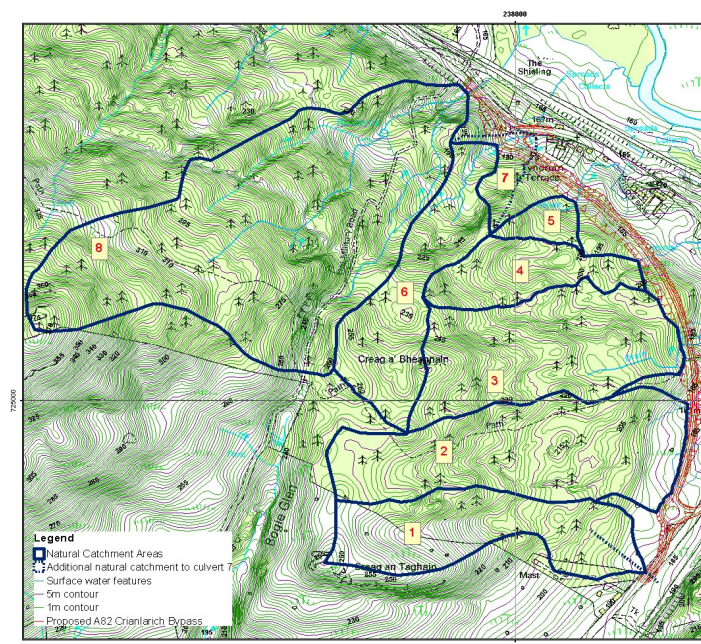


APPENDIX B GREENFIELD RUNOFF CALCULATIONS

Natural Catchments

Catchment Area	Area km ²	Area hectares
1	0.0807	8.07
2	0.1276	12.76
3	0.1077	10.77
4	0.0413	4.13
5	0.0116	1.16
6	0.0734	7.34
7	0.0861	8.61
8	0.2807	28.07

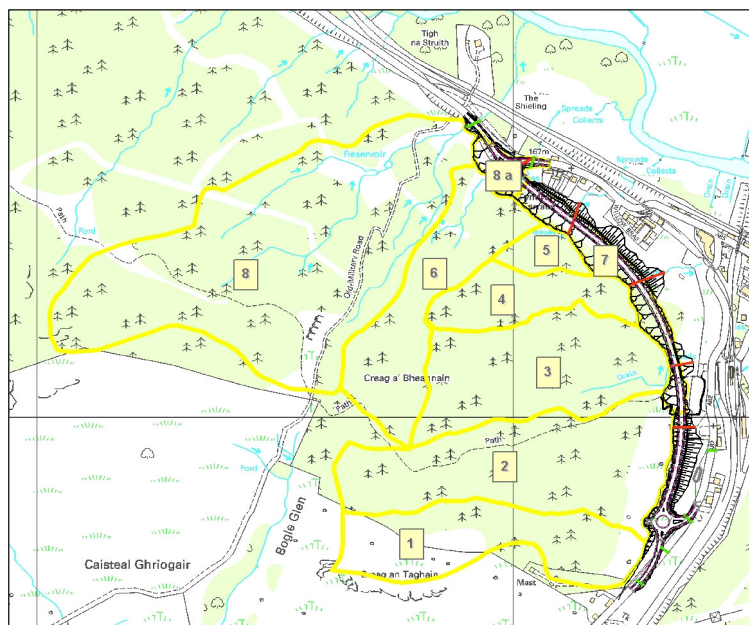
NB: Catchment 7 is the natural catchment to culvert 7 (catchment to culvert 6 + additional area to culvert 7 (0.0127km²))



Drainage Areas

Drainage Area	Area km ²	Area hectares
1	0.0832	8.32
2	0.1331	13.31
3	0.1049	10.49
4	0.0424	4.24
5	0.0140	1.40
6	0.0842	8.42
7	0.1127	11.27
8 & 8a	0.2913	29.13
Total	0.866	86.567

NB: Drainage Area 7 is the proposed drainage to culvert 7 which includes drainage area 6 (0.0842km²) the road area and the embankments associated with network B (0.0286km²). Drainage Area 8 (0.2823km²) includes the additional road drainage associated with area 8a (0.0090km²)



Values obtained from imported data in ArcGIS for ADAS calculations

Drainage / catchment area	Drainage Area km ²	Catchment width (top of catchment divide to	Average height of catchment divide (m)					
			length of catchment divide (m)	highest elevation (mAOD)	lowest elevation (mAOD)	Average height (mAOD)	Elevation at the point of discharge	Height at catchment divide (m)
1	0.0832	687	134	265	259	262	189	73.0
2	0.1331	748	164	259	257	258	186	72.0
3	0.1049	588	296	258	238	248	190	58.0
4	0.0424	460	222	238	217	227.5	186	41.5
5	0.0140	176	193	217	198	207.5	183	24.5
6	0.0842	612	202	260	254	257	177	80.0
7	0.1127							
8	0.2823	1086	656	375	251	313	165	148.0
Additional road area to 7 (Network C)	0.0286	626	20	187	185	186	171	15.0
Additional road area to 8 (8a) (Network C)	0.0090	130	49	182	168	175	165	10.0

IH 124

$$QBAR_{RURAL} = 0.00108 \cdot AREA^{0.89} SAAR^{1.17} SOIL^{2.17}$$

$QBAR_{RURAL}$ = mean annual flood for small rural catchments (m³/s)

AREA = catchment area

SAAR = standard average annual rainfall in mm for the period 1941 to 1970

SOIL = soil index (obtained from Flood Studies Report)

FROM CIRIA SUDs Manual C697

	Value	Unit	Source
SAAR	2471	mm	(FEH software)
SOIL	0.53	dimensionless	soil index obtained from Flood Studies Report

Return Period	UK Growth Curve Factors for Hydrometric Area 2 (Crianlarich)
2	0.91
5	1.11
10	1.42
25	1.81
50	2.17
75	2.38
100	2.63
200	2.98
500	3.45

Natural Catchment Area	Area (km ²)	AREA ^{0.89}	SAAR ^{1.17}	SOIL ^{2.17}	QBAR per 0.5km ² (m ³ /s)	QBAR scaled to area (QBAR x (Area km ² / 0.5 km ²) m ³ /s)	Q50 m3/s = (QBAR x 2.17)	Q75 m3/s = (QBAR x 2.38)	Q100 m3/s = (QBAR x 2.63)	Q200 m3/s = (QBAR x 2.98)	Q50 l/s	Q75 l/s	Q100 l/s	Q200 l/s
1	0.0807	0.5396	9325.26	0.2522	1.3704	0.22	0.48	0.53	0.58	0.66	479.98	526.43	581.73	659.15
2	0.1276	0.5396	9325.26	0.2522	1.3704	0.35	0.76	0.83	0.92	1.04	758.61	832.02	919.42	1041.78
3	0.1077	0.5396	9325.26	0.2522	1.3704	0.30	0.64	0.70	0.78	0.88	640.30	702.27	776.03	879.31
4	0.0413	0.5396	9325.26	0.2522	1.3704	0.11	0.25	0.27	0.30	0.34	245.84	269.63	297.95	337.60
5	0.0116	0.5396	9325.26	0.2522	1.3704	0.03	0.07	0.08	0.08	0.09	68.85	75.51	83.44	94.55
6	0.0734	0.5396	9325.26	0.2522	1.3704	0.20	0.44	0.48	0.53	0.60	436.84	479.12	529.45	599.90
7	0.0861	0.5396	9325.26	0.2522	1.3704	0.24	0.51	0.56	0.62	0.70	512.08	561.64	620.63	703.23
8	0.2807	0.5396	9325.26	0.2522	1.3704	0.77	1.67	1.83	2.02	2.29	1669.58	1831.15	2023.50	2292.79

Drainage Area	Area (km ²)	AREA ^{0.89}	SAAR ^{1.17}	SOIL ^{2.17}	QBAR per 0.5km ² (m ³ /s)	QBAR scaled to area (QBAR x (Area km ² / 0.5 km ²) m ³ /s)	Q50 m3/s = (QBAR x 2.17)	Q75 m3/s = (QBAR x 2.38)	Q100 m3/s = (QBAR x 2.63)	Q200 m3/s = (QBAR x 2.98)	Q50 l/s	Q75 l/s	Q100 l/s	Q200 l/s
1	0.0832	0.5396	9325.26	0.2522	1.3704	0.23	0.49	0.54	0.60	0.68	494.84	542.73	599.74	679.55
2	0.1331	0.5396	9325.26	0.2522	1.3704	0.36	0.79	0.87	0.96	1.09	791.44	868.03	959.21	1086.86
3	0.1049	0.5396	9325.26	0.2522	1.3704	0.29	0.62	0.68	0.76	0.86	623.74	684.10	755.96	856.56
4	0.0424	0.5396	9325.26	0.2522	1.3704	0.12	0.25	0.28	0.31	0.35	252.29	276.70	305.77	346.46
5	0.0140	0.5396	9325.26	0.2522	1.3704	0.04	0.08	0.09	0.10	0.11	83.00	91.03	100.59	113.98
6	0.0842	0.5396	9325.26	0.2522	1.3704	0.23	0.50	0.55	0.61	0.69	500.61	549.06	606.73	687.47
7	0.1969	0.5396	9325.26	0.2522	1.3704	0.54	1.17	1.28	1.42	1.61	1171.04	1284.36	1419.28	1608.15
8	0.2913	0.5396	9325.26	0.2522	1.3704	0.80	1.73	1.90	2.10	2.38	1732.28	1899.92	2099.49	2378.89

With Climate Change (+ 20%)

Catchment Area	Q100 m ³ /s	Q200 m ³ /s
1	0.70	0.79
2	1.10	1.25
3	0.93	1.06
4	0.36	0.41
5	0.10	0.11
6	0.64	0.72
7	0.74	0.84
8	2.43	2.75
Drainage Area	Q100 m ³ /s	Q200 m ³ /s
1	0.72	0.82
2	1.15	1.30
3	0.91	1.03
4	0.37	0.42
5	0.12	0.14
6	0.73	0.82
7	1.70	1.93
8	2.52	2.85

Calculation note:

Drainage area 7 incorporates flow from drainage area 6. The areas of the two catchments have been combined before IH124 calculations.
 Drainage area 8 incorporates flow from drainage area 8 and additional road area 8a (network C).

ADAS

$$Q = AREA(0.0443 \bullet SAAR - 11.19)SOIL^{2.0} * \left[\frac{18.79T^{0.28} - 1}{10T} \right]$$

Q = mean annual flow

AREA (in km²) is the catchment plan area

SAAR (in mm) is the standard average annual rainfall

SOIL = 0.5 (obtained from flood studies report)

T is the time of concentration (in hours)

where T =

$$T = 0.1677 \frac{W^{0.78}}{Z^{0.39}}$$

W is the max catchment width in metres

Z is the average height of the catchment divide in metres above the discharge level (ditch level)

FROM CIRIA SUDs Manual C697

	Value	Unit	Source
SAAR	2471	mm	(FEH software)
SOIL	0.5	dimensionless	soil index obtained from Flood Studies Report

Return Period	UK Growth Curve Factors for Hydrometric Area 2 (Crianlarich)
2	0.91
5	1.11
10	1.42
25	1.81
50	2.17
75	2.38
100	2.63
200	2.98
500	3.45

Catchment Area	Area (km ²)	W	Z	T	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s	Q50 l/s	Q75 l/s	Q100 l/s	Q200 l/s
1	0.0807	705	73.0	5.24	1.09	2.37	2.60	2.87	3.26	2371	2600	2873	3256
2	0.1276	739	71.5	5.48	1.67	3.63	3.98	4.40	4.98	3630	3981	4399	4984
3	0.1077	538	60.0	4.58	1.60	3.48	3.82	4.22	4.78	3479	3816	4217	4778
4	0.0413	457	41.5	4.66	0.61	1.32	1.45	1.60	1.81	1320	1448	1600	1813
5	0.0116	174	27.5	2.58	0.26	0.56	0.62	0.68	0.77	563	617	682	773
6	0.0734	655	85.0	4.66	1.08	2.34	2.57	2.84	3.22	2344	2571	2841	3219
7	0.0127	750	46.0	6.59	0.15	0.32	0.35	0.38	0.44	317	348	384	436
8	0.2807	1048	151.5	5.37	3.73	8.10	8.89	9.82	11.13	8104	8889	9822	11130
7 (incorporating catchments 6+7)	0.0861				1.23	2.66	2.92	3.23	3.65	2661	2919	3226	3655

Drainage Area	Area (km ²)	W	Z	T	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s	Q50 l/s	Q75 l/s	Q100 l/s	Q200 l/s
1	0.0832	687	73	5.14	1.14	2.48	2.72	3.01	3.40	2479	2719	3005	3405
2	0.1331	748	72	5.52	1.74	3.77	4.13	4.57	5.18	3769	4133	4567	5175
3	0.1049	588	58	4.98	1.47	3.20	3.51	3.87	4.39	3196	3506	3874	4389
4	0.0424	460	42	4.68	0.62	1.35	1.48	1.64	1.85	1350	1481	1636	1854
5	0.0140	176	25	2.72	0.30	0.65	0.72	0.79	0.90	653	716	792	897
6	0.0842	612	80	4.53	1.26	2.74	3.01	3.32	3.77	2743	3008	3324	3767
7	0.1127	130	15	2.60	2.51	5.45	5.97	6.60	7.48	5445	5972	6600	7478
8	0.2823	1086	148	5.57	3.66	7.94	8.71	9.62	10.90	7938	8706	9621	10901
8a	0.0090	130	10	3.04	0.18	0.39	0.43	0.47	0.53	389	426	471	534

7 (incorporating catchments 6+7)	0.1969				3.77	8.19	8.98	9.92	11.24	8188	8981	9924	11245
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Total drainage to 8 (incorporating catchments 8 and 8a)	0.2913				3.84	8.33	9.13	10.09	11.44	8327	9133	10092	11435
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With Climate Change (+ 20%)

Catchment Area	Q100 m ³ /s	Q200 m ³ /s
1	3.45	3.91
2	5.28	5.98
3	5.06	5.73
4	1.92	2.18
5	0.82	0.93
6	3.41	3.86
7	3.87	4.39
8	11.79	13.36
Drainage Area	Q100 m ³ /s	Q200 m ³ /s
1	3.61	4.09
2	5.48	6.21
3	4.65	5.27
4	1.96	2.22
5	0.95	1.08
6	3.99	4.52
7	11.91	13.49
8	12.11	13.72

Peak flow calculations for catchment 7 include catchment 6 flows as catchment runoff combines before culvert 7.
Peak flow calculations for drainage area 8 include drainage area 8 and flows from additional road area 8a.

IH 124

		IH 124					IH 124 with climate change				
Natural Catchment Area	Area (km2)	QBAR m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s
1	0.0807	0.22	0.48	0.53	0.58	0.66	0.27	0.58	0.63	0.70	0.79
2	0.1276	0.35	0.76	0.83	0.92	1.04	0.42	0.91	1.00	1.10	1.25
3	0.1077	0.30	0.64	0.70	0.78	0.88	0.35	0.77	0.84	0.93	1.06
4	0.0413	0.11	0.25	0.27	0.30	0.34	0.14	0.30	0.32	0.36	0.41
5	0.0116	0.03	0.07	0.08	0.08	0.09	0.04	0.08	0.09	0.10	0.11
6	0.0734	0.20	0.44	0.48	0.53	0.60	0.24	0.52	0.57	0.64	0.72
7	0.0861	0.24	0.51	0.56	0.62	0.70	0.28	0.61	0.67	0.74	0.84
8	0.2807	0.77	1.67	1.83	2.02	2.29	0.92	2.00	2.20	2.43	2.75
Drainage Area	Area (km2)	QBAR m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s
1	0.0832	0.23	0.49	0.54	0.60	0.68	0.27	0.59	0.65	0.72	0.82
2	0.1331	0.36	0.79	0.87	0.96	1.09	0.44	0.95	1.04	1.15	1.30
3	0.1049	0.29	0.62	0.68	0.76	0.86	0.34	0.75	0.82	0.91	1.03
4	0.0424	0.12	0.25	0.28	0.31	0.35	0.14	0.30	0.33	0.37	0.42
5	0.0140	0.04	0.08	0.09	0.10	0.11	0.05	0.10	0.11	0.12	0.14
6	0.0842	0.23	0.50	0.55	0.61	0.69	0.28	0.60	0.66	0.73	0.82
7	0.1969	0.54	1.17	1.28	1.42	1.61	0.65	1.41	1.54	1.70	1.93
8	0.2913	0.80	1.73	1.90	2.10	2.38	0.96	2.08	2.28	2.52	2.85

ADAS

		ADAS					ADAS with climate change				
Catchment Area	Area (km2)	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s
1	0.0807	1.09	2.37	2.60	2.87	3.26	1.31	2.84	3.12	3.45	3.91
2	0.1276	1.67	3.63	3.98	4.40	4.98	2.01	4.36	4.78	5.28	5.98
3	0.1077	1.60	3.48	3.82	4.22	4.78	1.92	4.18	4.58	5.06	5.73
4	0.0413	0.61	1.32	1.45	1.60	1.81	0.73	1.58	1.74	1.92	2.18
5	0.0116	0.26	0.56	0.62	0.68	0.77	0.31	0.68	0.74	0.82	0.93
6	0.0734	1.08	2.34	2.57	2.84	3.22	1.30	2.81	3.09	3.41	3.86
7	0.0861	1.23	2.66	2.92	3.23	3.65	1.47	3.19	3.50	3.87	4.39
8	0.2807	3.73	8.10	8.89	9.82	11.13	4.48	9.73	10.67	11.79	13.36
Drainage Area	Area (km2)	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s	Q m ³ /s	Q50 m ³ /s	Q75 m ³ /s	Q100 m ³ /s	Q200 m ³ /s
1	0.0832	1.14	2.48	2.72	3.01	3.40	1.37	2.98	3.26	3.61	4.09
2	0.1331	1.74	3.77	4.13	4.57	5.18	2.08	4.52	4.96	5.48	6.21
3	0.1049	1.47	3.20	3.51	3.87	4.39	1.77	3.84	4.21	4.65	5.27
4	0.0424	0.62	1.35	1.48	1.64	1.85	0.75	1.62	1.78	1.96	2.22
5	0.0140	0.30	0.65	0.72	0.79	0.90	0.36	0.78	0.86	0.95	1.08
6	0.0842	1.26	2.74	3.01	3.32	3.77	1.52	3.29	3.61	3.99	4.52
7	0.1969	3.77	8.19	8.98	9.92	11.24	4.53	9.83	10.78	11.91	13.49
8	0.2913	3.84	8.33	9.13	10.09	11.44	4.60	9.99	10.96	12.11	13.72

Calculation Note:
Flows calculated using ADAS for catchment 7 combine flows calculated separately for catchments 6 and 7. The ADAS methodology requires catchment characteristics to be calculated as a first step and then the flows are summed. Using IH124, catchment 6 and 7 areas are summed prior to calculation. The same has been done for drainage area 8 which includes area 8a (Network C drainage) via filter trench.