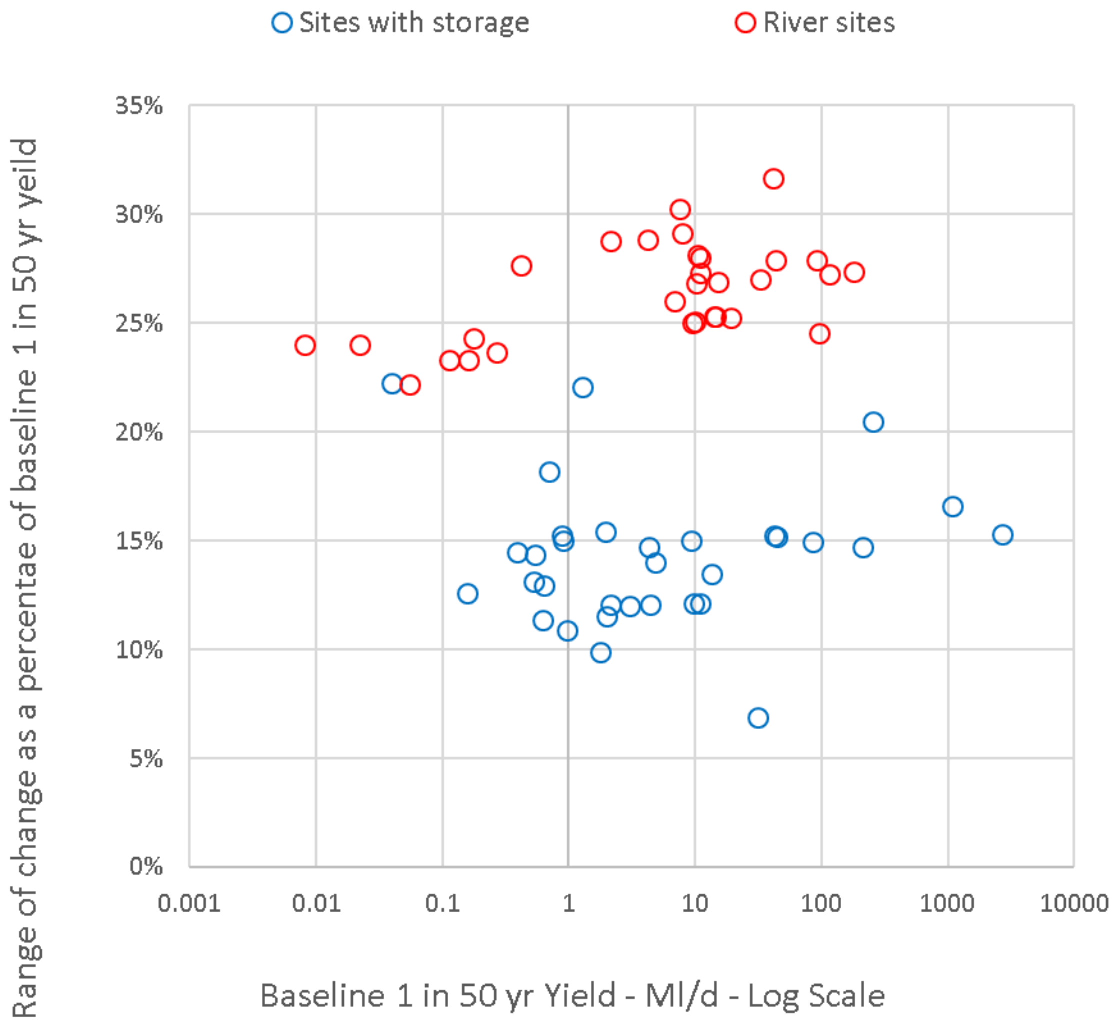


Figure 1-6 Range of uncertainty compared to source size for differing source types

1.6 Climate Sensitive Catchments Project

Whilst there is recent work on potential climate effects including rainfall, there is less work on the projected impacts of climate change to river flow regimes across Ireland. There is also no Ireland-wide guidance available at present outlining the effects of future climate change. Recognising this, we commissioned the Climate Sensitive Catchments Project (see Box 1 below), which concluded in April 2019.

Whilst it is now complete, the Climate Sensitive Catchments Project was not available during the development of this Framework Plan. We will update this element in a future iteration of the Framework Plan when the outputs from the Climate Sensitive Catchments Project will have been subject to further peer review.

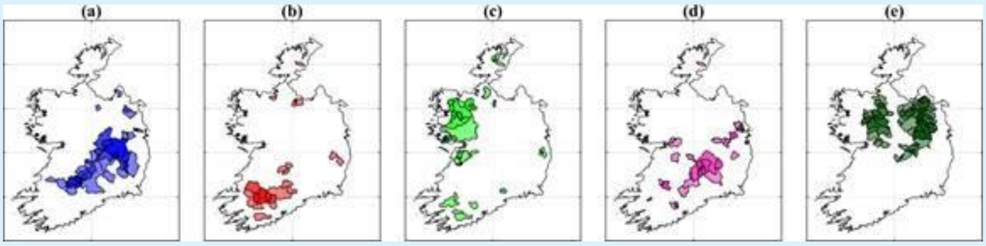
Box 1 - Climate Sensitive Catchments Project

Project Partner: Maynooth University Irish Climate Analysis and Research Units (ICARUS)

The Climate Sensitive Catchments research project improved our understanding on how river flows may change due to climate change and how best to prepare for a hotter climate. This research concluded in April 2019.

The traditional methodology to identify and assess catchments vulnerable to climate change takes a 'top down' approach, which applies information about large-scale climate change trends to small areas. This can result in inaccurate forecasting for catchments because it does not take area-specific information into consideration. This project applied a 'bottom up' methodology, which assessed how sensitive catchments are to climate change by building a catalogue of data specific to each catchment. This will allow us to identify the particular stressors and vulnerabilities in each area. By better assessing the sensitivity of catchments to climate change, we aim to increase the effectiveness of our national water management and to develop a more resilient water service.

The 206 river catchments included in this research were characterised into 5 catchment sensitivity types (a) to (e) as illustrated below. The research concluded that catchment types (a) are the least sensitive to changes in seasonality of wetter winters and dryer summers due to high groundwater storage in these catchments. Catchment types (b) and (c) have lower natural water storage and see the greatest decreases in flow due to wetter winters and dryer summers. Catchment types (d) and (e) lose more water due to evaporation and are mostly drier catchments in the midlands and east. Catchment types (d) are most sensitive to changes in annual mean precipitation. When changes in seasonality and mean amount are considered together, catchment types (d) are also the most sensitive and types (b) the least. Catchment types (e) experience less evaporative losses than (d) and while sensitive to changes in seasonality and mean amount are less sensitive to these changes than catchment type (d).



This research projected low flow allowances for each of the 5 catchment sensitivity types. These low flow allowances provide resilience for less river flows in the future due to climate change. The project concluded that in some instances an allowance for a 30% reduction in low flow would be insufficient to avoid future climate change impacts.

The findings of this research project will address the water quantity aspects of climate change, but because of changes either to temperature or flow regimes, changes in water quality will also have a bearing. In addition, climate change may result in land use changes which may compound the observed effects.