Ministry for the Environment
Manatū Mō Te Taiao

Culvert and Bridge Construction

Guidelines for Farmers

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1 Introduction

These guidelines provide dairy farmers considering constructing a culvert or bridge with information and design details to simplify the process for gaining resource consent and ensure that a suitable standard of bridge/culvert is constructed. They have been developed as part of the Clean Streams Accord signed by the Ministry and Fonterra in 2003.

2 Culvert Guidelines

2.1 Resource consent

If you wish to construct a culvert in a stream you are likely to need a resource consent. Consent requirements for culvert construction vary throughout the country. Contact your local regional council to discuss your proposal to find out if a consent is required and what information you need to provide.

2.2 Guideline criteria

These guidelines are **not** suitable when the following situations apply:

- overtopping of the culvert could cause flooding to nearby houses or buildings
- the crossing point is within 1 km of a residential area where the backup of flow behind the culvert could cause flood problems
- high debris loads are likely, eg, significant gravel bedload, flood debris such as trees or logs
- locations where the embankment above the culvert is greater than 1.5 m above the soffit and/or overtopping could cause embankment failure with significant consequences
- steep hill catchments
- catchments larger than 500 ha.

2.3 Culvert size

To determine what size of culvert is required, first look near your proposed crossing to see if there are any other culverts on the same stream which work well in storms (ie, do not flood upstream in smaller floods and do not regularly overtop). This may give you a guide as to an appropriate pipe size, although in many cases culverts in place on the stream may not be appropriately sized.

To size a culvert using this guide:

1. Check the criteria to confirm that these guidelines are suitable for your location.
2. Determine the catchment area above the crossing point. If using NZMS 1:50,000 maps note that one square on the map equals 100 ha.
3. Locate the catchment on the rainfall maps and identify the rainfall band. Note: if the catchment lies across two rainfall bands, use the higher band.
4. Refer to the culvert sizing tables for the relevant rainfall band and choose the catchment area closest to your catchment. This will give you a recommended culvert diameter. Note: a single large pipe can be replaced by two or more smaller pipes. See the table below for equivalent culvert capacities using smaller pipe.

If your catchment is larger than those in the culvert tables you should contact your local regional council or an agricultural/rivers engineer for advice. You may require a bridge rather than a culvert.

The minimum recommended culvert size is 300 mm in all situations. This is because smaller culverts are easily blocked by only a small amount of debris.

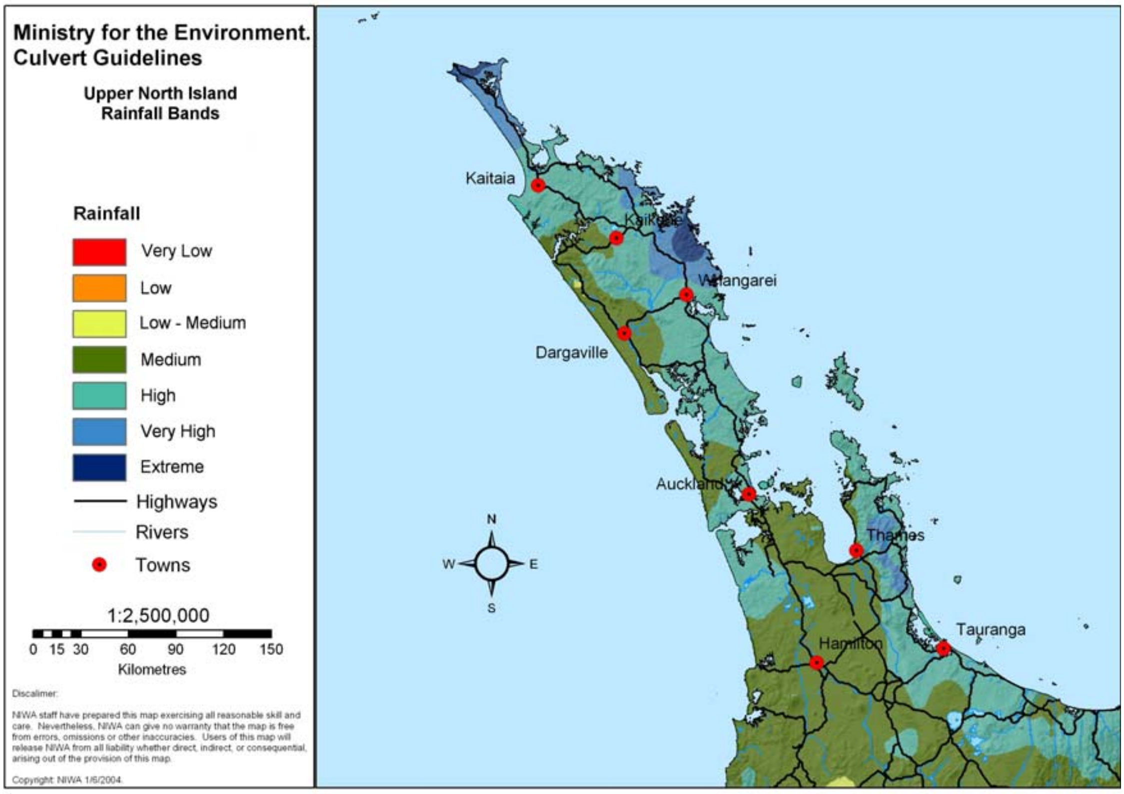
In some cases a large single culvert may not be the most practical option. Table 2.1 gives equivalent multiple barrel culvert installations, which will provide the required culvert capacity.

Table 2.1: Equivalent capacities for multiple barrel culverts

Pipe diameter	Equivalent to		
300 mm			
375 mm	2 x 300 mm		
450 mm	2 x 375 mm	3 x 300 mm	
525 mm	2 x 450 mm	3 x 375 mm	4 x 300 mm
600 mm	2 x 450 mm	3 x 375 mm	4 x 375 mm
675 mm	2 x 525 mm	3 x 450 mm	4 x 375 mm
750 mm	2 x 600 mm	3 x 450 mm	4 x 450 mm
825 mm	2 x 675 mm	3 x 525 mm	4 x 450 mm
900 mm	2 x 675 mm	3 x 600 mm	4 x 525 mm
975 mm	2 x 750 mm	3 x 600 mm	4 x 525 mm
1050 mm	2 x 825 mm	3 x 675 mm	4 x 600 mm
1200 mm	2 x 900 mm	3 x 750 mm	4 x 675 mm
1350 mm	2 x 1050 mm	3 x 825 mm	4 x 750 mm
1600 mm	2 x 1200 mm	3 x 975 mm	4 x 900 mm
1800 mm	2 x 1350 mm	3 x 1200 mm	4 x 975 mm
1950 mm	2 x 1600 mm	3 x 1200 mm	4 x 1050 mm
2100 mm	2 x 1600 mm	3 x 1350 mm	4 x 1200 mm
2550 mm	2 x 1950 mm	3 x 1600 mm	

The culvert sizes provided in this guide will in most cases pass storm flows equating to about the 1 in 5 year storm. Therefore from time to time they can be expected to overtop and in very large storms may scour out. If you wish to have a higher level of storm protection, or gain a more site-specific understanding of your risk, you will need to take advice from your regional council or a suitably experienced consulting engineer.

The maps and culvert tables on the following pages show the Rainfall Bands for different locations in New Zealand together with the recommended culvert size depending on the size of the relevant catchment.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Rainfall
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Low - Medium
Medium
High
Very High
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Highways
Rivers
Towns
1:2,500,000
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Kilometres
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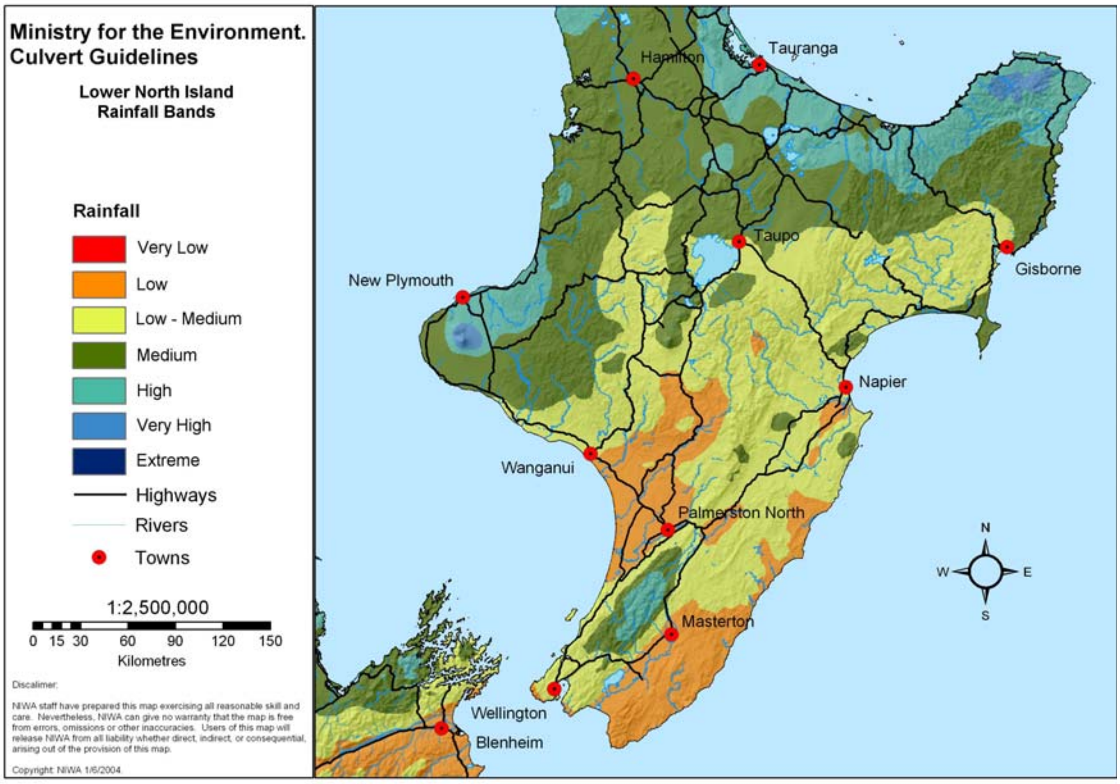
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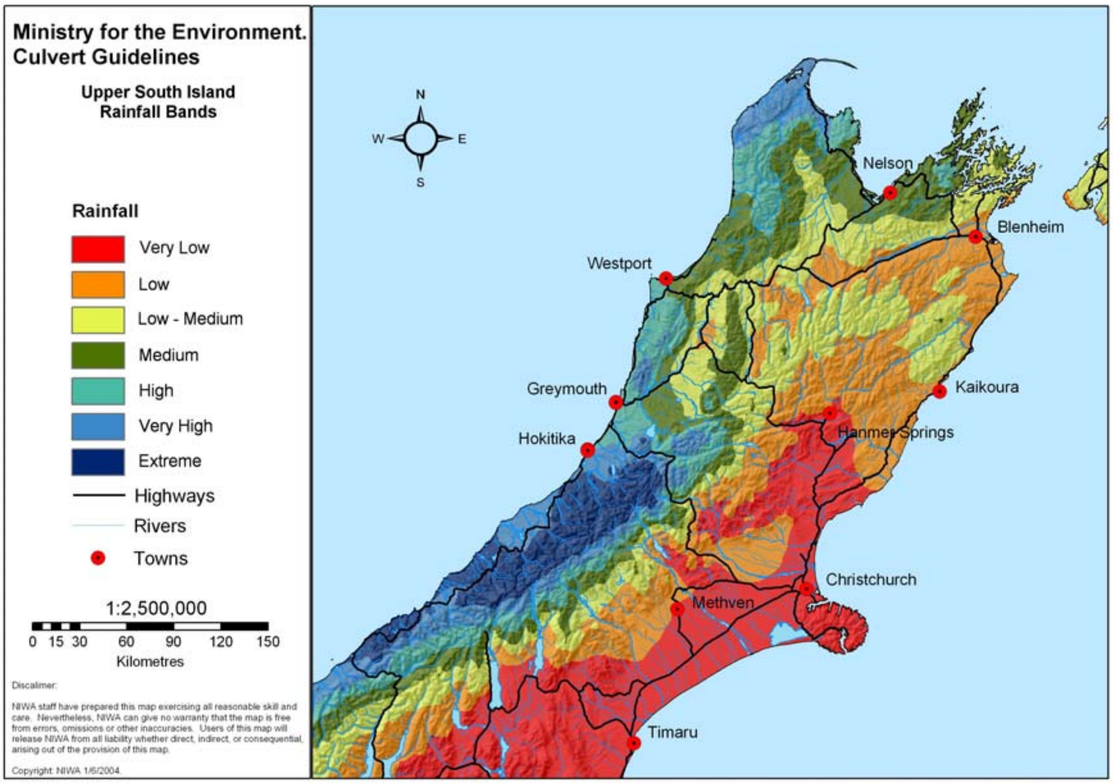

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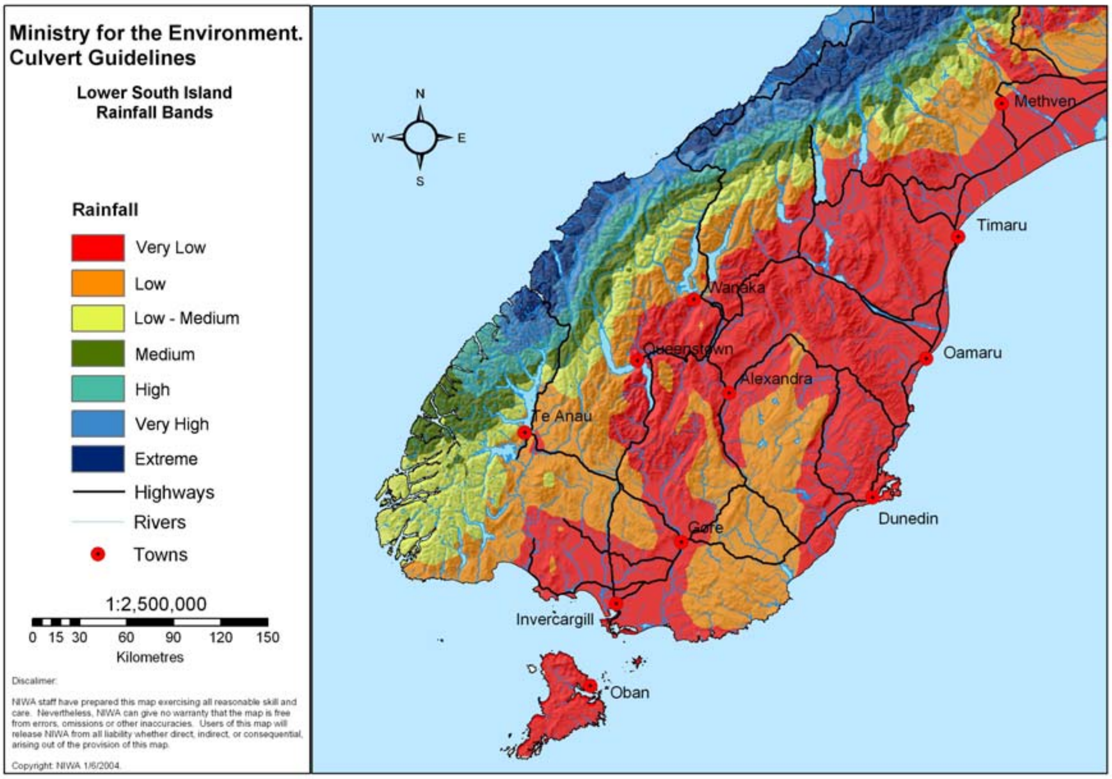

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E
S
Methven
Timaru
Wanaka
Oamaru
Queenstown
Alexandra
Te Anau
Dunedin
Gore
Invercargill
Oban

Table 2.2: Culvert tables

	Very low
5 ha	300 mm
10 ha	375 mm
15 ha	450 mm
20 ha	525 mm
30 ha	600 mm
40 ha	675 mm
50 ha	825 mm
100 ha	975 mm
150 ha	1200 mm
200 ha	1350 mm
250 ha	1600 mm
300 ha	1600 mm
350 ha	1600 mm
400 ha	1800 mm
450 ha	1800 mm
500 ha	1950 mm
	Very low

	Low
5 ha	300 mm
10 ha	450 mm
15 ha	525 mm
20 ha	600 mm
30 ha	675 mm
40 ha	825 mm
50 ha	900 mm
100 ha	1200 mm
150 ha	1350 mm
200 ha	1600 mm
250 ha	1800 mm
300 ha	1800 mm
350 ha	1800 mm
400 ha	1950 mm
450 ha	2100 mm
500 ha	2100 mm
	Low

	Low–medium
5 ha	375 mm
10 ha	450 mm
15 ha	600 mm
20 ha	675 mm
30 ha	825 mm
40 ha	900 mm
50 ha	975 mm
100 ha	1350 mm
150 ha	1600 mm
200 ha	1800 mm
250 ha	1950 mm
300 ha	1950 mm
350 ha	2100 mm
400 ha	2100 mm
450 ha	2550 mm
500 ha	2550 mm
	Low–medium

	Medium
5 ha	375 mm
10 ha	525 mm
15 ha	600 mm
20 ha	675 mm
30 ha	825 mm
40 ha	975 mm
50 ha	1050 mm
100 ha	1350 mm
150 ha	1600 mm
200 ha	1950 mm
250 ha	2100 mm
300 ha	2100 mm
350 ha	2550 mm
400 ha	2550 mm
450 ha	2550 mm
500 ha	n/a
	Medium

	High
5 ha	450 mm
10 ha	600 mm
15 ha	675 mm
20 ha	750 mm
30 ha	900 mm
40 ha	1050 mm
50 ha	1200 mm
100 ha	1600 mm
150 ha	1800 mm
200 ha	2100 mm
250 ha	2550 mm
300 ha	2550 mm
350 ha	2550 mm
400 ha	2550 mm
450 ha	n/a
500 ha	n/a
	High

	Very high
5 ha	450 mm
10 ha	600 mm
15 ha	675 mm
20 ha	825 mm
30 ha	975 mm
40 ha	1200 mm
50 ha	1200 mm
100 ha	1600 mm
150 ha	1950 mm
200 ha	2550 mm
250 ha	2550 mm
300 ha	2550 mm
350 ha	2550 mm
400 ha	n/a
450 ha	n/a
500 ha	n/a
	Very high

	Extreme
5 ha	525 mm
10 ha	675 mm
15 ha	825 mm
20 ha	975 mm
30 ha	1200 mm
40 ha	1350 mm
50 ha	1600 mm
100 ha	1800 mm
150 ha	2550 mm
200 ha	2550 mm
250 ha	n/a
300 ha	n/a
350 ha	n/a
400 ha	n/a
450 ha	n/a
500 ha	n/a
	Extreme

2.4 Culvert materials

There are a number of possibilities for culvert materials such as concrete, polyethylene/plastic, and corrugated steel. When choosing a material, consider the site conditions and the expected traffic loads over the culvert.

- In difficult to access locations a lighter material may make construction simpler whereas if the traffic loading is high the pipe material will need to be able to cope with this.
- In areas where agricultural and fertiliser runoff occur, steel culverts can suffer accelerated corrosion.
- In soft soils a single length flexible pipe will cope better than multiple section rigid pipes. In very soft soils, settlement of the pipe can affect the culvert performance – in these cases an engineer should be consulted.
- If high traffic loads are anticipated eg, logging trucks, contact an engineer to provide a specific design.

Contact your local rural supplier for prices and availability.

2.5 Culvert construction

You will need to consider crossing location. This may be determined by track locations but there may be more suitable alternative crossing points. Ideally a crossing point should be at the narrowest point of the stream with flat approaches on either side.

The culvert sizes in this guide allow for low flood flows. An allowance needs to be made for larger flood flows to prevent damage to the culvert and track. The best way to achieve this is to create a lowered spillway (approx 0.5 m deep) to the side of the culvert to allow controlled overtopping of the culvert. The spillway should be wide and level across the track and away from the culvert fill material. The outlet side of the spillway should be gently sloping back to the stream and grassed or rock armoured to prevent erosion.

If there is no suitable location for a spillway adjacent to the culvert, the spillway can be over the culvert. In this case special care must be taken in the construction of the culvert headwalls to protect the fill material from being washed out.

Allowance must be made in construction for fish passage through the culvert. The simplest way of achieving this is to make sure the base of the culvert is slightly below the streambed and that the culvert is laid on the same grade as the natural stream. As a rough guide culverts less than 600 mm should be buried 75 mm into the streambed; culverts less than 1000 mm should be buried 100 mm; and culverts larger than 1000 mm should be buried in the stream by 150 mm.

Headwalls should be provided at the culvert entry and exit. Headwalls retain earthfill and improve the hydraulic capacity for culverts as well as protecting against turbulence, which can erode stream banks and undermine culverts and tracks leading to expensive maintenance. A variety of headwall constructions may be suitable including precast concrete, posts with timber lagging, gabions, concrete filled bags, insitu concrete and rock.

Using rock armouring in the streambed at the culvert outlet will help prevent undermining of the culvert and improve conditions for fish to pass through the culvert. Rocks 200–300 mm in diameter will be suitable for most situations, preferably with a geotextile layer below to prevent fine material washing away and gradually eroding the area.

Runoff from tracks leading to and from the culvert should be diverted away from the stream using earth cutoff drains.

Fill over the culvert should be no higher than 1.5 m. High fills allow for greater depths of water backing up and will increase the flow velocity and erosive potential at the outlet and immediately downstream of the culvert, increasing the likelihood of damage. The fill depth should be checked against the pipe manufacturer’s recommendations to ensure the pipe is capable of supporting the load. In most cases the culvert should have at least 0.5 metres of compacted material above. This protects the culvert by using the soil structure to spread loads across the pipe and preventing high point loads.

Backfill around the culvert should be compacted during construction and it is important that the pipe bedding (the material the pipe is directly sitting in) is firm and supports the pipe barrel. Fill should be clean and free of debris, vegetation and topsoil. Vegetation and topsoil must be cleared from the crossing point before the culvert is installed.

2.6 Culvert maintenance

It is important that culvert entries and outlets are kept clear of debris as this can seriously reduce the flow capacity of the culvert and result in additional flooding and damage. Ensure culverts are clear by checking regularly particularly before and immediately after heavy rain. A small amount of time can save a large amount of dollars!

2.7 Culvert costs

Culvert costs vary with the location, pipe material and the pipe size. Typical costs would be in the range of $2,500 to $25,000 depending on size and location.

3 Information about Bridges

If your crossing point is not within the criteria for culverts referred to in Section 2.2 or the geography of the crossing point make a culvert impractical you are likely to require a bridge. If this is the case you will need to contact an engineer or bridging contractor to develop a design suitable for your location.

As is the case with most culverts, resource consent will be required for all bridge structures. Contact your local regional council to discuss your proposal and find out what information you need to provide. A building consent will also be required from your local district council.

As a general rule the bridge deck should, where possible, be 0.5 m higher than the surrounding ground/floodplain. This allows debris to pass under the bridge during flood events and prevents the bridge becoming a major obstruction in high flows, as water can pass around the bridge.

A number of companies are able to produce prefabricated concrete bridge decks for spans up to 12 m. These are often quick to construct and cheaper to install. The costs to construct a bridge vary depending on a number of factors eg, bridge location, access to the site, the bridge span required, the expected bridge loading, abutment piling, and erosion protection. For a typical situation the costs generally range from $2,500 to $4,000 per metre span of the bridge.

As for culverts, regular inspections of the bridge can save money and reduce flood risks. Monitoring the abutments for signs of erosion is also important as is checking for damage to the bridge deck.

4 Culvert Worked Examples

4.1 Worked example 1

Jack and Jill Jersey have a dairy farm a few kilometres north of Gisborne and are planning to culvert a stream crossing on their farm.

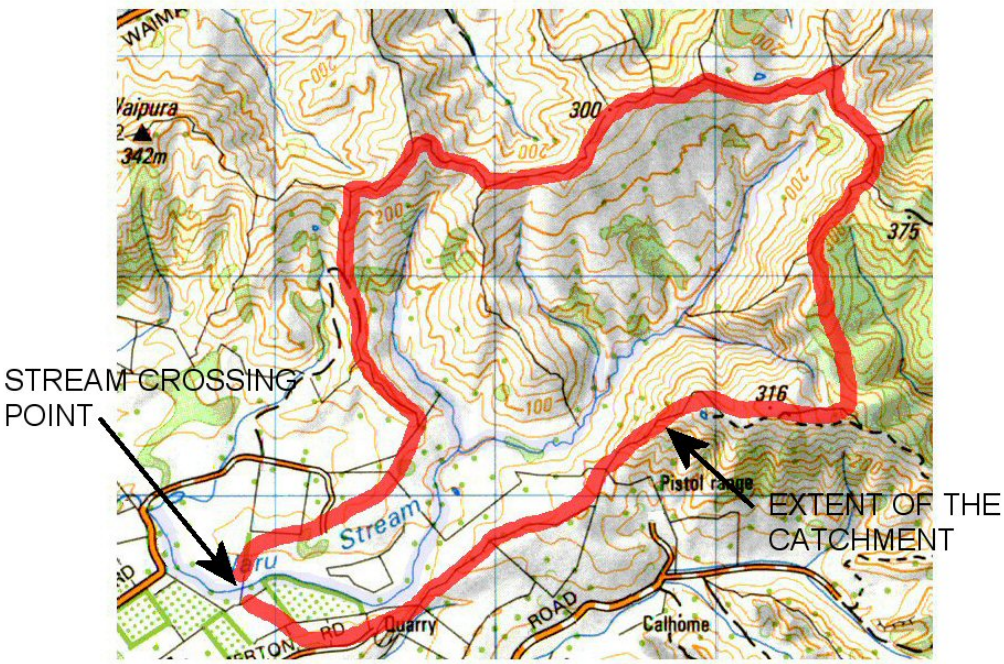
Using the culvert guidelines to size their culvert, they first check that there are no low lying buildings or residential areas upstream of their proposed crossing point. They also know that the amount of debris in the stream during floods is low.

Jack and Jill use a topographic map to calculate their catchment area (the area of land from which water runs into the stream). Knowing that 1 grid square on the map equals 100 hectares they estimate their catchment area at 380 hectares, and check that it fits the criteria for using the culvert guidelines.

Looking at the rainfall maps, the Jerseys can see that they are close to the boundary between the *low–medium* rainfall area and the *medium* rainfall area. To ensure the culvert is properly sized they select the *medium* rainfall band as this will give a larger culvert.

Jack and Jill now know the size of their catchment, and the rainfall area their catchment is within. They can now check the culvert tables to find the required culvert size. Their catchment at 380 hectares is closest to 400 hectares on the table, which shows that they require a 2550 mm diameter culvert.

Figure 4.1: Jack and Jill Jersey's crossing point and catchment



4.2 Worked example 2

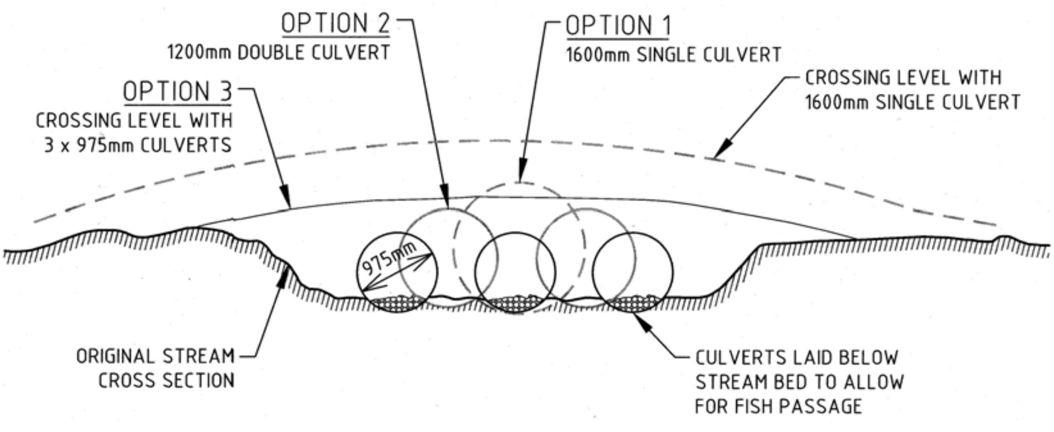
Fred and Fiona Friesian have a dairy farm near Oamaru and are putting in a stream crossing on their property. Like the Jerseys (Worked example 1), they also check that their crossing location and catchment is suitable to use the guidelines, by looking at possible areas of flooding and how the water build-up that will occur upstream of a culvert may affect any nearby buildings. They confirm that the other criteria listed in the guidelines apply to their catchment.

Fred and Fiona have calculated their catchment area as 350 hectares and have identified from the maps that they are in the *low* rainfall area. Looking at the tables, Fred and Fiona see that they need a 1600 mm diameter culvert. However, the stream that runs through Fred and Fiona's farm is wide and shallow and constructing a 1600 mm culvert will mean the stream crossing is over 1 metre above the surrounding ground. This would also require a large amount of fill to be placed in the stream.

Instead of using a single pipe, Fred and Fiona decide to look at using more than one pipe to get the same capacity as a single 1600 mm pipe but with less earthworks. Looking at the multiple pipe table in the guidelines, they can see that they have the option of using two 1200 mm pipes or three 975 mm pipes. They draw up a simple cross section of the stream (see Figure 4.2 below) to compare their options. The three 975 mm pipes look to be the best option for the Friesians, as this gives a crossing which least impedes the waterway at a high level and requires less fill material across the stream bed.

While a multiple pipe option was the best for Fred and Fiona it is preferable to use a single pipe culvert where possible, as multiple pipe culverts are more prone to blockage.

Figure 4.2: Fred and Fiona Friesian's stream crossing cross-section



5 Acknowledgements

The rainfall maps developed for these guidelines were produced by NIWA using HIRDs (High Intensity Rainfall Distribution software).