

CHAPTER XXXIV.

CUMBERLAND STREAMS NORTH OF THE CENTRAL
WATERSHED.*O.S. CATCHMENT BASIN XVII.*

AREA about 17* square miles, all of which are occupied by Coal Measures covered with Drift. This basin occupies a triangular area intervening between the *DERWENT* and *EHEN* Basins; it has a coast-line of 9 miles, its watershed commences at St. Bees Head at 323 feet, rising to 704 feet on the eastern angle of the area, descending to 129 feet at Chapel Hill immediately south of Workington. To the south a small stream drains the Hensingham and Whitehaven valley; another, Distington and Moresby; and a third flows out at Harrington.

WHITEHAVEN.—*Acres*, 310; population, 19,321; rateable value, 50,074*l.*; constant supply of 900,000 gallons, by gravitation from Ennerdale Lake; 12 Vict. c. 17; 27 & 28 Vict. c. 121.

RIVER DERWENT (XVIII).

This river is 31 miles in length; area, 262 square miles, of which 229 consist of Lower Silurian rocks, 11 of Carboniferous Limestone, and 22 of Carboniferous, the latter being chiefly Coal Measures.

The southern margin of this basin is formed by the central east and west watershed, commencing at Seat Sandal; it descends to Dunmail Raise, 774 feet, ascending to 1811 feet at Steel Fell, overhanging Wythburn, whence it ranges south-west to High White Stones 2500 feet, running along the peat-covered ridge separating Long Strath from the

* Six miles of this is included by the O.S. in the basin of the *EHEN*.

Great Langdale valley, by Rossett Pass to Bow Fell, 2500 feet, whence it trends northward to Great End, 2984 feet. The ridge between these two mountains, 1½ mile in length, is the central point of divergence of the watershed of five of the principal basins of the Lake District, a sixth basin (that of the Ennerdale valley) being included, by the continuation of the ridge 1½ mile further north-west to Great Gable, 2949 feet; lying under the trough of the high mountain pass, between the ridge and other crags, are Angle Tarn, Sparkling Tarn, and Styehed Tarn, drained by the head waters of the *DERWENT*.

From Great Gable by Green Gable (2474 feet), to Brandreth the watershed trends north, separating the *Liza* from the *DERWENT*. At Brandreth the northward direction is continued to Dale Head by the minor watershed separating the waters flowing into the Buttermere valley from those of Borrowdale. The central or "pass" watershed trends north-west following the strike, the Buttermere valley, by Scarth Gap to Gale Fell and Great Borrer, 2019 feet, and Gravel Fell, 1720 feet, forming the ridge between Ennerdale Lake and Crummock Water; thence it descends rapidly, and reaches the sea north of Whitehaven, overhanging the head waters of *EHEN* at a height of 565 feet.

Following the left bank of the *DERWENT* from its estuary at Workington, which is built on this bank, by Stamburn and Great Clifton, it receives the River *Marron*, rising on Knock Murton Fell, 1461 feet, to Lamplugh, thence by Branthwaite, Dean, and Little Clifton to the *DERWENT*. The Cleator and Egremont Railway follows the left bank of the *Marron*, crossing the "Pass Watershed" at Rowrah, at about 540 feet.

River Cocker.

This river is 12 miles in length; on its left bank, at the foot of the Fells, are the hamlets of Southwaite, Thackthwaite, and St. Bartholomew's; the latter place is situated in the angle between the foot of Crummock Water and the stream draining Lowes Water lake and valley, which is re-

markable for sloping in a direction contrary to the general drainage trend of the country, south-east instead of north-north-west. The lake was scooped out by a glacier occupying the valley between Carling Knott and Low Fell. Crummock Water is $2\frac{1}{2}$ miles in length, 320 feet above the sea, and 132 feet in depth: it is separated by a little more than half a mile of alluvium from Buttermere lake $1\frac{1}{4}$ mile in length, receiving the drainage of Wernscale Bottom, and the stream flowing through the rocky gorge forming Honnister Pass; Buttermere is 330 feet above the sea. The secondary watershed separating this valley from the *DERWENT*, ranges parallel with it from Dale Head by Robinson, 2417 feet, and Lorton Fells. On the right bank of the alluvial flat, between the lakes, is the village of Buttermere. At Low Lorton, *Whit Brook* comes in, rising near Lord's Seat, (1811 feet), within a mile of Bassenthwaite lake.

Following the *DERWENT* from the infall of the Cocker, the stream rises to the foot of Bassenthwaite lake, which is 4 miles in length, 225 feet above the mean sea-level, and 68 feet deep, receiving at its head two streams, *Newland Beck* and the River *DERWENT*. The former stream is about 7 miles long, rising under Dale Head, and flows past Little Town, Stair, and Braithwaite, draining the vale of Newlands, a valley running parallel to Borrowdale, and separated from it by the Cat Bells range, rising to 1482 feet, forming the western margin of Derwentwater.

From the head of Bassenthwaite to the foot of Derwentwater is an alluvial flat tract, $2\frac{1}{2}$ miles long, once part of the lake, and since filled up by *débris* brought down by streams, separating the lake into two portions. Following the left bank of Derwentwater to the head of the lake, two valleys are seen, the larger being drained by the *DERWENT*, and the smaller and eastern valley by *Watendlath Beck*. Derwentwater is nearly 3 miles long, is 238 feet above the sea, and 72 feet deep. On the left bank of the *DERWENT*, on the plains at the bottom of the valley, are the villages of Grange and Seattoller; at the latter place, *Horse Gill*, draining

the east side of Honnister Pass, has its outfall. The source of the *DERWENT* at Styehed Pass has already been referred to; on its right bank are the hamlets of Seathwaite, Thornythwaite, and Rosthwaite, where the infall of *Longstrath Beck* occurs.

Between this stream and its tributary, *Greenup Gill*, and the Thirlmere valley, are two ridges forming minor watersheds uniting at Ullscarf, 2370 feet; the western spur ranging by Green Comb, 1580 feet; and Brund Fell, 1383 feet, separates Longstrath from *Watendlath Beck*, which flows through Blea Tarn and Watendlath to the lake at Lodore, falling over rocks of the altered volcanic ashes, and forming the well-known Falls of Lodore. East of this valley is the watershed ranging through Armboth Fell, 1588 feet, Castlerigg Fell, 1932 feet, on which rises *Brackle Beck*, flowing past Castlerigg to the lake opposite Lord's Island.

River Greta.

Immediately below the foot of Derwentwater, the *DERWENT* receives the *Greta*, 9 miles in length, on the left bank of which the town of Keswick, and the suburb of Brigham, two powerful feeders, come in on the left bank, *Naddle Beck*, rising under the Pewits, west of the foot of Thirlmere, and flowing past Dale Bottom, and *St. John's Beck*, falling a mile higher up the stream; this Beck carries off the drainage of the Wythburn and Thirlmere Basin; it is bounded to the south by Steel Fell, Dunmail Raise, and Seat Sandal, to the east by the Helvellyn ridge, 3118 feet, and west by Armboth Fells, 1588 feet. At the head of the lake, on the right bank of Wythburn, is the hamlet, and "Wythburn's modest House of Prayer," 588 feet above the sea. At Green Dodd, 2804 feet, the watershed separating the *DERWENT* Basin from the streams flowing into Ulleswater trends to the north by Matterdale Common and Great Mell Fell. Thirlmere is $2\frac{3}{4}$ miles in length, 533 feet above the mean sea-level, and 108 feet in depth; it has a top-water area of 335 acres, which will be increased to 800 acres by the proposed embankment, 50 feet high, raising its surface,

sanctioned by Parliament for the supply of Manchester.* At first only 10,000,000 gallons will be drawn daily, and this will be gradually increased to 50,000,000 gallons. The compensation water given is very small, being only 5,500,000 gallons daily to be sent down *St. John's Beck*.

Above the infall of *St. John's Beck*, the *DERWENT* takes the name of *River Glenderamackin*, receiving *Mosedale* and *Trout Becks*, draining *Matterdale Common*, and following it near *Wallthwaite*.

The right bank of the valley is very steep, being bounded by *Saddleback*, 2847 feet, and *Lowseat Fell*, 2344 feet, separated by *Glenderaterra Beck* and *Skiddaw*. At the foot of the slope are the villages of *Applethwaite* and *Millbeck*, 403 feet.

KESWICK.—*Acres*, 542; population, 3219; rateable value, 11,430*l.* Supply from streams on *Skiddaw*, on *Lord Ormathwaite's* land, impounded, constant, 70,000 gallons per day.

The *Keswick* registration sub-district contains 76,709 acres, with a population of 6935.

WORKINGTON.—*Acres*, 267; population, 13,305; rateable value, 19,098*l.* 9*s.* 3*d.* Constant supply of 400,000 gallons pumped from well into reservoir by two small engines, and partly from *River DERWENT*. Works purchased from *Waterworks Company* under *Local Government Act*, 1868, an inadequate scheme sanctioned by Parliament to obtain a supply by gravitation from *Crummock Water* for *Cockermouth* and *Workington*.

The *Workington* registration sub-district contains 19,944 acres, with a population of 20,840.

COCKERMOUTH.—*Acres*, 2424; population, 5354; rateable value, 13,000*l.* Constant supply of 136,000 gallons pumped into reservoir from *River Cocker*; *Public Health Act*, 1848. Rainfall at *Whin Fell Hall*, 250 feet above the sea:—

1876.	1877.	1878.	1879.	1880.
45·07	71·68	43·03	44·20	45·61

Average of twenty-five years, 53·11 inches.

* The aqueduct, 102 miles in length, will consist of 14 miles of tunnels, 39 miles of "cut and cover" channel, in the ground, and 33 miles of cast-iron syphon-pipes, and bridges.

The *Cockermouth* registration sub-district contains 51,721 acres, with a population of 10,965.

TABLE showing the AVERAGE RAINFALL in the ENGLISH LAKE DISTRICT, from OBSERVATIONS made by the late DR. MILLER, F.R.S., from 1844 to 1853.

Highest summit of the district 3000 feet above the sea, lowest 200 feet.

Place of Gauge.	Elevation above the sea.	No. of years' observations.	Mean rainfall.
<i>Keswick</i>	258	10	59·6
<i>Loweswater</i>	336	10	67·29
<i>Crummock Lake</i>	260	10	84·1
<i>Gatesgarth</i>	290	9	114·7
<i>Eskdale Head</i> .. .. .	..	7	77·9
<i>Wastdale Head</i>	247	10	101·4
<i>Selside</i>	736	5	73·5
<i>The Howe, Troutbeck</i>	503	10	79·3
<i>Ambleside</i>	190	5	79·6
<i>Seathwaite</i> .. .. .	..	9	140·5
<i>Stonethwaite</i>	340	7	111·4
Mean rainfall of the district ..	..	..	89·93

From a more extended table of *Dr. Miller's*, given in *Beardmore's 'Hydrology'*, a mean annual fall of 100·56 inches is deduced for the years 1847 to 1853 inclusive; for the latter year only, which was exceedingly dry, the mean fall was 80·60 inches.

The rainfalls of the highest points were as follows:—

	Elevation.	1848.	1849.	1850.	1851.	1852.	1853.	Total.	Mean.
<i>The Pike</i>	3166	94·70	83·20	80·30	71·30	81·30	56·20	467·00	77·83
<i>Great Gable</i>	2925	91·30	84·90	87·30	85·70	81·20	59·70	490·10	81·68
<i>Sprinkling Tarn</i>	1900	108·60	121·10	127·80	134·80	125·30	94·60	752·20	125·37
<i>Brant Rigg</i>	924	109·20	87·30	91·10	89·50	98·20	73·40	548·70	91·45
<i>Seattoller Common</i>	1338	109·50	109·00	138·80	141·40	156·60	111·40	796·70	132·78
<i>The Sty</i>	948	..	..	174·30	169·60	167·70	124·90	636·50	159·12

The observations taken both in *Wales* and the *Lake District* mountains show a steady increase of the precipitation

of rain with elevation above the sea, but this does not go on indefinitely, for the maximum precipitation of all is not found on the highest summits but on the lee-side of hills, where the clouds, impelled by prevalent sea-winds (west-south-west to west-north-west), have been carried through mountain passes; as for example, at Stonethwaite, Seathwaite, little more than 300 feet above the sea, the fall is nearly double that of the Pike and Great Gable, averaging 3000 feet above the sea.

RIVER ELLEN (XVI).

Length, 16 miles; area, 72 square miles, of which Lower Silurians occupy 6, Carboniferous Limestone 13, Carboniferous rocks 18, and 35 of Permian Sandstone.

MARYPORT.—Population, 8177; rateable value, 17,175*l.*; constant supply pumped from River *DERWENT* at Goat's Mill Race, into storage reservoir; Maryport Improvement and Harbour Act, 1866.

Maryport registration sub-district contains 21,781 acres, with a population of 18,050.

RIVER WAVER (XV).

Length, 12 miles; area, 70 square miles, of which 12 consist of Carboniferous Limestone, 4 of Carboniferous rocks, 4 of Permian (St. Bees) Sandstone, and 49 of Upper Gypseous Permian Marls.

The outfall of the river unites with that of *WAMPOOL* in Morecambe, and then trends west by Skinburness and Silloth.

Off Beckfoot, low-water mark at Catherine Scar is more than a mile from the coast-line, but at Silloth Bay it approaches within a quarter of a mile of the coast; eastward both banks of the estuary are fringed with salt marshes, and the area between this river and the *WAMPOOL* is Widholme Flow, and other mosses; on the south side of the Moss is Kelsick and Abbey Town.

SILLOTH.—Rainfall:—

1878.	1879.	1880.
29·26	35·57	30·55

Average of twenty-six years was 34·01 inches.

RIVER WAMPOOL (XIV).

Length, 14 miles; area, 78 square miles, of which 8 consist of Carboniferous, 61 consist of Permian (14 being St. Bees Sandstone, and the remaining 47 are Upper Gypseous Marls), 3 of Trias, and 6 of Lias.

The western watershed commences in the Newton Arlosh Mosses, crosses Widholme Flow, thence by Oulton Village, 101 feet, and Dockray, and south to the Caldew Valley, which it overhangs at 520 feet, then trending north the eastern watershed separates this basin from the *EDEN* Basin, by Great Orton, 221 feet, and Kirkbampton to Burgh Marshes, at Boustead Hill.

The general northerly direction of the stream ceases at its outfall, and instead of flowing out at Port Carlisle, across the low tract formed by Glasson Moss, it turns abruptly westerly, forming a trumpet-shaped estuary between Newton Arlosh and Anthorn; west of the latter place the coast-line trends north-east to Bowness and then south-east by Port Carlisle, Drumburgh, and Boustead Hill. The whole of this tract is low and peat-covered, and would be converted into an island by a 15 feet depression, the channel being between Drumburgh and Whitrigg. The western feeder is the River *Wiza*, the eastern is *Shalk* Beck, on which is Carthwaite.

WIGTON.—*Acres*, 775; population, 3600; rateable value, 11,887*l.*; constant supply of 40,000 gallons from reservoir in Red Dial, 1½ mile from town, storing water from a 'boiling spring' and the River *WAVER*. Works will be purchased from the Company by the Sanitary Authority.

Wigton registration sub-district contains 43,484 *acres*, with a population of 9124.

RIVER EDEN (XIX.)

Length, 69 miles; area, including its tributaries, 915 square miles, of which 135 are occupied by Silurians, 391 by Carboniferous Limestone, much split up by Sandstones and Shales, 357 by Permian rocks, chiefly of the Penrith division, 18 by Triassic (Kirklington) Sandstone, and 12 by the Stanwix Marls, which are probably Keuper, and 10 by Lias.

From the watershed at Boustead Hill to Red Kirk Point, on the Scotch side of the Solway Firth, is $3\frac{1}{2}$ miles, measured from the railway and Roman VALLUM, for traversing the sands between the two points is not only the channel of the *EDEN*, but that of the *ESK*, the two uniting off Port Carlisle. The eastern watershed of the *EDEN* terminates at Wetheral and Rockcliff Marshes, from which to the Burgh Marshes, traversed by the watershed, is only $2\frac{3}{4}$ miles, representing the whole sea-frontage of this very large basin.

On the low grounds fringing the left bank of the river are Burgh-by-Sands, Beaumont, and Kirkandrews-upon-Eden; and above the 100-foot contour is Moorhouse and Bellevue. The top of the valley is higher on the left bank than on the right.

River Caldew.

Seven miles from the sea, at the bottom of the valley, is the infall of the River *Caldew*, 16 miles in length. Following its left bank, it receives, south of Dalston, *Gill Beck*, rising in the mosses on the *WAMPOOL* watershed, and draining Cardew. Its chief feeders rise on the hills 2300 feet above Bassenthwaite lake. On this stream are Dalton and Sibergham.

The City of *CARLISLE* is built in the angle between the *EDEN* and the *Caldew*. Acres, 1570; population, 35,866; rateable value, 112,982*l.*; constant supply of 1,134,600 gallons pumped from *EDEN*; purchased from *Carlisle Waterworks* under Public Health Act. Rainfall at Spittal Cemetery, 113 feet above the sea:—

1876.	1877.	1878.	1879.	1880.
31·70	44·68	29·68	26·19	29·33

The Carlisle registration district is divided as follows:—

Sub-Districts.	Acres.	Population.
Wetheral	16,202	4,033
St. Cuthbert	10,098	17,276
St. Mary	2,097	22,214
Stanwix	12,359	4,110
Burgh	9,647	1,360
Dalston	18,761	3,750

I have to thank my former colleague Mr. Holmes, F.G.S., for the following sequence of the Secondary and Permian rocks in the *Carlisle district*:—

1. LIAS, limestones and shales (mistaken for coal), first determined by Mr. Brocklebank, of Ackton and Orton.
2. KEUPER (?) MARLS, drift-covered, of Stanwix and West Linton, 50 to 100 feet. *Unconformity.*
3. BUNTER SANDSTONES, red and white current-bedded soft sandstones, of Kirklington and Rockcliffe. There is little doubt they are of Bunter age, as suggested by Professor Harkness, but they contain a band resembling the St. Bees Sandstone, 400 to 500 feet.
4. GYPSEOUS SHALES, only found in borings 600 to 700 feet, cut off by a fault in the valley of the Calder.
5. ST. BEES SANDSTONES, Red Sandstone of grey bed at the top, probably 1500 feet thick south-east of Carlisle, and resting on the Carboniferous rocks, north of that city.
6. SHALEY BEDS.
7. PENRITH SANDSTONES, Red Sandstones not occurring north of the line bringing in the St. Bees Sandstones, but reappearing in Dumfriesshire.

The Stanwix Marls form an inlier extending from Carlisle, Stanwix, and Houghton, to Westlinton, on the south bank of the River *LINE*.

The older Kirklington Sandstones occupy a larger area: their southerly extension is cut off by an E.S.E. fault, ranging south of Cummersdale; northward, at the mouth of the *EDEN*, these beds rest on upper Gypseous Marls; while still further north and east from the mouth of the *ESK*, by

Solway Moss, the River *Liddel*, and River *LINE*, it rests on the St. Bees Sandstone.*

River Petterill

Is 21 miles in length. The Preston and Carlisle Railway follows the left bank of the valley of the River *Petterill*, by Southwaite, Culthwaite, and Catterlen, east of which the valley trends westward, the railway crossing the stream at the bend of the town, from which the stream flows by Laithes, Greystoke, rising between Motherby and Penruddock, at about 875 feet. The source is close to the railway-station, but the railway here has not been carried down the valley, but eastward, through a cutting in Beacon Hill, so as to intercept the town of Penrith, which is drained by a stream flowing into the *Eamont*, but the valley in which this stream flows was probably continuous before the Glacial epoch with the valleys of the *Lowther* and *Eamont*, the junction of which is 3 miles to the south of the present *Petterill* watershed; the watershed separating the waters of the latter basin, and the Eden ranges north-north-west, half-way between the two streams by Lazonby Fell, 811, and Blazefell, 792 feet, Aiketgate, and Barrack Fell. The old coach road to the north is carried on along the right side of the valley of the *Petterill*, on the line of the still older Roman Road, by Plumpton Head, the Roman Station of VOREDA, and High and Low Heskett.

Between Armathwaite and Lazonby the *EDEN* flows through a narrow gorge, widening out between this place and Great Salkeld and Edenhall, south of which the valley is breached by the tributary valley of the *Eamont*, flowing at right angles to the course of the *EDEN*.

PENRITH.—Acres, 7587; population, 9268; rateable value, 24,389*l.* Supplied by water pumped from the *Eamont*, the

* Mr. T. V. Holmes, "On the Permian, Triassic, and Liassic Rocks of the Carlisle Basin," 'Quarterly Journal Geological Society,' 1881, p. 286, with map.

only outlet of Ulleswater Lake, raised by the water-power of the river up to 1862, in which year there was not water-power enough to turn the wheel, and a permanent steam-engine of 14-horse power has been fixed for short water seasons. The works are a mile from the town, and a flour-mill near the waterworks wheel has a right to half the water-power. Mr. John Taylor says that, in 1862, the water flowing from Ulleswater, with its gathering ground of about 54,500 acres, was reduced to 20,000,000 gallons per day for some months. The flow down the river on the 26th of May, 1868, was 120,000,000 gallons per day, being about an average flow, showing that, in dry seasons, the water is reduced to one-sixth its ordinary volume. The supply is constant: 230,000 gallons are used for domestic purposes, and 200,000 gallons for manufacturing purposes. Under Public Health Act, 1848, and Local Government Act, 1858.

River Eamont.

The drainage area of Ulleswater is given by Mr. Bateman, C.E., at 36,198 acres, or the same as that of Bala Lake: the actual area of the water of the lake is 2243 acres. Mr. Bateman was of opinion that if the present level of the lake, 470 feet above Ordnance Datum, were raised 5 feet, it could supply 50 million gallons a day, after 100 days' drought, and allowing for compensation.

Ulleswater is $7\frac{3}{4}$ miles in length, it is 476 feet above the mean sea-level, and is 210 feet in depth.

Several square miles on the left banks of Ulleswater are drained by *Cary Beck*, flowing past Downtwaitehead and Dockray, higher up the lake, in the infall of *Glencoin Beck*; and still further south is *Glenridding Beck*, draining the eastern recesses of Helvellyn. One feeder rises above Green-side Lead Mines, another above Keppel Cove Tarn, and a third in Red Tarn, separated from the former tarn by the sharp spur Cat-stye-Cam. At the foot of the lake a stream falls in, carrying the united waters flowing down Grisedale,

and rising above the Tarn under Seat Sandal, and then rising on Kirkstone Pass, and flowing through Brothers Water 520 feet, with feeders rising on High Street, which form the minor watershed between the *Eamont* and Ulleswater valley, and the *Lowther* and Haweswater valley. The watershed descends from High Raise, 2634 to 1832 feet, on Swarth Fell, falling into *Eamont* at the infall of the *Lowther* at 375 feet, between the foot of the lake and the point of the village of Pooley Bridge, Stockbridge, Yanwith, and Eamont Bridge.

River Lowther.

This river is 12 miles long. Following its left bank, by Askham, it receives *Heltondale Beck*, between Helton Flecker and Butterweek, and *Haweswater Beck* at Bampton, at 575 feet; the stream flows out of Haweswater (694 feet), on its left bank flows in *Measand Beck*, forming a headland dividing the lake into two divisions, known as High Water and Low Water. At the head of the lake is an alluvial tract, marking its former extension, through which flows the stream, descending Wasdale and Blea Tarn, 1584 feet, under High Street. On the right bank of Haweswater is Naddle Forest, rising to 1427 feet, and Rosgill Moor, drained by *Swindale Beck*, falling into the *Lowther*, $1\frac{1}{2}$ mile above the infall of the Haweswater stream. Following the left bank of *Lowther* to its source past Ralfland Forest, the feeders rise on Shap Fells, at a little above the 1700-foot contour, around Wasdale Pike, 1853 feet, from which the *Leen* watershed ranges, by Low Fell, 1133 feet, and Shap Summit, at Col valley, through which the London and North-Western Railway is carried, at about 930 feet. The minor watershed, separating the waters of the *Lowther* from those of the River *Lyvonn*, runs parallel and close to the former stream, by Oddendale, 100 feet, Shap, Rosgill, Lowther Park, Newtown, Clifton, and Brougham Hall.

In 1865-6 a scheme was prepared by Messrs. G. Willoughby, Hemans, and R. Hassard, for the supply of London

from Lakes Ulleswater, Haweswater, and Thirlmere, and laid before the Royal Commission on Water Supply, who instructed Dr. W. Pole, F.R.S., to collect additional information and samples of water for analysis. The natural drainage of Thirlmere is 13 square miles of Green Slates and Porphyries; the lake was proposed to be raised 64 feet, and the drainage of several areas was to have been added to it by artificial means, viz.:—(1.) Watendlath Tarn, Blea Tarn, in Borrowdale and *Naddle Beck*, in all 5 square miles, with a very heavy rainfall and rugged surface, mostly bare of grass; (2.) North-Eastern Streams:—*Barrow Beck*, *Trout (Greta) Beck*, Mosedale Gill, and Helvellyn Gill, in all 21 square miles of drainage; (3.) Southern additions by a conduit intercepting the *Rothay* and *Easedale Beck*, and conveying the water through a tunnel under Dunmail Raise into Thirlmere, draining in all 6 square miles.

Haweswater is situated in an even still more rugged country, and in a similar geological formation; it drains 12 square miles; the lake is $2\frac{1}{2}$ miles in length and 694 feet above Ordnance Datum-line, and has an area at its present level of 400 acres. It was proposed to raise its level 42 feet by a dam at its outlet, two intercepting conduits intercepting drainage, flowing directly into the *Lowther*, viz.:—*Heltondale*, Gill, and *Hews Becks* to the north, and the *High Lowther* at Cooper's Green, and Swindale (with auxiliary reservoir to the south, in all 26 square miles). Mr. Bateman, F.R.S., proposed, in 1875, to raise the level of Haweswater 25 feet, and to draw from it 25 million gallons daily, in combination with 55 millions from Ulleswater for the joint supply of Liverpool and Manchester: the scheme was not accepted. Thirlmere drains into the *Greta*, which joins the *DERWENT* at the foot of Derwentwater, drains into Bassenthwaite Lake, and is separated from Ulleswater by the Helvellyn Ridge; the latter lake is divided by the *Eamont*, which also receives the *Lowther* bringing the overflow of Haweswater. It was proposed to intercept the waters of the *Lowther*, and convey them by a conduit from a point near Askham to Ulleswater, which was to be

tapped at the head by a large aqueduct, which was to be carried through or under Kirkstone Pass, by Ambleside, Kendal, East Lancashire, the Potteries, and Birmingham to London, at a cost of 12,200,000*l.*, with a daily yield of 250,000,000 gallons. Compensation reservoirs were to have been made at *St. John's Beck* below Thirlmere, and at Swindale, and the water of the *Lower Lowther*, draining several square miles of somewhat indifferent water, would also have been chiefly used for compensation purposes, which would have amounted in all to one-third of the abstracted rain. The minimum rainfall was taken at 80 inches per annum, evaporation and absorption at 16 inches, leaving 66 available, giving nearly 465,000,000 gallons daily throughout the year, one-third of which is 450,000 gallons daily for each square mile of drainage, which would have utilized floods, and doubled the volume in droughts.

The particulars of the proposed reservoirs were as follows:—

Name.	Area in square miles.	Area of reservoir in acres.	Contents in cubic feet.		Total storage.
			For supply to towns.	For compensation.	
Swindale ..	38	166	..	187,000,000	187,000,000
Haweswater ..		683	235,200,000	961,100,000	1,196,300,000
Martindale ..	95	255	336,000,000	..	336,000,000
Ulleswater ..		2300	1,742,400,000	..	1,742,400,000
Thirlmere ..	44	875	1,721,977,600	..	1,721,977,600
St. John's Beck		360	..	380,000,000	380,000,000
	177	4639	4,035,577,600	1,528,100,000	5,563,677,600

Dr. Pole estimated the water running out of Ulleswater, at Pooley Bridge (21st May, 1867), as probably 35,000,000 to 40,000,000 gallons a day, the lake being low at the time; the *Lower Lowther* he estimated at 50,000,000 gallons a day, the *Upper Kent*, 20,000,000 gallons.

Soft waters like those of Cumberland and the Welsh mountains contain a smaller proportion of gases, those waters

containing salts of lime and magnesia, and more nearly resembling distilled water.

	Distilled Waters.	Welsh Waters.			Cumberland.			Loch Katrine, Glasgow.
		Min.	Max.	Mean.	Min.	Max.	Mean.	
Nitrogen ..	1·133	1·226	1·412	1·323	1·310	1·551	1·424	1·731
Oxygen ..	·617	·566	·642	·612	·667	·749	·726	·704
Carbonic Acid	·105	·107	·335	·227	·085	·793	·281	·113
	1·855	1·899	2·389	2·162	2·062	3·093	2·431	2·548

These waters contain but little more air in solution than recently distilled water. In waters free from organic matter, the proportion of oxygen to nitrogen in the dissolved gases ought to be nearly as 1:2; the Bala Lake is as 1:2·03; Ulleswater as 1:2·08, the Cumberland waters are somewhat better aerated than the Welsh samples.

The complete analysis by Drs. Frankland and Odling of samples of Lake District waters collected by Dr. Pole, F.R.S.

	Thirlmere.	Upper Rothay.	Haweswater.	Lower Lowther.	Ulleswater.
Total solid residue from 100,000 parts of water, evaporated and dried at 100° C.	2·659	3·061	3·559	9·286	3·626
Hardness in 100,000 parts before boiling	0·7	1·3	1·3	6·7	1·9
Hardness in 100,000 parts after boiling	0·7	1·3	1·3	6·3	1·4

With the exception of the *Lower Lowther*, which Mr. Bateman proposed to use chiefly for compensation purposes, these waters leave a smaller residue than those of Wales, and Dr. Frankland states that the storage of water appears to diminish the proportion as compared with that contained in the feeders of such lakes, which is also the case at Bala Lake, in which a residue of 2·79 parts is left, whilst that of its feeders amounts to 4·10 (average of 4 feeders).

From the in-fall of the River *Lowther* into the *Eamont*, to

the infall of the *Eamont* into the *EDEN*, no stream of importance falls into the *Lowther*. Following the left bank of the *EDEN*, by Whinfell Park, it receives the River *Leith*, at a point opposite Temple Sowerby Railway Station, the Eden Valley Railway following the left bank of the valley from Clifton Junction, this stream flows from the west, by Cliburn and Melkinthorpe, where it changes its direction, and instead of flowing directly to the *Lowther*, at Brougham Castle, flows into the *EDEN*. Rising at Hardendale, on Reagill Common on its west or left bank are *Lowther* and *Hackthorpe*; on its right bank are *Little* and *Great Strickland*, and a tributary draining *Sleagill*, flowing by *Newby*, 642 feet, and *Mosland*, into the River *Lyvennet*, rising at *Crosby Ravensworth Fell*, which passes through that village at 600 feet, descending to 450 feet at *King's Meaburn*, and falling into the *Leith* at about 375 feet, and into the *EDEN* at about 350 feet. On the left bank of the *EDEN* above the infall of the *Leith*, is *Bolton*, 420 feet, *Bovley Castle* and *Colby*, where it receives *Hoff Beck*, rising above *Great Asby* 600 feet above the infall, and the stream immediately below the town of *Appleby*, built on the left bank in a bend of the river; the 400-foot contour terminates in the stream.

The registration sub-district of *Appleby*, contains 60,983 acres, with a population of 5548.

From *Appleby* the south-east to north-west course of the river is continued to east of *Little Musgrove*, where the valley trends south, to the source of the *EDEN*; at the southern end of the *Mallerstang* trough-shaped Valley, south of *Little Musgrove*, on the left bank of the *EDEN*, is the infall of the *Sandal Beck*, rising at *Harter Fell*, and flowing past *Ravenstonedale* and *Soulby*, falling into the *EDEN* at 475 feet. Further south, on the left bank of the *EDEN*, at 550 feet above the sea, is the town of *Kirkby Stephen*. To the south the river basin is bordered by the hills on either side of *Mallerstang Valley*, rising 2323 feet to the west at *Wild Boar Fell*, overlooking the basin of

the *LUNE*, and to 2328 feet at *High Scar* on the east, overhanging the source of the *SWALE*, and forming the boundary between *Westmoreland* and *Yorkshire*; to the south the boundary leaves the watershed and follows the line of *Hell Gill Beck*, the chief source of the *EDEN*; leaving this stream, it crosses the *Col* valley, between the *EDEN* and the *Ure*, at 1189 feet, and ascends *Swarth Fell*, on the opposite side, from which it descends to the River *Rawthey*.

The registration sub-district of *Kirkby Stephen* contains 74,466 acres, with only 5665 inhabitants.

On the right side of *Mallerstang* are the remains of *Pen-dragon* and *Lammerside Castles*, and at the entrance to the village of *Nateby*, between which and *Kirkby Stephen* the *EDEN* is crossed by the *Tebay* and *Darlington Railway*, at about 600 feet. To the north is the village of *Winton* and the infall of the River *Belah*, flowing in from the east and draining *Kaber* and *Kaber Fell*, crossed by the *Darlington Railway*, at 900 feet. On the right bank, below *Oxen-thwaite*, at 675 feet, it receives *Argill Beck*, traversing an outlier of the *Durham* coalfield, preserved by a fault; the numerous coal seams dip at a high angle in close proximity to each other on the side of the valley; they were discovered by *Mr. Goodchild*, of the *Geological Survey*. The stream rises at 1550 feet on the south side of *Stainmore Common*, close to the point where the railway crosses the summit-level near *Barras Station*. The watershed ranges across the common, parallel to the line of county boundary, but a mile to the west of it, by *Iron Band*, *Warcop Fell*, 2042 feet, *Breston Fell*, 2399 feet, *Hilton Fell*, *Murton Fell*, and *Dufton Fells*, overhanging the *TEES*, and *Lune Dale*, a tributary of that river. On the right bank of the *Belah* is the village of *Brough Sowerby*, 600 feet, and the river falls into the *EDEN* at 475 feet; half a mile lower down the stream is the infall of the *Augill Beck*, rising under *Iron Band*, and draining on its right bank *Brough* under *Stainmore*, 622 feet, and falling into the *EDEN* at *Great Musgrave*, below which the river is crossed by the *Eden Valley Rail-*

way, which follows the right side of the valley, by Warcop, Sandford, Coupeland, Crackenthorpe, and Brampton, between which and Kirkby Thorpe is *Trout Beck*, draining Dufton and Long Marton; at Skygarth, south of Temple Sowerby, the railway again crosses the river, running to Clifton Junction, in a tributary basin.

The north-east trend of the valley of the *EDEN* is continued by Culgaith, Long Wathby, and Little Salkeld, near which two streams, draining the Cross Fell range, find their outfall at the same point; the southern is *Briggle Beck*, composed of two feeders, one draining Kirkland and Skirwith, and *Blencairn Beck*, on which are the HANGING WALLS OF MARK ANTHONY. Above the streams Cross Fell rises to 2892 feet, and Ousby Fell, 2429 feet; northward the watershed ranges by Melmerby Fell, 2331 feet, and Fiends' Fell, 2082 feet, between which and Hartside Heights, 2046 feet, there is a slight depression, through which is carried the road from Penrith to Alston.

From the foot of the steep escarpment, at about 600 feet, a long slope commences, trending to the river, which is intersected by numerous streams, whose valleys are cut through the Glacial Drift, and occasionally into the underlying Penrith Sandstone, draining Melmerby, Gamblesby, and Glassonby.

Kirkoswald is at the outfall of *Raven Beck*, draining the valley above Renwick. A mile and a half lower down the valley is the infall of *Croglin Water*, rising on Black Fell, 2179 feet, overlooking Gilderdale Forest.

The registration sub-district of Kirkoswald contains 65,578 acres, with 5764 inhabitants.

In the Cross Fell range the watershed does not define the county boundary, which, however, after traversing Gilderdale Forest up Gilderdale Burn, ascends the Fell west of Middle Carrick, and runs north-north-west along the crests of Farlam Carrick, Great Blacklaw Hill, 1952 feet, Cold Fell, 2059 feet; here the county boundary again leaves the watershed, and follows streams flowing east into the River *TYNE*.

The watershed trends north-west from Cold Fell, and

descends to 1241 feet at Kelky Fell, from which it trends north-east, by Denton Fell, 838 feet, descending to about 575 feet, between Gilsland and Thirlwall Castle, at which point it is crossed by the Carlisle and Newcastle Railway, in a cutting, between Upper Denton and Greenhead; still continuing a north-east direction, it traverses Thirlwall Common, rising 855 feet at Burn Divot, and 1065 feet at Round Top, forming the eastern limit of the valley of the Irthing; at Round Top the watershed turns abruptly to the north-west, as does the river, which runs parallel to it, and ascends to 1613 feet at Humble Hill; westward, the watershed runs on and becomes the county boundary between Northumberland and Cumberland, but it separates the *TYNE* from the waters of the *LINE*. The Eden Watershed, leaving it at Sightly Crag, 1702 feet, running south to Greyfell Common, and High Grains Waste, 1211 feet, thence trending south-west.

River Irthing.

Following the right bank of the *EDEN* from the infall of the *Croglin*, it is intersected by the 200-foot contour; passing Great and Little Corby, it receives the River *Irthing*, after which it changes its direction and flows west; following the left bank of the *Irthing*, it receives small streams from Hayton Hill; at 95 feet it receives the River *Gelt*, rising in the wild valley of Geltsdale, and draining Castle Carrock on the left bank and Talkin Tarn on the right.

On the left bank of the *Irthing* is Brampton and Naworth Park. Eastward the railway runs parallel to the valley as far as Gilsland, when it turns to the north-north-east, and the stream drains a wild moorland country varying from 600 to 1700 feet.

Following its right bank, by Bank, past Gilsland Spa, is the infall of *Cam Beck*; on the left of the latter is Walton, and Newtown, below which, on the right bank of the *River Irthing*, is Irthington and Newby, below which it falls into the *EDEN* at 50 feet above the sea; the top of the valley

on the right bank by High Crosby and Tarraby only averages 100 feet. At Cargo, Rockcliff, and Wetheral it only rises to 50 feet. The watershed at Blackford is only 58 feet, and ranges through the mosses south of Tod Hills.

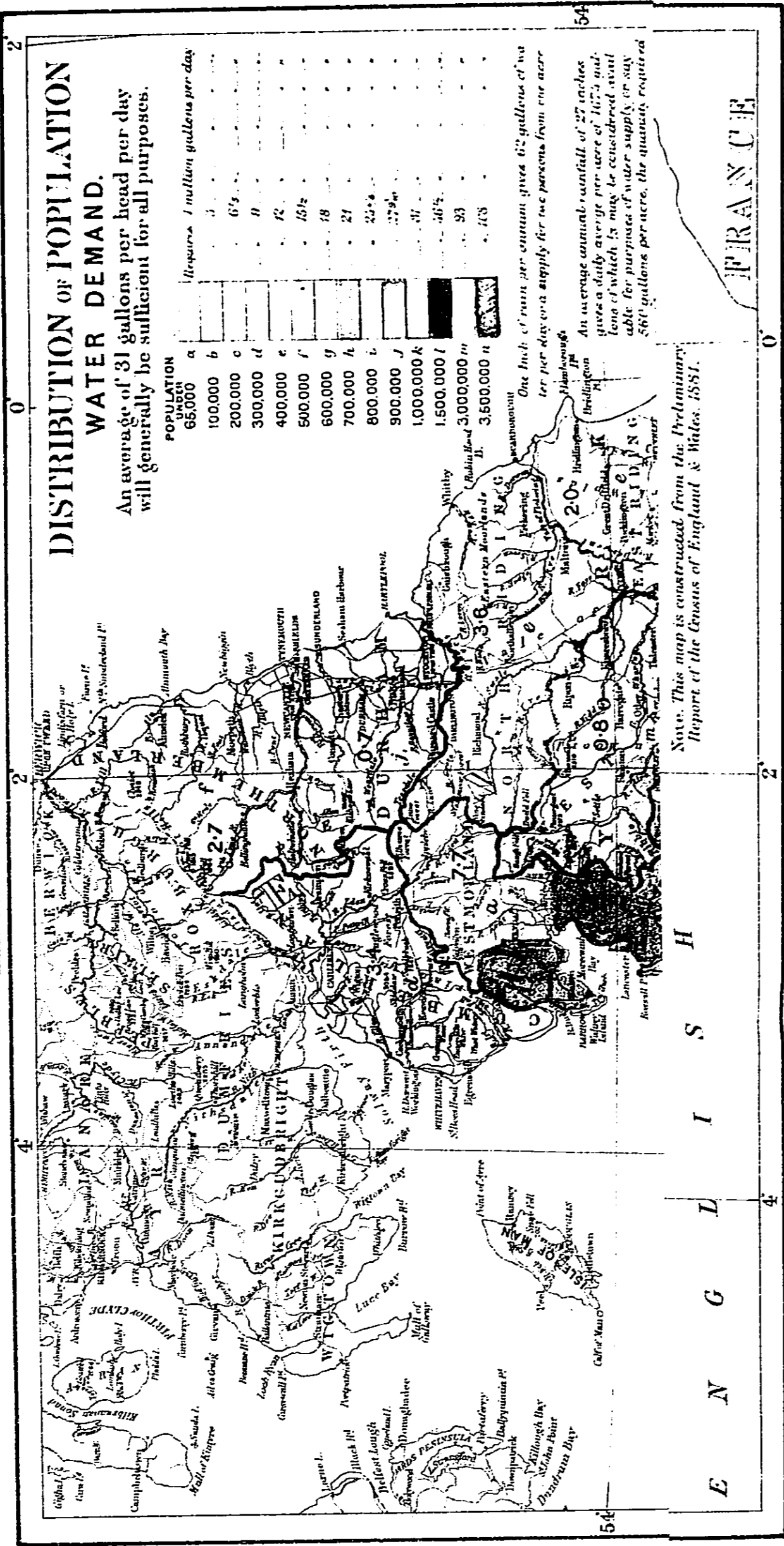
RIVERS LINE (VII.) AND ESK (VI.).

Length of the *LINE*, 20 miles; area, 104. In considering the geological formations existing in this basin, it will be convenient to consider it with that portion of the basin of the Scotch River *ESK*, that drains a distance of 21 square miles within the English border. The *LINE*, and the English portion of the *ESK*, drain 7 square miles of Silurian, 89 of Carboniferous Limestone, which is largely made up of Sandstone and Slates, 13 square miles of Permians, and 21 of Trias, of which 7, lying south of the *LINE*, are Stanwix Marls, and the remainder Kirklington Sandstones.

The *ESK*, between Todhill and Gretna Junction, is crossed by the Caledonian Railway and the great Scotch road; immediately above the bridge of the latter it receives the River *LINE*; on the left bank of the latter is Westlinton and Kirklington at 50 feet; at 275 feet it receives the *White Line*, flowing past Lime Holme Ford at 375 feet; at 400 the latter receives *Kirk Beck*, draining St. Cuthbert's, Shepford. The main stream, above the infall of the *White Line*, is called the *Black Line*, rising in Bewcastle Fells, on Glen Dhu, 1500 feet above the sea. On the right bank there are no tributaries or villages of importance.

Following the left bank of the *ESK*, and ascending the valley, is Longtown and Kirkandrews-upon-Esk; the North British Railway is carried along the left bank of the stream, entering Scotland at the infall of *Kers Hope Burn* at 300 feet above the sea. After receiving on its left bank the *Liddell Water*, the *ESK* passes into Scotland; for a considerable distance the River *Liddell* forms the boundary between Scotland and England.

The registration sub-district of High Longtown contains



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48,824 acres, with 2358 inhabitants; of Low Longtown contains 39421 acres, with a population of 5352.

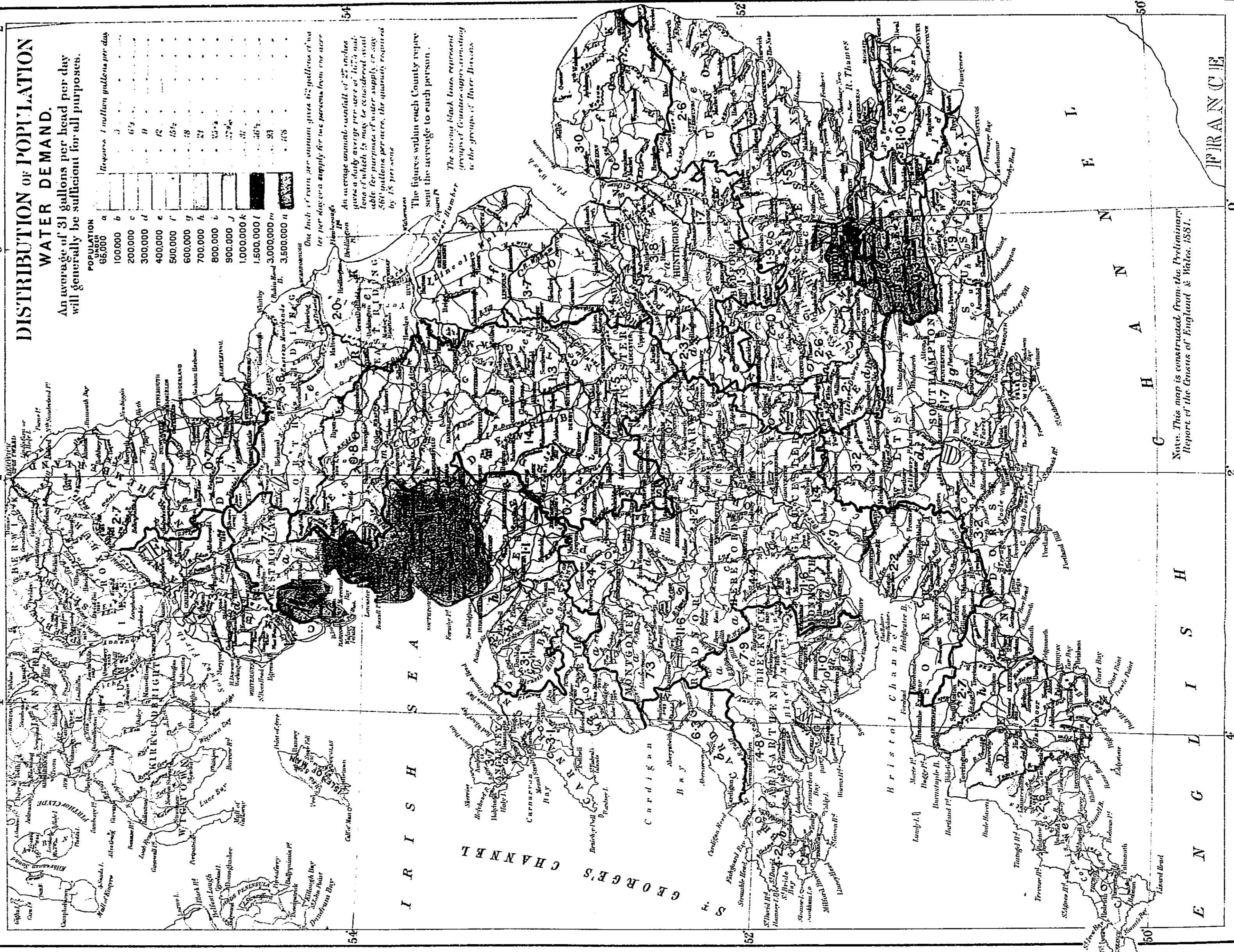
On the north bank of the estuary of the River *ESK* is the infall of the River *Sark*, near Gretna Green, which for a few miles forms a boundary between England and Scotland. The Scotch coast, from the north of the *SARK* to *ANNAN*, consists of St. Bees Sandstone; while still further west, from Caerlaverock Castle to Dumfries, the Penrith Sandstones, absent in the Carlisle area, reappear:—

POPULATION of SOLWAY FIRTH STREAMS in 1871.

COUNTY.	Population.	Density. Acres per Individual.	Probable proportion living in this Group.	Probable Population.
Cumberland	220,245	4.5	$\frac{17}{32}$	170,157
Westmoreland	65,000	7.4	$\frac{1}{2}$	32,502
In 1881.				
Cumberland	250,630	3.4	$\frac{17}{32}$	193,664
Westmoreland	64,184	7.7	$\frac{1}{2}$	32,092

ENGLAND AND WALES.

The Rance's Water Supply.



DISTRIBUTION OF POPULATION WATER DEMAND.
 An average of 31 gallons per head per day will generally be sufficient for all purposes.

POPULATION	Requires 1 million gallons per day
a 65,000	2
b 100,000	3
c 200,000	6 1/2
d 300,000	9
e 400,000	12
f 500,000	15 1/2
g 600,000	18
h 700,000	21
i 800,000	25 1/2
j 900,000	28 1/2
k 1,000,000	31
l 1,500,000	46 1/2
m 2,000,000	61
n 3,000,000	91 1/2
o 3,500,000	108

One inch of rain per annum gives 65 gallons of water per acre or a supply for two persons from the water supply.
 An average annual rainfall of 27 inches gives a daily average per acre of 16 1/2 tons of which 15 may be considered available for purposes of water supply or say 560 gallons per acre, the quantity required by 18 persons.

The figures within each County represent the average to each person.
 The strong black lines represent groups of Counties approximating to the groups of three Divisions.

Note. This map is constructed from the Preliminary Reports of the Census of England & Wales, 1881.

Miles 0 10 20 30 40 50 60

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