The river basin management plan for the Solway Tweed river basin district 2009–2015

Chapter 1 Appendices

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Appendix A: How was the classification derived?

The natural characteristics of surface waters differ markedly from place to place. For example, rivers in the Solway Tweed river basin district range from the wide, deep and slower flowing rivers, such as the lower Annan, the Tweed mouth and lower Eden, to small, steep, shallow and very fast-flowing rivers. Differences in the characteristics of these waters are mirrored in differences in the plant and animal communities they support.

The classification scheme must be able to take into account these natural variations when assessing the extent to which ecological quality has been changed by human activities. To help do this, the water environment has been divided into types. These types are also comparable across the UK.

The types identified include:

- broad types that describe major changes in the environmental characteristics[1];
- a range of sub-types that reflect the different sensitivities of different plant and animal communities to change in different environmental conditions (water quality, water flows and levels etc).

Information on the methods and associated sub-types can be found on the website of the UK Technical Advisory Group on the Water Framework Directive (UKTAG): www.wfduk.org/bio_assessment/

Classification process for surface waters
The ecological quality of surface waters is classified by monitoring and assessing the condition of a number of indicators of ecological quality (see Table A1). These include a range of water plants and animals as well as environmental conditions necessary for water life:

- good water quality;
- good water quantity;
- good condition of habitats;
- good continuity of rivers for fish migration.

Table A1: Indicators of ecological quality used in classifying water bodies

Water body type	Indicator
River	**Water plants** • Algae that live on river beds • Mosses and flowering plants **Water animals** • Fish • Insects and other invertebrate animals that live at the bottom of rivers or in river beds **Water quality** • Nutrient levels • Oxygen levels

[1] Information on these types can be found in Appendix D to this chapter and the characterisation report for the Scotland river basin district: www.sepa.org.uk/water/water_publications/characterisation_reports.aspx

Water body type	Indicator
	• Acidity • Temperature • Toxic pollutants including priority substances and certain other pollutants identified at European level **Beds, banks and shores** **Continuity for fish migration** **Water flows and levels**
Loch/lake	**Water plants** • Algae and bacteria that live in the water column collectively called phytoplankton • Algae that live on lake beds • Mosses and flowering plants **Water animals** • Insects and other invertebrate animals that live at the bottom of lakes or in lake beds **Water quality** • Nutrient levels • Oxygen levels • Acidity • Salinity • Toxic pollutants including priority substances and certain other pollutants identified at European level **Beds, banks and shores** **Continuity for fish migration** **Water flows and levels**
Estuary	**Water plants** • Seaweeds **Water animals** • Fish • Shellfish, worms and other invertebrate animals that live at the bottom of estuaries or in estuary beds **Water quality** • Nutrient levels • Oxygen levels • Toxic pollutants including priority substances and certain other pollutants identified at European level **Beds, banks and shores** **Water flows and levels**
Coastal water	**Water plants** • Algae and bacteria that live in the water column collectively called phytoplankton • Seaweeds

Water body type	Indicator
	Water animals • Shellfish, worms and other invertebrate animals that live on or in the sea bed **Water quality** • Nutrient levels • Oxygen levels • Toxic pollutants including priority substances and certain other pollutants identified at European level **Beds, banks and shores** **Water flows and levels**

For any particular water body or group of water bodies, the assessments were based on the most sensitive indicator or indicators to each of the pressures on the water body. The most adversely affected of the assessment results was used as the indicator to classify the ecological quality or status of the water body. To make these assessments, monitoring information on the relevant indicators was collected from a large number of water bodies.

Water bodies that were not monitored directly were grouped with others that were. This was done on the basis of information from SEPA and the Environment Agency's analysis of water body characteristics and pressures. Monitoring a representative sub-set of water bodies allowed the agencies to model the condition of other bodies in the group.

A number of water bodies in the Solway Tweed river basin district cross the national boundary between Scotland and England. The agencies agreed a protocol to ensure that the monitoring and classification of these water bodies is co-ordinated and only one agency is responsible for the classification scheme of these water bodies.

The classification results provide the best ever picture of the overall ecological condition of our waters – not just of the condition of the plants and animals used as indicators in making the assessment.

Work is ongoing across the UK to develop the methods necessary to further expand the number of indicators to be used in assessing ecological quality. These additional indicators will include:

- phytoplankton in estuaries;
- sea grasses and flowering plants of salt marshes in both estuaries and coastal waters.

Classification process for groundwater
The process of classifying a body of groundwater involves developing an understanding of how abstractions and inputs of pollutants are affecting groundwater flows, levels and quality and, in turn, the condition of associated surface waters and wetlands. This requires an understanding of the characteristics of bodies of groundwater, including:

- direction and rate of groundwater flow;
- rate at which they are replenished by rainfall;
- their interactions with the surface waters and wetlands to which they are connected;
- protection from pollution provided by their overlying soils and sub-soils;
- nature and location of potential point and diffuse sources of pollution;
- volumes and locations of groundwater abstractions.

An initial assessment of the characteristics of bodies of groundwater was completed in 2004. This was used to inform an analysis of the likely impact of pressures on the status of these water bodies. Since 2004, water bodies identified as 'at risk' on the basis of this analysis have been reviewed as information and understanding of their characteristics and the affects of pressures on their status improves.

To make this easier with respect to the chemical status of bodies of groundwater, a series of threshold values for those pollutants likely to be adversely affecting groundwater quality have been established. Exceedance of a threshold value acts as a further indication that groundwater chemical status may be adversely impacted. Further investigations are then conducted to determine whether or not the body is meeting the criteria required for good groundwater chemical status. Threshold values and information on how they were identified can be found in UKTAG guidance on groundwater chemical classification[2].

There are also a series of risk indicators to help identify potential impacts on groundwater quantitative status and so focus further investigations.

[2] www.wfduk.org/stakeholder_reviews/stakeholder_review_1-2007/LibraryPublicDocs/gw_chemical_classification_paper_final_draft

Appendix B: Classification information by parameter

Table B1: Classification results for rivers

	High		Good		Moderate		Poor		Bad	
Element	**No.**	**Length (km)**	**No.**	**Length (km)**	**No.**	**Length (km)**	**No.**	**Length (km)**	**No.**	**Length (km)**
Overall status	5	39	224	2487	203	2583	65	778	23	296
Overall ecology	5	39	222	2521	199	2505	69	804	25	311
Overall chemistry	3	44	378	4246	5	205	0	0	0	0
Water quality	181	2054	171	2190	132	1574	14	232	0	0
Specific pollutants	97	1422	387	4431	13	196	0	0	0	0
Ammonium	429	5315	20	262	8	72	0	0	1	2
Soluble reactive phosphorus	368	4556	68	837	19	231	3	27	0	0
pH	409	5123	21	241	17	202	11	97	1	7
Dissolved oxygen	425	5324	19	179	6	66	8	82	0	0
Phytobenthos (diatoms)	259	2772	82	1170	61	720	1	10	0	0
Macrophytes	358	3918	29	601	8	126	2	22	0	0
Macroinvertebrates	250	2971	163	2228	40	411	9	101	1	2
Fish ecology	342	3774	36	535	61	1005	29	380	5	53
Hydrology	388	4195	63	1052	34	480	13	128	19	252
Continuity for fish	330	3736	4	44	18	235	27	286	0	0
Beds and banks	15	98	378	4631	92	1012	3	25	2	16

Table B2: Classification results for lochs/lakes

Element	High		Good		Moderate		Poor		Bad	
	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)
Overall status	0	0	7	5	20	32	4	5	4	3
Overall ecology	0	0	4	1	19	28	6	7	6	9
Overall chemistry	0	0	25	31	0	0	0	0	0	0
Water quality	9	11	7	14	13	19	1	1	0	0
Specific pollutants	4	13	25	31	0	0	0	0	0	0
Total phosphorus	13	12	4	14	9	16	3	3	1	1
Acid neutralising capacity	25	38	1	1	1	1	0	0	0	0
Phytoplankton	21	30	7	5	2	9	0	0	0	0
Phytobenthos (diatoms)	26	40	0	0	0	0	0	0	0	0
Macrophytes	23	30	4	1	2	9	0	0	0	0
Macroinvertebrates (Acid-sensitive)	6	23	6	7	1	1	0	0	0	0
Macroinvertebrates (organic sensitive)	4	32	3	10	3	2	1	1	0	0

Table B3: Classification results for estuaries

Element	High		Good		Moderate		Poor		Bad	
	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)
Overall status	5	57	5	27	1	306	0	0	0	0
Overall ecology	5	57	4	26	2	307	0	0	0	0
Overall chemistry	0	0	11	390	0	0	0	0	0	0
Water quality	10	84	0	0	1	306	0	0	0	0
Specific pollutants	0	0	10	387	0	0	0	0	0	0
Dissolved inorganic nitrogen	9	82	0	0	1	306	0	0	0	0
Benthic invertebrates	10	387	0	0	0	0	0	0	0	0

† Overall status includes ecological status and ecological potential assessments.
‡ Chemical elements classified as 'pass/fail' are represented as 'good/moderate'.

Table B4: Classification results for coastal waters

	High		Good		Moderate		Poor		Bad	
Element	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)	No.	Area (km^2)
Overall status†	0	0	7	1871	1	42	0	0	0	0
Overall ecology	0	0	7	1871	1	42	0	0	0	0
Overall chemistry‡	0	0	8	1913	0	0	0	0	0	0
Water quality	2	1512	6	401	0	0	0	0	0	0
Specific pollutants	0	0	8	1913	0	0	0	0	0	0
Dissolved inorganic nitrogen	3	443	5	1470	0	0	0	0	0	0
Benthic invertebrates	4	1470	3	401	1	42	0	0	0	0
Macroalgae	2	401	6	1512	0	0	0	0	0	0
Phytoplankton	8	1913	0	0	0	0	0	0	0	0

† Overall status includes ecological status and ecological potential assessments.
‡ Chemical elements classified as 'pass/fail' are represented as 'good/moderate'.

Table B5: Classification results for groundwaters

	Good		Poor	
Element	**No.**	**Area (km^2)**	**No.**	**Area (km^2)**
Overall status	60	13446	13	2238
Groundwater quality	65	13707	8	1977
Groundwater quantity	63	14655	10	1029
Water resources	72	15493	1	191
Saline intrusion	73	15684	0	0
River impacts	63	14628	10	1029
Wetland interactions	73	15684	0	0
Water balance	72	15493	1	191

Appendix C: Main pressures and impacts

Table C1: Potential impacts of water quality pressure

Presence of:	Water body type	Potential impact	Sectors/ activities contributing to the pressure	Protected areas that may be affected
Nutrients (nitrogen and phosphorus)	Rivers, lochs/lakes, estuaries, coastal waters and groundwaters	• Eutrophication – growth of algae, low oxygen levels at night, change in plant species, loss of biodiversity and loss of amenity • Reduced quality of drinking water	Agriculture/ forestry Sewage and industrial discharges	Drinking waters Freshwater fish Special Areas of Conservation and Special Protection Areas Nutrient sensitive areas
Organic matter and ammonia	Rivers, lakes, lochs, estuaries and coastal waters	• Breakdown of organic matter causes low oxygen levels during the night • Direct toxic impacts from ammonia – can affect the number and type of water invertebrates present	Sewage and industrial discharges Agriculture – particularly livestock	Special Areas of Conservation and Special Protection Areas Freshwater fish
Acidification	Rivers and lochs/lakes	• Acidic deposition – may affect acid sensitive invertebrates and fish under certain conditions	Areas with geology with low buffering capacity – particularly afforested areas of Galloway	Special Areas of Conservation Freshwater fish
Faecal pathogens	Coasts, estuaries and lochs/lakes	Human health impacts due to: • reduced quality of bathing waters • reduced drinking water quality • contamination of shellfish	Sewage discharges that reach coastal/ estuarial waters Agriculture – particularly where livestock have direct access to surface water	Bathing waters Shellfish waters Drinking waters

Substances identified under Water Framework Directive as toxic	Rivers and lochs/lakes, coast, estuaries and groundwaters	• Potentially toxic to aquatic plants and animals • Reduced drinking water quality – potential health impacts • Potential to accumulate up the food chain	Sewage and industrial discharges Urban and road run-off Agriculture/ forestry – herbicides, pesticides and veterinary products including sheep dip Contaminated land Landfill sites Mining (active and abandoned sites) Other activities, eg boat anti-foulants Forestry	Freshwater fish Shellfish waters Drinking waters Special Areas of Conservation and Special Protection Areas
Sediment	Rivers, lochs/lakes	• Sediments and soils entering surface water can smother habitats, eg fish spawning grounds • Pathway for those chemicals bound to sediment to reach water environment, eg phosphorus • Quality of the water supply	Agriculture Forestry Urban and road runoff Sewage disposal	Freshwater fish Drinking waters Special Areas of Conservation and Special Protection Areas

Table C2: Potential impacts of water quantity pressure

Change	Water body type	Potential impact	Sectors/ activities contributing to the pressure	Protected areas that may be affected
Low flows or loch/lake levels caused by abstractions	Rivers and lochs/lakes	• Direct loss of habitat for animals and plants – stranding of fish and loss of animals and plants • Drying out of wetlands at the edge of rivers and lochs/lakes • Rivers have higher temperatures or pollution due to lack of dilution	Hydropower Water supply Agriculture	Special Area of Conservation Special Protection Area
Changes to flow patterns caused by dams and associated abstractions	Rivers	• Downstream sediment movements interrupted affecting fish spawning areas • Frequency or size of large flows needed for migratory fish reduced at key spawning times	Hydropower Water supply	Special Area of Conservation Special Protection Area Freshwater Fish Directive
Barriers to fish migration	Rivers and lochs/lakes	• Migratory fish such as salmon, sea trout, eels and lamprey are unable to access habitat - This reduces the overall population and impacts upon fisheries	Hydropower and water supply Large number of weirs constructed to allow abstraction for industry/ agriculture widespread across the lowlands	Special Area of Conservation Special Protection Area Freshwater Fish Directive
Low groundwater levels	Groundwater and rivers, wetlands and lochs/lakes dependent on groundwater	• Drying out of wetlands and terrestrial habitats dependent upon groundwater • Reduced river flows and loch/lake levels during dry weather • Polluted or salty water drawn into aquifers	Abstractions for drinking water, industry and agriculture	Special Area of Conservation Special Protection Area

Table C3: Potential impacts of physically changing the water environment

Change	Water body type	Potential impact	Sectors/ activities contributing to the pressure	Protected areas that may be affected
Straightening and deepening of rivers	Rivers	• Direct loss of habitat for animals and plants, reducing biodiversity value • Direct loss of the links between habitats • Flood risk is increased by reducing storage of flood water within the system • Resilience to pollution is reduced •	Agriculture Flood risk management	Freshwater fish Special Area of Conservation Special Protection Area
Barriers to fish migration	Rivers, lochs/lakes and estuaries	• Long-distance migration stopped for salmon, sea trout, eels and lamprey • Reduction in fish stock and potential fishery • Limits short distance migration by brown trout, grayling and char (but can also limit spread of invasive species) • Creates isolated populations which are less resilient to environmental change	Dams, weirs and other structures throughout both rural and urban parts of the river basin district	Special Area of Conservation Special Protection Area
Barriers to sediment movement	Rivers, estuaries and coasts	• Dams prevent or limit movement of gravels downstream – spawning areas for salmonids lost (spawning areas for lamprey improved) • Ports and breakwaters divert sediment movement along the cost increases vulnerability to erosion and therefore flooding	Dams, weirs and other structures throughout both rural and urban parts of the river basin district	Special Area of Conservation Special Protection Area
Engineering structures within water environment	Rivers, lochs/lakes, estuaries and coastal waters	• Direct loss of habitat for plants and animals (depending on the scale); may prevent development of normal ecology • Affects the amenity value of water bodies • Land protected from coastal	Bank reinforcements and culverts across urban areas Outfalls, piers, breakwaters across urban	Special Area of Conservation Special Protection Area Bathing

Change	Water body type	Potential impact	Sectors/ activities contributing to the pressure	Protected areas that may be affected
		erosion and tidal flooding at the expense of important coastal habitats – sand dunes, saltmarsh, etc	coastal areas Urban development including roads and bridges	water beaches
Loss of flood plain and intertidal areas	Rivers, estuaries	• Removes link to wetlands and buffer against diffuse pollution. • Increases flood risk by removing flood plain storage. • Removes intertidal areas which are important feeding and spawning areas • Increases risk of erosion and reduces resilience to flooding.	Lowland areas Urban coastal areas	Special Area of Conservation Special Protection Area
Loss of natural bankside vegetation	Rivers, lochs/lakes estuaries coasts	• Causes increased erosion and sedimentation • Direct loss of habitat and reduction of leaf input to rivers (important source of food for insects) • Removes link to wetlands and buffer against diffuse pollution	Intensive grazing of banks of rivers, lochs/lakes and coasts Ploughing up to bankside Intensive forestry plantations up to the edge of rivers	Special Area of Conservation Special Protection Area Freshwater fish
Operation of abstractions and reservoirs	Rivers, lochs/lakes and reservoirs	• Large variation in water levels can lead to a wide scour zone around the edge – this prevents the establishment of plants and spawning of some types of fish	Sites used for water supply and hydropower	Special Area of Conservation Special Protection Area

Table C4: Potential impacts of invasive non-native species

Invasive non-native species	Water body type	Potential impacts
North American signal crayfish (*Pacifastacus leniusculus*)	Rivers	The North American signal crayfish was introduced to Britain as recently as 1970 and was first recorded in the Solway Tweed river basin district in the Dee–Ken system. Once present in a watercourse, its numbers can increase rapidly and it can disperse throughout a catchment. Its presence can have a negative impact on the water body through: • predation on native fauna (invertebrates, fish eggs

Invasive non-native species	Water body type	Potential impacts
		and juveniles); • habitat degradation through burrowing; • impact on freshwater pearl mussel (*Margaratifera margaratifera*); • damage to river banks potentially causing increased erosion and associated risks of flooding, livestock safety and undermining of infrastructure. Once North American signal crayfish are established in a water body they are difficult to eradicate.
Australian swamp stonecrop (*Crassula helmsii*)	Lochs/lakes, reservoirs and rivers	The Australian swamp stonecrop was introduced to Britain in 1911 from Tasmania. In recent years it has spread much more widely and rapidly due to the increased availability of the plant at garden centres and aquatic nurseries. The plant will grow around the damp margins of ponds and in water up to 3m deep. It forms very dense stands, first appearing as a small light green tussock on the sediment. These tussocks grow and spread rapidly to form a dense mat of vegetation. The dense mat out-competes all other aquatic vegetation, eliminates native flora and creates a poorer ecosystem for invertebrates and fish. Severe oxygen depletion can occur below dense growths of this plant.
Canadian pondweed (*Elodea canadensis*)	Lochs/lakes, reservoirs and rivers	Canadian pondweed was first recorded wild in the UK in 1842. Initially its expansion was prolific, but slowed down in the 1900s. It causes problems by competing for nutrients and outgrowing many native species. It appears to expand to levels that cause problems in water bodies that are subject to eutrophication. In others, it appears to co-exist without impacts on the native plants and animals.
Wireweed (*Sargassum muticum*)	Coasts and estuaries	Wireweed is a seaweed native to the western Pacific. It was first introduced to Scotland in 2004 and is now present in Loch Ryan. It competes with our native flora by growing over and shading out other species.
Cord grass (*Spartina anglica*)	Coasts and estuaries	The cord grass plant is a hybrid resulting from a cross between one of our native cord-grasses and a non-native species introduced in the late 1800s. It is able to colonise open mud flats, which are valuable feeding areas for waders and wildfowl. It increases the rate of sedimentation and outgrows many native species in saltmarsh communities.

Appendix D: Water body characteristics

Surface water bodies have been grouped into broad types according to their physical and chemical characteristics. These types give a general indication of the sorts of plants and animals that are likely to be present in water bodies of that type in undisturbed conditions.

For rivers, broad types have been distinguished on the basis of altitude, catchment size and geology[3]. Fifteen different river types are found in the Solway Tweed RBD (Map D1). All these types lie within the Great Britain ecoregion for rivers and lochs[4].

Loch/lake types have been distinguished on the basis of natural characteristics that have the greatest bearing on their ecological condition of lochs/lakes. These are the geology of the catchment, expressed as the base status (alkalinity) of the loch, and the depth of the loch/lake, expressed as the mean depth[5]. Seven different loch/lake types are found in the Solway Tweed RBD (Map D2).

Estuary and coastal water types have been distinguished on the basis of latitude, longitude, tidal range, salinity, mixing characteristics, mean substratum composition and wave exposure[6]. Two different estuary types and three coastal water types are found in the Solway Tweed RBD (Maps D3 and D4 respectively).

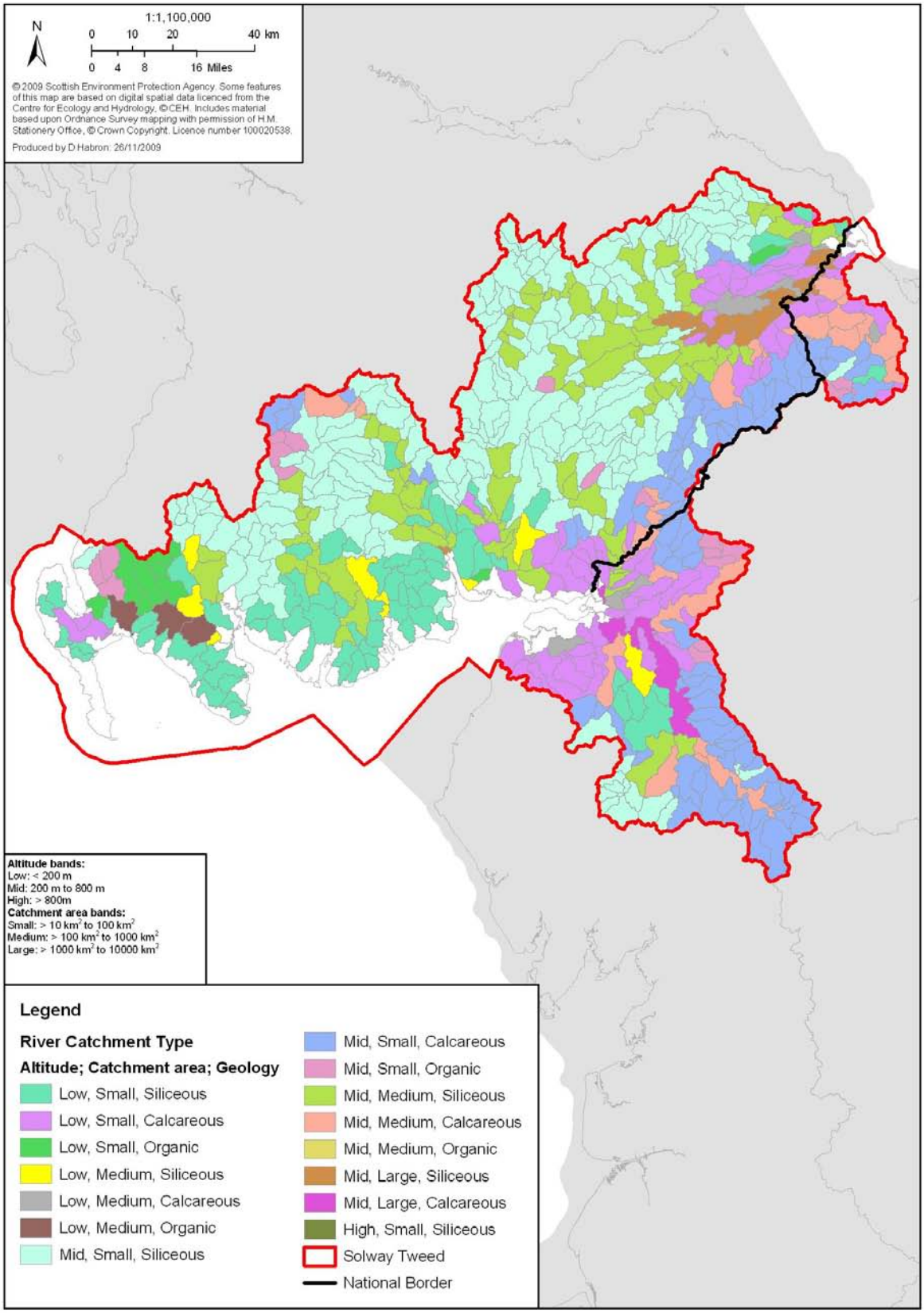
The Solway Tweed is geologically diverse, containing many groundwater aquifers with differing characteristics. The aquifers have been grouped into categories based on how groundwater flows within them and how much water is available for abstraction (their productivity).

The aquifer categories range from the low productivity mountainous highlands to low-lying, highly productive sandstone basins. The flow mechanism and size of the aquifer determines how much interaction there is between the rock and the groundwater. Greater interaction means that more contaminants are likely to be removed or reduced by physical filtration, chemical or biological reactions. For example, bedrock aquifers are dominated by flow in rock fractures and hence the potential for reducing contaminants is minimal.

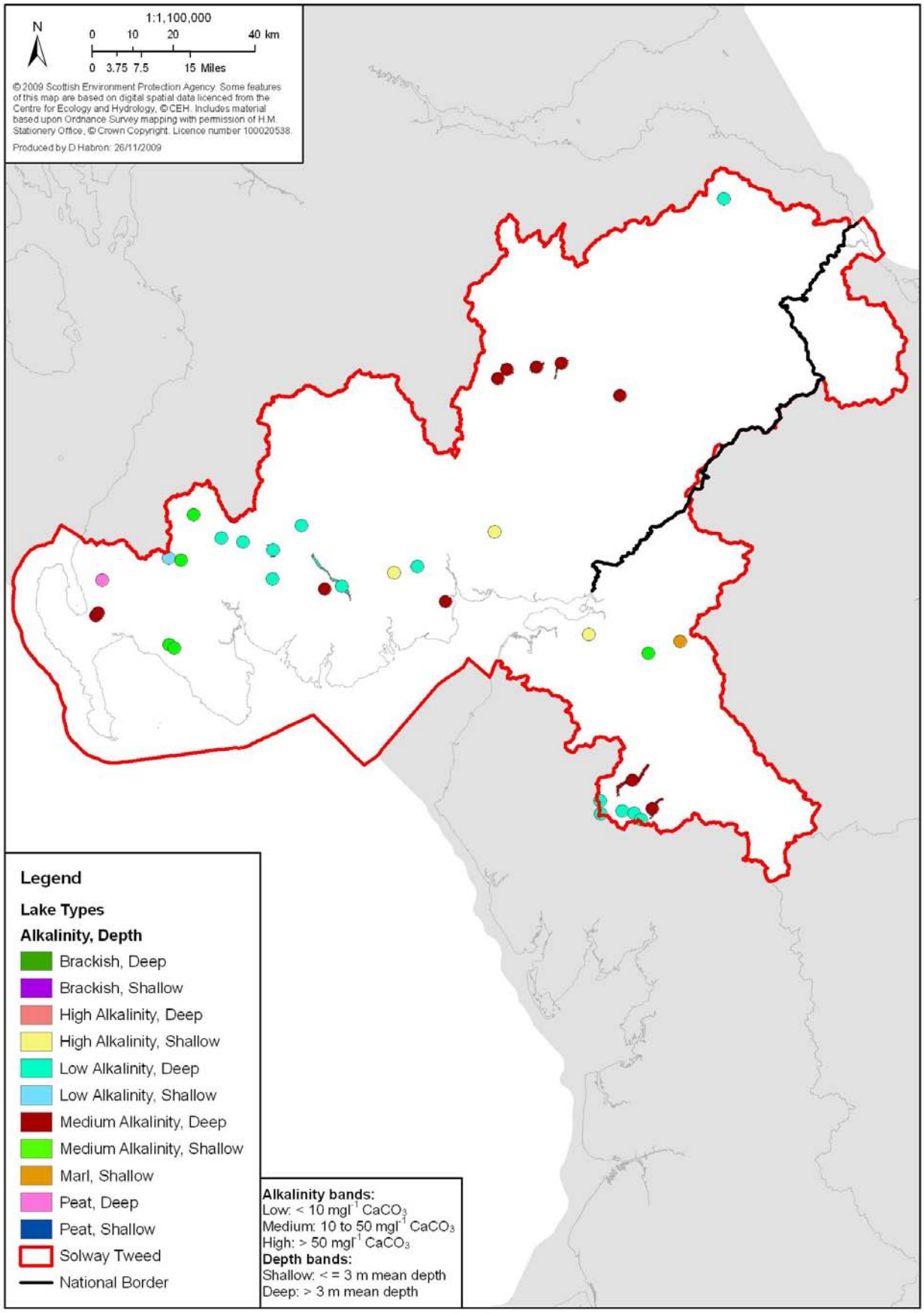
Bodies of groundwater have been identified to reflect the seven different aquifer categories found in the Solway RBD (Map D5).

[3] The system used for identifying river types (System A) is set out in Annex II to the Water Framework Directive.
[4] See Annex XI to the Water Framework Directive.
[5] The system used for identifying loch types (System B) is set out in Annex II to the Water Framework Directive. The other factors in system B (altitude, latitude, longitude and size) are of less relevance to ecological character of loch/lakes in the Solway Tweed RBD and were therefore allocated to a single category for the UK.
[6] The system used for identifying estuary and coastal water types (System B) is set out in Annex II to the Water Framework Directive.

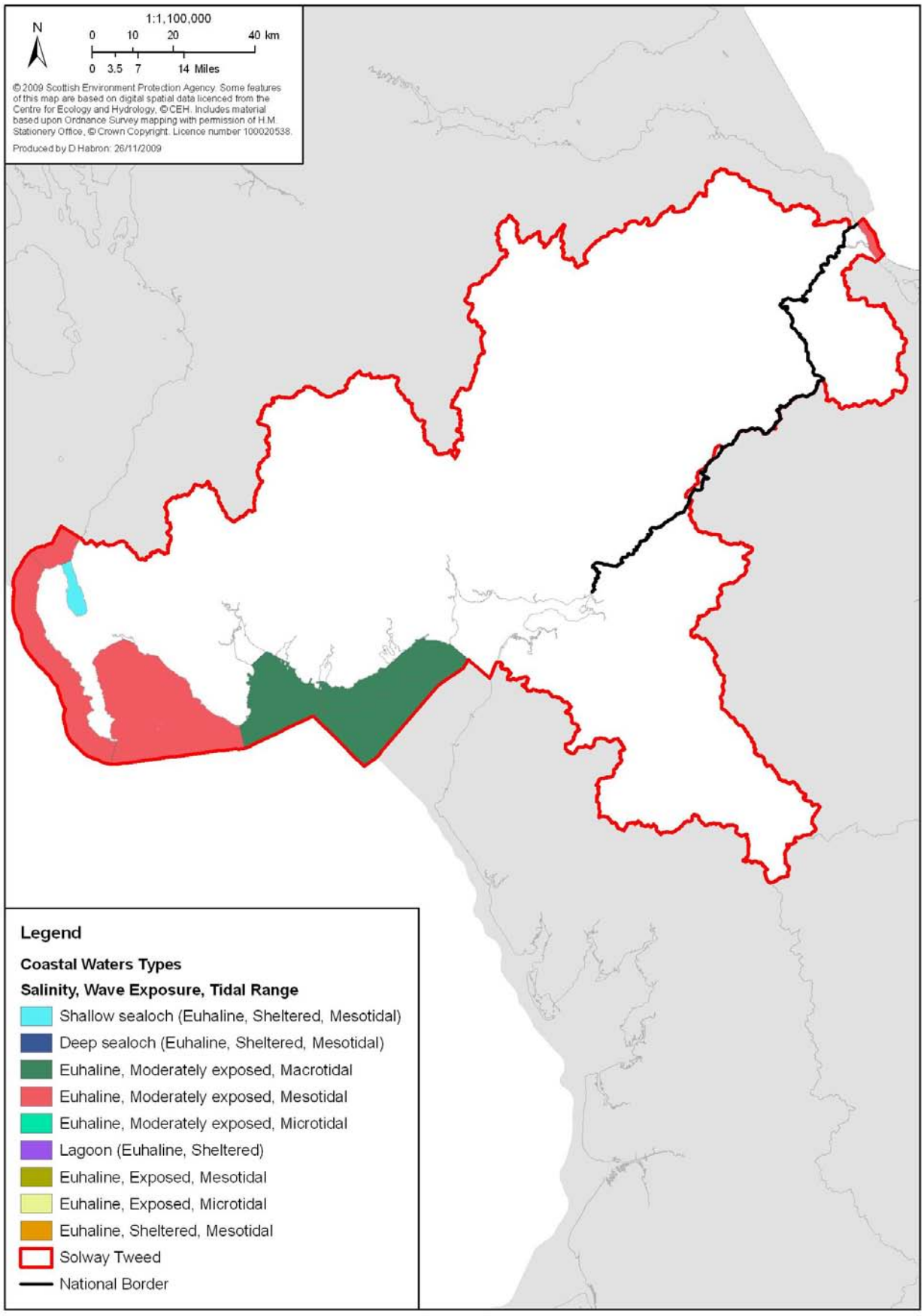
Map D1 Characteristics of river water bodies in Solway Tweed



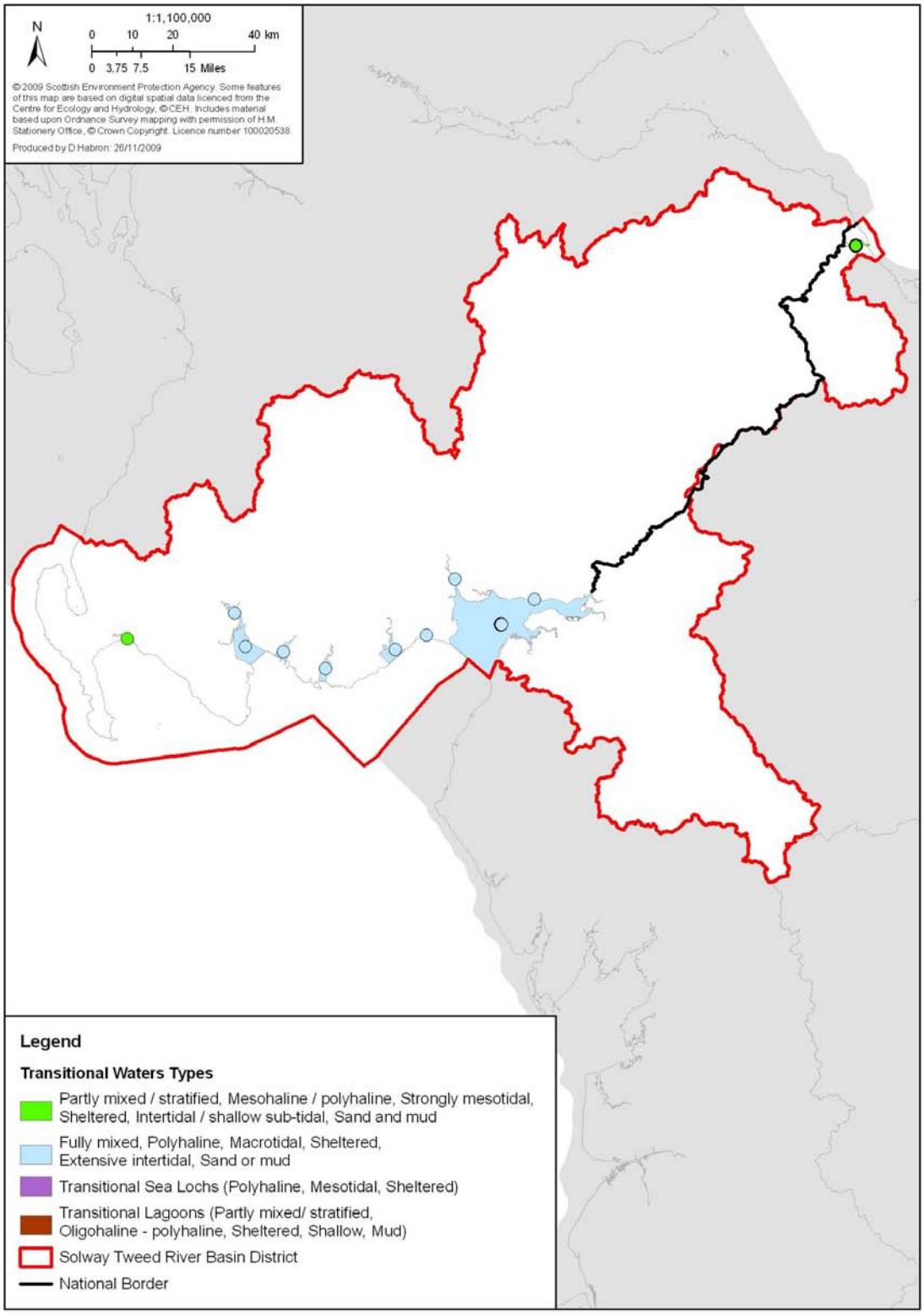
Map D2 Characteristics of lochs/lakes in Solway Tweed



Map D3 Characteristics of coastal waters in Solway Tweed



Map D4 Characteristics of the estuaries in Solway Tweed



Map D5 Characteristics of groundwater in Solway Tweed