Appendix 1

Table 1: Culverts Amendments Design following *New Zealand Fish Passage Guidelines for Structures up to 4 Metres* (2018).

Culvert	Chainage (m)	Priority for fish passage[1] *	Catchment size (ha)	AEE Design	Amended Solution			
					Hierarchy achieved Fish passage type		Bridge/ Culvert type	Design Comments
8	1700	Moderate	7.95	1200 mm Dia Pipe Culvert 35 m long 4.0% Grade Fish Baffle	3	Hydraulic Design Culvert >1.3 bank width	1500 mm Dia Pipe Culvert 45 m long 3.0% Grade 30% Embedment	Existing bank width ranges from 1.0 to 1.5 m. Typical bankfull width approximately is 1.1 m. AEE design included providing a fish baffle for fish passage. Amended design increases culvert diameter to 1500 mm and provides embedment depth to 30% of the culvert height. Change in culvert length is due to design development. The culvert grade is reduced from 4% to 3%, improving low flow velocities for fish passage. This culvert provides hydraulic design for fish passage and in addition a culvert width of 1.3 x bankfull width.
9	1850	High	66.8	4 x 1350 mm Dia Circular Culverts 56 m long 0.5% Grade 20% Embedment	2	Stream simulation	3000-4000 mm span Arch/Box Culvert 43 m long 0.3% Grade Stream Bed	The existing stream is an incised channel with steep / near vertical sides. Typical stream dimensions are 1.7 m wide x 0.8 m deep. AEE design comprised of 4 pipe culverts installed with 20% embedment depth of culvert height. The culvert size was limited by fill embankment height. Geotechnical investigations indicate geometry can be raised to allow an arch/box culvert to be used. An arch or box culvert with a bottom below the created streambed is equivalent to a bottomless arch culvert for stream simulation. Final design will require assessment of ground conditions. Design of culvert sized to achieve stream simulation

[1] Relative Priority as advised by ecology expert

Culvert	Chainage (m)	Priority for fish passage[1] *	Catchment size (ha)	AEE Design	Amended Solution			
					Hierarchy achieved Fish passage type		Bridge/ Culvert type	Design Comments
12	2400	Moderate	9.84	1200 mm Dia Circular Culvert 74 m long 7.0% Grade Fish Baffle	1	Bridge	Bridge	Existing stream top water surface width = 0.65 m with gradient approximately 6%. Design amended to bridge span to provide highest level of fish passage design. Erosion protection above stream bankfull width for bridge abutments to be provided if required.
14	2900	Low	4.72	900 mm Dia Circular Culvert 117 m long 16% Grade Fish Baffle	3	Hydraulic Design Culvert >1.3 bank width	1500 mm Dia Circular Culvert 140 m long ≤1.0% 30% Embedment	Existing stream top water surface width = 0.4 m. AEE design included providing a fish baffle for fish passage. Amended design increases culvert diameter to 1500 mm and provides embedment to 30% of the culvert height. Change in culvert length is due to design development and improves fish passage by significantly reducing culvert gradient from 16% to 1%. This culvert provides hydraulic design for fish passage and in addition a culvert width of >1.3 x bankfull width.
15	2960	High	50.5	2550 mm Dia Circular Culvert 210 m long 1% Grade 20% Embedment	3	Hydraulic design	2500 mm Dia Circular Culvert 250 - 280 m long 1% grade 25% Embedment	Existing stream width varies from 1.0 to 2.5 m wide with a gradient between waterfalls of 3 – 4% according to LiDAR survey. Existing waterfalls up to 5.5 m in height. AEE culvert design provided 20% embedment of the culvert height for fish passage. The proposed SH3 alignment runs along the stream for > 300 m in length approximately 40 m above the streambed at the greatest height difference and therefore a bridge is not considered practically feasible. Construction of a stream simulation within a culvert /250 m long would be difficult and costly to construct and maintain. Therefore, hydraulic design for fish passage has been adopted. The proposed culvert solution has been modified from AEE by increasing embedment to 25% of the culvert height. This culvert provides hydraulic design for fish passage and a culvert width similar to the bankfull width at the proposed culvert inlet. The proposed culvert grade is significantly lower than the existing stream grade reducing velocities to aid fish passage.

Culvert	Chainage (m)	Priority for fish passage[1] *	Catchment size (ha)	AEE Design	Amended Solution			
					Hierarchy achieved Fish passage type		Bridge/ Culvert type	Design Comments
16	3800	Moderate	13.6	1500 mm Dia Circular Culvert 115 m long 3% Grade Fish Baffle	3	Hydraulic Design	2100 mm Dia Circular Culvert 147 m long <1% Grade 30% Embedment	Existing channel maximum width is approximately 2.1 m narrowing to 1.5 m where incised. Mountain stream with drops and small waterfalls. Upgrade can be achieved providing a flatter gradient and a wider embeded substrate. Amended design increases culvert diameter to 1500 m, and provides 30% embedment of the culvert height. Change in culvert length is due to design development and improves fish passage by reducing culvert gradient from 3% to <1%. This culvert provides hydraulic design for fish passage and in addition a culvert width similar to the bankfull width.
17	4400	Low	3.04	825 mm Dia Circular Culvert 22 m long 14% Grade Fish Baffle	3	Hydraulic Design Culvert >1.3 bank width	900 mm Dia Circular Culvert 22 m long 14.0% Grade 30% Embedment	Existing channel is 0.4 m with a bankfull width of approximately 0.6 m. Amended design increases culvert diameter to 900 mm and provides 30% embedment of the culvert height at the culvert outlet. This culvert provides fish baffles and a culvert width of >1.3 x bankfull width.
18	4750	High	25.5	2100 mm Dia Circular Culvert 29 m long 1.0% Grade 20% Embedment	2	Stream simulation	2500 -3000 mm span Arch/Box Culvert 29 m long 1.0% Grade Stream bed	Existing stream is an incised channel with steep / near vertical sides. Width is approximately 0.5 m -1.2 m as measured on site with bankfull width assessed as 1.2 m. The existing stream does not currently connect directly to the main stream, but runs over land across pasture and through a small farm culvert. An arch or box culvert with a bottom below the created streambed is equivalent to a bottomless arch culvert for stream simulation. Final design will require assessment of ground conditions. Design of culvert sized to achieve stream simulation.
19	4750		25.5	2100 mm 1.0% Grade	No longer required for project. Refer to Mr Peter Roan's evidence for reasons of removal of the associated fill site.			

Table 2 Summary of Project Culverts

Culvert	Chainage (m)	Fish Passage	Size (mm)	Gradient (%)	Length (m)	Fish Passage Type
1	250	Yes	1050 dia	0.5	24	Hydraulic Design
2	300	No	825 dia	1.0	26	Not Required
3	570	Yes	1500 dia	0.3	67	Hydraulic Design
4	750	Yes	600 dia	1.0	81	Hydraulic Design
5	870	Yes	1350 dia	2.0	87	Hydraulic Design
6	1300	Yes	1350 dia	0.5	27	Hydraulic Design
7	1500	Yes	1200 dia	3.0	36	Hydraulic Design
8	1700	Yes	1500 dia	3.0	45	Hydraulic Design
9	1850	Yes	3000 to 4000 span arch/box culvert	0.3	43	Stream Simulation
10	2220	No	750	1.0	37	Not Required
11	2300	Yes	750	17	15	Steep culvert with baffles
12	2400	Yes	Culvert Replaced with a bridge			Bridge
13	2700	No	600	14	25	Not Required
14	2900	Yes	1500	≤1.0	140	Hydraulic Design
15	2960	Yes	2500	1.0	250-280	Hydraulic Design
16	3800	Yes	2100	< 1.0	147	Hydraulic Design
17	4400	Yes	900	14	22	Steep culvert with baffles
18	4750	Yes	2500 to 3000 span arch/box culvert	1.0	29	Stream Simulation
19	4750	Culvert removed from project				
20	5150	Yes	1650	1.0	40	Hydraulic Design
21	5650	Yes	1650	1.0	34	Hydraulic Design