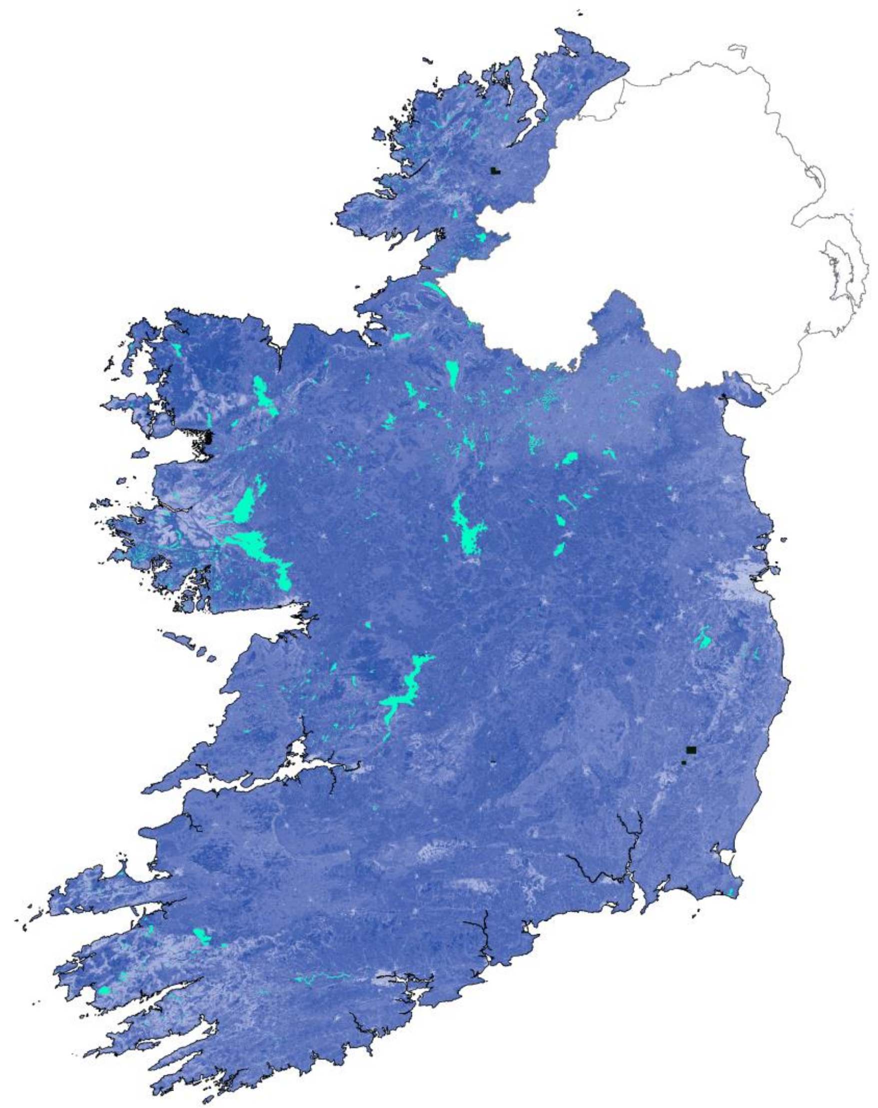
An Roinn
Ealaíon, Oidhreachta agus Gaeltachta
Department of
Arts, Heritage and the Gaeltacht

Land temporarily storing water: Indicator document - Ecosystem Service Modelling & Rule-base development

National Parks & Wildlife Service

Land that temporarily stores water
Ecosystem service: **Regulation of flows (Regulating)**

29/03/2016



Legend

Higher contribution to temporary water storage

Lower contribution to temporary water storage

Freshwater

Compromised data in urban input

How to interpret the map:
Darker colours represent areas that are helping to slow water. The lighter colours represent areas where water is moving quickly through the environment and therefore contributing to flood risk down the catchment.

Ecosystem service:
Regulation and mediation of liquid flows - Land that temporary stores water helping to mitigate flooding

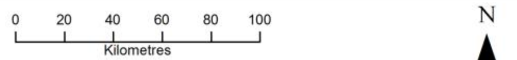
What the service is:
This map shows where the environment is helping to slow the movement of surface water run-off over the land into rivers (also known as overland flow), and where is most at risk of flooding.

Why it is important:
Increased climate variability will increase the risk of both floods and drought, both of which will be mitigated against to varying degrees by vegetation and substrate. For example, habitats such as woodlands have many layers of vegetation, which help slow down the rain drops by friction. Therefore, by the time they reach the ground they have, to some extent, been dispersed and are subsequently travelling slowly enough to sink into the soil.
The other contributing factors are soil type, landform and land management.

How the map was created:
This map was created using a combination of datasets. Habitat information from the derived habitat map, together with slope, soil and geology data have been considered. The soil and geology are also important, as some areas can absorb and hold water whilst others hold very little. Topography is significant, where flat land holds water whilst steep slopes shed water rapidly. The map should be interpreted as showing the best information with the current data available.

Valuation Example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Mediation of liquid flows for flood protection – by land cover, soils and slope.	Vegetation effect on interception	Habitats	Dense vegetation	high
			Sparse vegetation	low
	Infiltration and drainage characteristics of the ground	Soil / geology	Free draining soils and permeable rock	high
			Poor draining soils and impermeable rock	low
	Drainage	Topography	Gentle slopes	high
			Steep slopes	low



Cartography by Environment Systems Ltd, May 2016.
Ordnance Survey Ireland Licence No EN 0059216

Contains data prepared by the Environmental Protection Agency based on Ordnance Survey Ireland information.
For full list of datasets used for this map, please refer to the final project report.

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Department of Arts, Heritage and the Gaeltacht
National Parks & Wildlife Service
Environment SYSTEMS evidence and insight

Indicator	**CICES classification**
AREAS OF LAND THAT TEMPORARILY STORE WATER (FLOOD CONTROL) Section: Regulation & Maintenance	**Class**: Hydrological cycle and water flow maintenance **CICES IE Sub Classes:** Water storage Mitigation of peak flows (esp. winter)
Scale	**CICES Cascade Level[1]**
Strategic/National/~~Regional/Local~~	~~Structure/Function~~/Service/~~Benefit/Value~~

[1]Potschin, M. and R. Haines-Young (2016): Frameworks for ecosystem assessments. In: Potschin, M., Haines-Young, R., Fish, R. and Turner, R.K. (eds) Routledge Handbook of Ecosystem Services. Routledge, London and New York, pp 125-143.

What the service is

Excess water in the landscape can cause flooding events which can lead to severe social and economic consequences. Conversely, too little water over a long period causes drought conditions and water restrictions. The regulation of water is complex and is affected by obvious factors such as climate (rainfall in particular), but also less obvious ones such as topography, soil, vegetation and land cover type (especially sealed surfaces, such as concrete and tarmac).

At its simplest, soil temporarily stores water that falls as rain as it percolates through the system towards rivers and streams, or into the groundwater resource. The ability of soil to perform this function depends on its texture, depth and organic matter content, as well as the overall context of the soil in the landscape. Habitat, through its link to vegetation type and soil type, has an important influence on the amount of overland flow. This is linked largely to the structure of the vegetation present and its effects on infiltration (the process by which water on the ground surface enters the soil). Steep slopes shed water more rapidly than shallow slopes. Steep slopes are also more likely to be in the upper reaches of catchments and are characterised by small streams with rocky banks, which in times of heavy rainfall can quickly rise.

Service indicator(s) mapped

This ecosystem service was mapped using information about habitats, substrate, landform and land management.

Habitat structure influences water quantity regulation through its capacity to intercept water. Habitat structure and species composition also influence soil quality and the time taken for water to infiltrate through the soil, influencing the severity of surface run-off.

Soil structure, the combination of topsoil and subsoil, determines the capacity of soil to hold water and regulate flows; fine-grained soils such as clays have small pores between their particles, and can retain water, depending on their condition. Medium grained, sandy soils have little retention capacity. Organic matter increases the pore size of soils, so that soils with higher organic matter content are able to store more water, and thereby provide greater flow attenuation. Geology also affects water-holding capacity through its influence on soil generation and ground water storage.

Landform has been considered on the basis that steep slopes shed water while basins collect water.

Land management can moderate or enhance each of the other indicators. For example, intense grazing regimes, or trafficking by heavy machinery can lead to soil compaction, resulting in lower soil pore space. A long history of cultivation can degrade the level of soil organic matter through oxidisation.

Datasets used	**Dataset requirements**[2]
Habitat Asset Register[3]	Essential
Teagasc Soil	Essential
Teagasc Subsoil	Essential
National Draft Generalised Bedrock Map	Essential
NextMap 5m DTM	Essential
Article 17 – 6130	Desirable
Article 17 – 5130	Desirable
Article 17 – 2140	Desirable
Article 17 – 2150	Desirable
Groundwater Recharge	Desirable

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

How the map was created

This map was created using a combination of datasets. Habitat information from the habitat asset register, together with slope, soil and geology data have been considered. Soils and geology are important, because some areas can absorb and hold water whilst others hold very little. Topography is also significant, as flat land has the capacity to hold water, whilst steep slopes shed water rapidly.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the national/strategic scale, and a field visit should be conducted before decisions are made regarding a particular location.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring[4]
Above ground habitat structure, especially where there are multiple layers of vegetation. Amount of leaf litter, water uptake through roots, vegetation species type and likely rooting depth leading to, prevention of surface runoff	Habitat Asset Register	Broadleaved woodland	High
		Semi-natural dry grassland	Medium
		Built environment	Disbenefit
Capability to absorb water and hold water	Teagasc Soil	AeoUND (Aeolian (undifferentiated)	High
		AminPD (Acid Deep Poorly Drained Mineral)	Medium
		BminSPPT (Basic Shallow Poorly Drained Peaty Mineral)	Low
Capability to absorb water and hold water	Teagasc Subsoil	Alluvium, Silty	High
		Till, Sandy	Medium
		Esker composed of gravels, Acidic.	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Rate of infiltration and water holding capacity	National Draft Generalised Bedrock Map	Dinantian Lower Impure Limestones	High
		Namurian Sandstones	Medium
		Cambrian Metasediments	Low
Contribution to surface water runoff or storage	NextMap 5m DTM	None	High
		None	Medium
		None	Low
		>18°	Disbenefit
Above ground habitat structure, especially where there are multiple layers of vegetation. Amount of leaf litter, water uptake through roots, vegetation species type and likely rooting depth leading to, prevention of surface runoff.	Article17 - 6130	None	High
		None	Medium
		6130	Low
Above ground habitat structure of Juniper heath	Article17 - 5130	None	High
		5130	Medium
		None	Low
Buffered point data to show where dune heath might help retain water in some sandy soils	Article17 - 2140	None	High
		None	Medium
		2140	Low
Buffered point data to show where dune heath might help retain water in some sandy soils	Article17 - 2150	None	High
		None	Medium
		2150	Low
Speed of water movement through the soil	Groundwater Recharge	None	High
		DRY, High	Medium
		Water, Low	Low

Data gaps associated with this map during the pilot project

This service has been developed using the above available datasets for the key factors available to the project team in autumn 2015. The outputs could be enhanced in the future by integration of higher resolution data from the EPA Integrated Catchment Management plans and OPW CFRAMS programmes respectively.

The data used includes habitat cover, soils, geology and topography. This provides a good indication of how water is naturally stored by different ecosystems.

Inclusion of data such as drainage networks (e.g. non-river channels that water flows through after heavy rainfall events) could be included to determine where exactly water will travel through the landscape. Depth of soils profiles (particularly peat depth) could add a greater level of detail to the mapping of this service.

Incorporation of rainfall data could highlight areas under particular pressure, which could be considered in conjunction with this map to identify which catchments have a high flood risk and why the flood risk in these regions is higher than in other areas.

NOTE – Whilst the Habitat Asset Register (HAR) is based on the best data currently available, it does contain some inherent limitations due to the manner in which LPIS categorises permanent pasture. This may lead to an underestimation of semi-natural grassland and heaths. For details, please refer to the section on data gaps and the section on the preparation of LPIS data for usage in the HAR. Additionally, habitat condition data was not available on a national scale for all habitats, but could form another proxy for ecosystem service provision.

Scientific framework for modelling 'Areas of land that temporarily store water'

Overview	The regulation of water is complex and is affected by a number of factors; climate (rainfall in particular), soils, vegetation and land cover type. There is good supporting evidence regarding the factors influencing this indicator, with the most important material summarised here
Soil	The ability of soil to perform this function depends on its texture, depth and organic matter content, as well as the overall context of the soil in the landscape (Gupta and Larson, 1979; Brady and Weil, 2002; Farmer et al., 2003; Baines, 2008). The role of mineral soils in water regulation depends very much on the clay content within both the topsoil and subsoil horizons, as clay soils impede the percolation of water through the profile, causing the surface of the soil to become waterlogged quickly (Gupta and Larson, 1979; Winter et al., 1998; Brady and Weil, 2002). Conversely, sandy soils have very effective drainage (Small, 1989; Winter et al., 1998) and hold little water (Gupta and Larson, 1979). Soils with high silt content can become 'capped' by an impenetrable layer of particles when they dry out and this again can lead to higher overland flows, even when the soil is not fully at field capacity, i.e. its maximum water retention capacity (Dominati et al. 2010).

	Organo-mineral soils can either act as a water store or a water-shedding resource (Winter et al., 1998) depending on the subsoil clay content (Gupta and Larson, 1979; Ward and Robinson, 1989), the water inputs to the system and slope of the area (Farmer et al., 2003). Heavy clay soils with unstable soil structures resist infiltration and encourage run off (Brady and Weil, 2002). Organic soils are highly absorbent (Baines, 2008) and have high capacity to store water after a rainfall event (Holden, 2005; Acreman et al., 2011; Bain et al., 2011).
	Good information regarding soil composition, particle size, pore spaces, and peat content in Ireland have been recorded by Teagasc (Teagasc Soils Guide[5]; Teagasc, 2007).

[5]http://gis.teagasc.ie/soils/soilguide.php

Soil systems	Peat based wetland systems have a relatively high capacity to absorb high rainfall (Baines, 2008), which in turn reduces the amount of run-off until the peat system is saturated and additional water inputs run off the soil surface (Holden, 2005; Acreman et al., 2011; Bain et al., 2011). Mineral soil systems are very dependent on particle size, organic matter content (Gupta and Larson, 1979; Brady and Weil, 2002) and compaction (Dominati et al., 2010). Mechanical and biological soil management practices, which improve the structure of the soil by allowing more air into the system, reduce compaction and allow the soil to store more water (Brady and Weil, 2002; Lavelle et al., 2006; Bhogal et al., 2009).
Geology	The underlying geology affects the soil type, as it is the parent material which determines the mineral composition and particle size of the soil (Jenny, 1994; Cottle, 2004). Geology also has an effect on topography (Cottle, 2004), the course of rivers and, within rock, throughflow characteristics. These drive the drainage cycle (Small, 1989; Ward and Robinson, 1989) and determine whether an aquifer forms (Fetter, 1994; Winter et al., 1998).
Landform	Steep slopes shed water more rapidly than shallow slopes (Reaney et al., 2011). Steep slopes are also more likely to be in the upper reaches of catchments, which in times of heavy rainfall can quickly rise (Hanna et al., 1982). In the lower reaches, where the land is relatively flat or gently sloping, rivers are generally wider and the flow rate of the water is slower (Small, 1989). When flood waters arrive in the lower reaches, the banks of the river can be breached and water inundates the surrounding flood plains (Middelkoop and Van Der Perk, 1998; Rotherham, 2008).

	The drainage density of an area is significant for the speed with which water travels through the system (Small, 1989). Simple barriers, such as hedgerows, can have a profound effect on the speed at which water moves through the hydrological cycle (Heathwaite et al., 2005).
Habitat	Habitat, through its link to vegetation type and soil type, has an important influence on water quantity. This is linked largely to the structure of the vegetation present. Mature woodland provides the most vegetative benefits to water quantity regulation (Nisbet et al., 2011) through the following processes: • Vegetation cover provides a number of functions in relation to rainfall interception. It dissipates its energy and reduces its erosivity. It delays its movement, increases the opportunity for evaporation or absorption into the soil and allows the soil to store water for longer (Teklehaimanot et al., 1991; Crockford and Richardson, 2000; Farmer et al., 2003; Baines, 2008). • The structural diversity slows overland flows and creates root channels, both of which increases the chance of water infiltrating the soil. • The retention of water in the soil is increased through enhancing organic soil content (Gupta and Larson, 1979; Brady and Weil, 2002) from leaf litter (Melilo et al., 1989; Angers and Caron, 1998; Rasse et al., 2005). In many areas an increase in built up infrastructure (namely concrete or tarmac surfaces) that is unable to absorb rainfall has resulted in the alteration of water flow and increased the risk of surface water flooding (Bolund and Hunhammar,1999; Pauleit and Duhme, 2000; Perry and Nawaz, 2008; Van Wyk, 2014). Biomass and canopy height are important influences on water quantity. The more levels of vegetation structure within the canopy, the higher the interception rate and transpiration potential (Teklehaimanot et al., 1991; Crockford and Richardson, 2000; Viramontes and Descroix, 2003). Additionally, the efficiency of interception of precipitation is influenced by leaf area, which differs between tree species (Crockford and Richardson 2000). The distribution of roots in the soil profile determines how different vegetation types absorb soil water (Brady and Weil, 2002). Deep rooted plants are able to effectively slow water movement (Calder et al., 2008). The root system opens the soil structure, creating a large capacity for water storage (Angers and Caron, 1998; Gyssels et al., 2005; Lavelle et al., 2006). The roots of shallow rooting species, such as annuals, have little effect on water holding capacity.

	Above ground species richness of vegetation can result in varying rooting depths being present in an area (Silvertown, 2004; Mommer et al., 2010) with varying influences on the soil water storage potential (Angers and Caron, 1998; Gyssels et al., 2005; Lavelle et al., 2006). Species diversity can also mean a varied structure of the vegetation present within an area, with several structurally diverse layers of vegetation intercepting more water (Farmer et al., 2003). Macro fauna, especially earthworms, have a strong influence on soil water holding capacity by aerating the soil and maintaining an open structure, which is more effective at storing water (Brussaard, 1997; Carter, 2004; Lavelle et al., 2006).

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