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# Water Supply Project Midlands and Eastern Region (WSP) Economic Needs Report

# Economic Evaluation of Likely Future Deficiencies in Water Supply Infrastructure

## Water Supply Project, Eastern and Midlands Region (WSP) Economic Needs Report

Prepared by Indecon Research Economists

Indecon

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# Glossary of Terms and Abbreviations

| | |
|---|---|
| **Accounted for Water (AFW)** | The daily volume of water passed into supply that can be accounted for as legitimate use by authorised parties. The sum of Domestic and Non-Domestic Demands, Household Losses, and Operational Use. |
| **ARIMA** | Autoregressive Integrated Moving Average (ARIMA). A statistical analysis model that uses time series data to predict future trends. |
| **Community Gain** | The wider socio-economic implications and benefits of infrastructure projects. |
| **Corridor of Benefit/Benefitting Corridor** | The areas of Tipperary, Offaly, Laois, Westmeath and parts of Counties Kildare and Meath that potentially stand to benefit from the proposed projects in addition to the Greater Dublin Water Supply Area. |
| **Customer Side Leakage (CSL)** | Water leakage from within the customers' property boundary. |
| **DR** | Dublin Region |
| **Dublin Water Supply Region** | Includes the administrative areas of Dublin City, Dun Laoghaire- Rathdown, Fingal, South Dublin and parts of Wicklow, Kildare and Meath. |
| **Economic Level of Leakage** | The level of leakage in the water supply system at which the cost of repairing additional leakage is equal to the benefit associated with the fixing of these leaks. |
| **EI** | Enterprise Ireland |
| **FDI** | Foreign Direct Investment. |
| **Food Harvest 2020** | Government strategy for the medium-term development of the agri-food (including drinks) fisheries and forestry sector for the period to 2020. |
| **Gross Value Added** | Gross value added is the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector. |
| **Headroom/Capacity Margin** | The excess supply capacity beyond average demand levels included in the system to ensure continuity and security of supply in the face of uncertainties and risks surrounding future supply and demand. |
| **IDA** | Industrial Development Agency (Ireland) |
| **Mega-litres per day (Ml/d)** | One mega-litre is equal to one million litres of water. Mega-litres per day refer to the number of million litre quantities of water produced or consumed on a daily basis. |
| **Non-Residential Demand** | Demand associated with commercial, industrial, agricultural, tourism and institutional related activities. |
| **Occupancy Rate** | The average number of people per-household. |
| **Operational Usage** | Water used in the operation and maintenance of the distribution system (e.g. scouring of mains and reservoirs) and by authorised third party organisations (e.g. fire authority, road authority). |
| **Peaking Factor** | The allowance added to average water demand to account for periods of peak demand when calculating supply requirements. The peaking factor in this report is 20%. |

| | |
|---|---|
| **Per Capita Consumption** | The average amount of water consumed by each member of the population on a daily basis. |
| **Production Requirement** | The total amount of water required to satisfy all the subcomponents of water demand including an allowance for peak demand and the targeted allowances for headroom and outage. |
| **Residential Demand** | Demand associated with permanently occupied residential properties. |
| **Resiliency** | The ability or capacity of a system to absorb or cushion against damage or loss. Resiliency is quantified in terms of the percentage of output which can continue to be produced in the event of water outage. |
| **System Leakage/Distribution Losses** | The loss of water from the distribution network between the point of water treatment and delivery of water to the customer. |
| **Greater Dublin Area (GDA)** | Includes the administrative areas of Dublin City, Dun Laoghaire- Rathdown, Fingal, South Dublin and all of Kildare, Meath and Wicklow. |
| **Unaccounted for Water (UFW)** | Real and apparent losses within the distribution system. Calculated as the difference between Total Distribution Input and the total Accounted for Water. |
| **Water Intensity** | A measure of the amount of water required in industrial and commercial activities to produce a single unit or euro of output. |
| **WIOD** | World Input Output Database. |
| **WSP** | Water Supply Project, Eastern and Midlands Region: Includes Greater Dublin Area, Tipperary, Offaly, Laois, Westmeath and parts of Kildare and Meath. |
| **WSSP** | Water Services Strategic Plan |

# Executive Summary

## Introduction, Background and Scope

This report has been prepared by Indecon Research Economists. This concerns an independent economic evaluation of the likely future deficiency in water supply infrastructure to meet residential, industrial and commercial requirements of the Irish economy. The report represents one input to the project assessment by Irish Water for the WSP, and provides an independent assessment of the economic need for water in the key parts of the Eastern Region area. This assessment includes new independent estimates of the demand for water over the planning period. It is based on new empirical findings. It includes detailed econometric and other modelling of water demand, in line with best international practice, which have not been undertaken previously in Ireland.

The Indecon Economists believe that the consequences of any deficiencies in water infrastructure caused by the historic underinvestment by the Irish State or for other reasons should not be underestimated and as a result an evidence based analysis of need is essential. The practical impacts on individuals was illustrated in the recent EPA report[1] on drinking water where it highlighted the number of cases where there were failures to comply with aluminium standards and with the other limits. Also of relevance is the fact that during 2013 there were 57 boil water notices and 12 water restriction notices in Ireland in 16 counties and affecting over 35,831 individuals. In our research we also quantify the economic consequences of any failure to address deficiencies in available supply. For example based on international research the estimated cost of even a 1 day disruption for GDA area would be likely to be in excess of €78 million. There are also very significant negative employment impacts if adequate water supply is not available to meet the needs of indigenous and overseas businesses. Given the continuing high unemployment rate in Ireland this consequence should not be underestimated.

The background to this assessment is that the WSP's objective in relation to this project is to ensure that, in combination with other projects, the long-term (2050+) water supply needs of the Region (the Water Supply Region) are met in a sustainable manner. The next stage in the development of the WSP project involves application to An Bord Pleanála to seek statutory consent for the Project under the Planning and Development (Strategic Infrastructure) Act 2006. The application process requires the undertaking of an Environmental Impact Assessment (EIA), consistent with European Union directives.

Indecon Economists would point out that while this immediate assessment focuses initially on main parts of the Eastern Region including the Greater Dublin Area and parts of Tipperary, Offaly, Laois, Westmeath and Kildare and Meath, it is important to emphasise that all regions in the State require reliable and sustainable water supply to support the needs of the population as well as non-residential requirements. We understand that this economic needs assessment will subsequently be conducted at a national level, in addition to this region.

The overall objective of this economic needs assessment is to input to the WSP project capacity (and phasing) in the context of expected growth scenarios out to 2050, having regard to national and regional projections and the requirements of the eastern region. In addition to projecting the demand for water and identifying the overall supply requirement, this assessment provides some initial inputs to the assessment of the wider importance of adequate water resources.

Indecon Economists believe that any major infrastructural investment has economic costs as well as benefits, and given the need to ensure the effective and efficient allocation of scarce economic resources, any evaluation of need must therefore be based on detailed evidence of likely future demand. In this research report, we present new estimates of water demand. In considering this it is relevant to take account of the Water Services (No. 2) Act 2013 and in particular Section 39 which states that the

[1] EPA, Drinking Water Report 2013

[1] All estimates for the GDA were arrived at by grossing up per person per day estimates to the size of the GDA population.

[2] Dublin City Council, (2011) 'Water Supply Project-Dublin Region – The Plan'

[3] The process will also incorporate an application to An Bord Pleanála for a Water Abstraction Licence under the Water Supplies Act

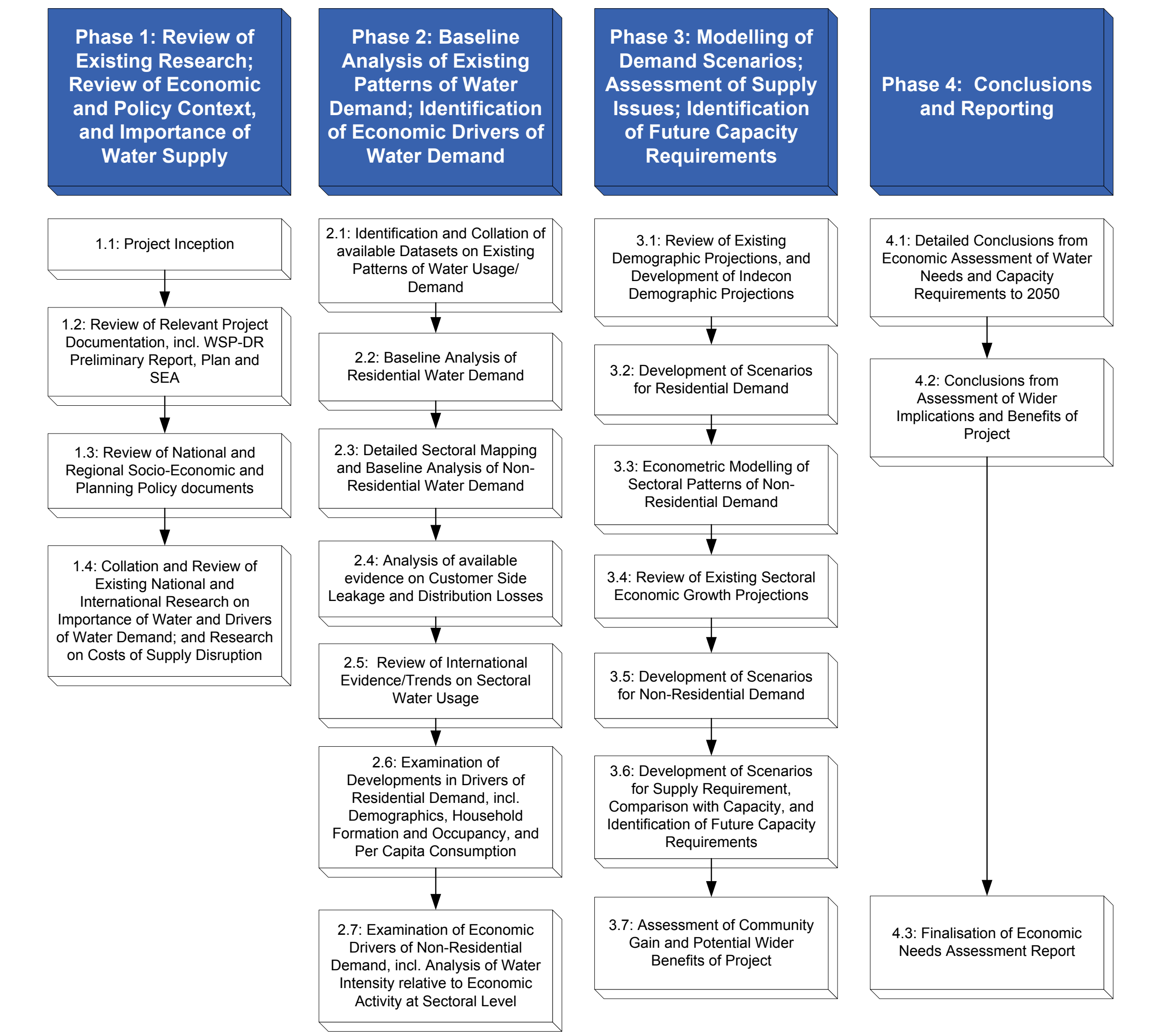
Commission of Energy Regulation needs to ensure that "Irish Water can meet all reasonable demands for water both current and foreseeable".

In Indecon Economists' view this suggests that in strategic planning, Irish Water should seek abstraction planning for a higher demand than would be assumed in any central forecast in order to accommodate foreseeable potential demand. In evaluating demand for water, all regions in Ireland must have adequate strategic reserves to accommodate potential demand for the needs of Irish citizens as well as the requirements of indigenous and multinational firms and the expansion of the tourism and agri sectors.

## Methodological Approach

A rigorous methodological approach has been applied in completing this assessment and is summarised in the figure overleaf. This is in line with international best practice and has involved an analysis of evidence on existing demand and new empirical modelling to evaluate likely future requirements for the residential and non-residential sectors.

**Overview of Methodological Approach to Economic Needs Assessment**




**Source: Indecon Research Economists**

One particular feature of our approach is the reflection of economic principles in the formulation of scenarios for water demand and the evaluation of empirical evidence in developing key assumptions. The objective is to ensure that projections for both residential and non-residential demand are informed by careful assessment of relevant economic drivers. The methodology has taken account of international research and has utilised econometric modelling and other approaches to test the validity of the estimates.

In assessing the likely future evolution of non-residential water demand, Indecon Economists have reservations with regard to some of the traditional approaches applied to estimating non-residential water demand given the dependence of the Irish economy on external trade and investment. To address these issues, Indecon Economists' approach was to combine evidence on sectoral water usage and economic growth patterns to forecast future non-residential demand. This approach is supplemented by our modelling of intensities of water usage at a sectoral level. Our estimation also takes account of the declining level of water intensity over time in many sectors.

As noted earlier, Indecon Economists fully recognise the need to have sufficient water capacity to respond to the expansion needs of existing users and potential new users. The analysis undertaken in this report seeks to forecast these needs using detailed sectoral economic output forecasts. Expansion of demand outside the bounds of the base case scenario for these sectoral forecasts is possible in the case of large existing and potential future water users. This must be considered by Irish Water in the evaluation of capacity options and in deciding on the levels for which to seek abstraction provision.

## Population and Economic Context in the Region

Examination of demographic and economic drivers of water demand is a vital component of the assessment of future water needs in any Region. Growing population levels, other things being equal, imply increased demand for water for the residential sector. The Region water supply area has a population of over 2 million persons. This includes a population of the Dublin Area of 1.51 million and population of 0.53m in other parts of the Eastern region of relevance to this assessment namely Tipperary, Offaly, Laois, Westmeath and parts of Counties Kildare and Meath, and South Dublin. The population of the Region is shown in the table below, with the overall population being in excess of 2 million people.

**Population of the 'Defined Water Supply Zone' and 'Zone of Benefit'**

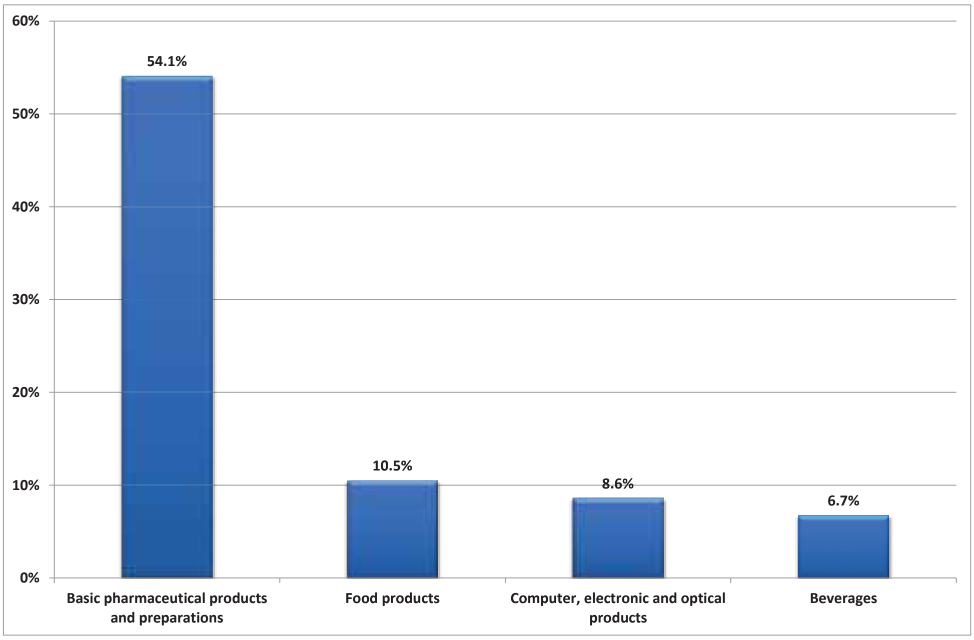
| Area | Persons |
|---|---|
| Dublin Region - Defined Water Supply Zone | 1,516,133 |
| WSP Potential Corridor of Benefit | 533,984 |

**Source: Indecon Economists analysis of data from CSO, 2011 Census of Population**

Developments in economic activity in the area will influence the requirements by both residential and other water users. In terms of economic activity, a detailed review of the economic characteristics of the Region was undertaken and included a sectoral analysis. This sectoral analysis is critical, as new evidence presented in this report highlights very marked variances in water intensity by sector. While data to facilitate the same granular analysis of other parts of the benefiting corridor was not available we believe this does not materially alter the sectoral structure of demand in the Region. Specific dimensions highlighted by the review include the following:

- Gross Value Added or GDP in the (Dublin + Mid-East regions) amounted to an estimated €73.6 billion in 2013. Approximately 84% of this is in services-related activities, while about 16% is in manufacturing sectors.
- Within the manufacturing sector, key areas of activity which have implications for non-residential water usage include pharmaceuticals (representing 54.1% of total manufacturing output in the Area), Food and Beverages (17.2%) and ICT manufacture (8.6% of total output) (see chart overleaf).

**Sectoral Output as % of Total Manufacturing Output for Selected Top Manufacturing Sectors in Dublin and Mid Eastern Area**




**Source: Indecon Economists Analysis of CSO COIP Data.**

## Existing Patterns of Water Demand

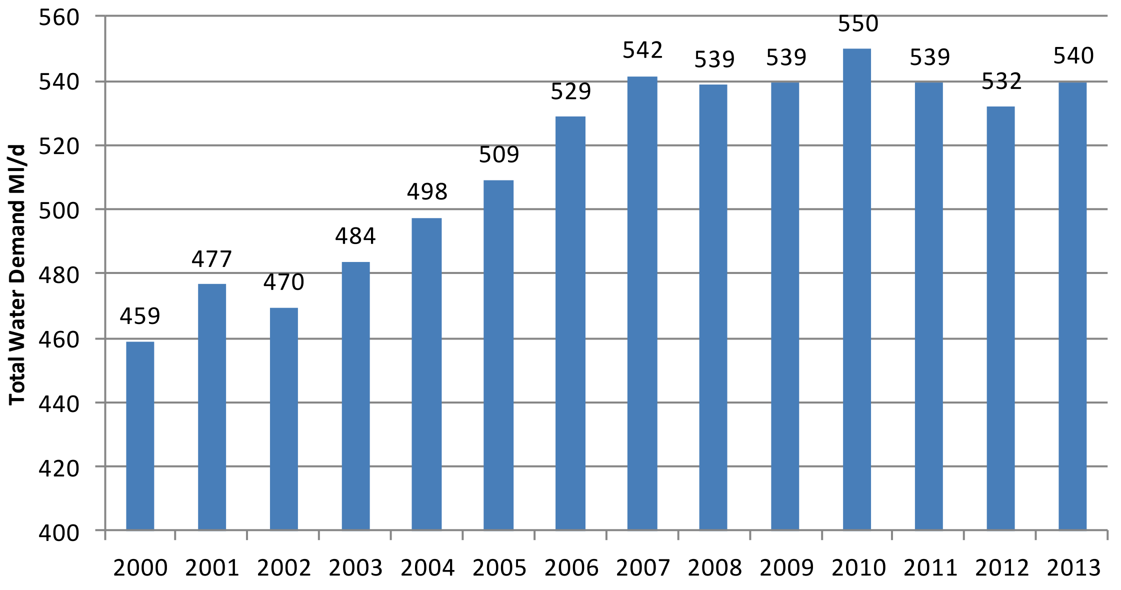
The demand for water in the Ireland is comprised of usage by the residential/household sector and consumption for non-residential purposes, including agricultural, commercial and industrial activities and public organisations including the health sector (see table below).

| Demand for Water in Ireland |
|---|
| **Sectors of Water Demand** |
| **Residential/Household Users:** |
| Households, apartments and residences |
| |
| **Non-Residential Users:** |
| Manufacturing sector |
| Agriculture and forestry |
| Internationally traded service sector |
| Tourism and hospitality sector |
| Construction sector |
| Health sector |
| Other government services |
| Other domestically traded services including retail and wholesale |
| Transport |
| Other |
| **Source: Indecon Economists** |

*Overall water demand*

The recent trend in demand for water in the Region is presented in the next figure. While this trend data was only available for the Dublin Water Supply Region given the significance of demand in this area it is of relevance to the overall assessment. Based on observing total water distribution, which equates with the total level of water supplied, a rising trend was observed up to 2007, with a fall-off in 2008 and 2009 during the economic recession, and another decline in 2011 and 2012. The period since 2008 has seen greater volatility, with declining water consumption evident in 2008 and 2009, followed by recovery in 2010 when demand reached a recent peak of 549.8 Ml/d (million litres per day) on average. By 2013, overall average water demand in the Dublin Region averaged 539.8 Ml/d. In the benefitting corridor average water demand is estimated to be of the order of 67.5 Ml/d.

**Historical Trend in Total Water Demand in the Dublin Water Supply Region**




**Source: Indecon Economists, based on data of water consumption**

## Predicting Future Water Demand

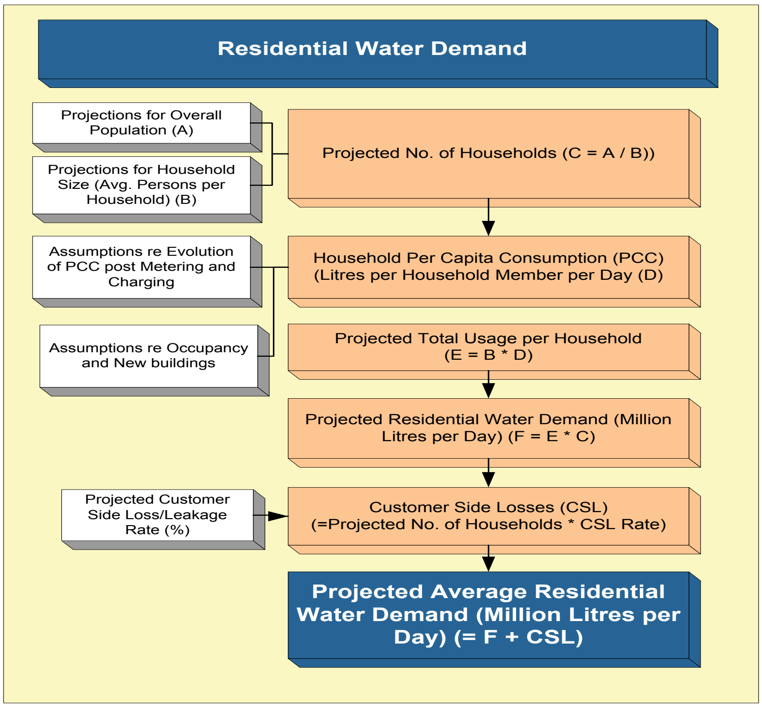
In undertaking an assessment of the economic need for water Indecon Economists developed a methodological framework for projecting future water demand for both the residential and non-residential sectors.

*Residential Water Demand*

A schematic description of the methodology applied in developing the projections for residential water demand is presented in the figure overleaf. This shows how the key drivers of population, household numbers and occupancy and per capita consumption are combined to estimate the likely trajectory of future residential water usage and demand.

Residential demand for water will be influenced by population levels, household composition and Per Capita Consumption (PCC). The absence to date of residential metering means that existing characteristics of residential water demand must be estimated. This is typically undertaken through combining information on assumed or verified average per capita water usage, or Per Capita Consumption (PCC) measured in litres per person per day, with data on the number of households and population levels. The most recently available estimates, developed based on initial readings from residential metering in Dublin during April 2014 along with sampling from other areas in the Region, place PCC at an estimated 125.5 litres per person per day. These are lower than average reported levels in the UK but it should be noted that there are wide variances in the UK. Any estimate of PCC is based on an average and in practice this may hide significant variation in per capita water usage from house to house and area to area. There is also a degree of uncertainty relating to the impact of Customer Side Leakage (CSL). A more accurate estimate of average PCC will emerge as metering is rolled out. Our base line analysis is therefore based on current estimates of PCC and is subject to revision. We also estimate the likely changes in PCC over time.

**Schematic Overview of Components of Methodology for Projecting Demand for Water – Residential Water Demand**




**Source: Indecon Economists**

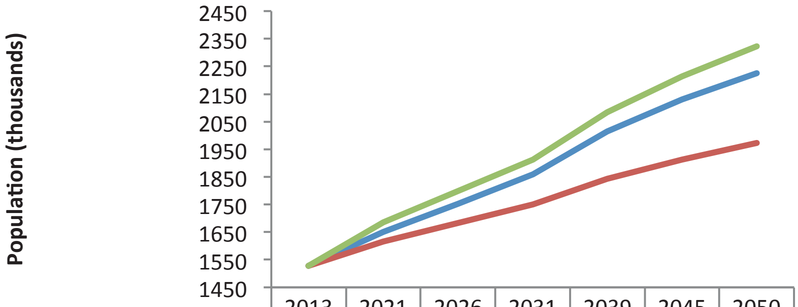
In order to forecast the level of water demand for the residential sector in the region it is necessary to forecast population growth and the likely path of future PCC for water. Demographic forecasts for Ireland at a national level as well as for different regions out to 2050 include scenarios based on the forecasts of independent demographers informed by CSO population forecasts. A key uncertainty with population forecasts relates to migration, which is in turn influenced by economic developments. Given the importance of population as a determinant of residential water demand, Indecon economists have therefore used alternative approaches to test the validity of the population projections using an econometric model.

The primary forecast provided by this model represents Indecon Economists' 'Base Case' forecast. This research broadly validates the most likely growth scenario produced by the independent demographers. By taking the upper and lower bounds of the 95% confidence interval surrounding the 'Base' forecast we also include in our analysis Indecon Economists 'High' and 'Low' population growth scenarios. Thus the three Indecon Economists population forecasts are:

- Indecon Economists Base –the population implied by the best fit of our forecasting model.
- Indecon Economists Low – the lower bound of the 95% confidence interval of our analysis.
- Indecon Economists High - the upper bound of the 95% confidence interval of our analysis.

These forecasts are illustrated graphically in the figure below. In our modelling of water demand we utilise population forecasts prepared by demographers as discussed below. However the Indecon Economists modelling has guided the choice of which scenarios to use and also provided a validation of the forecasts and their consistency with other variables used in our analysis.

**Indecon Economists Population Projection Scenarios for the Dublin Water Supply Region**

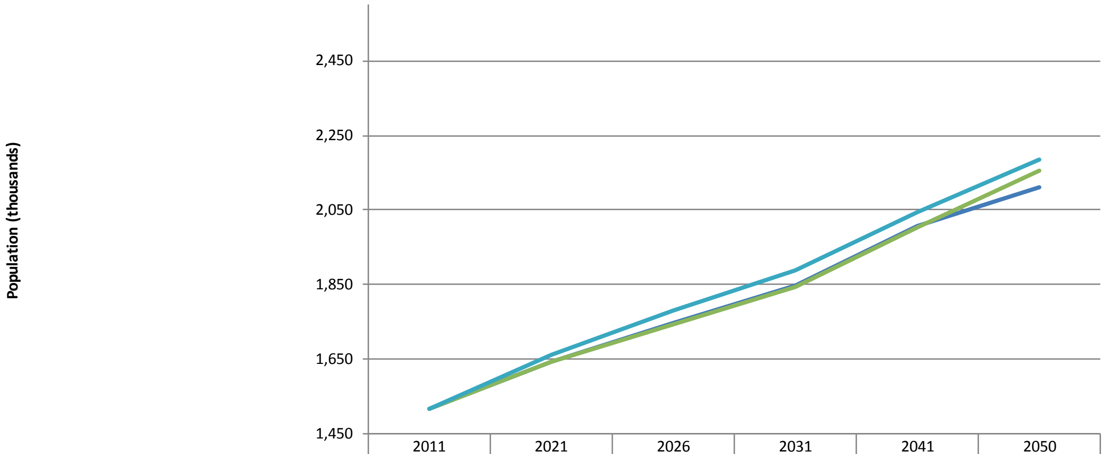



| | 2013 | 2021 | 2026 | 2031 | 2039 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|
| Indecon Base Case | 1527 | 1650 | 1753 | 1860 | 2015 | 2130 | 2226 |
| Indecon Low | 1527 | 1616 | 1683 | 1750 | 1843 | 1913 | 1972 |
| Indecon High | 1527 | 1686 | 1799 | 1914 | 2085 | 2215 | 2323 |

**Source: Indecon Economists Analysis**

The forecasts produced by demographers AOS, cover six different growth scenarios. These scenarios range from forecasting a total population in the Dublin Region of 1.7 million people by 2050 to a higher scenario of 2.5 million people. Three of the key forecast scenarios are outlined in the figure below.

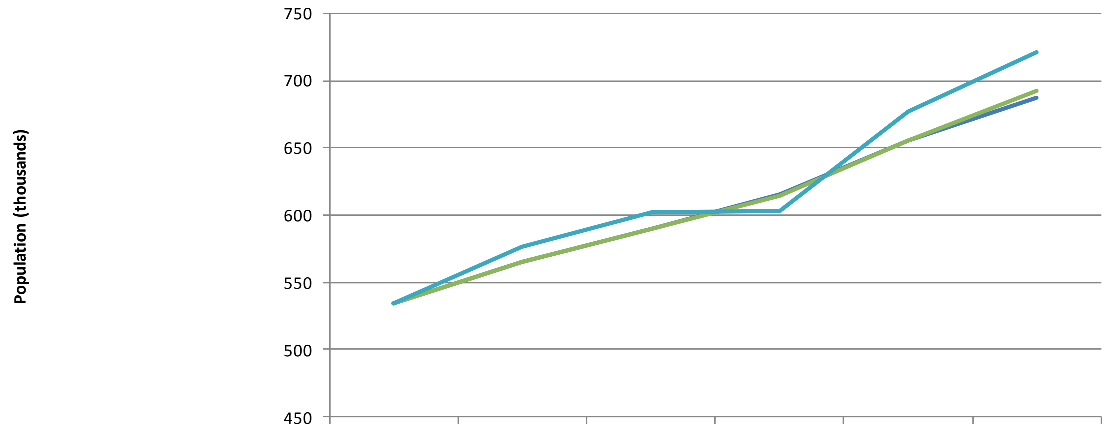
**Independent Demographers Population Projection Scenarios for the Dublin Water Supply Region**




| | 2011 | 2021 | 2026 | 2031 | 2041 | 2050 |
|---|---|---|---|---|---|---|
| Scenario 1(a): Planned Growth | 1,516 | 1,644 | 1,745 | 1,846 | 2,008 | 2,111 |
| Scenario 2: Most Likely Growth | 1,516 | 1,642 | 1,742 | 1,842 | 2,003 | 2,154 |
| Scenario 4 (a): Maximum Expected Economic Growth | 1,516 | 1,660 | 1,780 | 1,888 | 2,042 | 2,185 |

It is also useful to provide population estimates for the benefitting corridor area. The population of this area is forecast under the same scenarios as outlined above. The forecasts for the region suggest that the population of the benefitting corridor is forecast to grow from its current level of 534,000 people to a potential high of 805,000 people. Three of the key scenarios used are presented below.

**Independent Population Projection Scenarios for the Benefitting Corridor**




| | 2011 | 2021 | 2026 | 2031 | 2041 | 2050 |
|---|---|---|---|---|---|---|
| Scenario 1(a): Planned Growth | 534 | 565 | 590 | 615 | 655 | 688 |
| Scenario 2: Most Likely Growth | 534 | 565 | 590 | 615 | 655 | 692 |
| Scenario 4 (a): Maximum Expected Economic Growth | 534 | 576 | 602 | 603 | 677 | 721 |

In addition to forecasting population levels and household size it is necessary to predict Per Capita Consumption (PCC). A key factor in forecasting the likely path of future water demand in the Region concerns how PCC is likely to evolve in future years, particularly following the introduction of residential water metering.

PCC will also be influenced by occupancy levels per household. The average household size is predicted to continue to fall. This will have the impact of increasing estimates of PCC and Indecon Economists has formally built this into our modelling.

In forecasting the likely future path of Per Capita Consumption in the Region over the forecast horizon in addition to taking account of average household size, Indecon Economists have considered the following factors:

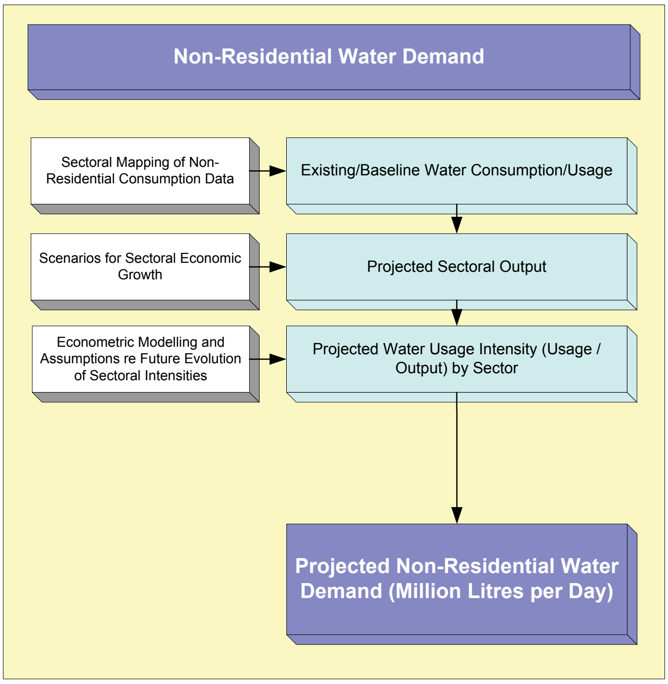
- Evidence from other jurisdictions on the path of water consumption;
- The roll-out of metering of households in the region;
- Impact of new housing stock in influencing water intensity.

International evidence suggests that PCC is likely to be between 5% and 15% lower in response to metering. In light of the differences between the Irish approach and the international experience, our base case assumptions assume a decline of 5% in residential water demand as a result of the introduction of metering and flat rate charging in the Region. This reduction in water consumption is assumed to be driven by additional awareness of water usage particularly given the installation of water meters. This has the impact of reducing predicted PCC from existing estimated level of 125.5 to 119. Our analysis also models the impact of greater efficiencies in water usage due to new housing stock which will reduce the average PCC. However, when combined with the lower household occupancy rates our modelling predicts an increase in PCC to 121 in our base case by 2050 even after taking account of the impact of charges.

*Non-Residential Water Demand*

A schematic description of the methodology which we applied in developing the projections for non-residential water demand is presented in the next figure. This illustrates the process of the sectoral mapping of existing non-residential water consumption with output projections and econometric estimates for the future path of water intensity.

**Schematic Overview of Components of Methodology for Projecting Demand for Water – Non-Residential Water Demand**




**Source: Indecon Economists**

Non-residential water demand encompasses usage of water for a wide range of industrial and services sectors, with very different water usage characteristics. Because of this, an approach which attempts to predict the future evolution of non-residential water demand without taking into account sectoral variances in usage is likely to lead to misleading outcomes.

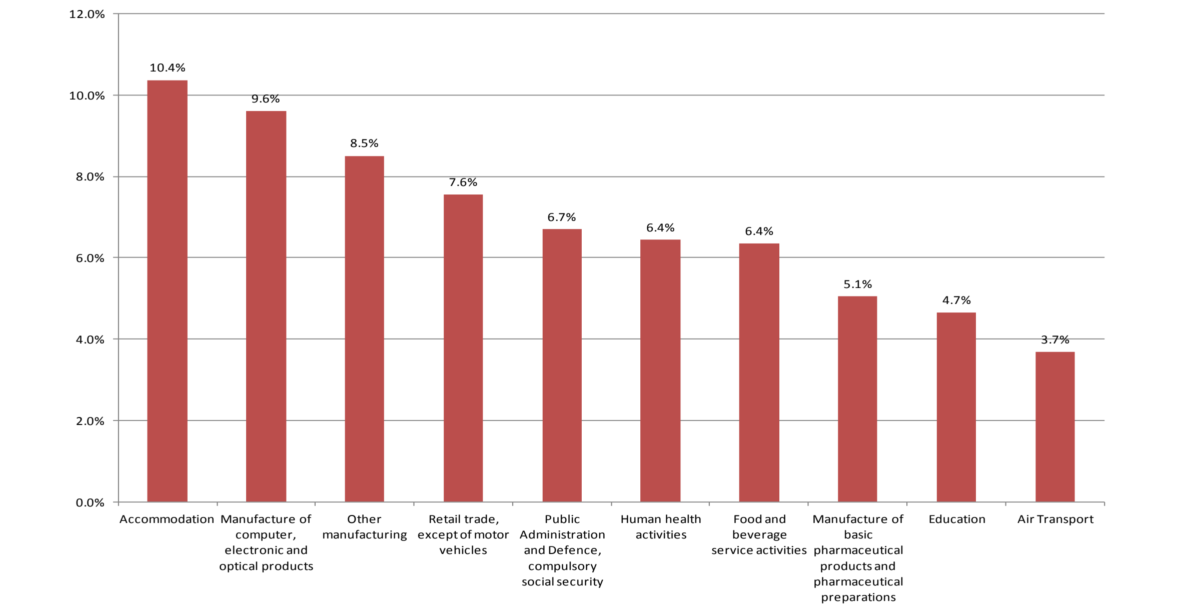
Previous studies of non-residential water demand in Ireland have attempted to forecast non-residential demand using methodologies based around demographic growth or the quantity of lands zoned for industrial and commercial development. In the case of the Irish economy the fact that the economy has a significant internationally traded sector suggests that economic growth is unlikely to be closely correlated with demographic changes. Previous reports have simply assumed that non-residential water demand will grow in line with population growth based on the inappropriate assumption that population growth will drive non-residential water demand on a one to one basis. For example, under this assumption, a 5% increase in population will result in a 5% increase in non-residential water demand. Indecon Economists believe this was a flaw in previous analysis and takes no account of the differential growth experience of economic sectors compared to population growth. It also takes no account of marked variance in water intensity between sectors or the trend towards water efficiency within the non-residential sectors. As a result, population growth may not be the main driver of economic activity in the Dublin Region and it is not be prudent to assume a one to one relationship between population growth and change in demand for water by the non-residential sector. This point is taken into account in best practice modelling of water demand in other countries but had not been reflected in previous Irish work. This is particularly relevant given the significant amount of FDI and internationally traded services in the region.

Due to the weaknesses associated with these previous methodological approaches, Indecon Economists' approach in this assessment has applied what we believe is a more robust methodology for projecting non-residential water demand. This approach utilises evidence on sectoral water usage and economic growth patterns to drive future demand. Econometric modelling techniques have also been incorporated in the approach to provide estimates for the likely future path of water intensity across different industrial and commercial sectors.

In relation to the sectoral profile of non-residential water usage, as part of this assessment Indecon undertook a detailed analysis of available customer level data on water usage and allocated this to appropriate sectors, based on a NACE 2-digit classification system. This enabled for the first time a sectoral estimation of existing patterns of non-residential water usage, in addition to the development of sectorally differentiated projections for future water demand in the Region.

The figure below indicates the sectors exhibiting the highest volume of water usage in terms of average daily consumption and also based on percentage of total non-residential water consumption in the Region.

**Sectoral Breakdown of Water Consumption by the Top 10 Sectors***

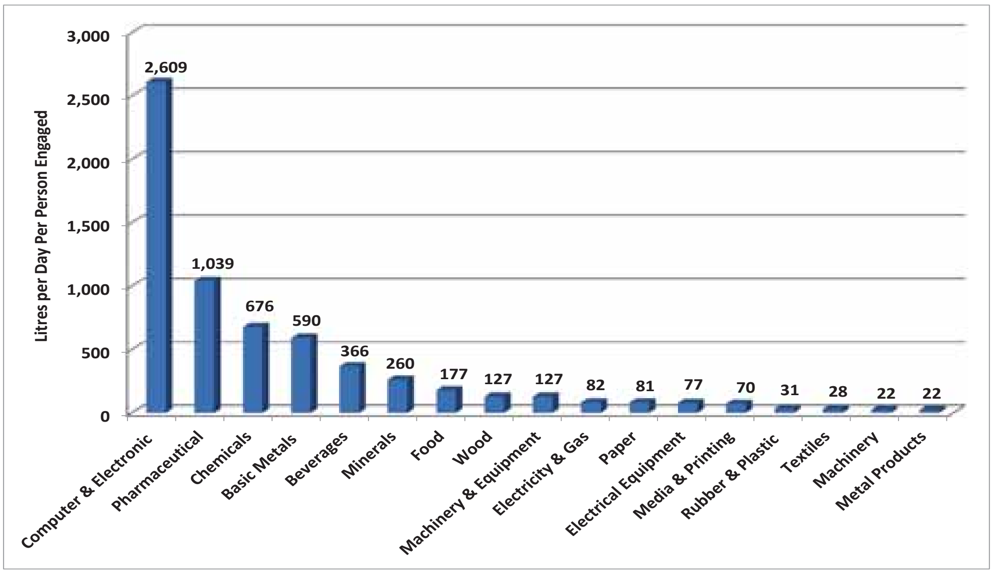



**Source: Indecon Economists analysis, based on data on water consumption**
* Based on figures for 2011 for Dublin Region (baseline year of assessment).

The largest individual economic sectors for non-residential water usage are the accommodation sector, accounting for an estimated 13.3 Ml/d of total average daily consumption or 10.4% of total non-residential consumption, followed by the manufacture of computer, electronic and optical products (12.3 Ml/d or 9.6%). Other important sectors of water usage in the region include retailing, public administration, health services, food and beverage service activities, pharmaceuticals manufacture, education and air transport. Indecon Economists' analysis also indicated the presence of a number of very large individual users of water, and found that the top 50 individual customers in the region account for approximately 26% of total non-residential water demand.

While the above analysis provides insight into the drivers of non-residential water demand in the region, to fully understand these sectoral features it is also necessary to relate the information on sectoral consumption with data on economic activity within the same sectors. In this assessment, Indecon Economists combined the above data on sectoral water usage with CSO data on sectoral economic characteristics to carry out an assessment of the water *intensity* of economic activity at a sectoral level. The figure below compares the ratio of water consumption to employment across a range of manufacturing sectors. The analysis highlights a very wide variation in sectoral water usage intensity when economic activity is factored into the analysis – in this instance by reference to employment. The most water-intensive sector is the manufacture of computers and electronic equipment, with chip/semi-conductor production in particular being a highly water intensive activity. This is followed by the pharmaceuticals and chemicals sectors, while other water intensive areas of activity include the food and beverages sector.

**Water Consumption Per Person Engaged by Sector**

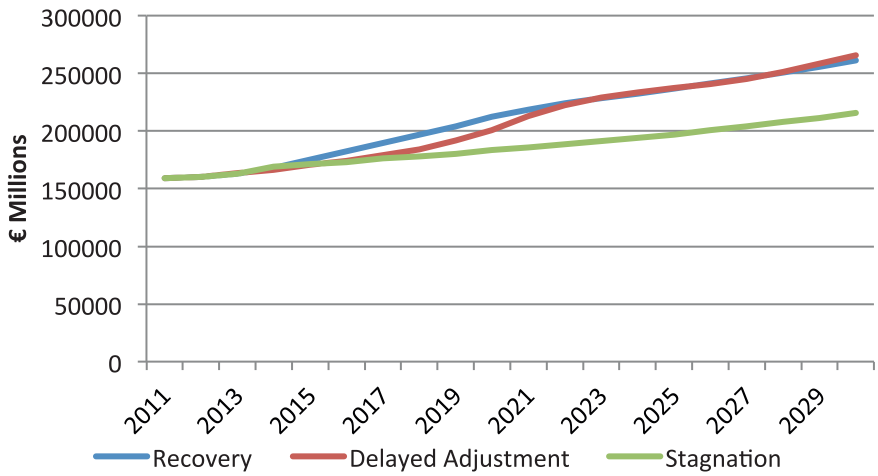



**Source: Indecon Economists analysis, based on data on water consumption**
* 2011 figures for Dublin area for manufacturing sectors

A broadly similar pattern was found when relating water usage to the value of output produced rather than employment, with computers and electronics manufacturing and chemicals in particular being the most water-intensive sectors in terms of water use per unit of output. Given the wide variations in water usage and intensity at a sectoral level, Indecon Economists' approach to projecting non-residential water demand takes into account these variations.

In examining non-residential demand it is necessary to consider likely future growth prospects for the Irish economy. For the period to 2030 we utilise the underlying assumptions in the ESRI Medium-Term Review (2013) growth forecasts for the Irish economy. These forecasts provide projections for output at a sectoral level while also providing overall GDP forecasts. A forecast growth path of Irish GDP is estimated for a number of different scenarios as presented in the next figure. The recovery scenario sees the fastest growth in GDP with the delayed adjustment scenario not matching the recovery scenario until the early 2020s. The stagnation scenario forecasts only a slight rise in GDP out to 2030. In our analysis we take account of the fact that Irish Water are considering infrastructure planning for a longer time period to 2050.

| ESRI Medium-Term Review GDP Growth Scenarios |
| --- |




**Source: ESRI Medium-Term Review, 2013.**

*Changes in water intensity of economic activity*

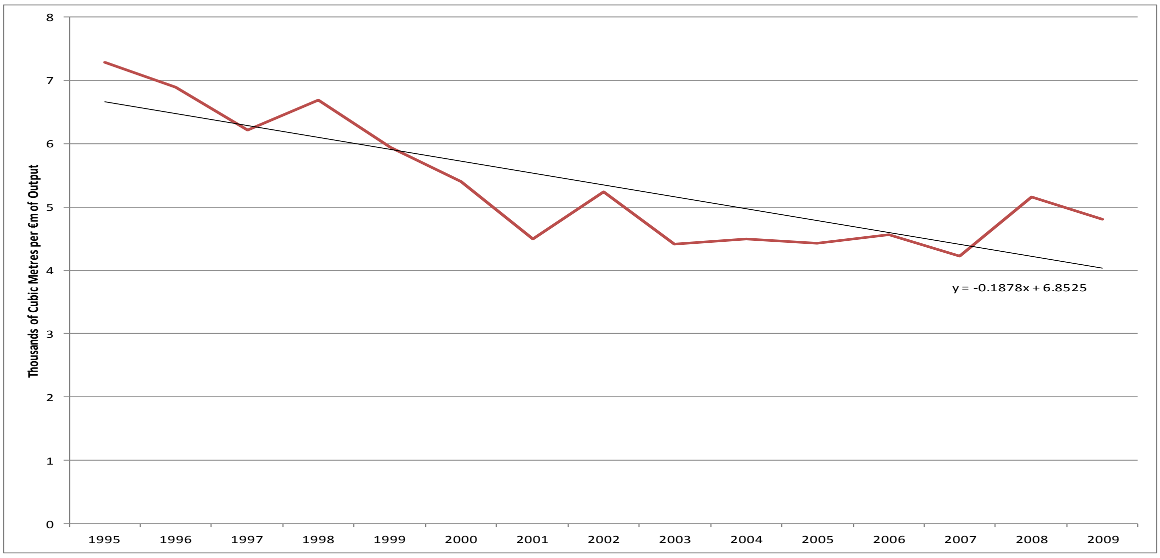
Indecon Economists also believe that any assessment of future water demand should reflect not only the water intensity of different types of activity but how this is likely to change over time. As part of this study we completed some econometric modelling to inform estimates for the future path of water intensity across different industrial and commercial sectors. We estimated alternative models based on production function specifications, where output is explained by a variety of variables, including labour, capital, materials, water, state-industry-specific random and fixed effects, and time. This enabled computation of water intensity in the estimation process. In terms of modelling results, interpretation focused on the impact of time on water intensity, i.e. the annual movements in water intensity over time. We found that the coefficient on time is negative for each sector, which indicated that water intensity is falling over time. It would therefore, in our view, be prudent to include a measure of this likely future decline in water intensity in any scenarios for future water demand. In addition, the decline in water intensity is of a higher magnitude for some sectors examined. The results from the estimation of the Cobb-Douglas production function with constant returns to scale are provided in the next table. The overall predicted annual change in water intensity across the sectors considered is -2.8%.

| Predicted Annual Change in Water Intensity by Sector, Cobb Douglas Production Function | |
| --- | --- |
| Agriculture, Hunting, Forestry and Fishing | -1.03% |
| Manufacturing | -2.55% |
| Utilities | -4.05% |
| Health and Education | -3.57% |
| **Total** | **-2.81%** |

**Source: Indecon Economists analysis of World Input Output Database (WIOD)**

When looking at water intensity in Ireland we observe a downward trend. The figure illustrates the trend in average water intensity for all sectors per million euro of output. The red line represents the historical data while the black line represents the trend.

**Trend in Average Water Intensity per €m Output for All Sectors – Ireland**




**Source: Indecon Economists Analysis of WIOD data.**

## Scenarios for Water Demand in the Region

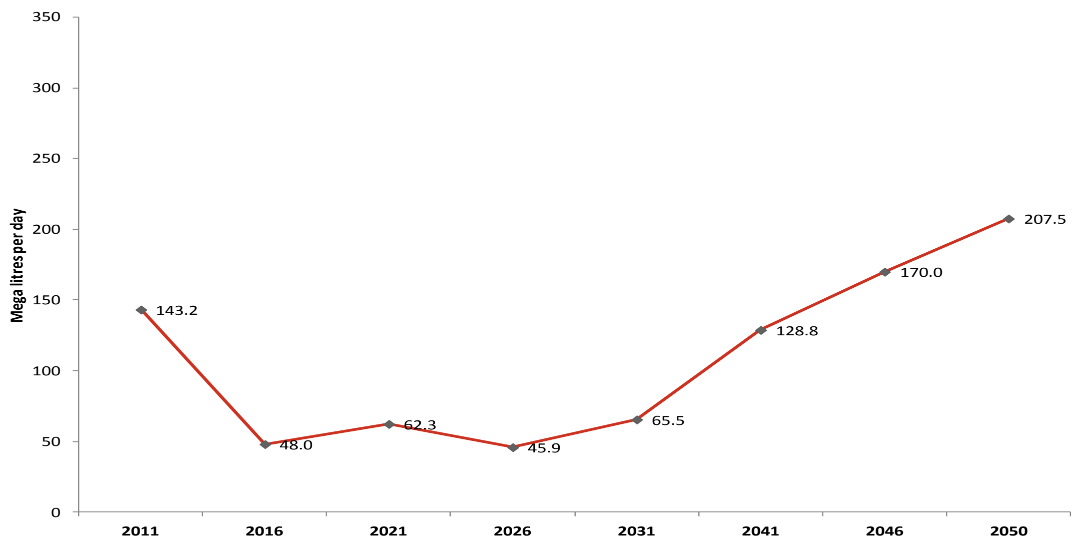
Three main broad scenarios for the possible future evolution of water demand in the Region are examined in our main report. These scenarios are informed by different assumptions with regard to demographic and economic growth drivers. The Indecon Economists Base Case Scenario is presented below. This scenario is based on the evidence of existing residential and non-residential demand levels of water usage and an evaluation of how these levels are likely to change over time. Our estimates model the combined impact of water metering and the imposition of a flat charge, lower occupancy levels and enhanced water efficiency due to the new housing stock envisaged. In our main report we also include a scenario whereby we examine the impact on our base case of alternative assumptions for PCC changes over time. Our estimates also assume some levels of falling water intensity over time in the non-residential sector. We also account for peaks in demand and the targeted allowance for headroom and outage in the system. The below table takes account of both forecasted demand within the Dublin Water Supply Region and the Benefitting Corridor up to and including the year 2050.

| Water Demand to 2050 – Indecon Economists Base Case Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Per Capita Consumption | l/hd/day | 125.5 | 119.9 | 120.4 | 120.6 | 120.7 | 120.9 | 121.0 | 121.0 |
| Residential Demand Projection | Ml/d | 190.3 | 189.3 | 197.7 | 210.1 | 222.3 | 242.2 | 251.7 | 260.6 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.9 | 155.9 | 164.8 | 176.0 | 205.2 | 222.6 | 238.2 |
| Customer Side Loss Rate | l/house | 66.0 | 54.5 | 45.0 | 35.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Customer Side Losses | Ml/d | 40.8 | 37.0 | 32.8 | 27.9 | 21.8 | 25.5 | 27.5 | 29.6 |
| Leakage Rate | % | 33.0 | 30.0 | 26.3 | 24.9 | 23.5 | 21.4 | 20.4 | 19.6 |
| Distribution Losses | Ml/d | 178.1 | 157.6 | 139.4 | 135.0 | 130.0 | 130.0 | 130.0 | 130.0 |
| Operational Usage | Ml/d | 3.6 | 3.6 | 3.9 | 4.0 | 4.2 | 4.7 | 5.0 | 5.3 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **524.4** | **529.7** | **541.8** | **554.3** | **607.6** | **636.9** | **663.7** |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **597.8** | **607.8** | **623.2** | **639.2** | **703.1** | **738.3** | **770.5** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| Average Day Peak Week Demand - Benefitting Corridor | Ml/d | **73.6** | **71.0** | **70.6** | **70.3** | **70.4** | **73.0** | **74.5** | **75.7** |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **668.8** | **678.4** | **693.5** | **709.5** | **776.2** | **812.7** | **846.2** |
| **Total Production Requirement Dublin & BC (Including allowance for risk and uncertainty via headroom)** | **Ml/d** | 753.6 | 738.5 | 752.8 | 771.3 | 790.9 | 854.2 | 895.4 | 933.0 |
| **Source: Indecon Economists** | | | | | | | | | |

The figure below depicts the forecast supply deficit under the base case scenario in chart form. The base case scenario forecasts a supply deficit in each period. The estimated deficit of 143.2 Ml/d in 2011 is largely due to the inclusion of the best practice allowance for peaking and the allowance for headroom and outage required for a sustainable level of water supply. Without these peaking factors and other allowances total demand in 2011 is estimated at 611.5 Ml/d. This suggests that in 2011 the supply infrastructure was working at nearly 100% capacity in order to meet average water demand levels. This evidence of operation at nearly full capacity reflects our understanding of the current strains on water supply in the Dublin Region.

The deficit is forecast to fall to 48 Ml/d in 2016 due to the combined impacts of expansion in supply in 2014 and the impact of declining Per Capita Consumption in 2016 following the introduction of residential water metering and the flat charge. The deficit is forecast to continue to decline out to 2026 due to the achievement of leakage reduction targets. However, from 2026 onwards, the base case forecast predicts that the supply deficit in the Region including the benefitting corridor will continue to grow as leakage levels flatten out, population growth continues and industrial and non-residential demand continues to expand. The base case scenario forecasts a deficit of 207.5 Ml/d by 2050. There are, however, significant uncertainties regarding any forecasts of water demand and we have therefore also included estimates based on higher and lower demand assumptions. We would also point out that the supply estimates for the benefitting corridor relate to specific supply projects which we have been advised by Jacobs-Tobin are currently at risk or are inadequately supplied or are constrained. Some or all of these small existing supplies may need to be replaced in order to ensure that the water supply needs of parts of Tipperary, Offaly, Laois, Westmeath and Meath are met. To the extent to which these existing small supply options are not adequate the deficit may be larger than indicated. In this context we note that any investment which Irish Water would need to incur to upgrade existing supplies in the benefitting corridor which would remain dependent on inadequate hydrological yield could be avoided by connecting to a water spine drawing from a quality assured source. This would represent an important advantage for the benefiting corridor. This supports the merit of utilising our higher demand estimates for abstraction planning purposes.

**Projected Supply Deficit – Indecon Economists Base Case Demand Scenario**



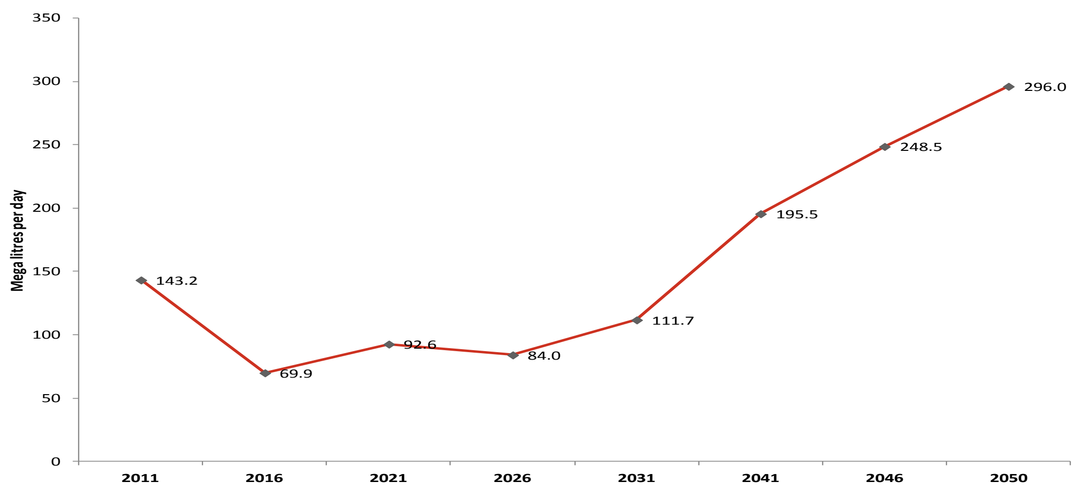

**Source: Indecon Economists modelling**

The table overleaf illustrates the water demand forecasts under the Indecon Economists High Demand Scenario. The High Demand Scenario assumes a higher population forecast than the Base Case Scenario while also incorporating higher expected economic growth in certain key water using sectors. Alternative assumptions as regards the likely impact of metering, charging and leakage have also been incorporated. In light of these assumptions, the High Demand Scenario forecasts a higher supply requirement by 2050.

| Water Demand to 2050 – Indecon Economists High Demand Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Per Capita Consumption | l/hd/day | 125.5 | 126.4 | 127.0 | 126.8 | 126.5 | 125.9 | 125.3 | 124.7 |
| Residential Demand Projection | Ml/d | 190.3 | 200.8 | 210.8 | 225.7 | 238.9 | 257.2 | 266.0 | 272.4 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.1 | 155.6 | 166.9 | 183.1 | 225.9 | 250.2 | 272.4 |
| Customer Side Loss Rate | l/house | 66.0 | 55.8 | 47.3 | 36.8 | 26.3 | 26.3 | 26.3 | 26.3 |
| Customer Side Losses | Ml/d | 40.8 | 39.3 | 36.9 | 32.9 | 26.7 | 33.9 | 38.5 | 43.8 |
| Leakage Rate | % | 33.0 | 29.8 | 26.4 | 24.8 | 23.1 | 20.7 | 19.6 | 18.7 |
| Distribution Losses | Ml/d | 178.1 | 161.5 | 146.4 | 141.8 | 136.5 | 136.5 | 136.5 | 136.5 |
| Operational Usage | Ml/d | 3.6 | 3.8 | 4.0 | 4.3 | 4.5 | 5.2 | 5.5 | 5.9 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **541.4** | **553.6** | **571.4** | **589.7** | **658.7** | **696.8** | **731.0** |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **617.4** | **635.1** | **657.4** | **680.3** | **763.1** | **808.9** | **849.8** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| Average Day Peak Week Demand - Benefitting Corridor | Ml/d | 73.6 | 71.0 | 70.6 | 70.3 | 70.4 | 73.0 | 74.5 | 75.7 |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **688.4** | **705.7** | **727.7** | **750.7** | **836.1** | **883.3** | **925.5** |
| **Total Production Requirement Dublin & BC (Including allowance for risk and uncertainty via headroom)** | **Ml/d** | 753.6 | 760.4 | 783.0 | 809.5 | 837.1 | 920.9 | 974.0 | 1021.5 |
| **Source: Indecon Economists** | | | | | | | | | |

The graph overleaf illustrates the supply deficit associated with this level of demand. The deficit under the high demand assumptions is forecast to rise from 69.9 Ml/d in 2016 to 296 Ml/d by 2050. This compares to a deficit of 207.5 Ml/d in the base case scenario.

**Projected Supply Deficit - Indecon Economists High Demand Scenario**




**Source: Indecon Economists Analysis**

## Need to Meet Water Needs of Users Reflecting Economic Costs of Water Disruption

There is a need to meet foreseeable demand for water for both the residential and non-residential sectors. In addition to the needs of economic sectors, of even greater importance are the needs of the residential sector. Despite being vital for human life and being recognised as a basic right, clean water is also a quantifiable and scarce natural resource. Principle 4 of the Dublin Declaration of the International Conference on Water and the Environment recognises the special status of water as a fundamental human right but also posits that treating water as a scarce resource is appropriate to limit wastage, improve efficiency and encourage environmental responsibility in water supply. From the perspective of a residential water user, a reliable and sustainable water supply is vital to maintaining the quality of life for individuals and families throughout Ireland including in the Region.

For the non-residential sector, Indecon Economists believe there will be a requirement for increased water demand to accommodate the expansion plans of a number of major existing large industrial users. We believe this could involve an increased demand of between 30 to 50 Ml/d. There will, however, be potential to improve water intensity over time but this will depend on the timing of new projects and technological advances. Indecon Economists believe that Irish Water should therefore ensure sufficient capacity to accommodate such users. In this context the IDA has indicated the following:

> ***"The continued strategic planning and investment in the provision of utilities, including water, waste water, power, gas etc. is paramount as it assists in maintaining Ireland's attractiveness to secure utility intensive investments against stiff global competition. The provision of these utilities are a key components to meet the requirements of industry, both FDI and indigenous.***
>
> ***The Dublin region and its hinterland must plan to ensure that water supply to the region can meet demand and opportunities to secure future investments and related job creation. Therefore this region must have the ability to demonstrate robust and scalable infrastructure capable of delivering increased water supply and treatment capacity of 34 – 50 Ml/d within the next five year timeframe."***

In our base case estimates we are assuming that even after efficiencies in water intensity are taken into account, there will be a need for an increase in water demand by the non-residential sector of over 38 mega litres per day by 2026 and indeed our base case scenario assumes this will increase to 110 mega litres per day by 2050. This takes account of the impact of sectoral shifts in demand and, as noted previously, also takes account of an assumed reduction in water intensity. In our high demand scenario our estimates assume a higher level of water demand for the non-residential users of over 40 mega litres per day by 2026 and over 145 Ml/d by 2050. This takes account not only of the likely increased demand by existing or new large users, but also the need to accommodate the expected demand increases of other non-residential users, consistent with our assumptions for economic growth. Indecon Economists believe there is merit from an infrastructural planning perspective of ensuring adequate supply to accommodate a higher demand scenario. The significant economic costs of water supply disruption indicated by our research supports the case for accommodation of a higher demand scenario than indicated in our base case. While there is uncertainty regarding whether the high demand scenario will be realised, it is based on a credible possible outcome for the Irish economy.

As noted above, our projections for non-residential demand implicitly include an estimate of increased water demand required to meet the strategic needs of the manufacturing sector. Some manufacturing water users may, however, close or contract over the period and it is also assumed that there will be enhanced water efficiency across sectors. Even taking account of these factors, our estimates assume the need for a strategic reserve to meet new overall sector demand. In the table below we include our overall estimates of water demand for the manufacturing sector. These estimates suggest an allowance for increased water demand over the period by the manufacturing sector of nearly 64 Ml/d by 2050, even taking account of potential closures and greater water efficiency. Before taking account of the reduction in water intensity over the forecast horizon, the projections assume a net growth in water demand and an implied strategic reserve for the manufacturing sector of 92.7 Ml/d by 2050.

**Strategic Reserve for Growth in the Manufacturing Sector**

| Description | Units | 2011 | 2016 | 2021 | 2026 | 2031 | 2041 | 2046 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Forecast Demand in the Manufacturing Sector | Ml/d | 35.1 | 39.6 | 48.1 | 54.1 | 61.3 | 80.2 | 90.0 | 99.1 |
| Forecast Demand in the Manufacturing Sector - Excluding Improvements in Water Efficiency | Ml/d | 35.1 | 41.5 | 52.5 | 61.4 | 71.9 | 99.6 | 114.3 | 127.8 |
| Net Growth in Manufacturing Demand | Ml/d | | 4.5 | 12.9 | 19.0 | 26.1 | 45.1 | 54.8 | 63.9 |
| Net Growth in Manufacturing Demand - Excluding Improvements in Water Efficiency | Ml/d | | 6.3 | 17.3 | 26.3 | 36.8 | 64.4 | 79.2 | 92.7 |

Source: Indecon Economists

International evidence supports the assumption that water is important for non-residential sectors. Of particular interest to the Irish experience is the documented importance of reliable water supply in computer equipment (semi-conductor) chemicals and pharmaceuticals and agriculture and food and beverages sectors. Those sectors which are both dependent on water-supply for production and which export a significant proportion of total output are of particular importance in this context. Indecon Economists believe that this highlights the relevance of tailoring water demand modelling to the characteristics of a small open economy. It is, therefore, important that all regions have access to a reliable and sustainable water supply. An unreliable water supply would have significant economic costs. Interruptions in supply or intermittent falls in water quality have the potential to interrupt business for those firms already operating while simultaneously discouraging similar firms from setting up in Ireland.

The available evidence indicates that water resilience is a key factor for many industry sectors. Some estimates of resiliency factors by industry sectors are presented in the table below. Many industries would only be able to produce at a capacity of around 50% following a water outage; however this falls to 30% as the outage extends in duration.

| Overall Resiliency Factors by Industrial Sector | | | |
|---|---|---|---|
| **Industry Sector** | **Water-outage duration** | | |
| | **< 1 week** | **1-2 weeks** | **> 2 weeks** |
| Agriculture | 0.53 | 0.35 | 0.3 |
| Business/repair services | 0.45 | 0.33 | 0.27 |
| Communication/utilities | 0.65 | 0.49 | 0.43 |
| Construction | 0.68 | 0.47 | 0.43 |
| Durable manufacturing | 0.42 | 0.34 | 0.28 |
| Educational services | 0.45 | 0.33 | 0.27 |
| Entertainment services | 0.45 | 0.33 | 0.27 |
| Finance | 0.44 | 0.27 | 0.24 |
| Health services | 0.27 | 0.21 | 0.19 |
| Insurance | 0.44 | 0.27 | 0.24 |
| Mining | 0.73 | 0.48 | 0.44 |
| Nondurable manufacturing | 0.42 | 0.34 | 0.28 |
| Other services | 0.45 | 0.33 | 0.27 |
| Personal services | 0.45 | 0.33 | 0.27 |
| Real estate | 0.44 | 0.27 | 0.24 |
| Retail trade | 0.46 | 0.32 | 0.28 |
| Transportation | 0.65 | 0.49 | 0.43 |
| Wholesale trade | 0.51 | 0.36 | 0.3 |
| **Mean** | **0.49** | **0.35** | **0.30** |
| **Source: Chang et al. (2002). Figures are the average of the factors for the two regions (Memphis and Northridge)** | | | |

Estimates of the cost of even 1 day's disruption are presented in the table below combined with Indecon Economists estimates of the potential impacts of the costs of 1 day disruption in water outage for the Greater Dublin Region. However, a linear approach to aggregating costs would not be appropriate so that the costs of water disruption for the residential sector of a 100 day outage may be significantly less than 100 times daily cost estimates. Indecon Economists note that for many sectors including high tech ICT and pharmaceutical sectors the issue of resilience is of particular importance and the consequences for Ireland's reputation as a location for investment would be higher than any estimates of daily costs.

| Summary of Selected Previous Studies on the Cost of a Loss in Water Supply | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Summary of Previous Studies** | | | | | | **Indecon Economists Estimations** | |
| **Authors** | **Country** | **Service** | **Disruption** | **Method** | **Unit** | **Cost per Person per Day - € 2014 prices** | **Estimated cost of 1-day disruption for GDA - €m[1]** |
| FEMA method (2009) presented in Aubuchon and Morley (2013) | U.S. | Water | Outage | Constant elasticity demand curve | per capita per day | 44 | 78.9 |
| Aubuchon and Morley (2013) | U.S. | Water | Outage | Constant elasticity demand curve | per capita per day | 122 | 219.4 |
| **Source: Indecon Economists Analysis**<br>*Estimates rounded to the nearest €. | | | | | | | |

[1] All estimates for the GDA were arrived at by grossing up per person per day estimates to the size of the GDA population.

From the preceding analysis of existing research, it can be observed that industrial sectors respond differently to water outages and this is influenced by factors such as input substitutability, the availability of water reserves, the water intensity of output, and the duration of the outage. However, the extent of potential losses to both the business and residential sectors of a water supply outage highlight the importance of ensuring a reliable and adequate water supply.

Several of the industries in which Ireland attracts the largest amount of foreign direct investment are heavy water users. Pharmaceuticals, the manufacture of computer chips and facets of the information and communication technology (ICT) services sector are examples of these water-dependent industries. For these industries, a reliable, sustainable and high quality supply of water is a factor in their location decisions when contemplating foreign investment.

The Forfás report, "*Adaptation to Climate Change: Issues for Business*" (Forfás, 2010), underlines the importance of water supply to these sectors and continued FDI inflows by highlighting the sectors of the Irish economy that are potentially most vulnerable to water shortages. Forfás highlights both the pharmaceuticals sector and the Information and Communication Technology (ICT) manufacturing and services sectors as industries with a particular reliance in their business processes on a dependable supply of water. The Forfás report points to several technical factors in the pharmaceuticals and chemicals sectors accounting for their dependence on a reliable source of plentiful clean water. For example, the report refers to the importance of water in vaccine production:

> "The availability of fresh water is essential for operations in the biotechnology sector, as vaccine manufacturing operates under strict norms that require fresh water"

Beyond the pharma sector, Forfás also highlights the water needed for cooling data centres as a key vulnerability of the ICT services sector to disruptions in water supply. Similarly, ICT manufacturing is also highly dependent on a reliable water supply, and the manufacture of semiconductors, for example, is a water intensive process.

## Overall Conclusions

*Need for Long-Term Planning*

Increasing water demand in Ireland has been met within a very narrow 'supply-demand balance' operational regime, and there is very limited spare capacity in the existing supply system. Establishment of a new long-term water supply source for the Region is recognised as a long-term infrastructure project that could take up to 10 years to fully realise. It is thus vitally important for the security of water supply in the region that long-term planning is commenced now. This is further highlighted by the limited potential to abstract further water from existing sources in the region. A short-term reprieve to the water supply network is likely to occur due to increased water conservation, but the evidence suggests this is not likely to eliminate the need for an expansion of supply over the medium- to long term as presented in this report.

It is also important to consider the opportunity cost of resources when examining the merits of large investment decisions to expand water infrastructure, as well as the opportunity cost of leakage repairs. This latter factor represents a key issue in calculating the optimal or economic level of leakage in the water supply system. Repairing certain types of leakage in the water supply whereby the costs of addressing the leakage is low compared to alternative investments costs may have high economic returns. Addressing customer side leakages and a 'first fix' policy could be important in this context.

*Estimates of Future Demand*

Our analysis has provided forecasts of likely future demand for water. Indecon Economists had concerns about the applicability in an Irish context of some of the historical approaches used to forecast water demand, particularly for the non-residential sectors. Often such forecasts were based on assumptions of the levels of zoned land or simply assumed non-residential demand would grow in line with that in the residential sector. While this may have some validity for large closed economies, Indecon Economists believe there is no basis for such an assumption in a small open economy. Also of importance is the need to take account of sectoral differences in water usage in the non-residential sector and the trend towards declining water intensity. Some previous projections for water demand for the residential sector did not take account of the impact of economic developments on migration and on household size. For the residential sector it is also necessary to factor in the impact of water metering and charges, changes in occupancy levels and enhanced water efficiency of new building stock. Indecon Economists' estimates have explicitly examined and taken account of each of these issues. Our analysis of the evidence highlights the need for significant investment to address the expected gap between supply and demand for water over time.

There is merit from an infrastructural planning perspective in seeking permission for abstraction levels of adequate supply to accommodate foreseeable demand. The significant economic costs of water supply disruption indicated by our research supports the case for accommodation of a higher demand scenario than in our base case. Indecon Economists would, however, recommend that investment in treatment capacity should be planned on a modular basis and increased over time based on emerging requirements so as to minimise investment expenditures.

**Acknowledgements and Disclaimer**

Indecon Economists would like to thank a number of individuals and organisations for their inputs during the course of completing this research. We would like to thank Dr Alan Ahearne, Professor of Economics, NUI Galway. Thanks are due to CSO for provision of data. We would like to thank officials within the four Dublin area local authorities for their inputs, including Adrian Conway, Dermot Collins, Dick Gleeson and John O'Hara (Dublin City Council), Gerry Hayden (Dun Laoghaire-Rathdown County Council), Brendan Colgan (Fingal County Council) and Eddie Taafe (South Dublin County Council). In addition, we would like to thank Ray Bowe, Michael Lohan and James Boyle (IDA Ireland), and Cathy Holahan, Paul Butler and Neil Cooney (Enterprise Ireland) for their inputs. We also acknowledge the information provided by the staff at Irish Water, including Jerry Grant, Gerry Geoghegan, John Barry, Claire Coleman, Richard Kent, Victor van der Walt, Mark Macaulay, Angela Ryan, Niall Tuke and Kate Gannon. We would like to thank Mick Garrick (Tobin), Ciarán O'Keeffe and Patrick McGill (Jacobs), and to demographers, including Conor Skehan and Ciara Kellett (AOS Planning), for their inputs. We also acknowledge the extensive research on econometric and other work on water demand undertaken by economists internationally as reflected in the bibliography. Indecon Economists also note valuable inputs from a range of other individuals who have indirectly provided inputs which have informed our analysis. The usual disclaimer applies, and responsibility for the analysis and findings in this independent report remain the sole responsibility of Indecon Economists.

# 1 Introduction and Background

## 1.1 Introduction

This independent report is submitted by Indecon Research Economists. The report represents one input to the Project Need assessment for the Water Supply Project, Midlands and Eastern Region (WSP), and provides an assessment of the economic need for water in Dublin and in the benefitting corridor, including new independent estimates of the demand for water over the planning period.

## 1.2 Background and Scope of Assessment

The background to this assessment is that the WSP's objective is to ensure that, in combination with other projects within the Area, the long-term (2050+) water supply needs of the Water Supply Area are met in a sustainable manner. (The Supply Area includes Greater Dublin Area and parts of Tipperary, Offaly, Laois, Westmeath and parts of County Kildare and Meath).The need for a new long-term additional secure and sustainable water source for the Region was originally identified in 1996, while feasibility studies to assess need and possible options were undertaken between 2004 and 2008. In October 2010, a Plan for the WSP-DR Region was adopted, which was subsequently published alongside a Strategic Environmental Assessment (SEA) in September 2011 in accordance with the European Communities (Environmental Assessment of Certain Plans and Programmes) Regulations 2004.[2] The Plan identified a range of new water supply options to sustainably augment existing sources in the Region from approximately 2022 onwards. It recommended that further and more detailed assessments be carried out to determine the environmental and other criteria which would have to be met for a sustainable new water supply scheme. The next stage in the development of the WSP project involves application to An Bord Pleanála, to seek statutory consent for the Project under the Planning and Development (Strategic Infrastructure) Act 2006.[3] The application process requires the undertaking of an Environmental Impact Assessment (EIA), consistent with European Union directives. This, inter alia, must clarify the strategic need for the Project. Indecon Economists believe that, regardless of any planning requirements, a rigorous assessment of water need is required in order to decide on the best use of scarce economic resources.

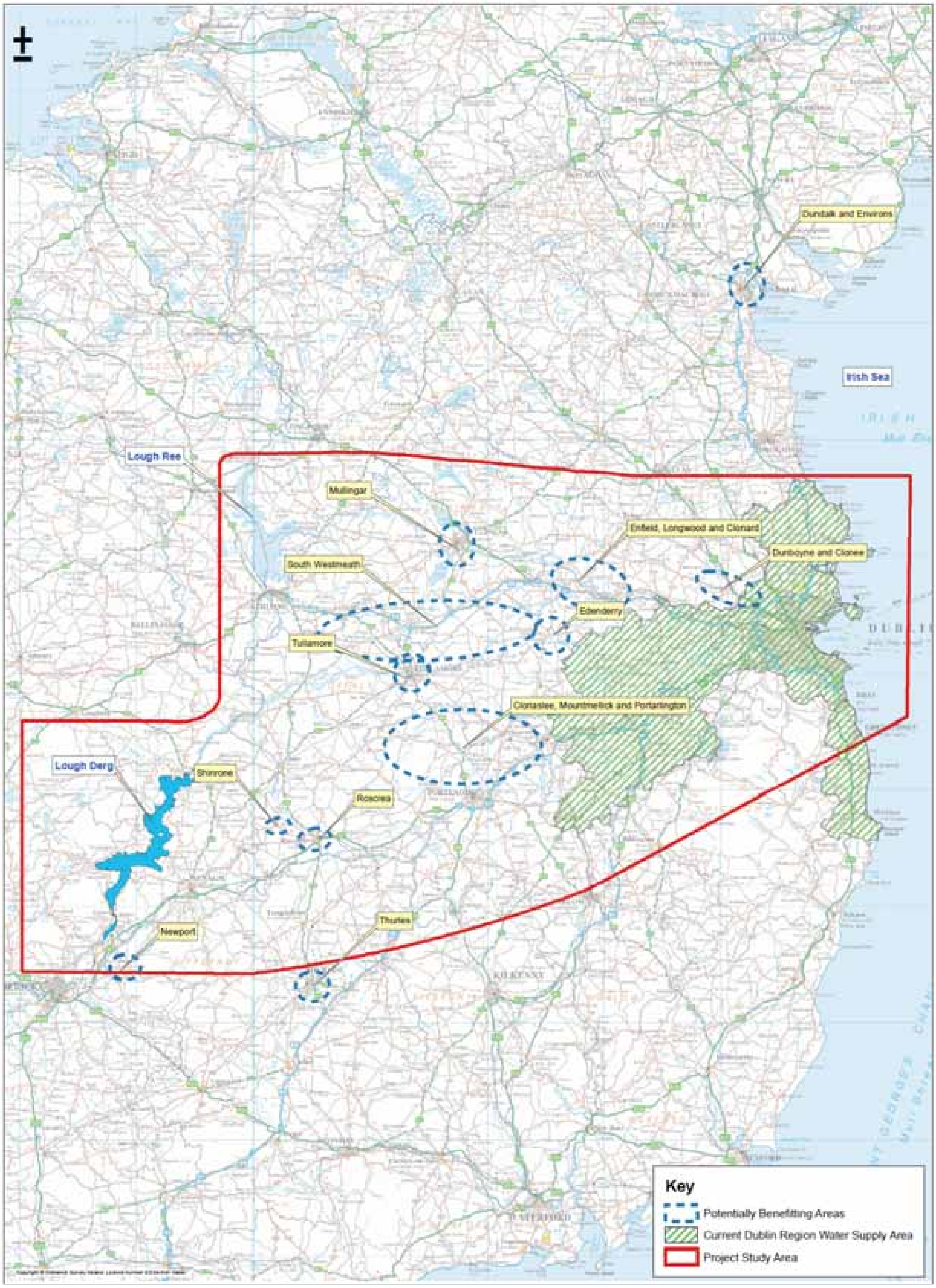
The development of the Project is undertaken in the context of also ensuring that it contributes appropriately to supporting balanced regional development. Consequently, the Project is also being planned to integrate with the overall strategy of Irish Water and the Water Services Strategic Plan (WSSP). In this context, the WSP are proposing to make specified quantities of treated water available to local authorities in the full economic zone defined by the source and the water transfer system. The project therefore has the potential to deliver new water supplies and support economic development in other benefitting regions, as well as in the Dublin region. The potential water supply need areas within the 'benefitting' corridor of the WSP project are depicted in the map presented overleaf.

---

[2] Dublin City Council, (2011) 'Water Supply Project-Dublin Region – The Plan'

[3] The process will also incorporate an application to An Bord Pleanála for a Water Abstraction Licence under the Water Supplies Act 1942, and for confirmation of Compulsory Purchase Orders and Wayleave Notices served under the Planning and Development Act, 2000.

**Figure 1.1: Potential Water Supply Need Areas within WSP 'Benefitting' Corridor**



Scope of assessment

The overall objective of the assessment is to define the basis of the economic need for water in the context of expected growth scenarios out to 2050, having regard to national and regional projections which are consistent with national policy support for balanced regional development and the requirements of the eastern region. This report assesses the macroeconomic aspects of the case for the WSP, in establishing the need for the project. The review includes identification of the importance of a reliable, wholesome and sustainable water supply for the Region. Indecon Economists would point out that while this immediate assessment focuses initially on the Eastern Region, it is important to emphasise that all regions in the State should have access to reliable and sustainable water supply to support the needs of population and as well as non-residential requirements. We understand that this type of assessment will also subsequently be conducted at a national level in line with Irish Water's national remit.

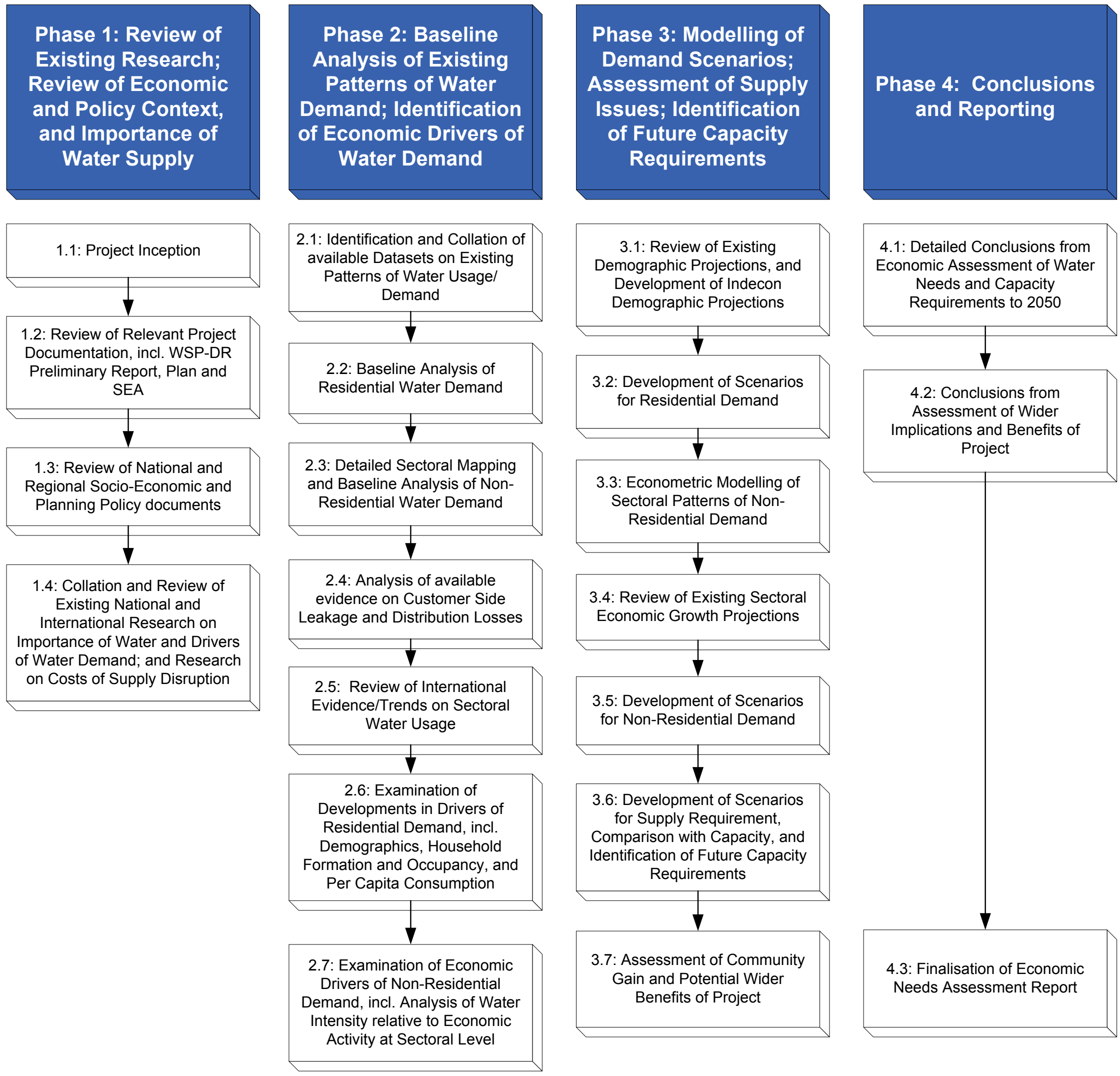
Indecon Economists believe that any major infrastructural investment has economic costs as well as benefits, and given the need to ensure the effective and efficient allocation of scarce economic resources, any evaluation of need must therefore be based on the analysis of the available evidence. In this report, we present new modelling and estimates of potential water demand, which we believe represents a more rigorous evaluation than may have traditionally been undertaken. This is important because if demand is overestimated this has implications for costs that are ultimately borne by users or the Irish Exchequer/taxpayers. However, water shortages also have a significant economic cost.

In addition to projecting the demand for water and identifying the overall supply requirement, taking into account national and regional socio-economic development policy, this assessment also provides some initial inputs to the assessment of the wider need to ensure adequate water resources.

## 1.3 Methodological Approach to Assessment

A rigorous methodological approach has been applied in completing this assessment. Of particular importance is the reflection of economic principles and the examination of empirical evidence in the formulation of scenarios for water demand. The objective is to ensure that projections are informed by an assessment of the economic drivers of demand. The methodology is consistent with international research, and has also utilised econometric modelling and other approaches to test the validity of assumptions on water intensity by sector and to validate the population projections. A schematic outline of the methodological approach is presented in the figure overleaf.

**Figure 1.2: Overview of Methodological Approach to Economic Needs Assessment**




**Source: Indecon Economists**

### 1.3.1 Data sources

In relation to water usage data, certain constraints were faced with regard to the availability of detailed consumption data within the residential and non-residential sectors at individual local authority level. Our assessment therefore included an examination of detailed local authority data and other data sources.

The range of sources utilised in our assessment included:

- ❑ Local authority data on Water Usage/Demand, provided via Irish Water;
- ❑ Estimates of existing levels of PCC;
- ❑ Central Statistics Office (CSO) datasets, including:

  - Census of Population, including data on population, household formation and household occupancy by region;
  - Census of Industrial Production – published datasets, in addition to special request to CSO for a detailed breakdown of output and employment by sector;
  - National Income Accounts, including Regional Value-Added;
  - Quarterly National Household Survey, labour market data.
- Forfás, Annual Employment Survey;
- World Input-Output Database – a European Commission-funded database, containing data on water usage and sectoral inputs and outputs over time across OECD economies;[4]
- Eurostat dataset[5].

### 1.3.2 Modelling of water demand projections

Indecon Economists undertook a review of the approaches previously used to predict water demand as well as guidelines on estimation of water demand and the result of academic research in other countries. This informed our methodological framework. The framework applied in this assessment reflects an assessment of the economic drivers of water demand within the residential and non-residential sectors.

**Residential Demand**

Water consumption within the residential sector is determined by population levels, household occupancy and average/per capita consumption. Residential water demand forecasting thus requires an evaluation of the likely future demographic developments, as well as the factors influencing per capita consumption. In our methodology, the key drivers of population, household numbers and occupancy and per capita consumption are combined to estimate the likely trajectory of future water usage and demand. This approach is consistent with that recommended by the UK Water Resource Guidelines (2012)[6] and official guidelines for forecasting water demand in other countries including Australia[7], New Zealand[8], and the United States[9]. Our analysis, however, is tailored to reflect the specific characteristics of the Irish economy and of demographic and other developments in Ireland. Our analysis also takes account of academic studies in forecasting future water demand including work by Musolesi and Nosvelli (2007), Gaudin (2006), Nauges and Thomas (2003), Martinez-Espeneira (2002), and Stevens et al (1992).

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[4] Marcel P. Timmer (ed.) (2012), "The World Input-Output Database (WIOD): Contents, Sources and Methods", WIOD Working Paper Number 10. See: www.wiod.org.

[5] Eurostat data on water usage on a national level.

[6] EA, Defra, Ofwat and the Welsh Government (2012) 'Water Resource Planning Guidelines' http://wrse.org.uk/sites/default/files/GEHO0612BWPE-E-E.pdf

[7] http://www.depi.vic.gov.au/__data/assets/pdf_file/0005/177017/Water-Supply-Demand-Strategy-Guidelines.pdf

[8] http://www.oag.govt.nz/2010/water/part4.htm#information

[9] Billing, R. and Jones, C. (2008) 'Forecasting Urban Water Demand' American Water Works Association

A key uncertainty attached to demographic projections driving residential water demand in Ireland relates to migration, and without a basis for evaluating the linkages between expected economic performance and migration it is difficult to provide a validation of which of the available population scenarios for Ireland represents the most appropriate base case. Ireland's small open economy status means that fluctuations in economic growth strongly influence migration patterns. Reflecting this factor and also to provide a validation on projections developed by the wider WSP project team, our assessment includes new econometric modelling which takes account of economic growth as a driver of migration.

Another factor influencing residential demand for water is the levels of per capita consumption (PCC). The UK Water Resource Guidelines (2012)[10] highlight the importance of incorporating PCC into demand estimates and the existing international academic research utilises assumptions for PCC in developing demand estimations. PCC within the residential sector is influenced by a complex range of factors, including household size, socio-economic characteristics, age of premises, and other factors. In addition, in the Irish context, consumption behaviour will be influenced by the introduction of metering and charging. In this assessment, account has been taken of the available evidence on current household water consumption patterns to establish a baseline, in addition to international evidence on the likely response to metering.

**Non-Residential Demand**

In relation to non-residential water demand, previous methodologies have attempted to project demand by reference to demographic growth or, alternatively, based on the assumption of development of lands zoned for industrial and commercial usage. In relation to the former approach, while this may be relevant in a larger, more closed economy, in the case of the Irish economy which is very dependent on the internationally traded sector, economic growth patterns, particularly given the impact of large multinationals, are unlikely to be closely correlated with population growth. With regard to the second traditional approach, while there may be a relationship between water usage and the development of zoned lands (for example, through assuming certain relationships between employment densities and water consumption), the precise outcomes at a sectoral level would be highly uncertain and would be dependent on the extent to which lands are developed for different sectoral uses, as well as the timing of such development. For these reasons, Indecon Economists have reservations with regard to some of the traditional approaches used and we believe that such approaches do not represent an adequate basis for assessment of non-residential water demand in an Irish context.

Indecon Economists' approach to forecasting non-residential water demand in this assessment combines evidence on sectoral water usage and economic growth patterns to drive future non-residential demand. This is informed by econometric modelling of intensities of water usage at a sectoral level using international datasets. The approach is consistent with practice internationally and is reflected in guidelines by the UK Water Industry Research (1997)[11] and the UK Water Resource Planning Guidelines (2012)[12]. Econometric modelling and the variable flow approach are

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[10] Environment Agency, Defra, Ofwat and the Welsh Government (2012) 'Water Resource Planning Guidelines' http://wrse.org.uk/sites/default/files/GEHO0612BWPE-E-E.pdf

[11] UKWIR (1997) Forecasting Water Demand Components Best Practice Manual http://ukwir.forefront-library.com/report/94658/Reports/90179/Water-Resources/90180/Demand/83/UKWIR-EA-Forecasting-Water-Demand-Components---Best-Practice-Manual

[12] Environment Agency, Defra, Ofwat and the Welsh Government (2012) 'Water Resource Planning Guidelines' http://wrse.org.uk/sites/default/files/GEHO0612BWPE-E-E.pdf

also methods advised by these guidelines, depending on the availability of data. The variable flow approach modifies water intensity factors (consumption per household or employee) over time to account for changes in price or supply restrictions. Indecon Economists employ a combination of the variable flow approach and sectoral disaggregation for the purpose of this study. The variable flow approach was also applied in Hansen et al (1979) by using water use per employee and output per employee projections and a study in Idaho[13], funded by the U.S. Bureau of Reclamation (USBR), which estimated industrial and commercial water demand applied the sectoral disaggregation approach. The UK Severn Trent Water Forecast[14] of non-domestic demand applied econometric techniques relating water consumption to indicators of economic performance and this analysis was also carried out on a sectoral basis. Other examples of relevant research includes Rees (1969), Turnovsky (1969) and De Rooy (1974) in which a single demand function is estimated using a price variable derived from total expenditure divided by total consumption, and Grebenstein and Field (1979), Babin et al. (1982), Renzetti (1993) and Dupont and Renzetti (2001) who estimate translog functions, among others.

The detailed methodological approach applied in this study and the resulting projections for non-residential water consumption are set out in Section 3.

## 1.4 Report Structure

The remainder of this report is structured as follows:

- Section 2 sets the context for the subsequent detailed assessment of future water needs by examining the demographic and economic drivers of water demand in the Region;
- Section 3 assesses the demand for water and projected water needs over the long-term planning horizon for the WSP. This includes the development of new projections for water demand based on Indecon Economists' economic modelling.
- Section 4 considers a number of aspects of the supply of water, including existing supply and capacity margin. This section also integrates the assessment of likely supply capacity with Indecon Economists' preceding demand scenarios to identify scenarios for future water supply requirements in the Dublin Region.
- Section 5 reviews a number of dimensions of the importance of reliable and sustainable water supply from an economic perspective.
- Section 6 presents a summary of our key conclusions.

[13] *Domestic, Commercial, Municipal and Industrial Water Demand Assessment and Forecast in Ada and Canyon Counties Idaho* https://www.idwr.idaho.gov/waterboard/WaterPlanning/PDFs/DCMI_Report.pdf

[14] www.severntrent.com/content/ConMediaFile/1379

## 1.5 Acknowledgments and Disclaimer

Indecon Economists would like to thank a number of individuals and organisations for their inputs during the course of completing this research. We would like to thank Dr Alan Ahearne, Professor of Economics, NUI Galway. Thanks are due to CSO for provision of data. We would like to thank officials within the four Dublin area local authorities for their inputs, including Adrian Conway, Dermot Collins, Dick Gleeson and John O'Hara (Dublin City Council), Gerry Hayden (Dun Laoghaire-Rathdown County Council), Brendan Colgan (Fingal County Council) and Eddie Taafe (South Dublin County Council). In addition, we would like to thank Ray Bowe, Michael Lohan and James Boyle (IDA Ireland), and Cathy Holahan, Paul Butler and Neil Cooney (Enterprise Ireland) for their inputs. We also acknowledge the information provided by the staff at Irish Water, including Jerry Grant, Gerry Geoghegan, John Barry, Claire Coleman, Richard Kent, Victor van der Walt, Mark Macaulay, Angela Ryan, Niall Tuke and Kate Gannon. We would like to thank Mick Garrick (Tobin), Ciarán O'Keeffe and Patrick McGill (Jacobs), and to demographers, including Conor Skehan and Ciara Kellett (AOS Planning), for their inputs. We also acknowledge the extensive research on econometric and other work on water demand undertaken by economists internationally as reflected in the bibliography. Indecon Economists also notes valuable inputs from a range of other individuals who have indirectly provided inputs which have informed our analysis. The usual disclaimer applies, and responsibility for the analysis and findings in this independent report remain the sole responsibility of Indecon Economists.

# 2 Economic Growth and Development in the Dublin Region

## 2.1 Introduction

This section sets the context for the subsequent detailed assessment of future water needs by examining aspects of demographic and economic characteristics in the Dublin region.

## 2.2 Demographic Features

A key determinant of domestic/household demand for water is likely changes in population, number of households and household occupancy. The table below presents estimates of the existing level of population in the Water Supply Region, including the 'benefitting corridor' and the remainder of the country. The population of this wider potential corridor of benefit for the WSP project is shown in the table below, indicating an overall population across the Region including corridor of benefit in excess of 2 million people. The total population of Ireland as of the 2011 census was 4.6 million people.

**Table 2.1: Population of the Dublin Region, the Project Potential Corridor of Benefit and the Rest of Ireland**

| Area | Population – Persons (2011 Census) |
|---|---|
| Dublin Region - Defined Water Supply Zone | 1,516,133 |
| WSP Potential Corridor of Benefit* | 533,984 |
| Rest of Ireland | 2,538,135 |

**Source: Indecon Economists analysis of data from CSO, Census of Population and AOS.**
* The benefiting corridor includes areas within North Tipperary, Laois, Offaly, Westmeath, Kildare, Meath and Dublin (outside the main Dublin water supply area).

## 2.3 Economic Characteristics

Developments in economic activity in the Region will impact on both residential and non-residential demand for water in a number of complex ways. Of particular relevance are the trends in value-added and output and in employment by sector. Gross Value Added (GVA) represents a measure of the value of goods and services produced minus the cost of intermediate inputs. Estimates suggest that GVA in the Greater Dublin Area amounted to €73.6 billion in 2013 (see table below). The level of economic activity has a direct impact on water requirements in the Greater Dublin Area, although this will vary by sector.

**Table 2.2: Economic Activity - Gross Value Added in Greater Dublin Area**

| | 2013 – € Million (Est.*) |
|---|---|
| Greater Dublin Area, All Sectors - €m | 73,647 |

**Source: Indecon Economists estimate for 2013 based on CSO data**
Note: Greater Dublin Area includes Dublin and the Mid-East.

Table 2.3 provides a broad sectoral breakdown of value added for the Greater Dublin Area. This highlights the significance of services.

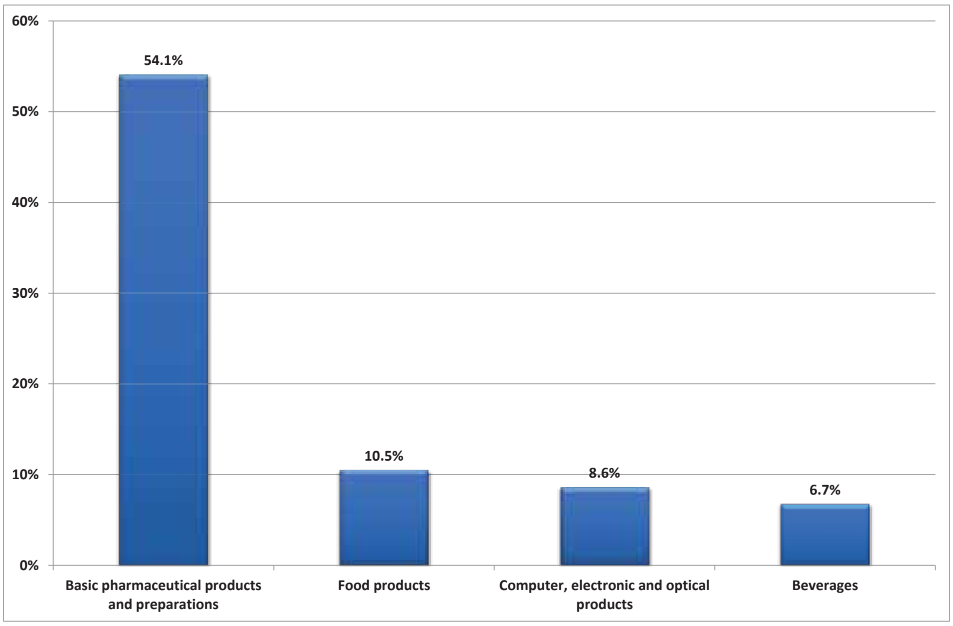
**Table 2.3: Gross Value Added by Broad Sector for Greater Dublin Area 2010 and 2011**

| | 2010 | 2011 | % Share 2011 |
|---|---|---|---|
| Market and Non-Market Services -€m | 57,381 | 60,911 | 83.9% |
| Manufacturing, Building and Construction - €m | 12,247 | 11,339 | 15.6% |
| Agriculture, Forestry and Fishing - €m | 306 | 360 | 0.5% |

Note: Greater Dublin Area includes Dublin and the Mid-East. GVA is in basic prices.
**Source: Indecon Economists Analysis of CSO Data**

It is, however, necessary to look at a much more gradual analysis of the sectoral composition of the economy in the Region. The figure below highlights those sectors which account for the largest proportion of total manufacturing output. In particular, pharmaceuticals accounts for over half of manufacturing output and other important sectors include food and beverages and computers and electronics.

**Figure 2.1: Output as % of Total Manufacturing Output for Selected Top Manufacturing Sectors in Greater Dublin 2012**




**Source: Indecon Economists Analysis of CSO COIP Data.**
Note: Greater Dublin Area includes Dublin and the Mid-East.

The value of gross output for 2012 for manufacturing sectors in the greater Dublin Area is presented in the next table. This also highlights the importance of pharmaceuticals, food, computer and electronics and machinery and electrical equipment.

**Table 2.4: Gross Output by Detailed Sector in Manufacturing in 2012 - €000**

| | Greater Dublin Area |
|---|---|
| Basic pharmaceutical products and preparations | 14,936,445 |
| Food products | 2,894,892 |
| Computer, electronic and optical products | 2,367,173 |
| Tobacco; coke and refined petroleum products; furniture; Other Manufacturing | 2,117,554 |
| Beverages | 1,856,184 |
| Printing and reproduction of recorded media | 619,875 |
| Chemicals and chemical products | 612,484 |
| Paper and paper products | 365,502 |
| Other non-metallic mineral products | 300,706 |
| Other Machinery and equipment | 259,151 |
| Electrical equipment | 257,324 |
| Fabricated metal products, except machinery and equipment | 246,454 |
| Repair and installation of machinery and equipment | 234,818 |
| Rubber and plastic products | 222,281 |
| Basic metals | 87,084 |
| Textiles | 66,477 |
| Wearing apparel | 64,521 |
| Wood and wood products, except furniture, Leather and related products | 64,339 |
| Motor vehicles, trailers and semi-trailers | 53,964 |

**Source: Indecon Economists analysis of CSO COIP Data (special request undertaken by CSO)**
Note: Greater Dublin Area includes Dublin and the Mid-East.

### 2.3.1 Employment

The levels of employment are also a determinant of water supply needs. Table 2.5 presents data on employment in the Greater Dublin Area for 2012 to the first quarter of 2014 from the Quarterly National Household Survey. The data shows significant growth in employment for the Greater Dublin Area.

**Table 2.5: Employment in Greater Dublin Area 2012-2014 (Thousands)**

| | 2012 – 000s | 2013 – 000s | 2014 – 000s* |
|---|---|---|---|
| All NACE Economic Sectors | 548.4 | 561.1 | 572.9 |

Note: Greater Dublin Area includes Dublin and the Mid-East.
*Data relates to position in first quarter of 2014.
**Source: Indecon Economists Analysis of CSO QNHS Data**

Table 2.6 presents data on employment for the broad sectors of industry and construction, and services. Again the significance of services to the Dublin economy is highlighted. This is relevant given the variance in water intensity by sector.

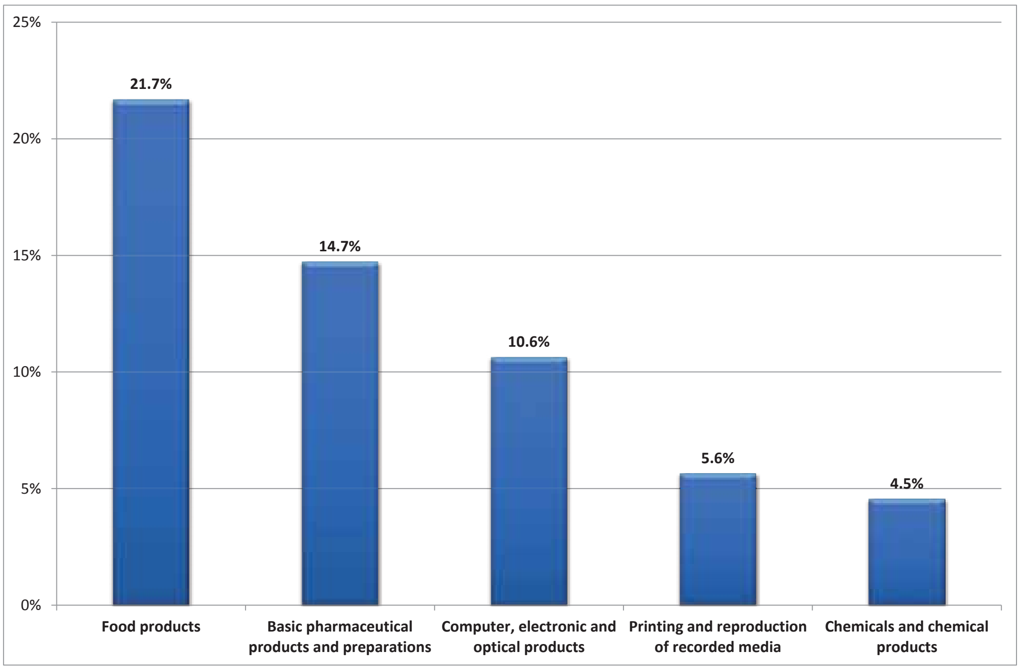
**Table 2.6: Employment in Greater Dublin by Broad Sector 2012-2014 (Thousands)**

| | 2012 | 2013 | 2014* |
|---|---|---|---|
| Industry and Construction | 60.88 | 64.05 | 65.10 |
| Services | 485.43 | 494.00 | 504.90 |

Note: Greater Dublin Area includes Dublin and the Mid-East. Trend data on the agricultural sector alone for Greater Dublin was not available for this period.
*Data is only available for the first quarter of 2014.
**Source: Indecon Economists Analysis of CSO QNHS Data**

The main manufacturing sectors in terms of share of manufacturing employment are shown in Figure 2.2. The production of food products accounts for the largest share of employment with pharmaceuticals and computers also significant.

**Figure 2.2: Employment in the Greater Dublin the Top Manufacturing Sectors as % of Total Manufacturing Employment in the Region 2012**




**Source: Indecon Economists analysis of CSO COIP Data (special request undertaken by CSO).**
Note: Greater Dublin Area includes Dublin and the Mid-East.

A breakdown of employment by detailed manufacturing sector is presented in Table 2.7. Food products, pharmaceuticals, and computers and electronics rank the highest in terms of economic activity. Manufacturing of food and pharmaceuticals together supported a total of over 17,000 jobs.

**Table 2.7: Persons Engaged by Manufacturing Sector Greater Dublin and State 2012 (Thousands)**

| | Greater Dublin Area |
|---|---|
| Food products | 10,151 |
| Basic pharmaceutical products and preparations | 6,895 |
| Tobacco; coke and refined petroleum products; furniture; Other Manufacturing | 5,551 |
| Computer, electronic and optical products | 4,974 |
| Printing and reproduction of recorded media | 2,642 |
| Chemicals and chemical products | 2,127 |
| Paper and paper products | 2,065 |
| Beverages | 2,053 |
| Fabricated metal products, except machinery and equipment | 1,862 |
| Other Machinery and equipment | 1,661 |
| Rubber and plastic products | 1,533 |
| Other non-metallic mineral products | 1,359 |
| Repair and installation of machinery and equipment | 1,186 |
| Electrical equipment | 691 |
| Wearing apparel | 486 |
| Textiles | 478 |
| Wood and wood products, except furniture, Leather and related products | 464 |
| Motor vehicles, trailers and semi-trailers | 368 |
| Basic metals | 285 |

**Source: Indecon Economists analysis of CSO COIP Data (special request undertaken by CSO)**
Note: Greater Dublin Area includes Dublin and the Mid-East.

### Tourism Activity

Tourism-related water needs are included to some extent in the levels of output of the overall service sector referred to previously. It is however instructive to consider overall levels of tourism activity. In 2012, over 4.3 million overseas tourists visited the Greater Dublin Area and these visitors spent a total of almost €1.27 billion. These tourists constitute part of the requirements for water resource in the region.

## 2.4 Summary of Findings

This section highlights some of the demographic and economic characteristics of the Region. Some of the key findings are summarised below:

- The combined population of the defined water supply zone and the zone of benefit was in excess of 2 million people;
- The level of economic activity in the Region is significant in the context of the overall Irish Economy with gross value added amounting to €73.6 billion;
- Services activity is particularly prominent;
- Within the manufacturing sector pharmaceuticals, food, computer and electronic and machinery and electrical equipment represent key sectors;
- Tourism numbers to Dublin reached over 4.3 million in 2012.

# 3 Assessment of Water Demand and Future Needs

## 3.1 Introduction

This section assesses the demand for water and projected water needs over the long-term planning horizon for the WSP. The assessment commences by examining the existing patterns of water demand, both within the residential/household sector and the non-residential sectors. It then considers the issues of customer side leakage, system distribution losses and the impact of climate change. This is followed by a description of the methodological approach applied in this assessment to projecting future water needs, before presenting a number of scenarios for likely future residential and non-residential water needs.

## 3.2 Existing Patterns of Water Demand

### 3.2.1 Water using sectors

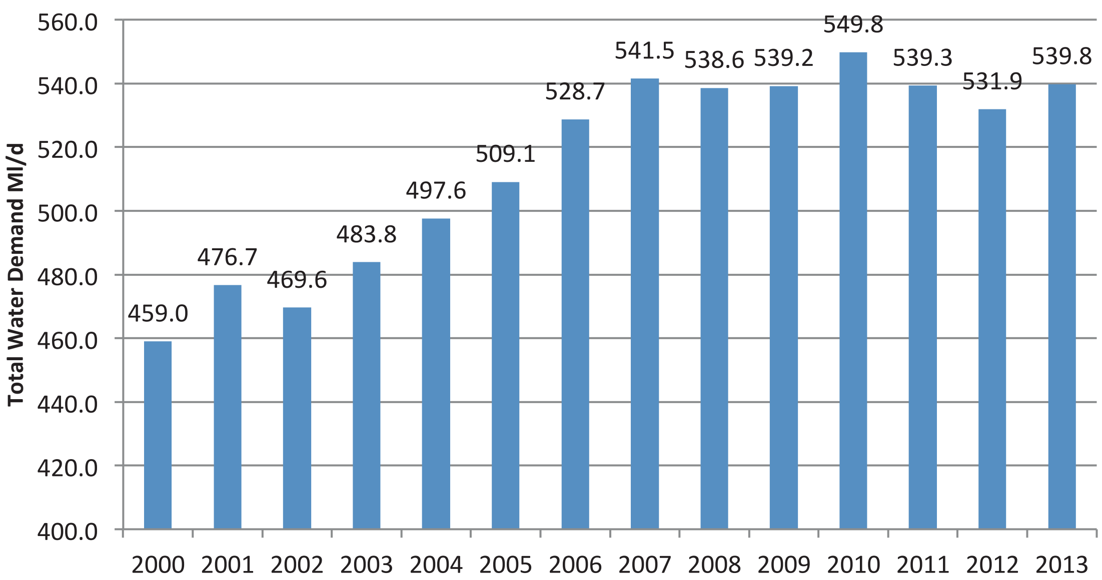
The overall demand for water in Ireland is comprised of usage for domestic/household purposes and for non-domestic purposes, including agricultural, commercial and industrial activities and the activity of public organisations (for example, health facilities). The table below outlines the broad primary sectoral components of water demand. The existing levels of water consumption are examined overleaf.

| Table 3.1: Demand for Water in Ireland |
|---|
| **Sectors of Water Demand** |
| **Residential/Household Users:** |
| Households, apartments and residences |
| |
| **Non-Residential Users:** |
| Manufacturing Sector |
| Agriculture and forestry |
| Internationally traded service sector |
| Tourism and hospitality sector |
| Construction sector |
| Health sector |
| Other government services |
| Other domestically traded services including retail and wholesale |
| Transport |
| Other |
| Source: Indecon Economists |

## 3.3 Trends in Overall Water Demand

The recent trend in demand for water in the Region is presented in the next figure. While this trend data was only available for the Dublin Water Supply Region given the significance of demand in this area it is of relevance to the overall assessment. Based on observing total water distribution, which equates with the total level of water supplied, a rising trend was observed up to 2007, with a fall-off in 2008 and 2009 during the economic recession, and another decline in 2011 and 2012. The period since 2008 has seen greater volatility, with declining water consumption evident in 2008 and 2009, followed by recovery in 2010 when demand reached a recent peak of 549.8 Ml/d (million litres per day) on average. The spike in water demand in 2010 is likely due to the particularly cold winter that year which may have lead to additional leakage both on the customer side and distribution side as well as increased water usage as households and businesses ran taps to attempt to avoid freezing pipes. There may also have been specific sectoral developments in 2010 which caused the unexpected increase to arise for example due to the rapid expansion of some large industrial users. By 2013, overall average water demand in the Dublin Region averaged 539.8 Ml/d. In the benefitting corridor average water demand is estimated to be of the order of 67.5 Ml/d.

**Figure 3.1: Historical Trend in Total Water Demand in the Dublin Water Supply Region**




**Source: Indecon Economists Analysis of Water Consumption Data**

## 3.4 Residential Water Usage Patterns

The absence to date of residential metering means that existing characteristics of residential water demand must be estimated. This is typically undertaken through combining information on assumed or verified average per capita water usage, or Per Capita Consumption (PCC) measured in litres per person per day, with data on household numbers and population levels.

The pattern of residential water consumption, including PCC, is influenced by a complex range of factors. The 2010 WSP-DR 'Plan' document outlined some of the main factors influencing residential demand for water[15] and some of the key factors influencing residential demand are as follows:

- The occupancy rate of households: As occupancy rates rise, the overall household demand for water increases, however, the per capita average daily usage levels generally fall.
- Household type and age: A number of studies have indicated that average consumption per household is higher in detached houses and lowest in apartments due to garden use and greater available space for water using appliances and bathrooms. The age of houses is an indicator of the type of water use appliances, toilets etc. that may be present with potential for water use reduction.
- Climate: Seasonal variations in demand are well documented with summer peaks common usually due to increased garden watering. Warmer and drier summers as a result of climate change in coming years may need to be factored in to forecasts of water demand.
- Average income levels/wealth: Affluence has effects on water use both in the number and scale of water using appliances and fittings in the home and their replacement rate but also in relation to the ability to pay for water use "above the norm".
- Metering: The introduction of metering with water charging is generally regarded to reduce water use by up to 10% (UK Walker Report[16]). Meters can also be used to assist consumers monitor and reduce their water use and identify leaks if sufficient access to meter data is enabled.
- Water charges: The level of water charges relative to average incomes will likely be a key determinant of future water demand.
- Public environmental awareness: If the general population are aware and interested in environmental issues, including the cost of water and merits of conservation then this may impact on per capita consumption levels.

In a residential context, water is used for tasks ranging from drinking, cooking, cleaning, showering and bathing, to gardening and a myriad of other uses. Overall residential water demand in the Region has been in part determined by population increases and by changes in household size, but there has also been an impact from rising income levels. These factors have led to lifestyle changes, including greater penetration of household appliances requiring increased water usage. In the WSP-DR '*Plan'* document, published in 2010, PCC was estimated at 147 litres per head per day in 2010. A breakdown of the 2010 estimate of PCC is presented in the next table.

[15] WSP-DR, The Plan, Op. Cit. Appendix A, p11-12

[16] Walker, A. (2009) 'The Independent Review of Charging for Household Water and Sewerage Services'

| Table 3.2: Previous Estimates of Components of Water Use in an Average Home | | | | | | |
|---|---|---|---|---|---|---|
| **Household Use** | | **% of Total Use*** | **Per Capita Consumption** | **Litres per Use** | **Average Frequency of Use (per house per day)** | **Total/house @ 2.5 pph Average Occupancy Rate** |
| Kitchen | Washing Machine | 12% | 17.76 | 60 | 0.75 | 45 |
| | Dish Washer | 4% | 5.92 | 21 | 0.7 | 14.7 |
| | Sink | 18% | 26.64 | 2 | 35 | 70 |
| | Drinking Water | 3% | 4.44 | 1.11 | 10 | 11.1 |
| | Toilets | 28% | 41.44 | 9.4 | 11.5 | 108.1 |
| | External Use | 3% | 4.44 | 13 | 0.89 | 11.57 |
| Baths and Showers | Bath | 18% | 26.64 | 71 | 0.95 | 67.5 |
| | Shower | 14% | 19.98 | 35 | 1.5 | 52.5 |
| | **Total** | **100%** | **147** | | | **380** |

* Source: Ofwat (UK)
**Source: WSP-DR 'The Plan' "Detailed Technical Review of Demand Component Targets and Demand Side Management Approaches", 2010**

As is clear from the analysis, both the quantity of water required in each use and the frequency of use is important in calculating average consumption patterns. In addition to describing how residential water demand is influenced by both volume per use and frequency of usage, there is potential for water usage savings through provision of devices which use less water and/or through encouraging behavioural changes among households.

More recent estimates of PCC have, however, been developed based on initial readings from residential metering in Dublin during April 2014, with the latest data taken from an early validation study of a District Metering Area (DMA) in North Dublin with a low percentage of non-residential premises. The early validation study, along with sampling from other areas in the Dublin Region, placed PCC at an estimated 125.5 litres per person per day. This estimate is substantially lower than the previous 147 l/hd/day estimate in the 2010 Plan document. However, given the up to date nature of the latest estimates and the improved measurability of water consumption after the roll out of water meters, the estimate of 125.5 l/hd/day is viewed by Irish Water as the most accurate available estimate of current PCC in the Dublin Region.

Any estimate of PCC is based on an average and in practice this may hide significant variation in actual per capita water usage from house to house and area to area. Beyond natural variation in water usage between different households there is also a degree of uncertainty surrounding these per capita consumption estimates due to ambiguity surrounding the levels of Customer Side Leakage (CSL) in different parts of the Region. For example, some areas and households may display higher PCC levels, but this could mask higher levels of CSL driving the apparent increased water demand and may not necessarily be indicative of higher underlying levels of actual demand. A more accurate estimate of average per capita residential consumption will emerge as metering is rolled out.

Data received by Indecon Economists indicates that residential water demand is the largest single component of the total demand for water in the Dublin Region. As the largest single driver of water demand, it is imperative that any long-term forecast of overall water demand contains accurate estimates of the likely future path of residential water demand. Due to the uncertainty attached to the prevailing levels of residential PCC, the assessment in this report includes the development of alternative water demand scenarios using different assumptions for PCC to take into account the level of uncertainty surrounding the current estimate, as well as the likely impact of residential water metering and charging. We also take account of expected changes in household occupancy and changes in the age of the housing stock in Dublin.

## 3.5 Non-Residential Water Usage Patterns

Non-residential water demand encompasses usage of water for industrial and commercial entities, as well as for public sector organisations. Non-residential water users include many different sectors with very different water usage characteristics. Because of this, an approach which attempts to predict the future evolution of non-residential water demand without taking into account sectoral variances in usage is likely to lead to misleading outcomes. This report seeks to inform our forecasts of non-residential water demand by analysing water consumption and future output growth at a sector level.

In relation to existing patterns of demand, non-residential water users have been metered in the Dublin Region since late-2008 and have been receiving water bills based upon these meter readings since 2009. However, due to transitional issues, detailed, up-to-date data on non-residential water usage data was not available across all local authorities in the Dublin Water Supply Region at the time of preparation of this assessment, with comprehensive data available only for Dublin City Council, Fingal County Council and Dun Laoghaire Rathdown County Council. This data was supplemented by summary water balance data for Wicklow County Council, Bray Town Council, Kildare County Council, and South Dublin County Council to enable construction of a full picture on non-residential demand. The resulting figures are presented in the next table.

**Table 3.3: Non-Residential Water Demand by Local Authority Area in the Dublin Region**

| Local Authority | Total Non-Residential Water Consumption (Ml/d) – 2011 Figures |
|---|---|
| Dublin City Council | 42.5 |
| Dun Laoghaire-Rathdown County Council | 11.7 |
| Fingal County Council | 33.1 |
| South Dublin County Council | 12.9 |
| Kildare County Council | 22.9 |
| Wicklow County Council | 1.9 |
| Bray Town Council | 1.5 |
| **Total of Above** | **126.5** |

**Source: Customer data made available to Indecon Economists for Dublin City Council, Fingal County Council and Dun Laoghaire-Rathdown County Council. The remaining data was averages of monthly water balance estimates provided by local authorities.**

*Sectoral usage patterns*

Examining sectoral water usage and relating this to the profile and expected changes in the sectoral composition of the economy in Dublin is an important step in accurately forecasting likely future water demand. Due to the very wide variation in water usage at a sectoral level, to insure accuracy of demand forecasts it is important to differentiate demand growth across sectors. In order to obtain a picture of the sectoral breakdown of water usage in the Region, it was necessary to assign data at individual customer level to appropriate sector descriptors, based on a NACE 2-digit industry sector classification system. Given the number of customers in the local authority datasets made available for this assessment, the approach applied was to allocate/assign data so that the top 75% of water using customers in the region were correctly assigned to economic sectors. The remaining 25% of water consumption was then divided sectorally on the assumption that the sectoral breakdown of this residual would mirror that of the 75% of water customers for which accurate sector information had been constructed. This residual was then added to the sectoral water consumption totals for each sector according to the size of that sector in terms of total water consumption. For local authorities for which detailed industrial and commercial water use data was not available, a similar process was carried out in order to estimate the sectoral breakdown of industrial and commercial water demand in the Region.

The above process facilitated a detailed sectoral analysis of existing patterns of non-residential water usage, in addition to the development of sectorally differentiated projections for future water demand in the Dublin Region. To provide a picture of existing patterns of sectoral non-residential water demand in the Dublin Region we indicate the sectors exhibiting the highest volume of water usage. The analysis presented in the table overleaf indicates both average daily consumption (mega-litres per day (Ml/d)) and percentages of total non-residential water consumption in the Dublin Region. The next table presents Indecon Economists' estimates of sectoral water consumption in the top 10 sectors by usage in 2011 in the Region. The largest individual economic sectors for non-residential water usage are the accommodation sector, accounting for an estimated 13.3 Ml/d of total average daily consumption[17] or 10.4% of total non-residential consumption in the Dublin Region, followed by the manufacture of computer, electronic and optical products (12.3 Ml/d or 9.6%). Other important sectors of water usage in the region include retailing, public administration, health services, food and beverage service activities, pharmaceuticals manufacture, education and air transport.

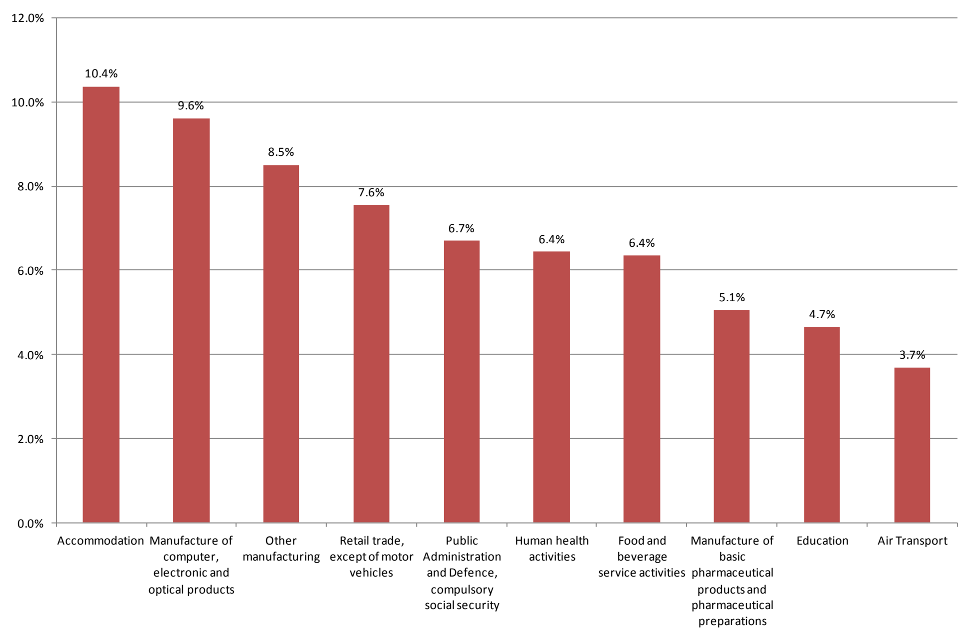
[17] Total average daily water consumption is the total amount of water consumed on a daily basis implied by the average individual daily water consumption rates.

| Table 3.4: Estimated Sectoral Breakdown of Water Consumption by the Top 10 Sectors | | | |
|---|---|---|---|
| **Ranking** | **Sector** | **Daily Consumption (ML/D) – 2011 Figures** | **% of Dublin Total Non-Residential Water Demand** |
| 1 | Accommodation | 13.30 | 10.4% |
| 2 | Manufacture of computer, electronic and optical products | 12.32 | 9.6% |
| 3 | Other manufacturing | 10.91 | 8.5% |
| 4 | Retail trade, except of motor vehicles | 9.68 | 7.6% |
| 5 | Public Administration and Defence, compulsory social security | 8.59 | 6.7% |
| 6 | Human health activities | 8.25 | 6.4% |
| 7 | Food and beverage service activities | 8.14 | 6.4% |
| 8 | Manufacture of basic pharmaceutical products and pharmaceutical preparations | 6.48 | 5.1% |
| 9 | Education | 5.96 | 4.7% |
| 10 | Air Transport | 4.73 | 3.7% |
| | **Total of Top 10 Sectors** | **88.37** | **68.9%** |

**Source: Indecon Economists analysis of data on water consumption**
Note: Other manufacturing includes bulk water metre readings for business parks and industrial estates.

Figure 3.2 illustrates graphically the top 10 sectors for non-residential water consumption in the Dublin Region. It is noteworthy that the above analysis includes a number of very large individual customers (for example, one such customer accounted for 7-8% of total non-residential demand in the region). The analysis indicated that the top 50 individual customers in the Dublin region are likely to account for approximately 26% of total non-residential water demand.

**Figure 3.2: Estimated Sectoral Breakdown of Water Consumption by the Top 10 Sectors***



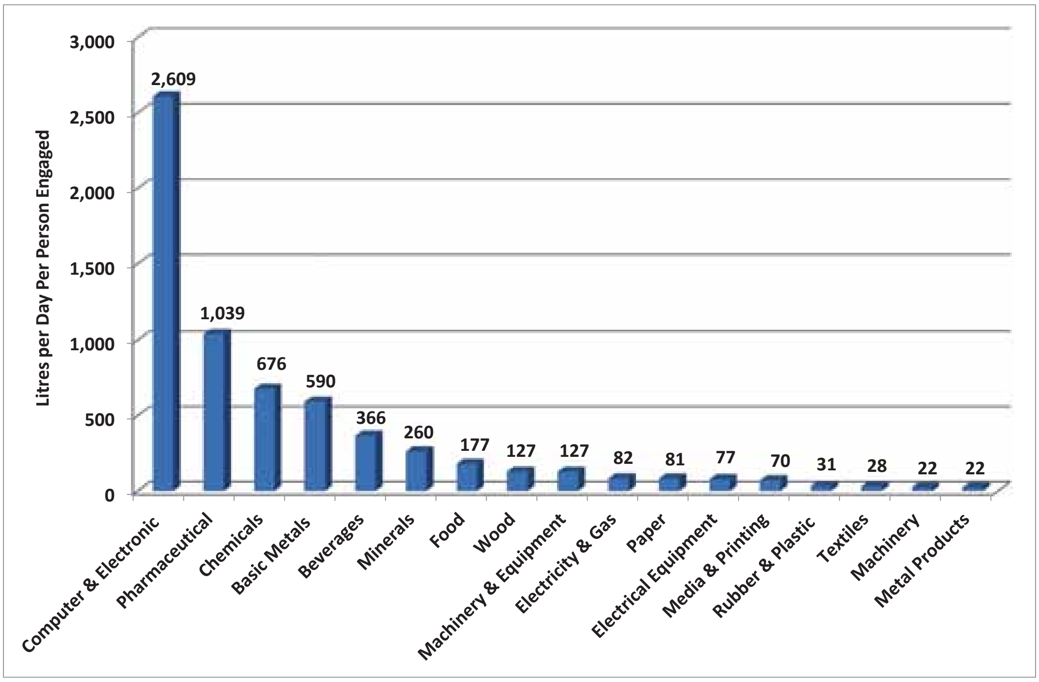

**Source: Indecon Economists analysis, based on data on water consumption**
* Based on figures for 2011 (baseline year of assessment).

*Sectoral water intensity*

The above analysis provides new evidence of the sectoral patterns of non-residential water demand and demonstrates the importance of certain sectors. While the above analysis provides a certain level of insight into the drivers of non-residential water demand, to fully understand the drivers of these sectoral features, it is necessary to relate the information on sectoral consumption with data on economic activity within the same sectors. In this assessment, Indecon Economists have combined the above data on sectoral water usage with CSO data on sectoral economic characteristics to carry out an assessment of the water *intensity* of economic activity at a sectoral level.

The figure below compares the ratio of water consumption to employment across a range of manufacturing sectors. The analysis highlights a very wide variation in sectoral water usage intensity when economic activity is factored into the analysis – in this instance by reference to employment. The most water-intensive sector is the manufacture of computers and electronic equipment, with chip/semi-conductor production in particular being a highly water intensive activity. This is followed by the pharmaceuticals and chemicals sectors, while other water intensive areas of activity include the food and beverages sector. Separate analysis of customer-level data indicated that the services sector is generally less water intensive than manufacturing, with notable exceptions being the hospitality and restaurant sectors, and other organisations such as hospitals/healthcare facilities.

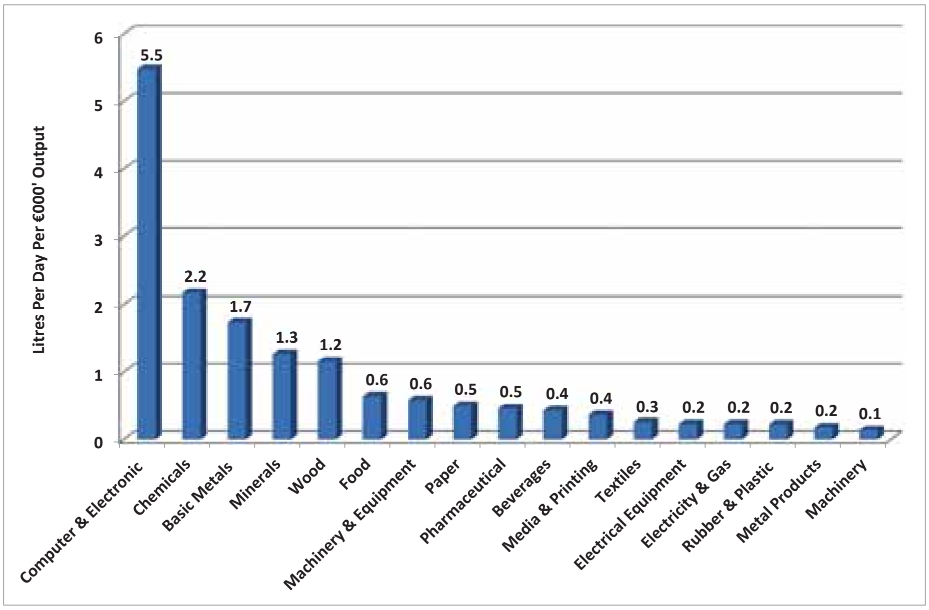
**Figure 3.3: Water Consumption Per Person Engaged by Sector in Greater Dublin Area**




**Source: Indecon Economists analysis, based on data on water consumption**
* 2011 figures for manufacturing sectors

The next figure considers sectoral water intensity from a different perspective, in this case relating water usage to the value of output produced rather than employment. The broad sectoral features remain similar with computers and electronics manufacturing and chemicals in particular being the most water-intensive sectors in terms of water use per unit of output.

**Figure 3.4: Water Consumption per €'000 of Output by Sector in Greater Dublin Area**




**Source: Indecon Economists analysis, based on data on water consumption**
* 2011 figures for manufacturing sectors

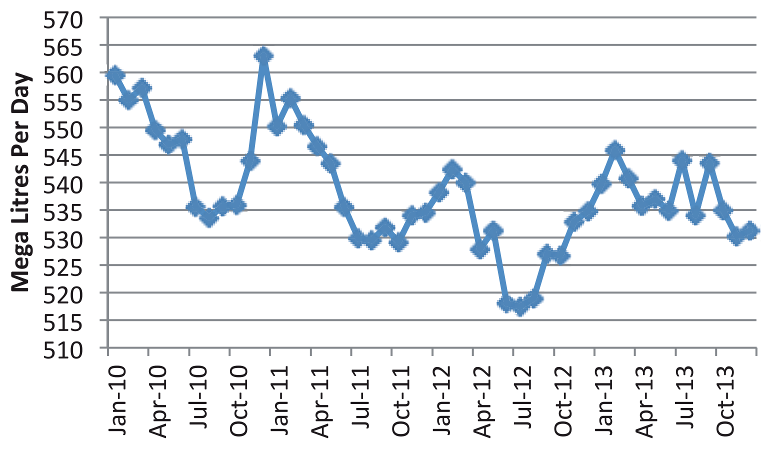
## 3.6 Peaking of Water Demand

The data on existing patterns of water demand presented in this section represent average daily levels of usage. However, water supply systems experience variations in demand throughout the day, as well as on a seasonal basis. These fluctuations in demand need to be accounted for in the design of any water supply network. Typically the peaking factor is based on observing the average day in the peak demand week of the year.

Peaks in water demand are often seasonal in nature. Summer peaks are primarily due to increased water usage associated with warm dry weather, as well as increased bursts and subsequent leakage associated with soil shrinkage. Winter peaks are primarily due to bursts associated with cold weather and with consumers running water to waste to prevent their plumbing from freezing.

Data of monthly average water supply was made available to the review team by Irish Water. The chart below illustrates the monthly and seasonal peaks in water demand in the Dublin Region between 2010 and 2013. The peaks in the winter months are clearly visible. The relative size of the peaks in the winters of 2010 and 2011 most likely reflect the severity of winters relative to those of 2012 and 2013. The peaks in the summer of 2013 most likely reflect the warm summer of that year relative to previous years. The January 2011 peak value of 563 Ml/d is 6.2% above the July/August 2011 values of 530 Ml/d.

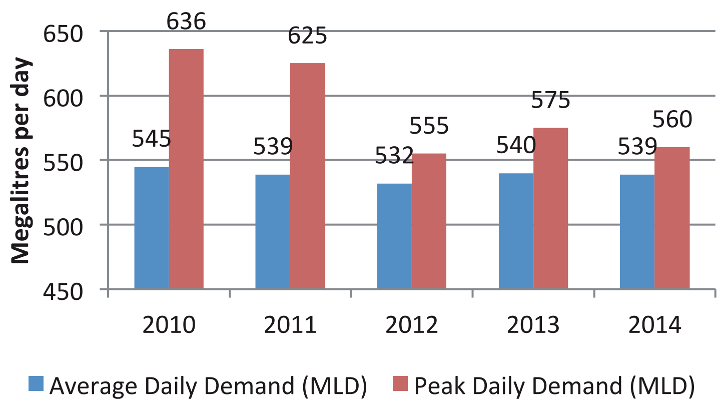
**Figure 3.5: Dublin Water Supply Region – Recent Movements in Distribution Input**




**Source: Dublin City Council**

As the above data is based on monthly averages, these figures may underestimate the daily peaks experienced during each month. An indication of the impact of peak demand can be seen by reference to the figure below which compares the estimated average daily demand for water and peak daily demand in the Dublin Region over the period 2010-2014, based on data compiled by Dublin City Council. On average over this period, peak daily demand was between 3.9% and 16.7% higher than average daily demand.

**Figure 3.6: Average and Peak Daily Water Demand in the Dublin Region**




**Source: Indecon Economists Analysis of data on water consumption**

Where the metering infrastructure and data is available, peaking factors are generally calculated using historical daily records of water supply. Where such data is not available peak demand is estimated by applying typical peaking factors. The table below displays some typical UK peaking factors.

| Table 3.5: Typical Peaking Factors in the UK | |
|---|---|
| **Type of Area** | **Peak Demand as a percentage of Average Daily Demand** |
| Seaside and holiday resorts | 130% - 150% |
| Residential towns, rural areas | 120% - 130% |
| Industrial Town | 115% - 125% |
| **Source: Twort et al., Water Supply, 6th Edition.** | |

In applying an appropriate peaking factor in the context of formulation of projections for water demand in the Region it is important to consider that leakage levels may be masking the true peaking factor. In light of this, and on the advice of Jacobs-Tobin, this report applies a peaking factor of 20% to Accounted for Water[18] in projecting water demand.

## 3.7 Projecting Future Water Demand

A key aspect of the assessment of the economic need for water is to develop a rigorous methodological framework for projecting future water demand for both the residential and non-residential sectors. This section sets out the methodological framework and assumptions underlying Indecon Economists' scenarios for water demand in the context of the WSP.

### Projecting residential water demand

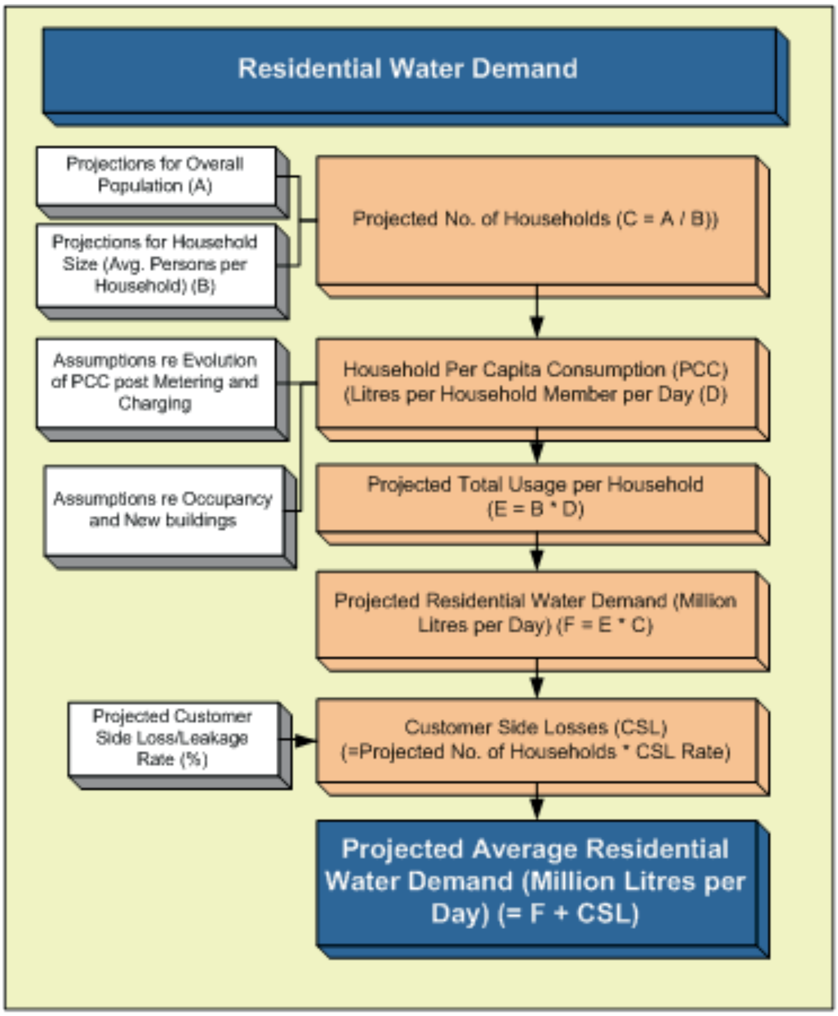
The key drivers of residential water demand as discussed previously are as follows:

- Population;
- Number of households; and
- Per Capita Consumption (PCC) of water.

The latter factor is in turn influenced by water metering and charges, occupancy rates and the age of the housing stock. A schematic description of the methodology applied in developing the projections for residential water demand is presented in Figure 3.7. This shows how the key drivers of population, household numbers and occupancy and per capita consumption are combined to estimate the likely trajectory of future water usage and demand.

[18] Accounted for Water = residential demand + customer side loss + non-residential demand - system operational usage.

**Figure 3.7: Schematic Overview of Components of Methodology for Projecting Demand for Water – Residential Water Demand**




**Source: Indecon Economists**

*Population*

In order to forecast the total level of water demand in the region it is necessary to forecast population levels. The analysis in this report includes scenarios based on the forecasts of independent demographers tailored for the Region and independent Indecon Economists population forecasts which we used to validate the available projections.

A number of population forecasts were developed by independent demographers, as outlined below.

- Scenario 1: A Planned Growth Scenario: providing for both 'High' and 'Low' population variations.
  - (a) High - This Scenario anticipates that the likely objective of the forthcoming National Spatial Strategy, as in the case of the 2002-2020 NSS, will seek to achieve a balanced approach to developing all areas of the country. The adjudged 'best fit' baseline for this Planned 'High Growth' variation is the CSO's M2F2 Traditional scenario forecasts.
  - (b) Low - The assumption made in this variation is for modest, balanced growth for Dublin as is projected in the CSO M2F2 'Recent' Projection, with higher rest of the state (RoS) regional growth.

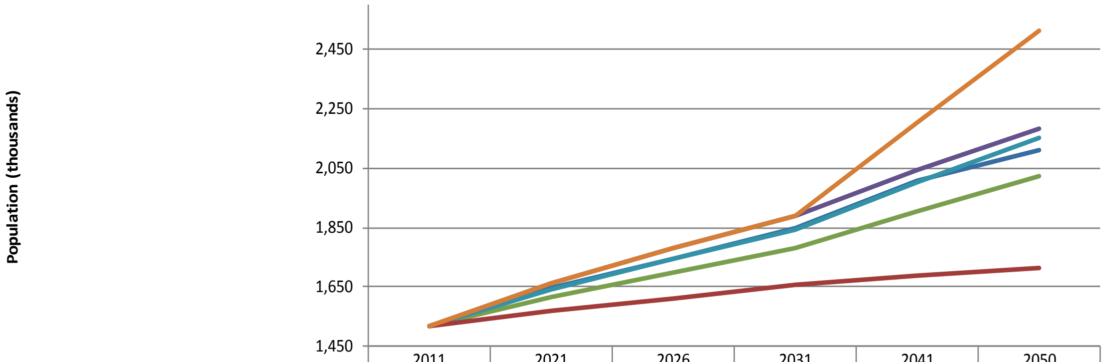
- Scenario 2: A Most Likely Growth Scenario: This market and economy-driven Scenario reflects the patterns of evidence-based demographic growth as is evident from the trends of recent censuses particularly that of 2011 and of the emerging recovery patterns of the Irish economy. This 'Most Likely Growth Scenario' envisages a greater GDA growth pattern, driven by FDI clusters and a recovering building industry. The CSO baseline forecast chosen as the best fit for this scenario is the M2F2 Modified projection.

- Scenario 3: A Minimum Expected Economic Growth Scenario: For this Scenario, it is assumed that inward migration has been insufficient to balance larger out-migration movement. Accordingly, M3F2-type conditions prevail, wherein migration remains negative throughout the lifetime of these projections. Indecon Economists, however, believes this scenario is unlikely.

- Scenario 4: A Maximum Expected Economic Growth Scenario: The high-growth Scenarios anticipate and accommodate city-led growth and this is reflected in their post-2031 accelerations of population.
  - (a) Low - The 'Low' variation shows the GDA share of State population increasing to 42.75% in 2046 and to 42.84% in 2050. The projection for 2046 is similar to the CSO M2F1 projection. This Scenario assumes that conditions have been conducive to Ireland's strong economic performance, reflected in its steady net inward migration and economic growth.
  - (b) High - The higher variant for Scenario 4 assumes an additional effect due to inward migration pressure as per the CSO M1F2 Projection. This 'High' variant is the only M1 parameter addressed in this Study and as at 2046 the projected population is some 8.7% greater than the Scenario 4 'Low' projection as at that year.

The population growth implied in each of these scenarios for Dublin is displayed in Figure 3.8.

**Figure 3.8: Independent Population projection scenarios for the Dublin water supply region**




| | 2011 | 2021 | 2026 | 2031 | 2041 | 2050 |
|---|---|---|---|---|---|---|
| Scenario 1(a): Planned Growth - High | 1,516 | 1,644 | 1,745 | 1,846 | 2,008 | 2,111 |
| Scenario 1(b): Planned Growth - Low | 1,516 | 1,617 | 1,698 | 1,778 | 1,906 | 2,022 |
| Scenario 2: Most Likely Growth | 1,516 | 1,642 | 1,742 | 1,842 | 2,003 | 2,154 |
| Scenario 3: Minimum Expected Economic Growth | 1,516 | 1,567 | 1,611 | 1,655 | 1,689 | 1,714 |
| Scenario 4 (a): Maximum Expected Economic Growth - Low | 1,516 | 1,660 | 1,780 | 1,888 | 2,042 | 2,185 |
| Scenario 4 (b): Maximum Expected Economic Growth - High | 1,516 | 1,660 | 1,780 | 1,888 | 2,206 | 2,513 |

The above forecasts project the highest population level in scenario 4(b). This scenario assumes high levels of economic growth and inward migration leading to a population of 2.2 million people by 2041. The lowest population projections are produced in the minimum growth scenario 3 and this assumes the lowest level of economic growth of all the four scenarios and forecasts a population in the Dublin region of nearly 1.7 million people by 2041. Scenario 2, the most likely growth scenario, forecasts a population of around 2 million people by 2041.

In relation to projecting residential water demand over the planning period, a key uncertainty attached to any demographic projections driving residential demand relates to migration. This is particularly the case in the context of a small, open economy such as Ireland's, where fluctuations in economic growth can strongly influence migration patterns. Reflecting these uncertainties, our assessment includes new econometric modelling to inform population projections, which takes account of economic growth as a driver of migration.

We forecast population using lagged values of the single population time series and GDP. Under this approach, we use lags of the dependent variable and a GDP time series to forecast future population growth. More specifically, our approach here involves the Autoregressive Integrated Moving Average (ARIMA) approach to time series forecasting, known as the Box-Jenkins methodology. This uses the stochastic properties of the time series to develop the forecasts. The nature of the approach involves estimating the number of lagged (differenced) dependent variables and lagged error terms, along with the appropriate coefficients to be estimated.

In order to identify the appropriate ARIMA (p,d,q) model, three factors need to be determined: the order of differencing required to make the series stationary (transforming it into an integrated adaptation of a stationary series), the number of autoregressive (AR) terms, or past values of the series appearing, in the prediction equation and the number of moving average (MA) terms, or lagged values of the forecast errors from the white noise error term.

To identify the number of AR and MA terms in a series we use Autocorrelation Functions (ACFs) and Partial Autocorrelation Functions (PACFs). Autocorrelation Functions measure the correlation coefficients between a time series and various lags of itself, while Partial Autocorrelation Functions measure the correlation between a time series and a specific lag which is not explained by their mutual correlations with other lags.

Our judgment in terms of forecast, model, fit, and standard econometric procedures (autocorrelation functions (ACFs) and partial correlation functions (PCFs)) indicates the best fitting model is an ARIMA (1,1,0), an AR(1) first differenced stationary time series. Thus, we estimate the population regression equation as:

### Equation 1: ARIMA (1,1,0) Model

$$\Delta Y_t = \beta_0 + \beta_1 \Delta Y_{t-1} + \beta_2 (\Delta GDP_t - \Delta GDP_{t-1}) + e_t$$

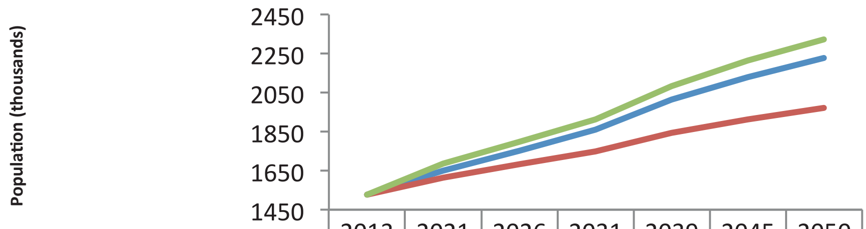
In this equation $Y_t$ represents the population in the year t, $Y_{t-1}$ represents population in the previous year, $GDP_t$ represents GDP in year t while $GDP_{t-1}$ represents GDP in the previous year. The β symbols represent coefficients on each variable while $e_t$ represents the error term.

From the estimated coefficients of this equation we forecast the population of the Dublin region between 2013 and 2050. As mentioned above, the inclusion of GDP in our model aims to capture the potential impact of migration on population growth. Higher GDP is assumed to lead to higher inward migration and thus faster population growth. As fertility rates in advanced economies decline to levels around that needed to maintain a stable population the importance of migration in forecasting future population growth increases. Ireland's fertility rate of 2.01 births per woman reflects this broader trend and highlights the importance of including migration in population forecasts for the Dublin Region. The primary forecast provided by this model represents Indecon Economists' 'Base Case' forecast. This research broadly validates the most likely growth scenario produced by the independent demographers. By taking the upper and lower bounds of the 95% confidence interval surrounding the 'Base Case' forecast we also include in our analysis Indecon Economists high and low population growth scenarios. Thus the three Indecon population forecasts are:

- Indecon Economists Base Case –The population implied by the best fit of our forecasting model.
- Indecon Economists Low – The lower bound of the 95% confidence interval of our analysis.
- Indecon Economists High - The upper bound of the 95% confidence interval of our analysis.

These forecasts are illustrated graphically in Figure 3.9.

**Figure 3.9: Indecon Economists population projection scenarios for the Dublin Water Supply Region**




| | 2013 | 2021 | 2026 | 2031 | 2039 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|
| Indecon Base Case | 1527 | 1650 | 1753 | 1860 | 2015 | 2130 | 2226 |
| Indecon Low | 1527 | 1616 | 1683 | 1750 | 1843 | 1913 | 1972 |
| Indecon High | 1527 | 1686 | 1799 | 1914 | 2085 | 2215 | 2323 |

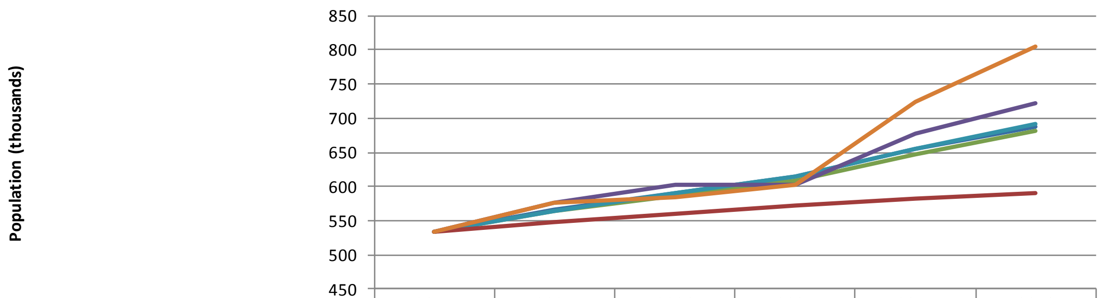
**Source: Indecon Economists modelling**

The base case forecasts suggest a population in the Dublin region of 2,226,000 by 2050, or just over 2.2 million. This is very similar to the forecast of 2.15 million suggested by the demographers' most likely growth scenario and our range of estimates are within the range projected by the demographers. Our modelling therefore validated the detailed work undertaken by the demographers.

### Benefitting Corridor

The independent demographers also provide population estimates for the benefitting corridor area. The population of this area is forecast under the same scenarios as outlined above. The six forecasts for the region are illustrated below. The population of the benefitting corridor is forecast to grow from its current level of 534,000 people to between a potential high of 805,000 people under scenario 4 (b) and a potential low of 590,000 under scenario 3.

**Figure 3.10: Independent Population projection scenarios for the Benefitting Corridor**

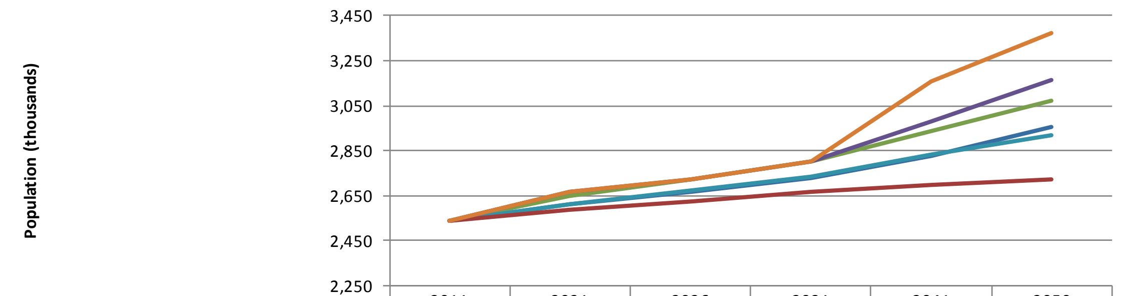



| | 2011 | 2021 | 2026 | 2031 | 2041 | 2050 |
|---|---|---|---|---|---|---|
| Scenario 1(a): Planned Growth - High | 534 | 565 | 590 | 615 | 655 | 688 |
| Scenario 1(b): Planned Growth - Low | 534 | 564 | 586 | 609 | 647 | 682 |
| Scenario 2: Most Likely Growth | 534 | 565 | 590 | 615 | 655 | 692 |
| Scenario 3: Minimum Expected Economic Growth | 534 | 548 | 561 | 573 | 582 | 590 |
| Scenario 4 (a): Maximum Expected Economic Growth - Low | 534 | 576 | 602 | 603 | 677 | 721 |
| Scenario 4 (b): Maximum Expected Economic Growth - High | 534 | 576 | 584 | 603 | 725 | 805 |

**Rest of the State**

Given the forecast populations for the Dublin water supply area and the benefitting corridor, the demographers provide forecasts for the rest of the state under the same six scenarios. The forecast path of population in the rest of the state under these scenarios is illustrated in the below figure.

**Figure 3.11: Independent Population projection scenarios for the Rest of Ireland**




| | 2011 | 2021 | 2026 | 2031 | 2041 | 2050 |
|---|---|---|---|---|---|---|
| Scenario 1(a): Planned Growth - High | 2,538 | 2,611 | 2,669 | 2,727 | 2,827 | 2,957 |
| Scenario 1(b): Planned Growth - Low | 2,538 | 2,647 | 2,724 | 2,802 | 2,938 | 3,072 |
| Scenario 2: Most Likely Growth | 2,538 | 2,614 | 2,673 | 2,732 | 2,833 | 2,921 |
| Scenario 3: Minimum Expected Economic Growth | 2,538 | 2,587 | 2,627 | 2,667 | 2,700 | 2,720 |
| Scenario 4 (a): Maximum Expected Economic Growth - Low | 2,538 | 2,665 | 2,721 | 2,802 | 2,982 | 3,162 |
| Scenario 4 (b): Maximum Expected Economic Growth - High | 2,538 | 2,665 | 2,721 | 2,802 | 3,156 | 3,375 |

*Number of households and household size*

An estimate of the number of households in the Dublin Region over the forecast horizon can be obtained by combining the forecasts for population growth with the forecasts for average household size in the region. The 2010 WSP-DR 'Plan' document estimated average household size in the Dublin region at 2.5 persons per household. The 'Plan' document maintains this occupancy rate at a constant 2.5 persons for each year of their forecasting out to 2040. As discussed above, should household size fall over the time period then per capita water consumption is likely to increase. The Housing Agency[19] estimates that 57% of households in the Dublin region are composed of two or less persons while 18% of households contain three people with the remaining 25% of households containing more than 3 people.

[19] Housing Agency. (2014) 'Housing Supply Requirements in Ireland's Urban Settlements 2014 – 2018'

The table below describes the recent historical trends in both the number of households and household occupancy rates in the Greater Dublin Area. The number of households has been growing steadily while the average occupancy rate has fallen from an average of 3.36 people per household in the Dublin Area in 1991 to 2.8 people per household according to the latest (2011) Census of Population.

**Table 3.6: Trends in Household Numbers and Average Household Occupancy in the Greater Dublin Area**

| | 1991 | 1996 | 2002 | 2006 | 2011 |
|---|---|---|---|---|---|
| **Number of Households** | | | | | |
| Greater Dublin Area | 402,080 | 446,431 | 509,489 | 579,563 | 649,224 |
| **Average Household Occupancy** | | | | | |
| Greater Dublin Area | 3.36 | 3.15 | 3.01 | 2.87 | 2.80 |

**Source: Indecon Economists analysis of CSO data.**
* Note: Greater Dublin Area includes Dublin and the Mid-East.

The table below provides similar information as shown above but in this instance describes the percentage changes in household numbers and average household size over a longer period.

**Table 3.7: Historical Trends in Growth in Household Numbers and Average Household Occupancy in the Greater Dublin Area**

| | 1991-1996 | 1996-2002 | 2000-2006 | 2006-2011 |
|---|---|---|---|---|
| **Growth in No. of Households** | | | | |
| Greater Dublin Area* | 11.0% | 14.1% | 13.8% | 12.0% |
| **Growth in Average Household Occupancy** | | | | |
| Greater Dublin Area* | -6.3% | -4.4% | -4.7% | -2.6% |

**Source: Indecon Economists analysis of CSO data.**
* Note: Greater Dublin Area includes Dublin and the Mid-East.

The projections provided by the demographers, AOS also include forecasts for average household size in the Dublin Region based on a number of population growth scenarios. The table below outlines the projected household sizes under each scenario. Across all population growth scenarios, the average household size is predicted to continue to fall. The most likely growth scenario is forecast to result in an average of two persons per household in the Dublin Region by 2050, with the wider set of scenarios indicating a decline to between 1.44 and 2.43 over this period.

| Table 3.8: Projected Average Household Size – Dublin Water Supply Region | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2011** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| **Population Growth Scenario** | **Average Persons per Household** | | | | | | |
| Scenario 1(a): Planned Growth 'High' | 2.64 | 2.54 | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 |
| Scenario 1(b): Planned Growth 'Low' | 2.64 | 2.54 | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 |
| Scenario 2: Most Likely Growth | 2.64 | 2.48 | 2.4 | 2.32 | 2.16 | 2.08 | 2 |
| Scenario 3: Minimum Expected Economic Growth | 2.64 | 2.54 | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 |
| Scenario 4 (a): Maximum Expected Economic Growth (Low) | 2.64 | 2.34 | 2.19 | 2.04 | 1.74 | 1.59 | 1.44 |
| Scenario 4 (b): Maximum Expected Economic Growth (High) | 2.64 | 2.34 | 2.19 | 2.04 | 1.74 | 1.59 | 1.44 |
| **Source: Water Supply Project, Midlands and Eastern Region – Summary of Demographic Projections (May 2014)** | | | | | | | |

The demographers' assessment for the WSP also provides estimates of the total number of households in the Dublin Region based on each of the population forecasts. These forecasts are outlined in Table 3.9 and indicate that the number of households is projected to reach over 1.18 million by 2050 under the demographers' most likely growth scenario, but ranging between 776,108 households and up to 1.92 million households across the six scenarios considered.

| Table 3.9: Projected Number of Households – Dublin Water Supply Region | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **2011** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| **Population Growth Scenario** | **Number of Households** | | | | | | |
| Scenario 1(a): Planned Growth 'High' | 618,460 | 712,000 | 789,993 | 835,756 | 909,061 | 934,434 | 955,661 |
| Scenario 1(b): Planned Growth 'Low' | 618,460 | 700,208 | 768,424 | 804,943 | 862,841 | 890,725 | 915,452 |
| Scenario 2: Most Likely Growth | 618,460 | 728,480 | 798,520 | 873,391 | 1,020,126 | 1,100,648 | 1,184,839 |
| Scenario 3: Minimum Expected Economic Growth | 618,460 | 678,809 | 894,085 | 749,023 | 764,506 | 770,440 | 776,108 |
| Scenario 4 (a): Maximum Expected Economic Growth (Low) | 618,460 | 780,439 | 894,085 | 1,017,963 | 1,291,014 | 1,468,329 | 1,668,783 |
| Scenario 4 (b): Maximum Expected Economic Growth (High) | 618,460 | 780,439 | 729,280 | 1,017,963 | 1,394,875 | 1,643,847 | 1,919,396 |
| **Source: Water Supply Project, Midlands and Eastern Region – Summary of Demographic Projections (May 2014)**<br>Note: Estimates Include an allowance for vacant households of 10%. | | | | | | | |

The number of households forecast in each scenario is directly related to the projected population for that period and the projected average household size. These projections do, however, also include an allowance for vacant dwellings in the housing stock of 10%. Vacancy rates were sourced by the demographers from Housing Agency research.[20] The Housing Agency estimates vacancy rates of 7% for the wider Dublin and Mid-East region, while vacancy rates in Dublin City were estimated at 10%. The demographers have included the higher vacancy rate in this range of 10% as a worst case scenario in their projections. From forecasting perspective, vacant housing units are not included in estimates of the residential demand for water. However, vacant units are included in estimates of the level of Customer Side Leakage in the water supply system. While vacant houses may not display the level of direct water usage expected in an occupied dwelling, the fact that they are still connected to the water supply system means that it is important to include them in forecasts for the total amount of water lost through Customer Side Leakage.

*Per capita consumption*

As discussed previously, the most up to date information estimates per capita consumption of water at 125.5 litres per person per day. A key factor in forecasting the likely path of future water demand concerns how PCC is likely to evolve in future years, particularly following the introduction of residential water metering and charging.

In forecasting the likely future path of per capita consumption in the Dublin Region over the forecast horizon Indecon Economists have taken into account the following factors:

- The roll-out of metering of households in the region and the introduction of annual water charges;
- The experience of other jurisdictions with regard to the response of residential water consumption to the introduction of metering and charging;
- Impact of new housing stock in influencing water intensity;
- Impact on PCC changes of average household size.

In relation to the experience of other jurisdictions and the response of per capita consumption to the introduction of metering and charging, Indecon Economists have reviewed evidence from:

- The UK government's Water Strategy for England (2008)[21];
- UK Environment Agency 'Using Science to Create a Better Place: The Costs and Benefits of Moving to Full Water Metering' (2010)[22] ;
- Thames Water[23];
- Ofwat[24] (The Water Services Regulatory Authority in the UK).

These sources suggest that for various jurisdictions in the UK water consumption amongst metered households is between 5% and 15% lower on average than consumption in unmetered households.

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[20] Housing Agency report on "*Housing Supply Requirements in Ireland's Urban Settlements 2014 – 2018*".

[21] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69346/pb13562-future-water-080204.pdf

[22] UK Environment Agency 'Using Science to Create a Better Place: The Costs and Benefits of Moving to Full Water Metering' (2010) Science Report – SC070016/SR1 (WP2) http://www.swan-forum.com/uploads/5/7/4/3/5743901/_env_agency.pdf

[23] http://www.thameswater.co.uk/your-account/17386.htm

[24] Ofwat (2013) 'Water meters – your questions answered' http://www.ofwat.gov.uk/mediacentre/leaflets/prs_lft_101117meters.pdf

Traditional economic models of demand would suggest that as water charges are imposed on households their demand for water will fall from its current levels. The higher the unit price of water relative to income levels the larger the fall in residential demand for water we would expect to observe. On top of this disincentive effect to consume water, a unit price of water could also incentivise households to fix customer side leakage and install more water efficient household appliances. Lower leakage levels and less water intensive appliances will both serve to lower per capita water consumption and further lower aggregate water demand.

Information from international sources suggests that per capita consumption is likely to fall by between 5% and 15% in response to residential charging and metering with the average reduction coming at around 10%. This report thus assumes a fall of 5% in residential water demand as a result of the introduction of metering and charging as currently proposed in Ireland.

As discussed previously, levels of occupancy are likely to have an impact on per capita consumption and Indecon Economists incorporate this into our formal modelling. In the recent submission by Irish Water to the Commission for Energy Regulation (CER)[25], detailed analysis of the relationship between occupancy and per capita consumption was presented as outlined in the next table.

**Table 3.10: Analysis of the Relationship between PCC and Occupancy**

| Occupants | litres per day (PCC) | sample weight |
|---|---|---|
| 1 | 203 | 6% |
| 2 | 156 | 21% |
| 3 | 118 | 22% |
| 4 | 104 | 27% |
| 5 | 87 | 17% |
| 6+ | 89 | 7% |

**Source: Data included in Submission to the CER**

On the issue of the impact of new build on PCC, recent evidence[26]indicates that there may be significant efficiency gains in terms of water consumption for new houses. This will be dependent on a large number of factors but it is important to take this into account in our modelling. In our base case scenario, estimates for the projected number of households by 2050 indicate that the number of households is likely to nearly double by 2050. Given the implications of this for the housing stock it is important to make an adjustment for this in our estimates of PCC.

Table 3.11 illustrates the impact of charging and metering, changing occupancy rates and the improved water efficiency of new builds on the forecast path of PCC using the assumptions underlying the Indecon Economists base case scenario. The effect of falling occupancy is to raise average PCC as per row 2 in the table. The improved efficiency of new builds, without accounting for falling occupancy, leads to a fall in PCC, as per row 3. The effect of metering, charging, falling occupancy and new builds all together is demonstrated in row 4. All of these scenarios assume that the initial 5% reduction in PCC in our base case scenario is maintained over the duration of the forecast horizon.

[25] http://www.cer.ie/document-detail/CER-Water-Charges-Plan-Consultation/979

[26] Dublin City Council. (2010a) 'Water Supply Project-Dublin Region – The Plan Appendix A Demand Appendix' Appendix AB p.E5

| Table 3.11: Impact of Water Metering, Charging, Household Occupancy and New Builds on Per Capita Consumption – Indecon Economists Base Case Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **PCC (litres per capita per day)** | | | | | | | |
| | **Factors Influencing PCC** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| 1 | 5%  fall due to impact of metering | 125.5 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 | 119.3 |
| 2 | Effect of falling occupancy and 5% fall | 125.5 | 120.6 | 122 | 123.4 | 124.8 | 127.6 | 129.1 | 130.6 |
| 3 | New Build and 5% fall due | 125.5 | 118.9 | 118.5 | 118 | 117.6 | 117 | 116.7 | 116.5 |
| 4 | Occupancy, new build and 5% fall | 125.5 | 119.9 | 120.4 | 120.6 | 120.7 | 120.9 | 121 | 121 |

**Source: Indecon Economists modelling**

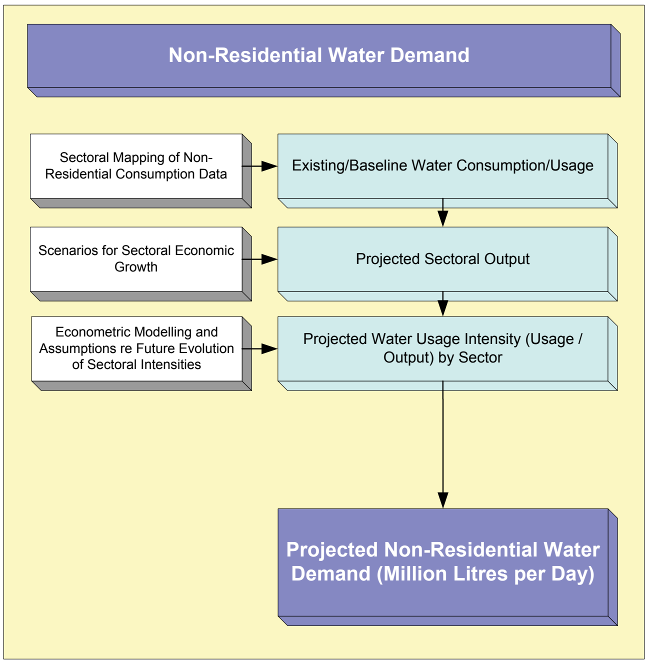
## Projecting non-residential demand

The key drivers of the likely future level of non-residential water usage are as follows:

- The projected level and sectoral composition of activity; and
- The projected movements in water usage intensity by economic sector.

A schematic description of the methodology applied in developing the projections for non-residential water demand developed in this assessment is presented in the Figure 3.12. This figure illustrates the process by which this report constructs its analysis of the non-residential demand for water in the Dublin Region from the sectoral mapping of existing non-residential water consumption data to combining this data with sectoral output projections and econometric estimates for the future path of water intensity to provide figures for projected non-residential water demand.

**Figure 3.12: Schematic Overview of Components of Methodology for Projecting Demand for Water – Non-Residential Water Demand**




**Source: Indecon Economists**

Previous studies of non-residential water demand in Ireland have attempted to forecast non-residential demand using methodologies based around demographic growth or the quantity of lands zoned for industrial and commercial development. In the case of the Irish economy the fact that the economy has a significant internationally traded sector suggests that economic growth is unlikely to be closely correlated with demographic changes. Previous reports have simply assumed that non-residential water demand will grow in line with population growth based on the inappropriate assumption that population growth will drive non-residential water demand on a one to one basis. For example, under this assumption, a 5% increase in population will result in a 5% increase in non-residential water demand. Indecon Economists believe this was a flaw in previous analysis and takes no account of the differential growth experience of economic sectors compared to population growth. It also takes no account of marked variance in water intensity between sectors or the trend towards water efficiency within the non-residential sectors. As a result, population growth may not be the main driver of economic activity in the Dublin Region and it is not be prudent to assume a one to one relationship between population growth and change in demand for water by the non-residential sector. This point is taken into account in best practice modelling of water demand in other countries but had not been reflected in previous Irish work. This is particularly relevant given the significant amount of FDI and internationally traded services in the region.

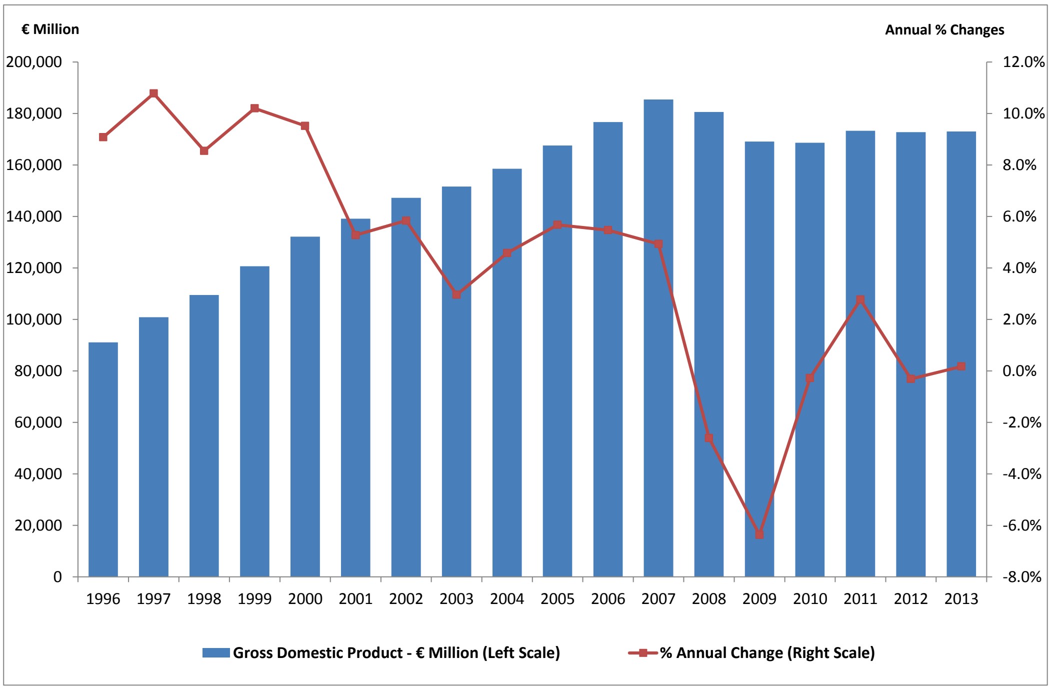
The quantity of zoned land approach is also unlikely to provide a reliable forecast of non-residential water demand given the previously discussed variety of water intensity across different industrial and commercial activities.

Due to the weaknesses associated with these previous methodological approaches, Indecon Economists' approach in this assessment has applied what we believe is a more robust methodology for projecting non-residential water demand. This approach utilises evidence on sectoral water usage and economic growth patterns to drive future demand. Econometric modelling techniques have also been incorporated in the approach to provide estimates for the likely future path of water intensity across different industrial and commercial sectors.

*Overall economic activity and sectoral activity*

Ireland experienced rapid economic growth from the mid-1990s and the period up until the late-2000s. With the onset of the global financial crisis, the collapse of the domestic property bubble and the consequences of the domestic banking crisis began to impact on the economy. This period of steady growth followed by the onset of recession is depicted in the figure below, which indicates the annual level and percentage change of Ireland's GDP over the period 1995 to 2013.

**Figure 3.13: GDP 1995-2013**




**Source: Indecon Economists analysis of CSO National Income Accounts data**

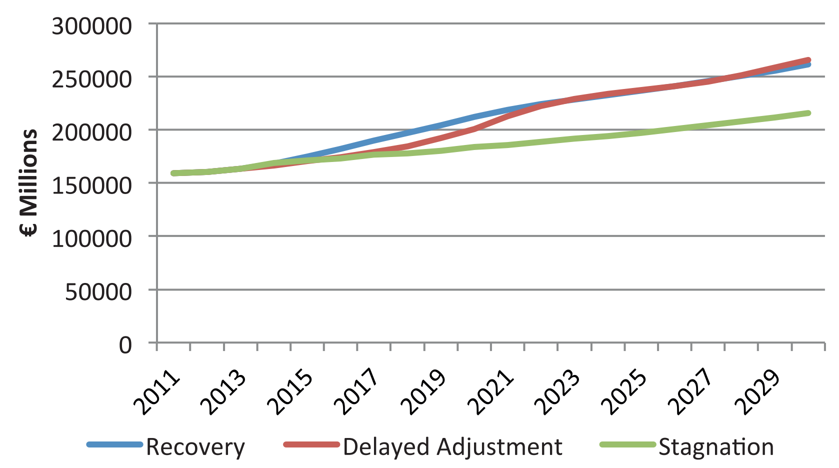
Economic growth is a key factor in the assessment of the economic need for water supply infrastructure in any region or county. Economic growth directly drives both industrial and commercial demands for water while the provision of government services, another large water user, also tends to grow in line with economic growth. This section of the report summaries the GDP forecasts for Ireland used in this report.

This report makes use of the ESRI Medium-Term Review 2013 growth forecasts for the Irish economy. These forecasts provide projections for output at a sectoral level while also providing overall GDP forecasts. The ESRI provides forecasts for economy-wide GDP growth out to 2030 in Ireland under three distinct scenarios. The MTR provides for three growth broad scenarios in its analysis:

- A recovery scenario – This scenario assumes that the EU economy returns to a reasonable rate of growth over the rest of the decade. It is also assumed that the continuing problems in the Irish financial sector are tackled effectively.
- A delayed adjustment scenario – This scenario considers what would happen if the EU economy recovered but domestic policy failed to resolve the ongoing problems in the Irish financial system, or if some other domestic event or policy delayed a recovery. Such a scenario could see the economy seriously underperform relative to its potential.
- A stagnation scenario - The Stagnation scenario considers the circumstances where the EU economy does not return to growth in the near future.

The forecast growth path of Irish GDP under each scenario is outlined Figure 3.14. The recovery scenario sees the fasted growth in GDP with the delayed adjustment scenario not matching the recovery scenario until the early 2020's. The stagnation scenario forecasts only a slight rise in GDP out to 2030.

**Figure 3.14: ESRI Medium-term review GDP Growth Scenarios**




***Source: ESRI Medium-term review***

As the ESRI Medium-term review only forecasts out to 2030, for the purposes of our analysis we assume that the economy continues to grow at the prevailing rate in 2030 under each scenario until the end of the forecast horizon in 2050. In the case of the delayed adjustment scenario, we assume that the economy grows at the prevailing rate in the recovery scenario from 2031 onwards to avoid an unintended divergence in these scenarios in the long run out to 2050.

*Projections for growth at sector level*

While the forecasts for overall real GDP growth above are an important factor in projecting water demand in Ireland, more granular estimates of growth across different sectors in the Irish economy are required in order to accurately forecast future water demand. The differing intensity of water usage across different industries and sectors makes using aggregate GDP forecasts as the sole measure of industrial demand for water a very crude tool. More detailed data on sectoral output and employment is available for the economy.

The contribution of these sectors to Irish GDP along with numbers employed is outlined in the table below. The manufacturing and internationally traded services sectors make the largest contributions to GDP while domestically traded services are the largest single employer.

| Table 3.12: Industrial and Commerical Sectors and their Economic Contribution | | |
|---|---|---|
| **Industrial and commercial users** | **% of GDP (2012)** | **Number employed (2014)** |
| Manufacturing industry and mining | 27% | 237,000 |
| Internationally Traded services sector | 25% | 294,200 |
| Tourism and hospitality | 2% | 133,800 |
| Construction | 2% | 102,300 |
| Health Sector | 7% | 244,300 |
| Other government services | 12% | 246,700 |
| Other domestically traded services including retail and wholesale | 13% | 330,700 |
| Agriculture and forestry | 2% | 110,500 |
| Transport sector | 4% | 89,500 |
| Other | 5% | 98,600 |
| **Source: Indecon Economists analysis, based on CSO data** | | |

While the contribution of each of the above sectors to GDP is an indicator of their importance to the Irish economy, it is the volume of output in these sectors, not the amount of value added in each sector, which is important in forecasting the demand for water on a sector by sector basis. Measuring economic activity in these sectors by the contribution to GDP is problematic in the context of forecasting water demand as the key issue is the change in the volume of output and the amount of water used in the production process.

The ESRI Medium-Term Review forecasts sectoral output growth under the three scenarios discussed previously. This report uses these forecasts, in combination with sectoral water demand data from Irish Water, to predict the likely path of future non-domestic water demand in the Dublin Region. The table below shows the cumulative output growth forecast from 2011 out to 2050 under the 'recovery scenario'. These projections implicitly assume a fast rate of overall net growth in a number of IDA and EI high tech sectors and also fast growth in the food sector. Of particular interest are the growth projections for the electrical goods (which include manufacture of computers and electronics) and chemicals (which includes pharmaceuticals), due to the fact that these sectors are water intensive. Growth projections are above the average for both these sectors. Output forecasts show growth in other water intensive sectors such as agriculture and industrial machinery and construction. Such projections are important in the context of future water demand.

| Table 3.13: Sectoral Output Forecasts –Cumulative Output Growth (Recovery Scenario) | | |
|---|---|---|
| | **2011-2026** | **2011-2050** |
| Agriculture, fishing, forestry | 17% | 67% |
| Coal, peat, petroleum, metal ores, quarrying | 74% | 147% |
| Food, beverage, tobacco | 74% | 147% |
| Textiles Clothing Leather and Footwear | 74% | 147% |
| Wood and wood products | 74% | 147% |
| Pulp, paper and print production | 74% | 147% |
| Chemical production | 79% | 170% |
| Rubber and plastic production | 74% | 147% |
| Non-metallic mineral production | 135% | 423% |
| Manufacture of Basic Metals | 135% | 423% |
| Manufacture of Fabricated Metal Products | 79% | 170% |
| Agriculture and industrial machinery | 79% | 170% |
| Electrical goods | 79% | 170% |
| Transport equipment | 79% | 170% |
| Other manufacturing | 74% | 147% |
| Fuel, power, water | 74% | 204% |
| Construction | 135% | 423% |
| Transport | 54% | 135% |
| Services* | 62% | 322% |
| Health and Education | 20% | 94% |
| Public Administration | 15% | 85% |

Note: Forecasts beyond 2030 assume sectors continue to grow at 2030 rate for each year between 2030 and 2040.
*Wholesale and retail of vehicles, wholesale and retail excl. motor vehicles, accommodation, food services.
**Source: Indecon Economists Analysis of ESRI Medium-Term review.**

Beyond the above existing sectoral growth scenarios, this assessment has also benefitted from Indecon Economists' analysis of recent performance and plans, and discussions with IDA Ireland and Enterprise Ireland in relation to broad features of likely future sectoral growth within key water-intensive FDI sectors.

Indecon Economists fully recognises the need to have sufficient water capacity to respond to the expansion needs of existing users and potential new users. The analysis undertaken in this report seeks to forecast these needs using detailed sectoral economic output forecasts. Expansion of demand outside the bounds of the base case scenario for these sectoral forecasts is possible in the case of large existing and potential future water users. This should be considered by Irish Water in the evaluation of capacity options and in particular in seeking planning permission for abstraction levels.

*Water intensity of economic activity*

Estimates for the future path of water intensity[27] across different industrial and commercial sectors are obtained via econometric analysis using the World Input Output Database. This database contains socio-economic data and water use data for a number of countries. Indecon Economists have undertaken an econometric analysis of data from the World Input-Output Database (WIOD), with the objective of estimating likely future changes in water intensity by industry sector. Indecon Economists utilised data from OECD countries as well as EU27 member states.

We estimated alternative models based on production function specifications, where output is explained by a variety of variables, including labour, capital, materials, water, state-industry-specific random and fixed effects, and time. This enabled computation of water intensity in the estimation process. A detailed description of the econometric analysis undertaken by Indecon Economists, including data utilised, model specifications and results, is presented in Annex 1.

In terms of modelling results, interpretation focused on the impact of time on water intensity, i.e. the annual movements in water intensity over time or, to put it another way, how water efficiency of production changes over time. We found that the coefficient on time is negative for each sector, which indicated that water intensity is falling over time which in turn implies that water efficiency is improving over time. It would therefore seem prudent to include a measure of this likely future decline in water intensity in any scenarios for future water demand. In addition, the decline in water intensity is of a higher magnitude for the services sectors of education and health and social work than for the agricultural and industrial sectors examined.

We considered the impact of time on water intensity for aggregate sector groups. We report our findings for the following sectors:

- Agriculture and other primary production;
- Manufacturing;
- Utilities;
- Education and Health.

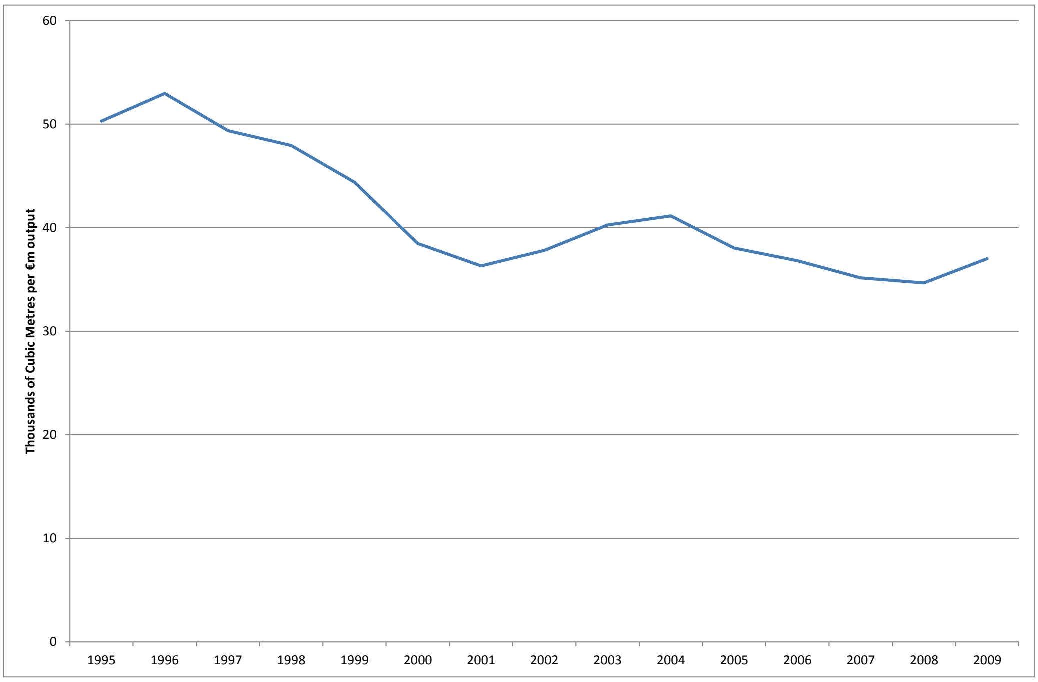
The results from the estimation of the Cobb-Douglas production function with constant returns to scale are provided in the table overleaf. The overall predicted annual change in water intensity across the sectors considered is -2.8%.

[27] Water intensity refers to the amount of water required to produce a single unit of output.

| Table 3.14: Predicted Annual Change in Water Intensity by Sector, Cobb Douglas Production Function | |
|---|---|
| Agriculture, Hunting, Forestry and Fishing | -1.03% |
| Manufacturing | -2.55% |
| Utilities | -4.05% |
| Health and Education | -3.57% |
| **Total** | **-2.81%** |
| **Source: Indecon Economists analysis of WIOD data** | |

Using data from the World Input Output Database it is possible to examine the global trend in water intensity of industrial and commercial activity. The below figures contain data calculated on value basis rather than volume basis. Figure 3.15 clearly demonstrates that, in the aggregate, all industrial and commercial sectors have experienced a fall in water intensity since the mid 1990s. While the majority of the fall in water intensity occurred between 1995 and 2000, with the exception of a small rise in the period from 2001 to 2004, the downward trend continued at a less pronounced level for the subsequent years.

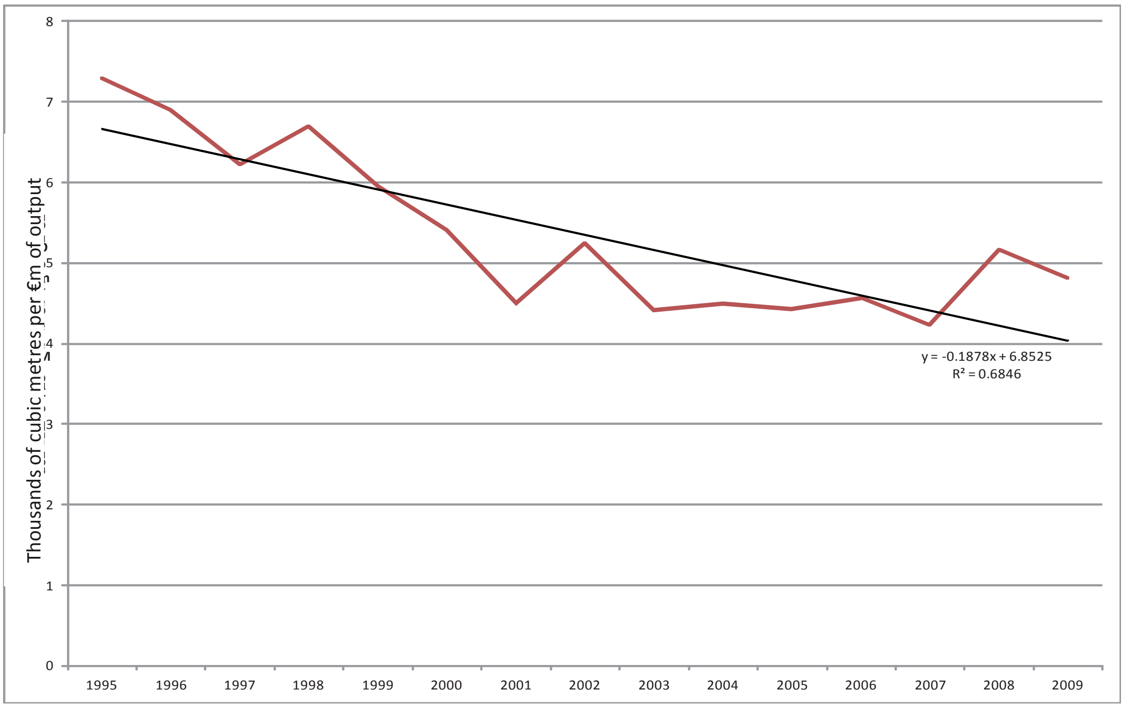
**Figure 3.15: Trend in World Average Water Intensity per €m Output for All Sectors**




**Source: Indecon Economists Analysis of WIOD data.**

Similarly, when looking at water intensity in Ireland we observe a similar downward trend. Figure 3.16 illustrates the trend in average water intensity for all sectors per million euro of output since 1995. The red line represents the historical data while the black line represents the trend.

**Figure 3.16: Trend in Average Water Intensity per €m Output for All Sectors – Ireland**




**Source: Indecon Economists Analysis of WIOD data.**

## Leakage, Distribution Losses and Impact of Climate Change

A key component of estimating the levels of water supply required to meet future demand levels is an accurate forecast of the leakage levels in the system. Lower leakage levels lead to lower levels of water supply required to meet a given level of demand. Given the relatively high levels of leakage in the Dublin region and the Irish water supply system in general, a dramatic reduction in leakage rates could go some way to extending the ability of the existing water supply sources to meet future growth in water demand. For the purposes of this report, future leakage rates are based on Irish Water leakage reduction targets.

System leakage is defined as leakage present on the Local Authorities' water mains network up to the customers' property boundary including leakage from reservoirs, trunk mains and distribution mains and service connections to the property boundary.

The level of system leakage is largely determined by the age, materials and conditions of the network coupled with the level of leak detection and repairs being carried out and the water pressure in the system. In 1998 Dublin City Council undertook The Dublin Region Water Conservation Project (DRWCP), a major leakage reduction project. The project ran until 2002 and aimed to address the high levels of unaccounted for water leakage in the region. The project is credited with lowering leakage in the region from 42% to 28%. Between 2002 and 2004 Dublin City Council also replaced the piping on 10% of the existing network in a further effort to reduce system leakage. Nevertheless, the WSP-DR 'Plan' document still estimated total system leakage in the Dublin region at around 161 Ml/d or 30% of total supply.

Updated data for April 2014 made available to Indecon Economists by Irish Water provides broadly similar estimates for total system leakage in the Dublin Region. The 2014 data estimates system leakage at 31% of total supply. As the 2014 data is broken down by local authority, we can observe the differing levels of leakage across the region. Bray Town Council reports leakage of 14% of total supply and South Dublin County Council reports leakage of 18% of supply. At the other end of the spectrum Dublin City Council reports leakage rates of 37%. The 2014 data estimates total system leakage at 164.5 Ml/d. The level of leakage estimated for the base year of 2011 is 178 Ml/d or 33% of average daily supply.

***Customer side and system leakage***

Customer side leakage is defined as leakage from within the customers' property boundary. Customer side leakage is often a result of the age of the plumbing and piping on the property or poor quality workmanship on newer plumbing. The amount of water lost through customer side leakage varies across regions and jurisdictions. This variation is due to the differing age profiles of the plumbing and piping infrastructure in different areas and differing levels of water pressure. Areas with higher water pressure will lose more water from an identical leak than would be lost in an area with lower water pressure.

Without metering customer side leakage is difficult to detect and even in cases when it is detected is often both difficult and expensive to repair. Prior to the introduction of water charges households had very little incentive to undertake such costly repairs even if leaks are discovered. The Dublin City Council 2010 Plan document estimated customer side leakage in the Dublin region at around 38 Ml/d. Latest estimates from the roll out of meters areas of Dublin estimate customer side leakage at 66 litres per house per to give an estimated total customer side leakage figure of 40.8 Ml/d.

As the rollout of water meters to households in the region approaches 100% penetration in the coming years a more accurate assessment of the levels of customer side leakage is likely to emerge. When all domestic water users are metered then customer side leakage will become considerably easier to detect for individual households. The ability to detect leaks after the installation of water metres will likely lead to an increase in leakage repair rates and a subsequent fall in customer side leakage. The government's announcement of a scheme to fund the repair of the first leak discovered by any household may lead to a reduction in the quantity of water lost through customer side leakage in the coming years.

Leakage reduction targets reported to Indecon Economists by Jacobs Tobin state that customer side leakage is targeted to fall to 25 litres per household per day by 2031. This fall in leakage is anticipated to be driven by increased leakage reduction efforts by households, renewal of a certain portion of the housing stock and improved leak detection following the rollout of metering. This process is not expected to be linear as with the roll out of metering and charging it is likely that many of the most easily fixed leaks on the customer side will be fixed in the first few years following charging.

System leakage targets reported to Indecon Economists report that the level of distribution leakage is targeted to achieve 130 Ml/d by 2031.

***Impact of Climate Change***

The recent report from the United Nations body, the Intergovernmental Panel on Climate Change, released in April 2014 highlights that global emissions are still on course to lead to a greater than two degree increase in average global temperatures by the end of the century. Ireland is not immune from the effects of this changing global climate.

In 2013 Met Éireann produced a report titled "*Ireland's Climate: The Road Ahead*" which outlined the forecast for Ireland's climate in the coming years in the face of global climate change. The report forecasts that average temperatures in Ireland will rise by around 1.5 degrees by the middle of the century. In terms of average rainfall, the report forecasts wetter winters and drier summers by the mid-century. Under the high-emissions scenario, Met Éireann is forecasting increases of up to 14% in average rainfall during the winter months and up to a 20% reduction in average precipitation during the summer months. The report also suggests that these changes in precipitation rates will have a significant impact on river catchment hydrology, though the exact impact is uncertain. The report suggests higher average precipitation will lead to an elevated risk of flooding.

Changes in climate conditions in Ireland could potentially impact on both the supply and demand for water in the Dublin region. Drier summers are likely to place upward pressure on water demands while also reducing the supply of raw water during the summer months. While there is some scope for raw water storage facilities at existing reservoirs offsetting the fall in supply of water in the summer by storing additional rainfall from the winter months, the overall impact of climate change will serve to lower the sustainable yield of existing water sources in the Dublin Region. The uncertainty surrounding the impact of climate change on Ireland's average rainfall figures will need to be incorporated in any projections of future water supply and demand. To accommodate this and other uncertainties, Indecon Economists have developed a number of scenarios of future demand.

## 3.8 Scenarios for Water Demand

Forecasting total water demand is a complex process as each component of total demand is impacted by a number of external factors. The uncertainty surrounding important factors such as population growth, economic growth and water intensity amongst other factors makes it prudent to forecast total water demand for a number of scenarios. This section outlines the Indecon Economists projections for total water demand for three main scenarios. These scenarios are:

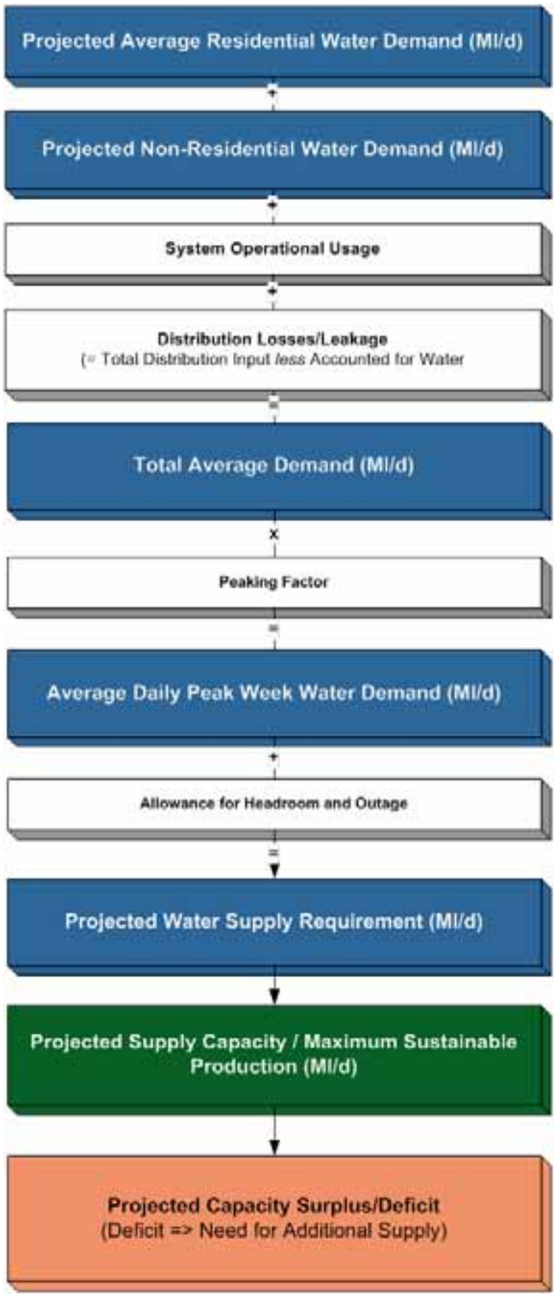
- Indecon Economists base case scenario;
- Indecon Economists high demand scenario; and
- Indecon Economists low demand scenario.

Indecon Economists would note that it is not recommended that the low demand scenario is used for infrastructural planning but is useful to examine as there is great uncertainty in predicting the drivers of demand and it is important to consider the range of possible outcomes.

This section of the report outlines the assumptions underlying each of these scenarios and then discusses the demand projections implied by these assumptions.

Figure 3.17 illustrates the components of total water demand and how they are combined in the calculation of overall demand.

**Figure 3.17: Schematic Overview of Components of Methodology for Projecting Demand for Water – Overall Water Demand**




Source: Indecon Economists

In the scenarios presented in this report, 2011 is used as the baseline year for the analysis. This reflects the latest census of population in 2011 and also the year for which the most complete data was available for water demand. The table below presents a summary of the assumptions underpinning the demand scenarios.

| Table 3.15: Components of Demand Scenarios | |
|---|---|
| **Demand Forecast Component** | **Calculation** |
| Total Residential Demand | Per capita consumption rate multiplied by the forecast population. |
| Total Non-Residential Demand | The sum of the forecast water usage in each sector of the economy. |
| Total Customer Side Leakage | Leakage per household multiplied by the projected number of households (including vacant housing). |
| Total Distribution Leakage | Gradual reduction to target level by 2031. Maintaining this target level from then on. |
| Total Average Demand | Sum of total domestic demand, total non-domestic demand, customer side leakage, distribution leakage and operational usage. |
| Average Peak Demand | Total average demand plus 20% of accounted for water (total average demand less distribution leakage). |
| Total Demand including allowance for headroom and outage | The headroom allowance is calculated by subtracting distribution leakage from the total average demand figure and taking the target percentage of this remaining figure. This is the target headroom allowance. This target headroom allowance is then added to the average peak demand figure to provide the total demand including allowance for headroom and outage. |
| Supply Capacity | This figure represents the total supply capacity to the Dublin Region and is exogenous to the model. |
| Difference | This figure represents the amount of surplus or deficit in the supply infrastructure. It is calculated by subtracting total demand including the allowance for headroom from the supply capacity. A negative figure here indicates that demand is exceeding supply. |
| **Source: Indecon Economists** | |

**Indecon Economists Base Case scenario**

The assumptions underlying the forecasts for water demand in the base case scenario are outlined below.

*Population and household size*

The population of the Dublin Water Supply Region is forecast to grow according to the AOS ‘Scenario 2: Most Likely Growth’ population forecast. This forecast assumes a population in the Dublin Region of 2.15 million people by 2050. Household occupancy rates are also assumed to progress at the rate forecast by AOS Planners in their ‘Most Likely Growth’ scenario. This scenario forecasts an average household size of two people per household by 2050.

*Per capita consumption and the effect of metering and charging*

Per capita consumption is assumed to be 125.5 litres per day as per the latest information from Irish Water. The base case scenario assumes that per capita consumption will fall by 5% in light of the beginning of metering and charging by 2016. This 5% fall is in line with international experience of the impact of the introduction of metering and charging for domestic water use while also taking into account the specific details surrounding Ireland charging scheme. Per capita water demand is also forecast to change related to changes in occupancy and new build. New housing stock is assumed to achieve average PCC levels of 110 Ml/d.

*Economic growth, water intensity and non-residential demand*

The base case scenario for non-residential demand assumes that economic growth will grow in line with the ESRI Medium-term review 'Recovery' Scenario. The base case scenario assumes that the annual reduction in water intensity for each industry sector will be half that estimated by econometric analysis of the WIOD international water usage database. This metric is chosen given the uncertainty surrounding applying international data to the Irish economy and the likelihood that water intensity reductions will taper off over the coming years from the levels achieved in the past. The annual falls in water intensity included in the base case scenario across the different sectors of the economy are outlined in the table below.

**Table 3.16: Assumed Annual Decrease in Non-Domestic Sectoral Water Intensity – Indecon Economists Base Case Scenario**

| Sector | Annual Decrease in Water Intensity - % per annum |
|---|---|
| Manufacturing | 1.25% |
| Health and Education | 1.75% |
| Agriculture | 0.50% |
| Utilities | 2.00% |
| Remaining Sectors | 1.00% |
| Average | 1.30% |

**Source: Indecon Economists**

*Leakage*

Customer side leakage is forecast to achieve the target level of 25 litres per household per day by 2031 and remain constant after this point.

Distribution leakage in the system is forecast to achieve the target to 130 Ml/d by 2031 and remain constant after this point.

*Benefitting Corridor*

The benefitting corridor used in the water demand forecasts in this report is narrower than the benefitting corridor considered by the demographers in their population forecasts. On advice from Jacobs Tobin, the benefitting corridor for forecasting purposes is restricted to those areas which are experiencing stress in their water supply infrastructure and would directly benefit from additional supplies from any additional abstraction of water from the Shannon. The water supply schemes included in the benefitting corridor for water demand forecasting purposes, as well as the population of these areas and the water supplied to these areas in 2012 are outlined below.

**Table 3.17: Water Supply Schemes Included in the Benefitting Corridor for Forecasting Purposes**

| County | Population Served (2012) | Water Supply Scheme | Water Supplied 2012 (Ml/d) |
|---|---|---|---|
| Tipperary | 18,918 | Newport RWSS | 8.0 |
| | | Roscrea RWSS | |
| | | Thurles Urban District | |
| Offaly | 21,193 | Tullamore WSS | 11.8 |
| | | Edenderry WSS | |
| | | Shinrone PWS | |
| | | Portarlington | |
| Westmeath | 36,228 | Mullingar | 19.5 |
| | 20,645 | South Westmeath RWSS (Athlone) | 10.2 |
| | 4,358 | South Westmeath RWSS (Balance of supply area) | 1.0 |
| Laois | 18,453 | Clonaslee | 4.3 |
| | | Mountmellick | |
| | | Portarlington PWS | |
| | | Portarlington 2 | |
| Meath | 68,900 | Dunboyne/Clonee | 22.9 |
| | | Enfield | |
| | | Longwood | |
| | | Clonard | |
| | | East Meath (Staleen) | |
| | | Curragha GW | |
| | | Dunshaughlin GW | |
| | | Rath GW | |
| Louth | 36,200 | Dundalk & Environs WSS | 18.4 |
| Total | 224,895 | | **96.1** |

**Note:** Athlone and Louth are anticipated to remain on their current supply and so are excluded from forward projections. Should these areas come under water supply stress however they could potentially be served by the project. Excluding Athlone and Louth from current supply estimates of the Benefitting Corridor gives a total supply of 67.5 Ml/d.

While we understand that precise granular data is not available to take account of some of the key drivers of demand at the level of the benefitting corridor, Indecon Economists have considered this issue in more detail in evaluating likely future demand in the benefitting zone. Effectively we have assumed the same percentage breakdown between non-residential and residential demand in the benefitting zone as applies elsewhere in our analysis of the region. However, due to a lack of granular data on PCC and the sectoral breakdown of non-residential demand we limit our analysis to assuming that both residential and non-residential demand grow in line with population for the forecast period. Population is forecast to grow by 0.67% per annum in the benefitting corridor.

We assume a similar percentage allowance for headroom and outage as in the projections for the Dublin Region and we also assume that demand will respond to the introduction of metering and charging as per our base case assumptions. In addition, we assume that water intensity in non-residential sectors will continue to fall. While from an engineering perspective we understand that some of the existing supply sources in this benefiting zone may be replaced by new infrastructure, in estimating the deficit we first take account of existing supply. The forecast water demand for the benefitting corridor can be seen in the bottom half of the below table.

***Base Case Water Demand Forecast***

A detailed breakdown of the likely path of water demand between 2011 and 2050 under the assumptions outlined above is contained in the table below. This table outlines the forecast path of residential demand as well as the underlying drivers of this demand, population, occupancy, households and per capita consumption for the Dublin Region. The table also displays the forecast path of non-residential demand and both customer side and distribution leakage. The table contains less detailed demand forecasts for the benefitting corridor due to the comparative lack of data on water demand in the benefitting corridor relative to the Dublin Region. The final section of the table appraises total forecast demand including peak demand requirements for the Dublin Region and the benefitting corridor combined.

The peaking factor applied to the demand levels forecast here is 20% of accounted for water. Accounted for water is calculated as residential and non-residential demand plus customer side leakage but excludes distribution leakage.

| Table 3.18: Water Demand to 2050 – Indecon Economists Base Case Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Population | hd | 1,516,133 | 1,579,262 | 1,642,391 | 1,742,226 | 1,842,060 | 2,003,156 | 2,081,225 | 2,154,252 |
| Occupancy Rate | hd/house | 2.64 | 2.56 | 2.48 | 2.40 | 2.32 | 2.16 | 2.08 | 2.00 |
| Households | No. | 618,460 | 678,921 | 728,480 | 798,520 | 873,391 | 1,020,126 | 1,100,648 | 1,184,839 |
| Per Capita Consumption | l/hd/day | 125.5 | 119.9 | 120.4 | 120.6 | 120.7 | 120.9 | 121.0 | 121.0 |
| Residential Demand Projection | Ml/d | 190.3 | 189.3 | 197.7 | 210.1 | 222.3 | 242.2 | 251.7 | 260.6 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.9 | 155.9 | 164.8 | 176.0 | 205.2 | 222.6 | 238.2 |
| Customer Side Loss Rate | l/house | 66.0 | 54.5 | 45.0 | 35.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Customer Side Losses | Ml/d | 40.8 | 37.0 | 32.8 | 27.9 | 21.8 | 25.5 | 27.5 | 29.6 |
| Leakage Rate | % | 33.0 | 30.0 | 26.3 | 24.9 | 23.5 | 21.4 | 20.4 | 19.6 |
| Distribution Losses | Ml/d | 178.1 | 157.6 | 139.4 | 135.0 | 130.0 | 130.0 | 130.0 | 130.0 |
| Operational Usage | Ml/d | 3.6 | 3.6 | 3.9 | 4.0 | 4.2 | 4.7 | 5.0 | 5.3 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **524.4** | **529.7** | **541.8** | **554.3** | **607.6** | **636.9** | **663.7** |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **597.8** | **607.8** | **623.2** | **639.2** | **703.1** | **738.3** | **770.5** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| **Average Day Peak Week Demand - Benefitting Corridor** | **Ml/d** | **73.6** | **71.0** | **70.6** | **70.3** | **70.4** | **73.0** | **74.5** | **75.7** |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **668.8** | **678.4** | **693.5** | **709.5** | **776.2** | **812.7** | **846.2** |
| **Source: Indecon Economists** | | | | | | | | | |

We also considered the impact on our base case of alternative assumptions for PCC. These are based on assuming that PCC rises to 130.0 by 2050. Such an outcome could arise if incomes rose to an extent which counterbalanced any price effects or could also reflect a scenario where overall existing levels of PCC were higher than currently estimated from the recent survey research or in the case where the discipline underpinning the initial reduction in usage is not maintained over time.

| Table 3.19: Water Demand to 2050 – Using Jacobs-Tobin Assumptions on PCC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Population | hd | 1,516,133 | 1,579,262 | 1,642,391 | 1,742,226 | 1,842,060 | 2,003,156 | 2,081,225 | 2,154,252 |
| Occupancy Rate | hd/house | 2.64 | 2.56 | 2.48 | 2.40 | 2.32 | 2.16 | 2.08 | 2.00 |
| Households | No. | 618,460 | 678,921 | 728,480 | 798,520 | 873,391 | 1,020,126 | 1,100,648 | 1,184,839 |
| Per Capita Consumption | l/hd/day | 125.5 | 119.2 | 119.3 | 121.1 | 123.0 | 126.7 | 128.6 | 130.0 |
| Residential Demand Projection | Ml/d | 190.3 | 188.3 | 195.9 | 211.0 | 226.6 | 253.8 | 267.6 | 280.2 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.9 | 155.9 | 164.8 | 176.0 | 205.2 | 222.6 | 238.2 |
| Customer Side Loss Rate | l/house | 66.0 | 54.5 | 45.0 | 35.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Customer Side Losses | Ml/d | 40.8 | 37.0 | 32.8 | 27.9 | 21.8 | 25.5 | 27.5 | 29.6 |
| Leakage Rate | % | 33.0 | 30.1 | 26.4 | 24.9 | 23.3 | 21.0 | 19.9 | 19.0 |
| Distribution Losses | Ml/d | 178.1 | 157.6 | 139.4 | 135.0 | 130.0 | 130.0 | 130.0 | 130.0 |
| Operational Usage | Ml/d | 3.6 | 3.6 | 3.8 | 4.0 | 4.2 | 4.8 | 5.2 | 5.5 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **523.4** | **527.9** | **542.8** | **558.6** | **619.3** | **652.9** | **683.5** |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **596.6** | **605.6** | **624.4** | **644.3** | **717.2** | **757.5** | **794.2** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| **Average Day Peak Week Demand - Benefitting Corridor** | **Ml/d** | **73.6** | **71.0** | **70.6** | **70.3** | **70.4** | **73.0** | **74.5** | **75.7** |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **667.6** | **676.2** | **694.7** | **714.7** | **790.2** | **831.9** | **869.9** |
| **Source: Indecon Economists** | | | | | | | | | |

### Indecon Economists 'High Demand' scenario

The high demand scenario differs from the base case scenario in assuming no fall in per capita consumption as metering and charging takes effect. The only factors influencing PCC in this high demand scenario are thus changes in household occupancy rates and the increased water efficiency of new additions to the housing stock. The high demand scenario assumes higher growth rates in certain sectors than the base case scenario. The detailed assumptions underlying the forecasts for water demand in the high demand scenario are outlined below.

*Population and household size*

The population of the Dublin Water Supply Region is forecast to grow according to the AOS Scenario 4 (a). This forecast assumes a population in the Dublin Region of 2.18 million people by 2050.

Household occupancy rates are assumed to progress at the rate forecast by AOS Planners. This scenario forecasts average household size of 1.44 people per household by 2050. Indecon Economists accept that even higher population forecasts are possible as indicated by some of the demographers' higher scenarios which we do not use in our modelling.

*Per capita consumption and the effect of metering and charging*

Per capita consumption is assumed to be 125.5 litres per day as per the latest information from Irish Water. The high demand scenario assumes that per capita consumption will not respond to the beginning of metering and charging by 2016. Per capita water demand is forecast to change over the forecast horizon period based on assumed changes in occupancy and new build housing stock. New housing stock is assumed to achieve average PCC levels of 110 Ml/d.

*Economic growth, water intensity and non-residential demand*

As in the case of Indecon Economists' base case scenario, the high demand scenario assumes that economic growth will grow in line with the ESRI Medium-term review 'Recovery' Scenario for the majority of sectors in the economy. Higher growth rates are however assumed in those water intensive sectors which are actively targeted for expansion by the IDA. The high demand scenario assumes higher annual growth rates for both chemical and pharmaceutical manufacturing and computer manufacturing. The higher growth rates are outlined in Table 3.20. This is similar to an assumption of discrete levels of increased demand to account for an expansion of individual higher water users.

**Table 3.20: Growth Rates for Pharmaceuticals and Computer Manufacturing in the High Demand Scenario**

| Sector | Average Annual Growth Rate | |
|---|---|---|
| | 2014-2021 | 2022-2050 |
| Computer, Electronic and Optical Products | 4% | 3% |
| Chemicals and Pharmaceuticals Manufacturing | 7% | 5% |

The high demand scenario assumes that the annual reduction in water intensity for each industry sector is the same as that assumed in the base case. The annual reductions in the water intensity of output for each sector of the economy under the high demand scenario are outlined in Table 3.21.

| Table 3.21: Assumed Annual Decrease in Non-Domestic Sectoral Water Intensity – Indecon Economists High Demand Scenario | |
|---|---|
| **Sector** | **Annual Decrease in Water Intensity - % per annum** |
| Manufacturing | 1.25% |
| Health and Education | 1.75% |
| Agriculture | 0.50% |
| Utilities | 2.00% |
| Remaining Sectors | 1.00% |
| Average | 1.30% |
| **Source: Indecon Economists** | |

*Leakage*

Customer side leakage is forecast to fail to achieve the target level of 25 litres per household per day by 2031. The high demand scenario assumes that leakage levels are 5% higher in 2031 and remain flat at this new 26.3 litres per household level out to 2050.

Distribution leakage in the system is forecast to fail to achieve the target to 130 Ml/d by 2031. As with customer side leakage, the high demand scenario assumes that distribution leakage is 5% higher than target and remains at this 136.5 Ml/d level for the remainder of the forecast horizon.

**Benefitting Corridor**

As mentioned in the discussion of the benefitting corridor in the base case scenario, detailed water usage data is unavailable for the benefitting corridor. Given this limitation, we assume the same growth in water demand in the benefitting corridor under each scenario.

***High Demand Scenario Water Demand Forecast***

The high demand scenario forecasts an average day peak week demand for the Dublin Region and the benefitting corridor of 925.5 Ml/d by 2050. In comparison to the base case scenario, both domestic and non-domestic demand forecasts are higher due to higher per capita consumption and higher growth rates in water intensive industries. The assumed failure to achieve the leakage reduction targets also leads to higher levels of both customer side leakage and distribution leakage in the high demand scenario.

| Table 3.22: Water Demand to 2050 – Indecon Economists High Demand Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Population | hd | 1,516,133 | 1,588,170 | 1,660,207 | 1,780,042 | 1,887,859 | 2,042,149 | 2,122,403 | 2,184,589 |
| Occupancy Rate | hd/house | 2.64 | 2.49 | 2.34 | 2.19 | 2.04 | 1.74 | 1.59 | 1.44 |
| Households | No. | 618,460 | 702,878 | 780,439 | 894,085 | 1,017,963 | 1,291,014 | 1,468,329 | 1,668,783 |
| Per Capita Consumption | l/hd/day | 125.5 | 126.4 | 127.0 | 126.8 | 126.5 | 125.9 | 125.3 | 124.7 |
| Residential Demand Projection | Ml/d | 190.3 | 200.8 | 210.8 | 225.7 | 238.9 | 257.2 | 266.0 | 272.4 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.1 | 155.6 | 166.9 | 183.1 | 225.9 | 250.2 | 272.4 |
| Customer Side Loss Rate | l/house | 66.0 | 55.8 | 47.3 | 36.8 | 26.3 | 26.3 | 26.3 | 26.3 |
| Customer Side Losses | Ml/d | 40.8 | 39.3 | 36.9 | 32.9 | 26.7 | 33.9 | 38.5 | 43.8 |
| Leakage Rate | % | 33.0 | 29.8 | 26.4 | 24.8 | 23.1 | 20.7 | 19.6 | 18.7 |
| Distribution Losses | Ml/d | 178.1 | 161.5 | 146.4 | 141.8 | 136.5 | 136.5 | 136.5 | 136.5 |
| Operational Usage | Ml/d | 3.6 | 3.8 | 4.0 | 4.3 | 4.5 | 5.2 | 5.5 | 5.9 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **541.4** | **553.6** | **571.4** | **589.7** | **658.7** | **696.8** | **731.0** |
| Average Day Peak Week Demand – Dublin Region | Ml/d | **611.5** | **617.4** | **635.1** | **657.4** | **680.3** | **763.1** | **808.9** | **849.8** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| Average Day Peak Week Demand - Benefitting Corridor | Ml/d | **73.6** | **71.0** | **70.6** | **70.3** | **70.4** | **73.0** | **74.5** | **75.7** |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **688.4** | **705.7** | **727.7** | **750.7** | **836.1** | **883.3** | **925.5** |
| **Source: Indecon Economists** | | | | | | | | | |

Indecon Economists believe there will be a requirement for increased water demand to accommodate the expansion plans of a number of major existing large industrial users. We believe this could involve an increased demand of between 30 to 50 Ml/d. There may be potential to reduce water intensity over time but this will depend on the timing of new projects and technological advances. Indecon Economists believe that Irish Water should ensure sufficient capacity to accommodate such users. In our base case estimates we are assuming that even after efficiencies in water intensity are taken into account, there will be a need for an increase in water demand by the non-residential sector in the Dublin Region of over 38 Ml/d by 2026 and indeed our base case scenario assumes this will increase to 110 Ml/d by 2050. This takes account of the impact of sectoral shifts in demand and, as noted previously, also takes account of an assumed reduction in water intensity. In our high demand scenario our estimates assume a higher level of water demand for the non-residential users of over 40 Ml/d by 2026 and over 140 Ml/d by 2050. This takes account not only of the likely increased demand by existing or new large users, but also the need to accommodate the expected demand increases of other non-residential users, consistent with our assumptions for economic growth. There is merit from an infrastructural planning perspective and in seeking permission for abstraction levels of ensuring adequate supply to accommodate the high demand scenario. The significant economic costs of water supply disruption indicated by our research (see Section 5) supports the case for accommodation of higher demand scenario than in our base case. While there is uncertainty regarding whether such high demand scenario will be realised, it is based on a credible possible outcome for the Irish economy.

An assessment of the importance of sufficient water demand to the continued economic growth of the Dublin Region and Ireland was noted by the IDA who indicated the following:

> ***"The continued strategic planning and investment in the provision of utilities, including water, waste water, power, gas etc. is paramount as it assists in maintaining Ireland's attractiveness to secure utility intensive investments against stiff global competition. The provision of these utilities are a key components to meet the requirements of industry, both FDI and indigenous.***
>
> ***The Dublin region and its hinterland must plan to ensure that water supply to the region can meet demand and opportunities to secure future investments and related job creation. Therefore this region must have the ability to demonstrate robust and scalable infrastructure capable of delivering increased water supply and treatment capacity of 34 – 50 Ml/d within the next five year timeframe."***

The above estimates implicitly include an estimate of increased water demand required to meet the separate strategic needs of the manufacturing sector. Some manufacturing water users may close over the period and it is also assumed that all will have some enhanced water efficiency across sectors. Even taking account of these factors, our estimates assume the need for a strategic reserve to meet new overall sector demand. In the table below we include our overall estimates of water demand for the manufacturing sector. These estimates suggest a strategic allowance of nearly 64 Ml/d by 2050, even taking account of potential closures and greater water efficiency. When we no longer assume a fall in water intensity over time our analysis estimates a reserve of nearly 93 Ml/d by 2050.

**Table 3.23: Strategic Reserve for Growth in the Manufacturing Sector**

| Description | Units | 2011 | 2016 | 2021 | 2026 | 2031 | 2041 | 2046 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Forecast Demand in the Manufacturing Sector | Ml/d | 35.1 | 39.6 | 48.1 | 54.1 | 61.3 | 80.2 | 90.0 | 99.1 |
| Forecast Demand in the Manufacturing Sector - Excluding Improvements in Water Efficiency | Ml/d | 35.1 | 41.5 | 52.5 | 61.4 | 71.9 | 99.6 | 114.3 | 127.8 |
| Net Growth in Manufacturing Demand | Ml/d | | 4.5 | 12.9 | 19.0 | 26.1 | 45.1 | 54.8 | 63.9 |
| Net Growth in Manufacturing Demand - Excluding Improvements in Water Efficiency | Ml/d | | 6.3 | 17.3 | 26.3 | 36.8 | 64.4 | 79.2 | 92.7 |

Source: Indecon Economists

**Indecon Economists 'Low Demand' scenario**

The low demand scenario differs from the base case and high demand scenarios due to lower population and growth projections, differing assumptions on the responsiveness of PCC to the introduction of metering and charging and a substantially larger annual fall in water intensity in the industrial and commercial sectors of the economy. While the other two scenarios tempered the econometric findings used the WIOD data in light of uncertainty surrounding their applicability to Ireland, the low demand scenario applies the annual reduction rates estimated by the econometric analysis directly to Irish industrial and commercial water use with the caveat that if the econometric evidence suggested a annual fall of greater than 2% we have capped this annual fall at 2%. The rationale for applying this cap is discussed in detail below. The low demand scenario also differs from the other scenarios in that it assumes a greater fall in PCC following the introduction of metering and charging and also assumes a greater fall in PCC for new builds. Indecon Economists believe, however, that it would not be prudent to use this low demand scenario as the basis for infrastructural planning. The detailed assumptions underlying the low demand forecasts are outlined below.

*Population and household size*

In the low demand scenario the population of the Dublin Water Supply Region is forecast to grow according to the AOS Scenario 1 (a) population forecast. This forecast assumes a population in the Dublin Region of 2.1 million people by 2050. Household occupancy rates are assumed to progress at the rate forecast by AOS Planners in their Scenario 1 (a). This scenario forecasts average household size of 2.43 people per household by 2050.

*Per capita consumption and the effect of metering and charging*

Per capita consumption is assumed to be 125.5 litres per day as per the latest information from Irish Water. The low demand scenario assumes that per capita consumption will fall by 10% in light of the beginning of metering and charging by 2016 for existing households. We assume that these existing households' reduction in PCC is constrained by technology and engineering factors and is thus unlikely to fall by more than 10% as a response to charging. For newly constructed households however we assume a fall in average PCC of 15% to 107 Ml/d, as opposed to the assumed PCC for new builds of 110 Ml/d in the base and high demand scenarios.

*Economic growth, water intensity and non-residential demand*

The Low demand scenario assumes that economic growth will grow in line with the ESRI Medium-term review Delayed Adjustment Scenario. No allowance is made for higher growth in targeted industries. The low demand scenario caps the annual reduction in water intensity for each industry sector at 2% per annum should the econometric analysis of the WIOD data imply a higher annual reduction. For those sectors for which the analysis of the WIOD data implies an annual reduction of less than 2% we include this value. In Indecon Economists' judgement the likelihood is that the annual fall in water intensity will reduce as time goes by and the room for improvements in water efficiency diminishes. For this reason we impose a cap of 2% on the annual reduction in water intensity under the low demand scenario. The annual reductions in the water intensity of output for each sector of the economy under the low demand scenario are outlined in Table 3.24.

| Table 3.24: Assumed Annual Decrease in Non-Domestic Sectoral Water Intensity – Indecon Economists Low Demand Scenario | |
|---|---|
| **Sector** | **Annual Decrease in Water Intensity - % per annum** |
| Manufacturing | 2.00% |
| Health and Education | 2.00% |
| Agriculture | 1.00% |
| Utilities | 2.00% |
| Remaining Sectors | 1.50% |
| Average | 1.70% |
| **Source: Indecon Economists analysis** | |

*Leakage*

Customer side leakage is assumed to fall to the target level of 25 litres per household per day and by 2031 and remain at this level for the remainder of the forecast horizon.

Distribution leakage in the system is forecast to achieve the target to level of 130 Ml/d by 2031. It is assumed to remain at this level for the remainder of the forecast horizon.

***Benefitting Corridor***

As discussed above, growth in water demand in the benefitting corridor is assumed to be the same in all three scenarios. The assumed growth in the low demand scenario is thus the same as the demand growth in the benefitting corridor in the base case scenario and the high demand scenario.

***Low Demand Scenario Water Demand Forecast***

The low demand scenario results are presented in Table 3.25. This suggests an average day peak week demand of 757.6 Ml/d by 2050.

| Table 3.25: Water Demand to 2050 – Indecon Economists Low Demand Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Population | hd | 1,516,133 | 1,580,103 | 1,644,072 | 1,745,167 | 1,846,262 | 2,008,198 | 2,064,250 | 2,111,142 |
| Occupancy Rate | hd/house | 2.64 | 2.59 | 2.54 | 2.43 | 2.43 | 2.43 | 2.43 | 2.43 |
| Households | No. | 618,460 | 671,211 | 712,000 | 789,993 | 835,756 | 909,061 | 934,434 | 955,661 |
| Per Capita Consumption | l/hd/day | 125.5 | 113.4 | 113.7 | 114.5 | 114.1 | 113.5 | 113.3 | 113.2 |
| Residential Demand Projection | Ml/d | 190.3 | 179.1 | 187.0 | 199.8 | 210.6 | 227.9 | 233.9 | 239.0 |
| Non Residential Demand Projection | Ml/d | 126.5 | 124.7 | 141.1 | 148.6 | 157.5 | 173.9 | 183.7 | 192.5 |
| Customer Side Loss Rate | l/house | 66.0 | 54.5 | 45.0 | 35.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Customer Side Losses | Ml/d | 40.8 | 36.6 | 32.0 | 27.6 | 20.9 | 22.7 | 23.4 | 23.9 |
| Leakage Rate | % | 33.0 | 31.4 | 27.7 | 26.2 | 24.9 | 23.3 | 22.6 | 22.0 |
| Distribution Losses | Ml/d | 178.1 | 157.6 | 139.4 | 135.0 | 130.0 | 130.0 | 130.0 | 130.0 |
| Operational Usage | Ml/d | 3.6 | 3.4 | 3.6 | 3.8 | 3.9 | 4.2 | 4.4 | 4.6 |
| Total Average Demand – Dublin Region | Ml/d | 539.3 | 501.4 | 503.1 | 514.9 | 522.9 | 558.8 | 575.4 | 590.0 |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **570.1** | **575.8** | **590.8** | **601.5** | **644.5** | **664.5** | **681.9** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| **Average Day Peak Week Demand - Benefitting Corridor** | **Ml/d** | **73.6** | **71.0** | **70.6** | **70.3** | **70.4** | **73.0** | **74.5** | **75.7** |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **641.1** | **646.5** | **661.2** | **671.8** | **717.6** | **739.0** | **757.6** |
| Source: Indecon Economists | | | | | | | | | |

## 3.9 Summary of Findings

This section assessed the demand for water and projected water needs over the long-term planning horizon for the WSP. The key findings were as follows:

- Water demand in Ireland had been rising in line with economic and population growth in the years before the financial crisis. There was a fall in total water demand during the crisis but demand has been growing again in recent years.
- The most up-to-date estimate of per capita residential water demand is 125.5 litres per day.
- In 2011, the largest sectoral water users were the accommodation sector with 10.4% of total non-residential water demand, and the computer manufacturing sector with 9.6% of total non-residential water demand. Other major water using sectors included the retail sector, health activities, food and beverage production and pharmaceutical manufacturing.

- Other key factors to be accounted for when forecasting total water demand include the likely path of both distribution and customer side leakage and the impact of peak demand factors.
- The key factors in forecasting residential water demand include population growth, the number of households, the average household occupancy rate, water efficiency improvements of new builds and the per capita level of water consumption.
- Our forecasts for non-residential water demand take account of expected levels and sectoral composition of economic activity and the changes in water intensity of this economic activity.
- This report provides water demand forecasts for three main scenarios. These scenarios include:
    - The Indecon Economists base case scenario
    - The high demand scenario
    - The low demand scenario
- These scenarios differ in their assumptions regarding population levels, economic growth, the future path of water intensity of industrial activity, the likely impact of metering and charging on residential water demand and the likely levels of leakage reduction to be achieved over the forecast horizon.
- The Indecon Economists base case scenario predicts average day peak week demand in 2050 of 846.2 Ml/d in the Dublin Region and the benefitting corridor while our high demand scenario suggests demand of 925.5 M/ld by 2050.

# 4 Water Supply and Future Capacity Requirements

## 4.1 Introduction

This chapter examines water supply capacity and future capacity requirements of the Dublin Water Supply Region and the proposed benefitting corridor.

## 4.2 Existing Water Supply and Capacity

### 4.2.1 Dublin Water Supply Region

Supply is estimated based on ‘sustainable’ levels of hydrological yield and water supply systems. These data have been provided to the Indecon Economists via Jacobs-Tobin and Irish Water. The total sustainable water supply to the Dublin Water Supply Region is estimated at 623 Ml/d[28]. This total supply comes from several sources. The sources, treatment plants and sustainable output levels of each plant are outlined in Table 4.1. This table also outlines the supply capacity for the 2011 baseline year.

**Table 4.1: Existing Water Supply Sources to the Dublin Region**

| Water Treatment Plant | Production Capacity/Deployable Output (Ml/d) | |
|---|---|---|
| | **2011** | **2015** |
| Ballymore Eustace | 310 | 310 |
| Leixlip | 148 | 215 |
| Vartry | 65 | 65 |
| Ballyboden | 12 | 12 |
| Srowland | 0 | 13 |
| Bog of the Ring | 3 | 3 |
| Rathangan Wellfield | 3 | 3 |
| Monasterevin Wellfield | 2 | 2 |
| **Total** | **543** | **623** |

The majority of the Dublin region’s water supply currently comes from the river Liffey and is treated at the Ballymore Eustace and Leixlip treatment plants. Additional supply is scheduled to come on stream in 2022 to bring the total supply capacity to 633 Ml/d rising to 658 Ml/d by 2026.

[28] 1Ml/d = 1 million litres per day or one thousand cubic metres per day.

| Table 4.2: Future Known Supply of Dublin Water Supply Region – Ml/d | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **2011** | **2016** | **2022** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Supply Capacity (Maximum Production Potential of Dublin Region sources) | 543.0 | 623.0 | 633.0 | 658.0 | 658.0 | 658.0 | 658.0 | 658.0 |

**Source Indecon Economists Analysis**
Note: It is important to note that these estimates are based on 'sustainable' output. Although the output in 2011 was 580, this figure was not considered sustainable.

### 4.2.2 Benefitting Corridor

The data on existing water supply to the benefitting corridor was provided to Indecon Economists by Jacobs-Tobin. The data was limited to 2012. A breakdown of the quantity to the relevant areas of each county is illustrated below. Total water supplied in 2012 to the water supply schemes which are judged to be most likely to benefit from the Shannon pipeline project is estimated at 67.5 Ml/d in 2012.

| Table 4.3: Existing Water Supply Sources to the Benefitting Corridor | |
|---|---|
| **County** | **Water Supplied 2012 (Ml/d)** |
| Tipperary | 8 |
| Offaly | 11.8 |
| Westmeath | 20.5 |
| Laois | 4.3 |
| Meath | 22.9 |
| **Total** | **67.5** |

**Note:** Contains water supply figures only for those areas of the benefitting corridor assumed to be in need of additional supply from the Shannon pipeline project by 2050.

Indecon Economists have received detailed information and data on the technical issues in the benefitting corridors water supply from Jacobs-Tobin and some of these issues are summarised below. We understand that in meeting the projected demand there will be a need to have regard to securing the greatest possible national benefit from development of a new source. Taking account of this we understand that a transfer pipeline, from a new source to a Terminal Reservoir near the metropolitan area, will effectively function as a 'national water spine'. The water supply position for communities adjacent to the route of such a pipeline from the Shannon, for example, or adjacent to an alternative source, such as Desalination in north Fingal, are a factor to be considered in scaling the overall requirement, where the aspiration is to achieve nationally uniform standards of service from consolidated, efficient, water treatment plants and resilient distribution systems.

In looking at the Benefitting Corridor, we have been informed it will be a different corridor, depending on the eventual preferred option of supply. A pipeline from the Shannon, for example, will have different beneficial opportunities than a Desalination Option from North Fringe. It is useful to consider each area of the Benefitting Corridor.

**Co Tipperary**

We understand from evidence available to Jacobs-Tobin that County Tipperary would benefit from a Shannon supply option, but not from a Desalination option located in North Fingal. Considering the potential benefitting zone from any option drawing from the Shannon at Lough Derg/Parteen Basin, the existing circumstances for the water supplies of Thurles, Roscrea and Newport, should be considered. Details of water potential supply in County Tipperary are presented in Table 4.4.

**Table 4.4: Potential benefitting supplies in County Tipperary**

| Water Supply Scheme with potential to benefit from WSP | Existing Source | Population Served (2012) | Volume into Supply (Ml/d); 2012 | Constraints |
|---|---|---|---|---|
| Newport RWSS | Ground Water (Barnacoole)<br>Mulcair River | 7,656 | 2.5 | Insufficient WTP capacity |
| Roscrea RWSS | Glenbaha Spring<br>Little Brosna River | 4,860 | 2.7 | Condition of Glenbaha Spring |
| Thurles Urban District | Creamery Well<br>Lady's Well<br>Tobernaloo (ground water)<br>Knockalough impounding reservoir | 6,402 | 2.8 | Creamery Well in private ownership<br>Condition of Knockalough (runs dry 3 months per year) |

We have been informed by Jacobs-Tobin that these sources are characterised by inadequate, shallow, vulnerable groundwater supplies and storage capacity. Demand from these three supply areas is projected to reach 11 Ml/d by 2018, and the retirement of these sources should be an objective of the WSP for the Midlands and Eastern Region.

### Co. Offaly

Details of potential benefitting supplies in County Offaly are outlined in Table 4.5.

| Table 4.5: Potential benefitting supplies in County Offaly | | | | |
|---|---|---|---|---|
| **Water Supply Scheme with potential to benefit from WSP** | **Existing Source** | **Population Served (2012)** | **Volume into Supply (Ml/d); 2012** | **Constraints** |
| Tullamore WSS | 9 ground Water sources<br>2 limited surface water sources | 13,080 | 7.5 | Capacity of sources estimated at 9Ml/d |
| Edenderry WSS | number of ground water sources | 3,825 | 2.9 | Vulnerable aquifer |
| Shinrone PWS | local source augmented by imports from neighbouring LAs | 2,250 | 0.8 | Low source yield |
| Portarlington | Total supply imported from neighbouring LAs | 2,038 | 0.6 | |

The water supplies for the communities of Tullamore, Portarlington, Edenderry and Shinrone were highlighted in a Briefing Note from Offaly County Council dated April 2012, and based on their Water Supply Strategic Plan for the county (2009). Offaly County Council at that time sought a provision for 20-30 Ml/d from a national water spine from the Shannon through the Midlands / East. The multiple sources serving Tullamore have an estimated reliable yield of 9 Ml/d, where existing supply is already at 7.5 Ml/d. Edenderry draws from shallow and vulnerable groundwater supplies. On review of the position, Jacobs-Tobin's analysis suggests the need for the long term retirement of all four sources.

### Co. Westmeath

The assessment of potential benefitting supplies in County Westmeath is presented in Table 4.6.

| Table 4.6: Potential benefitting supplies in County Westmeath | | | | |
|---|---|---|---|---|
| **Water Supply Scheme with potential to benefit from WSP** | **Existing Source** | **Population Served (2012)** | **Volume into Supply (Ml/d); 2012** | **Constraints** |
| Mullingar Regional WSS | Lough Owel | 36,228 | 19.5 | Algal Blooms; Cryptosporidium risk |
| South Westmeath Regional WSS, which includes: | | | | |
| Athlone | Lough Ree | 20,645 | 10.2 | |

Lough Owel supplies water to Mullingar (23 Ml/d); to the Royal Canal (23 Ml/d) and to a Fish Farm (14 Ml/d). This combined volumetric abstraction from Lough Owel is considered by Jacobs-Tobin to be unsustainable. There is a proposal to replace the feed from Lough Owel to the Royal Canal, with a compensating abstraction of 23 Ml/d from Lough Ennell to feed the Royal Canal, thereby potentially permitting future increased abstraction from Lough Owel for Mullingar. The proposed abstraction from Lough Ennell received An Bord Pleanála approval in November 2012. However, we understand legal & technical challenges are ongoing and still have to be resolved, consequently we have been advised that a prudent contingent provision needs to be made for a supply from a national water spine for Mullingar. In 2008, a proposal was approved by An Bord Pleanála, to extract 40 Ml/d from Lough Ree at Killinure to extend the current Athlone supply to the other towns/villages in the South Westmeath RWSS. Assuming that Athlone will continue to be supplied from a local abstraction, the projected needs of a South Westmeath scheme from a national water spine have been developed assuming that Athlone itself will continue to be supplied from a local abstraction.

**Co. Laois**

The details re the relevant schemes in County Laois have been sourced from Jacobs-Tobin and are presented in Table 4.7.

**Table 4.7: Potential benefitting supplies in County Laois**

| Water Supply Scheme with potential to benefit from WSP | Existing Source | Population Served (2012) | Volume into Supply (Ml/d); 2012 | Constraints |
|---|---|---|---|---|
| Water needed in: | | | | |
| Clonaslee | Tullamore UDC | 1,304 | 0.3 | Vulnerable groundwater supplies |
| Mountmellick | Mix - groundwater, borewell, Derryguile and Portlaois PWS | 5,268 | 1.5 | Vulnerable groundwater supplies |
| Portarlington PWS | Mix- River Barrow at Ballymorris | 6,784 | 1.4 | Barrow low flow yield |
| Portarlington 2 | Ground Water source near Mountmellick- Deepbore wells at Doolough and la bergerie | 5,097 | 1.1 | Water quality & quantity issues in Portarlington |

In a stakeholder briefing with Laois County Council in earlier planning stages on the project, we were informed they suggested that they would have a provisional requirement of between 10 – 15 Ml/d from the new source. However, on review of the population projections and water requirements for the main supplies at risk, Jacobs-Tobin have estimated that a provision of 6.3 Ml/d is the likely requirement from the new source in order to retire the existing inadequate sources.

### Co. Meath

Potential benefitting supplies in County Meath are presented in Table 4.8 based on analysis by Jacobs-Tobin.

| Table 4.8: Potential benefitting supplies in County Meath | | | | |
|---|---|---|---|---|
| **Water Supply Scheme with potential to benefit from WSP** | **Existing Source** | **Population Served (2012)** | **Volume into Supply (Ml/d); 2012** | **Constraints** |
| South RWSS (including Dunboyne & Clonee) | | | | |
| Dunboyne/ Clonee | Fingal import (3.1Ml/d - agreed limit) & groundwater (2Ml/d) | 8,476 | 2.1 | Vulnerable groundwater supplies |
| Enfield | Groundwater | 2,853 | 1.1 | Vulnerable groundwater supplies |
| Longwood | Groundwater | 1,244 | 0.4 | Vulnerable groundwater supplies |
| Clonard | Groundwater | 380 | 0.03 | |
| East Meath (Stalleen) | River Boyne | 51,932 | 15.95 | Quantity issues at Staleen WTW |
| Curragha GW | Groundwater | | 0.9 | limited groundwater sources |
| Dunshaughlin GW | Groundwater | 4,000 | 1.50 | |
| Rath GW | Groundwater | | 0.9 | |

Jacobs-Tobin have indicated to Indecon Economists that a new major source (Shannon/Desalination) has the potential to supply areas of County Meath and obviate the need to develop groundwater sources. It could also replace the Roughgrange/Stalleen supply to East Meath, thereby releasing this water (15 Ml/d) for use northwards in Louth.

### Co. Louth

An analysis of potential benefitting supplies in County Louth is presented below.

| Table 4.9: Potential benefitting supplies in County Louth | | | | |
|---|---|---|---|---|
| **Water Supply Scheme with potential to benefit from WSP** | **Existing Source** | **Population Served (2012)** | **Volume into Supply (Ml/d); 2012** | **Constraints** |
| Dundalk & Environs WSS | Lough Muckno via River Fane | 36,200 | 18.4 | Expansion of water rights on environmentally sensitive Lough Muckno |

In the case of County Louth water supplies, we understand that water abstraction from the River Boyne is currently serving both the East Meath Regional Scheme and the Borough of Drogheda. Further north along the north east coastal economic zone, the Strategic Review of the Dundalk and Mid-Louth Environs water supply requirements in 2008, estimated that demand at 2031 would be 60.3 Ml/d, with a strategic industrial allowance of 20 Ml/d included in that figure. Recognising that the limit on water rights on the existing River Fane Scheme serving Dundalk and Mid Louth is 36.4 Ml/d, the Strategic Review recommended that an allowance be made in a national water spine from the Shannon, or in a Desalination option, for 25 Ml/d to come from a new source. Jacobs-Tobin has suggested that the required additional water is contingent on materialisation of the strategic industrial water provision. We have been informed that the same desired outcome can be achieved strategically, by discontinuing the current supply of the East Meath area from the River Boyne, thereby releasing the Boyne abstraction at Roughgrange to serve areas northwards from Drogheda. The water supply of East Meath would then be included in the Benefitting Corridor from either the Shannon or a Desalination option, as referred to above in relation to County Meath. This is effectively a planned displacement of available water northwards by making a strategic supply available to East Meath from the new source.

### 4.2.3 Total Supply Capacity to the Dublin Water Supply Region and Benefitting Corridor

The total supply capacity of the Dublin Water Supply Region on the benefitting corridor over the forecast horizon is outlined in the below table.

**Table 4.10: Future Known Supply of Greater Dublin Area – Ml/d**

| | 2011 | 2016 | 2022 | 2026 | 2031 | 2041 | 2046 | 2050 |
|---|---|---|---|---|---|---|---|---|
| Dublin Water Supply Region | 543.0 | 623.0 | 633.0 | 658.0 | 658.0 | 658.0 | 658.0 | 658.0 |
| Benefitting Corridor | 67.5 | 67.5 | 67.5 | 67.5 | 67.5 | 67.5 | 67.5 | 67.5 |
| Total | 610.5 | 690.5 | 700.5 | 725.5 | 725.5 | 725.5 | 725.5 | 725.5 |

**Source Indecon Economists**

## 4.3 Capacity Margin and Headroom

In estimating future capacity requirements, account has to be taken of the capacity margin required to ensure continuity and security of supply. The capacity margin in a water supply system is also generally referred to as the headroom in that system. Headroom is therefore of key importance to determining the supply needs of the GDA.

Target Headroom is broadly defined as "a buffer between supply and demand designed to cater for specified uncertainties". The target level of headroom is the minimum buffer that a prudent supplier should allow between supply capacity and average demand to cater for uncertainties and risks on both the supply and demand sides. The target headroom in the system should be set at such a level that ensures the ability to meet service requirements[29]. A particular capacity margin should take account of volatility of demand and outages. Indecon Economists understand that over 80% of Dublin's water supply at present comes from a single source, the Liffey. This gives a sense of the vulnerabilities in water supply and the need to include targeted headroom.

[29] Again, policy is only emerging in initial stages, and either statutory requirements, license requirements, legislation, or a combination of these may determine the overall obligations of Irish Water to meet service levels. Currently, our understanding is that Irish Water is putting in place service level agreements (SLAs) with the Local Authorities (LAs) to define agreed service levels in the near term.

Operating at very restricted levels of capacity could also mean that the existing water treatment plants are unable to shut down at any stage to undergo regular maintenance or upgrade work. The 2010 WSP-DR 'Plan' document found that demand for treated water in the Dublin Region exceeded the sustainable production capability of the four existing water treatment plants. The report also concluded that given the age of the network and its vulnerability to leakage from pressure variations, frost heave, failure of joints and corrosion effects on pipelines, the water supply to the metropolitan region would remain marginal in its ability to meet essential demands even with major capital investment over the coming years in additional production capacity and implementation of best practice water conservation and leakage reductions.

### 4.3.1 Demand and Supply Side Uncertainties

It is important that there is sufficient headroom to ensure a consistent level of supply in the face of unexpected demand spikes or interruptions to supply. In assessing the need for headroom in the system both demand and supply side uncertainties should be considered. Potential demand side uncertainties which merit inclusion of sufficient headroom in the system include:

- Uncertainty surrounding the achievement of water efficiency targets;
- Uncertainty around future per capita consumption levels;
- The impact of climate change on demand;
- Impact of expansion in demand by very large users;
- Peak factor uncertainty.

International best practice is to include a degree of headroom in any water supply system to take account of these uncertainties. Best practice also incorporates a degree of spare capacity in the system to account for supply side risks and uncertainties. Uncertainties and risks surrounding future supply side capacity also include:

- The impact of climate change on raw water source yields;
- Uncertainly surrounding the accuracy of supply side data;
- Pollution of raw water sources ultimately leading to a reduction in abstraction rates;
- Uncertain surrounding the accuracy of assumptions for output levels from new sources.

In the UK, water companies undertake detailed analysis of demand and supply side uncertainties to develop a figure for the target headroom allowance at each water source. This involves probabilistic simulation of future scenarios. The more uncertain a company is on the above components of supply and demand the higher the percentage allowance. Water suppliers also generally include an allowance in their headroom calculation for supply side outage. The allowance for outage accounts for instances where the achievable output from existing water supply infrastructure falls below normal output levels. This reduction in supply can be for a variety of reasons, such as asset failures, planned maintenance or upgrade work.

In our modelling Indecon Economists has used Jacobs-Tobin and Irish Water estimates for the estimates of headroom requirements. Therefore, the forecasts for future water supply requirements in this report assume a combined headroom and outage requirement of 17.5% of accounted for water between 2011 and 2031 and 15% between 2031 and 2050. The headroom requirements calculations are based on accounted for water, which is composed of domestic demand, non-domestic demand and customer side leakage and excludes distribution losses, any allowance for major industrial users and operational usage. Distribution losses and operational usage are excluded from the headroom calculation as leakage in the system and operational usage are unlikely to vary regardless of the amount of water being supplied through the existing infrastructure, and thus they should not impact the required capacity margin in terms of Ml/d.

We would also point out that in evaluating existing supply levels and future capacity requirements account has to be taken of hydrology, weather and planning issues. These have been incorporated in the engineering estimates of supply.

## 4.4 Scenarios for Future Capacity Requirements

Relating Indecon Economists' scenarios for water demand presented earlier in this report with existing and future known supply capacity enables estimation of future additional supply requirements necessary to meet projected demand. In this sub-section we present Indecon Economists' scenarios for the future water supply requirement. The below tables contain outline the supply requirement for a combination of the Dublin Water Supply Region and the benefitting corridor.

**Projected Water Supply Requirement - Indecon Economists Base Case Demand Scenario**

A summary of the supply capacity requirements using the Indecon Economists base case is presented in Table 4.11 and indicates that by 2050 the supply deficit will be around 207.5 Ml/d for the Dublin Region and the benefitting corridor (see Figure 4.1 for graphical illustration of this).

**Table 4.11: Projected Water Supply Requirement versus Capacity - Indecon Economists Base Case Demand Scenario**

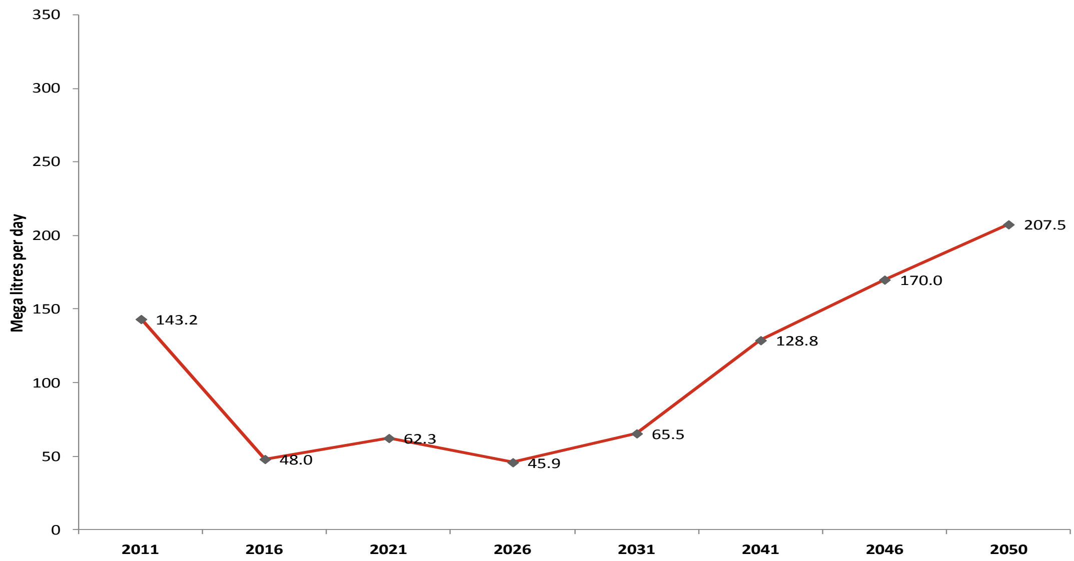
| | Units | 2011 | 2016 | 2021 | 2026 | 2031 | 2041 | 2046 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Average Day Peak Week Demand | Ml/d | 685.1 | 668.8 | 678.4 | 693.5 | 709.5 | 776.2 | 812.7 | 846.2 |
| Allowance for Headroom and Outage | Ml/d | 68.6 | 69.7 | 74.3 | 77.8 | 81.4 | 78.1 | 82.7 | 86.8 |
| Production Requirement (Including Allowance for risk and uncertainty via Headroom and Outage Allowances) | Ml/d | 753.6 | 738.5 | 752.8 | 771.3 | 790.9 | 854.2 | 895.4 | 933.0 |
| Supply Capacity (Maximum Production Potential of Dublin Region sources) | Ml/d | 610.5 | 690.5 | 690.5 | 725.5 | 725.5 | 725.5 | 725.5 | 725.5 |
| Difference | Ml/d | -143.2 | -48.0 | -62.3 | -45.9 | -65.5 | -128.8 | -170.0 | -207.5 |

**Source: Indecon Economists**

The estimated deficit of 143.2 Ml/d in 2011 is largely due to the inclusion of the best practice allowance for peaking and the allowance for headroom and outage required for a sustainable level of water supply. Without these peaking factors and other allowances total demand in 2011 is estimated at 606.7 Ml/d. This suggests that in 2011 the supply infrastructure was working at nearly 100% capacity in order to meet average water demand levels. This evidence of operation at nearly full capacity reflects our understanding of the current strains on water supply in the Dublin Region.

The next figure graphically outlines the forecast path of the supply deficit under the base case scenario. The base case scenario forecasts a supply deficit at every point in the forecast scenario when including the target allowance for headroom and outage. The deficit is forecast to fall to only 48 Ml/d in 2016 compared to 143.2 Ml/d in 2011 due to an expansion in total supply and the impact of declining per capita consumption in 2016. The deficit is forecast to continue to fall out to 2026 due to continued achievement of leakage reduction targets. However, from 2026 onwards, should there be no expansion in supply capacity, the base case forecast predicts that the supply deficit in the Dublin Region will continue to grow as leakage levels flatten out, population growth continues and industrial and commercial demand continues to expand. The base case scenario forecasts a deficit of 207.5 Ml/d by 2050.

**Figure 4.1: Forecast Supply Deficit – Indecon Economists Base Case Demand Scenario**




**Source: Indecon Economists Analysis**

We also outline below an alternative projection for the residential sector if changes in PCC were to subsequently gradually rise over the planning period towards the UK average value for PCC for metered households and that by 2050 it would be 130 Ml/d.

| Table 4.12: Projected Water Supply Requirement versus Capacity - Indecon Economists Base Case Demand Scenario but using Jacobs-Tobin assumptions for PCC | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Average Day Peak Week Demand | Ml/d | 685.1 | 667.6 | 676.2 | 694.7 | 714.7 | 790.2 | 831.9 | 869.9 |
| Allowance for Headroom and Outage | Ml/d | 68.6 | 69.5 | 74.0 | 78.0 | 82.1 | 79.8 | 85.1 | 89.8 |
| Production Requirement (Including Allowance for risk and uncertainty via Headroom and Outage Allowances) | Ml/d | 753.6 | 737.1 | 750.2 | 772.7 | 796.8 | 870.1 | 917.0 | 959.7 |
| Supply Capacity (Maximum Production Potential of Dublin Region sources) | Ml/d | 610.5 | 690.5 | 690.5 | 725.5 | 725.5 | 725.5 | 725.5 | 725.5 |
| Difference | Ml/d | -143.2 | -46.6 | -59.8 | -47.2 | -71.4 | -144.6 | -191.6 | -234.2 |
| **Source: Indecon Economists** | | | | | | | | | |

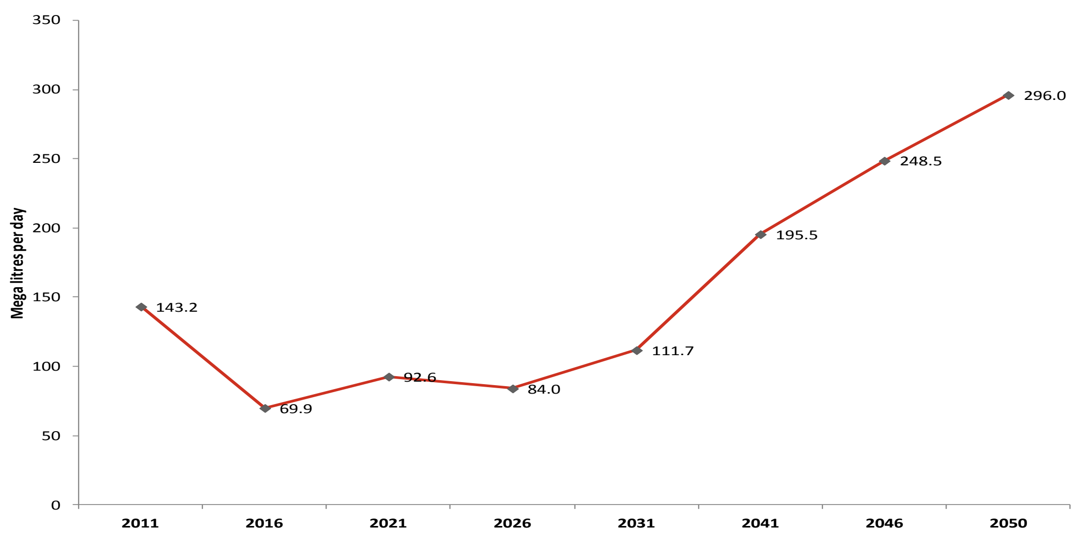
**Projected Water Supply Requirement - Indecon Economists High Demand Scenario**

The table below compares the projected peak demand for water in the Dublin Region with the existing level of supply, after including an allowance for headroom and outage, under Indecon Economists' high demand scenario. Similarly to the base case scenario, the high demand scenario forecasts a supply deficit for every year of the forecast horizon when accounting for headroom requirements.

| Table 4.13: Projected Water Supply Requirement versus Capacity – Indecon Economists High Demand Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Average Day Peak Week Demand | Ml/d | 685.1 | 688.4 | 705.7 | 727.7 | 750.7 | 836.1 | 883.3 | 925.5 |
| Allowance for Headroom and Outage | Ml/d | 68.6 | 72.0 | 77.3 | 81.8 | 86.4 | 84.8 | 90.7 | 95.9 |
| Production Requirement (Including Allowance for risk and uncertainty via Headroom and Outage Allowances) | Ml/d | 753.6 | 760.4 | 783.0 | 809.5 | 837.1 | 920.9 | 974.0 | 1021.5 |
| Supply Capacity (Maximum Production Potential of Dublin Region sources) | Ml/d | 610.5 | 690.5 | 690.5 | 725.5 | 725.5 | 725.5 | 725.5 | 725.5 |
| Difference | Ml/d | -143.2 | -69.9 | -92.6 | -84.0 | -111.7 | -195.5 | -248.5 | -296.0 |
| **Source: Indecon Economists** | | | | | | | | | |

Figure 4.2 illustrates graphically the forecast path of water demand under the high growth scenario and the implied supply deficit.

**Figure 4.2: Forecast Supply Deficit - Indecon Economists High Demand Scenario**




**Source: Indecon Economists Analysis**

### 4.4.1 Projected Water Supply Requirement – Indecon Economists Low Demand Scenario

Table 4.14 presents forecasts for projected water demand under a low demand scenario.

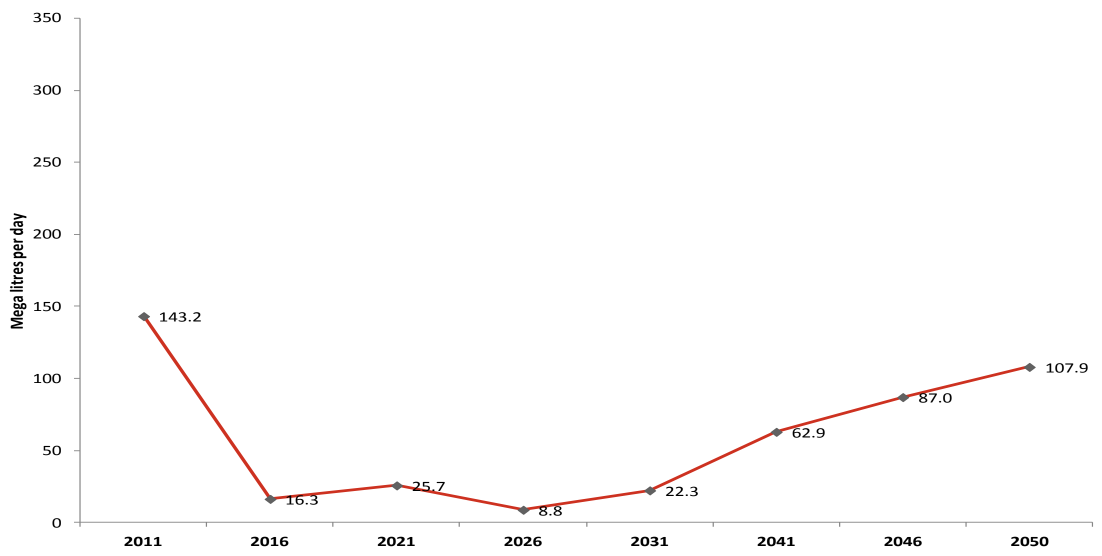
**Table 4.14: Projected Water Supply Requirement versus Capacity – Indecon Economists Low Demand Scenario**

| | Units | 2011 | 2016 | 2021 | 2026 | 2031 | 2041 | 2046 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Average Day Peak Week Demand | Ml/d | 685.1 | 641.1 | 646.5 | 661.2 | 671.8 | 717.6 | 739.0 | 757.6 |
| Allowance for Headroom and Outage | Ml/d | 68.6 | 65.6 | 69.7 | 73.1 | 75.9 | 70.8 | 73.4 | 75.8 |
| Production Requirement (Including Allowance for risk and uncertainty via Headroom and Outage Allowances) | Ml/d | 753.6 | 706.8 | 716.2 | 734.3 | 747.7 | 788.3 | 812.4 | 833.4 |
| Supply Capacity (Maximum Production Potential of Dublin Region sources) | Ml/d | 610.5 | 690.5 | 690.5 | 725.5 | 725.5 | 725.5 | 725.5 | 725.5 |
| Difference | Ml/d | -143.2 | -16.3 | -25.7 | -8.8 | -22.3 | -62.9 | -87.0 | -107.9 |

**Source: Indecon Economists**

Figure 4.3 shows the impacts of assuming low demand on projected capacity shortages.

**Figure 4.3: Forecast Supply Deficit – Indecon Economists Low Demand Scenario**




**Source: Indecon Economists analysis**

## 4.5 Summary of Findings

In this section, we examined a number of key concepts that are likely to be important in determining the economic needs of further investment in supply capacity. The key findings can be summarised as follows:

- The total sustainable water supply to the Dublin Water Supply Region is estimated at 623 Ml/d. There is also additional supply and connectivity measures scheduled to come on stream in 2022 to bring total capacity to 633 Ml/d, rising to 658 Ml/d by 2026;
- Total supply in the benefitting corridor is estimated at 67.5 Ml/d and assumed to remain at this level for the forecast horizon. It should be noted that Irish Water and Jacobs Tobin have reservations about the sustainability of this existing supply however for the purposes of our analysis we take the conservative assumption that this existing supply continues to contribute to total water supply for the forecast period.
- Total supply to the Dublin Region and the benefitting corridor is thus estimated at 610 Ml/d in 2011 and forecast to rise to 725 by 2026 given the additional supply scheduled for the Dublin Region.
- Headroom relates to the capacity margin of the water system. There are a number of both demand and supply uncertainties which are important in determining the optimum headroom allowance. Based on international evidence, it is clear that the headroom requirement should be a number of at least above 10%. We use an estimate of headroom of 17.5% of accounted for water between 2011 and 2031 and 15% between 2031 and 2050;
- Indecon Economists' analysis of the difference between capacity and demand in our base case suggests a deficit of 207.5 Ml/d by 2050. In our high demand scenario this deficit rises to 296 Ml/d.

# 5 Policy Context and Economic Value of Water

## 5.1 Introduction

This section assesses a number of aspects of the value and importance of water supply from an economic perspective.

## 5.2 Policy Context

### 5.2.1 National and Regional Context

National Spatial Strategy (NSS), which is currently under review, provides a twenty-year national planning framework designed to deliver more balanced social, economic and physical development between the State's regions. The strategy emphasises continued growth in the GDA, but also aims for significant improvement in the regions outside the capital. The provision of reliable infrastructure, including water supply and waste water systems, is identified as an important component in maintaining international competitiveness. The NSS was also supported by the National Development Plan (NDP), with the last plan covering the period 2007-2013.

During 2012, the Government set out a strategy 'Our Sustainable Future – A Framework for Sustainable Development for Ireland'[30], which emphasised the need for sustainable future economic development in Ireland. The strategy identified enhancement of water services infrastructure in the state as an important aspect of sustainable development goals.

The strategic national importance of water infrastructure was further underlined in the Government's recent Medium Term Economic Strategy[31], which noted that:

> *"Investing in quality water infrastructure is essential for the future economic development of the country and for job creation."*

The economic role of Dublin is also highlighted in the Regional Planning Guidelines (RPGs) for the GDA.[32] This includes the need for continued investment in leakage reduction and effective management of the current water supplies, as well as long-term sustainable expansion of supply in order to meet growing demand pressures and ensure acceptable levels of headroom and resilience in the system. The Government's Infrastructure and Capital Investment plan (2012-2016)[33] also cites the planning of a new long-term source of water supply for the Greater Dublin Area as a key target of the Water Services Investment Program between 2012 and 2016.

[30] *Our Sustainable Future – A Framework for Sustainable Development for Ireland*. Department of the Environment, Community and Local Government, 2012.

[31] Medium Term Economic Strategy, 2014-2020. Department of Finance, December 2013.

[32] *Regional Planning Guidelines for the Greater Dublin Area 2010-2022*, Regional Planning Guidelines Office, June 2010.

[33] *Infrastructure and Capital Investment 2012-2016: Medium Term Exchequer Framework*, Department of Public Expenditure and Reform, November 2011.

## 5.3 Importance of Water for Competitiveness and FDI

The KOF globalization index[34] ranks Ireland as the second most economically globalised economy in the world. Ireland's openness to trade is highlighted by the portion of its GDP that is composed of exports. Those sectors which are both dependent on water-supply for production and which export a significant proportion of total output are of particular importance in this context. This highlights the need to ensure competitiveness, but also impacts on the appropriateness of different methodologies to forecast water demand. Indecon Economists believe that this highlights the relevance of tailoring demand modelling to the characteristics of a small open economy.

Table 5.1 illustrates the importance of exports to the Irish economy. In recent years exports have been equal to more than 100% of Ireland's GDP.

**Table 5.1: Exports as a Percentage of Irish Gross Domestic Product***

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| Exports as % of Irish Economy GDP | 77% | 77% | 80% | 87% | 96% | 98% | 106% | 105% |

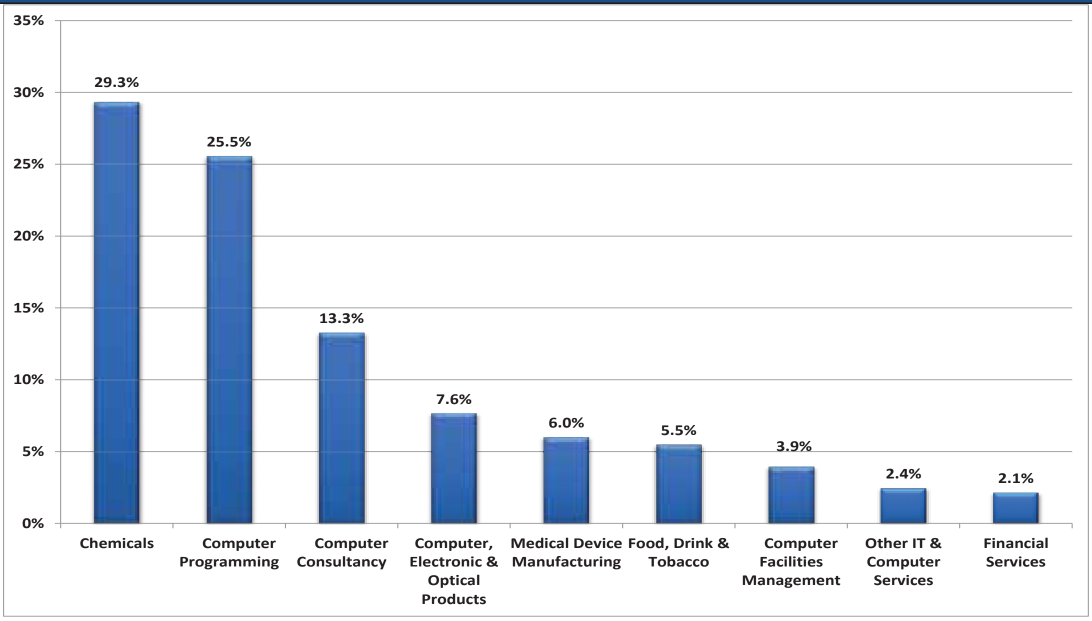
**Source: Indecon Economists analysis of CSO data**
*Exports of goods and services excluding factor flows.

The largest sectors to which Ireland has attracted FDI to date are high-tech manufacturing, chemicals and pharmaceuticals manufacturing and financial services. While inward investment in financial services is unlikely to be particularly dependent on the reliability of the water supply in the country, chemical, pharmaceutical and high-tech manufacturing all require consistent and reliable water supplies to carry out their manufacturing processes.

According to the Forfás "*Annual Business Survey of Economic Impact*" (Forfás, 2012) for 2012, exports from foreign owned, agency assisted companies accounted for nearly 70% of the value of all exports from Ireland in 2012. Importantly from the perspective of this report, two of these most export-reliant sectors, chemical and pharmaceuticals manufacturing and the manufacture of computer, electronic and optical products are water intensive sectors. For these sectors, in particular, an unreliable water supply could pose a particular problem and could undermine Ireland's attractiveness as an investment location in these areas. These sectors account for the largest share of total sales among all agency-assisted foreign-owned firms (see figure overleaf).

[34] http://globalization.kof.ethz.ch/cite/

**Figure 5.1: Sectoral Breakdown of Sales of Foreign-owned Firms - % of Total Sales of Foreign-owned Firms 2012 – Selected Top Sectors**




Source: Indecon Economists Analysis of CSO Data.

Total sales in 2012 for foreign-owned agency-assisted firms are broken down for the manufacturing sector only in the table below. The data presented here, in combination with the data in Figure 3.3 and Figure 3.4, suggests that the top manufacturing sectors in terms of sales are water intensive sectors.

**Table 5.2: Total Sales by Foreign-owned Agency-assisted Manufacturing Companies 2012 - €m**

| | 2012 |
|---|---|
| Chemicals | 37,980 |
| Computer, Electronic and Optical Products | 9,899 |
| Medical Device Manufacturing | 7,750 |
| Food, Drink and Tobacco | 7,094 |
| Machinery and Equipment | 1,096 |
| Rubber and Plastics | 971 |
| Transport Equipment | 802 |
| Basic and Fabricated Metal Products | 757 |
| Electrical equipment | 658 |
| Non-Metallic Minerals | 290 |
| Other Misc. Manufacturing | 243 |
| Wood and Wood Products | 222 |
| Paper and Printing | 123 |
| Agriculture, Fishing, Forestry, Mining and Quarrying | 63 |
| Textiles, Clothing, Footwear and Leather | 15 |
| **Total Manufacturing** | **67,963** |
| **Total All Sectors** | **129,551** |

Source: Forfás Annual Business Survey of Economic Impact 2012.

The table below provides a detailed sectoral breakdown of employment in manufacturing among the foreign-owned agency-assisted firms in Ireland. Similar to that of sales above in Table 5.2, the top sectors in terms of employment are also heavily dependent on water supplies for their production.

**Table 5.3: Total Employment in Manufacturing by Foreign-owned Agency-assisted Companies**

| | **2012** |
|---|---|
| Medical Device Manufacturing | 22,657 |
| Chemicals | 19,326 |
| Computer, Electronic and Optical Products | 14,113 |
| Food, Drink and Tobacco | 7,702 |
| Machinery and Equipment | 3,447 |
| Transport Equipment | 2,912 |
| Rubber and Plastics | 2,887 |
| Electrical equipment | 2,126 |
| Basic and Fabricated Metal Products | 1,936 |
| Other Misc. Manufacturing | 1,637 |
| Wood and Wood Products | 846 |
| Non-Metallic Minerals | 678 |
| Paper and Printing | 650 |
| Agriculture, Fishing, Forestry, Mining and Quarrying | 289 |
| Textiles, Clothing, Footwear and Leather | 156 |
| **Sub Total** | **81,362** |
| **Grand Total - All Sectors** | **140,382** |

**Source: Forfás Annual Business Survey of Economic Impact 2012.**

Focusing on the Dublin area, total industrial output for foreign-owned companies in the Greater Dublin Area amounted to €24.7 billion in 2012. This demonstrates the significant contribution that foreign owned companies make to the region and the importance of ensuring essential utility services, including water.

**Table 5.4: Gross Industrial Output in Foreign-Owned Local Units in the Greater Dublin Area**

| | **2011 - € Million** | **2012 - € Million** |
|---|---|---|
| Greater Dublin Area | 21,499 | 24,714 |

Note: Greater Dublin Area includes Dublin and the Mid-East.
**Source: Indecon Economists Analysis of CSO COIP Data.**

Table 5.5 shows that employment in foreign-owned agency-assisted companies in Dublin has been growing steadily since 2010 and reached a significant total of 84,003 in 2013.

**Table 5.5: Employment in Foreign-owned Agency Assisted Companies in Greater Dublin Area**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| Greater Dublin Area | 78,055 | 71,890 | 72,389 | 75,975 | 79,967 | 84,003 |

**Source: Indecon Economists analysis of Forfás, Annual Employment Survey of Agency-assisted Companies**
Note: Agency-assisted companies include IDA Ireland, Enterprise Ireland and Údarás na Gaeltachta. Greater Dublin Area includes Dublin and the Mid-East.

The evidence from both employment and output data of foreign owned companies in the Dublin Area suggests that it is important that Dublin, as well as all other regions have access to a reliable and sustainable water supply.

Several of the industries in which Ireland attracts the largest amount of foreign direct investment are heavy water users. Pharmaceuticals, the manufacture of computer chips and facets of the information and communication technology (ICT) services sector are examples of these water-dependent industries. For these industries, a reliable, sustainable and high quality supply of water is a key factor in their location decisions when contemplating foreign investment.

The Forfás report, "*Adaptation to Climate Change: Issues for Business*" (Forfás, 2010), underlines the importance of water supply to these sectors and continued FDI inflows by highlighting the sectors of the Irish economy that are potentially most vulnerable to water shortages. Forfás highlights both the pharmaceuticals sector and the Information and Communication Technology (ICT) manufacturing and services sectors as industries with a particular reliance in their business processes on a dependable supply of water. The Forfás report points to several technical factors in the pharmaceuticals and chemicals sectors accounting for their dependence on a reliable source of plentiful clean water. For example, the report points to the importance of water in vaccine production:

> "The availability of fresh water is essential for operations in the biotechnology sector, as vaccine manufacturing operates under strict norms that require fresh water"

Beyond the pharma sector, Forfás also highlights the water needed for cooling data centres as a key vulnerability of the ICT services sector to disruptions in water supply. Similarly, ICT manufacturing is also highly dependent on a reliable water supply, and the manufacture of semiconductors, for example, is a water intensive process.

## 5.4 Economic Costs of Supply Interruption

A wide range of existing studies estimate the costs to users of supply disruptions in essential utility services. Such estimates highlight the economic importance of a reliable service. The common methodological approaches to estimating the cost of a loss in an essential utility service include production functions for estimating output losses and consumer demand functions, willingness to pay or willingness to accept, and reporting the cost of previous disruptions through surveys. In an Irish context the willingness to pay will in part be influenced by the availability of a reliable service. The overall approach and types of costs incurred for water outages are similar to that of other utility services with the exception of the case of water contamination which is also discussed. The use of sectoral resilience factors is an important part of estimating the costs of a water supply interruption to industry and we also review the existing literature on this.

Internationally, there has been research on the cost of a water supply disruption. Chang et al (2002) use a simulation approach combined with an economic losses model to investigate the cost to both residential consumers and business sectors as a result of a six different 'scenario' earthquakes. The model links the physical infrastructure to the economy through the infrastructure service. Damage to the infrastructure causes a reduction in service which is an essential input into economic output. Direct economic losses in gross output terms ranged from $5 million to $2.4 billion, depending on the severity of the earthquake and the restoration time. The study captures the extent to which a business would need to reduce its production as a result of a water shortage through industry-level resilience factors for a range of sectors including agriculture, manufacturing, wholesale and retail trade, services and finance. In this context, the resilience factors indicate the capacity of a sector to maintain output in the event of a water supply disruption. Manufacturing sectors reported lower levels of resilience to water supply disruptions than the services sectors.

Brozovik et al (2007) use loss functions and demand functions to estimate the cost of a loss in water supply due to two potential scenarios to the San Francisco Bay area of California. The study takes into account the length of time it takes to restore the service and incorporates a 'cut off point' after which business ceases to operate. Estimated total business losses were $9.3 billion and $14.4 billion. Residential losses ranged from $37 million to $279 million.

In the United States a framework developed by FEMA[35] established a number of values for loss of service utilities including the economic impact of a complete disruption in water supply services. The FEMA research provided the starting point of the Aubuchon and Morley (2013) study which estimates a range of total economic losses per capita of disruption to water supply services for both residential and business sectors of between $67 and $457 per day. This study applies regional variations in per capita water consumption and variations in elasticity over time to the FEMA methodology, thus testing the underlying assumptions of the FEMA model. The study suggests it is more appropriate to use lower elasticity values which reflect the short-term trade-off between price and demand and therefore it is likely that the original FEMA methodology underestimates the potential losses. The authors arrive at an overall estimate of $208 per capita per day for total economic losses due to a water supply disruption. The estimated average value for losses incurred by business sectors in this study was $55 per capita per day and residential costs were $153 per capita per day. To estimate losses for various industry sectors, the industry level GDP is multiplied by the resilience factors for each sector – where a resilience factor $r_i$ is the percentage of capacity which a sector can operate at without water based on contingency plans.

Rose et al (2012) use a computable general equilibrium model to estimate the impacts of potential water supply disruptions on output, employment and prices. The model consists of a set of integrated supply chains which capture behavioural responses of consumers and businesses to resource constraints and their model is specifically focused for water production and use. Loss estimates varied greatly depending on timing, hydrologic conditions, resilience, rationing and pricing. The study suggests a potential 6-month impact of water supply disruptions to the county of a -3.8% reduction in GDP, -3.6% in employment and a 10.92% increase in water prices in the case of no storage water available.

[35] Federal Emergency Management Agency (2009) 'Final BCA Reference Guide', URS Group Inc. Federal Emergency Management Agency (2013) 'Hazard Mitigation Assistance Unified Guidance'.

***Economic Resilience Factors***

Economic resilience refers to the ability or capacity of a system to absorb or cushion against damage or loss (Rose and Liao, 2005). Resilience refers to post disaster conditions, which are distinct from pre disaster activities to reduce potential losses through mitigation. A number of studies have attempted to quantify the extent of resilience across industrial sectors in terms of the percentage of output which can continue to be produced in the event water outage.

Kajitani and Tatano (2009) use a survey to estimate resilience factors for 27 Japanese industrial sectors to disruptions from water outage, as well as electricity and gas outages. They report that resilience to disruptions from electricity was less than 10%, while resilience to water disruption was between 38% and 71%, depending on the industry.

An earlier study on resilience factors from the Applied Technology Council-25 (ATC 1991) also tried to quantify the economic losses from water disruption, and these were based on a previous report by ATC-13 (1985). However, due to lack of data, ATC estimates were largely based on expert judgement. The resilience factors associated with this study are presented in the annex of this study. For example, it is estimated that the construction sector can continue to operate at 50% of capacity during a water outage.

Chang et al. (2002) estimated resilience factors for 18 industries based on ex ante and ex post empirical studies of resilience to water outages caused by earthquakes. A probabilistic simulation methodology is developed for estimating the economic impact of natural disasters. The methodology is applied to the water supply system serving Memphis and other parts of Shelby County in Tennessee and to Northridge in California, which are key regions at risk from earthquakes. Estimates of resilience are based on two business surveys conducted by the Disaster Research Centre at the University of Delaware with questions such as the importance of water to business and the number of days businesses could go without water. Businesses were also asked whether or not the water outage forced them to close for a period of time and the principal reasons for this closure. The authors cross tabulate the level of disruptiveness of water outage by industry group for businesses. Disruption relates to anything from loss of water to building damage to employees being unable to travel to work. Some industries report much higher water disruptiveness than others, for example 80% of health service firms report water outage as 'very disruptive.' The extent of disruption also appears to rise substantially as the duration of the outage increases – for example, 46% finance and insurance firms report an outage of less than 1 week as very disruptive, while for a greater than 2 week outage, this number rises to 77%. However, it should be noted that some of these percentages are based on small samples of firms in these industries. A full list of reported disruptiveness by sector from this study is presented in a table in the annex of this study.

The disruptiveness categories provide the basis for developing overall business resilience measures. Overall resiliency factors (incorporating the extent of disruption and the duration of disruption) are given by:

$$rj,t \;\; = 1 - p(Z_{j,t}),$$

$$p(Z_{j\,,t}) = \sum_{y=2}^{4} [p(Z_j | Y_j = y) p(Y_j = y \,|T_j = t)]$$

where $r_{j,t}$ is the resiliency factor for industry i at time t, $p(Z_{j,t})$ is the probability of business closure, $y$ is the level of business disruption from water outage (1 being not at all disruptive, 4 being very disruptive), Y is the disruptiveness of water outage and T is the duration of water outage. The overall resiliency is modelled within a Monte Carlo analysis framework.

The available evidence indicates that water resilience is a key factor for many industry sectors. Some estimates of resiliency factors by industry sectors are presented in the table below. Many industries would only be able to produce at a capacity of around 50% following a water outage; however this falls to 30% as the outage extends in duration.

**Table 5.6: Overall Resiliency Factors by Industrial Sector**

| Industry Sector | Water-outage duration | | |
|---|---|---|---|
| | < 1 week | 1-2 weeks | > 2 weeks |
| Agriculture | 0.53 | 0.35 | 0.3 |
| Business/repair services | 0.45 | 0.33 | 0.27 |
| Communication/utilities | 0.65 | 0.49 | 0.43 |
| Construction | 0.68 | 0.47 | 0.43 |
| Durable manufacturing | 0.42 | 0.34 | 0.28 |
| Educational services | 0.45 | 0.33 | 0.27 |
| Entertainment services | 0.45 | 0.33 | 0.27 |
| Finance | 0.44 | 0.27 | 0.24 |
| Health services | 0.27 | 0.21 | 0.19 |
| Insurance | 0.44 | 0.27 | 0.24 |
| Mining | 0.73 | 0.48 | 0.44 |
| Nondurable manufacturing | 0.42 | 0.34 | 0.28 |
| Other services | 0.45 | 0.33 | 0.27 |
| Personal services | 0.45 | 0.33 | 0.27 |
| Real estate | 0.44 | 0.27 | 0.24 |
| Retail trade | 0.46 | 0.32 | 0.28 |
| Transportation | 0.65 | 0.49 | 0.43 |
| Wholesale trade | 0.51 | 0.36 | 0.3 |
| **Mean** | **0.49** | **0.35** | **0.30** |

**Source: Chang et al. (2002). Figures are the average of the factors for the two regions (Memphis and Northridge)**

Heflin, Jensen and Miller (2013) examine three case studies in the U.S. where residents and businesses were adversely affected by unexpected water disruptions. 31.9% of businesses reported loss in revenue due to water disruption and 8.5% were forced to close temporarily. In the case of food and beverage industries (both manufacturing and service), 100% reported losses in revenue ranging from less than \$100 to \$400,000. Overall the study found the cost to the businesses sector to be greater than that of households.

Heflin (2014) documented the cost of previous water supply disruptions through residential surveys conducted in known affected areas. This study includes the direct household costs of replacing water, the cost of making adjustments to the household routine in relation to cooking or eating, work or school schedules and additional travel costs. Disruptions which lasted less than one day were excluded from the estimations and costs were reported as the average household costs per event. The average household cost[36] of an outage of water supply was $62.31 per day which was higher than the average cost of water contamination, $35.10 per day. Average reported costs for all disruptions were also slightly higher for urban areas ($58.53 per day) than that of rural areas ($54.54 per day).

A feature of water supply disruptions is contamination. An outbreak of contamination can render the water unsafe to consume but consumers may choose to consume the water despite warnings. If consumption results in illness, there will be other health costs and the cost of sick leave from work to consider. Contaminated water may still be safe for other uses such as showering, cleaning or cooking but may require precautions such boiling or bleaching which are additional costs to consider (Heflin 2014, Halonen et al 2012 and Ailes et al 2013).

Studies such as Ailes (2013) and Halonen et al (2012) focused on the economic costs of a water supply disruption due to contamination. These studies mainly focus on the cost of sick leave or work days lost. Ailes (2013) included some costs that were similar to that of Heflin (2014) such as the cost of replacing or treating water and the cost of moving out of home temporarily. The additional costs of water contamination (which do not apply to a water supply outage) are medical costs, cost of sick leave and potential long-term illness. Ailes (2013) also touches on the potential for loss of trust in public water systems following an outbreak of a waterborne illness. Similarly, consumers will likely lose trust in the water service following an outage. Loss of trust in an essential service such as water supply can be damaging to a region's economic reputation.

**Summary of Cost Estimates from Research**

Table 5.7 presents a summary of various estimates of the cost of a disruption in the supply of water to the residential sector. Each estimate has been expressed as the cost per person per day in euros for ease of comparison. It must be noted that these estimates are not comparable to standard economics metrics such as GDP or GVA as these metrics are measures of economic output. The estimates below are related to a measure of economic welfare rather than economic output.

Residential estimates vary considerably depending on the methodological approach. Studies which documented the various household cost of adapting to a water supply outage generally have lower costs than those studies which measure loss in consumer surplus or willingness to pay or willingness to accept. Grossing up the various per person-day estimates to the size of the Greater Dublin Area revealed an indicative range of estimates of the cost to the residential sector of a 1-day water supply outage to the region. Estimates of the cost of 1 day's disruption are presented in the table combined with estimates of the potential impacts of the costs of 1 day disruption in water outage for the Greater Dublin Region. It is, however, likely that a 100% outage on any day is likely to be a worse case scenario and the economic costs of short term disruption of less than one day to the residential sector may be less than indicated by the estimates in the table. However, the costs of multiple disruptions over different time periods could be more significant. However, a linear approach to aggregating costs would not be appropriate so that the costs of water disruption for the residential sector of a 100 day outage, to take an extreme example, may be significantly less than 100 times daily cost estimates.

[36] Median values were used for reporting average costs.

| Table 5.7: Summary of Selected Previous Studies on the Cost of a Loss in Water Supply | | | | | | | |
|---|---|---|---|---|---|---|---|
| Summary of Previous Studies | | | | | | Indecon Economists Estimations | |
| Authors | Country | Service | Disruption | Method | Unit | Cost per Person per Day - € 2014 prices | Estimated cost of 1-day disruption for GDA - €m[1] |
| FEMA method (2009) presented in Aubuchon and Morley (2013) | U.S. | Water | Outage | Constant elasticity demand curve | per capita per day | 44 | 78.9 |
| Aubuchon and Morley (2013) | U.S. | Water | Outage | Constant elasticity demand curve | per capita per day | 122 | 219.4 |
| Source: Indecon Economists Analysis | | | | | | | |
| *Estimates rounded to the nearest €. | | | | | | | |

However, possibly of greater economic cost is the cost for the non-residential sector of water outages. Indecon Economists notes that for many sectors including our high tech ICT and pharmaceutical sectors resiliency and security of water supply are of particular importance and the consequences for Ireland's reputation as a location for investment would be higher than any estimates of costs. The costs of a 1 day water disruption for some sectors may therefore be a multiple of the economic output produced on a given day. This will be examined in more detail as part of the benefit assessment.

From the preceding analysis of existing research, it can be observed that industrial sectors respond differently to water outages and this is influenced by factors such as input substitutability, the availability of water reserves, the water intensity of output, and the duration of the outage. However, the extent of potential losses to both the business and residential sectors of a water supply outage estimated in the various studies highlight the importance of reliable and adequate water supply.

## 5.5 Community Gain and Wider Regional Development

As noted in Section 1, the development of the WSP project is undertaken in the context of ensuring that in addition to supplying water to the Dublin Region, it also contributes appropriately to supporting balanced regional development. This means that the Project will facilitate in an Irish Water National context the provision of quantities of treated water to local authorities in a wider economic or benefitting zone, defined by the source and the water transfer system. Thus, the Project has the potential to deliver new water supplies to support economic development and deliver socio-economic benefits in these benefitting areas.

In the context of examining the merits of potential new supply options involving the Shannon River basin, the potential benefitting region could take in a wider corridor, which was highlighted in Figure 1.1 in Section 1, and includes areas within Tipperary, Laois, Offaly, Westmeath, Kildare, Meath and Dublin (outside of the main Dublin water supply area).

[1] All estimates for the GDA were arrived at by grossing up per person per day estimates to the size of the GDA population.

In the context of infrastructure projects, the concept of community gain can take various forms, depending on factors including the nature of the project involved and the geographic areas of potential impact. It is traditionally more narrowly associated with projects or initiatives designed to bring benefits from the infrastructure to local communities adjacent to the supply infrastructure.

As the options for addressing future water supply requirements have yet to be fully identified, the specifics in relation to potential community gain and wider socio-economic benefits, and how to maximise such benefits, remain to be fully assessed. However, some examples of areas of potential wider benefit that are likely to be relevant in the context of the WSP include the following:

- Potential to release additional water supplies to local authorities within the benefitting corridor, which could support economic development in these areas;
- Addressing second level capacity constraints in other areas of infrastructure that undermine the ability to capture the full benefits from a new water supply source.
- Supporting provision of community, civic amenity, and tourism projects;
- Facilitation of development of projects bringing educational benefits;

A potential direct benefit of the WSP for the benefitting zone would be in the potential for the project to deliver additional water supplies and facilitate economic development in these areas. Analysis of water demand in the benefitting corridor suggests that, as is currently the case in the Dublin Region, a supply deficit, taking account of an allowance for outage and headroom, is likely to emerge over the coming years. To the extent that a new supply source would address some of these supply requirements, this could support industrial investment and economic development, with associated employment and other socio-economic benefits.

Other areas of potential wider economic benefit at community level would include opportunities to provide local recreation, amenity and other facilities to support community cohesion and identity, and to develop local tourism potential. Examples of such facilities can be seen internationally where major infrastructure projects have been developed.[37] In the context of the WSP, opportunities arise along the benefitting corridor/zone to develop facilities such as cycling, walking, fisheries and other water-based recreational, amenity and tourism activities.

In addition to recreation, amenity and other community facilities, the Project could also have the potential to deliver educational benefits. For example, longer term education benefits may be derived from the development of interpretive centres or similar facilities. Potential abstraction locations for the project, such as the Lough Derg and Parteen Basin area and North Fingal (Desalination), may offer the opportunity to apply such approaches. At a single location, aspects such as interaction with the aquatic environment, provision of potable water and, where applicable, continued monitoring under the Water Framework Directive in the Shannon River Basin could be explored, for example as part of a research-based facility.

[37] One such example in a different context is the 'Cyclopark' developed by Kent County Council alongside the A2 trunk road in Gravesend in Kent (see www.cyclopark.com). The park emerged from a linear land strip that came available following the truck road realignment and was developed following research and consultation with the local community to identify an optimal use for this land which would benefit the community.

A holistic perspective on the wider benefits would also factor in the potential benefits that could flow from aligning the objectives of the WSP with the assessed priorities of Irish Water investments at a local level within the potential benefitting zone/corridor.

While further examination will be required at options identification stage, Indecon Economists would identify certain principles which we believe should inform the approaches to maximising potential community gain and wider socio-economic development benefits arising from the WSP. These include the following:

- Implementation of collaborative approaches between local authorities and Irish Water to identification potential community and wider development opportunities,
- Leveraging opportunities for water resource sharing;
- Exploiting economies of scale in water and wastewater provision;
- Maximising the resilience of water supply and minimising the probability of supply outages which affect residential and non-residential users.
- There is also likely to be employment and other community gains associated with the investment programme.

## 5.6 Summary of Findings

This section assessed a number of aspects of the value and importance of water supply from an economic perspective. Among the main findings were as follows:

- The importance of water and a sustainable and reliable water supply has been underlined in a wide range of policy areas.
- Water is an important factor in maintaining Ireland's competitiveness as a destination for foreign direct investment due to the reliance of the internationally traded sectors operating in Ireland on a reliable and sustainable water supply. The water intensity of the pharmaceuticals and computer manufacturing sectors in particular, two of the largest FDI sectors in Ireland, means that a reliable and plentiful water supply is a crucial component of the international competitiveness of the Dublin region.
- International evidence suggests a significant economic cost of supply interruptions in the water sector.
- There is potential for community gain in the Eastern Region including the benefitting zone arising from the investment.

# 6 Overall Conclusions

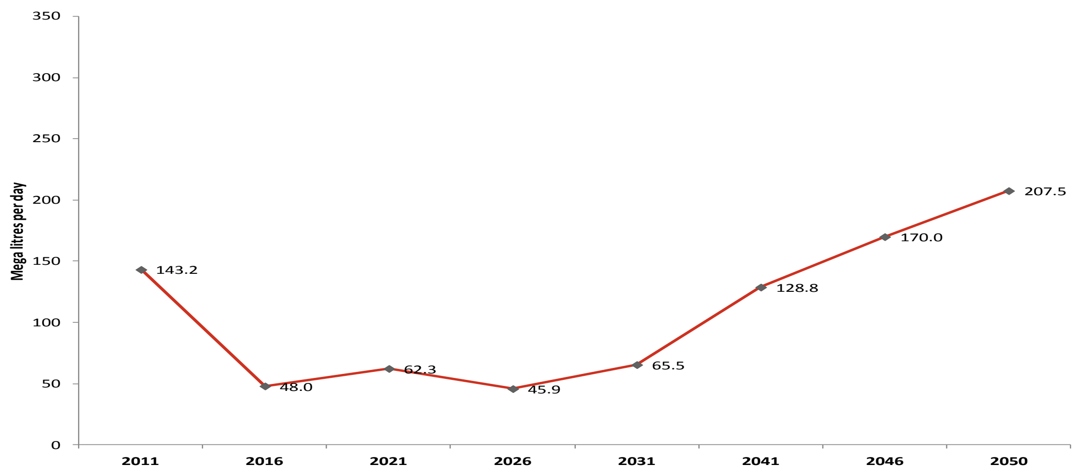
Our analysis in this report has provided forecasts of likely future demand for water. Indecon Economists had concerns about some of the historical approaches used to forecast water demand, particularly for the non-residential sectors. Often such forecasts were based on assumptions of the levels of zoned land or simply assumed non-residential demand would grow in line with that in the residential sector. While this may have some validity for large closed economies, Indecon Economists believe there is no basis for such an assumption in a small open economy. Some previous assumptions for water demand for the residential sector did not take account of the impact of economic developments on migration and on household size. Also of importance is the need to take account of sectoral differences in water usage in the non-residential sector and the trend towards declining water intensity. For the residential sector it is also necessary to factor in the impact of water charges, changes in occupancy levels and enhanced water efficiency of new building stock. Indecon Economists estimates have explicitly examined and taken account of each of these issues.

Three main broad scenarios for the possible future evolution of water demand in the Dublin Region are examined in our main report. These scenarios are informed by different assumptions with regard to demographic and economic growth drivers. The Indecon Economists Base Case Scenario is provided below. This scenario is based on the evidence of existing residential and non-residential demand levels of water usage and an evaluation of how these levels are likely to change over time. Our estimates model the combined impact of water metering and charging, lower occupancy levels and enhanced water efficiency due to the new housing stock envisaged. The estimates also assume some levels of falling water intensity over time in the non-residential sector. We also account for peaks in demand and the targeted allowance for headroom and outage in the system.

| Table 6.1: Water Demand to 2050 – Indecon Economists Base Case Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Population | hd | 1,516,133 | 1,579,262 | 1,642,391 | 1,742,226 | 1,842,060 | 2,003,156 | 2,081,225 | 2,154,252 |
| Occupancy Rate | hd/house | 2.64 | 2.56 | 2.48 | 2.40 | 2.32 | 2.16 | 2.08 | 2.00 |
| Households | No. | 618,460 | 678,921 | 728,480 | 798,520 | 873,391 | 1,020,126 | 1,100,648 | 1,184,839 |
| Per Capita Consumption | l/hd/day | 125.5 | 119.9 | 120.4 | 120.6 | 120.7 | 120.9 | 121.0 | 121.0 |
| Residential Demand Projection | Ml/d | 190.3 | 189.3 | 197.7 | 210.1 | 222.3 | 242.2 | 251.7 | 260.6 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.9 | 155.9 | 164.8 | 176.0 | 205.2 | 222.6 | 238.2 |
| Customer Side Loss Rate | l/house | 66.0 | 54.5 | 45.0 | 35.0 | 25.0 | 25.0 | 25.0 | 25.0 |
| Customer Side Losses | Ml/d | 40.8 | 37.0 | 32.8 | 27.9 | 21.8 | 25.5 | 27.5 | 29.6 |
| Leakage Rate | % | 33.0 | 30.0 | 26.3 | 24.9 | 23.5 | 21.4 | 20.4 | 19.6 |
| Distribution Losses | Ml/d | 178.1 | 157.6 | 139.4 | 135.0 | 130.0 | 130.0 | 130.0 | 130.0 |
| Operational Usage | Ml/d | 3.6 | 3.6 | 3.9 | 4.0 | 4.2 | 4.7 | 5.0 | 5.3 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **524.4** | **529.7** | **541.8** | **554.3** | **607.6** | **636.9** | **663.7** |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **597.8** | **607.8** | **623.2** | **639.2** | **703.1** | **738.3** | **770.5** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| **Total Average Demand - Benefitting Corridor** | **Ml/d** | **67.5** | **64.8** | **63.7** | **62.7** | **62.2** | **64.4** | **65.6** | **66.6** |
| **Average Day Peak Week Demand - Benefitting Corridor** | **Ml/d** | **73.6** | **71.0** | **70.6** | **70.3** | **70.4** | **73.0** | **74.5** | **75.7** |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **668.8** | **678.4** | **693.5** | **709.5** | **776.2** | **812.7** | **846.2** |
| **Total Production Requirement Dublin & BC (Including Allowance for risk and uncertainty via headroom)** | **Ml/d** | 753.6 | 738.5 | 752.8 | 771.3 | 790.9 | 854.2 | 895.4 | 933.0 |
| **Source: Indecon Economists** | | | | | | | | | |

The figure below depicts the forecast supply deficit under the base case scenario in chart form. The base case scenario forecasts a supply deficit in each period. The deficit is forecast to fall to 48 Ml/d in 2016 due to the combined impacts of expansion in supply in 2014 and the impact of declining Per Capita Consumption in 2016 following the introduction of residential water charges. The deficit is forecast to continue to decline out to 2026 due to the achievement of leakage reduction targets. However, from 2026 onwards, the base case forecast predicts that the supply deficit in the Region including the benefitting corridor will continue to grow as leakage levels flatten out, population growth continues and industrial and non-residential demand continues to expand. The base case scenario forecasts a deficit of 207.5 Ml/d by 2050. There are, however, significant uncertainties regarding any forecasts of water demand and we have therefore also included estimates based on higher and lower demand assumptions. We would also point out that the supply estimates for the benefitting corridor relate to specific supply projects which we have been advised by Jacobs-Tobin are currently at risk or are inadequately supplied or are constrained. Some or all of these small existing supplies may need to be replaced in order to ensure that the water supply needs of parts of Tipperary, Offaly, Laois, Westmeath and Meath are met. To the extent to which these existing small supply options are not adequate the deficit may be larger than indicated. In this context we note that any investment which Irish Water would need to incur to upgrade existing supplies in the benefitting corridor which would remain dependent on inadequate hydrological yield could be avoided by connecting to a water spine drawing from a quality assured source would represent an important advantage for the benefiting corridor. This supports the merit of utilising our higher demand estimates for abstraction planning purposes.

**Table 6.2: Projected Supply Deficit – Indecon Economists Base Case Demand Scenario**



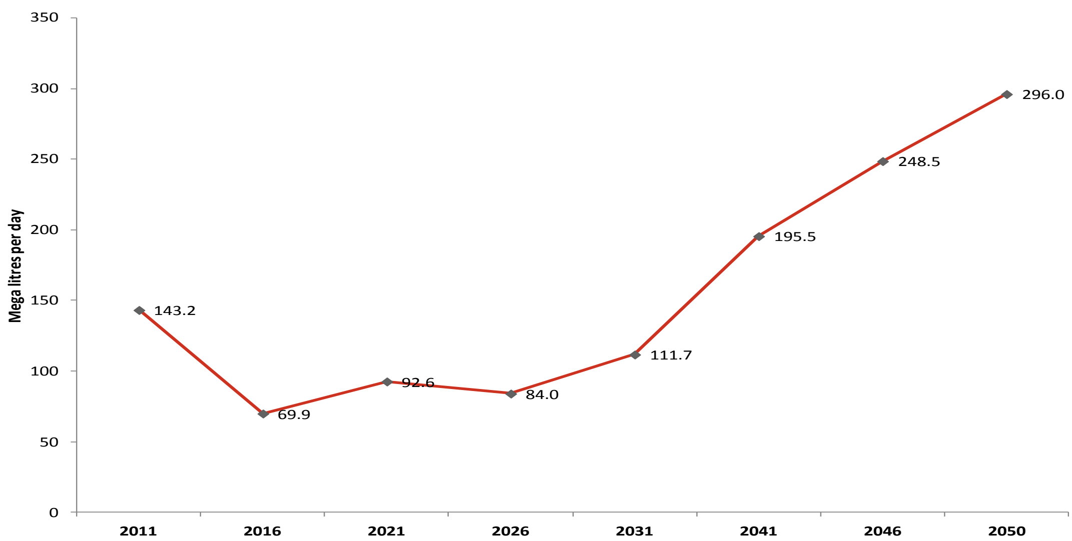

**Source: Indecon Economists Analysis**

The table overleaf illustrates the water demand forecasts under the Indecon Economists High Demand Scenario. The High Demand Scenario assumes a higher population forecast than the Base Case Scenario while also incorporating higher expected economic growth in certain key water using sectors. Alternative assumptions as regards the likely impact of metering, charging and leakage have also been incorporated. In light of these assumptions, the High Demand Scenario forecasts a higher supply requirement by 2050.

| Table 6.3: Water Demand to 2050 – Indecon Economists High Demand Scenario | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Description** | **Units** | **2011** | **2016** | **2021** | **2026** | **2031** | **2041** | **2046** | **2050** |
| Dublin Water Supply Region | | | | | | | | | |
| Per Capita Consumption | l/hd/day | 125.5 | 126.4 | 127.0 | 126.8 | 126.5 | 125.9 | 125.3 | 124.7 |
| Residential Demand Projection | Ml/d | 190.3 | 200.8 | 210.8 | 225.7 | 238.9 | 257.2 | 266.0 | 272.4 |
| Non Residential Demand Projection | Ml/d | 126.5 | 136.1 | 155.6 | 166.9 | 183.1 | 225.9 | 250.2 | 272.4 |
| Customer Side Loss Rate | l/house | 66.0 | 55.8 | 47.3 | 36.8 | 26.3 | 26.3 | 26.3 | 26.3 |
| Customer Side Losses | Ml/d | 40.8 | 39.3 | 36.9 | 32.9 | 26.7 | 33.9 | 38.5 | 43.8 |
| Leakage Rate | % | 33.0 | 29.8 | 26.4 | 24.8 | 23.1 | 20.7 | 19.6 | 18.7 |
| Distribution Losses | Ml/d | 178.1 | 161.5 | 146.4 | 141.8 | 136.5 | 136.5 | 136.5 | 136.5 |
| Operational Usage | Ml/d | 3.6 | 3.8 | 4.0 | 4.3 | 4.5 | 5.2 | 5.5 | 5.9 |
| Total Average Demand – Dublin Region | Ml/d | **539.3** | **541.4** | **553.6** | **571.4** | **589.7** | **658.7** | **696.8** | **731.0** |
| **Average Day Peak Week Demand – Dublin Region** | **Ml/d** | **611.5** | **617.4** | **635.1** | **657.4** | **680.3** | **763.1** | **808.9** | **849.8** |
| Benefitting Corridor | | | | | | | | | |
| Residential Demand Projection | Ml/d | 18.1 | 19.1 | 22.7 | 26.3 | 29.5 | 32.3 | 33.8 | 35.0 |
| Non Residential Demand Projection | Ml/d | 12.1 | 11.8 | 11.4 | 11.0 | 10.7 | 10.0 | 9.7 | 9.5 |
| Total Leakage | Ml/d | 36.9 | 33.5 | 29.2 | 24.9 | 21.5 | 21.5 | 21.5 | 21.5 |
| Operational Usage | Ml/d | 0.3 | 0.4 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 | 0.7 |
| Total Average Demand - Benefitting Corridor | Ml/d | 67.5 | 64.8 | 63.7 | 62.7 | 62.2 | 64.4 | 65.6 | 66.6 |
| Average Day Peak Week Demand - Benefitting Corridor | Ml/d | 73.6 | 71.0 | 70.6 | 70.3 | 70.4 | 73.0 | 74.5 | 75.7 |
| **Total Average Day Peak Week Demand – Dublin & BC** | **Ml/d** | **685.1** | **688.4** | **705.7** | **727.7** | **750.7** | **836.1** | **883.3** | **925.5** |
| **Total Production Requirement Dublin & BC (Including allowance for risk and uncertainty via headroom)** | **Ml/d** | 753.6 | 760.4 | 783.0 | 809.5 | 837.1 | 920.9 | 974.0 | 1021.5 |
| **Source: Indecon Economists** | | | | | | | | | |

The below overleaf illustrates the supply deficit associated with this level of demand. The deficit under the high demand assumptions is forecast to rise from 69.9 Ml/d in 2016 to 296 Ml/d by 2050. This compares to a deficit of 207.5 Ml/d in the base case scenario.

**Table 6.4: Projected Supply Deficit - Indecon Economists High Demand Scenario**




**Source: Indecon Economists Analysis**

## Need to Meet Water Needs of Users Reflecting Economic Costs of Water Disruption

There is a need to meet foreseeable demand for water for both the residential and non-residential sectors. In addition to the needs of economic sectors, of even greater importance are the needs of the residential sector. Despite being vital for human life and being recognised as a basic right, clean water is also a quantifiable and scarce natural resource. Principle 4 of the Dublin Declaration of the International Conference on Water and the Environment recognises the special status of water as a fundamental human right but also posits that treating water as a scarce resource is appropriate to limit wastage, improve efficiency and encourage environmental responsibility in water supply. From the perspective of a residential water user, a reliable and sustainable water supply is vital to maintaining the quality of life for individuals and families throughout Ireland including in the Region.

For the latter sector Indecon Economists believe there will be a requirement for increased water demand to accommodate the expansion plans of a number of major existing large industrial users. We believe this could involve an increased demand of between 30 to 50 mega litres per day. There will, however, be potential to improve water intensity over time but this will depend on the timing of new projects and technological advances. Indecon Economists believe that Irish Water should therefore ensure sufficient capacity to accommodate such users. In this context the IDA has indicated the following:

> ***"The continued strategic planning and investment in the provision of utilities, including water, waste water, power, gas etc. is paramount as it assists in maintaining Ireland's attractiveness to secure utility intensive investments against stiff global competition. The provision of these utilities are a key components to meet the requirements of industry, both FDI and indigenous.***
>
> ***The Dublin region and its hinterland must plan to ensure that water supply to the region can meet demand and opportunities to secure future investments and related job creation. Therefore this region must have the ability to demonstrate robust and scalable infrastructure capable of delivering increased water supply and treatment capacity of 34 – 50 M/d within the next five year timeframe."***

In our base case estimates we are assuming that even after efficiencies in water intensity are taken into account, there will be a need for an increase in water demand by the non-residential sector of over 38 Ml/d by 2026 and indeed our base case scenario assumes this will increase to 110 Ml/d by 2050. This takes account of the impact of sectoral shifts in demand and, as noted previously, also takes account of an assumed reduction in water intensity. In our high demand scenario our estimates assume a higher level of water demand for the non-residential users of over 40 Ml/d by 2026 and over 145 Ml/d by 2050. This takes account not only of the likely increased demand by existing or new large users, but also the need to accommodate the expected demand increases of other non-residential users, consistent with our assumptions for economic growth. Indecon Economists believe there is merit from an infrastructural planning perspective of ensuring adequate supply to accommodate a higher demand scenario. The significant economic costs of water supply disruption indicated by our research supports the case for accommodation of a higher demand scenario than indicated in our base case. While there is uncertainty regarding whether the high demand scenario will be realised, it is based on a credible possible outcome for the Irish economy.

Our projections for non-residential demand implicitly include an estimate of increased water demand required to meet the strategic needs of the manufacturing sector. Some manufacturing water users may, however, close or contract over the period and it is also assumed that there will be enhanced water efficiency across sectors. Even taking account of these factors, our estimates assume the need for a strategic reserve to meet new overall sector demand. In the table below we include our overall estimates of water demand for the manufacturing sector. These estimates suggest an allowance for increased water demand over the period by the manufacturing sector of nearly 64 Ml/d by 2050, even taking account of potential closures and greater water efficiency. Before taking account of the reduction in water intensity over the forecast horizon, the projections assume a net growth in water demand and implied strategic reserve for the manufacturing sector of 92.7 Ml/d by 2050.

**Table 6.5: Strategic Reserve for Growth in the Manufacturing Sector**

| Description | Units | 2011 | 2016 | 2021 | 2026 | 2031 | 2041 | 2046 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Forecast Demand in the Manufacturing Sector | Ml/d | 35.1 | 39.6 | 48.1 | 54.1 | 61.3 | 80.2 | 90.0 | 99.1 |
| Forecast Demand in the Manufacturing Sector - Excluding Improvements in Water Efficiency | Ml/d | 35.1 | 41.5 | 52.5 | 61.4 | 71.9 | 99.6 | 114.3 | 127.8 |
| Net Growth in Manufacturing Demand | Ml/d | | 4.5 | 12.9 | 19.0 | 26.1 | 45.1 | 54.8 | 63.9 |
| Net Growth in Manufacturing Demand - Excluding Improvements in Water Efficiency | Ml/d | | 6.3 | 17.3 | 26.3 | 36.8 | 64.4 | 79.2 | 92.7 |

Source: Indecon Economists

International evidence supports the assumption that water is important for non-residential sectors. Of particular interest to the Irish experience is the documented importance of reliable water supply in computer equipment (semi-conductor) chemicals and pharmaceuticals and agriculture and food and beverages sectors. Those sectors which are both dependent on water-supply for production and which export a significant proportion of total output are of particular importance in this context. Indecon Economists believe that this highlights the relevance of tailoring water demand modelling to the characteristics of a small open economy. It is, therefore, important that all regions have access to a reliable and sustainable water supply. An unreliable water supply would have significant economic costs. Interruptions in supply or intermittent falls in water quality have the potential to interrupt business for those firms already operating while simultaneously discouraging similar firms from setting up in Ireland.

The analysis indicates that there is a high economic cost of water interruptions and that having adequate supply is a key requirement for continued economic progress. The existing capacity will not be sufficient to meet the strategic need for water in the Dublin and Eastern region.

Indecon Economists believe there will be a requirement for increased water demand to accommodate the expansion plans of a number of major existing large industrial users. We believe this could involve an increased demand of between 30 to 50 Ml/d. There may be potential to reduce water intensity over time but this will depend on the timing of new projects and technological advances.

Indecon Economists believe that Irish Water should ensure sufficient capacity to accommodate the supply needs not only of manufacturing sector but of the entirety of the non-residential sector. In our base case estimates we are assuming that even after efficiencies in water intensity are taken into account, there will be a need for an increase in water demand by the non-residential sector of over 38 Ml/d by 2026 and indeed our base case scenario assumes this will increase to 110 Ml/d by 2050. This takes account of the impact of sectoral shifts in demand and, as noted previously, also takes account of an assumed reduction in water intensity. In our high demand scenario our estimates assume a higher level of water demand for the non-residential users of over 40 Ml/d by 2026 and over 140 Ml/d by 2050. This takes account not only of the likely increased demand by existing or new large users, but also the need to accommodate the expected demand increases of other non-residential users, consistent with our assumptions for economic growth.

There is merit from an infrastructural planning perspective in seeking permission for abstraction levels of sufficient levels to ensure sufficient supply to accommodate a higher demand scenario. The significant economic costs of water supply disruption indicated by our research (see Section 5) supports the case for accommodation of higher demand scenario than in our base case. While there is uncertainty regarding whether such high demand scenario will be realised, it is based on a credible possible outcome for the Irish economy.

Indecon Economists as part of our demand assessment has considered however the balance the costs and benefits of likely under and over provisions of infrastructure. This will be assessed in more detail in a subsequent report but we have been informed by Jacob-Tobin on some of the technical options which may be available. Based on this we believe a number of issues are relevant as follows. The risks and delays in the planning process are such that a prudent utility, in strategic planning, would seek abstraction permission for a demand scenario higher than the base case projections but one which is of reasonable likelihood, having regard to its statutory obligation. That would allow a prompt response to actual emerging demand. A Water Treatment Plant could typically be sited on acquired land of sufficient size to eventually accommodate at least a High Demand scenario. However to avoid unnecessary costs treatment capacity should be modularly increased over time, from a Phase 1 position, in response to developing demand. Tankage and filters could be added, on a preplanned layout, only as required. With Pumping Stations, the practice should be to construct the Phase 1 civil works with adequate space internally to add more mechanical units as actual demand grows. With a cross country pipeline, which has a life in excess of 75 years, and which is required to cross rail, canal, river, and motorway, in rock, peat and other ground of varying degrees of difficulty, the practice should be to construct that pipeline, not only for the High Demand scenario, with prudent regard, in the choice of its diameter, to the capacity it will need over its effective working life. This is because the cost of a constructed pipeline, in the diameters, is not greatly sensitive to the inclusion of the next diameter increment, from say 1200 mm to 1300mm. The risks of having to go back later and lay another pipeline, close to the existing, but now-operational pipeline, are very significant.

These considerations should apply in the evaluation of Specific Options subsequently by Irish Water. In summary, infrastructural planning should be a mix of the modularly expandable but seeking permissions for higher demand scenarios.

Increasing water demand in Ireland has been met within a very narrow 'supply-demand balance' operational regime, and there is very limited spare capacity in the existing supply system. Establishment of a new long-term water supply source for the Region is recognised as a long-term infrastructure project that could take up to 10 years to fully realise. It is thus vitally important for the security of water supply in the region that long-term planning is commenced now. This is further highlighted by the limited potential to abstract further water from existing sources in the region. A short-term reprieve to the water supply network is likely to occur due to increased water conservation, but the evidence suggests this is not likely to eliminate the need for an expansion of supply over the medium- to long term as presented in this report.

It is also important to consider the opportunity cost of resources when examining the merits of large investment decisions to expand water infrastructure, as well as the opportunity cost of leakage repairs. This latter factor represents a key issue in calculating the optimum or economic level of leakage in the water supply system. Repairing certain types of leakage in the water supply whereby the costs of addressing the leakage is low compared to alternative investments costs may have high economic returns. Addressing customer side leakages and a 'first fix' policy could be important in this context.

There is merit from an infrastructural planning perspective in seeking permission for sufficient abstraction levels to ensure adequate supply to accommodate foreseeable demand. The significant economic costs of water supply disruption indicated by our research supports the case for accommodation of a higher demand scenario than in our base case. While there is uncertainty regarding whether such high demand scenario will be realised, it is based on a credible possible outcome for the Irish economy. Indecon Economists would, however, recommend that investment in treatment capacity should be planned on a modular basis and increased over time based on emerging requirements so as to minimise investment expenditures.

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# Annex 1 Econometric Analysis of Water Intensity

## A1.1 Introduction

The scenarios presented elsewhere in this report are predicated on a number of assumptions regarding future trends of water use, economic growth and specifically water intensity in industry and commercial sectors. It is useful to examine international evidence over time to identify whether these assumptions are realistic and to consider alternative scenarios based on changes in these assumptions. This section therefore presents details of our empirical examination of these trends. Changes in water intensity over time are examined via the econometric estimation of a model of water intensity by sector using a variety of specifications, including sectoral output or production functions, as well as time trend regression analysis. The subsequent sections present the data considered, a description of the models estimated and the results of the models.

## A1.2 Data

The primary dataset utilised to estimate the models was obtained from the World Input Output Database (WIOD). Various data is available from this database, notably water use by sector in the Environmental Accounts. Water use data is divided into blue water (consumption of ground and surface water), green water (rainwater used mainly in the agricultural sector) and grey water (water required to assimilate pollutants so as to meet water quality standards).[38] Blue water was identified as the variable of interest in our study.

Blue water use was available for 40 countries in the database, including the EU 27 countries and Australia, Canada, Russia and the USA.[39] It should be noted that water use data was not available for every sector, but rather was specifically available for:

- Agriculture, Hunting, Forestry and Fishing;
- Food, Beverages and Tobacco;
- Textiles and Textile;
- Pulp, Paper, Printing and Publishing;
- Chemicals and Chemical;
- Other Non-Metallic Mineral;
- Basic Metals and Fabricated Metal;
- Electricity, Gas and Water Supply;
- Education; and
- Health and Social Work.

Data on blue water use by households was also available.

[38] Genty, A., Arto, I. and Neuwahl, F. (April 2012). *Final Database of Environmental Satellite Accounts: Technical Report on Their Compilation.* WIOD Deliverable 4.6, Documentation.

[39] Please see Annex for a complete list of the countries for which data was available in the WIOD dataset.

It is useful to consider changes in water use over time, and specifically, changes in water intensity. It was thus necessary to gather variables such as output, labour, capital etc. in order to estimate a model using the production function approach. These variables were also obtained from the World Input Output Database, in the Socioeconomic Accounts.

## A1.3 Model Specifications

The most common and general economic methodology for measuring the effect of an input on output is the neoclassical producer approach as developed over a period of several decades by Dale W. Jorgenson and numerous co-authors and contributors, including Solow, Griliches, Hall, Christensen and Lau. The framework and methodology provide a unified approach and way of thinking about, and thus modelling, producer behaviour in general, and the impacts of certain input variables. The approach was applied to a variety of sectors using US data to calculate aggregate TFP rates by Jorgenson, Gollop, and Fraumeni (1987)[40], Jorgenson and Gollop (1992)[41] and state-specific TFP rates by Ball et. al. (1999).[42]

The most basic model is the production function approach.

At the aggregate national level, the production function is:

$$1) \quad Y = F(L, K, T)$$

Where:

- Y is output
- L is labour input
- K is capital input
- T is a technology index or time.

At the sectoral level, we must allow for intermediate inputs or materials.

$$2) \quad y = f(l, k, m, T)$$

Where y is now gross sectoral output.

The model can be specified as an income and/or growth accounting relationship, or relationships between variables can be estimated using econometric techniques.

The dual or 'cost function' approach can also be applied, and this approach is generally used when scale or scope economies are assumed or estimated.

[40] Dale W. Jorgenson, Frank M. Gollop, and Barbara M. Fraumeni (1987), Productivity and U.S. Economic Growth, Cambridge, Harvard University Press

[41] Jorgenson, Dale W. and Frank M. Gollop, *American Journal of Agricultural Economics,* Vol. 74, No. 3 (Aug., 1992), pp. 745-750

[42] V. Eldon Ball and Frank M. Gollop and Alison Kelly-Hawke and Gregory P. Swinand, 1999. "Patterns of State Productivity Growth in the U.S. Farm Sector: Linking State and Aggregate Models," *American Journal of Agricultural Economics*, vol. 81(1), pages 164-179.

The method is flexible enough to accommodate different assumptions. We can for example additionally assume that the impact of water usage on output is separable and that we can thus include water use as an additional RHS input variable for the purposes of estimating the production function. The equation to be estimated is then of the following form:

$$3)\quad y = f(l, k, m, w, T)$$

Where *w* is sectoral water usage.

With micro-data, the econometric approach might be utilised. The method is simply to measure the different impacts of water inputs, after specifying a functional form. A common form is the so-called Cobb-Douglas form (which may impose constant returns to scale, if the sum of the slope coefficients is equal to 1, although this can be relaxed). In this scenario, the equation to be estimated is thus:

$$4)\quad lny_i = \alpha + \beta_l lnl_i + \beta_k lnk_i + \beta_m lnm_i + \beta_w lnw_i + \beta_t t$$

For sector i.

The specification of various measures such as water intensity can be calculated directly from the parameter estimates above. Under certain assumptions, such as constant returns, water intensity could be the dependent variable; rearranging the above would give:

$$5)\quad ln\left(\frac{w_i}{y_i}\right) = a + \beta_k ln\left(\frac{k_i}{w_i}\right) + \beta_l ln\left(\frac{l_i}{w_i}\right) + \beta_m ln\left(\frac{m_i}{w_i}\right) + \beta_t t$$

Where now the water per unit of output is the dependent variable and the independent variables are capital per unit of water input, labour per unit of water input, and intermediate materials per unit of water input. This specification imposes the restriction of constant returns to scale.

A more general specification of the production function is given by the translog production function, which includes higher order terms and allows non-linearity of impact by input – in this way, interactions between inputs such as capital and labour are included and additionally the impact of input variables is allowed to change as the magnitude of the input changes. This latter effect is derived by including a squared term for each of the input variables. The standard translog equation with four input variables can thus be stated as:

$$6)\quad lnY = \beta_k lnK + \beta_L lnL + \beta_m lnM + \beta_w lnW + \beta_t t + \frac{\beta_{kk}}{2} lnK^2 + \frac{\beta_{LL}}{2} lnL^2 + \frac{\beta_{mm}}{2} lnM^2 + \frac{\beta_{ww}}{2} lnW^2 + \frac{\beta_{tt}}{2} t^2 + \beta_{kl} lnKlnL + \beta_{km} lnKlnM + \beta_{kw} lnKlnW + \beta_{kt} lnKt + \beta_{lm} lnLlnM + \beta_{lw} lnLlnW + \beta_{lt} lnLt + \beta_{mw} lnMlnW + \beta_{mt} lnMt + \beta_{wt} lnWt$$

Assuming constant returns to scale, the translog function can then be rearranged to give:

7) $lnW - lnY =$
$\beta_k(lnK - lnW) + \beta_L(lnL - lnW) + \beta_m(lnM - lnW) + \beta_t t + \beta_{kk}(\frac{1}{2}lnK^2 - lnKlnW) + \beta_{LL}\left(\frac{1}{2}\ lnL^2 - lnLlnW\right) + \beta_{mm}\left(\frac{1}{2}\ lnM^2 - lnMlnW\right) - lnW^2(\frac{1}{2}\beta_{ww} + \beta_{kw} + \beta_{lw} + \beta_{mw}) + \frac{\beta_{tt}t^2}{2} + \beta_{kl}(lnKlnL - lnKlnW - lnLlnW) + \beta_{km}(lnKlnM - lnKlnW - lnMlnW) + \beta_{kt}(lnKt - lnWt) + \beta_{lm}(lnLlnM - lnLlnW - lnMlnW) + \beta_{lt}(lnLt - lnWt) + \beta_{mt}(lnMt - lnWt)$

***Estimation of Model***

We estimate the above models in a panel data framework with two identifier variables, country and sector. This allows for various approaches to the estimation of the model.

It is first possible to consider a setting in which each country/sector pairing is a separate identifier when estimating – this gives 400 separate groups to consider over time. Another way to proceed is to consider that there might be certain country and sector specific effects interacting simultaneously. We can estimate this using a mixed model, which allows for the consideration of specific fixed and random effects.

## A1.4 Results

We are specifically interested in the impact of time on water intensity, i.e., we are interested in the coefficient $\beta_t$ from the Cobb Douglas production function outlined previously in Equation 5.

As our data on economic growth and the water sector in Ireland exists at a certain level of aggregation, we aggregated our results to reflect the sectoral aggregates available in our data. We thus combine the sectors into the following four categories: Agriculture, Hunting, Forestry and Fishing; Manufacturing; Utilities; Education and Health. The results from the estimation of the Cobb-Douglas production function with constant returns to scale are provided in the table below. The overall predicted annual change in water intensity across the sectors considered is -2.8%. The coefficient on time is negative for each sector, which indicates that water intensity is falling over time. It would therefore seem prudent to include a measure of this likely future decline in water intensity in any scenarios for future water demand. In addition, the decline in water intensity is of a higher magnitude for the services sectors of education and health and social work than for the agricultural and industrial sectors examined.

| Predicted Annual Change in Water Intensity by Sector, Cobb Douglas Production Function | |
|---|---|
| Agriculture, Hunting, Forestry and Fishing | -1.03% |
| Manufacturing | -2.55% |
| Utilities | -4.05% |
| Health and Education | -3.57% |
| **Total** | **-2.81%** |
| **Source: Indecon Economists analysis of WIOD data** | |

We now examine the results from the estimation of the generalised translog function, once more assuming constant returns to scale.

As outlined previously, we are interested in the coefficient on the time trend included in the equation to be estimated. We are therefore interested in derivative of Equation 7) with respect to time, or:

$$8)\quad \frac{\partial(lnW-lnY)}{\partial t} = \beta_t + \beta_{tt}t + \beta_{kt}(lnK - lnW) + \beta_{lt}(lnL - lnW) + \beta_{mt}(lnM - lnW)$$

It is clear that the derivative with respect to time changes depending on time and also capital, water use, labour and intermediate inputs. In order to derive a point estimate of the impact of time on water intensity, it is therefore necessary to examine the data at a particular point. We examine the impact of time on water intensity using the average values for each of the inputs in order to determine the impact of time on water intensity at the means. We also consider the average for countries in the same size class as Ireland, defined as countries with a similar level of gross output to Ireland in the most recent available year, namely 2011. This size class is thus comprised of Ireland, Denmark, Czech Republic, Finland, Greece, Portugal, Romania and Hungary. An overall average for each variable across these countries is considered in addition to a sector-specific average across these countries.

It is instructive to consider the predicted annual change in water intensity for aggregate sector categories. The results are not sensitive to the choice of average.

| Predicted Annual Change in Water Intensity by Sector, Translog Production Function | | | |
|---|---|---|---|
| | **Average across all countries and sectors** | **Average across select countries and all sectors** | **Average across select countries for each sector** |
| Agriculture, Hunting, Forestry and Fishing | -1.82% | -1.80% | -1.02%** |
| Manufacturing | -2.03%*** | -2.08%*** | -2.53%*** |
| Utilities | -4.78%*** | -5.03%*** | -4.93%*** |
| Health and Education | -1.58% | -1.50% | -4.94%*** |
| **Total** | -2.92%*** | -2.86%*** | -2.86%*** |
| **Source: Indecon Economists analysis of WIOD data** | | | |

Finally, we considered the results from an alternative transformation of the translog production function, the demeaned translog production function. In this specification, the observations were centred on the mean observation by subtracting the mean of the particular variable from the observation. The benefit of this to the estimation is that the first order coefficients form the estimates of the elasticity at the means. The impact of time on water intensity thus becomes:

$$9)\quad \frac{\partial((lnW-ln\overline{W})-(lnY-ln\overline{Y}))}{\partial t} = \beta_t + \beta_{tt}t + \beta_{kt}((lnK - ln\overline{K}) - (lnW - ln\overline{W})) + \beta_{lt}((lnL - ln\overline{L}) - (lnW - ln\overline{W})) + \beta_{mt}\big((lnM - ln\overline{M}) - (lnW - ln\overline{W})\big)$$

Where $\overline{X}$ denotes the mean of $X$.

It is thus clear that when Equation 9 above is evaluated at the means, many of the terms are equal to zero. The impact of time on water intensity when estimated at the means for the demeaned translog production function can thus be expressed as:

$$10)\quad \frac{\partial((lnW-ln\overline{W})-(lnY-ln\overline{Y}))}{\partial t} = \beta_t + \beta_{tt}\overline{t}$$

The results from this estimation should, by construction, be very similar to those obtained when estimating the simple translog production function described previously.

Estimates of the demeaned translog production function for aggregated sectors are provided in the table below. As above, the estimates are broadly similar to those derived from estimation of the simple translog production function evaluated at the means. The overall estimate of the annual predicted change in water intensity is lower, at -1.25%.

| **Predicted Annual Change in Water Intensity by Sector, Demeaned Translog Production Function** | |
|---|---|
| Agriculture, Hunting, Forestry and Fishing | -0.70%* |
| Manufacturing | -2.39%*** |
| Utilities | -4.47%*** |
| Health and Education | -3.96%*** |
| **Total** | **-1.25%*** ** |
| **Source: Indecon Economists analysis of WIOD data** | |

## A1.5 Additional modelling using alternative datasets

As the WIOD is just one source of data on water use with some limitations (the water use data did not include more disaggregated sectoral information, for example) and other sources from official data agencies exist, we also undertook additional modelling on water intensity using separate sectoral datasets. This entailed utilisation of data published by Eurostat and a separate dataset published by Statistics Denmark. This was designed to facilitate modelling of different sectors not available in the WIOD dataset, while also providing a cross-check on the findings of the WIOD-based modelling.

### A1.5.1 Modelling based on Eurostat dataset

Data on water use by sectors is obtained for a number of European countries from Eurostat. This data was combined with output, value added and intermediate consumption volume indices from WIOD database, in addition to measures of capital and labour. We then estimated production function-based models of water intensity by sector using OLS and Panel data techniques.

We began our analysis with the simple regression of water intensity on time, for each sector. The following table considers a simple regression of water intensity (defined as use of water from public supply divided by an output volume index based at 1995) against time. The coefficients can be interpreted in a similar way to that described above.

**OLS Regression Results by Sector**

| Sector | Coefficient | Standard Error | t statistic | P-value | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | LL | UL |
| Manufacture of food products and beverages | -0.032 | 0.008 | -4.18 | 0 | -0.05 | -0.02 |
| Manufacture of textiles, wearing apparel, leather and related products | -0.080 | 0.017 | -4.72 | 0 | -0.11 | -0.05 |
| Manufacture of paper and paper products | -0.044 | 0.008 | -5.22 | 0 | -0.06 | -0.03 |
| Manufacture of coke and refined petroleum product; chemicals and chemical products; basic pharmaceutical products and pharmaceutical preparations | -0.096 | 0.012 | -7.92 | 0 | -0.12 | -0.07 |
| Manufacture of basic metals | -0.042 | 0.015 | -2.76 | 0.007 | -0.07 | -0.01 |
| Manufacture of motor vehicles, trailers, semi-trailers and of other transport equipment | -0.115 | 0.013 | -9.13 | 0 | -0.14 | -0.09 |
| Agriculture, forestry and fishing | -0.076 | 0.020 | -3.88 | 0 | -0.11 | -0.04 |
| Mining and quarrying | -0.030 | 0.011 | -2.68 | 0.009 | -0.05 | -0.01 |
| Production and distribution of electricity | -0.074 | 0.011 | -6.82 | 0 | -0.10 | -0.05 |
| Construction | -0.049 | 0.018 | -2.71 | 0.009 | -0.08 | -0.01 |
| Services | -0.069 | 0.008 | -9.22 | 0 | -0.08 | -0.05 |
| Other manufacturing (C15, C23, C27, C31, C32, C33) | -0.107 | 0.010 | -11.16 | 0 | -0.13 | -0.09 |

**Source: Indecon Economists analysis of Eurostat and WIOD**

We next estimated a production function-based model to estimate water intensity using fixed effects, where the group variable is a country and sector-specific identifier.

| Fixed Effects Production Function Results | |
|---|---|
| | lnw_q |
| lnk | 0.295** |
| | 2.05 |
| lnl | 0.352** |
| | 2.38 |
| lnm | -0.794*** |
| | -11.08 |
| t | -0.0475*** |
| | -7.21 |
| constant | -2.954*** |
| | -2.68 |
| N | 1054 |

**Source: Indecon Economists analysis of Eurostat and WIOD SEA data**
Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

However, fixed effects does not fully capture the dynamics between countries and sectors in this instance and it is thus may be preferable to consider a mixed model.

| Mixed Model Production Function Results | |
|---|---|
| | lnw_q |
| lnk | 0.087** |
| | 2.19 |
| lnl | 0.407*** |
| | 6.02 |
| lnm | -0.806*** |
| | -12.53 |
| t | -0.0399*** |
| | -6.1 |
| constant | -1.654*** |
| | -3.52 |
| N | 1054 |

**Source: Indecon Economists analysis of Eurostat and WIOD SEA data**
Note: z statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

Finally, we considered a value added production function, which removes intermediate inputs from output prior to calculating water intensity. We also assume constant returns to scale.

| Mixed Model Value Added Production Function Results | |
|---|---|
| | lnw_va |
| lnk_lnw | -0.266*** |
| | -7.38 |
| lnl_lnw | -0.681*** |
| | -18.56 |
| t | -0.0229*** |
| | -3.59 |
| constant | 1.586*** |
| | 4.63 |
| N | 1054 |

**Source: Indecon Economists analysis of Eurostat and WIOD SEA data**
Note: z statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

It is also instructive to consider the implications of an estimation of the value added production function for certain aggregated sectors.

| Mixed Model Value Added Production Function by Sector | |
|---|---|
| Agriculture, forestry and fishing | 0.0080 |
| Manufacturing | -0.0337*** |
| Production and distribution of electricity | -0.0447*** |
| Services | -0.0247*** |
| Total | -0.0229*** |

**Source: Indecon Economists analysis of Eurostat and WIOD SEA data**
Note: * p<0.10 ** p<0.005 ***p<0.01

### A1.5.2 Modelling based on Statistics Denmark dataset

We also considered an econometric analysis using the data on sectoral patterns in Denmark. This examined changes in water intensity over time and additionally considered a production function approach which captured the impacts of capital and labour on changes in output. The usefulness of the Denmark data is consistent and more detailed disaggregated sectoral data and water use data was available, for a broadly similar European country comparator for Ireland.

The data utilised was obtained from Statistics Denmark. Water use is defined as final consumption of water by sector and is available from 1995 to 2005. Data on sectoral output, intermediate consumption and capital is obtained at 2000 prices for this period and hours worked by persons engaged by sector is also included. Water intensity is constructed by dividing water use by output at 2000 prices.

We first considered separate regressions of water intensity on time using OLS by sector. The results from these regressions (i.e. the coefficients on time obtained in the regression) are presented in the table below. A coefficient of -0.039 on wholesale and retail trade, hotels and restaurants means that water intensity is predicted to fall by 3.9% annually in this sector.

| OLS Regression Results by Sector | | | | | | |
|---|---|---|---|---|---|---|
| Sector | Coefficient | Standard Error | T statistic | P value | 95% Confidence Interval | |
| | | | | | LL | UL |
| **Agriculture, fishing and quarrying** | **-0.102** | **0.02** | **-5.22** | **0.001** | **-0.147** | **-0.058** |
| Agriculture, horticulture and forestry | -0.088 | 0.02 | -3.92 | 0.004 | -0.139 | -0.037 |
| Fishing | -0.040 | 0.05 | -0.76 | 0.468 | -0.160 | 0.080 |
| Mining and quarrying | -0.125 | 0.02 | -6.82 | 0 | -0.166 | -0.083 |
| **Manufacturing** | **-0.044** | **0.01** | **-6.11** | **0** | **-0.061** | **-0.028** |
| Mfr. of food, beverages and tobacco | -0.031 | 0.01 | -4.18 | 0.002 | -0.048 | -0.014 |
| Mfr. of textiles and leather | -0.005 | 0.02 | -0.25 | 0.805 | -0.047 | 0.038 |
| Mfr. of wood products, printing and publ. | -0.061 | 0.02 | -3.12 | 0.012 | -0.106 | -0.017 |
| Mfr. of chemicals and plastic products | -0.029 | 0.01 | -3.44 | 0.007 | -0.047 | -0.010 |
| Mfr. of other non-metallic mineral products | -0.037 | 0.02 | -2.3 | 0.047 | -0.074 | -0.001 |
| Mfr. of basic metals and fabr. metal prod. | -0.087 | 0.02 | -5.58 | 0 | -0.122 | -0.051 |
| Mfr. of furniture; manufacturing n.e.c. | -0.145 | 0.02 | -7.17 | 0 | -0.190 | -0.099 |
| **Electricity, gas and water supply** | **-0.043** | **0.01** | **-4.04** | **0.003** | **-0.066** | **-0.019** |
| **Construction** | **-0.112** | **0.09** | **-1.29** | **0.231** | **-0.308** | **0.085** |
| **Ws. and retail trade; hotels, restaurants** | **-0.039** | **0.00** | **-9.23** | **0** | **-0.048** | **-0.029** |
| Sale and repair of motor vehicles sale of auto. fuel | -0.027 | 0.01 | -2.52 | 0.033 | -0.051 | -0.003 |
| Wholesale except of motor vehicles | -0.048 | 0.01 | -5.96 | 0 | -0.066 | -0.030 |
| Re. trade and repair work exc. of m. vehicles | -0.045 | 0.01 | -7.95 | 0 | -0.058 | -0.032 |
| Hotels and restaurants | -0.020 | 0.01 | -2.96 | 0.016 | -0.035 | -0.005 |
| **Transport, post and telecomm.** | **-0.097** | **0.01** | **-11.13** | **0** | **-0.117** | **-0.078** |
| Transport | -0.088 | 0.01 | -8.81 | 0 | -0.110 | -0.065 |
| Post and telecommunications | -0.087 | 0.02 | -5.53 | 0 | -0.122 | -0.051 |
| **Finance and business activities** | **-0.042** | **0.00** | **-10.74** | **0** | **-0.050** | **-0.033** |
| Finance and insurance | -0.089 | 0.01 | -9.9 | 0 | -0.110 | -0.069 |
| Letting and sale of real estate | -0.013 | 0.01 | -2.27 | 0.049 | -0.025 | 0.000 |
| Business activities | -0.057 | 0.01 | -6.75 | 0 | -0.076 | -0.038 |
| **Public and personal services** | **-0.040** | **0.00** | **-12.92** | **0** | **-0.047** | **-0.033** |
| Public administration | -0.048 | 0.03 | -1.81 | 0.104 | -0.108 | 0.012 |
| Education | -0.042 | 0.00 | -17.41 | 0 | -0.048 | -0.037 |
| Human health activities | -0.050 | 0.00 | -20.44 | 0 | -0.056 | -0.045 |
| Social institutions etc. | -0.026 | 0.00 | -6.88 | 0 | -0.035 | -0.017 |
| Associations, culture and refuse disposal | -0.047 | 0.00 | -11.47 | 0 | -0.056 | -0.038 |
| **Source: Indecon Economists analysis of Statistics Denmark** | | | | | | |

Water intensity is also likely to be impacted by changes in capital and labour due to the relationship between capital and labour outlined in the production function. For this reason we consider a production function approach for the overall sample using fixed effects. The results of this regression are provided in the table below. The coefficient on time is the coefficient of interest and an annual fall in water intensity of 3.75% is predicted across sectors.

**Fixed Effects Production Function Results**

| | lnw_q |
|---|---|
| lnk | -1.256*** |
| | (-4.37) |
| lnl | 0.432** |
| | (2.42) |
| t | -0.0375*** |
| | (-6.10) |
| constant | 14.684*** |
| | (5.1) |
| N | 352 |

**Source: Indecon Economists analysis of Statistics Denmark**
Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

We also considered the impact of intermediate inputs in the production function approach. Including intermediate inputs as an explanatory variable gives the following results. The predicted impact of time in this specification was a -3.3% annual decrease in water intensity, controlling for other influences.

**Fixed Effects Production Function with Intermediate Inputs Results**

| | lnw_q |
|---|---|
| lnk | -1.095*** |
| | (-3.57) |
| lnl | 0.579*** |
| | (2.85) |
| lnm | -0.232 |
| | (-1.49) |
| t | -0.0329*** |
| | (-4.79) |
| constant | 13.406*** |
| | (4.47) |
| N | 352 |

**Source: Indecon Economists analysis of Statistics Denmark**
Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

This was accomplished by removing intermediate inputs from output prior to creating the water intensity and then imposing constant returns to scale – creating a "value added" production function. The results of this estimation, calculated using fixed effects, are presented in the table below. Water intensity is predicted to decrease by 1% annually across all sectors when accounting for capital, labour and intermediate inputs.

| Fixed Effects Value Added Production Function Results | |
|---|---|
| | lnw_qva |
| lnk_lnw | -0.491*** |
| | (-7.42) |
| lnl_lnw | -0.481*** |
| | (-6.94) |
| t | -0.0090*** |
| | (-4.53) |
| constant | 1.350*** |
| | (22.8) |
| N | 352 |

**Source: Indecon Economists analysis of Statistics Denmark**
Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

## A1.5.3 Eurostat and Denmark Data comparison

The following figure considers the results for the broadly similar sectors included in both the Denmark and Eurostat datasets. The Denmark data is considered separately by sector in an OLS regression framework. For the Eurostat data we take account of the panel nature of the data by running separate regressions by sector, including country-specific fixed effects. The equation estimated is the following:

$$lnw - lnq = \alpha + \beta t$$

| OLS Regression Results by Sector – Denmark Eurostat Comparison | | |
|---|---|---|
| | **Denmark data OLS** | **Eurostat data, by Sector with Country Fixed Effects** |
| Manufacture of food products and beverages | -0.031*** | -0.032*** |
| Manufacture of textiles, wearing apparel, leather and related products | -0.005 | -0.080*** |
| Manufacture of paper and paper products | -0.061** | -0.044*** |
| Manufacture of coke and refined petroleum product; chemicals and chemical products; basic pharmaceutical products and pharmaceutical preparations | -0.029*** | -0.096*** |
| Manufacture of basic metals | -0.087*** | -0.042*** |
| Agriculture, forestry and fishing | -0.064** | -0.076*** |
| Mining and quarrying | -0.125*** | -0.030*** |
| Production and distribution of electricity | -0.043*** | -0.074*** |
| Construction | -0.112 | -0.049*** |
| Services | -0.050*** | -0.069*** |
| Manufacturing Total | -0.044*** | -0.073*** |
| **Source: Indecon Economists analysis of Statistics Denmark, Eurostat and WIOD** | | |

We now consider a production function form for the estimation, with capital and labour included as explanatory variables. The Denmark results are calculated using industry fixed effects, while for Eurostat fixed effects for country/industry.

The equation to be estimated is the following:

$$lnw - lnq = \alpha + \beta_k lnk + \beta_l lnl + \beta_t t$$

| Production Function Results – Denmark Eurostat Comparison | | |
|---|---|---|
| | **Denmark data**<br>**Fixed effects** | **Eurostat data**<br>**Fixed effects** |
| lnk | -1.256*** | -0.152 |
| | (-4.37) | (-1.03) |
| lnl | 0.432** | -0.166 |
| | (2.42) | (-1.11) |
| t | -0.0375*** | -0.0659*** |
| | (-6.10) | (-9.71) |
| constant | 14.684*** | 0.179 |
| | (5.1) | (0.16) |
| N | 352 | 1054 |
| **Source: Indecon Economists analysis of Statistics Denmark, Eurostat and WIOD**<br>Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01 | | |

Model including intermediate inputs:

$$lnw - lnq = \alpha + \beta_k lnk + \beta_l lnl + \beta_m lnm + \beta_t t$$

| Fixed Effects Production Function with Intermediate Inputs Results – Denmark and Eurostat Comparison | | |
|---|---|---|
| | **Denmark**<br>**Fixed effects** | **Eurostat**<br>**Fixed effects** |
| lnk | -1.095*** | 0.295** |
| | (-3.57) | (2.05) |
| lnl | 0.579*** | 0.352** |
| | (2.85) | (2.38) |
| lnm | -0.232 | -0.794*** |
| | (-1.49) | (-11.08) |
| t | -0.0329*** | -0.0475*** |
| | (-4.79) | (-7.21) |
| constant | 13.406*** | -2.954*** |
| | (4.47) | (-2.68) |
| N | 352 | 1054 |
| **Source: Indecon Economists analysis of Statistics Denmark, Eurostat and WIOD**<br>Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01 | | |

Next we considered a value added production function, estimated using fixed effects. We also imposed constant returns to scale, as per:

$$lnw - lnva = \alpha + \beta_k(lnk - lnw) + \beta_l(lnl - lnw) + \beta_t t$$

The results of this model estimation are presented below.

| Fixed Effects Value Added Production Function Results | | |
|---|---|---|
| | **Denmark<br>Fixed effects** | **Eurostat<br>Fixed Effects** |
| lnk_lnw | -0.491*** | -0.439*** |
| | (-7.42) | (-9.14) |
| lnl_lnw | -0.481*** | -0.523*** |
| | (-6.94) | (-10.88) |
| t | -0.0090*** | -0.0162*** |
| | (-4.53) | (-6.41) |
| constant | 1.350*** | 2.184*** |
| | (22.8) | (13.68) |
| N | 352 | 1054 |

**Source: Indecon Economists analysis of Statistics Denmark, Eurostat and WIOD**
Note: t statistics in parentheses. * p<0.10 ** p<0.005 ***p<0.01

UISCE
ÉIREANN : IRISH
WATER