

Economic Case Appendix

Only Rainwater into Windermere

October 2026



Economic Case Appendices

Client name:

Project name:

Client reference:

Document no:

Revision:

Date:

Document status:

United Utilities

Only Rainwater into Windermere

ORiW

ORIW-JMM-BC-ALL-PRE-BC-87_Economic_Case_Appendix

Phase 2 Final

09 October 2026

Phase 2 Final

Project no:

Project manager:

Prepared by:

File name:

ORIW-JMM-BC-ALL-PRE-BC-87_Economic_Case_Appendix

Document history and status

Revision	Date	Description	Author	Checked	Reviewed	Approved	Verify
1	July 2026	First Draft					
2	October 2026	Phase 2 Final					

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Purpose of this document

This document provides the supporting evidence, methodologies, assumptions and detailed analysis underpinning the Economic Case for the Only Rainwater into Windermere (ORiW) programme. It supplements the Economic Case by providing a transparent and auditable record of the analytical approaches used to assess the costs, benefits, distributional impacts and deliverability considerations associated with the shortlisted options.

The appendices are structured around the four pillars of the appraisal framework. The four pillars organise the appraisal so that the factors which differentiate the options, over and above headline costs and benefits, are made explicit and considered consistently. Each pillar draws on established Green Book principles and supplementary guidance (HM Treasury, 2026).

- **Appendix A (Pillar 1 – Environment and social value)** sets out the methodology used to assess environmental, social and economic impacts and benefits. This excludes the amenity assessment methodology, which is the largest benefit category and covered in Appendix E.
- **Appendix B (Pillar 2 – Whole-life cost)** details the development of capital, operational and whole-life cost estimates.
- **Appendix C (Pillar 3 – Distributional and place-based effects)** presents the methodology used to assess distributional and place-based impacts.
- **Appendix D (Pillar 4 – Risk, resilience and deliverability)** outlines the sources of evidence supporting the delivery confidence and implementation assessment.
- **Appendix E (Pillar 1 – Amenity assessment methodology)** describes the amenity valuation approach, including the application of willingness-to-pay evidence and value transfer techniques.
- **Appendix F (Value transfer literature review)** summarises the wider literature reviewed to inform the appraisal.

Together, these appendices provide the technical evidence base supporting the Economic Case and provide justification that the conclusions are transparent, proportionate and consistent with HM Treasury Green Book (HM Treasury, 2026) principles and wider best practice guidance.

The appendices have been prepared to:

- Provide a clear audit trail for the methodologies, assumptions and data sources used in the appraisal for the ORiW Economic Case.
- Support transparency and quality assurance of the economic, social, environmental and deliverability assessments.
- Document key uncertainties, evidence gaps and limitations appropriate to this stage of programme development.
- Enable future refinement and updating of the analysis as additional evidence becomes available through subsequent stages of project development.
- This document should be read alongside the overarching ORiW Business Case chapters, which present the key findings, option comparisons and recommendations derived from the evidence contained within these appendices.

1 Appendix A Pillar 1 methodology: Environmental and social value (excluding amenity)

This appendix sets out the methodology used to estimate the benefits and disbenefits associated with options for achieving the objectives of ORiW. This methodology does not consider the main benefit, which is Amenity, as this is set out in Appendix E.

1.1 Recreation and safety at other waterbodies

The study team has developed indicative water quality effects of the options at waterbodies other than the Windermere North and South basins, valued separately to the Windermere main amenity assessment. This analysis covers upstream waterbodies in the Windermere catchment and downstream receiving waters where the options remove, consolidate or relocate wastewater treatment works and storm overflow inputs.

Water Environment Benefits Survey (WEBS) values, which have been provided by the Environment Agency, but are yet unpublished, were applied by identifying where a step change in water quality category, or a prevention in deterioration is determined as plausible or likely. Detailed receiving waterbody modelling for each water body would be disproportionate at this stage, given the likely scale of impact, so the assessment uses first principles logic to establish the expected direction of water quality at each waterbody under each option. Three variables are assessed: whether direct inputs to that waterbody are removed; whether water quality improves at waterbodies upstream of it; and whether it receives a new or increased treated effluent input treated to a higher standard. Baseline status is taken from 2022 Water Framework Directive (WFD) ecological classification, used as a proxy for baseline WEBS status.

The combination of these three variables determines which outcome category applies at each waterbody: an improvement in status; prevention of deterioration through active intervention; no deterioration caused, being an incidental outcome that carries no WEBS value; or no material effect. Outcomes are assessed separately for each WEBS benefit dimension, since an option may move one dimension without moving the others. Values are applied per dimension for each waterbody where a status change is identified, scaled by waterbody length and profiled across the appraisal period at the Green Book discount rate.

Disbenefits. No option is assessed as causing a step change deterioration at any waterbody. Under the options that relocate the discharge, the receiving waterbody takes a higher load and flow than previously, offset by a higher treatment standard. The assessment does not credit a benefit at those waterbodies rather than recording a negative value, on the basis that the outcome is incidental non-deterioration rather than deterioration prevented. The net effect of relocation is therefore expressed as forgone benefit within this category, not as a disbenefit.

Sensitivities. Low and high cases are presented alongside the central estimate to reflect uncertainty in the assumed step change, the number and type of waterbodies affected, and the timing of benefit realisation.

Limitations. This is a screening-level assessment. It establishes the relative water quality performance of the options and the categories of WEBS value each supports and infers an applicable monetised value; it is not a substitute for detailed receiving waterbody modelling, and it does not directly assess changes in flow, dilution, or WFD status. Values are indicative and subject to confirmation through water quality modelling and/or expert assessment. Coastal and transitional waterbodies are included in the step change analysis but the applicability of WEBS values to those waterbody types is subject to specialist confirmation.

1.2 Carbon sequestration

1.2.1 Methodology

Carbon sequestration impacts have been assessed in accordance with Enabling a Natural Capital Approach (Defra, 2026) (ENCA) guidance and supporting ecosystem service valuation resources. The methodology for estimating carbon sequestration impacts identifies and quantifies the habitat types impacted by each shortlisted option. Impacts are differentiated by temporary and permanent impacts, with the assessment of temporary impacts assuming reinstatement after completion of construction. Existing baseline case habitats have been based on OS MasterMap (Ordnance Survey, 2025).

For each option, the areas of each habitat type within the option footprint are recorded in hectares. This is because different habitats can sequester different amounts of carbon from the atmosphere, and these

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differences are central to the carbon sequestration calculation. The extent of the option footprints was derived from the feasibility study design option corridors (Jacobs Mott MacDonald, 2026c).

Each habitat type is assigned a carbon sequestration rate, expressed in tonnes of carbon dioxide equivalent (tCO₂e) per hectare per year. These rates are taken from sources referenced in ENCA (Defra, 2026), including Carbon Storage and Sequestration by Habitat (Natural England, 2021) and Exploring the Economics of Land Use Change (Committee on Climate Change, 2021).

To estimate the annual carbon sequestration potential impacted by each option, the area of each impacted habitat is multiplied by its respective sequestration rate. The resulting total annual carbon sequestered is then monetised using the government's non-traded carbon values, which are published by the Department for Energy Security and Net Zero (DESNZ, 2023). The carbon price is provided in pounds per tonne of carbon dioxide and is adjusted for the relevant appraisal year (e.g., £318/tCO₂e in 2026, rising in future years). This method captures both negative impacts from habitat loss and any positive effect on carbon storage or sequestration arising from environmental enhancement measures, including green infrastructure where relevant.

The annual monetary value of carbon sequestration is then projected over the full appraisal period, 100 years. Discounting is applied using standard Green Book discount rates to calculate the present value of future benefits.

1.2.2 Uncertainty

The carbon sequestration assessment was based on GIS analysis using option construction corridors derived from the feasibility study (Jacobs Mott MacDonald, 2026c). The design status is high level and subject to change as the design develops. The carbon sequestration ecosystem service impact is therefore also subject to change as the design is developed.

To capture uncertainty in the total areas of land impacted, and on the pre-and post-construction condition of the habitats, the upper and lower DESNZ carbon prices (DESNZ, 2023) were applied as a sensitivity test. These range from £159 – £477/tCO₂e in 2025 and rise in line with DESNZ projections.

Table 1.1 shows the outcome of the sensitivity assessment for the lowest and highest impact options for carbon sequestration.

Table 1.1: Sensitivity assessment for carbon sequestration

	Low benefit estimate	Central estimate	High benefit estimate
Option with the smallest impact to carbon sequestration – Leven Rising Main	£3.9 million	£2.6 million	£1.3 million
Option with the greatest impact to carbon sequestration – Windermere Tunnel	£6.5 million	£4.4 million	£2.2 million

The assumptions set out below have been developed to align with the stated guidance as far as possible and are considered to be reasonable and proportionate given the level of site information and design detail available at the time of reporting and proportionate to the level of estimated impact relative to other more material impact category valuations presented in Table 2-1 of the Economic Case

An assumption has been applied that all impacts on lowland mixed deciduous woodland will be fully avoided, for example by directional drilling or by re-siting engineering elements, resulting in no loss of baseline habitat and carbon sequestration potential during or after construction. This aligns with the avoidance assumptions used within the biodiversity net gain (BNG) assessment.

1.3 Food production

1.3.1 Methodology

Food in its various forms is produced by a range of different natural capital assets (habitats). Habitats e.g. arable land provide food through provisioning services, can either be consumed directly or used as raw

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materials that are processed into food products. Food production impacts have been assessed in accordance with ENCA and supporting ecosystem service valuation resources. Existing baseline case habitats have been based on MasterMap (Ordnance Survey, 2025).

Impact to annual food production benefits is structured around assessing the area (ha) of habitats impacted under each option. The loss in cropping arable land has been assessed to estimate the loss of food provisioning services in the option footprints. Impacts are differentiated by temporary and permanent impacts, with the assessment of temporary impacts assuming reinstatement after completion of construction.

The monetary value of “Average annual farmland rent for general cropping” from the ENCA services databook (Defra, 2026) was applied and adjusted using GDP deflators to a consistent price reporting year of 2026 (£307.37/ha/yr, rising in future years). This monetary value was multiplied by the area of agricultural land impacted, expressed as pounds per hectare per year (£/ha/yr). This method captures both negative impacts from habitat loss and any positive effect on food production arising from environmental enhancement measures, including retaining habitats where relevant.

The annual monetary value of food production benefits is then projected over the full appraisal period of 100 years. Discounting is applied using standard government discount rates to calculate the present value of future benefits.

1.3.2 Uncertainty

The food provision assessment was based on GIS analysis using option construction corridors derived from the feasibility study (Jacobs Mott MacDonald, 2026c). The design status was high level and subject to change as the design develops. The food production ecosystem service impact is therefore also subject to change as the design is developed.

To capture uncertainty in the total areas of land impacted and the type of farmland, and on the pre-and post-construction condition of the habitats, the upper and lower general cropping values were applied as a sensitivity test; these range from £220.30 – £394.44/ha/year. Table 1.2 shows the outcome of the sensitivity assessment for the lowest and highest impact options for food provision.

Table 1.2: Sensitivity assessment for food provision

	Low benefit estimate	Central estimate	High benefit estimate
Option with the smallest impact to food provision – Ulverston Rising Main and Barrow Rising Main	-£4.0 million	-£3.3 million	-£1.7 million
Option with the greatest impact to food provision – Leven Tunnel	-£5.9 million	-£3.4 million	-£1.3 million

This method has been developed in line with the stated guidance as far as practicable and is reasonable and proportionate given the level of site information and design detail available at the time of reporting. It is also proportionate to the level of estimated impact relative to other more material impact category valuations presented in Table 2-1 of the Economic Case.

1.4 Flood risk

1.4.1 Methodology

Flooding related benefits have been assessed following the guidance detailed in the Flood and Coastal Erosion Risk Management - Handbook for Economic Appraisal (Flood Hazard Research Centre, 2026). The change in flood damages at properties are estimated to capture the impact of the interceptor sewer, surface water separation and sustainable drainage systems (SuDS) measures proposed. The following assessments have been conducted:

- **Sewer network flood damage assessment**, to understand the impact of the sewer interceptor option elements on flooding originating from sewer surcharge.
- **Surface water flood damage assessment**, to understand the impact of the surface water management measures on flood water that has not yet entered a sewer or watercourse.

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A hydraulic model of the sewer network was developed to understand how the ORiW project impacts the sewer network and to estimate the likely changes in sewer network flooding performance. The one-dimensional sewer network hydraulic model was developed in InfoWorks ICM 2026.2 by combining nine United Utilities drainage models to represent key sewer assets. Network modelling suggests the interceptor sewer reduces the volume of flooding from the network by removing some existing restrictions at pumping stations, however, other issues are not reduced due to local incapacity issues.

The surface water flooding assessment reflects the effect of interventions such as sewer separation, network upgrades and SuDS. These are assumed to intercept surface water runoff, reduce flows entering the combined sewer system and provide marginal improvements in flood risk to properties and infrastructure. The surface water separation and attenuation proposed could improve the resilience of the downstream combined sewer network and reduce sewer flooding.

The valuation of flood benefits associated with the interceptor sewer measures uses the Environment Agency's RATE tool (Environment Agency, 2025) and modelled sewer network manhole flooding volumes to monetise potential property flood risk management benefits. Only manholes that are within 75m of a recorded internal or external property flooding location (as reported by United Utilities) were considered in the sewer network flood benefits assessment. Internal property flood damages will be greater than external flood damages, but this assessment has not distinguished between internal or external flood risk. The accuracy of the benefits assessment could be improved by more detailed flood benefits assessments in future stages of the project appraisal.

The National Receptor Dataset (NRD) was used to identify the type and location of properties (Environment Agency, 2024), within 75m of the flooding manholes and with a property ground level lower than the manhole ground level. Benefits are based on an assumed standard of protection, using percentage reduction in modelled manhole flood volumes in the pumped rising main (23% reduction in damages) and tunnel interceptor sewer (43% reduction in damages) options. The valuation differentiates between the tunnel and rising main options but does not distinguish between discharge locations.

The surface water management measures flood benefits valuation uses the Environment Agency's RATE tool and Environment Agency national mapping of risk of flooding from surface water (Environment Agency, 2025) to monetise potential property flood risk management benefits. The National Receptor Dataset (NRD) was used to identify the type and location of properties (Environment Agency, 2024) within appraisal cells that were defined to estimate targeted areas that may benefit from the proposed surface water management options. The estimated flood benefits are based on an assumed standard of protection (changing the onset of flooding from a 1:25-year return period to a 1:50-year return period storm event). This assumed standard of protection formed the central estimate, with alternative assumed flood risk reduction estimates considered in the uncertainty analysis. These benefits are assumed to be relatively modest and consistent across options, as they are based only on the surface water separation, SuDS and rural runoff management measures which are common to all options.

1.4.2 Uncertainty

The flood risk management benefits estimates are subject to uncertainty and should be interpreted as indicative. The indicative Environment Agency RATE tool uses standardised flood damage values that do not capture property-specific flood damage considerations, e.g. threshold step height. Improved flood damage assessment could be undertaken using the full methods presented in Flood and Coastal Erosion Risk Management - Handbook for Economic Appraisal (Flood Hazard Research Centre, 2026).

The surface water flood risk analysis has been based on national surface water flood mapping. The accuracy could be improved by conducting local flood modelling of both the baseline and proposed option scenarios to verify that the nationally mapped flood risk is representative and that the proposed interventions will reduce flood risk to the affected properties. The assessment assumes the surface water management measures change the onset of flooding from a 1:25-year return period to a 1:50-year return period storm event, in the central estimate. A low and high benefit estimate was determined by assuming a 10% and 50% reduction in flood damages.

The assessment of surface water management measures assumes that flood risk benefits are relatively uniform across options, whereas in practice the scale of benefit may vary depending on the location, design and effectiveness of drainage interventions. In addition, the approach does not explicitly model hydraulic or flood risk changes and therefore does not capture potential non-linear or threshold effects in system performance.

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The hydraulic model developed to assess the interceptor sewer options estimates the tunnel option provides greater reductions in sewer network surcharge volumes compared to the rising main option. Only one storm event has however been modelled and there is uncertainty in how the property flood risk reduction has been inferred from one-dimensional modelled manhole flooding results. A range of events should be modelled for all options to enable a more comprehensive analysis of sewer flooding benefits. The baseline flood damages were estimated by distributing the property risk counts from one modelled storm event across a range of storm events and assuming an onset of flooding. Due to uncertainty, the sensitivity of this assumption was tested. In the central estimate, the onset of flooding was assumed to be the 1:20-year return period event. This was changed to the 1:75-year and 1:10-year return period event for the low and high estimates.

The assessment assumes the sewer interceptor measures reduce property damages by a percentage reduction determined from a percentage reduction in modelled manhole flood volumes (23% reduction in damages for the pumped rising main option and 43% reduction in damages for the tunnel option).

Overall, the values provide a high-level representation of water regulation benefits suitable for this stage and proportionate to the level of estimated benefit relative to other more material benefit category valuations presented in Table 2-1 of the Economic Case. This benefit assessment is primarily intended to support comparison across options, with further refinement expected through detailed hydraulic modelling and site-specific analysis at later stages.

1.5 Avoided cost

1.5.1 Methodology

Avoided costs are estimated to capture the economic savings associated with changes in wastewater treatment, pumping requirements and site rationalisation resulting from each option. The approach identifies existing wastewater treatment works and infrastructure that could be partially or fully decommissioned or repurposed and applies unit cost assumptions to estimate reductions in operating expenditure, maintenance costs, and capital renewal requirements. These include avoided treatment costs (based on flow volumes and scale of works), reduced pumping and energy costs, and avoided capital maintenance associated with ageing assets.

The assessment was informed by a schedule of WwTW sites and asset information including mean daily flow, site footprint and treatment works capacity that was provided by United Utilities. Standardised unit rates are applied by asset type and size band with flows derived from population equivalents or modelled volumes. Annual avoided costs are calculated as a stream of positive benefits and applied over the appraisal period, alongside any one-off conversion or decommissioning costs where relevant. It should be noted that write off cost, which is a financial cost, is not factored in. This is considered a sunk cost which is not considered in the Economic case. The approach to write-off costs will be agreed with Ofwat and estimated in a financial case, to be completed at an Outline Business Case stage.

The avoided cost assessment draws on publicly available wastewater operating and maintenance cost benchmarks published by Southern Water (2018), alongside other industry sources. These values are used as generic proxy estimates of the costs associated with wastewater treatment, pumping and asset maintenance and are not intended to represent Southern Water-specific costs. All unit rates have been converted to the economic appraisal price base year using appropriate inflation assumptions before application. Given the strategic nature of the assessment, the use of published industry benchmarks is considered proportionate and provides a consistent basis for comparing options. The estimates will be refined at Outline Business Case stage using both asset-specific and company-specific cost information where available.

Table 1.3: Avoided cost key assumptions

Category	Assumption	Description / Application
Treatment OPEX (unit rates)	Small works: £0.46/m ³ (Southern Water, 2018)	Applied to low-flow treatment works removed or downsized
	Medium works: £0.24/m ³ (Southern Water, 2018)	Applied to medium-scale treatment facilities
	Large works: £0.13/m ³ (Southern Water, 2018)	Applied to large treatment facilities benefiting from economies of scale
Pumping OPEX	£0.04/m ³ (Southern Water, 2018)	Applied to flows requiring pumping; avoided where infrastructure is rationalised
Capital maintenance	£13.10 per population equivalent per year (Southern Water, 2018)	Proxy for avoided long-term capital maintenance of existing treatment assets
Conversion / decommissioning CAPEX	£0.5m – £5.6m per site (Defra, 2015)	One-off costs for repurposing or decommissioning assets depending on size
Pumping station maintenance	£16k–£36k per year per site (Defra, 2015)	Annual maintenance cost avoided where pumping stations are removed
Flow assumptions	0.2 m ³ /person/day (Defra, 2015)	Used to estimate treatment volumes for each site

1.5.2 Uncertainty

The use of generalised unit cost assumptions may not fully reflect site-specific operating costs, asset condition or efficiency, and actual savings will depend on detailed design and future operational strategies. Assumptions on flows and treatment requirements also influence results and may change over time.

The assessment assumes that avoided costs persist over the full appraisal period and does not explicitly capture transitional inefficiencies or reconfiguration costs beyond initial assumptions.

1.6 Transport disruption during construction

1.6.1 Methodology

Transport disruption is assessed as a monetised cost reflecting the temporary economic and wellbeing impacts arising from construction. All options involve significant construction works that will require partial and full closure of roads, leading to potentially significant delays.

The focus of the transport disruption assessment is on the A591 and A592, as shown in Figure 1.1 All options require works on the A591/A592 corridor, the single transport spine connecting Ambleside, Windermere and Bowness, which is the primary access route for the visitor economy and the most disruption-sensitive section of the programme. The location of the option construction footprints along the A591/A592 corridor were derived from the feasibility study design (Jacobs Mott MacDonald, 2026f). The project would require construction of either a tunnel or twin rising main along these roads, which would require full closure and potentially significant disruption to traffic.

Disruption to traffic on other roads in the Windermere catchment has not been monetised as this is common across all options and does not influence option selection. The other roads are generally minor roads with lower traffic flow and with smaller rising mains that will likely have less construction disruption. It is assumed that this infrastructure could be constructed through less constrained land adjacent to road corridors and therefore transport disruption would be limited. It is assumed that disruption to these roads would not materially impact the project benefit-cost ratio.

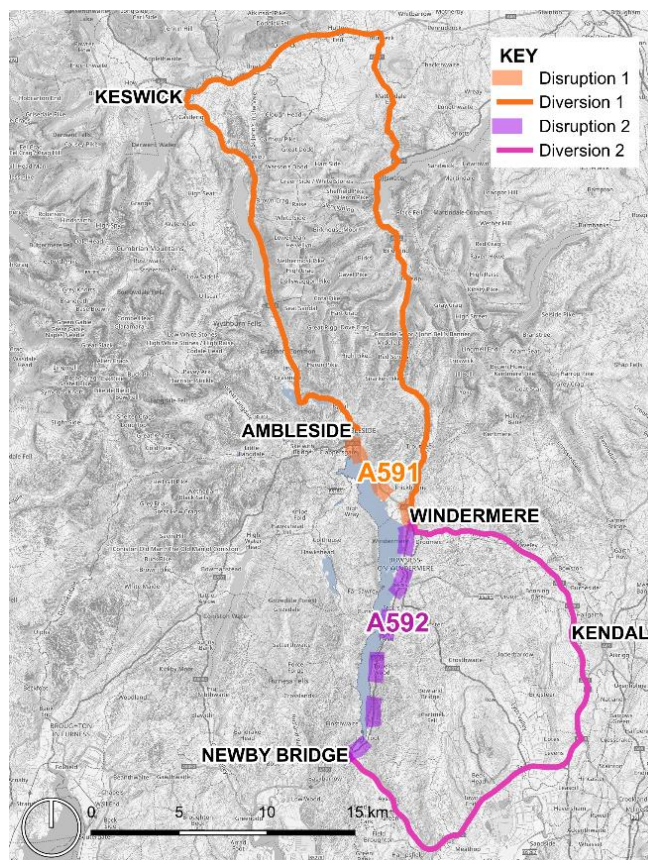
Disruption to the A590, which connects Newby Bridge with Ulverston and Barrow-in-Furness, has not been monetised in this assessment. Although the Ulverston and Barrow options may require works in the vicinity of the A590, significant traffic disruption is considered unlikely, as the Highways Authority would be unlikely

to permit closures of this strategic route. Consequently, any interceptor sewer would need to be routed and constructed adjacent to the road where necessary. On this basis, impacts associated with significant disruption to the A590 have not been monetised.

This assessment considers the impact of transport disruption to the A591/A592 alongside Windermere, which may be fully closed during the construction of the proposed options. It is assumed that closure of the roads would only be acceptable during Winter periods, as Summer aligns with peak visitor periods where significant disruption and full road closure would likely not be acceptable. During road closures, alternative traffic diversions on similarly classed A roads are approximately 10 times longer. Two diversion routes were considered in the assessment: between Ambleside and Windermere and between Windermere and Newby Bridge. Figure 1.1 highlights these diversion routes.

This valuation uses Transport Assessment Guidance (Department for Transport, 2024) to capture the value of time, fuel, operating costs and emissions associated with the increased journey times of traffic diversions. The volume of disrupted traffic was estimated using traffic flow data for the A591 and A592 from the Department for Transport Road Traffic Statistics (Department for Transport, 2024). The annual average daily flow counts were seasonally adjusted to represent the lower traffic volumes expected in winter, when the road closures are likely to occur. It was assumed winter traffic is 60% of the annual average traffic.

Figure 1.1: Transport disruption diversion routes¹



1.6.2 Uncertainty

The transport disruption assessment has a high level of uncertainty. No transport modelling has been undertaken to understand the impact of construction activities on traffic, which could be undertaken to improve the accuracy of the assessment.

The transport disruption has only been monetised for the impact of constructing the interceptor sewer along the A591 and A592, which are key road networks connecting communities and visitors. The wider ORIW project will however also lead to reasonable traffic disruption to other minor roads in the area, which have not been monetised. Although the extent of disruption to these roads may be reasonable, the likely monetised disruption may be comparatively low due to lower traffic volumes and less disruptive construction techniques compared to the large open-cut and full closure required along the A591/A592. The wider interventions are also common to all options and therefore will not influence the preferred option selection between the short-listed options.

The monetisation of transport disruption uses Transport Assessment Guidance (Department for Transport, 2024) to capture the value of time, fuel, operating costs and emissions associated with the increased journey times of traffic diversions. Most of the cost comes from the value of time estimation. Although there is reasonable confidence in the reference valuations, the assumptions could be reviewed.

The largest transport disruption costs are associated with construction of the rising main between Ambleside and Windermere, as the diversion route is long. There is however reasonable confidence in the route of this diversion, as no other route on a similarly classified A-road is available. A proportion of traffic may however use minor local roads to shorten diversion distances, but this will not be appropriate for all traffic. The assessment assumes that the current level of ordinary traffic will continue to follow the diversion route.

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Visitors may, however, be fully deterred from travelling to the region and the number of vehicles using the long diversion routes may be significantly lower than the observed existing traffic.

The largest uncertainty is in the duration of construction. For open-cut construction methods, an average rate of 300m/month has been assumed. To test the sensitivity of this assessment to this assumption, a low and high rate of 200m/month and 400m/month has been assumed. For tunnelling construction methods, an average rate of 400m/month has been assumed. To test the sensitivity of this assessment to this assumption, a low and high rate of 300m/month and 500m/month has been assumed.

Overall, the values provide a high-level representation of transport disruption suitable for this stage and proportionate to the level of estimated impact relative to other more material impact category valuations presented in Table 2-1 of the Economic Case.

1.7 Whole-life carbon emissions

1.7.1 Methodology

Whole-life carbon emissions are assessed as a monetised cost reflecting the disbenefit to the economy, environment and society throughout the lifecycle of the asset. This includes carbon emissions associated with the capital construction, operation and maintenance, and demolition, renewal and replacement, using carbon prices (£/tCO₂e) from supplementary guidance to the HM Treasury Green Book (DESNZ, 2023).

Capital carbon emissions have been estimated using a high-level top-down estimating approach proportionate to the project stage of development and aligned with the quantities, assumptions and engineering scope used to develop the project cost estimates. The capital carbon assessment covers the following lifecycle modules:

- carbon embodied within the construction materials used within project design,
- the transportation of these materials from assumed factory locations to site and,
- an estimation of onsite construction emissions including waste disposal.

The main source of carbon model data is the Mott MacDonald capital carbon model library. These models have been developed using engineering design assumptions for typical assets in the water industry. These carbon models cover the lifecycle modules for each asset and equipment model.

The emissions factors used in the carbon models use data sources including the Inventory of Carbon and Energy (ICE v3) Database (Circular Ecology, 2019), Civil Engineering Standard Method of Measurement – Carbon and Cost Price Book (CESMM4) (ICE, 2012) and Environmental Product Declarations (EPDs). The emissions data sources used reflect and are consistent with infrastructure sector recognised sources.

Operational carbon has been based off the input data used to calculate the operational expenditure and has used a 100-year operational period. The operational carbon estimates include for Energy & Chemicals usage. Power grid decarbonisation is accounted for over the operation time. Transmission and distribution losses have also been accounted for in accordance with the published BEIS modelling data table. Chemical emission factors are from the Carbon Accounting Workbook (CAWv19 2025) (UKWIR, 2025).

Replacement carbon over a 100-year period is reported in line with the Whole-Life Cost (WLC) methodology implemented in the option cost estimates.

1.7.2 Uncertainty

The whole-life carbon emissions estimates are subject to uncertainty and should be interpreted as indicative. There is inherent uncertainty in conducting a whole-life carbon emissions assessment – particularly early in the design development stages. This uncertainty arises from several areas, including:

- **Scope capture:** Whilst efforts are made to capture all required scope, it is common for additional scope items to be identified as the detail builds within a scheme design, and the project progresses towards construction.
- **Representativeness of carbon emission factors:** Even industry recognised lifecycle assessment sources are based on analysing lifecycle data and producing industry average carbon emissions values for construction materials and activities. Therefore, there is always an uncertainty that the industry average values do not represent the actual carbon emissions intensity of the materials to be specified and procured within the final design.

- **Representativeness of carbon models in scheme design:** Due to reliance on asset level mapping at this stage of the whole-life carbon emissions assessment, there is additional uncertainty associated with the design assumptions within the asset level carbon model aligning to the design assumptions in the scheme design.
- **Monetising carbon emission estimates:** Carbon prices (£/tCO₂e) have been applied using supplementary guidance to the HM Treasury Green Book (DESNZ, 2023), and the sensitivity of the monetised assessment has been tested by using low, central and high estimates for carbon prices.

1.8 Health and safety

1.8.1 Methodology

Construction health and safety effects are assessed as a monetised cost reflecting temporary hazards to contractors and the public during construction works. The number of fatal and non-fatal injuries were estimated as a proportion of the estimated construction jobs created via the project, with injury rates informed by construction statistics in Great Britain (HSE, 2025). The number of construction jobs was estimated as a proportion of the construction cost. The monetised cost of fatal and non-fatal injuries was estimated using appraisal values representing the total cost to society, considering both human and financial cost (HSE, 2024). These could be manageable through safe-by-design principles and a competent contractor.

1.8.2 Uncertainty

The health and safety cost assessment is subject to uncertainty and should be interpreted as indicative. Injury and fatality rates are derived from national construction industry statistics and therefore represent sector-wide averages rather than risks specific to the options, construction methodology, site conditions or contractor performance. The estimation of construction employment is also based on high-level assumptions relating construction expenditure to workforce requirements, which may vary depending on the nature, complexity and delivery approach of the works – which may vary between tunnel or open-cut rising main construction.

Overall, the values provide a high-level representation of health and safety impacts suitable for this stage and proportionate to the level of estimated impact relative to other more material impact category valuations presented in Table 2-1 of the Economic Case.

2 Appendix B Pillar 2 methodology: Whole-life cost

This appendix sets out the methodology for developing the cost estimates used as the basis of the economic business case, including Capital Expenditure (CAPEX), Operational Expenditure (OPEX) and Whole-Life Costs (WLC).

Jacobs Mott MacDonald (JMM) provides leading estimating expertise in the water sector and has a background in all types of estimating including price reviews, major schemes and running water company estimating functions as a managed service. All estimates have been prepared by suitably qualified subject matter experts and produced in line with industry best practice.

2.1 Estimating overview

2.1.1 Scope

The scope information forming the basis of estimate production was derived from the feasibility study design, as reported in the Option Feasibility Report (Jacobs Mott MacDonald, 2026f) and Design, Process, Principles and Parameters report (Jacobs Mott MacDonald, 2026a).

The scoping information detailed key dimensions, asset quantities, and supporting drawings or flow diagrams. Operational information, such as power and chemical usage, was also provided to support OPEX estimation.

The estimating technique applied to each element is determined by the level of scope definition available.

2.1.2 Cost data

Cost data has primarily been sourced from Mott MacDonald's sector cost database, containing over £28 billion of UK and Ireland water-sector cost data. This has been cross-checked and supplemented with United Utilities' cost information (United Utilities, 2026) to align with United Utilities' delivery experience while maintaining an unbiased sector-wide basis. Supplier quotations have been obtained for specialist equipment.

United Utilities' current OPEX rates have been used as the basis for operational cost calculations (United Utilities, 2026). All costs have been normalised to a 2025/26 price base and adjusted using the Building Cost Information Service (BCIS) North West location factor (BCIS, 2025).

2.1.3 Estimate classification

The Association for Advancement of Cost Engineering (AACE) classification matrix has been used to assess the estimate maturity and advise on expected accuracy ranges (AACE, 2020).

The AACE classification matrix uses as primary indicator maturity level of project definition deliverables and as secondary the end usage of the estimate, estimating methodology, and the effort and time needed to prepare the estimate.

Table 2.1: AACE classification matrix

	Primary Characteristic	Secondary Characteristic		
	Maturity level of Project definition Deliverables	End usage	Methodology	Expected accuracy Range
Estimate Class	Expressed as percentage of completion	Typical purpose of estimate	Typical estimating method	Typical variation in low (L) and high (H) ranges
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

The cost estimates presented in this Appendix have been prepared to support comparative option appraisal. They are based on the information available at the time of assessment and reflect Class 4 estimate maturity. The estimates should be interpreted as option-selection costs rather than delivery budgets and are subject to the uncertainty ranges mentioned in Table 2.1 and assumptions described throughout this Appendix. Class 4 has an uncertainty range of -30% to +50%.

2.2 CAPEX

2.2.1 Direct costs

Direct costs in construction are the costs directly associated with the execution of construction work and can be traced to a specific project, job, or activity.

Estimating of the direct works has been carried out using the following primary estimating techniques:

- **Top-Down Estimating** where cost models have been utilised from key scope parameters to develop appropriate costs
- **Bottom-Up Estimating** where cost rates have been used at a granular level to build up appropriate costs
- **Composite Estimating**, a combined mix of top-down and bottom-up estimates and rates has been utilised.

The estimating technique used is determined by the scoping information provided and the level of best quality cost data available.

2.2.2 Indirect costs

Indirect costs in construction are the costs that are not directly attributable to a specific work activity but are required to manage, support, and execute the project. Indirect costs have been split into two major components. These are Client and Contractor overheads.

The estimates assume a conventional United Utilities delivery model. DPC/SIPR-specific financing and transaction costs have not been separately estimated as the delivery model has not yet been determined. For the purposes of option appraisal, a consistent indirect cost methodology has been applied across all options. If a DPC/SIPR route is pursued, these additional costs would be considered at the next stage.

Table 2.2: Indirect cost structure

Overhead Type	Indirect Type	Inclusions
Contract Indirects	Contract Management and Supervision	Programme Management, Site Management and Supervision, Site Investigations and Surveys
	Contractor Design	Design, Site Investigations and Surveys
	Contractor Preliminaries	Site Accommodation and Setup, Temporary Works, Testing and Commissioning
	Fee	Contractual Fee
Client Indirects	Client Management	Programme Management, Commercial Management, Statutory Management
	Client Design	Design, Site Investigations and Surveys
	Operational Costs	Operational staff and attendance
	Third Party Costs	Land, Compensation
	Corporate Overheads	Corporate Overheads
	Biodiversity Net Gain	Biodiversity Net Gain

Indirect costs are calculated as a multiplication of the direct works and are based on water sector average cost data, from Mott MacDonald's sector cost database. The indirect costs are not a set percentage; they have been derived for indirect cost curves and reflect efficiencies in delivery in scale.

Biodiversity Net Gain (BNG) costs have been calculated for all areas of habitat loss, using BNG tool based on (Defra, 2025). For habitat that cannot be reinstated in full within two years it has been assumed that the lowest biodiversity score within the habitat type can be achieved. A 10% net gain from the baseline calculation has been included for both temporary and permanent biodiversity loss, assumed to be achieved within the current area. BNG credits have been assumed at this stage, however, there is an opportunity to potentially achieve BNG within United Utilities' land holding.

2.2.3 Estimating uncertainty

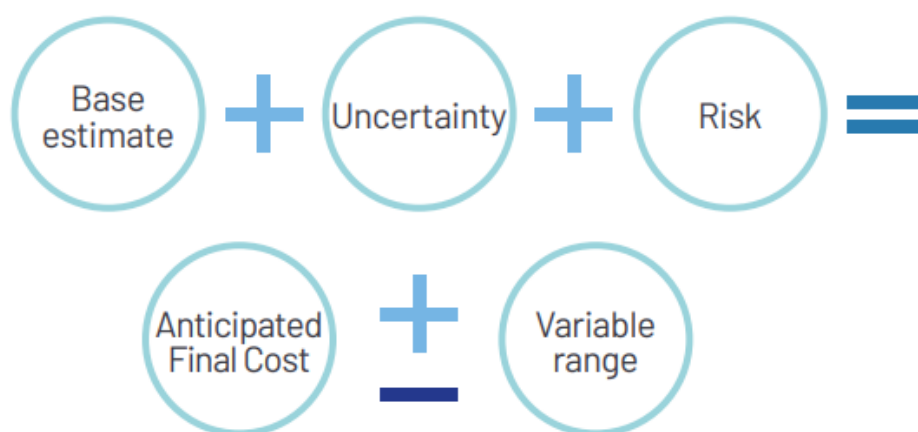
To establish a realistic view of the anticipated final cost an estimate should include a risk-adjustment which is reflective of the estimate and scope maturity for the delivery stage.

The inclusion of estimating uncertainty and risk allowance, appropriate to the stage in a project, is recognised as industry best practice as outlined in the following guidance:

- National Infrastructure and Service Transformation Authority (NISTA) – Cost Estimating Guidance (National Infrastructure and Service Transformation Authority, 2021)
- APM/Association of Cost Engineers – Estimating Guide (Management, 2019)
- Association for the Advancement of Cost Engineering (AACE) – Recommended Practices

The NISTA outlines their recommended approach to risk and uncertainty as shown in the following risk and uncertainty equation.

Figure 2.1: Estimate Risk & Uncertainty Equation from NISTA Cost Estimating Guidance



The ORiW project is high value, covers a large area of Cumbria and has many complex and varied construction elements. To reflect this complexity and provide representative and robust risk and uncertainty estimates, a separate risk and uncertainty allowance has been calculated for each estimate to ensure specific and appropriate adjustments have been included, shown in Table 2.3.

Table 2.3: Estimating Uncertainty Assessment Matrix

Category	Definition
Design Definition	Likelihood of design change from the scope used as basis of estimate
Ground Conditions	View on the potential for change in ground conditions from the conditions priced in the estimate build-up.
Other Services	Potential of unknown services or high quantities if charted services in the construction area
Power Upgrades	Cost of power upgrade to serve new project assets
Site Access	Potential access issues to work area
Working Conditions	The conditions construction activities will be completed in
Delays	Potential for third party delays
System Integration	Integrating new assets into existing systems e.g. Scada
Planning Permission	Understanding of planning permission requirements
Land Acquisition/ Compensation	Cost to acquire land or pay compensation to others, e.g. land access
Environmental Constraints	Cost associated with working in external environment
Biodiversity Net Gain	Cost associated with BNG requirements change

The specific estimate is assessed against 12 categories and scored high, medium or low with full consideration of the known information and scope maturity to determine the estimating uncertainty percentage that is applied. Categories that are not applicable to the estimate are not included in the assessment.

By using this approach to assessing estimating uncertainty, compared to applying a set percentage, full consideration is given to higher risk elements, whilst not overestimating lower risk areas.

The estimating uncertainty allowances applied to the estimates for ORiW is between 20%-35%, with an average of 29%. This allowance accounts for potential change in delivering the scope that forms the basis of the estimates.

2.3 OPEX

Operational Expenditure (OPEX) has been estimated on an annual basis based on the engineering scope developed by JMM engineers; and detailed in the 'Option Scope and Feasibility Report'. The following OPEX categories have been used to calculate costs:

- Power Usage
- Chemical Usage
- Operator Attendance
- SuDS Maintenance

Operational costs have only been calculated for new assets proposed under the ORiW scheme. Existing United Utilities' assets have not been included as they are accounted for in existing operational expenditure allowances.

2.4 Optimism bias and contingency

Optimism bias, which accounts for potential changes in scope and other sources of cost uncertainty, has been applied to the cost estimation as part of the economic modelling process. This is additional to the estimating uncertainty outlined in section 2.2.3.

The estimating uncertainty allowance described in Section 2.2.3 reflects uncertainty within the cost estimate itself arising from factors such as scope maturity, design definition, ground conditions, planning requirements and construction delivery risks. This forms part of the development of the cost estimate.

Optimism bias is applied separately within the economic appraisal in accordance with HM Treasury Green Book guidance. It recognises the tendency for early-stage projects to underestimate costs and overestimate benefits despite the application of project-specific estimating and risk assessment processes. Optimism bias is therefore applied in addition to the estimating uncertainty allowances used in cost estimation.

In line with Green Book recommendations (HM Treasury, 2026), an optimism bias of 66% has been applied to CAPEX, while a 44% optimism bias has been applied to the whole-life cost replacement and maintenance expenditure. A 30% contingency has also been applied to annual OPEX estimates.

The evidence base has been reviewed to establish whether a project-specific reference class forecast (RCF) could be applied in place of the generic uplift. No published RCF dataset exists for wastewater treatment works, SuDS, or first-time sewerage. These components account for a substantial amount of Programme CAPEX. The only broadly relevant published RCF evidence, the DfT/Oxford Global Projects (Oxford Global Projects, 2021) "Fixed Links" class, is derived from transport infrastructure and is not directly applicable but is instructive: at the current stage of assessment, it indicates a P50 cost overrun of c.20% rising to a P80 of c.123%. The 66% high rate applied here therefore sits within the evidenced range for comparable early-stage civil infrastructure and is not an outlying assumption.

2.5 Whole-life cost

All costed elements include a whole-life cost assessment, with asset replacement and maintenance costs projected for a 100-year period. Costs have been discounted using the Green Book Social Time Preference Rate (STPR) (HM Treasury, 2026). The 100-year period aligns with the derivation of Pillar 1 benefits.

Table 2.4 shows the asset life and major maintenance intervals assumed, with full replacement cost at end of asset life and a proportion of the capital spend to maintain assets.

Table 2.4: Asset life interventions

Asset Type	Asset Life – major replacement (Years)	Major Maintenance Frequency (Years)	Maintenance Intervention (percentage of CAPEX)
Civil General	60	20	10%
Mechanical General	20	10	25%
Electrical General	20	10	25%
ICA General	10	0	0%
Pipework General	120	30	5%
Tunnels	120	30	5%

2.6 Checking and approvals

All estimates produced have been checked and approved by a suitably qualified estimating professional as part of peer review and quality procedure. Checking process includes the following activities:

- Calculation review
- Verify that all scope elements have been priced
- Confirm appropriate cost data and models used
- Correct contract and client overheads applied
- Estimating uncertainty suitably applied
- All OPEX costs have been captured and OPEX rates correctly assigned
- WLC cost categories and asset life durations have been correctly applied

Table 2.5: Do/Check

Stage	Definition
Do	Estimator or Senior Estimator
Check	Estimator or Cost Intelligence Director
Approve	Estimating Director

Check: All solution estimates have been subject to a 'Check' from a peer level estimator or higher under a delegation matrix. All estimates carried out by the estimating team have been checked internally to identify any issues or necessary amendments before distribution.

Approve: The delegation matrix prescribes the suitable qualifications and experience for solution approval by scale, complexity and estimating level. All estimates carried out for ORiW have been checked by a senior estimator or director, with all estimates approved by Cost Estimating Director.

2.7 Asset life interventions – ADORE

All cost estimates have been issued with an accompanying ADORE (Assumptions, Dependencies, Opportunities, Risks and Exclusions) section (Shermon & Gilmour, 2017). The ADORE comprises the following:

- **Assumptions** reflect design and delivery conditions across the projects.
- **Dependencies** include acquisition of Engineering Outputs, operational access, third-party approvals.
- **Opportunities** typically arise from standardisation, modularisation, procurement strategies.
- **Risks** include design immaturity, site constraints, interfaces, geotechnical uncertainty.
- **Exclusions** are those items not included within the scope or requested to be excluded from the cost estimate by investment decision makers.

The following sections outline the ADORE for each of the major cost elements.

2.7.1 First time network

2.7.1.1 Background

First time sewerage involves connecting properties with private Wastewater Treatment Works (WwTW) into the sewer network. Scope involves making connection within customers property boundaries and transferring into the existing network via a series of new sewers, pumping stations and rising mains. Estimates have been prepared for the following first-time sewerage catchments:²

- Ambleside
- Elterwater
- Hawkshead
- Skelwith Bridge
- Troutbeck
- Windermere East
- Windermere West
- Grasmere

The cost estimate has been developed as a composite of bottom-up estimating for the pipework, manholes and septicity dosing, with top-down cost modelling for the pumping stations. The scope provided is at a high level outlining overall lengths of sewers and number of property connections for each catchment.

Table 2.6: ADORE, First Time Network

ADORE	Notes
Assumptions	▪ With no route or individual pipe runs scoped, average sewer diameter has been assumed to be 225mm diameter with manholes every 50m ▪ An additional manhole per connection ▪ Connection into properties to be 25% through front garden, 25% through driveway, 25% around perimeter to rear of the property and 25% connection into rear of terraced house ▪ 15kw network pumping stations and 2kw property pumping stations ▪ Assumes 100mm diameter rising main in road ▪ Septicity dosing required due to low flows
Dependencies	▪ Requires detailed scope review, including surveys, hydraulic modelling and route design to confirm feasibility ▪ Assessment of environmental impact ▪ Utility diversion and existing infrastructure interfaces
Opportunities	▪ Early contractor involvement to refine methodology and reduce risk. ▪ Potential economies of scale by bundling procurement. ▪ Potential for spoil reuse in local construction or restoration schemes (All spoil assumed as inert and disposed offsite).
Risks	▪ Significant scope uncertainty. ▪ Unknown ground conditions. ▪ Community opposition. ▪ Supply chain inflation. ▪ Environmental constraints. ▪ Interfaces with existing infrastructure. ▪ Programme delays due to permitting or stakeholder engagement.
Exclusions	▪ Specific requirements for service diversions or power network upgrades have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

² Esthwaite was assessed for FTS but did not meet the criteria as defined under the risk-based approach. Therefore, for the solution for these assets will be an upgrade of the existing tanks to Fujiclean to improve removal of nutrients.

2.7.2 First time treatment

2.7.2.1 Background

First time treatment involves replacing septic tanks with Fujiclean treatment solutions serving both individual and groups of properties not connected to the existing sewer network. First time treatment solutions have been selected when it is impractical to connect to the network as part of the first-time network options.

2.7.2.2 Estimate

The cost estimate has been developed as primarily using bottom-up estimating with cost data developed from previously undertaken similar projects using Fujiclean. The scope outlines the number of treatment sites, the Population Equivalent size for each site and the indicative unit that would meet the project requirements.

Table 2.7: ADORE, First Time Treatment

ADORE	Notes
Assumptions	50m of interconnecting pipework and 40m of outlet pipework per Fujiclean unit - Access to land and agreement with property owners to allow installation of new treatment units
Dependencies	- Land available to construct Fujiclean solutions - Agreement with customers to replace septic tanks with Fujiclean solutions - Assessment of environmental impact - Utility diversion and existing infrastructure interfaces
Opportunities	- Early contractor involvement to refine methodology and reduce risk. - Potential economies of scale by bundling procurement. - Potential for spoil reuse in local construction or restoration schemes. - Digital twin and smart monitoring to optimise operations post-delivery.
Risks	- Unknown ground conditions. - Community opposition. - Supply chain inflation. - Environmental constraints. - Interfaces with existing infrastructure. - Programme delays due to permitting or stakeholder engagement.
Exclusions	Specific requirements for service diversions or power network upgrades have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

2.7.3 Highway drainage

2.7.3.1 Background

Highway drainage interventions have been identified to reduce, delay or eliminate flows into the sewer network from highway runoff. Typical solutions include:

- Filter drains
- Vortex separators
- Ponds
- Detention basis
- Permeable paving
- Bioretention systems/raingardens
- Associated pipework and manholes

2.7.3.2 Estimate

The cost estimate has been developed primarily using bottom-up estimating, with unit rates calculated for each intervention. The scope provided comprised high-level quantities and sizes of the interventions required across all catchments under consideration.

Table 2.8: ADORE, Highway Drainage

ADORE	Notes
Assumptions	▪ A factor of 1.5 has been applied to linear features to account for interventions on both sides of the road. ▪ Quantities for ponds, detention basins, permeable paving, and raingardens assume that the solutions focus on water quality measures rather than attenuation. Accordingly, they have been designed for a 2-year return period with no climate change allowance. ▪ Land is available to install the highway drainage interventions.
Dependencies	▪ Land available to construct solutions. ▪ Traffic management can be designed to keep roads open throughout construction. ▪ Assessment of environmental impact. ▪ Utility diversion and existing infrastructure interfaces.
Opportunities	▪ Early contractor involvement to refine methodology and reduce risk. ▪ Potential economies of scale by bundling procurement. ▪ Potential for spoil reuse in local construction or restoration schemes (All spoil assumed inert and disposed offsite). ▪ Digital twin and smart monitoring to optimise operations post-delivery.
Risks	▪ Significant scope uncertainty. ▪ Unknown ground conditions. ▪ Community opposition. ▪ Supply chain inflation. ▪ Environmental constraints. ▪ Interfaces with existing infrastructure. ▪ Programme delays due to permitting or stakeholder engagement. ▪ Significant traffic impact.
Exclusions	▪ Specific requirements for service diversions have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

2.7.4 Reduced weather dependent flows

Background

Reduced Weather Dependent Flows (RWDF) includes for sewer relining, smart water butts to aid re-use solutions, new surface water sewers to aid separation and natural flood management to manage flows. Estimates have been prepared for the following drainage catchments:³

- Ambleside
- Elterwater
- Hawkshead
- Near Sawrey
- Far Sawrey
- Outgate
- Windermere East
- Windermere West
- Grasmere

2.7.4.1 Estimate

The cost estimate has been developed primarily using bottom-up estimating, with unit rates calculated for each intervention.

³ Esthwaite was assessed for FTS but did not meet the criteria as defined under the risk-based approach. Therefore, for the solution for these assets will be an upgrade of the existing tanks to Fujiclean to improve removal of nutrients.

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The scope provided consisted of high-level quantities and intervention scale required across all catchments under consideration.

Table 2.9: ADORE, Reduced Weather Dependent Flows

ADORE	Notes
Assumptions	- Manholes have been assumed at 1200mm diameter - One manhole assumed every 50m of pipework - Smart water butts assumed 240l storage volume - Land available to install interventions - Land/Property owners agree to RWDF solutions being implemented
Dependencies	- Land available to construct solutions - Acceptance from property owners - Assessment of environmental impact - Utility diversion and existing infrastructure interfaces
Opportunities	- Early contractor involvement to refine methodology and reduce risk. - Potential economies of scale by bundling procurement. - Potential for spoil reuse in local construction or restoration schemes. - Digital twin and smart monitoring to optimise operations post-delivery.
Risks	- Significant scope uncertainty. - Unknown ground conditions. - Community opposition. - Supply chain inflation. - Environmental constraints. - Interfaces with existing infrastructure. - Programme delays due to permitting or stakeholder engagement.
Exclusions	Specific requirements for service diversions have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

2.7.5 Rising mains

2.7.5.1 Background

Rising mains have been specified in works common to all options and as an option for conveyance in tunnel and hybrid options. Rising main estimates include pipework, pumping stations and septicity dosing.

2.7.5.2 Estimate

The cost estimate has been developed primarily using top-down estimating for pipework and pumping stations, supplemented by bottom-up rates and supplier quotes for septicity dosing.

The scope provided comprised high-level quantities and scale of interventions required across all options considered.

Table 2.10: ADORE, Rising Mains

ADORE	Notes
Assumptions	▪ Transfer rising mains from each catchment to interceptor assumed as single pipes. ▪ Conveyance rising main dual to increase resilience. ▪ Septicity dosing required throughout. ▪ Backup diesel generators included at pumping stations. ▪ Battery backup for instrumentation and controls at pumping stations. ▪ Rising main assumed to be laid in road for costing purposes. ▪ An additional 10% pipe length included to account for route realisation. ▪ 12.5% efficiency assumed for dual pipes in one trench.
Dependencies	▪ Land available to construct solutions. ▪ Assessment of environmental impact. ▪ Utility diversion and existing infrastructure interfaces. ▪ Route design being completed.
Opportunities	▪ Early contractor involvement to refine methodology and reduce risk. ▪ Potential economies of scale by bundling procurement. ▪ Potential for spoil reuse in local construction or restoration schemes. ▪ Digital twin and smart monitoring to optimise operations post-delivery. ▪ Reduce costs by routing rising mains outside of carriageway where possible. ▪ Trenchless techniques to avoid environmentally sensitive areas and reduce traffic impact.
Risks	▪ Significant scope uncertainty as pipe routes have not been specified. ▪ Unknown ground conditions. ▪ Community opposition. ▪ Supply chain inflation. ▪ Environmental constraints. ▪ Interfaces with existing infrastructure. ▪ Programme delays due to permitting or stakeholder engagement. ▪ Significant traffic impact.
Exclusions	▪ Specific requirements for service diversions have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

2.7.6 Tunnels

2.7.6.1 Background

Interceptor tunnels have been scoped in tunnel and hybrid sub-options to convey wastewater flows away from the Lake to treatment at either Windermere WwTW, Ulverston WwTW or Barrow WwTW. All tunnels are 4m diameter and constructed using Tunnel Boring Machine (TBM) techniques.

2.7.6.2 Estimate

The cost estimate has been developed primarily using bottom-up estimating, based on data from other major wastewater tunnelling schemes. The scope provided consisted of high-level tunnel lengths and shaft locations.

Table 2.11: ADORE, Tunnels

ADORE	Notes
Assumptions	- TBM tunnelling technique assumed in cost estimating. 4m diameter tunnel and 15m diameter shafts throughout all tunnelling options. - Replacement TBM machines assumed to be required for each major tunnel leg. - Shaft distance frequency. - Additional tunnel lining under lake. - Additional allowances assumed for poor ground/rock as per geotechnical advice received. - Diaphragm shaft construction assumed where poor ground identified. - Steel internal dry weather flow pipe included to prevent silting and septicity. - Spoil removed from site, priced as disposal of inert waste to landfill. - TBM power supply.
Dependencies	- Land available to construct solutions. - Traffic management can be designed to keep roads open throughout construction. - Assessment of environmental impact. - Utility diversion and existing infrastructure interfaces. - Ground conditions suitable for tunnelling. - Availability of specialist suppliers and delivery partners.
Opportunities	- Early contractor involvement to refine methodology and reduce risk. - Potential economies of scale by bundling procurement. - Potential for spoil reuse in local construction or restoration schemes. - Digital twin and smart monitoring to optimise operations post-delivery. - Rationalisation of scope through further route design and potential reduction in shaft numbers.
Risks	- Significant scope uncertainty. - Unknown ground conditions. - Community opposition. - Supply chain inflation. - Environmental constraints. - Interfaces with existing infrastructure. - Programme delays due to permitting or stakeholder engagement. - Significant traffic impact.
Exclusions	Specific requirements for service diversions have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

2.7.7 Treatment

2.7.7.1 Background

To be able to cope with increased flows and achieve enhanced effluent consent requirements, the receiving treatment works require significant upgrades. Treatment works considered in the study include:

- Windermere WwTW
- Ulverston WwTW
- Barrow WwTW

Only CAPEX and OPEX costs for the upgrade treatment elements have been included, all existing treatment assets are deemed to be included in United Utilities' existing costs.

2.7.7.2 Estimate

The cost estimate has been developed using a top-down asset model for the estimating, supplemented with bottom-up estimating for site mitigation measures.

The scope provided comprised asset sizes, process flow information and indicative site layouts.

Table 2.12: ADORE, Treatment

ADORE	Notes
Assumptions	- Existing treatment assets not part of the upgrade are in good working order and performing to current requirements. - Site mitigation measures, including piling, erosion protection, land profiling and flood defences are as scope provided. - All works can be delivered on United Utilities' current land ownership. - Existing treatment processes will be maintained throughout construction.
Dependencies	- Land available to construct solutions. - Traffic management can be designed to keep roads open throughout construction. - Assessment of environmental impact. - Utility diversion and existing infrastructure interfaces. - Ground investigation carried out to confirm suitable site mitigation measures.
Opportunities	- Early contractor involvement to refine methodology and reduce risk. - Potential economies of scale by bundling procurement. - Potential for spoil reuse in local construction or restoration schemes. - Digital twin and smart monitoring to optimise operations post-delivery.
Risks	- Significant scope uncertainty. - Unknown ground conditions. - Community opposition. - Supply chain inflation. - Environmental constraints. - Interfaces with existing infrastructure. - Programme delays due to permitting or stakeholder engagement. - Significant traffic impact.
Exclusions	Specific requirements for service diversions have not been included in the cost build up. Instead, generic allowances have been included in the indirect costs and estimating uncertainty.

3 Appendix C Pillar 3 methodology: Distributional and place-based effects

Appendix C supports Pillar 3 of the appraisal framework, which assesses the distributional and place-based impacts of the ORiW options. In line with HM Treasury Green Book principles, the assessment considers how impacts are distributed across different places, communities, businesses and user groups, alongside their overall scale and significance. This Appendix sets out the detailed methodology, evidence base and rating framework used to undertake the Pillar 3 assessment presented in the ORiW Economic Case. It is structured as follows.

- Section 3.1 explains the indicators used in the place comparison.
- Section 3.2 sets out the quantitative place comparison (Table 3.2).
- Section 3.3 translates the quantitative evidence into structured fairness characterisations of each place (Table 3.3) which classify each place according to four dimensions relevant to fairness considerations: community vulnerability, existing infrastructure burden, construction-disruption sensitivity, and long-term benefit alignment.
- Section 3.3 sets out the construction disruption data.
- Section 3.4 sets out the Red, Amber, Green (RAG) methodology and decision rule in detail.
- Section 3.5 explains where Pillar 3 stops and the other pillars begin.
- Section 3.6 lists outstanding evidence gaps.

A note on terminology used in this Appendix

LSOA: Lower-layer Super Output Area. A statistical unit used by the Office for National Statistics (ONS, 2021), roughly the size of several streets (around 1,500 residents). The Indices of Deprivation rank every LSOA in England from most deprived (rank 1) to least deprived (rank 32,844). A 'Decile 1' LSOA is in the most deprived 10% nationally.

MSOA: Middle-layer Super Output Area. A larger statistical unit used by ONS, around 7,500 residents — typically a small town or a neighbourhood within a city. MSOAs are used for income estimates and life expectancy at small-area level.

BUA: Built-Up Area. An ONS geography defining a contiguous built-up area; here used to refer specifically to the named settlements (Windermere, Bowness-on-Windermere, Ambleside, Ulverston, Barrow-in-Furness BUAs).

IoD 2025: English Indices of Deprivation 2025. The Ministry of Housing, Communities and Local Government (MHCLG) measure of relative deprivation in England, published 30 October 2025. Contains seven domains of deprivation: Income, Employment, Education, Health, Crime, Barriers to Housing, and Living Environment. Each LSOA gets a rank and decile on each domain and on the overall combined Index of Multiple Deprivation (IMD).

WwTW: Wastewater Treatment Works. The receiving facility for sewage flows. 'PE' (Population Equivalent) is the standard measure of plant capacity — Barrow WwTW has a PE of around 73,000.

3.1 Indicator reference table

The table below explains each indicator used in Table 3.1: what it measures, why it was selected for this assessment, and where it comes from.

Table 3.1: Indicator reference table

Indicator	Source and notes
ONS Census 2021 usual resident population estimates	ONS Census 2021 usual resident population estimates. Windermere and Ulverston figures drawn from ONS Parish-level Census 2021 data; Barrow figure taken from ONS Built-Up Area/Locality Census 2021 population statistics (ONS, 2021).
Median age and 65+ share (Census 2021 TS007)	ONS Census Table TS007 (Age by single year), ward-level. Median age derived from cumulative age band data (ONS, 2021).
Median net household income (ONS, Financial Year End 2023)	ONS Small Area Income Estimates for Middle-layer Super Output Areas, financial year ending 2023, published December 2025. Windermere and Ulverston figures are MSOA-level (South Lakeland 001/002 and 012 respectively). Barrow figure is the Local Authority District (LAD) median (ONS, 2023)
Household deprivation dimensions share (Census 2021 TS011)	ONS Census 2021 Table TS011 (Households by Deprivation Dimensions), ward-level download from NOMIS, May 2026 (ONS, 2021).
Percentage LSOAs in IMD Decile 1	MHCLG, English Indices of Deprivation 2025 (IoD, 2025), published 30 October 2025. File 7 (LSOA-level data) cross-referenced with ONS LSOA (2021) to Built-Up Area to LAD Best-fit Lookup (December 2022) to identify LSOAs within each BUA.
Percentage LSOAs in Health Deprivation Decile 1	MHCLG, English Indices of Deprivation 2025. File 7, health domain decile column. Same BUA lookup as IMD Decile 1 row above (IoD, 2025).
General health – percentage good or very good (Census 2021 TS037)	ONS Census 2021 Table TS037 (General Health), ward-level download from NOMIS, May 2026.
Male life expectancy (MSOA level, 2016–2020)	OHID/fingertips, public health profiles, life expectancy at birth at MSOA level, 2016-2020 period. W&F Joint Local Health and Wellbeing Strategy 2024-2034 for W&F MSOA comparisons. MSOA codes for Windermere (E02004015, E02004016) and Ulverston (E02004026) now identified — figures to be retrieved from OHID Fingertips before the next stage.
NVQ Level 4+ qualifications	Barrow figure from totalpopulation.co.uk drawing on ONS Census 2021 and Annual Population Survey. Ward-level Census 2021 data not available for Windermere or Ulverston at this geography.
Dominant industry of employment (Census 2021 RM063)	ONS Census 2021 Table RM063 (Industry by Economic Activity Status), ward-level download from NOMIS, May 2026. Resident-based data — reflects where workers live, not where they work (relevant for Barrow workplace versus resident figures).
Occupational profile - Standard Occupational Classification (SOC) 1-3 and 8-9 (Census 2021 TS063)	ONS Census 2021 Table TS063 (Occupation), ward-level download from NOMIS, May 2026.

3.2 Quantitative place comparison

The table below sets out the quantitative indicators on which the place context in Section 3.1 of the core chapter is built.

Table 3.2: Quantitative place comparison (sources of data captured in Table 3.1)

Indicator	Windermere / Bowness / Ambleside	Ulverston	Barrow-in-Furness	England avg.
A: Community profile				
Resident population (2021 Census)	~14,600 (aggregate: Windermere & Bowness civil parish 7,676; Ambleside BUA 2,627; Lakes civil parish 4,280)	11,826 (Ulverston ward, Census 2021)	67,437 (locality, Census 2021)	—
Median age and 65+ share (Census 2021)	Median ~51 (Windermere and Ambleside ward, Census 2021); 65+ = 26.7%	65+ = 22.2%; median age ~49 (Census 2021 TS007 ward-level data). Well above England average for 65+ share.	65+ = 21.6%; median age 44 (up from 42 in 2011). Youngest of the three places.	18.6% (65+); 40 (median)
Median net household income (ONS FYE 2023)	£33,451 (Bowness BUA, Locara/ONS). MSOA-level: South Lakeland 001 (Windermere/Ambleside) £33,384; South Lakeland 002 (Windermere/Bowness) £34,718. All below England average.	£32,972 (MSOA South Lakeland 012, ONS FYE 2023) — four LSOAs all within Ulverston BUA; this MSOA covers Ulverston town specifically. Below South Lakeland district median (£34,944) and closer to Barrow than to the England average.	£31,141 (Barrow LAD median, ONS FYE 2023); lowest MSOA £23,831; highest MSOA £37,033. Range reflects internal inequality within Barrow.	~£37,100
Household deprivation (Census 2021 TS011)	47.6% of households deprived in 1+ dimensions; 12.8% in 2+ dimensions; 1.9% in 3+ dimensions	45.8% of households deprived in 1+ dimensions; 14.6% in 2+ dimensions; 2.8% in 3+ dimensions	53.3% of households deprived in 1+ dimensions; 20.5% in 2+ dimensions; 4.7% in 3+ dimensions	—
B: Deprivation and health				
% LSOAs in IMD Decile 1 (IoD 2025)	0% - confirmed at individual LSOA level (6 LSOAs across Windermere, Bowness and Ambleside BUAs; all in IMD deciles 6–8). Source: IoD 2025 File 7 linked via ONS LSOA-to-BUA lookup.	0%: confirmed at individual LSOA level (5 LSOAs in Ulverston BUA; deciles range 5–9, with two LSOAs in Decile 5). Source: IoD 2025 File 7 linked via ONS LSOA-to-BUA lookup.	18.8% (9 of 48 LSOAs): confirmed from IoD 2025 File 7 LSOA data. 24.5% under IoD 2019 — methodology change means different editions not directly comparable.	10%
% LSOAs in Health Deprivation Decile 1 (IoD 2025)	0% confirmed at LSOA level (health deciles 7–10 across all 6 LSOAs; Bowness LSOA and one Ambleside LSOA in Health Decile 10 — among the least health-deprived 10% nationally).	0% confirmed at LSOA level (health deciles 5–8; two LSOAs in Health Decile 5 — middle of national distribution).	31.2% (15 of 48 LSOAs). Most deprived LSOA ranked 32nd nationally for health deprivation. 36.8% of Barrow BUA LSOAs in Health Deprivation Decile 1.	10%
General health: % good or very good (Census 2021 TS037)	82.7% good/very good; 4.4% bad/very bad	80.9% good/very good; 5.8% bad/very bad	77.9% good/very good; 7.2% bad/very bad	~82%
Male life expectancy (MSOA level, 2016–2020)	MSOAs now identified: South Lakeland 001 (E02004015) covers Windermere/Ambleside; South Lakeland 002 (E02004016) covers Windermere/Bowness.	MSOA now identified: South Lakeland 012 (E02004026) covers Ulverston town. OHID Fingertips figure not yet retrieved — evidence gap	70.5 years (Barrow Central MSOA) — 8.9 years below England average of 79.4 years; 16.1 years below highest W&F MSOA	~79.4 years

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Indicator	Windermere / Bowness / Ambleside	Ulverston	Barrow-in-Furness	England avg.
	OHID Fingertips figures for these MSOAs not yet retrieved — evidence gap to close before next stage.	to close before next stage.		
NVQ Level 4+ qualifications	37.2% - greater than the national average	35.8% - greater than the national average	24.8% - less than the national average	33.9%
C: Economic character				
Dominant industry of employment (Census 2021 RM063)	Distribution, hotels and restaurants: 46.1% of resident workforce — nearly half. This is the quantitative basis for the visitor economy characterisation.	Public admin, education and health: 32.3% — dominant sector. Manufacturing: 13.4%. Highest-skilled workforce of the three places (SOC 1-3: 46.1%).	Public admin, education and health: 34.4%. Manufacturing: 17.9% of resident workers (workplace figure ~29% — reflects Barrow as regional employment centre drawing commuters from wider area).	Services ~80%; manufacturing ~9%
Occupational profile: higher skilled (SOC 1-3) and routine/manual (SOC 8-9) (Census 2021 TS063)	SOC 1-3: 38.5%; SOC 8-9: 18.6%; elementary occupations 15.2% (highest of three — reflects seasonal low-wage hospitality work)	SOC 1-3: 46.1% (highest of three — reflects GSK/life sciences heritage and BAE supply chain); SOC 8-9: 16.7%	SOC 1-3: 38.6%; SOC 8-9: 18.8%; process/plant/machine operatives 7.4%	SOC 1-3: ~43%
% non-residential catchment properties that are hospitality	78% of ~2,200 non-residential catchment properties — directly reflects visitor-economy character	Not applicable (export host, outside primary catchment)	Not applicable (export host, outside primary catchment)	—
D: Existing infrastructure burden				
Wastewater infrastructure	Windermere WwTW — current discharges are the primary ORiW programme driver. Infrastructure is the subject of remediation, not an additional hosting burden.	Ulverston WwTW — capacity and PE headroom not confirmed	Barrow WwTW (Headin Haw): PE ~73,000. Multiple CSO improvements 1995–2013. Walney Island sewerage transferred to Barrow WwTW. AMP8 (Asset Management Plan period 8, 2025–2030) further CSO works planned. Also accepts tankered industrial waste imports.	—
Other major infrastructure	National Park landscape setting; lake and recreational infrastructure. No major industrial or port infrastructure.	North Lonsdale Road: 75-year pharmaceutical manufacturing legacy (GSK). Canal and estuary context. BAE Systems acquisition October 2025 introduces new land-use complexity — purpose and planning status unresolved.	Port of Barrow; Devonshire Dock Hall (BAE defence nuclear); Walney offshore wind; nuclear and energy infrastructure; flood and coastal exposure.	—

3.3 Structured distributional assessment

The table below is the bridge between the quantitative evidence in Table 3.2 and the option ratings in the core chapter. This process translates that evidence into four place characterisations:

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- Community vulnerability;
- Existing infrastructure burden;
- Construction-disruption sensitivity, and
- Long-term benefit alignment.

Each place is rated High, Medium or Low on each dimension. These are place characterisations, not option ratings – they describe the inherent fairness sensitivity of each place before any specific option is considered.

The logic chain runs:

- Table 3.2 (raw data)
- Table 3.3 (place characterisation)
- Option ratings in the core chapter.

The option ratings inherit the place characterisations in Table 3.3; that is why Ulverston and Barrow options receive different ratings despite both being 'export options', and why Barrow options' rating is contingent on a Barrow-specific local benefit case. It is also why Windermere and Leven options, which share the Windermere host profile, receive different ratings in Table 4-4 of the Economic Case: Windermere options keep both the construction burden and the long-term benefit within the same community and is rated Green, whereas Leven option relocates the discharge to a smaller downstream community on the River Leven downstream of the weir at Newby Bridge, which bears a localised effect without receiving the benefit, and is rated Amber. No River Leven-specific data is available at this stage.

Table 3.3: Structured distributions assessment

Fairness dimension	Windermere / Bowness / Ambleside	Ulverston	Barrow-in-Furness
Community vulnerability	Low–Medium 0% LSOAs in IMD Decile 1 (IoD 2025 confirmed). 82.7% good/very good health (ONS, 2021). 65+ = 26.7% well above England average of 18.6%. Net household income below national median (£33,384 Bowness BUA vs ~£37,100 England) reflecting tourism wages, not deprivation. 46.4% of households deprived in 1+ dimensions.	Low 0% LSOAs in IMD Decile 1 - but the five Ulverston LSOAs sit in deciles 5 to 9, with two in Decile 5, making Ulverston somewhat more deprived than the Windermere/Bowness cluster (deciles 6–8). Median net household income £32,972 (MSOA South Lakeland 012) below South Lakeland district median and closer to Barrow than to the England average. 80.9% good/very good health. 65+ = 22.2%. Highest-skilled workforce of the three places (46.1% SOC 1-3). Not a deprived community by national standards, but less affluent than the Windermere catchment.	High 18.8% of LSOAs in IMD Decile 1; 31.3% in Health Deprivation Decile 1 (IoD 2025). 77.9% good/very good health vs 82.7% Windermere (Census 2021 TS037).; most deprived LSOA ranked 32nd nationally for health. Median net household income £31,141 (ONS FYE 2023); lowest MSOA £23,831. 53.3% of households deprived in 1+ dimensions; 20.5% in 2+ dimensions.
Existing infrastructure hosting burden	Low Windermere WwTW is the subject of ORiW remediation; the problem being addressed, not an additional burden. No major industrial, port or defence infrastructure.	Medium North Lonsdale Road site carries 75-year pharmaceutical manufacturing legacy (GSK, closed 2025; acquired by BAE Systems October 2025). Plans for the 96-acre site expected 2026 but not yet published. No planning application submitted as of May 2026. Canal and estuary context. Land-use complexity is the key risk.	High Barrow WwTW (Headin Haw) PE ~73,000 with multiple CSO improvement rounds since 1995. Port of Barrow; Devonshire Dock Hall (nuclear submarine construction); Walney offshore wind; nuclear and energy infrastructure; flood and coastal exposure. Highest existing infrastructure concentration of the three places.
Construction disruption sensitivity	High 46.1% of resident workforce in distribution, hotels and restaurants (Census 2021 RM063). 78% of ~2,200 non-residential catchment properties are hotels and hospitality. A591/A592 tourist corridor — full closure with diversions up to 5x normal route length. Seasonal constraint restricts rising main to ~5 months/year, extending programme to 4–5 years. Duration of disruption is as damaging as its intensity in this economy.	Medium Not a primary visitor economy. 19.3% of resident workforce in distribution/hotels/restaurants vs 46.1% Windermere. A590 corridor interface introduces National Highways as a key stakeholder. Lower sensitivity than Windermere but land-use transition context introduces risk.	Low–Medium Industrial and port character means construction more readily absorbed than in Windermere. No peak tourist season constraint on working window. However, disruption to a health-vulnerable community (77.9% good/very good health; 31.3% LSOAs in Health Deprivation Decile 1) carries greater place impact per affected household.
Long-term benefit alignment	High; direct All options improve Windermere water quality and lake amenity above AMP8. Primary beneficiary	Unconfirmed; Mixed Canal Foot opportunity is plausible but unconfirmed. Not attributable to ORiW without direct evidential link.	Unconfirmed' Mixed Team Barrow and BAE growth are real but driven by defence procurement, not ORiW. Not attributable

Fairness dimension	Windermere / Bowness / Ambleside	Ulverston	Barrow-in-Furness
	of ORIW regardless of option. Benefit confirmed and quantified.	On current evidence, Ulverston hosts burden for benefits realised elsewhere.	without a direct link. Barrow currently hosts burden for benefits realised in Windermere.
Overall Pillar 3 fairness position	Beneficiary community Receives construction disruption but confirmed direct long-term benefit. Burden and benefit locally aligned across all options.	Intermediate host Not a deprived community. Fairness concern moderate and contingent on local benefit confirmation. Could move to Acceptable if Canal Foot confirmed.	Most exposed host Most deprived and health-vulnerable of the three places. Highest existing infrastructure burden. Fairness concern is highest - requires the strongest benefit case.

3.4 Three-point scale (Red/Amber/Green – “RAG”) methodology and rating definitions

This section sets out in full how the ratings used throughout the chapter were arrived at.

Ratings are judgement-based assessments of the combined balance of four factors:

- Community vulnerability of the affected place;
- Existing infrastructure burden already hosted there;
- Sensitivity to construction disruption during the build period; and
- Evidence of direct local benefit being received in return for hosting burden.

They are not derived from a weighted scoring model. They should be read as initial-stage characterisations subject to revision as evidence develops in later programme development stages.

3.4.1 Recap of the three-point scale/Red Amber Green Rating

The rating scale used is as follows

Table 3.4: Three-point scale

Rating	Meaning
Green	Burden and benefit fall on the same host community, and the host is not nationally deprived.
Amber	A mixed but defensible position: burden is exported to a community of comparable vulnerability, or a direct local benefit case is not yet established.
Red	Burden transferred to a host whose vulnerability is materially higher than the beneficiaries, and a direct local benefit case is not yet evidenced.

A Green rating does not mean no impact. An Amber or Red rating does not mean an option is unacceptable - it identifies where the strongest mitigation and local benefit case is required.

3.4.2 How professional judgement was applied

Ratings are not the output of a scoring model. They are professional judgements made by reference to the framework set out above, applied consistently across all options. The decision rule below records the conditions under which each rating threshold was applied. It is provided to make the judgement auditable, not to produce a deterministic outcome. These ratings were used to inform a broad discussion, to support prioritisation of options to be further investigated.

Table 3.5: Rating decision rules

Rating	Decision rule applied
Green	Applied where the option produces a clearly better balance than the post AMP 8 baseline across all four factors: low or unchanged community vulnerability exposure; no transfer of the burden to a more vulnerable host; construction sensitivity moderated or contained; and direct local benefit confirmed and evidenced. No option in this assessment meets this threshold at the current appraisal stage. Green is reserved for cases where the evidential case for proportionate distribution and benefit alignment is positively established, not merely absent of concerns.
Amber	Applied where the option produces a mixed but defensible balance: either the burden remains aligned with benefit geography (such as Windermere options), or the burden is transferred but to a host with low community vulnerability (such as Ulverston: 0% LSOAs in IMD Decile 1; 80.9% good/very good health). Construction sensitivity may be high but is moderated by engineering method choice or proportionate to local benefit. Where local benefit is unconfirmed, the opportunity for it to be confirmed is credible on current evidence.
Red	Applied where two or more of the following conditions hold simultaneously: (a) the burden is transferred to a host community whose vulnerability is substantially higher than the primary beneficiary (Barrow: 18.8% LSOAs in IMD Decile 1; 31.2% in Health Deprivation Decile 1 vs 0% Windermere); (b) the host already carries significant existing infrastructure burden (Barrow WwTW PE 73,000, port, defence, energy infrastructure); and (c) direct local benefit case is not evidenced or attributable to ORiW. Red signals that the strongest local benefit case is needed to close the evidential gap — it does not signal unacceptability.

3.5 What Pillar 3 covers and what it does not

Pillar 3 considers the distribution of impacts between places and communities. It does not, on its own, decide which option is preferred. Several themes overlap with other pillars:

- construction disruption to the visitor economy also appears in the Economic Case (Pillar 1) and in deliverability (Pillar 4);
- regeneration potential at Ulverston or Barrow could be considered under Economic Case, social value, or place-based distribution.

Where overlap exists, Pillar 3 considers only the place-based and distributional dimension. The full picture comes from reading Pillar 3 alongside the other pillars rather than in isolation.

Pillar 3 does not consider:

- Total welfare value or benefit-cost ratio (Pillar 1 / Economic Case).
- Capital and operating cost efficiency (Pillar 2 / commercial and financial case).
- Engineering deliverability, programme risk and operational resilience (Pillar 4).
- Environmental performance against discharge consent or ecological objectives (covered as a part of Pillar 1, 4 and as a part assessment against Critical Success Factors)

These belong in their own pillars. An option that rates Amber or Red under Pillar 3 may still be the preferred option overall if the wider case is strong enough; an option that rates Amber under Pillar 3 may still be rejected for engineering or cost reasons. Pillar 3 ratings should be read as one input into the overall judgement, not as a verdict on their own.

3.6 Evidence gaps and caveats

The following gaps should be considered to enhance the evidence base around rating options, before the next stage commences. The current evidence is sufficient for the current assessment stage qualitative judgement; however, a final selection of options would require stronger assessment.

Table 3.6: Evidence gaps and caveats

Evidence gap	Why it matters	Priority
BAE Systems North Lonsdale Road (former GSK pharmaceutical facility) planning intent, Ulverston	BAE Systems confirmed acquisition in October 2025 and stated redevelopment plans would be finalised in 2026 (BBC, 2025). No planning application submitted to Westmorland and Furness Council as of May 2026. W&F Local Plan at early stage (Call for Sites 2024; Strategic Housing and Economic Land Availability (SHELAA) in preparation; no draft of the Local Plan in place). Directly affects whether Ulverston options' infrastructure at North Lonsdale Road supports or conflicts with local employment and regeneration. Confirmation of plans could strengthen the Ulverston options.	High for Ulverston options affects distributional rating
Direct and committed local ORiW benefit case for Barrow	Team Barrow and BAE growth are driven primarily by defence procurement, not by ORiW. A direct demonstrable link between ORiW infrastructure and Barrow employment, infrastructure sharing or growth enablement would demonstrate that infrastructure development supports local employment and potentially moderate the red rating; otherwise currently the additional infrastructure requirement in Barrow is not supported by a commensurate employment or local economic growth evidence.	High for Barrow options — swing variable

4 Appendix D: Pillar 4 methodology: Risk, resilience and deliverability

The Pillar 4 assessment considers the deliverability, resilience, consenting, operational and implementation risks associated with the shortlisted options. The assessment has not sought to reproduce the underlying engineering analysis within this Economic Case. Instead, it draws upon a suite of technical reports prepared by Jacobs Mott MacDonald (JMM), which collectively provide the evidence base used to inform the Pillar 4 assessment.

The reports encompass option development, engineering feasibility, operational performance, resilience, water quality outcomes, consenting requirements, environmental constraints, stakeholder considerations and construction impacts. Together, they provide the technical basis for the qualitative assessment of deliverability and implementation confidence presented within the Economic Case.

Table 4.1 summarises the principal documents used to inform the Pillar 4 assessment and their primary areas of relevance.

Table 4.1: Principal evidence sources informing Pillar 4

Document	Purpose and relevance to Pillar 4
ORiW Long List to Short List Report (Jacobs Mott MacDonald, 2026d)	Documents the option development and screening process, including the rationale for selecting the shortlisted options taken forward for detailed appraisal. Relevant across all Pillar 4 themes.
ORiW Option Scope and Feasibility Report (Jacobs Mott MacDonald, 2026f)	Defines the engineering scope, layout, key assets, design assumptions and feasibility considerations associated with each shortlisted option. Forms a core evidence source for deliverability and constructability assessment.
ORiW Operation and Maintenance Strategy (Jacobs Mott MacDonald, 2026e)	Sets out proposed operational arrangements, and operational risks associated with the different options. Informs operational resilience and long-term deliverability considerations.
Technical Note on Resilience: Windermere vs Ulverston WwTW (Jacobs Mott MacDonald, 2026h)	Provides a comparison of resilience considerations associated with alternative treatment locations, including operational flexibility and system performance considerations.
Environment, Stakeholder and Construction Deliverability Report (Jacobs Mott MacDonald, 2026c)	Assesses environmental constraints, stakeholder considerations, consenting requirements and construction-related risks. Forms the primary source for assessment of planning, environmental and stakeholder deliverability.
Rising Main vs Tunnel Constructability Review (Jacobs Mott MacDonald, 2026g)	Examines the practical engineering challenges associated with rising main and tunnel conveyance approaches, including construction methodologies, physical constraints and implementation risks.
Rising Main vs Tunnel Deliverability Comparison (Jacobs Mott MacDonald, 2026g)	Compares the relative delivery risks, programme implications and implementation considerations associated with rising main and tunnel solutions.
Future Permit Setting Assessment of Impact on Water Quality (Jacobs Mott MacDonald, 2026b)	Considers the performance of options under future environmental discharge and other permitting requirements and assesses implications for long-term water quality outcomes and regulatory compliance.

4.1 Application within Pillar 4

The evidence sources above were applied according to the aspect of deliverability being considered.

4.2 Constructability

The assessment of construction complexity, programme delivery risk and engineering practicality is informed principally by:

- ORiW Option Scope and Feasibility Report (Jacobs Mott MacDonald, 2026f)
- ORiW Operation and Maintenance Strategy (Jacobs Mott MacDonald, 2026e)
- Rising Main vs Tunnel Constructability Review (Jacobs Mott MacDonald, 2026g)

4.3 Consenting complexity and water quality

The assessment of planning risk, environmental constraints, stakeholder considerations and implementation complexity is informed principally by:

- Environment, Stakeholder and Construction Deliverability Report (Jacobs Mott MacDonald, 2026c)
- ORiW Option Scope and Feasibility Report (Jacobs Mott MacDonald, 2026f)

4.4 Operational adaptability

The assessment of operational resilience, future regulatory compliance and long-term performance is informed principally by:

- Technical Note on Resilience: Windermere vs Ulverston WwTW (Jacobs Mott MacDonald, 2026h)
- Future Permit Setting Assessment of Impact on Water Quality (Jacobs Mott MacDonald, 2026b)
- ORiW Operation and Maintenance Strategy (Jacobs Mott MacDonald, 2026e)

The Pillar 4 assessment therefore represents a synthesis of the evidence contained within these technical documents rather than a standalone engineering assessment. As the programme progresses, the findings should be refined and updated using subsequent engineering, environmental and regulatory studies undertaken during Outline Business Case development.

5 Appendix E: Amenity assessment methodology

Appendix E forms part of the Pillar 1 assessment and should be read alongside Appendix A, which sets out the methodology used to assess the remaining environmental, social and economic impacts and benefits.

Amenity benefits represent the largest monetised benefit identified within the ORiW Economic Case and are estimated using a distinct willingness-to-pay (WTP) and value transfer methodology. This Appendix sets out the evidence base, assumptions and methods used in that assessment.

The amenity valuation draws on a structured evidence review of research into the valuation of environmental outcomes for water bodies. The approach is broadly aligned with methods applied within the Water Industry National Environment Programme (WINEP), whilst being tailored to the specific characteristics of Windermere and the evidence available for the study area. Recommendations for further development of the amenity assessment, including opportunities to strengthen the evidence base through primary research including WTP research, refinement of transfer assumptions and consideration of currently unquantified benefits, are set out in Section 5.7.

5.1 Evidence base used

5.1.1 Valuation

The amenity valuation is based on a benefit transfer from a primary WTP study, with supporting literature used to inform the application of key assumptions and adjustment factors.

Valuing inland blue spaces: A contingent valuation of two large freshwater lakes (McDougall, 2020)

This study values protection of lakeside quality at two large Scottish lochs, Loch Lomond and Loch Leven, covering lake views, path quality and shoreline access. The author's preferred mid-point WTP using interval regression is £18.72 per household per year for Loch Lomond. The study also reports a higher mid-point WTP estimate of £21.76 per household per year from an alternative model specification and a lower bound estimate of £12.06 per household per year (2019 prices). The study also finds that values decline with distance from the lake, although it does not report a method that could be transferred to ORiW. This valuation captures both use values (recreational and amenity benefits to visitors) and non-use values (existence and bequest values) associated with maintaining lakeside environmental quality. Like Thames Tideway Tunnel (further below), this study supports the view that iconic waterbodies can generate values beyond local users. That point is arguably conservative for Windermere, given its status as England's largest natural lake, its location within the Lake District National Park, and its identity within a UNESCO World Heritage Site. Because the McDougall value is derived from a Scottish context with a broader stock of nationally recognised lochs, applying it to Windermere is arguably a cautious choice. The valuation also captures only lakeside visual and shoreline amenity, rather than WTP to reduce contamination from litter, sewage or combined sewer overflow (CSO) inputs directly, so using the McDougall mid-point interval regression value as the central estimate is reasonable and defensible.

5.1.2 Distance

A distance-decay adjustment was applied to reflect the decline in attachment and use values with increasing distance from Windermere. The following paper was used to inform the distance-decay assumption adopted within the appraisal.

Update Of The Economic Valuation of Thames Tideway Tunnel Environmental Benefits (Defra, 2015)

In addition to reviewing the underlying WTP estimate, consideration was also given to the treatment of distance-decay. A distance-decay coefficient of -0.003, derived from the Thames Tideway Tunnel study, has been applied within the appraisal. The coefficient was assessed alongside alternative evidence (See section 5.2.2) to verify that both the magnitude and spatial distribution of benefits were reasonable and proportionate for the Windermere context.

5.1.3 Income

An income adjustment was applied to reflect differences in WTP associated with variations in household income. The following paper was used to inform the income elasticity assumption adopted within the appraisal.

Global Evidence on the Income Elasticity of Willingness to Pay, Relative Price Changes and Public Natural Capital Values (Drupp, et al., 2025)

(Drupp, et al., 2025) undertakes a global meta-analysis of 735 income-WTP observations from 396 contingent valuation studies to estimate how WTP for ecosystem services changes with income. The authors find a central income elasticity of 0.6, indicating that a 10% increase in income is associated with a 6% increase in WTP for environmental improvements. This elasticity is applied in Equation 3 in section 5.4.

5.2 Evidence base reviewed

5.2.1 Valuation

In addition to (McDougall, 2020), a range of studies were reviewed to support the amenity assessment, and verification of the final value used. These studies were not selected as the primary value transfer as they were deemed less relevant to the environmental good being measured – either due to differences in environmental goods, waterbody types or policy contexts. However, they provide useful supporting evidence and have been used to verify the preferred valuation approach, helping to assess the credibility and conservatism of the adopted central estimate. Table 5.1 summarises the key studies reviewed and their relevance to the ORiW amenity assessment. Further details on selected studies within the wider value transfer literature are provided in Appendix F.

Table 5.1: Other WTP evidence reviewed but not used

Study	Method	Policy good valued	Unit value (source year)	Unit value (£, 2025)	Role in appraisal and relevance to ORiW
Thames Tideway Tunnel (Defra, 2015)	Contingent valuation	CSO reductions on tidal Thames	£25–£59 per household per year	£35 - £82 per household per year	Demonstrates WTP for reductions in sewage pollution and improvements in river water quality, recreation and environmental outcomes. Used as a precedent for considering wider household values associated with waterbody improvement. To note, Thames Tideway Tunnel had a materially different baseline to Windermere, associated with dissolved oxygen, fish mortality, sewage, litter, odour, and health risks for river users.
(Metcalf, et al., 2012)	Stated preference discrete choice experiment and contingent valuation	WFD ecological status improvements	£2,263–£39,168 per km ²	£3,265–£56,519 per km ²	Provides estimates of household WTP for Water Framework Directive ecological improvements; used as a lower benchmark for comparison with the preferred value transfer.
(Zhang & Sohngen, 2018)	Choice experiment	Reduction in harmful algal blooms	\$40–\$60 per trip	£39 - £59 per trip ⁴	Demonstrates increased visitation associated with reductions in harmful algal blooms and improved water quality; used as a recreational plausibility check.
(Hunter, et al., 2012)	Contingent valuation	Cyanobacteria bloom morbidity risk reduction	£9.99–£12.23 per household per year	£14.42 - £17.65 per household per year	Demonstrates WTP for reductions in health risks associated with cyanobacterial blooms; used to test whether health-related water quality benefits are consistent with the central estimate.
(Veronesi, et al., 2014)	Choice experiment	Reduction in ecological and health risks from CSOs in rivers and lakes and wastewater flooding	Around 71% of respondents willing to pay a higher annual local tax	n/a – no single transferable unit value used	Demonstrates WTP for reductions in ecological and public health risks associated with wastewater pollution. Used as supporting evidence for the broader direction and plausibility of the amenity valuation

5.2.2 Other studies reviewed to inform the final methodology

While the studies reviewed in this section were not used directly within the final appraisal, they provided an important evidence base for testing, validating and benchmarking the assumptions adopted in the assessment.

How Distance Influences Residents' Willingness to Pay for River Protection: Empirical Evidence Based on Contingent Valuation Method (Cai, 2025)

(Cai, 2025) finds a clear distance-decay effect in WTP for river protection. Households closest to the river exhibit the highest WTP, with mean values falling noticeably across successive distance bands (e.g. 180 → 128 → 108 ¥ per year). It also shows that drivers of WTP change with distance-proximity is a strong

⁴ Converted using an exchange rate of 1 GBP : 1.33 USD

determinant for nearby residents, while socioeconomic factors (e.g. income) become more important as distance increases, indicating spatial heterogeneity in preferences.

Contingent Valuation Model Based on Contoured Willingness to Pay and Empirical Analysis (Gao, 2016)

(Gao, 2016) also finds a clear distance-decay pattern in WTP, with values declining stepwise as distance from the environmental resource increases (from ¥123 to ¥64 per year across concentric zones), confirming that proximity strongly influences valuation.

Is the income elasticity of the willingness to pay for pollution control constant? (Hanley, 2015)

(Hanley, 2015) shows that income elasticity of WTP for environmental improvements is positive but less than one, meaning WTP increases with income, but not proportionally. Empirical estimates vary across income groups, with elasticity around 0.1–0.2 for lower-income households and 0.6–0.7 for higher-income households, indicating that the relationship is not constant and strengthens with income. As the study is based on evidence from Poland, the higher elasticity estimates are associated with households in higher-income settings such as the UK. This implies that environmental quality behaves as a normal good rather than a luxury good, and supports applying income adjustments in value transfer, but using conservative, sub-proportional scaling.

5.3 Preferred valuation approach and alignment with best practice

The literature review suggests that a credible approach is to apply a conservative value transfer from (McDougall, 2020), which aligns with the amenity outcomes experienced by households and is supported by a wider body of evidence regarding the scale of WTP for water-quality improvements. The final amenity outcome is always assessed relative to a baseline position – consequently people participating in these studies are asked to value a change in state. This is arguably a conservative approach, because the (McDougall, 2020) study captures WTP for protecting lakeside quality rather than WTP for removing CSOs, reducing perceived health risks, or avoiding wastewater spill events more directly. Other reviewed WTP studies suggest these additional dimensions can also carry material value.

The EfTEC Thames Tideway Tunnel (Defra, 2015) studies provide the methodological precedent for applying national aggregation to changes affecting iconic water bodies, while (McDougall, 2020) itself shows that households are willing to pay for protection of lakeside quality on a nationwide basis. The National Water Environment Benefits Survey (NWEBS) (Metcalf et al., 2012) is retained as a low benchmark for generic UK WFD ecological-status improvements. NWEBS is widely used in UK water-environment appraisal and provides a useful point of comparison, although it primarily reflects improvements across a broad range of waterbodies rather than the valuation of an iconic lake environment such as Windermere. Zhang, Hunter and Veronesi are used to test plausibility across the recreational, health-risk and spill-risk dimensions. These supporting studies are used to benchmark and bound the core transfer value rather than added to the total, helping the estimates to remain transparent, conservative and grounded in more than one source of evidence.

Alignment with Defra Guidance on Value Transfer⁵: To be consistent with recommendations for use of value transfer, we consider steps set out in (Defra, 2009) guidance. The structure follows the eight steps set out in the guidance's summary checklist. This is further referenced as the foundation for the current Environment and Historic Environment Outcomes Valuation Guidance (Environment Agency, 2023).

⁵ Note: Value transfer refers to the use of existing economic valuation evidence from previous studies to estimate the value of similar environmental changes in a new policy or project context. In this paper, it means using published WTP evidence from relevant lake and water quality studies to inform an indicative estimate of the amenity benefits associated with improving conditions at Windermere, with appropriate caution regarding differences in context and transferability.

Table 5.2: 8-step checklist for applied Value Transfer recommended by Defra

Step	Summary	How this is addressed
1. Establish the policy good and decision context	The valuation supports appraisal for a feasibility stage intervention aimed at preventing deterioration in lake conditions under future climate pressures which exacerbate the effect of eutrophication and contamination from urban runoff, spills and treated wastewater. Primary valuation would be resource-intensive and disproportionate at this stage – but recommended at the next stage. The need for value transfer above standard values (i.e. WEBS) was tested with the Environment Agency, given the unique status of Windermere.	A value transfer approach is adopted using the best available UK evidence for comparable final amenity outcomes, with uncertainty and limitations explicitly reported.
2. Define the policy good and affected population	The policy good is defined as the final welfare outcome for households from perception of avoiding climate-driven deterioration in visible lakeside quality (clearer views, absence of scums or odours, maintained shoreline enjoyment, avoidance of adverse health impacts, and access and security of experiencing this into future generations). Beneficiaries from England are segmented into mutually exclusive local, regional and national zones, recognising both use and non-use values for nationally significant assets.	The valuation focuses on the experienced amenity outcome, and the affected population is defined transparently for aggregation.
3. Define and quantify the change in provision of the policy good	Change is derived from the Environment Agency's Nutrient Futures modelling ⁶ under UKCP18 high-emissions projections (RCP8.5), including quantified changes in cyanobacteria bloom exceedance days (WHO10) and water clarity indicators for the South Basin.	A clear baseline and counterfactual ("Climate Change Only") are specified, and the magnitude of change informs conservative scaling assumptions in the transfer.
4. Identify and select monetary valuation evidence	Evidence reviewed and documented in this paper. McDougall et al. (2020) is selected as the primary study valuing lakeside quality at iconic UK lakes using a national sample. Supporting studies ((Zhang & Sohngen, 2018), (Metcalf, et al., 2012)) are used for triangulation and bounding. Studies on bloom-related welfare impacts and benefit-transfer reliability inform adjustments and sensitivity bounds.	The selection emphasises similarity in the welfare endpoint while acknowledging contextual differences and the indirect mapping from biophysical metrics to amenity.
5. Transfer evidence and estimate unit values (with adjustments)	Unit values are transferred from (McDougall, 2020) with explicit adjustments used for distance-decay, conservative downward adjustments to WTP parameters, and a scaling factor reflecting partial correspondence between the study scenario and the Windermere change plus real-world delivery considerations. Adjustments follow recognised sources of transfer error in the literature.	Adjustments are transparent and conservative. Income elasticity adjustments can be applied if relevant e.g. (Drupp, et al., 2025)
6. Aggregate to the policy population and estimate present values	Values are aggregated across mutually exclusive beneficiary zones using consistent household counts and distance-decayed WTP. Green Book discounting is applied to derive present values using the Social Time Preference Rate (STPR). The STPR is 3.5% to Year 30, 3.0% from Year 30 to 75, and 2.50% for all following years. Aggregation applies a distance-decay to represent declining use value the further beneficiaries are from the Lake.	Aggregation and time profiling are clearly stated and consistent with the evidence base and policy good definition.
7. Sensitivity analysis	Sensitivities test parameters materially affecting transfer results, including alternative scaling factors, alternative values, and varied beneficiary population in the high case.	Sensitivities are presented alongside the core estimate to provide transparent bounds on uncertainty.
8. Reporting and audit trail	Documentation covers the policy good, biophysical change, evidence selection, transfer method, adjustments, aggregation, discounting, sensitivities and limitations.	The approach is transparent and auditable, with explicit caveats on benefit-transfer uncertainty and mapping from modelling outputs to amenity.

⁶ Note report is as yet unpublished

5.4 Methodology

5.4.1 Application

Amenity benefits are estimated by applying real household income growth, distance-decay, and income adjustments to WTP values and aggregating per-household benefits across ten beneficiary regions (Table 5.5) in England. The assessment assumes that Windermere generates both use values (associated with recreation and direct enjoyment of the lake) and non-use values (including existence, option and bequest values). Consequently, benefits are not limited to households making direct recreational use of the lake but may also accrue to households that value the continued protection of a nationally significant environmental asset, regardless of whether they visit Windermere directly; this is consistent with the approach used to estimate the value of improvements delivered by Thames Tideway Tunnel.

The total amenity valuation combines the estimated number of households within each assessed region (0) with the relevant adjusted WTP value (5.4.2). The adjusted WTP value is derived by applying both the distance-decay adjustment (5.4.4) and income adjustment factors (5.4.5) to the source WTP estimate.

Equation 1: Total discounted WTP benefits (£, 2025)

$$Total\ PV\ WTP_i = \sum_{t=S_i}^{2125} \left(\sum_{r=1}^{10} HH_r \times WTP \times IG_t \times DD_r \times INC_r \right) \times DF_t$$

where $Total\ PV\ WTP_i$ is the total discounted WTP for option i , HH_r is the number of households in region r , WTP is WTP (£/household/year) presented in Table 5.3, IG_t is the real household income growth in year t , DD_r is the distance-decay adjustment for region r , INC_r is the income adjustment for region r , and DF_t is the discount factor in year t . The distance-decay adjustment factor is calculated using Equation 2 and the income-adjustment factor is calculated using Equation 3. For Westmorland and Furness, both distance-decay and income adjustment factors are equal to 1.00, reflecting the assumption that the local population receives the full unadjusted WTP value. Annual present value WTP is calculated by applying the income and discount adjustments and aggregating across all regions. $Total\ PV\ WTP_i$ is then obtained by summing annual values from the option-specific start year based on its construction end date (S_i) to the final appraisal year (2125).

Amenity benefits are assumed to commence once construction of the option has completed and the water quality improvements have been realised. As construction durations differ between options, the timing of benefit realisation also varies accordingly.

5.4.2 Willingness to pay

The central amenity estimate is based on McDougall et al. (2020), which values protection of lakeside quality at large iconic lakes. For the central case, this provides an annual household WTP value of £25.23 in 2025 prices. This is derived from the £18.72 household WTP estimate reported by McDougall et al, uprated from 2019 to 2025 prices using a GDP deflator (HM Treasury, 2026) and adjusted to reflect income differences between Scotland and Westmorland and Furness (ONS, 2024). The same uprating has been applied to the low and high case figures from McDougall et al. (2020), as shown in Table 5.3.

Table 5.3: Amenity WTP (£/household/year) figures used in the assessment

Case	Value from McDougall et al. (2020) £, 2019	Inflation and income adjusted value, Y0, 2025
Low	12.06	16.26
Central	18.72	25.23
High	21.76	29.33

Table 5.4 shows the adjustments used to derive the inflation- and income-adjusted value from the original value reported by (McDougall, 2020).

Table 5.4: Amenity WTP inflation using GDP deflator and income adjustments

Inflation adjustment from 2019 to 2025	Income adjustment between Scotland and Westmorland and Furness
1.2765	1.0559

5.4.2.1 Real household income growth

The WTP values are adjusted annually to reflect forecast growth in real household income. This is in line with the guidance provided by the Department for Transport (Department for Transport, 2026) that both work and non-work values of time are assumed to increase with income over time. The same principle can be applied to willingness-to-pay estimates, as individuals' valuation of goods and services is also expected to increase as incomes rise.

Household income forecasts are based on (OBR, 2026) projections to 2029, after which growth is assumed to decline linearly to half the 2029 growth rate by 2060 and remain constant thereafter. This is based on various literature suggesting that growth is projected to halve in developed economies in the coming decades, such as reports from the OECD (Reuters, 2023). Annual willingness to pay values are uprated using a household income growth index and an income elasticity of 0.6.

5.4.3 Household numbers

To reflect differences in proximity and income, households are segmented into ten geographic groups:

Table 5.5: Beneficiary regions

Regional segmentation used in the assessment	
1. Local households in Westmorland and Furness	2. Rest of North West
3. North East	4. Yorkshire and The Humber
5. West Midlands	6. East Midlands
7. East of England	8. South East
9. South West	10. London

This segmentation is intended to distinguish between local use and regional split based on differences in distance and income. The number of households in each group is derived from (ONS, 2025) household projections. Household numbers are then projected forward over time using an assumed annual population growth rate (ONS, 2026), ensuring consistency with the appraisal period.

5.4.4 Distance-decay adjustment

WTP values are adjusted to reflect distance-decay, recognising that households' valuation of water quality protection declines with increasing distance from the site. A distance-decay function is applied to all regions, based on empirical evidence from the literature (Section 5.2.2). Local households in Westmorland and Furness are assumed to experience no distance related reduction in WTP.

Distance-decay is informed by a distance-decay coefficient of -0.003 from Thames Tideway Tunnel (Defra, 2015). The same distance-decay function is applied across all valuation scenarios.

The Thames Tideway Tunnel coefficient was selected in preference to alternative distance-decay estimates identified in the literature because it is derived from a large-scale UK water quality improvement programme and therefore reflects preferences observed within a comparable institutional, cultural and environmental context. While other studies reviewed identify different distance-decay effects, these are derived from international case studies, such as (Cai, 2025) and (Gao, 2016), and may therefore be less transferable to a nationally significant English environmental asset. Windermere differs from many local environmental resources because it generates existence, bequest and option values that are likely to extend beyond direct users. Consequently, the Thames Tideway coefficient was considered the most appropriate balance between recognising distance-decay and capturing wider national values.

The Thames Tideway Tunnel approach was also considered more suitable than the distance-decay adjustment applied by (McDougall, 2020). McDougall's analysis was developed for Loch Lomond, where most of Scotland's population lives within relatively close proximity to the site. In contrast, the potential beneficiary population for Windermere is distributed across England, with population centres located

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considerably further from the lake, including London at 370 km from Windermere. The McDougall specification implies a relatively limited reduction in WTP with distance and was therefore considered insufficient to reflect the wider geographic distribution of beneficiaries in the Windermere context. The Thames Tideway coefficient applies a continuous proportional reduction in WTP with distance and was judged to provide a more credible representation of how values are likely to decline across a national population.

For each geographic group, a representative proxy location was selected to approximate the distance between Westmorland and Furness and the population within that region. Locations were chosen to provide a broadly representative point based on the geography and population distribution of each region, shown in Table 5.6. Straight-line distances between the nearest point of Windermere and each proxy location were then used to calculate the distance-decay adjustment. The North West is divided between Westmorland and Furness, which is treated as the local beneficiary area with no distance-related reduction in WTP, and the remainder of the North West.

Table 5.6: Proxy locations and distances used for distance-decay

Geographic group used in the model	Proxy location used for distance	Point on Windermere measured to	Kilometre distance to Windermere
Westmorland and Furness	Windermere	Eastern shore near Queen Adelaide's Hill	-
North East	Durham	Southern outlet near Fell Foot	96
Rest of North West	Warrington	Southern outlet near Fell Foot	112
Yorkshire and The Humber	Leeds	Southern outlet near Fell Foot	110
West Midlands	Birmingham	Southern outlet near Fell Foot	222
East Midlands	Leicester	Southern outlet near Fell Foot	227
East of England	Cambridge	Southern outlet near Fell Foot	316
South West	Bristol	Southern outlet near Fell Foot	327
South East	Reading	Southern outlet near Fell Foot	350
London	Westminster	Southern outlet near Fell Foot	370

Equation 2 was used to calculate the distance-decay adjustment for each of the ten regions with the distance term adjusted accordingly. The distance-decay function generates an adjustment factor between 0 and 1, which is then multiplied by the regional WTP estimate to reflect reduced benefits at greater distances from Windermere.

Equation 2: Distance-decay adjustment factor

$$DD_r = e^{-0.003 \times d_r}$$

where DD_r = distance-decay adjustment for region r , -0.003 was sourced from Thames Tideway Tunnel (Defra, 2015), and d_r = distance in km range from region r to Windermere.

A DD_r value of 1 indicates no reduction in WTP, while smaller values indicate progressively lower WTP as distance increases. For example, at 231 km the adjustment factor is 0.5, implying that the original WTP value has halved. The exponential functional form ensures that WTP declines smoothly with distance and remains positive at all distances, avoiding the possibility of negative valuation estimates.

5.4.5 Income adjustment

WTP values are further adjusted to account for differences in household income between population groups. This reflects the established relationship between income and WTP for environmental improvements, whereby households with higher incomes are generally willing to pay more for a given environmental benefit.

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Applying an income adjustment improves transfer validity by accounting for socio-economic differences between the source study population and the populations affected by the Programme.

Median household income data are used alongside an assumed income elasticity of demand (YED) to derive transferred WTP values that are consistent with the income levels of the populations to which they are applied.

Equation 3: Income adjustment factor

$$INC_r = \frac{Income_r^{YED}}{Income_{W\&F}}$$

where INC_r = income adjustment factor for region r , $Income_r$ = median household income in region r , $Income_{W\&F}$ = median household income in Westmorland and Furness, and YED = income elasticity of demand applied to environmental goods.

The YED parameter was derived from (Drupp, et al., 2025), which reports an estimate of 0.6 for ecosystem services. This implies that a 10% increase in income leads to a 6% increase in WTP for environmental improvements. For simplicity and consistency, a single YED value is applied across all beneficiary groups rather than adopting different elasticities for local, regional and national populations. (Drupp, et al., 2025) undertook a global meta-analysis of 735 income-WTP observations drawn from 396 contingent valuation studies covering a wide range of ecosystem services. The study identified a central income elasticity estimate of approximately 0.6 and provides one of the most comprehensive and up-to-date evidence bases currently available for ecosystem service valuation.

The selected value was preferred to the income elasticity estimate of 0.407 derived from the Thames Tideway Tunnel stated preference study (Defra, 2015). Whilst the Thames Tideway Tunnel estimate was developed within a UK water quality context, it is derived from a single site-specific valuation study focused on the River Thames catchment. The study area is centred on London and the South East, which contain some of the highest household income levels in England. As a result, the estimated elasticity reflects the relationship between income and willingness to pay within a relatively specific geographical and socioeconomic context. Applying this elasticity directly to a national appraisal of Windermere may not fully reflect the characteristics of the wider beneficiary population. In contrast, the estimate reported by (Drupp, et al., 2025) is derived from a substantially larger sample of ecosystem service valuation studies and is therefore considered to provide a more robust and transferable basis for appraisal across different environmental contexts.

The Thames Tideway study treated distance and household income as separate determinants of WTP, and a similar approach has been adopted in this assessment. However, the relationship between income and distance differs between the two case studies. In the Windermere context, some regions with higher average household incomes are located further from the lake than the reference region. Consequently, distance-decay and income adjustments may act in opposite directions for certain regions. Applying these adjustments independently allows regional WTP estimates to reflect both proximity to Windermere and differences in household income, without imposing a fixed relationship between the two factors.

The selected value is also consistent with the findings of (Hanley, 2015) who found that the income elasticity of WTP for eutrophication improvements increased with income and reached approximately 0.6 to 0.7 for higher-income households. Although the study is based on evidence from Poland, incomes within the appraisal area are representative of a higher-income economy, supporting the use of an elasticity value at the upper end of the range.

5.5 Sources

Table 5.7 summarises the sources of the key assumptions used in this assessment. More detailed descriptions of the literature can be found earlier in this section.

Table 5.7: Sources used in the amenity assessment

Description	Unit	Source
GDP deflator	index	(HM Treasury, 2026)
WTP for protection of lakeside space	£/household, 2025	(McDougall, 2020)
Real household income growth	%	(OBR, 2026)
Number of households	number of households	(ONS, 2026)
Annual population growth	%	(ONS, 2026)
Distance-decay rate	coefficient	(Defra, 2015)
Distances between regions and Windermere	km	Google Earth
Median income (Westmorland and Furness, other regions of UK)	£, 2023	(ONS, 2024)
Income elasticity of demand (YED)	exponent	(Drupp, et al., 2025)

5.6 Omitted assessments

The central amenity assessment is intended to provide a robust and conservative estimate of benefits. To avoid overstating value and minimise the risk of double counting, several additional assessments have been undertaken but are excluded from the core estimate. These assessments test the potential scale of wider benefits under alternative assumptions and provide an indication of the upside that may arise if a broader geographic scope or additional benefit categories are considered at later stages of appraisal. The results are presented separately to maintain transparency and allow decision-makers to understand the potential range of benefits beyond the core estimate.

5.6.1 Devolved nations

The appraisal excludes households in Wales, Scotland and Northern Ireland to maintain an England-focused appraisal boundary. The modelling indicates that devolved nations generate material additional WTP, particularly for Scotland due to proximity and higher income. Windermere is more readily accessible to the Central Belt of Scotland, which represents the country's main population concentration, compared to South Wales, where most of the Welsh population is located.

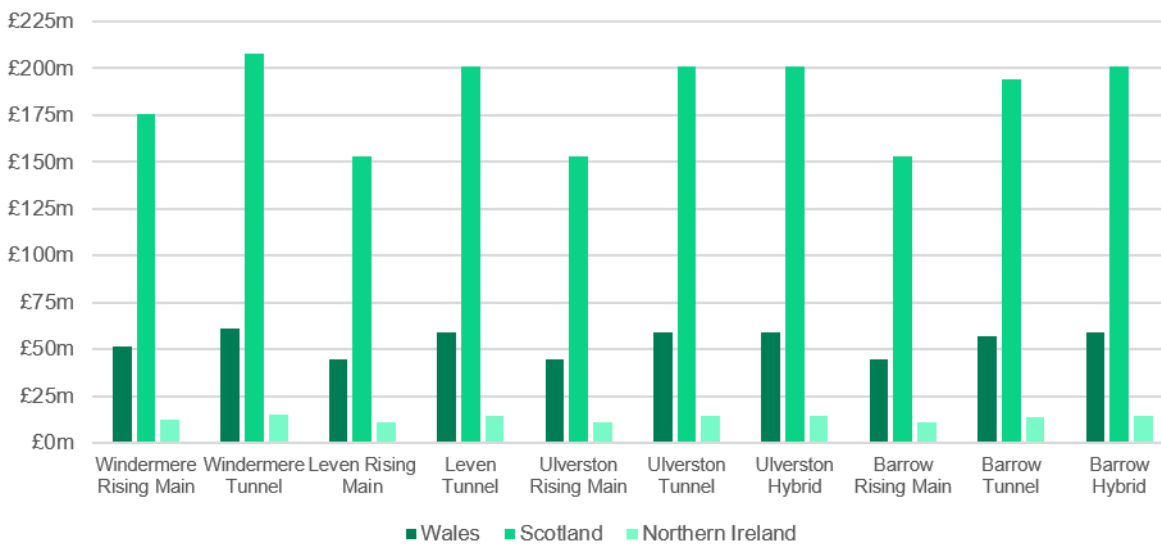
The potential beneficiary population is increased by extending the valuation to include households in Wales, Scotland and Northern Ireland using the same underlying WTP framework, with adjustments for population, income and distance-decay.

- **Population and household projections:** used to scale total WTP
- **Distance-decay adjustment (Section 5.4.4):** reducing WTP with increasing distance from Windermere
 - An additional adjustment was applied to the standard distance-decay function for Wales, Scotland and Northern Ireland to amplify the attenuation effect on WTP. This reflects the assumption that these regions sit outside the primary national catchment and therefore experience a reduced marginal value relative to England.
 - A further adjustment was applied to Northern Ireland to reflect its geographic separation from Great Britain. This accounts for the additional travel and accessibility constraints associated with an overseas location, resulting in a stronger decay effect compared to regions on the same landmass.
- **Income adjustment (Section 5.4.5):** adjusting values to reflect regional disposable income.

Including the devolved nations would increase total benefits, particularly from Scotland due to relative proximity, but would broaden the interpretation of the policy catchment beyond its core definition. This exclusion is therefore applied to avoid overstating benefits. The results are retained separately to demonstrate the potential scale of additional value under a wider national perspective.

Figure 5.1 presents the distribution of omitted WTP benefits across devolved nations and options.

Figure 5.1: Omitted amenity WTP benefits by option and region (PV, 2025)



5.6.2 Tourism

A separate assessment was undertaken to quantify potential increases in tourism associated with improved water quality. However, these tourism and recreational benefits are excluded from the central case to avoid potential double counting, as some or all these welfare effects may already be captured within households' WTP for improved environmental quality.

This builds on literature evidence, with (Börger, 2021) providing an estimated consumer surplus of €50.55 per recreational visit to blue space sites, which has been directly transferred to Windermere after being uprated to 2025 prices and converted to pounds sterling (£52.29 per visit). This represents the average net benefit per visit above travel costs, capturing the additional value visitors derive from the recreational experience. The increase in Windermere related tourism benefits is then calculated as:

Equation 4: Total discounted value of increased tourism (£, 2025)

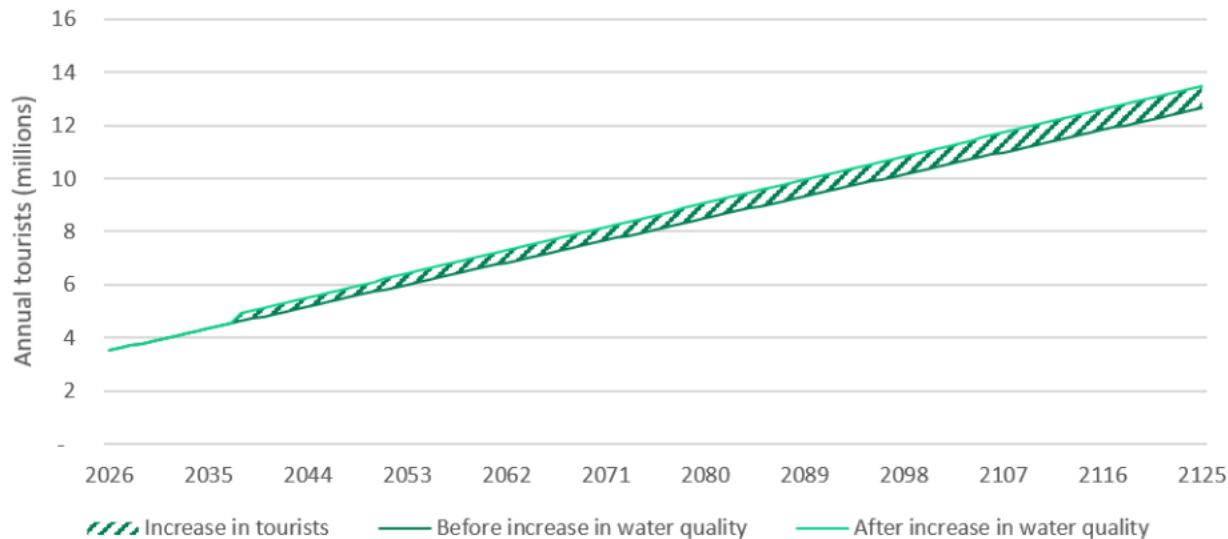
$$Total\ PV\ tourism_i = \sum_{t=S_i}^{2125} T_t \times U \times CS \times DF_t$$

where $Total\ PV\ Tourism_i$ is the total discounted value of increased tourism for option i , T_t is the forecasted tourist population in year t from (United Utilities, 2025) demand forecasts, U is the increase in tourism from a one-level water quality improvement (6.67%, (Börger, 2021)), CS is the consumer surplus per additional visit (£52.29), and DF_t is the discount factor in year t . $Total\ PV\ Tourism_i$ is then obtained by summing annual values from the option-specific start year based on its construction end date (S_i) to the final appraisal year (2125).

Figure 5.2 presents forecast annual visitor numbers to Windermere based on the (United Utilities, 2025) tourism growth projections. The figure compares baseline visitor forecasts with an adjusted scenario incorporating a 6.7% uplift in visitor numbers associated with a one-class improvement in water quality,

based on evidence from (Börger, 2021). The shaded area represents the additional visitors attributable to the water quality improvement over the appraisal period.

Figure 5.2: Annual tourist growth from increase in water quality (Ulverston Hybrid)



Within the omitted assessment, these effects are treated as consumer surplus, with any associated welfare improvements expected to be captured within the amenity assessment. These benefits have been excluded from the appraisal due to uncertainty around the elasticity of visitor demand and to avoid potential overlap with amenity valuation. The figure below presents omitted tourism benefits by option.

Figure 5.3: Omitted tourism benefits by option (PV, 2025)

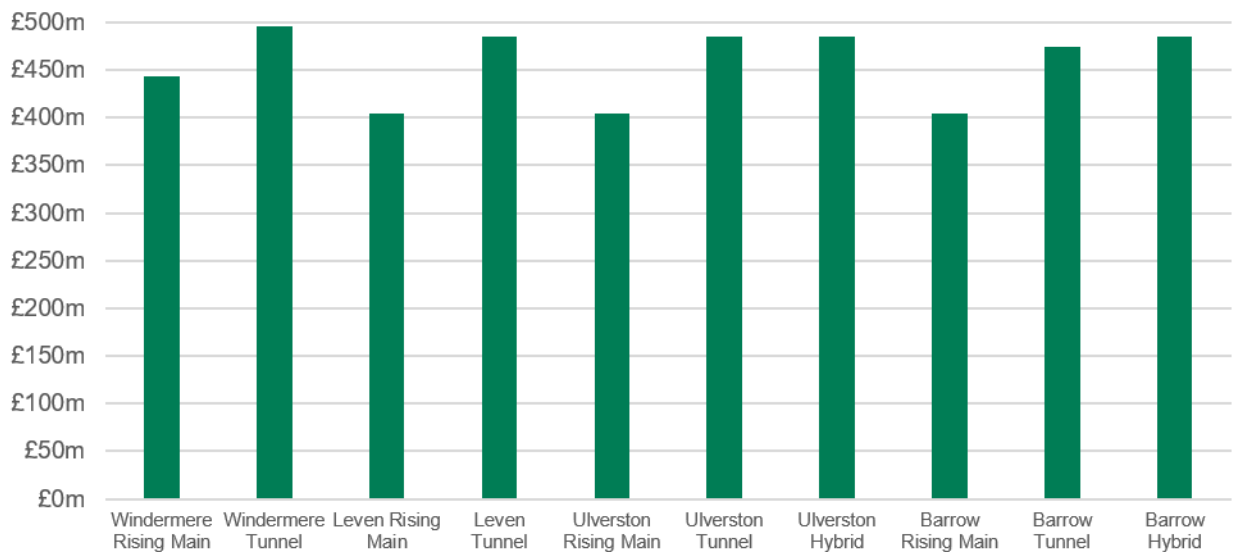


Figure 5.4 presents a breakdown of the estimated tourism benefits by activity type, showing how the total value is distributed across different forms of recreation associated with improved water quality at Windermere. Data on activities visitors to the Lake engaged in is taken from The State of Windermere in 2024 report (Freshwater Biological Association, 2024).

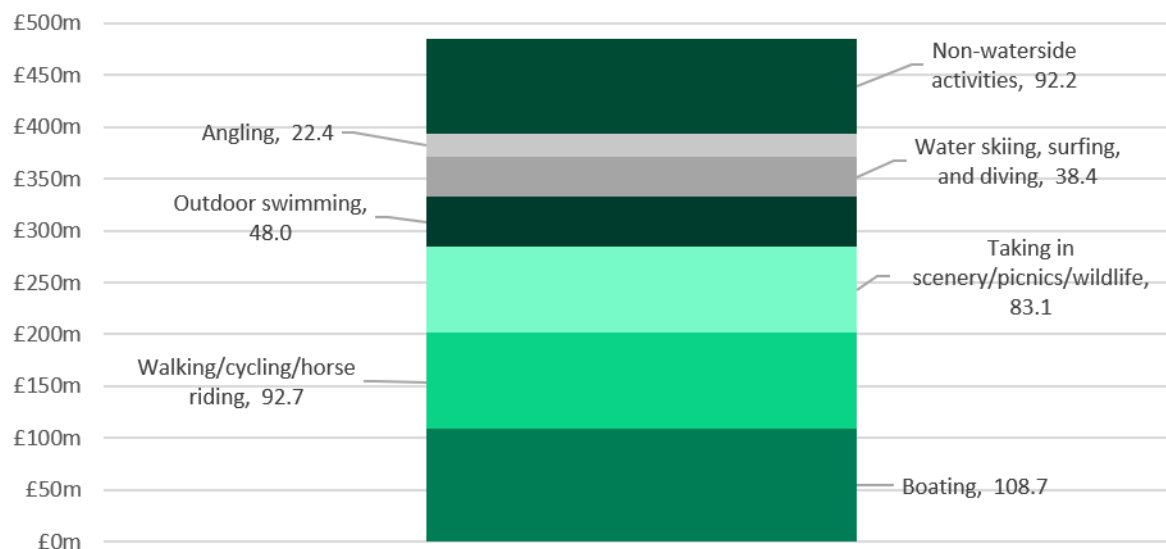
The figure indicates that boating (£108.7m) and walking, cycling and horse riding (£92.7m) account for the largest shares of tourism benefits, reflecting the strong reliance of visitor activity on access to and enjoyment of the lake and surrounding landscape. A similarly significant contribution arises from passive recreation activities such as taking in the scenery, picnics and wildlife viewing (£83.1m), highlighting the importance of general environmental quality for a broader visitor base.

More specialised water-based and contact activities contribute smaller but still material shares, including outdoor swimming (£48m) and water sports such as water skiing, surfing and diving (£38.4m). Angling

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(£22.4m) represents the smallest proportion, although still providing a notable contribution to overall tourism value.

Figure 5.4: Breakdown of tourist assessment (Ulverston Hybrid) (PV, 2025)



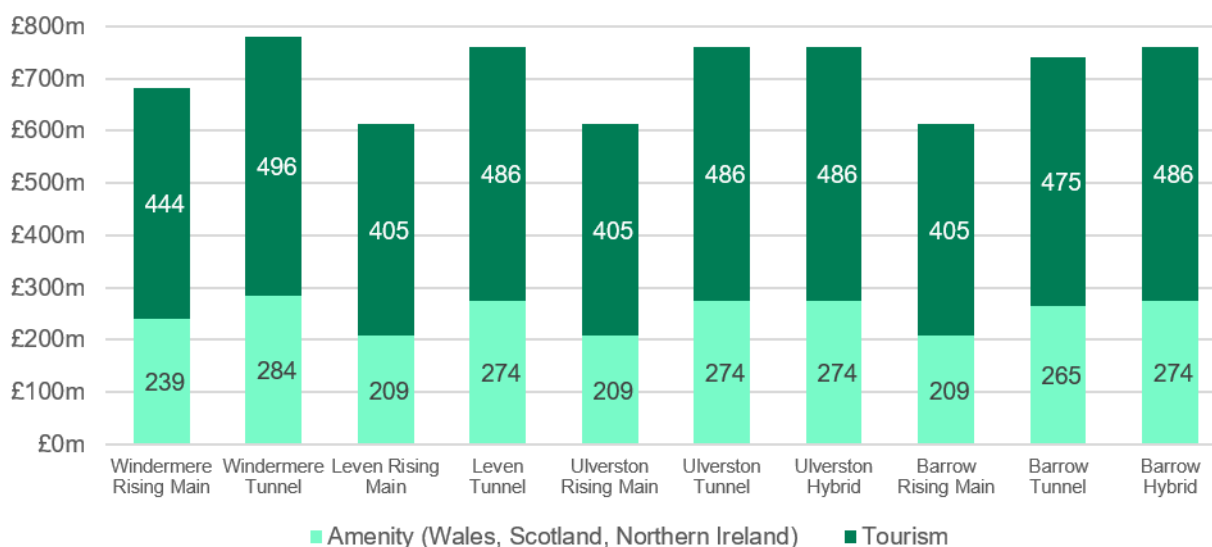
5.6.3 Summary

The amenity valuation has been designed to produce a prudent central estimate. The approach adopted is prudent in two ways:

- First, the appraisal adopts a single household WTP value drawn from (McDougall, 2020) using the preferred Loch Lomond estimate using interval regression as the central transfer value. This is because it reflects WTP to protect general lakeside access and views quality, rather than the potentially broader value people may place on avoiding sewage-related contamination, algal blooms, odours and associated health-risk perceptions.
- Second, the appraisal applies a structured approach to excluded benefits. Amenity impacts for households in Wales, Scotland and Northern Ireland are excluded from the appraisal to maintain a conservative geographic scope and avoid overstating benefits. Tourism and recreation impacts are excluded to avoid potential double counting with household WTP estimates.

Taken together, these choices mean the central estimate should be interpreted as a defensible central estimate for the programme's amenity benefits. If a less conservative transfer value were adopted, the amenity benefits would increase by £914m to £1.2bn (~16%), depending on the option. If the excluded benefit categories were also included, total benefits could increase by a further around £613m to £780m across options.

Figure 5.5: Summary omitted benefits by option (PV, 2025)



5.7 Reducing uncertainty

For the next stage of analysis, the priority is to improve the evidence base for distinguishing between core and additional benefits. In particular, the next stage should test whether tourism and wider geographic amenity effects are genuinely additional to household amenity WTP, or whether some overlap remains. It is important to refine the central transfer value by undertaking bespoke local, regional and national surveys including WTP surveys for Windermere and providing stronger evidence on the relationship between specific water quality changes at Windermere and the welfare outcomes experienced by households and visitors. These surveys should also include assessment of customer affordability and acceptability. This would allow the appraisal to move from a deliberately prudent strategic stage estimate toward a more robust estimate of total economic value at the next stage. This further research is recommended for the next stage of the project. Future research should also consider WTP within the context of rising household costs, including water and energy bills, to test the continued validity of stated preferences over time. Where appropriate, further research could explore whether the estimated values for Windermere are transferable to other lakes within the Lake District that experience similar water quality issues. The research could also explore benefits for Windermere in the context of investment that could be made to deliver benefits in other lakes.

The amenity assessment is specific to Windermere and does not capture potential benefits associated with improvements to other lakes that may also experience algal blooms. Extending the assessment to other waterbodies would require location-specific evidence, as the WTP values applied to Windermere should not be transferred directly. Windermere's cultural significance may generate a comparatively higher non-use value than other waterbodies. Further research or primary valuation evidence would therefore be required to determine whether, and to what extent, benefits could be applied elsewhere.

On that basis, the current central estimate is intentionally prudent, but this is appropriate for the current stage of development, where the priority is robustness and avoiding over-claiming. The sensitivity and omitted-benefit analysis demonstrate that there is likely to be material upside beyond the central estimate, which should be explored further in the next stage of the project.

6 Appendix F: Value transfer literature review

6.1 Environmental outcomes

6.1.1 Water Pollution Natural Capital Calculator, (Environment Agency, 2018)

This calculator is a practical tool for estimating the economic value of improvements in water quality across rivers, lakes, and other freshwater bodies. Developed within the. The calculator applies benefit transfer techniques based on underlying WTP evidence to estimate the value of reducing pollution and improving ecological status. It is aligned with UK Government guidance and offers a consistent method for monetising water quality improvements, although the estimates reflect aggregated ecosystem service values rather than isolating individual components.

6.1.2 A valuation of the natural capital of the Cam and Ely Ouse catchment, (vivedeconomics, 2017)

This study provides unit values for water abstraction across a range of sectors, expressed in £ per cubic metre. It includes estimates for industrial and commercial use, energy production, and public water supply, as well as a specific category for environmental abstraction. This latter category captures uses such as river and wetland support, transfers between water sources, and pollution remediation activities. The values are derived from a combination of Defra data and supporting economic evidence, allowing for differentiation between types of water use. As a UK-based catchment study, it offers relevant and structured valuation inputs for water-related ecosystem services, although the estimates remain specific to the Cam and Ely-Ouse region.

6.1.3 Economic Assessment of Freshwater, Wetland and Floodplain Ecosystem Services, (Morris & Camino, 2011)

This study provides valuation estimates for inland wetland ecosystem services, expressed in £ per hectare per year (2010 prices). It presents both average values of benefits provided by wetlands and marginal benefits associated with increases in wetland extent. The study quantifies a range of ecosystem services, including flood control and storm buffering (£608 per ha per year), surface and groundwater supply (£2 per ha per year), and water quality improvement (£436 per ha per year). It also provides estimates for non-consumptive recreation (£122 per ha per year), amenity and aesthetic benefits (£339 per ha per year), and biodiversity (£454 per ha per year). These values are derived using benefit transfer approaches and provide a comprehensive set of unit estimates for wetland-related services, although they represent aggregated averages across sites.

6.1.4 Valuation of greenhouse gas emissions: for policy appraisal and evaluation, (DESNZ, 2021)

This guidance provides the UK Government's official carbon values for use in appraisal, expressed in £ per tonne of CO₂ equivalent. These values represent the social cost of greenhouse gas emissions and are aligned with the Green Book (HM Treasury, 2026).

6.1.5 Is UK Agriculture Sustainable? Environmentally Adjusted Economic Accounts for UK Agriculture, (Hartridge & Pearce, 2001)

This study provides estimates of the environmental costs associated with greenhouse gas (GHG) emissions from agriculture, expressed in £ per tonne of CO₂/GHG. It presents marginal damage costs per tonne of emissions, reflecting the social cost of environmental degradation caused by agricultural activities. These values can be interpreted inversely in the context of natural capital appraisal, meaning that the sequestration of greenhouse gases represents a benefit of equivalent magnitude. The estimates are derived using economic valuation techniques grounded in WTP evidence and early environmental accounting approaches, although they are relatively dated and subject to uncertainty in both valuation methods and underlying data.

6.1.6 Storm Overflow Evidence Project, (Stantec, 2021)

This study provides valuation estimates for the ecosystem and social benefits associated with the creation of sustainable drainage systems (SuDS), expressed in £ per hectare per year (2021 prices). It presents a range

of values, with low estimates including air quality benefits (£115 per ha per year), amenity benefits excluding property price effects (£1,502 per ha per year), and biodiversity benefits (£11 per ha per year). Additional estimates are provided for carbon sequestration (£37 per ha per year), education benefits linked to learning about urban water systems (£114 per ha per year), and health benefits (£2,355 per ha per year). The largest quantified benefit relates to flood risk reduction (£5,465 per ha per year). These values are derived from a synthesis of evidence and represent the multiple co-benefits of SuDS interventions, although they reflect aggregated ecosystem service impacts.

6.1.7 Valuing Environmental Impacts: Practical Guidelines for the Use of Value Transfer in Policy and Project Appraisal, (Defra, 2010)

This study provides guidance on the application of value transfer methods in environmental policy and project appraisal, setting out best practice for adapting existing valuation evidence to new contexts. It outlines key approaches to transferring WTP values across sites, emphasising the importance of accounting for differences in environmental characteristics and population preferences. The report includes case study applications, such as catchment management interventions, and presents indicative valuation ranges for environmental impacts including carbon and ecosystem services. It provides a structured framework for implementing value transfer in a policy setting, although some of the underlying valuation estimates have since been superseded by more recent government guidance.

6.1.8 Environmental Costs of Freshwater Eutrophication in England and Wales, (Pretty, 2002)

This study examines the environmental costs of freshwater eutrophication, including the loss of recreational and amenity value associated with reduced water quality. Drawing on 37 valuation studies from the UK and internationally, it identifies recreational values that are generally within the range of £8 to £20 per person per visit. For its assessment, the study adopts a conservative value range of £8 to £14 per person per visit, in 1999 prices. These values represent consumer surplus associated with water-based recreation and general amenity, including bathing, boating, angling, walking, picnicking and aesthetic enjoyment. The study provides useful supporting evidence on the recreational and amenity value affected by eutrophication, although the estimates are drawn from a range of water bodies and recreational activities rather than being specific to Windermere.

6.1.9 ORVal (Irwell Catchment Study), (University of Exeter, 2026)

The ORVal estimates the recreational value of the water environment, expressed in £ per year, with an estimated welfare value of £32,542,876 per year. The value reflects the total annual wellbeing benefit derived from recreation and tourism activities associated with the water environment. It is based on a travel cost modelling approach that estimates consumer surplus from visits, capturing the value individuals place on access to and use of natural spaces. The estimate represents an aggregate welfare measure at the local area level rather than a unit value and therefore reflects overall recreational demand rather than marginal changes from specific interventions.

6.1.10 Protected Areas in England and Scotland – Lake District National Park Summary Report, (Lake District National Park, 2015)

This study provides valuation estimates for ecosystem services associated with Open Waters, Wetlands, and Floodplains (OWWF) in the Lake District, expressed in £ per hectare of OWWF (2013 prices). It also presents recreation values on a per-user basis, with an estimate of £1.92 per visitor (2013 prices). The analysis quantifies both the physical flow of ecosystem services and their monetary value, covering services such as recreation, water provision, and biodiversity. The study monetises these services to provide both total and unit values for OWWF assets within the Lake District, offering geographically specific and policy-relevant evidence. The recreation component is particularly relevant, as values are directly linked to visitor use of the natural environment.

6.1.11 Valuing the Benefits of Coastal Water Quality Improvements Using Contingent and Real Behaviour, (Hanley, et al., 2003)

This study estimates the benefits of improvements in water quality, expressed in £ per trip (2000 prices), with an estimated consumer surplus of £0.48 per trip. The value reflects the increase in welfare associated with cleaner water, derived from changes in recreational behaviour, including an increase in the number of visits to water bodies. The analysis combines contingent valuation and reveals preference approaches, linking

stated preferences with observed travel behaviour to estimate how water quality influences visitation patterns. The resulting estimate captures the additional value individuals place on improved environmental conditions through increased recreational use and associated travel decisions.

6.1.12 Effects of water quality changes on the recreation benefits of swimming in Finland, (Lankia, et al., 2019)

This study estimates the recreational benefits of water quality improvements for swimming, expressed in € per swimming visit. It provides consumer surplus values associated with different water quality levels, capturing how improvements in environmental conditions influence the value individuals derive from recreational use. The analysis applies travel cost and consumer behaviour methods to link observed visitation patterns with water quality, allowing for estimation of welfare changes per visit. The results demonstrate how recreational value varies with environmental quality, with higher-quality water generating greater consumer surplus for users.

6.1.13 National Water Environment Benefit Survey, (Environment Agency, 2013)

This study provides valuation estimates for improvements in water quality and ecological status, expressed in £ per km² (2012 prices). It quantifies the combined benefits of recreation, amenity, and non-use (existence) values associated with enhancements to the water environment. The values are linked to changes in overall waterbody status (e.g. from 'Bad' to 'Poor', 'Poor' to 'Moderate', or 'Moderate' to 'Good') for coastal, lake, and transitional waters, including those in North West England.

6.1.14 Economic Appraisal of the River Mersey, (Arup, 2016)

This study provides estimates of tourism-related economic activity, expressed in £ per tourist per day (2006 prices), with an average value of £19.79 per tourist per day. The estimate reflects typical visitor expenditure in the North West and includes spending associated with day visits, with additional values also reported for overnight stays. The analysis captures the contribution of environmental improvements to local economic activity by linking river quality to increased tourism and associated spending. As an expenditure-based metric, the value represents economic impact rather than a direct measure of welfare, although it provides useful contextual evidence of the economic importance of recreation and tourism linked to water environments.

6.1.15 Valuing the benefits of species recovery, (Defra, 2022)

This study provides valuation estimates for biodiversity improvements, expressed in 2022 prices as both £ per household per year (for quality improvements) and £ per 1,000 hectares improved (for quantity improvements). It estimates the economic value of changes in biodiversity based on improvements in wild species presence and abundance, capturing quality enhancements to ecosystems, as well as the value associated with increases in the extent of habitat. The analysis is based on stated preference methods, quantifying WTP for biodiversity improvements across the population, and provides a structured approach to valuing both qualitative and quantitative changes in ecological condition.

6.1.16 The Amenity Value of English Nature: A Hedonic Price Approach, (Gibbons, et al., 2013)

This study estimates the amenity value of environmental features, including freshwater bodies, using a hedonic pricing approach based on housing market data, with values expressed in £ house price (2008 prices) and as a percentage increase in house price. It finds a statistically significant relationship between the presence of water and property values, with an estimated increase of £1,926 in house price for each one percentage point increase in water coverage within a Census ward. The analysis captures the implicit value households place on environmental amenities through observed market behaviour, reflecting the capitalised benefits of proximity to water.

6.1.17 Benefit Transfer for Environmental Improvements in Coastal Areas: General vs. Specific Models, (Umea Universitet, 2011)

This study provides valuation estimates for environmental improvements in coastal areas, expressed in Swedish Krona (SEK) per month per household, with a value of 316.60 SEK per month for local households. The estimate is based on a WTP study assessing reductions in the risk of large-scale algal blooms, capturing

the perceived benefits of improved water quality. The valuation reflects non-market preferences for environmental improvements and is derived using stated preference methods.

6.1.18 Statutory Biodiversity Credit Prices, Defra, (Defra, 2026)

This guidance provides market-based valuation estimates for biodiversity, expressed in £ per credit (2025 prices), with a value of £650,000 per credit for high-distinctiveness lakes. The conversion of habitat to area depends on distinctiveness, one hectare does not equate to one unit. The prices represent the cost of statutory biodiversity credits used within the biodiversity net gain framework, reflecting the value assigned to compensating for ecological impacts where on-site mitigation is not possible. The values can be used as a proxy for the economic importance of biodiversity associated with lake environments, with separate credit prices also available for wetlands and other habitat types.

6.1.19 Water Industry National Environment Programme Methodology (Environment Agency, Defra and Ofwat, 2022)

The WINEP methodology provides the overarching framework for identifying, developing and accessing water-industry interventions that deliver environmental outcomes in England. It supports the use of evidence-led and proportionate appraisal, including the identification of environmental outcomes, assessment of options and consideration of wider environmental benefits. The methodology provides relevant water-sector context for the approach adopted in this assessment, although it does not provide directly transferable unit values for recreational or amenity benefits. It is therefore used as supporting methodological guidance rather than as primary valuation evidence.

6.2 Social outcomes

6.2.1 Green Book supplementary guidance: wellbeing, (HM Treasury, 2021)

This guidance provides standardised wellbeing valuation estimates for use in appraisal, expressed in £ per volunteer per year (2021 prices), with a value of £911 per volunteer per year, assuming the individual undertakes at least one volunteering activity annually. The estimate is derived using the UK Government's wellbeing valuation approach, which translates changes in life satisfaction into monetary equivalents. It provides a consistent and policy-aligned benchmark for valuing volunteering within economic appraisal, offering a more conservative estimate compared to earlier wellbeing studies.

6.2.2 A Survey of Freshwater Angling in England, (Environment Agency, 2018)

This study provides valuation estimates for recreational angling, expressed in £ per fishing trip. It is based on a two-phase approach, with Phase 2 focusing on the economic value associated with changes in the quality of fishing sites. The analysis estimates how variations in key attributes—such as fish abundance, size, and diversity—affect anglers' preferences and behaviour, generating WTP values per trip. The results capture the recreational benefit derived from improved freshwater ecosystems, linking environmental quality directly to user experience and economic value.

6.2.3 Culture and Heritage Capital Evidence Bank, (Department for Digital, Culture Media & Sport, 2022)

The Culture and Heritage Capital Evidence Bank is a compilation of valuation studies covering a wide range of cultural and heritage assets, including historic sites, cultural institutions, and aspects of natural heritage. It provides an accessible database of evidence drawn from both stated preference and revealed preference methodologies, including WTP, travel cost, and wellbeing valuation approaches. The resource is intended to support appraisal by offering a centralised evidence base for valuing cultural and heritage impacts within a capital framework. However, much of the evidence focuses on built heritage and cultural assets, and therefore its applicability to freshwater natural capital may be limited or require interpretation when used in environmental contexts.

6.3 Labour and productivity

6.3.1 Birmingham Natural Capital Accounts, (Birmingham City Council, 2019)

This study provides a framework for incorporating natural capital into urban accounting, including valuation of health benefits associated with access to green and blue space. It links physical activity to quality-adjusted life year (QALY) gains and applies monetary values consistent with Green Book guidance. The approach requires detailed data on recreational use and participation but offers a structured method for quantifying health benefits.

6.3.2 STREAT Tool, (Simetrica, 2019)

This tool provides valuation estimates for wellbeing impacts associated with environmental disruption, expressed in £ per individual per day (2019 prices), with a value of £0.67 per individual per day. The estimate reflects the overall reduction in life satisfaction experienced by individuals living within close proximity (within 500m) to streetworks. It captures an all-encompassing measure of wellbeing loss, derived using subjective wellbeing valuation methods that link self-reported life satisfaction to income equivalents. The value incorporates multiple dimensions of disruption, including noise, congestion, and general inconvenience, and provides a standardised measure of the social cost of temporary environmental disturbance.

6.3.3 Multi-Capitals Assessment of Land Management Options, (Yorkshire Water, n.d.)

This study applies a multi-capital framework to assess the benefits of land management interventions, including impacts on recreation, local economy, and skills development. It incorporates a range of valuation approaches, including expenditure-based estimates and unit cost databases. While the study provides a holistic view of value creation, details of the underlying methodology are not fully transparent.

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